THE SOCIAL CONSTRUCTION OF COMPATIBILITY: SETTING VOLUNTARY SAFETY STANDARDS FOR AGRICULTURAL TRACTORS.

by

Rafael J. Balderrama

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APPROVED:

Gary L. Downey, chair

Cornelia B. Flora

Richard F. Hirsh

Glen H. Hetzel

Marianne De Laet

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Blacksburg, Virginia

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Rafael J. Balderrama
Committee chairman: Gary L. Downey
Center for the Study of Science in Society

(ABSTRACT)

This dissertation concerns the ways engineers and safety specialists acting as part-time volunteers cooperate in the setting of voluntary industrywide product safety standards in the farm equipment industry. These cooperative efforts are based, I contend, on collective investment criteria shared by both companies and individual participants. Companies expect long-term benefits stemming not only from their early access to information about the proposed changes in product design, but also from the extent they can influence the outcome in ways that reduce their costs and accommodate their product design and manufacture requirements. Individual participants expect to benefit professionally from the knowledge exchanges taking place in the deliberations. I illustrate my argument through a case study in the development of a family of safety standards for agricultural tractors. The study shows that, in setting these standards, participants sought and achieved ways of making their proposed changes in product design more compatible with a changing legal order. The study also shows, however, that collective action may bring some unintended consequences. For instance, given the stiff demands of this order, participant companies' collective efforts to build such compatibility may and did ultimately compromise the voluntary character of both their participation in the deliberations and the implementation of the proposed changes in product design.

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CHAPTER 1
INTRODUCTION

This dissertation has two major aims. First of all, it examines from the perspective of the American farm equipment industry how standards setters agree and define product safety problems in the process of developing voluntary standards. Secondly, it analyzes more generally the ways their agreement and shared problem definitions are related to the problem of the social order.

Setting voluntary standards, I contend, is a collective way of prescribing and promoting uniform industrywide design practices. These promotional efforts are structured in terms of extended committee deliberations in which participants seek agreement, on a project-by-project basis, on documents written after extensive amendments. These documents are known under a number of equivalent titles, like for instance, nongovernmental standards, formal consensus standards, consensus voluntary standards, industry codes, technical standards, and intercompany standards. Agreeing on these documents only occurs, irrespective of the length or complexity of these documents, after extended and somewhat cumbersome deliberations in which participants examine a recurring industrywide problem, seek or produce relevant knowledge, bring it to the committee and share it with other

committee members, draft a proposal, subject it to a seemingly endless series of amendments, ballot the proposal, and finally release it to the public. Participants' lengthy deliberations are based on the assumption that they will ultimately agree and formalize their agreement in terms of sets of written provisions which industry practitioners will implement on a voluntary basis. 1/

Participants' efforts to write these documents and agree on their contents rest, I argue, on long-term cost reduction assumptions and benefits shared by all having a stake in a dominant product design. A design becomes dominant when a particular system or product configuration (e.g., a farm

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1.- The process of writing voluntary standards presents some interesting contrasts with industry practitioners' collaborative writing in corporate settings, which often takes place under severe time constraints and flows from below to the higher ranks of the corporate hierarchy. As a result, the process is likely to become painful, traumatic, and authoritarian. Setting voluntary standards is, by contrast, a much slower process and tends to flow from the upper levels towards the lower skeletons of the firms represented in the deliberations. Given the participatory logic of the process, it may attract large contingents of volunteers, as the texts incorporate countless minor changes from lower rank participants. See, e.g., Dorothy Winsor, "An engineer's writing and the corporate construction of knowledge," Written Communication 6 (1989), pp. 270-285; James Paradis, David Dobrin and Richard Miller, "Writing at Exxon ITD. Notes on the writing environment of an R&D organization," in Writing in Nonacademic Settings, ed. Lee Odell and Dixie Goswami (New York: Guilford Press, 1985), pp. 281-307. Cf. Lal C. Verman's time studies (Standardization [Hamden, Conn.: Archon Books, 1973], pp. 143-148).

tractor, an oil drilling rig, an automobile, a railroad network, and so on) evolves into a sufficiently stable and therefore typical product class as for manufacturers consider the search for economies of scale as one of their top priorities. A product design may stabilize as a broad coalition of corporate managers, engineers, marketers, consumers, repair shop technicians and so on concurs in viewing it, for a relatively extended period of time, as the best possible arrangement and only in need for minor or incremental improvements. As the more recent literature in the Social Studies of Technology shows, the stabilization of a product design relies not only on a temporary rejection of alternative design concepts, but also on their hierarchical treatment of problem definition, resource allocation, and problem solving. 2/ Thus, besides including a functionally

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2.- An early discussion of design practice as a form of resource allocation and an hierarchically structured search for satisfactory designs is in Herbert Simon (Sciences of the Artificial [Cambridge: MIT Press, 1969], esp. pp.69-80). More recent versions are in Kim M. Clark ("Integration of design hierarchies and market concepts in technological evolution," Research Policy 14 [1985], pp. 235-251) and Walter G. Vincenti ("The retractable airplane landing gear and the Northrop 'anomaly': Variation and selection and the shaping of technology," Technology & Culture 35 [1994], pp. 26-31). The literature on the ways relevant groups of practitioners commit themselves and provide support to a dominant design is somewhat fragmented. Richard Nelson and Sidney Winter (Evolutionary theory of economic change [Cambridge: Harvard University Press, Belknap Press, 1982], pp. 96-136), for instance, depict this support in terms of routines ascribable

related set of physical components, a dominant product design also embodies a set of long-term commitments based on its supporters' preference for planning, predictability, and an as-orderly-as-possible pace of technological change. These commitments, which are structured in sets of routines and skills related to the utility dimensions of both the product as a whole and its parts and components, are crucial in ensuring the continuity and permanence of a dominant product design. My contention is that once a dominant design emerges, the relevant groups of practitioners that support it subsume their own problem-solving strategies within the overall cost reduction logic of this design, even if some of their proposed

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to a technological trajectory. Thomas P. Hughes ("Evolution of large technological systems," in Social Construction of Technological Systems, ed. Wiebe Bijker, Thomas Hughes and Trevor Pinch [Cambridge: MIT Press,1987], pp. 51-82) argues that this support is part of practitioners' problem solving and location within a larger technological system. More recently, Michael L. Tushman and Lori Rosenkopf ("Organizational determinants of technological change: Toward a sociology of technological evolution," Research in Organizational Behavior 14 [1992], pp. 311-341) have related this support to the ways it decreases organizational uncertainties. A description of a dominant design as a process of black boxing and stabilization is in Mikael Hard, "Technology as practice: Local and global closure processes in diesel engine design," Social Studies of Science 24 (1994), pp. 549-585. Hughie Mackay and Gareth Gillespie ("Extending the social shaping of technology approach. Ideology and appropriation," Social Studies of Science 22 [1992], pp. 685-716), by contrast, argue that no description of a technological design is complete nor adequate if it fails to take into account the interactive roles of its promoters and users.

changes temporarily increase the cost of certain components. In short, standards setters' approach to the recurring problems of a dominant product design, among them safety problems, encompasses both clear ways of reducing its costs and other changes that, despite their added cost, they expect will remove some, even more burdensome, functional uncertainties from the dominant design.

The view of the standards-setting process as related to the recurring problems of a dominant product design captures, I contend, not only participants' shared concern with the scope and utility of their cooperation and promotional efforts, but also the complex ways they interact with other social groups. There are, I argue, at least three major ways groups having a stake in a dominant design, but unrepresented or underrepresented in the deliberations, may interact with participants' proposed design changes. First of all, the very search for economies of scale typical of a dominant design may put its supporters in contact with expanded markets and a broader context of standards implementation for which standards setters may consider re-negotiating a common approach with other players (i.e., foreign standards setters, overseas regulatory agencies, etc.) not initially seen as having a substantive interest in the dominant design. Secondly, some parties (e.g., manufacturers of specialized

equipment, domestic regulatory agencies, extension safety specialists, etc.) may see themselves as having a stake in the dominant design, but the intensity of their participation vary according to the ways they (re)interpret the scope of this stake and the merits of participant companies' solutions. Thirdly, other parties (e.g., product users) may also have a stake in a dominant design, but for practical reasons, find it preferable to seek alternative and, in their view, more expedient ways of airing their concerns and grievances, rather than being trapped in highly esoteric and seemingly endless deliberations. Further, since so little is known about how standards setters' agreement and promotional efforts take place and the ways their proposed changes to a dominant design interact with these groups, it seems appropriate to start with their study in as much detail as possible. Hence, this work will deal with participants' efforts to piece together their proposed design changes with an eye on how these interact with other groups' often disparate concerns with the cost implications of these changes for a dominant product design.

In this work I focus on the ways a group of standards setters interacts with other underrepresented or nonparticipant groups and, through this interactive process, examines a recurring industrywide design problem, defines it, and writes and re-writes documented solutions to it. I include a detailed case study in the development of a family of

voluntary safety standards related to the problem of how to protect farm tractor operators from being crushed in case of a tractor upset. My choice of a standard dealing with overturn protection for tractor operators stemmed from coming upon the intriguing occurrence of two different standards for the same purpose in the farm equipment industry. My curiosity about these two documents increased when I realized that, while most standards setters regard standards duplication as an unfortunate state of affairs, the official history of the development of overturn protection for farm tractors describes this kind of duplication largely as if unproblematic. The two standards, as I learned later, have their origin, first, in a document developed by engineers from the American farm equipment industry in the mid-1960s, and the other, in a parallel effort undertaken two decades later to produce a document that was fully compatible with the prevailing international standards.

The voluntary standards-making process in the American farm equipment industry is part of a larger endeavor that takes place in tens of thousands of committees functioning on a nationwide basis. Participants are part-time volunteers who devote a small portion of their working time to take part in committee meetings in a multitude of nongovernmental institutions as diverse as engineering societies, national

trade associations, and other specialized standards-writing organizations. There are, according to a recent directory of the National Institute of Standards and Technology (NIST), 41,500 voluntary standards written in the U.S. by 637 nongovernmental organizations. This listing is probably the most complete available in the U.S., though it errs on the side of magnifying the actual numbers. As the editor of the directory readily recognized, the listing included no corrections but "in the event of obviously erroneous entries", and "(e)ach responding organization" was left with the task of determining "by itself whether or not it is a 'standards developer'." 3/ Information on the aggregate costs of standards-setting programs is not readily available, but only national trade associations, which produce approximately one third of the standards listed in the NIST Directory, spend every year no less than $345 million in writing standards. These expenditures include staff salaries and other support activities taking place at the standards-writing organizations, but not member companies' expenditures (e.g.,

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3.- Robert B. Toth, Standards Activities of Organizations in the United States, National Institute of Standards and Technology, Spec. Publication No. 806, (Gaithersburg, Md., 1991), pp. 7-8. The directory of standards-writing groups produced by Toth is among the listings of these organizations published by NIST (formerly the National Bureau of Standards) approximately every ten years since 1941.

TABLE 1 - FIFTEEN MAJOR VOLUNTARY STANDARDS-WRITING ORGANIZATIONS IN THE U.S.

Organization	Number of Standards
American Society for Testing and Materials	8,500
Society of Automotive Engineers	5,100
U.S. Pharmacopeia	4,450
Aerospace Industries Association	3,000
Association of American Railroads	1,350
American Petroleum Institute	880
American Society of Mechanical Engineers	745
Underwriters Laboratories	630 (a)
Electronics Industries Association	600
Institute of Electrical and Electronics Engineers	575
American Railway Engineers Association	300
National Fire Protection Association	275
Technical Association of the Pulp and Paper Industry	270

SOURCE: Robert B. Toth, ed., Standards Activities of Organizations in the United States, National Institute of Standards and Technology Special Publication No. 806 (Gaithersburg, Md., 1991), p. 5.

(a) Does not include draft or unpublished standards.

the use of testing facilities, information gathering, and so on) nor the time and travel expenses of standards committee members. 4/ The bulk of these volunteers are engineers, managers and specialists on leave from their respective companies.

As it can be seen in the table above, not all private standards-writing organizations are equally committed to the production of voluntary standards. For instance, probably more than two hundred organizations among those listed in the NIST publication write standards that are not about design or engineering problems or at best require only a limited degree of engineering or technical expertise; these are documents chiefly aimed at simplified practices (even in fields outside industry), or at best at reducing product variety, rather than technical specifications for design. By contrast, virtually all engineering and technical societies engaged in setting standards produce documents that deal not only with design compatibility, interchangeability, safety, and product and materials quality problems, but also with data and technical terminology. Many organizations like, for instance, NISO (National Information Standards Organization), have each less

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4.- Charles S. Mack, Executive Handbook of Trade and Business Associations (New York: Quorum Books, 1991), p. 65.

than two dozen committees and are responsible for less than 50 active standards. By contrast, the American Society for Testing and Materials (ASTM), the largest and most prolific private standards-writing organization in the US, had more than 8,500 standards approved by 1989. Still, given the wide differences in the length of these documents, their number may only provide a vague indicator of the actual productivity of each organization. The total length of ASTM standards collection, for instance, is about 46,000 pages, while that of the 750 standards of ASME (American Society of Mechanical Engineers), including the Boiler and Pressure Vessel Code (11,000 pages), is longer than 48,000 pages 5/.

The most distinctive institutional features of this vast and diverse nongovernmental standards-writing network started to take today's recognizable shape in the mid-1920s. Shortly after the First World War, representatives of hundreds of technical societies and national trade associations began to look for more effective forms of inter-organizational coordination of their standards-writing activities under the encouragement of Secretary of Commerce Herbert Hoover. Hoover's influence on American standards-writing activities

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5.- Toth, Standards Activities, pp. 6-7. See also Walt Crawford, Technical Standards, 2d. edition (Boston: G. K. Hall, 1991), pp. 136-139.

included not only the development of a vast cost-reduction program for industry, but more important, the creation of a parallel structure of technical committees made up of volunteer experts from various industries having close links with professional, nonprofit organizations and community leaders. Hoover attempted, by means of this quasigovernmental structure, to speed up his own program of reforms with the aim of enhancing the performance of the American economy and implementing various, more selective forms of industry intervention and market stabilization without incurring in "blatant statism." 6/ His well-publicized War on Waste and

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6.- William R. Tanner, "Secretary of Commerce Hoover's War on Waste," in Herbert Hoover and the Republican Era, ed. Carl E. Krog and William R. Tanner (New York: University Press of America, 1984), pp. 21-24. See also Ellis W. Hawley, "'Industrial Policy' in the 1920s and the 1930s," in Politics of Industrial Policy, ed. Claude E. Barfield and William A. Schambra (Washington, DC: American Enterprise Institute, 1986), pp. 63-86. A complete history of the American standardization movement of the 1920s is not available. For general overviews on its links with American Progressivism, national trade associations and technical and engineering societies, and in particular on Hoover's influence on these organizations, see, e.g., Edwin T. Layton, Revolt of the Engineers (Cleveland: Case Western Reserve University Press, 1971), esp. pp. 25-52, 179-224; Donald R. Stabile, "Herbert Hoover, the FAES, and the AFofL," Technology and Culture 27 (1986), pp. 819-827; John M. Jordan, Machine-Age Ideology (Chapel Hill: North Carolina University Press, 1994), Ch. 5, Peter Meiksins, "'Revolt of the Engineers' reconsidered," Technology and culture 29 (1988), pp. 219-246. Some contemporaries, in particular Paul G. Agnew ("The national industrial standardization movement," Review of Scientific Instruments 1 [1930], pp 705-710; idem, "Development of the ASA," Industrial Standardization 14 [1943], pp. 322-329), provide detailed accounts of the inter-organizational problems

enthusiastic promotion of standards-writing groups and the use of standards and simplified practices in industry were aimed at persuading industrialists, managers and engineers about the merits of his and his followers' unsolicited technical advice in matters previously considered entirely private.

Hoover's cost-reduction program contemplated both

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of the standards movement; see also Edward B. Rosa ("Reorganization of the Engineering Standards Committee," Engineering News-Record 82 [1919], pp. 861-862, 916-918) and Norman F. Harriman (Standards and Standardization [New York: McGraw-Hill, 1928], pp. 155-164). For a few skeptical views, see, e.g., John H. Van Deventer, "Extreme variety versus standardization," Industrial Management 66 (1923), pp. 253-264; F. J. Schlink and Robert A. Brady, "Standards and specifications from the viewpoint of the ultimate consumer," Annals 137 (1928), pp. 231-239. For more specific accounts of the beginnings of standardization in particular industries, see, e.g., George V. Thompson ("Intercompany technical standardization in the early American automobile industry," Journal of Economic History 14 [1954], pp. 1-20), John Gaillard (Industrial Standardization [New York: H.W. Wilson, 1934], pp. 19-22), John K. Barnes ("The men who 'standardized' automobile parts," World's Work 42 [1921], pp. 204-208), and William F. Sherman ("The Society in Review: 75 years of SAE," in SAE Challenge [Warrendale, Pa.: Society of Automotive Engineers, 1980], pp 239-269) in the case of the automobile industry; Carole E. Stephens ("Impact of the telegraph and public time in the United States," IEEE Technology and Society Magazine 8 [February 1989], pp. 4-10) and R. L. Lockwood ("Railroad Standards" Harvard Business Review 12 [1934], pp. 398-406) in the case of time and railroad standards; Louis Galambos (Competition and Cooperation [Baltimore: Johns Hopkins Press, 1966], pp. 64-85) for the textile industry; Crawford (Technical Standards, pp. 127-142) in the case of the library and information industry; Bruce Seely (Building the American Highway System (Philadelphia: Temple University Press, 1987), pp. 118-135) for the highway construction industry.

intelligence and deliberative roles for nonprofit institutions, with informal contacts between these and key public officials. The availability of private information, knowledge and expertise was crucial, in his view, for the attainment of across-the-board cost-reduction benefits for the American economy. Once available, this information could become the basis for improvements in industry engineers' technically informed judgments and assist them in overcoming the sense of particularism and uncooperativeness imposed by the markets. Hoover's confidence in this arrangement was based on the war experience, which had "vindicated the scientific attitude in dealing with the problem of social organization." 7/ He strongly believed that the voluntary status of his cost-reduction program only had a chance to succeed if supported by closer links between engineers and national associations as those developed in the war. These links, he expected, would facilitate their work "toward coordination with each other in the solution of national economic problems." 8/ In his view, for instance, no cost-

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7.- Hoover, "Foreword", in America in the New Era, ed. Elisha M. Friedman (New York), p. XXIV, cited in Guy Alchon, Invisible Hand of Planning (Princeton: Princeton University Press, 1985), p. 43). See also Robert D. Cuff, War Industries Board (Baltimore: Johns Hopkins Press, 1973), pp. 148-190.

8.- Hoover, "The engineer's relation to our industrial problems", Engineering News Record 84 (1920), p. 1053

reduction benefits were attainable without economic agents (i.e., industry engineers) making extensive use of national trade associations as valuable, but until then largely untapped, sources of macroeconomic, statistical and technical information. This kind of information exchanges was part of a more relaxed interpretation of antitrust laws, at least in the sense of all competitors being entitled to know and share information about the aggregate impact of their own activities upon the markets. Particularly important in Hoover's cost-reduction program was an enhanced institutional coordination in simplification and standards-writing activities; this as a means of avoiding disparate -and therefore more difficult to evaluate- practices in industry. 9/

Hoover's emphasis on the public purpose of private information helped to legitimate standards-setters' conferences and meetings already taking place in a host of

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9.- Hoover's cost-reduction program contributed to the growth of standards-setting activities, but its emphasis was on simplified practices rather than standards. Rexmond C. Cochrane (Measures for Progress [Washington, DC: National Bureau of Standards, 1966], pp. 258-259) reports, for instance, that by 1925, the US Department of Commerce had assembled a National Directory of Commodity Specifications, with a listing of about 27,000 specifications for 6,550 commodities. See also Tanner, "Hoover's War on Waste," pp. 1-16. For a detailed discussion of Hoover's view of the role of macroeconomic information in economic agents' decisions, see, e.g., William J. Barber, From New Era to New Deal (New York:

corporate and nonprofit settings. Emboldened by a new sense of public responsibility, some standards-writing organizations' representatives intensified their efforts aimed at greater inter-organizational coordination. These efforts had first crystallized in 1918, with the creation of a central standardization body, the American Engineering Standards Committee (AESC). At the time of AESC inception there were, according to its Executive Secretary Paul G. Agnew, "...hundreds of organizations publishing standards, most of which were formulated without systematic methods of cooperation or exchange of information between the organizations concerned." 10/ In a less than a decade, AESC membership increased exponentially from its five original founders to 365 national standards-writing organizations,

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Cambridge University Press, 1985), pp. 7-41. The role of American engineering societies in Hoover's program remains nonetheless controversial, in particular the extent of their involvement with business interests. Louis Galambos ("Technology, political economy and professionalization," Business History Review 57 [1983], pp. 471-493), Alchon (Invisible Hand, pp. 33-70), and Hawley ("Industrial policy," pp. 63-86), have argued that a subordinate role for engineering societies in the business consolidation of the 1920s was inevitable. By contrast, Layton (Revolt, esp. pp. 201-253), and more recently Seely (Building the Highway System, pp. 118-135) and Meiksins ("Revolt reconsidered," pp. 219-246), have disputed the view of engineers' subordination as if unproblematic from ethical or even socioeconomic and policy perspectives.

10.- Agnew, "Standardization movement," p. 707. Agnew became ASCE Secretary in 1919 and served the standards coordinating body until his death in 1947.

about half of them national trade associations and 60 or more federal government agencies. The number of standards committees in AESC member organizations also grew at a torrid pace in a few years. Standards committees, for instance, in the American Society of Mechanical Engineers (ASME), multiplied from one in 1911 to 27 committees and 220 subcommittees in 1930. 11/ While each member organization retained its autonomy, the AESC framework was aimed not only at increasing these information exchanges, but also at the creation, wherever appropriate, of Sectional Committees for standardization work relevant to various industries, like for instance, in screw threads and ball bearings. 12/.

11.- Calvin W. Rice, "Fifty years of the ASME," Mechanical Engineering 52 (1930), pp. 261-276. See also Harriman, Standards and Standardization, p. 163; Cochrane, Measures for Progress, p. 256. A similar growth in the standards-writing activity in other original AESC founder, the Society of Automotive Engineers, is documented in Gaillard (Industrial Standardization, pp. 20-22).

12.- See, e.g., Sherman, "Society in review," p. 265; Harriman, Standards and Standardization, pp. 155-160). The Sectional Committee procedure was invented by the British and put into practice in the AESC, according to Comfort A. Adams ("National standards movement," in National Standards in a Modern Economy, ed. Dickson Reck [New York: Harper Publishers, 1956], p. 25), as a result of "a visit to the United States in 1919 of Mr. Charles le Maistre, then Secretary... of the British Standards Institution. Mr. le Maistre's twenty years' experience in standards work proved invaluable to the organizers of the American national standards agency, who consulted him freely. The structure of our technical committees followed closely that used by the British..." For detailed descriptions of the Sectional Committee Method,

AESC's participation in coordinating the enactment of national safety standards was crucial, according to Agnew, in imbuing this organization with a new sense of mission. Given the multiple interests represented in the AESC, it could act as a national forum in which the interested parties were able to discuss and solve conflicting safety regulations among states. This new coordination role was decisive, in his view, in setting AESC's future agenda and opening it up to the participation of a vast number of standards-writing organizations, in particular national trade associations. As he put it:

> One type of electric motor, in order to be legally safe in the State of Pennsylvania, had to be legally unsafe in the State of Wisconsin, and vice versa. As these problems grew in importance, it became increasingly evident that some machinery would have to be set up to bring together manufacturers, employers, employees, state regulatory bodies, insurance companies, and safety organizations to work out standards on which state regulations could be based.
>
> (I)t was not until a ... meeting at the National Bureau of Standards, where the AESC reported its organization plan, that the safety code program was actually agreed upon. The Safety Code Correlating Committee ... was organized ... to supervise and coordinate the work. This work has resulted in a consistent set of some 60 American Standard Safety Codes, which now form the backbone of the regulations of the state governments for the

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see, e.g., Rosa, "Reorganization," pp. 916-918; S. David Hoffman, "What is ASA?" Magazine of Standards 33 (1962), pp. 276-278.

> protection of workmen. They are used by insurance companies, both stock and mutuals in advice to their assured, and by manufacturers and employees. 13/

In subsequent decades AESC underwent three reorganizations until its transformation in today's American National Standards Institute (ANSI). These reorganizations included successive changes of title, first from AESC to ASA (American Standards Association) in 1928, from ASA to USASI (USA Standards Institute) in 1966, and from USASI to ANSI in 1969. Despite its successive reorganizations, ANSI's self-designated role as the "clearing house and coordinating body for standards activities at the national level" has remained remarkably stable. 14/ Throughout its long institutional history, it has organized numerous coordination programs in areas such as mining, building, mechanical and electrical standards. Still among ANSI chief objectives are the approval of national standards and the coordination of U.S. standards-writing work "to eliminate duplication of standards

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13.- Agnew, "Development of the ASA," p. 324. See also Eugene C. Crittenden, "Contributions of government and private agencies to national standards," in National Standards in a Modern Economy, ed. Dickson Reck (New York: Harper & Brothers, 1956), p. 36.

14.- Quoted from a five-paragraph explanatory text that accompanied every standard published by ANSI, at least until 1983. The same text appears, with slight modifications, in the standards published by ANSI immediate predecessor, the USA Standards Institute.

activities." 15/ ANSI, however, no longer interprets this aim in terms of setting up Correlating or Sectional Committees or the desirability of its direct participation in the standards-writing process. A more formal interpretation of coordination in the sense of a case-by-case review and approval of standards-setting procedures to verify whether "consensus" was achieved in the process has emerged in particular since the late sixties. 16/ ANSI verification service for consensus is only at the request of the interested parties and does not focus on the content of the documents submitted for approval, but on the process and procedures by means of which the respective standards-writing organization enacted a particular standard.

15.- See note 14, above. Interestingly, this older text included, in addition to the elimination of duplication, another even more ambitious aim, which was "to weld conflicting standards into single, nationally accepted standards [presumably through Sectional Committees] under the designation 'USA Standards'."

16.- This interpretation of consensus has drawn heavy criticism. As Miriam P. Opala ("Anatomy of private standards-making process," Oklahoma Law Review 22 [1969], pp. 45-68) shows, for instance, the links between consensus and coordination have never been clear. Not all voluntary standards-writing groups, for instance, readily agreed with the new ANSI role. The American Society for Testing of Materials (ASTM), in particular, on various occasions questioned ANSI "weak" coordination function and lack of a clear national standards policy; see, e.g., William A. McAdams et al, Voluntary Standards System of the U.S. (Philadelphia, ASTM, 1975); Richard O. Simpson et al, "Recommended national standards policy for the United States," ASTM Standardization News 6 (May

Federal agencies had an enthusiastic participation in AESC activities and in those of its immediate successor, ASA, at least until the mid-1960s. Federal support for ASA's role as coordinator began nonetheless to erode in 1948, when following the counsel of its legal advisors ASA became a membership corporation under the laws of New York state. This step, they argued, would help ASA to take advantage of a limited liability for the individual members of the Board of Directors and other ASA officers. Facing a severe financial crisis as a result of the suspension of Federal contracts the Association had relied upon in World War II, ASA decided that it had little choice but to find cost-effective ways of protecting its own staff. As a result of this decision, ASA became a private membership corporation, with little change in its management structure. Government lawyers' reaction to ASA's new legal status was negative, as they considered that no public agency could hold membership in private corporations such as the newly reconstituted ASA, and the ten Federal

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1978), pp. 8-22. More recently, however, ANSI President Donald Peyton ("Let's accentuate the positive," ASTM Standardization News 15 [March 1987], p. 9) adopted a conciliatory note in writing in an ASTM editorial that "... a good deal more must be done to fully coalesce the programs of ASTM and ANSI. ASTM is a standards developer and ANSI is the coordinator". He concluded "(t)ogether working in a fully integrated system, ASTM and ANSI can exponentially increase the productivity and market value of 21st Century standards, which will probably know few organizational or restrictive national boundaries".

agencies represented in ASA management withdrew. Government departure, if inconsequential from an economic viewpoint, as Federal agencies had held nonpaying memberships in ASA, added to the troubled situation of the Association in the midst of severe cuts in both staff and operations. 17/ To alleviate the possible consequences of Federal agencies' withdrawal, ASA promptly negotiated a compromise, by means of which these agencies agreed to continue their policy of encouraging their employees to have a voluntary participation in standards committees.

ASA private sponsors, if concerned with Federal withdrawal, remained confident on government agencies' cooperative mood and their willingness to ensure the ultimate success of ASA as a coordinating body. Over time, private standards-setting groups realized that this form of public policy delegation had both its privileges and disadvantages. By having a minor stake in the voluntary standards system, the government could contemplate other policy options, such as that of becoming itself a credible alternative to the use of

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17.- John R. Towsend, "Record -ASA from 1948 to 1962," Magazine of Standards 32 (1961), pp. 357-358. See also Adams, "Standards Movement," p. 26; Sherman Booth, Standardization Activities in the United States, National Bureau of Standards Misc. Publication No. 230 (Washington DC: Government Printing Office, 1960), p. 50.

voluntary standards as a form of industry self-regulation. As the standards-writing system entered the mid-1960s under the harsh criticisms of the consumer movement, ASA's successors, USASI and ANSI, sought, with little purpose, ways of bringing the government back to its fold. In 1967, nearly two decades after the Federal withdrawal, USASI President Harry E. Chesebrough featured the new challenge faced by the voluntary standards-making system in the following terms:

> (I)f we are to strengthen the voluntary system..., we must make every effort to eliminate every possible delay in development and approval of standards..., while maintaining the quality of the end product.
> The movement toward mandatory federal standards gains momentum every day [especially] on product safety and controls over a host of products. The only way of overcoming the insistence that only government can protect people is by building a strong voluntary standards system which is above reproach and suspicion. 18/

18.- Russell Hahn, "Progress Report," Agricultural Engineering 48 (1967), p. 674. Two years earlier, according to Lawrence Hodges, ASA President Franklin Roby had justified the transformation of ASA into USASI in terms of "mak[ing] provision for government support yet still continu[ing] the voluntary program directed by industry" ("75 years of progress through standardization," American Society of Agricultural Engineers Paper No. 82-5549 [St. Joseph, Mich., 1982], p. 10). See also Clare E. Wise, "Standards may be the key," Machine Design 40 (28 March 1968), pp. 30-32. For a description of federal agencies' growing ambivalence towards the voluntary standards system, see, e.g., J. Herbert Hollomon, "Standards and the public interest," Materials Research & Standards 7 (June 1967), p. 271; Patrick F. Cestrone, "Should the Federal Government develop safety standards?" National Safety News 101 (February 1970), pp. 42-46. Standards-writing organizations' efforts aimed at limiting or

ANSI, as its predecessor organizations, seeks the coordination of standards-writing groups at both the national and international levels. ANSI's international program includes, in particular, an increasingly important role in promoting and coordinating these groups' participation in worldwide standards-making bodies like the International Standardization Organization (ISO). 19/ ANSI's presence in ISO relies, therefore, on these groups' ultimate willingness to appoint and support their own delegations. This support, and with it the importance of ANSI's institutional role as coordinator, have shown a remarkably steady tendency to accompany the growth and fluctuations of international trade. After a strong start in the early 1920s, for instance, American interest in developing international standards showed

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forestalling government regulations are also discussed, for instance, in Francis Mardulier ("Is there a future for voluntary standardization?" Materials Research & Standards 8 [May 1968], p. 26), and Stuart K. Hopkins ("Voluntary standards at the crossroads," National Safety News 95 [April 1967], pp. 49-53).

19.- ISO is the largest among the family of international voluntary standards organizations. ANSI also represents the U.S. position in the other two, the IEC (International Electrotechnical Commission) and the CCITT (International Consultative Committee for Telegraph and Telephone). All these organizations have their headquarters in Geneva, Switzerland. ISO was established in 1947 with 25 national standards member bodies. Its membership increased to 73 member bodies in 1990. This year, ISO also had 14 correspondent members (with status of observers).

a sudden decline in the 1930s and the situation did not change before World War II. With the new expansion of international trade after the war, U.S. standards-writing groups showed renewed willingness to participate in the international dimension of standardization. This wave of American enthusiasm receded somewhat in the 1970's as a result of the perceived decline in the competitiveness of the U.S. industrial economy. More recently, however, American standards-writing groups' interest in international standards is again on the rise as it closely follows the growing importance of international trade for U.S. industry 20/.

20.- Some numbers are illustrative. According to Howard Coonely ("International standards movement," in National Standards in a Modern Economy, ed. Dickson Reck [New York: Harper & Brothers, 1956], p. 44), in 1948, for instance, there were 69 standards projects at ISO, with the U.S. taking part in nine. Of these, U.S. representatives held the secretariat in seven. In the mid-1950s American representatives had eight secretariats in 81 ISO projects. John H. Zich ("Implications and impact of worldwide standards," in Standards, a vital tool in engineering agriculture, ASAE-FIEI Symposium, Chicago [St. Joseph, Mich., 1965], p. 17) reported that in the mid-1960s, ISO had 139 subcommittees working on 116 different projects. According to Patrick Cooke ("Review of U.S. participation in international standards activities," National Bureau of Standards, NBSIR 88-3698 [Gaithersburg, Md., 1988]), the U.S. held in the mid-1960s ISO secretariats in 10 of these committees. In the mid-1980s, American representatives had 75 secretariats in 715 ISO subcommittees. This represents, in sum, about ten percent in terms of secretariats held by the U.S. representatives over nearly four decades.

With the recent trends towards the global economy since the mid-1980s, ANSI's international program has reached an economic importance without precedent in its long institutional history. From this global perspective, ANSI's role as a member of ISO adopts a new dimension of complexity as U.S. national standards acquire, in this larger context, the mere status of drafts in multiple negotiations with other countries' delegations. As a member of ISO, ANSI assumes a limited number of obligations, like paying dues, but not the negotiation of the U.S. position abroad. ANSI's lack of direct involvement in the standards negotiation process is atypical among other national standards organizations members of ISO. But as pointed out by ANSI Chairman George S. Wham, a further involvement is out of question, since ANSI "does not develop standards. It has no proprietary position on standards. Its representation is by those who are interested in and affected by potential international standards." 21/

21.- Wham, "Presentation," in Proceedings of the Conference on Standards and Trade, ed. Walter G. Leight (Gaithersburg, Md.: National Bureau of Standards,1987), p. 69. Other ANSI representatives, like for instance, Daniel Smith ("What is ISO and how does it work?," American Society of Agricultural Engineers Paper No. 87-5541 [St. Joseph, Mich.: 1987]) and Dorothy Hogan ("ANSI's role in national and international standardization," Standards Engineering 18 [February 1986], pp. 4-5), have made similar statements.

The contrasting perspectives of ANSI as coordinator and the U.S. standards-writing groups as negotiators of their standards with foreign delegations at ISO, provide me with the opportunity to analyze and discuss their differing views of consensus. From the coordination perspective, for instance, consensus and the process of marketing published standards go hand in hand. Once the content of these documents acquires some measure of stability as a result of their approval, standards setters' consensus acts, in this view, as a powerful inducement mechanism for implementation. Under this perspective, the more specific technical content of these documents is largely uninteresting or even irrelevant, at least to the extent that it does not overlap or duplicate that of other standards. This view also suggests that once standards setters identify the appropriate niche for a voluntary standard, their own agreement has a crucial role in persuading a growing number of potential users of the need for compliance. The ensuing bandwagon effect would indicate, as a standards-writer set out, how rarely are the potential users of a voluntary standard in condition to decide whether or not to observe it. In his view, once a sufficient number of them are persuaded about its value and adopt it "they expect others to conform. Individuals (or companies, etc.) that insist on doing things their own way may find themselves at an

increasing disadvantage." 22/

The second, and for our present purpose more interesting, view of consensus considers it as part of participants' collective efforts to negotiate and promote the prescriptive content of the documents they produce. There is no role for compliance in participants' agreement, under this approach, beyond that they readily regard as part of their problem-solving and promotional interests. Their own participation in seemingly endless committee deliberations suggests nonetheless that these take place in the light of long-term, rather than short-term, considerations. They may share, for instance, a long-term view on the benefits stemming from a sufficiently broad implementation of solutions to product design problems they anticipate as relevant for their industry at the time of the documents' approval. For these problems remain relevant after a long-time lag required for this approval, these are generally recurring problems, which standards setters do not expect to vanish or diminish in importance by the end of an extended decision-making process. 23/ Thus, in contrast with

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22.- Charles D. Sullivan, Standards and standardization (New York: Marcel Dekker, 1983), p. 8.

23.- The view of standards as documented solutions to recurring problems is widely used in the literature on standards. It was first introduced by Benjamin Melnitsky (Profiting from Industrial Standardization [New York: Conover-Mast Publicatns, 1953], pp.1-8).

the coordination perspective, participants' consensus-building strategies take place in the light of an expected rather than an actual context of implementation. Neither consensus nor its relationship with implementation is, therefore, the unproblematic outcome of their deliberations, but part of a complex and highly interactive style of making industrywide design decisions whose implementation is crucial for the benefits participants expect from these decisions.

The view of standards setters' agreement as related to their shared concern with the industrywide implementation of their proposed design decisions captures, I argue, crucial aspects of the process. At stake are not only the long-term benefits from greater product and interfirm compatibility against the time and expenses of individual participants, but also companies' resources committed to the process and the ways these companies are affected by standards setters' design decisions. Given the time and resources committed to the process and the cost implications of these decisions, both the promoters of a draft proposal and the other participants are likely to engage, I contend, in a continuous appraisal of the merits and liabilities of any change in the proposal. As the process unfolds, participants continuously interact with potential acceptors of the standard and are likely to make revisions in the light of their objections. Standards

setters' design decisions are, in sum, typical of collective investors concerned with the long-term benefits of their activity and the resources committed to it.

The use of an investment metaphor to describe consensus faces two kinds of unresolved difficulties which, I contend, are far less serious than they might seem at first sight. The first and seemingly more intractable difficulty is how to account for participants' individual interest in contributing to the production of what has been described as a public investment good. If one subscribes to the view that voluntary standards are in fact public investment goods, or goods from none of whose benefits can anyone be excluded, the voluntary participation in the production of these goods would make little sense for the rational, self-interested, agent. This problem, better known as the free-rider problem, seems to undermine the credibility of a collective investment approach in accounting for the standards setting process as a form of collective voluntary action. 24/ After all, the

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24.- David Hemenway (Industrywide voluntary product standards [Cambridge, Mass.: Ballinger Publishing Co., 1975], pp. 93-99) provides the first systematic discussion of voluntary standards as public goods. He follows the Orsonian approach and argues that large firms may only overcome the free-rider problem as long as they can internalize some benefits from the process. These include the use of standards as a barrier for entry or large purchasers' benefits from demand coordination. I

unremunerative character of the efforts involved in providing these goods -assuming that standards setters act merely on behalf of their own companies- should discourage them from becoming part of a process whose ultimate benefits would accrue to their employers irrespective of their contribution to it.

My contention is that even though these documents' content is public information (i.e., a public good), the free-rider assumption overlooks the ways some of the benefits of producing them are inherent to participation. An individual company's decision, for instance, to withdraw from the process would merely exclude it and its employees from being informed about the criteria on which committee decisions are based. This exclusion involves not only missed opportunities to influence the process and its outcome, but probably the more damaging, the lack of information about committee deliberations, which is only released to participants. This makes the nonparticipant firm a mere reader and likely acceptor of the final documents which standards setters expect to produce. A late access to the knowledge shared in the deliberations, as I further argue in Chapter 3, is not only a

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find this approach unduly restrictive as it fails to analyze individual standards setters' decisions beyond their ascription to their respective companies.

source of intellectual disadvantages for the nonparticipant firm, but may also entail a late and therefore costly adaptation of its internal cost structure in the implementation of participants' decisions.

The benefits of participation, moreover, need not be analyzed only in negative terms nor limited to the represented firms. My argument is that participants' deliberations involve long, complex and hierarchical sets of negotiations and consultations in which participant companies trade knowledge and proprietary information in exchange for support to their own written contributions. 25/ This entails the

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25.- The view of standards setting as an extended process of negotiations is an old topic in the literature on voluntary standards. See, e.g., Lockwood, "Railroad standards," pp. 398-406; Melnitsky, Profiting, pp. 2-8; Daune M. Kirkpatrick and David A. Rosenfeld, "Tomorrow's standardization," Standards Engineering 1 (June/July 1967), pp. 10-12; Verman, Standardization, pp. 431-442; Michael B. Spring and Martin B. Weiss, "Education in information systems standards," in Sourcebook on Standards Information, ed. Steven M. Spivak and Keith A. Winsell (Boston: G. K. Hall, 1991), pp. 53-72. These authors never make clear, however, what is the matter under negotiation. The role of interfirm knowledge trading in technology diffusion is, by contrast, a recent concern in the Social Studies of Technology. See, e.g., Eric Von Hippel, "Cooperation between rivals: Informal know-how trading, Research Policy 16 (1987), pp. 291-302; Anne P. Carter, "Know-how trading as economic exchange," Research Policy 18 (1989), pp. 119-133; Stuart Macdonald and Christine Williams, "Survival of the gatekeeper," Research Policy 23 (1994), pp. 123-132; Stephen Schrader, "Informal technology transfer between firms: Cooperation through information trading," Research Policy

transformation of companies' knowledge and proprietary information from a competitive tool into a promotional tool. The information released to committee members may include, for instance, offeror companies' testing data or studies concerning the costs and feasibility of certain projects or investment outlays considered essential to draft a standard proposal. This information, however, is also likely to affect the competitive position of the firms that release it. As a result, the release of this information is highly selective, involves a calculated risk, and the offeror firms expect due assurances that it will remain within the committee. 26/ Participant firms are likely to develop a shared interest in avoiding its divulgation and favor its presentation in an aggregate format (i.e., the standard proposal) that denies outsiders direct access to it. In other words, while committee members may treat the outcome of their deliberations as public information, they are likely to separate this

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20 (1991), pp. 153-170. None of these authors, however, pays attention to the ways standards committees may contribute to the exchanges of information mentioned above.

26.- According to one of my interviewees, not all relevant information is freely shared in standards committees. As he set out, "Sometimes the information is very sensitive and trade associations like the EMI [Equipment Manufacturers Institute] have to eliminate the companies' name from the data". The data would then appear as aggregate information, innocuous for the offeror firms.

information from the knowledge and information shared in the process, which they consider as a new form of proprietary information, available only to them as qualified problem solvers and document sponsors, and not to third parties.

The second difficulty is more specific. While all firms may expect long-term benefits from scale economies as a result of greater product compatibility and interchangeability, none of these benefits seems to accrue to the companies involved in both setting and implementing safety and quality standards. The presumption against the use of the interest approach to describe, in particular, companies' voluntary involvement with product safety standards is that writing and implementing them should have unfavorable consequences upon individual companies' competitive strategies. Though a similar argument is possible with respect to quality standards, in what follows I shall focus, for the sake of simplicity, on safety problems. I argue, in particular, that the collective decision to add safety features to a dominant product design needs not become the burden the cost-increase contention may suggest. There are at least two major ways standards setters and the firms represented in the process may expect to benefit from these design changes. Let us now briefly analyze them.

The first source of benefits participants may expect from

setting voluntary product safety standards stems, as I contended earlier, from the extent these may protect the integrity of a dominant design through minor and temporary cost increases. A second reason participants may have to contribute to the development of even more expensive safety standards requires, I argue, viewing the benefits of their deliberations against the likely consequences of their lack of action. They often assume, for instance, that the practicality and cost-effectiveness of their own solutions are superior to those stemming from government agencies' independent regulatory action. This suggests that participants' collective decision to deal with safety problems and produce documented solutions to these problems could take place, irrespective of their cost, as they promote these solutions on the assumption that these may become, at best, surrogates for government regulations. They may also act, given government agencies' frequent willingness to rely on voluntary industrywide standards as the basis for their safety regulations, on the assumption that their timely contribution to these is, in the worst case, better than regulators' costly and impractical solutions. Participants' attention may focus first on the less costly spectrum of safety problems, but given the preemptive nature of their activity, they could also act in more complex and costly areas when government

regulations seem imminent and unavoidable. 27/ For participants, the costs of these solutions are, accordingly, less important than their shared aim of avoiding industrywide, but impractical, or diverse, and hence inevitably incompatible, product design changes stemming from various regulatory agencies. I argue, in sum, that standards setters' agreement is not necessarily based on narrow cost reduction estimates; it may include a collective concern with both finding ways of protecting the integrity of a dominant design and the ultimate cost implications of solving product safety problems they anticipate as a potential area for government regulation.

These cost reduction considerations suggest that setting safety standards is a fully interactive and still highly focused process. Standards setters may alternate from frantic negotiations in the light of an adverse political and regulatory environment to a sober search for cost-effective ways of defining and decomposing problems and solving them by parts. As the process unfolds, participants may either fail to agree or shift their attention from a paralyzing appraisal

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27.- For a good overview of the literature on this subject, see, e.g., Ross E. Cheit, Setting Safety Standards (Berkeley: University of California Press, 1990), pp. 6-17. See also note 18 above.

of the short-term cost implications of their decisions to moreeffective problem-solving strategies. These are likely stress to how, by introducing somewhat expensive, but uniform, modifications to certain features of a dominant product design, participants can take advantage of its ultimate cost reduction benefits. Thus, no matter of how slow, messy or indecisive their search for agreement, standards setters' deliberations are likely to produce definitions for safety with solutions that remain within the ultimate cost reduction logic of the dominant design.

For all the expected benefits of standards setters' agreement, this may not satisfy all affected social groups. Some of them, like for instance consumers, often lack the necessary competences, specialized knowledge or specific concern with the prospective features of a dominant product design and therefore have little or no interest in the standards-setting process. Over time, they may find that the slow pace of the process and the voluntary implementation of the proposed solutions provide definitions for safety that are not satisfactory to them. Defining problems entails after all not only expert claims on problem solvability, but more importantly, a fragile compromise "on an account of causes and consequences of some circumstances that are deemed

undesirable." 28/ Those affected by and dissatisfied with standards setters' ways of reaching compromise may resist its practical consequences and seek alternative problem definitions based on the knowledge and resources available to them. While the uniformity of standards setters' solutions is a likely result of how these sanction, after repeated usage in actual accident situations, a particular allocation of responsibility (e.g., among standards setters, designers, vendors, purchasers, insurance companies, operators, bystanders, and so on), consumers may find it useful, by contrast, to invoke these solutions on an ad hoc basis and utilize them to redefine these problems in more favorable terms. This may entail, as I show in this study, a retrospective definition of accident responsibility in court, often turning standards setters' own knowledge against themselves. Consumers may act, in sum, as a distinctive social group as they use alternative resources (e.g., products liability litigation) to question the indecisiveness and delay of standards setters' deliberations and challenge their social status as reliable problem solvers and qualified builders of

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28.- Janet A. Weiss, "Powers of problem definition: The case of government paperwork," Policy Sciences 22 (1989), p. 97. A more systematic discussion on problem definitions as conflicting claims on ways of describing a problem is in David A. Rochefort and Roger W. Cobb, Politics of Problem Definition (Lawrence, Kans.: University Press of Kansas, 1994), esp. pp. 10-26.

an acceptable social order.

If a dominant product design becomes worldwide in scope, as suggested above, American standards setters dealing with safety problems may seek to export their agreements abroad and promote them as worldwide solutions to the dominant design. They may find, however, that other players in the international standards-making process (i.e., ISO committees, foreign regulatory agencies, etc.) may dispute the technical quality of American proposed solutions and refuse to see the U.S. documents as an appropriate basis, from the viewpoint of the protection afforded, for the development of worldwide standards. Further, some overseas groups of standards setters may even consider the voluntary status of implementation as unreliable or suspect, or unfit to a level of uniformity consistent with the new worldwide scope of the dominant design. These groups may in sum use both their knowledge and voting rights at international standards meetings to promote their own standards and challenge the role of American standards setters' agreement in the construction of a new global order.

The view of standards setters' agreement as a collective form of defining problems according to the ways these support a dominant design has considerable advantages for the analyst,

in particular from a Science and Technology Studies standpoint. First of all, the analyst can focus on how participants' solutions interact with other groups, absent from their agreements, and the ways this interaction shapes the safety features of a dominant design. Secondly, this interactive view entails a nonassuming description of standards setters' prerogatives in defining safety problems and promoting related design changes, a description that readily acknowledges the power of experts' agreement, but does not take it for granted. Thirdly, a less assuming perspective of standards setters' proposed changes in a dominant product design provides the analyst with the opportunity to examine how the knowledge shared in the deliberations is related to both their shifting descriptions of product safety problems and related legitimation strategies.

My account of standards setters' deliberations and the ways these interact with other affected groups relies on a case study in the farm equipment industry. I follow standards setters' decisions as they take place when developing and revising a family of safety standards clustered around the problem of how to provide overturn protection to agricultural tractor operators. These standards, basically four documents issued at differing times, are currently included under the common title of Roll-Over Protective Structures for

agricultural tractors, also known as ROPS. I examine the processes of discussing, writing and revising these standards within a time span of three decades, from approximately 1962 to 1990. In this study I document the interactive relationships between the relevant committees of three standards-writing groups involved in the development of ROPS standards. These groups are the Farm & Industrial Equipment Institute (FIEI), a national trade association with headquarters in Chicago, and two engineering societies, the Society of Automotive Engineers (SAE) and the American Society of Agricultural Engineers (ASAE). 29/ I also describe the ways the committees in charge of discussing, drafting and revising ROPS standards interact with other social groups like companies' engineers, agricultural safety specialists, federal and state regulatory agencies, farm implement dealers, trial lawyers, tractor purchasers, other standards-writing groups, and overseas regulatory agencies.

The study draws upon a diverse range of materials and methods. For a detailed inquiry of the standards-setting process, I went to three national meetings of the SAE and ASAE, where I was present at a number of standards committee

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29.- The FIEI changed its name to Equipment Manufacturers Institute (EMI) in 1990, at about the end of my case study.

sessions and other technical conferences held at these meetings. I also conducted in-depth interviews at these meetings, the interviewees' homes, their offices, and by telephone. Almost all my interviewees were or had been active members of ROPS standards committees at the FIEI and either of both engineering societies (SAE and ASAE), to which I could add four staff members of ANSI, the FIEI, and ASAE. My initial attempt to follow a questionnaire proved impractical and counterproductive in the light of my prospective interviewees' refusal to accept anything more than informal conversations, sometimes as we walked through the corridors at the meetings. The presence of tape recorders was also an initial source of friction, distrust or outright rejection to accept an interview. I had therefore to rely on the best of my perseverance, skills, memory and diplomacy to get something useful from these conversations. A complete listing of the interviews is in Appendix A.

I also had access to some valuable though rather scattered unpublished materials like summaries of letter ballots, the agendum of various standards committee meetings, unconfirmed minutes, and copies of a few letters relevant to my case study. These materials are inseparable components of standards committees' deliberations and support the whole process of discussing, drafting, revising and agreeing on the

content of any proposed standard. For all their heterogeneity, the content of these materials shows, for instance, a common stress on providing accurate information to the reader about the matter under discussion, pending issues, what was agreed upon, and who were expected attendants or actually present in a particular meeting. Their content is nonetheless sketchy and full of technical jargon, which probably reflects the writers' awareness of the potentially serious legal implications of their statements in case of being read by unfriendly eyes (e.g., in products liability lawsuits, or even worse, in antitrust action against them and the companies they represent). In spite of these limitations, these materials provide a unique and irreplaceable complement to the interviews, as they sharpen the researcher perspective on how committee members communicate among themselves, act as a group, organize their own agenda, examine the standards proposals, and build agreement. Both the interviews and the unpublished materials became crucial guideposts on how to organize and interpret the vast array of published materials used in this study. (For a list of the periodicals and magazines consulted see Appendix B).

My other primary sources are approximately two hundred technical papers published by the SAE and ASAE in the period 1962-1991. Each of these engineering societies publishes more

than two thousand papers annually, most of them available in microfiche at the university library. The papers I selected for my case study discuss tractor safety from technical, historical, epidemiological, institutional, legal, regulatory, and economic perspectives. I organized my selection according to four somewhat overlapping criteria; first, the papers' relevance to specific aspects of my case study; secondly, their authorship ascription to relevant standards committees (T-02 and PM.03 of ASAE, ROPS Committee of the EMI, and the Agricultural Tractor Technical Committee and Subcommittee 12 of the SAE); thirdly, their discussion of the legal, regulatory, economic, and international implications of ROPS standards and tractor safety; and lastly, the extent these papers provide a context for standards committees' decisions at differing times. These papers' content shows that for all the reticence of my interviewees to provide verbal or written statements, they possess not only excellent writing skills but are also prolific writers. Given the problems encountered in the interviews, I quote them, wherever possible, from their own papers and publications.

This study includes a discussion of the literature, first, on the standards-setting process, and then on the reasons participants commit themselves to a dominant product design and the ways their proposed design changes interact

with other social groups. This discussion constitutes Chapters 2 and 3. In Chapters 4 through 6, I provide a detailed description of how a group of U.S. standards setters developed and revised the first ROPS standards, the challenge of products liability, and the complex dilemmas and negotiations involved in re-writing these standards to accommodate the demands created by the new worldwide context. In the seventh and final chapter is a summary and conclusions.

CHAPTER 2
THREE APPROACHES TO THE STANDARDS SETTING PROCESS

This chapter discusses the ways the literature on voluntary standards has described their development process and critically examines and compares some of the more important perspectives on this process that are still given wide credence today. I do not attempt, in this chapter, to provide an exhaustive account of existing approaches to this process, but to analyze the merits and limitations of three distinctive approaches to the process. The two first perspectives considered in this chapter depict the process either in terms of the ways its output becomes relevant for greater industrywide coordination of design practices, or as part of a detailed system of procedures that standards setters are said to follow. Though these approaches provide important insights on the organizational and design implications of participants' agreement, none of these approaches can fully account, I argue, for individual participants' commitment to the deliberations, nor for the ways their agreement interacts with other affected but unrepresented groups.

In this chapter I also contend that besides these two approaches, there is another, more fragmented, body of literature that describes the process as a long and

hierarchically structured series of draft amendments. These amendments, according to this approach, are instrumental in ordering standards setters' problem-solving efforts and ensuring a sufficient degree of uniformity in their solutions as for these to remove costly functional uncertainties from compliers' activities. This third approach, though a good account of participants' deliberations and shared concern with the expected uniformity of their proposed design changes, still falls short, I conclude, of explaining their individual willingness to agree and the ways these proposed changes interact with other, nonparticipant, groups.

STANDARDS SETTING AS DESIGN COORDINATION

The coordination approach describes the standards-setting process in terms of how standards function to simplify market transactions and create greater design uniformity and compatibility in the activities of compliers. The benefits of coordination tend to increase, according to this approach, in a social context in which large industrial organizations prevail, but do not entirely dominate the market. Setting standards becomes, in this context, an inseparable component of these organizations' economic and self-regulatory strategies, their search for economies of scale, a more

decentralized and less cumbersome approach to design and investment decisions, and the commitment of vast resources to this purpose. This approach is pervasive among economists, standards-writing organizations' staff, consultants, corporate lawyers, engineers, and managers concerned with the costs and efficiency of the standardization efforts and an effective implementation of standards on a voluntary basis. 1/

Gaillard was probably the first to discuss, from a coordination perspective, the role and benefits of standards setting in a modern society. 2/ In his view, coordination entails a set of assumptions on which standards setters must base their judgments, discuss standards proposals, and agree on them. He emphasizes the ways design practice relies on these assumptions as follows:

1.- See, in addition to the authors discussed below, H. Landis Gabel, ed., Product standardization and competitive strategy (Amsterdam: Elsevier Science Publishers, 1987); Paul David and Shane Greenstein, "The economics of compatibility standards: an introduction to recent research", Economics and Innovation and New Technology 1 (1990): 3-41; Peter Swann, "Standards in ICTs: consensus, institutions and markets", in The single European market and the information and communication technologies, ed. Gareth Locksley (New York: Belhaven Press, 1990); Mostafa H. Sheriff and Duncan Sparrell, "Standards and innovation in telecommunications", IEEE Communications Magazine 30 (July 1992): 21-28; Antonio J. Bailetti and John R. Callahan, "Managing consistency between product development and public standards evolution," Research Policy 24 (1995): 913-931.

2.- John Gaillard, Industrial standardization. Its principles and application (New York: H. W. Wilson Co., 1934).

> (A)n industrial standardization program may be considered as engineering design on an enlarged scale. The designer of a machine begins by making definite assumptions which serve as a tentative basis for the determination of the details or the component parts of his design. In working out these details in an effort to harmonize their fitting together for the correct functioning of the whole, he may find that the lack of knowledge regarding some particular factor prevents proper coordination. The original assumptions made by the designer must then be revised accordingly. Therefore, in setting the goal, knowledge of the means by which that goal can be attained is pre-supposed. The most skilful designer is he who can best determine in advance the level of optimum result attainable with the means presently at his disposal. 3/

The benefits of a voluntary standard are therefore greater the smaller the disparity between standards setters' assumed conditions and the actual conditions under which this standard is implemented. This disparity fluctuates, in Gaillard's view, according to a long-term process of acceleration and deceleration in changes in the productive system, namely along a succession of stages that he features as a progress curve. At an initial stage of this curve changes occur at a too rapid and unpredictable pace, followed by a slower, steadier and, from a standards-setting process standpoint, more favorable rate of change.

Gaillard illustrates his argument through a case study in

3.- Ibid., pp. 25-26.

the automobile industry. Prior to 1910, for instance, changes in the productive processes took place in an exceedingly rapid succession, with sudden shifts in design assumptions and practice. By that year, however, automobile design stabilized and started to change along a slower and more foreseeable pattern. Accordingly, the Society of Automobile Engineers (SAE) could take advantage of this slower rate of technological change and set up its first standards committee in 1910. Gaillard also points out how in the three subsequent decades the number of SAE standards increased, on a cumulative basis, in close coincidence with the growth in the annual volume of passenger cars produced in the industry, namely on a ratio of about one standard per 10,000 cars. 4/ This coincidence suggests, in sum, a proper timing in setting standards, according to their temporal location within the late stage of a progress curve.

The view of standards setting as a stage in an evolutionary pattern of technological change has ample acceptance among some of the recent advocates of the coordination approach. Sirbu and Zwimpfer, for instance, contend that timeliness in setting voluntary standards has a critical role in the achievement of sufficient production

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4.- Ibid., pp. 21-22

volumes as to justify the massive investments typical of the computer and communications industry. They show, through a detailed case study in the development of a data communication standard, that the perseverance of a few large players may override other committee members' objections and contribute to a rushed outcome. 5/ As this outcome is susceptible of further refinements, the decision making style leading to it is, according to Sirbu and Zwimpfer, less likely to compromise coordination, even in case of a weak standard, than the absence of participants' agreement.

Farrell and Saloner argue, by contrast, that setting voluntary standards is not the only means of coordination nor the most cost-effective in all cases. 6/ In their view, standards committees coexist with other, at times more expedient, forms of coordination like government regulations and de facto standards. In a microeconomic analysis of firms'

5.- Marvin Sirbu and Lawrence Zwimpfer, "Standards setting for computer communication: the case of X.25", IEEE Communications Magazine 23 (March 1985): 35-45. For a similar, somewhat less detailed case study, see Sherif and Sparrell, "Standards and Innovation," pp. 25-26.

6.- Joseph Farrell and Garth Saloner, "Coordination through committees and markets", Rand Journal of Economics 19 (1988): 235-252; idem, "Competition, compatibility and standards: the economics of horses, penguins and lemmings," in Product standardization and competitive strategy, ed., Gabel, pp. 1-21.

rational behavior in the computer and communications industries, they compare, on the basis of a game theory model, the relative merits of voluntary standards and de facto standards. Coordination through de facto standards, they argue, retains the advantages of higher speed and flexibility, as competitors decide, on an individual basis, whether or not to make their offerings compatible with those of the market leader(s). The search for compatibility through committees is, by contrast, a two-pronged approach, with competitors active at both the committee and market levels. Committee deliberations, albeit slower, Farrell and Saloner conclude, should have a superior performance, at least in settling conflicting approaches in case of decisions that involve long-term commitments with large investment costs. This conclusion makes sense of individual companies' willingness to participate in committees and the long-term aims of their activity, even though the model simply assumes the stability of design problems over time. 7/

Other authors like Hunt, Kurdle, Reddy, and Genschel and

7.- Farrell and Saloner ("Coordination through committees," p. 250) readily recognize this limitation and point out that, contrary to the assumptions of their own model, "participants are often engineers who share information and view the committee as a design process, and pursue an 'ideal technology,' sometimes with little regard to their firm's economic interests."

Werle provide a more interactive approach to coordination. 8/ In his economic study in the major home appliance industry, Hunt finds, for instance, that interfirm coordination via voluntary standards takes place in a broader interactive context in which participant firms continuously assess the likely involvement of government regulatory agencies. In this interactive process, these firms often organize their voluntary standards programs on the assumption that these programs can provide similar benefits to the general public than government regulations, but at consistently lower costs. This assumption, Hunt contends, weighs heavily on manufacturers' preference for industry self-regulation, in particular when they only expect limited direct benefits from these programs. This is the case of programs on safety and product performance standards, which, in his view, improve the comparability of competitors' offerings, thus simplifying ----

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8.- Michael Hunt, "Trade associations and self-regulation: major home appliances," in Regulating the product, eds. Richard E. Caves and Marc J. Roberts (Cambridge, Mass.: Ballinger Publishing Company, 1975), pp. 39-55; Robert T. Kurdle, "Regulation and self-regulation in the farm machinery industry, in ibid., pp. 57-73; N. Mohan Reddy, "Voluntary product standards: linking technical criteria to marketing decisions," IEEE Transactions on Engineering and Management 34 (November 1987): 236-243; idem, "Product self-regulation: a paradox of technology policy," Technological Forecasting and Social Change 38 (1990): 49-63; Philipp Genschel and Raymond Werle, "From national hierarchies to international standardization: modal changes in the governance of telecommunications," Journal of Public Policy 13 (1993): 203-225.

customer choice. 9/ Given the assumed adverse cost implications of government regulations in this area, industry perceptions about their likely enactment may constitute, accordingly, a sufficient inducement for the preemptive organization of voluntary programs. Hunt depicts the role of regulatory pressures as follows:

> If an agency has jurisdiction over several industries and a limited budget, then to deter the government from becoming involved, self-regulation need not be perfect from the agency point of view. It has only to elevate the performance of the industry to the point where it does not represent a relatively attractive target to the resource-constrained agency. ... Of course, if all or most industries pursued self-regulation, then there would be less advantage for any one of them from doing so. To escape outside attention they would have to move closer and closer to the government-desired performance levels. However, since self-regulation is not now universal, this concern is not in fact relevant. 10/

Hunt concludes that at least in the consumer products area the feasibility of interfirm standards programs is contingent on their ultimate cost-effectiveness. Moreover, participant firms are only likely to succeed in promoting them if there is an independent organization that can perform this function at costs these firms perceive as significantly lower than those of government regulatory agencies (whose programs

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9.- Hunt, "Trade associations," 41-48.

10.- Ibid., p. 45.

are financed from general revenue). He describes the interfirm economies such organization may provide in the following way:

> (V)oluntary agreements require unanimity, which raises the cost of reaching self-regulatory decisions. If this is the case, decision making power may be given to an independent staff in order to reduce decision making costs. Indeed it may be that the whole enterprise is profitable for members only on this basis. In these circumstances... (t)he existence and power of an independent organization [e.g., a national trade association] that can carry out the self-regulation programs is positively related to the likelihood that such a program will develop. 11/

Kurdle's historical study in the farm equipment industry illustrates, by contrast, participant firms' early concern with voluntary standards programs aimed at greater compatibility, and simultaneous neglect of standardization in the safety and quality areas. 12/ The stress on compatibility was part of a tying strategy developed, according to him, by large, highly diversified manufacturers of agricultural equipment that had carved themselves, in the absence of major regulatory pressures, a dominant position in the North American market since the 1920s. He characterizes the expected benefits of this strategy as follows:

11.- Ibid., p. 52.

12.- Kurdle, "Regulation and self-regulation," pp. 60-69.

> With a stable technology and a differentiated product, full-line tying and an absence of standardization would tend to stabilize and isolate firms' market shares. But these same conditions, in a time of major product innovation, would be destabilizing and disruptive of established oligopoly behavior patterns. This is because, without compatibility, a major innovation by one company would swing demand to its full line and not just to the innovative implement or device itself. The 1927 power take-off standard and its widespread adoption by the industry indicates that the new full-line firms were concerned with the magnified impact on market share of any sweeping innovation in tractors or implements so long as incompatibility prevailed. The fortunes of the firms making power equipment shifted radically in the 1920s as innovations came from a number of different sources, thus suggesting the value of compatibility to all. 13/

The collapse of these tying arrangements in the 1950s is, in Kurdle's view, a clear indication of the risks of using voluntary standards to shield compliers from the consequences of innovations affecting the whole tied system. Participant companies had built this system on the assumption that only they, as established manufacturers with innovative devices, should and could benefit from coordination. As this strategy had to rely on instruments of ultimately voluntary usage, it was nonetheless vulnerable to a new competitor offering an alternative system that could outperform that established by the sponsors and users of the prevailing tying arrangements. 14/ Ironically, the voluntary status of standards

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13.- Ibid., p. 66.
14.- This innovation was the Ferguson system of hydraulically

implementation was, in Kurdle's view, better suited to serve the established firms' lack of concern with coordinated action in the safety area, in which farmers' perceived indifference provided these firms with good arguments for their own delays and indecisiveness.

More recently, Reddy has argued, from a marketing perspective, that the voluntary status of standards implementation introduces a crucial element of flexibility in the coordination process. 15/ This flexibility, he contends, provides the opportunity to both standards setters and product vendors to continuously adapt their offerings to changes in technology thus conferring a dynamic dimension to coordination problems. By sanctioning interfirm compatibility and removing uncertainties about the quality of inputs produced in an earlier stage of the productive system, voluntary standards only institutionalize a temporary level of coordination. This level of design coordination often leads to remarkable economies of scale based on a growing reliance on specialized

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controlled mounted implements. Kurdle fails nonetheless to note that the final acceptance of this innovation in the farm equipment industry was preceded by a lengthy legal battle over patent rights between Harry Ferguson and Henry Ford. See, e.g., Robert C. Williams, Fordson, Farmall and Poppin' Johnny (Chicago: University of Illinois Press, 1987), pp. 101-107.

15.- Reddy, "Voluntary product standards," pp. 237-238.

producers. This level of coordination may also promote, Reddy contends, important economic inefficiencies that individual buyers' procurement practices are generally unable to correct, in particular the more complex and composite the product. However, as established manufacturers' offerings are under continuous competitive pressures from alternative design concepts, the tying practices featured by Kurdle are at worst, in Reddy's view, inevitable but temporary outcomes of purchasers' use of standards in their procurement decisions. Developing and implementing new standards are, therefore, institutional dimensions of design coordination, whose dynamic features rely nonetheless on standards setters' ultimate ability to adapt their output to sudden demand shifts created by unexpected changes in technology. 16/

Genschel and Werle point out, by contrast, that the voluntary status of standards setters' output may become functionally related to an inherently dynamic process of coordination in the midst of industry growth. 17/ In their discussion on the long-term evolution of the telecommunications industry, Genschel and Werle argue that the use of voluntary forms of coordination is an adaptative

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16.- Ibid., pp. 237-238; idem, "Product self-regulation," pp. 49-63.
17.- Genschel and Werle, "National hierarchies," pp. 203-205.

strategy aimed at dealing not only with changes in technology, but with more compelling economic and sociopolitical considerations. They describe the transition from self-contained national networks to international telecommunication systems as a result of a vastly superior rate of growth, and requirements in terms of flexibility and decentralization, than that the old hierarchical structures (e.g., national regulatory agencies or state monopolies) could possibly accommodate. As these networks became more global in scope, their expansion beyond national boundaries required, according to them, the use of more expedite and less time-consuming procedures in settling a fast-growing number of compatibility problems. In their view, the flexibility of coordination via voluntary standards is an important, and possibly inevitable, institutional response not only to changes in technology but to an extremely rapid pace of industry growth.

The view of standards setting as coordination provides important insights on participant firms' commitment to the process and its ultimate economic benefits for compliers. The coordination approach shows, for instance, that none of these benefits are likely in the absence of an investment logic that favors interfirm participation and agreement. This does not imply, however, that only standards committees can promote satisfactory levels of coordination; there are, according to

the coordination perspective, alternative, though often less desirable, arrangements (e.g., de facto standards, government regulations, international treaty rules) in case standards setters fail to agree. An undue stress on the ultimate benefits of setting voluntary standards may nonetheless obscure the fact that individual participants do not invariably act on behalf of their firms' economic interests, and that some voluntary standards are never implemented. 18/ Moreover, the coordination approach generally fails to address issues such as how and why standards setters agree and disagree, the lengthy and time-consuming features of their deliberations, and the ways they organize and coordinate their own work. Given the emphasis on contextual factors, the coordination approach seems at best uninterested in further exploring the ways the standards-setting process is organized and at worst generally unable to account for it.

SETTING STANDARDS AS A RULE-FOLLOWING PROCESS

The view of standards setting as a rule-following process discusses standards setters' activities in terms of an elaborate system of rules and procedures, or "due process",

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18.- See note 7 above.

that they are said to follow and at times attempt to circumvent. The complexity of these rules is, according to this approach, commensurate with the organizational demands of the process and standards setters' overlapping duties as volunteers, corporate employees, and members of professional and trade organizations. This approach entails an administrative description of standards setters' behavior, with emphasis on the ways these rules balance participants' short-term interests and how this balance affects the speed of the process and the quality of its outcomes. This approach is typical of lawyers and economists concerned with the public policy dimensions of the standards development process, and a small group of standards setters interested in the ethical dimensions of the process.

The view of the process as a system of rules is split between those who see these rules as irremediably flawed and those who regard them as reasonable though still in need of further refinements. The first position is clearly exemplified by some lawyers like Opala, Brodsky and Cohen, and more recently, Curran, who have criticized the standards-writing system on two counts. 19/ First, they argue that the

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19.- Marian P. Opala, "The Anatomy of Private Standards-Making Process: The Operating Procedures of the USA Standards Institute," Oklahoma Law Review 22 (1969): 45-68; James

frequent dual status of committee members, as volunteers and company representatives, is better suited to serve business interests than the public interest. These committees, they concede, are formed by the most qualified people in their respective fields of expertise. Given the dual status of their membership, however, the benefits the general public could expect from the otherwise highly promising combination of volunteering and technical expertise all too often fail to materialize. Thus, for all their expertise and alleged credentials as volunteers, committee members generally fail to act as individual experts and behave and make their more important decisions primarily as company representatives. 20/

Secondly, these critics contend, the consensus principle on which standards setters base their decisions only rarely plays in favor of the public interest. Given the lack of

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A. Brodsky and Marsha N. Cohen, "'Uncle Sam,' the Product Safety Man: Consumer Product Safety Standards in the Marketplace and in the Courts,", Hofstra Law Review 2 (1974): 619-650; William J. Curran, "Volunteers... Not Profiteers: the Hydrolevel Myth," Catholic University Law Review 33 (1983): 147-162.

20.- Among the critics, Curran (Ibid., pp. 149-152) is particularly concerned with the antitrust implications of standards setters' dual status, which, in his view, creates unresolvable conflicts of interest and a pervasive inclination of volunteers to engage in collusive practices.

public scrutiny on both committee deliberations and standards approval, business interests often exert, according to these authors, an undesirable degree of dominance over the process and its outcomes. These interests frequently have, for instance, the necessary clout to block or delay unwanted initiatives and adverse clauses under the umbrella of consensus building. As a consumer movement representative, quoted by Brodsky and Cohen, put it:

> The consensus principle means in practice that the industry people have veto power over any actions taken by the committee.... In effect, then, the object of the exercise is to get industry agreement, often arranged before the meeting anyway, and to push the standard through the paperwork procedures so that it may be issued as a standard. Our proposals [as consumer representatives], our negative votes, are given 'due deliberation,' which is the phrase used in examining negative votes, but are ultimately vetoed or overridden, as without merit. After a while it seems fruitless to spend the time and money to go to such meetings.... If standards for consumer goods in general and safety standards in particular are to be developed in the consumer interest, a better way will have to be found than this consensus principle. 21/

Other critics, in particular economists, have argued that the organizational and economic demands of committee deliberations often operate against the aggregate interests of those who may have too little to gain, on an individual basis,

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21.- National Commission on Product Safety Hearings, vol. 1, I-296-298 (statement of Morris Kaplan), quoted in Brodsky and Cohen, "Uncle Sam," p. 632.

from their participation. Kurdle's study in the farm equipment industry suggests that the absence of farm machinery purchasers from standards committees may have delayed the development of voluntary standards related to parts and components against, for instance, an early standardization in the area of interchangeability and tractor-implement compatibility. 22/ Hemenway contends, from a microeconomic perspective, that large companies are more likely to have representatives in standards committees than smaller firms. He describes the difficulties faced by small firms in the following terms:

> It is not difficult to understand why small business is often underrepresented in the standardization process. The problem is that the absolute cost in terms of time and money of sending an employee representative to meetings is the same for the small as for the big business. But less of the total benefit of standards is internalized for the small firm. Moreover, without coordinated action, any individual small concern may correctly feel that, singly, it will be unable to substantially alter the resulting standard. Another problem limiting small firm participation is that since the matters covered at meetings are often highly technical and esoteric, it may not be readily known whether a small company has an expert in the particular field. 23/

The third group of critics focuses on the disturbing ethical implications of participants' frequent lack of

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22.- Kurdle, "Regulation and Self-Regulation," pp. 67-69.

23.- David Hemenway, Industrywide Voluntary Product Standards (Cambridge, Mass.: Ballinger Publishing Company, 1975), p. 67.

independent professional judgment in the process. Many standards setters, these critics contend, fail to act according to the best principles of engineering as a profession and conceal, through their silence, their employers' inaction and lengthy delays in solving problems that are in the public rather than in the companies' interest. 24/ Since the current rules merely assume that engineers act as individuals on behalf of their profession, most of them find it easy to confine themselves to their duties as corporate employees. Further, by allowing their travel and lodging expenses to be paid by companies' employees concurring to the meetings, these rules also tend to sanction their actual role as company representatives, with doubtful results particularly in the consumer safety area. As a committee member put it:

> The current system is too slow. How much of this inertia is due to the general conservatism of engineers and how much to the industry dominance of the process is not known. However, the industry consensus system has managed to have product safety standards lag the state-of-the-art by anywhere from ten (10) to twenty-five (25) years. This is not

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24.- The ethical dilemmas this situation entails are recurring topics in the literature. See, e.g., Edwin T. Layton, The Revolt of the Engineers (Cleveland: Case Western Reserve University Press, 1971); Lilian Weil, ed., Beyond Whistleblowing (Chicago: Illinois Institute of Technology Press, 1983); Bruce E. Seely, Building the American Highway System (Philadelphia: Temple University Press, 1987).

> acceptable. Engineers must strive to incorporate new technology into standards at the earliest possible time. 25/

And again:

> (B)ecause so many engineers are employed by industry rather than being in private practice, there is always the possibility of the engineer becoming a tool of some self-serving trade association. Engineers... should be willing to work on standards committees and should be willing to do so without always accepting pay from an employer for time and expenses associated with the effort. 26/

In contrast with the critics, the other group of analysts considers it more useful to examine the standards-setting process according to its welfare implications rather than in terms of its professional, organizational, or public accountability. Hamilton, for instance, argues that this system represents the initiative of private institutions which have invested and amassed over the years an amalgamation of technical expertise and organizational and procedural know-how that no government agency can easily replicate. 27/ His account on standards setters' deliberations is largely based on his impressions as an outsider at a convention of the

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25.- John B. Sevart, "Federal Trade Commission vs. the Voluntary Standards System: An Engineer's View", American Society of Agricultural Engineers, MCR-80-703 (St. Joseph, 1980), p. 6.

26.- Ibid., p. 2.

27.- Robert W. Hamilton, "Role of Nongovernmental Standards in the Development of Mandatory Federal Standards Affecting Safety or Health," Texas Law Review 56 (1978): 1329-1484.

American Society of Testing and Materials (ASTM) in Denver, Colorado. He depicts standards setters as exhibiting a remarkable concern with procedural issues and a rule-abiding behavior that seem the more striking to him as a lawyer. In his view, however, committee members must assume that the nonmandatory logic of standards implementation requires building a level of consensus to which all affected may acquiesce, including the parties absent from the process. As a result, he concedes, the process involves chronic underrepresentation problems, with some undesirable consequences, particularly in the consumer safety area. The analyst, he contends, has nonetheless to ponder the importance of these problems in the light of the obvious practical difficulty in attaining a perfect combination of technical expertise and an ideal convergence of criteria of all affected parties. As he puts it:

> Decisions affecting health and safety require tradeoffs between increased safety or health considerations on the one hand and increased costs and inconvenience on the other: the safest automobile would resemble an army tank more than a modern car. A balanced committee -that is, one that includes representatives of all substantial interests, each openly identified and free to present its views- working within one of the large standards-setting organizations in the private sector will balance these competing considerations at some point, although probably not the point chosen by other groups and almost certainly not the point selected by a Ralph Nader. Because of the... industry orientation of most technical committees, the costs and complexity of increased safety or purity will almost certainly be weighted more

> heavily by these committees than by an individual whose primary concern is safety and health. One cannot say, however, that the balance struck by the technical committee is 'wrong', because the issue turns on value judgments. 28/

Other analysts suggest that examining the links between committee deliberations and the public interest exclusively in terms of balance may lead to premature conclusions about the distribution of benefits from the system. Hunt's case study in the home appliance industry suggests, for instance, that industry dominance of the process needs not be against the interests that are absent or underrepresented in the process. This study indicates that, at least under certain circumstances (e.g., strong regulatory pressures), national trade associations' committees may write standards dealing with safety and product performance, whose benefits for those absent from the process go well beyond what individual member companies could think are appropriate. 29/

Other authors, such as Swankin and Crawford, contend that standards-writing organizations' efforts to improve their rules and procedures need not be confined to lengthy external accountability criteria typical of public regulatory agencies. 30/ In his study of rationale statements, Swankin argues, for

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28.- Ibid., p. 1378.
29.- Hunt, "Trade Associations," pp. 52-54.
30.- David A. Swankin, Rationale Statements for voluntary

for instance, that these are excellent tools to improve the visibility of committee deliberations. He defines rationale statements as short documents or notes that accompany approved standards and explain the scope, limitations, and provisions of these standards. Swankin compares rationales with legislative histories and finds that the former are and should remain considerably more concise and less burdensome than the latter. Rationale statements combine, accordingly, the merits of expediency, procedural flexibility, discipline, and enhanced accountability, at least to knowledgeable parties who are not necessarily represented but have voting rights or substantive interest in the issues under discussion. The growing use of rationale statements is, in sum, a clear demonstration of the responsiveness of the voluntary standards system to changes in technology and critics' objections to the alleged lack of fairness in the process. 31/

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standards -Issues, techniques, and consequences. Nov. 1981, National Bureau of Standards, NBS GCR 81-347 (Springfield, Va.: National Technical Information Service); Walt Crawford, Technical Standards 2d ed. rev. (Boston: G. K. Hall & Co., 1991).

31.- Swankin, Rationale statements," pp. 9-20. For a similar argument in the area of collusive practices, see, e.g., William H. Rockwell, "Hydrolevel Decision as applied to antitrust violations of standards making organizations," Perspectives 3 (Sept. 1983), pp. 3-5. Cf. in particular with Curran's opinion discussed in note 20 above.

In his detailed study of standards setting in the libraries and information industry, Crawford points out the advantages of analyzing the current rules and procedures according to the ways these compromise the quality of the end product. 32/ The enactment of defective standards is, in his view, a frequent result of standards setters' inadvertent or deliberate misuse of procedural ambiguities, as steps aimed at correcting these are often only possible after a careful evaluation of the facts. He briefly examines the reasons that may lead to standards that are difficult to implement, whose implementation is unlikely (because of lack of interest in them), or that are objectionable from the viewpoint of their alleged purpose (e.g., for antitrust reasons). In accounting for these defects, he describes a number of errors, such as the premature development of standards in areas of new emerging technologies, standards that lack cost-effective means of verification or with a too narrow level of tolerance for compliance, developers' excessive concern with detail, poorly written standards, and standards developed under "political consensus" rather than paying due attention to the technical problems involved in their development. Every standards-writing organization should identify, accordingly, its own defective standards, relate these defects to the

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32.- Crawford, Technical Standards, pp. 79-93.

technical or procedural errors incurred at the time of their development, and take corrective steps to prevent their repetition. He concludes as follows:

> ANSI [American National Standards Institute], ISO [International Standardization Organization], and other standardization agencies have established thoughtful procedures to defend against defective standards. Although these procedures help to make standardization slow and expensive, they are necessary. But they can never be perfect: there will always be defective standards, and they will always hurt the cause of standardization. 33/

The view of standards setting as a system of rules provides a valuable description of committee deliberations as a complex and often indivisible mixture of technical considerations and political compromises. The two positions examined in this section coincide in setting out that only a sufficiently fair system of rules can hold under control these compromises and minimize the ambiguities created by standards setters' overlapping and sometimes conflicting roles in the process. Both positions are cautious about these ambiguities and regard the behavior of the small groups that attempt to take advantage of them at best as suspicious and at worst as illegal. The two positions disagree, however, on how effective is the current system to keep in check these groups, in particular when acting around the edges of the "due

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33.- Ibid., p. 93.

process". The two positions stress, in sum, the need for adequate institutional safeguards that minimize the risks of opportunistic and politically motivated agreements made at the expense of fairness and good technical criteria; both positions fail nonetheless to analyze standards setters' behavior for what it is rather than for what it could or should be.

SETTING STANDARDS AS A PROBLEM-SOLVING PRACTICE

In this section I discuss the view of standards development as an hierarchical set of lengthy deliberative practices aimed at providing documented solutions to industrywide recurring problems. These practices, according to this approach, involve a long succession of draft amendments that are instrumental in shaping standards setters' ultimate agreement. Agreeing on each of these amendments represents, this approach suggests, not only a step towards draft standards' final approval, but more important, a particular stage in re-defining their contents. Standards setters are likely to proceed with this re-definition, according to this approach, in ways that provide sufficiently stable and robust problem definitions as for the solutions to become a suitable basis for uniform design practice. I argue that, in contrast with the other two

approaches, the problem-solving approach involves a penetrating though somewhat fragmentary description of standards setters' practices in terms of the problems they often agree on how to define and solve. I end the section with a brief discussion on the limitations of this approach and the need for a more interactive view of participants' and nonparticipants' concerns with the benefits from design uniformity this approach assumes.

Melnitsky was probably the first to describe standards setters' deliberations as a collective endeavor aimed at solving industrywide recurring problems. The advantages of dealing only with these problems are, in his view, twofold. First, the recurrence of these problems creates the sense of a pattern upon which standards setters can rely to make consultations with their companies and seek all relevant information required to agree on documented and hence uniform and cost-effective solutions to these problems. Secondly, this kind of problems, once properly documented and solved, can be fruitfully and profitably relegated "to the field of routine." 34/ Written from a marketing perspective, his study depicts the likely cost reduction benefits from setting

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34.- Benjamin Melnitsky, Profiting from Industrial Standardization (New York: Conover-Mast Publications, 1953), p. 1.

and implementing voluntary standards in the following way:

> It costs money to develop and use standards. This alone is sufficient reason for limiting their application to those problems that crop up time and time again... Over-standardization is generally accompanied by encroachment into the areas of industry where human ingenuity and personal judgment should reign supreme. 35/

And again:

> (A) standard... should be of such obvious [industrywide] desirability and its benefits so completely self-evident that it requires no policing. The manifest difficulty of this underlies the necessary slowness of the standards development process. The firm which overnight produces an encyclopedic book of purchasing specifications, standard testing methods, standard inspection practices, etc., ... (a)lmost certainly... will gain little for its efforts. 36/

The more recent literature, including authors like Cheit and Seely, suggests, by contrast, that though setting standards entails close interfirm cooperation, the involvement of standards setters' employers varies according to issues at stake and their ability to influence and evaluate the outcomes of the deliberations. Cheit contends, for instance, that the more uncertain and complex the issues involved in setting a safety standard the more likely is that the ways the problem is defined and solved remain within the scope of standards

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35.- Ibid., p. 8.
36.- Ibid., pp. 3-6

setters' professional judgment, at least when the cost implications are not high. Written from a public policy perspective, his study emphasizes the various possible approaches to committee deliberations can accommodate as they ponder all existing and foreseeable legal, regulatory, economic, and institutional implications of the proposed solutions. According to him, these multiple considerations and diversity of tradeoffs often make it difficult, if not impossible, for participant companies to assess and compare the benefits from alternative approaches. Accordingly, these companies frequently find it preferable

> to defer to 'professional judgment' within certain constraints. In other words, so long as particular provisions do not cost too much, engineers are given free reign in making the decisions. This strategy requires only rough estimates of costs and not necessarily any formal assessment of benefits. It also results in a substantial amount of guesswork. ... This explains... the potential for unreasonably strict (but economically inexpensive) provisions in private standards. 37/

Seely argues, from an historical perspective, that while drafting standards proposals is the most likely task of a few high-rank engineers, their approval includes a long series of minor amendments that are nonetheless crucial in building

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37.- Ross E. Cheit, Setting safety standards (Berkeley and Los Angeles: University of California Press, 1990), p. 165.

participants' agreement. In his studies in the American highway industry, he finds, for instance, that federal engineers at the Bureau of Public Roads (BPR) had a pivotal role in setting standards committees' agenda at the American Association of State Highway Officials (AASHO) and the American Society for Testing of Materials (ASTM). Having no direct responsibility in constructing roads, BPR engineers used AASHO and ASTM as national fora where they could promote their own standards and obtain their approval, often after minor amendments. 38/ Seely depicts BPR engineers' use of their intellectual leverage to have their proposals approved in AASHO and ASTM committees as follows:

> (T)he AASHO became the agency that promulgated highway standards for the federal-aid system, a role it acquired because it was congenial to both state highway officials and the BPR... Through the AASHO, the states had a voice in all decisions, thereby forestalling charges of federal dictation of policy. From the start, however, the BPR dominated the committee's work, for most of the data used to define the minimum federal-aid system were provided by the bureau's representative in the committee. 39/

38.- Bruce E. Seely, "Engineers and government-business cooperation: Highway standards and the Bureau of Public Roads, 1918-1940," Business History Review 58 (1984): 51-77; idem, Building the Highway System, pp. 118-135; idem, "Diffusion of Science into Engineering: Highway Research at the Bureau of Public Roads, 1900-1940," in Transfer and Transformation of Ideas and Material Culture, ed. Peter J. Hugill and D. Bruce Dickson (College Station: Texas A. & M. University Press, 1988), pp. 143-162.

39.- Seely, Building the Highway System, pp. 123-124.

And again:

> Committee members from the state highway departments were not merely rubber stamps, for many of them made valuable contributions, but only rarely did they initiate proposals. Usually their input consisted of comments and suggestions about material generated by the BPR. 40/

And again:

> The number of federal engineers working in ASTM projects was never as great as those serving in the AASHO's standards committee, but they were found on all committees related to road materials... Because few sources of technical information rivaled the bureau, the contribution of BPR engineers was out of proportion to their numbers, as they prepared numerous papers and committee reports. In this way they funneled their research into the ASTM's approval process, so that the research and standards topics that interested the BPR in the 1920s and 1930s, such as concrete and oil and asphalt, constituted the agenda of the ASTM. This congruity meant that almost every standard specification and testing method for road materials adopted by the ASTM emerged from BPR researchers. 41/

BPR engineers' choice of discussing their proposed standards in AASHO and ASTM committees was aimed, according to Seely, at providing a sense of enlarged problem ownership, useful in ensuring participants' agreement. By amending federal engineers' written contributions, other committee members had also to recognize their merits and commit themselves to their approval and implementation. These amendments, though slow and time-consuming, were also

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40.- Idem, "Engineers and Highway Standards," p. 62.
41.- Idem, Building the Highway System, p. 128.

important, as Seely's narrative suggests, to remove participants' misgivings about federal engineers' dominant role in the process. He shows, in sum, that federal engineers' encouragement of minor amendments was an essential component of their own strategies aimed at ensuring uniformity and bolstering, at the same time, their own credentials as qualified leaders at the top of an hierarchically structured problem-solving order.

Vincenti suggests, also from an historical perspective, that the more radical and substantive the amendments to a draft standard the more likely is that these amendments take place in close relationship with testing programs. There are, according to him, at least two ways a testing program may interact with these amendments. First, he contends, top engineers in charge or in close contact with the testing program may use the successive versions of the standard as a schedule in their search for information leading to further amendments. His narrative in this regard is rich in detail and insight; he provides a thick description of the role of a six-year testing program in the setting of flying-qualities specifications for airplanes. 42/ His account shows how once

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42.- Walter G. Vincenti, What engineers know and how they know it (Baltimore: Johns Hopkins Press, 1990), pp. 79-98.

a testing program is organized and a tentative solution proposed, the writers of the successive versions of the document may regard these versions as a means of broadening its scope of application from a specific piece of hardware to an entire family of products with similar design problems. The long series of refinements that took place after the first set of flying-qualities specifications written in 1936 for the DC-4E were accompanied, for instance, by a continuous growth in the testing program and the broadening of its initial purpose, including all kinds of aircraft, even a few airplanes that became available by chance. 43/ Having the theoretical background and access to these test results and relevant comments from final users, the small group of engineers at the top of the program was particularly well-positioned to write and rewrite the successive versions of the standard that ultimately led the testing program to an end.

Secondly, Vincenti suggests, testing programs provide not only data, but more important, valuable hints on how to interpret these data in terms useful for uniform design practice. In the course of the testing program, as he points out in his case study, two seemingly vague and contradictory aspects of a recurring but initially ill-defined problem

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43.- Ibid., pp. 89-91.

(i.e., the search for both aircraft longitudinal stability and control) slowly became recognized as depending on a single principle (the pilot's stick force). The way towards this solution included, as he shows in his narrative, not only an early identification of the recurring features of the problem, but more important, the search for repeatable readings that could become the basis for setting quantitative, specifiable requirements appropriate for uniform hardware design. As the program evolved, however, it provided not only these readings but also various hints that assisted the top engineers in charge of the program in the attainment of a reinterpretation of the problem that was robust enough to become the basis of a solution functionally relevant for all kinds of aircraft design. 44/ Each of the amendments involved, accordingly, a partial reinterpretation of the functional features of the problem in the light of these hints and data, and a way of re-defining the problem in terms these engineers thought satisfactory not only to final users but also to aircraft design engineers.

44.- Interestingly, Vincenti (ibid., p. 94) shows how the search for this solution involved a complete reversal in the importance conferred to particular aspects of longitudinal stability and the rejection of widely held mathematically based assumptions, with a complex and lengthy process of reinterpretation of these aspects in the light of testing data provided by the program.

The view of setting standards as a problem-solving process provides a patchy but consistent portrait of who are the standards setters and how their uneven forms of participation shape the outcomes of their deliberations. The problem-solving approach distinguishes, from the viewpoint of their written contributions, at least two groups of standards setters. The first and more numerous group has limited information, faces severe time constraints, and its participation is confined at best to mail exchanges, regular attendance to committee meetings, a careful reading of the proposals or draft standards made available to them by the second group, and an active involvement in the approval process, with suggestions and comments leading to minor amendments. The second group is made up of a handful of senior engineers with the time, access to sensitive information from their companies and organizations, and relevant data from testing facilities to write standards proposals or propose major amendments to existing ones. These two differing forms of participation tend to mimic the hierarchical features of standards setters' work place, namely the companies and organizations where they work as employees.

The problem-solving approach also provides, in contrast with the other perspectives discussed in this chapter, the most detailed account of how standards setters agree and the

intended use of their agreement in standards implementation. This approach shows, for instance, how only a long succession of major and minor amendments is likely to ensure both sufficiently uniform industrywide solutions to remove costly functional uncertainties from compliers' activities and sufficiently broad levels of agreement to legitimate the uniformity of these solutions. This approach also argues, in common with the coordination perspective, that standards setters are likely to ponder the merits of their solutions in terms of the ways they can possibly agree, sometimes at the expense of how well these solutions may fit an evolving context of implementation. Contrary to the coordination perspective, however, the problem-solving approach suggests that pondering these merits only becomes relevant to the decision making process in the light of an expected rather than an actual context of implementation. Standards setters' agreements may take into account compliers' actual concerns, but they are more likely to describe and evaluate these concerns from their own viewpoint as participants in the process. The problem-solving perspective, accordingly, describes the evolving contents of the documents on which standards setters can agree as part of a long-term interpretive process throughout which they continuously re-define the uniformity of their proposed solutions.

For all the importance of participants' agreement, this is only possible, according to the problem-solving perspective, as long as there are written contributions on which standards setters may compromise. This perspective emphasizes, accordingly, that the continuity of their deliberations relies not only on their declared willingness to seek agreement, but also, somewhat paradoxically, on their uneven forms of participation and commitment of resources to the process. In common with the rule-following approach, the problem-solving perspective readily concedes that the hierarchical features of the process tend to put the burden of responsibility upon the larger but often less well-informed group of standards setters. The problem-solving approach also concedes that the process includes a small, better informed, and very influential group of standards setters, but describes this group as engaged in initiating proposals, promoting them, introducing major amendments, or even failing to deal with certain issues, rather than being concerned with ways of taking advantage of procedural ambiguities or interfering with the approval process. In contrast with the rule-following perspective, the problem-solving approach contends, accordingly, that it is the amendment logic typical of the process, rather than the rules and procedures standards setters follow, which accounts for the slow pace of their agreement. In contrast with the rule-following approach, the

problem-solving perspective is in sum generally skeptical about the extent existing or alternative rules and procedures can possibly effect, beyond providing a sense of fairness and stability to the process, the pace of standards setters' deliberations or the ways they make written contributions, modify the existing documents' contents, and ultimately agree on them.

The problem-solving approach, though richer in detail than the other two perspectives, has two major limitations. First of all, this approach falls short, I argue, of providing a sufficient account of participants' continuous search for agreement and their possible concerns with the uniformity of their own approach. While this approach conceptualizes the deliberations as endless negotiations on the ultimate contents of the documents they agree upon, the more specific motives and reasons most standards setters may have to become assiduous participants in this process are either assumed and left unexamined or at worst reduced to their functional role in the process. Moreover, the characterization of the deliberations in terms of two groups, with differing agenda and concerns, further complicates matters, as both groups should have, accordingly, a shared but unexplicated concern with the merits and ultimate possibility of agreement. The point is that as long as one regards the benefits from setting

standards as limited to implementation, these benefits should accrue at best to the smaller and more influential group of standards setters, and no equivalent, likewise persuasive description of similar or alternative reasons for the second and much larger group's role in their search for agreement seems available.

The second, and even greater, limitation of the problem-solving perspective is its description of the deliberations' outcome as entirely definable in terms of participants' own aims and expectations. This description entails an internalist view of the process, as if standards setters' deliberations and design agreements could take place in isolation and independently from their consequences for other groups absent from the deliberations. Some nonparticipant groups may have, for instance, a stake in the proposed design uniformity standards setters aim to construct, and yet these groups' concerns and expectations fit poorly in participants' proposed solutions. In other words, the problem-solving approach overlooks the proposed, rather than the actual, character of these solutions, and disregards any possible role for implementation in defining the success or failure of participants' consensus-building efforts. The problem-solving approach assumes in short that implementation, beyond its voluntary character, is largely unproblematic, as if

participants and other nonparticipant groups had no role in reassessing the merits or even the need for the proposed solutions.

I suggest that a broader and more interactive approach is required. This approach can retain, I argue, the full advantages of the problem-solving perspective and simultaneously provide a more complete account of how the knowledge shared in the process becomes a powerful incentive for participation and agreement. To succeed, however, this approach must first show how standards setters' agreement can possibly increase, via the industrywide character of their design changes, the utility and relevance of this knowledge for them and their employers. Further, this perspective must also make sense of the benefits, opportunities, and shortcomings of these industrywide design changes not only for them and their employers, but also for all nonparticipant groups having a stake in such design changes. The task of the next chapter is to discuss how these benefits can at least partly converge in the process, and the ways participants and nonparticipants seek to ensure that their benefits are commensurate with their own concerns with the consequences of greater uniformity in product design and related engineering practices.

CHAPTER 3
NEGOTIATING INDUSTRYWIDE COMPATIBILITY

In this chapter I discuss the development of voluntary product safety standards as both a long-term collective undertaking and a highly interactive process clustered around the knowledge and cost reduction assumptions of a dominant product design. A dominant design is, as I further argue below, the embodiment of industrywide practices and knowledge into a specific product configuration (e.g., an automobile, a personal computer, a farm tractor, and so on) whose permanence as a product class is crucial in terms of the economic benefits its supporters, including standards setters, may expect in the long run. As this product class stabilizes into a typical set of parts and components functionally interrelated and with a specific overall configuration, all groups with a stake in it (e.g., plant managers, design engineers, marketers, maintenance technicians, dealers, consumers, etc.) seek and find ways of taking advantage of a better knowledge of the product and the benefits from mass production and its concomitant economies of scale. Standards setters' search for collective approaches to product safety design problems is based, I contend, not only on the expected economic benefits from making these approaches compatible with a dominant design, but also on the extent the industrywide

character of their proposed changes in product design may increase the utility of the knowledge shared in their deliberations.

Standards setters' concern with the informational and long-term economic benefits of their proposed design changes needs not be shared by all groups with a stake in a dominant product design. Some of these groups (e.g., product users, foreign manufacturers, overseas regulatory agencies or standards setters, etc.) may feel that participation in the standards-setting process is unwarranted either because they have little understanding or interest in the knowledge shared in the deliberations or because they regard the scope of the design decisions formalized in the process as beyond the national and institutional boundaries of the organizations they represent. My contention is that for all the informational and economic benefits from the process, the more specific ways these nonparticipant groups interact with a dominant product design may demand major compromises that define and redefine the terms of the design changes participants may find useful to promote or support.

My argument begins with a general discussion of why standards setters' efforts to rearrange their problem-solving commitments in terms of a long-term collective undertaking

need not be in conflict with their individual interests. The second section of the chapter describes their consensus-building strategies as ways of trading, on a project-by-project basis, the knowledge and proprietary information they share to define in industrywide terms the product design approaches they aim to promote or support. Over time, I argue, the industrywide character of these approaches and participants' authority as experts are likely to favor the institutionalization of these problem definitions and design approaches that may become widely accepted even by nonparticipants. I end the chapter with a brief discussion on how, despite standards setters' continuous efforts aimed at promoting and stabilizing their problem definitions and the knowledge embodied in them, these may become, at times, the target of conflicting interpretive approaches advanced by nonparticipant groups.

SHARED INTERESTS AND PUBLIC GOODS

In this section I contend that accounting for the ways standards setters structure their promotional and consensus-building strategies requires a prior discussion of the interests involved in their continuous participation and search for agreement. My argument starts with a brief

description of the interests model as developed, from the perspective of the Sociology of Scientific Knowledge, by Barry Barnes, Steven Shapin and a group of scholars better known as the Edinburgh School. In the view of these authors, the analysis of individuals' desires, wants and objectives should include the complex web of interactions that makes possible their involvement in particular forms of cooperation and use of cultural resources available to them; it is in this context that these individuals may develop social or shared interests with respect to certain activities or things. As long as these individuals do not exist as isolated entities, their interests must be understood in the social and historical context of their circumstances; in other words, since the ways individuals relate themselves to these forms of cooperation go beyond their psychological states or their individualistic concerns, the concept of interests is not reducible to these concerns or states. This suggested, in the view of these authors, that some links, possibly functional ones, could be established between knowledge producers' broader social interests and the ways their decisions were framed within particular interpretive approaches to the specific problems they aimed to solve. The study of these links would not necessarily invoke deterministic or teleological clauses; rather, social interests should be viewed, according to these authors, as exerting an influence on knowledge producers'

interpretive approaches, an influence whose scope and extent should be a matter of sociological and historical inquiry. 1/

Given the suggested but unspecified social links between interests and decision making, the model proposed by Barnes and Shapin became vulnerable to criticisms developed by some rational decision theorists and, from a social constructivist perspective, by Steve Woolgar 2/. The interests model was

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1.- See, e.g., Barnes, Scientific knowledge and sociological theory (London: Routledge & Kegan, 1974); idem., Interests and the growth of knowledge (London: Routledge & Kegan, 1977); Barry Barnes and Donald Mackenzie, "On the role of interests in scientific change," in On the Margins of Science, ed., Roy Wallis (Keele: Keele University Press, 1979); Barnes and Shapin, Natural Order (Beverly Hills: Sage, 1979); Donald Mackenzie, Statistics in Britain, 1865-1930 (Edinburgh: Edinburgh University Press, 1981); Steven Shapin, "Phrenological knowledge and the social structure of early nineteenth-century Edinburgh," Annals of Science 32 (1975): 219-243; Shapin and Barnes, "Science, nature and control: Interpreting mechanics' institutes," Social Studies of Science 7 (1977): 31-74.

2.- See Woolgar, "Interests and explanation in the social study of science," Social Studies of Science 11 (1981): 365-394. For replies, see Donald Mackenzie, "Interests, positivism and history," Social Studies of Science 11 (1981): 498-504; Barry Barnes, "On the 'hows' and 'whys' of cultural change," Social Studies of Science 11 (1981): 481-498; Woolgar, "Critique and criticism: Two readings of ethnomethodology," Social Studies of Science 11 (1981): 504-514. An alternative view of interests, in terms of the actor-network approach, is discussed in Michel Callon and John Law, "On interests and their transformation: Enrollment and Counter-enrollment," Social Studies of Science 12 (1982): 615-625. Not all social constructivists were unsympathetic to the interests model; Karin Knorr-Cetina ("Ethnographic study

seriously flawed, in Woolgar's view, because it embraced, in an unexplicated and unproblematic way, the use of causal-type formats in examining social agents' (i.e., scientists) decisions. The adoption of this kind of format included the imputation, by the analyst, of social characteristics or interests to the interpretive frameworks of the agents under study. Woolgar concluded that the use of this model was possible only at the expense of making the individuals under study unreflexive "interests-dopes". To be sure, his objection did not entail a rejection, in principle, to the inclusion of interests as part of the explanatory strategies of the analyst. His critique was about the procedure by means of which scientists' decisions and approaches to highly specific problems were treated as if these approaches could be reduced to the interests of the groups to which these scientists were said to belong. This kind of reductionism, as I further discuss below, removes any trace of complexity in the treatment, by the analyst, of individuals' decisions and those of the groups to which these individuals are said to

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of scientific work: Towards a constructivist interpretation of science," in Science Observed, ed., Karin Knorr-Cetina and Michael Mulkay [Beverly Hills: Sage, 1983], pp. 115-140), for instance, featured this model in terms of a congruence model, epistemically useful in a critical discussion of scientists' theoretical concerns, but of little interest in case of dealing with their shared beliefs.

belong, namely as if both kinds of decisions were mutually interchangeable. Though Woolgar's critique did not address this problem, his objections to matters of procedure called for a more detailed description of how and under what conditions these social interests could be possibly shared by both individuals and groups. 3/

The second and no less important challenge to the interests model came from some rational decision theorists,

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3.- For an interesting discussion on how stable are social interests and the epistemic and policy implications of this presumed stability, see John Abraham, "Interests, presuppositions and the science policy construction debate," Social Studies of Science 24 (1994): 123-132. See also Andrew Pickering, "Big science as a form of life," in Restructuring of Physical Sciences in Europe and the United States, 1945-1960, ed., Michelangelo De Maria, Mario Grilli, and Fabio Sebastiani (London: World Scientific, 1989), pp. 42-54; idem, "Pragmatism in particle physics: Scientific and military interests in the post-war United States," in Development of the Laboratory, ed., Frank A. James (London: MacMillan, 1989), pp. 174-183. Both studies of Pickering as well as that of Steven Shapin and Simon Schaffer emphasize how, in order to succeed, new "forms of life" based on research equipment and organizational models of their own must "insinuate themselves and their intellectual products" to other groups and institutions that can provide political and material support (Leviathan and the Air Pump [Princeton: Princeton University Press, 1985], esp. pp. 332-344). This view of knowledge producers' interests as clustered around particular forms of life entails an effort to accommodate Ludwig Wittgenstein's (Philosophical Investigations [Oxford: Basil Blackwell, 1968]) notions of language games and forms of life within a description of knowledge as a key dimension of the social order. See also Barry Barnes, Nature of Power (Cambridge: Polity Press, 1988), pp. 26-44, 141-152.

who used the free-rider problem as an argument against the relevance of shared interests in collective decision making. 4/ In the view of rational decision theory, the free-rider problem allegedly typical of all voluntary efforts aimed at providing a public good occurs precisely because it is not rational for individuals, under certain circumstances, to act as a group in the light of their own self-interest. The question is that while cooperation often brings benefits only to those individuals who are involved in these cooperative efforts (which seems rather unproblematic within the interests framework), the voluntary decision of individuals to cooperate no longer seems rationally grounded on their own self-interest when dealing with goods whose benefits are, in principle, indivisible and the exclusion of third parties impossible or unfeasible. In facing public investment decisions, the rational, self-interested agent would tend to free ride unless there are either extrarational considerations (i.e., a moral motivation, insufficient information, etc.) or short-term incentives (or sanctions) that dissuade him or her from doing so. This showed, in the view of rational decision theorists,

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4.- See, e.g., Mancur Olson, The Logic of Collective Action (Cambridge: Harvard University Press, 1965); Russell Hardin Collective Action (Baltimore: Johns Hopkins Press, 1982); Douglas D. Heckathorn, "Collective action and the second order free rider problem", Rationality and Society 1 (1989): 78-100.

that there was a frequent lack of agreement between individuals' interests and the alleged social interests of the group to which these individuals were attached. The problem seemed particularly intractable in the light of Woolgar's critique: if individuals' decisions were more than mere blind expression of group interests, then there was no plausible way of accounting for the importance of social interests in individuals' decisions in contributing to the provision of these goods.

There are, as the most recent literature suggests, at least three major limitations in the argument of traditional rational decision theorists against the social interests perspective of collective decision making. 5/ The first

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5.- The experiments conducted by Gerald Marwell and Ruth E. Ames ("Experiments on the provision of public goods. I. Resources, interest, group size, and the free-rider problem," American Journal of Sociology 84 [1979]: 1335-1360) showed the serious limitations of examining individuals' "rational decisions" as if leaving aside the social milieu could be inconsequential for these decisions. Other critics, such as Steven Shapin ("History of science and its sociological reconstructions," History of Science 20 [1982]: 157-211) and Mark Granovetter ("Economic action and social structure: The problem of embeddedness," American Journal of Sociology 91 [1985]: 481-510) have pointed out the coercive view of agency advanced by rational decision theorists. Others, like Richard Nelson and Sidney Winter (An evolutionary theory of economic change [Cambridge: Harvard University Press, 1982), Kenneth J. Arrow ("Rationality of self and others in an economic system," Journal of Business 59 [1986]: s385-s399), and Jon Elster (Solomonic Judgements [New

weakness of this argument concerns its treatment of the free-rider problem as if taking place in a social vacuum; in other words, the argument assumes that all possible considerations or incentives required to overcome this problem are "external" to individuals' rational self-interest. This divide between rational and extrarational considerations assumes that individuals' decisions are invariably utilitarian and must be framed in the heavily compartmentalized terms of rational decision theory. What the discussion of the free-rider problem by rational decision theory shows, in any event, is that as long as individuals must act individually, rather than as part of a group, they are unlikely to decide against their own self-interest. This, however, begs the question of the extent to which the interests of a group can be properly described in terms of mere aggregates of its members' self-interested behavior. The suggested reduction of group interests to the interests of its membership and the use of some standard analytical distinctions, like that of incentives and self-interest, may exhibit themselves as increasingly artificial barriers for the analyst. It is, for instance,

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York: Cambridge University Press, 1989]) emphasize its too assuming view of social agents' concern with optimization. My concern here is with rational decision theory but only to the extent that its arguments are directed against the implausibility of interests being defined as anything more than individuals' short-term self-interest.

unclear what might be the advantage of using this kind of distinctions in examining a group's behavior if this group develops its own incentives and individuals' self-interest becomes subsumed into the shared interests of a group. These incentives, as pointed out in particular by Coleman and Barnes, may include forms of mutual symbolic sanctioning, which constitute not only a very powerful means of inducing conformity, but also one whose economic costs are negligible. 6/

The second limitation of traditional rational decision theory is its assumption that the relationship between collective decision making and the technical content of public goods remains invariably subsumed within the general logic of optimization. As rational agents are assumed to engage in the continuous appraisal of this content, their choices are described as if having only limited bearing, if any, on the technical features of available goods, whose content is presumed as if given and largely unaffected by the ways these agents structure their decisions with respect to the provision of these goods. In the view of rational decision theory,

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6.- James S. Coleman, "Free riders and zealots," Sociological Theory 6 (1988): 52-57; Barnes, Nature of power, pp. 133-140; idem, "Status groups and collective action," Sociology 26 (1992): 259-270.

there are admittedly important asymmetries in the ways social agents may benefit from this technical content. These asymmetries entail an uneven distribution of benefits and opportunity costs, which is allegedly consequential only in terms of users' economies of scale and their ultimate ability to internalize lower costs and obtain higher returns in terms of their own investment decisions. Thus, though there are corresponding asymmetries in collective decisions that tend to vary according to the size of the groups involved, these asymmetries are not said to affect goods' technical content 7/. The difficulty set out here, however, concerns the assumption that rational agents can only choose (either as a group or in individual terms) rather than shape these goods' technical content, namely as if this content could be produced and evaluated in terms of a single, hierarchically defined and undisputed set of criteria. This assumption clearly denies that there could be more than one good solution satisfactory in terms of agents' own expectations 8/. As no other role

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7.- See, e.g., Hardin, Collective Action, pp. 76-89.

8.- Herbert Simon's (Sciences of the Artificial [Cambridge: M.I.T. Press, 1969]) emphasis on social agents' unwillingness to look for optimal solutions and their preference for satisficing, is an alternative and somewhat less coercive view of rationality. This, however, is not the preferred approach of traditional rational decision theorists. Hardin (Collective Action, p. 120), for instance, only examines satisficing as one among various possible extrarational motivations.

than optimizing is admitted in rational decision making, rational decision theorists tend to assume that interdependency in decision making (except for agents' competitive behavior) is largely inconsequential for goods' technical content. Moreover, as there is no other "rational" way of shaping this content but in terms of its optimization, under a single, undisputed approach, there seems to be no reason for agents to become interested in alternative approaches. Thus, rational decision theorists ultimately reduce goods' technical content as part of the setting rather than the very outcome of individuals' decisions.

The third and probably more serious flaw in the treatment of the free-rider problem in traditional rational decision theory concerns an oversimplified view of public goods, namely as if they were all alike. This presupposes that the ways individuals and groups relate themselves to the particular characteristics of these goods have no bearing on their own decisions in contributing to the provision of these goods. More recently, Uhlaner has suggested, from the perspective of political science, the need to adopt a more open-ended approach to the ways these goods' social characteristics may affect decisions by individuals and groups. In her view, rational decision theory needs to distinguish, for instance, between standard public goods (like bridges, dams, etc.) whose

utility for the people that consume them is limited by their own individual levels of consumption, and those goods whose consumption increases their utility. Her description of this latter kind of public goods, which she calls relational goods, emphasizes their lack of diseconomies of congestion typical of the use of other investment goods; rather, congestion itself provides a benefit. As she puts it, "a baseball game is more exciting when the park is full." 9/ By including the concept of relational goods as a subset within the general category of public goods, she also provides a new sense of diversity in the ways contributors can relate themselves to the provision of public goods. These contributory efforts are no longer described in terms of burdens, but at least in the case of relational goods, as highly rewarding for those involved in them.

Uhlaner's emphasis on the differing ways contributors to public goods can benefit from them also highlights interdependency and diversity in collective decision making. By focusing on interdependency, the concept of relational goods also makes the use of rational decision models compatible with earlier assumptions of the resource

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9.- Carole J. Uhlaner, "'Relational goods' and participation: incorporating sociability into a theory of rational action," Public Choice 62 (1989): 255.

mobilization perspective and other similar attempts to formalize more interactive views of collective action such as the threshold models developed, from a social network perspective, by Mark Granovetter. 10/ Needless to say, the concept of relational goods is complementary with the more recent assumptions of the interests model about the relational benefits that a "critical mass" of knowledge producers can provide in terms of the ways their interests get clustered into particular "forms of life." 11/ Also relevant for the practical purposes of this study is that the concept of

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10.- Mark Granovetter, "Threshold models of collective behavior," American Journal of Sociology 83 (1978): 1420-1423. The resource mobilization perspective, closely associated with empirical research in social movements, has long recognized the importance of a theory of collective action that overcomes the criticisms formulated by rational decision theorists. See, e.g., Charles Tilly "Revolution and collective violence," in Handbook of Political Science 3, ed. Fred I. Greenstein and Nelson W. Polsby (Reading, Mass.: Addison-Wesley, 1975); John D. McCarthy and Mayer N. Zald, "Resource mobilization and social movements: A partial theory," American Journal of Sociology 82 (1977): 1212-1241; Anthony Oberschall, "Protracted conflict," in Dynamics of Social Movements, ed., Mayer N. Zald and John D. McCarthy (Cambridge, Mass.: Winthrop, 1979), pp. 45-70; idem, "Loosely structured collective conflict: A theory and an application," Research in Social Movements, Conflicts and Change 3 (1980): 45-68; Gerald Marwell and Pamela Oliver, "Collective action theory and social movements research," Research in Social Movements, Conflicts and Change 7 (1984): 1-27; Pamela Oliver and Gerald Marwell, "Paradox of group size in collective action: A theory of the critical mass, II," American Sociological Review 53 (1988): 1-8.

11.- See note 3 above.

relational goods, by showing that not all public goods are limited resources, may help to overcome the prejudice created by the free-rider problem about collective action as if invariably unstable in case of large groups.

Now we are in condition to discuss in more detail the problem of how a more interactive version of the interests approach can provide a useful description of the standards-setting process and participants' individual concerns with participation and agreement. My argument is that Uhlaner's description of the diverse benefits social groups can expect from public goods and the ways these benefits are likely to affect their decisions about these goods need be made flexible enough as to accommodate at least a third subset of goods. This subset, which includes voluntary standards, combines some of the features of investment public goods and relational goods. Voluntary standards, for instance, are goods whose production may involve considerable investment in terms of time and resources, but they could also be regarded as relational goods. Standards provide the typical benefits of relational goods in two differing ways according to how standards setters and compliers relate to these documents. They are relational goods for the standards setters who benefit from interfirm exchanges of knowledge and technical information taking place in the development process. But once

produced they could also act as relational goods: the more widely standards are implemented the more both their promoters and users benefit. But they can only benefit if there is a single document for each particular purpose, namely if duplication and conflicting or overlapping standards are carefully avoided. This makes consensus building and demarcation work paramount for standards successful implementation. In other words, the relational benefits of standards use rely, to an important extent, on the ways these documents are developed and approved. Thus, the development process entails an investment process, with consensus building as its main asset.

The dual nature of voluntary standards as investment goods and relational goods is, from the standards-setters' perspective, a source of diverse and conflicting interests with respect to the costs and benefits of the process. The dual nature of the process creates a continuous tension between standards-setters' long-term interest in finding a sufficiently broad implementation of these documents and their often disparate short-term interests in terms of the acquisition of information and learning processes the standards-setting activity entails, its direct costs, and the indirect costs or practical implications for compliers (i.e., the manufacturers' expenses in developing design concepts

compatible with the approved standards). The first and most immediate concern of the various individuals and groups engaged in setting standards is to limit their time and resources without compromising their own access to relevant information or their ultimate influence on the process. The chief long-term interest of standards setters may share is to find ways of building a uniform perspective on the basis of which they can develop a document with the largest possible number of compliers in mind. Given the extended time span required for the development of a standard (e.g., five years), the tension created by the combination of these short-term and long-term interests may involve complex and almost endless sets of tradeoffs by means of which these documents are drafted, balloted and approved. As the outcomes of the deliberations include a cumulative series of partial agreements, we can say that these agreements are themselves structured in terms of negotiations. It is therefore the mentioned tension between disparate short-term interests and the search for a long-term uniform design perspective which accounts for standards setting as a negotiated process. As standards setters are no longer viewed as if bearers of a single set of interests, some of their short-term concerns may become themselves a matter of negotiation. This modified version of the interests model may account for the ways some of the standards-setters' interests become negotiable; it

cannot explain, however, how these negotiations occur.

INTERESTS AND NEGOTIATIONS IN CONSENSUS BUILDING

In this section I discuss how standards setters negotiate both the industrywide character of their approach and their access to the knowledge they expect useful in determining the proposed design changes on which they agree. My argument begins with a brief discussion of the negotiated order perspective, as developed in particular by Strauss and a group of symbolic interactionists. This perspective is based on earlier empirical work in mental hospitals, undertaken in the late 1950s and early 1960s. It emphasizes the temporary and socially situated character of the agreements required to maintain the viability of social agents' cooperative efforts (e.g., among psychiatrists, nurses, psychologists, and patients). Strauss features these agreements as part of a continuous process of accommodation of social agents' short-term aims and concerns into the demands of larger social settings. In his view, the search for workable agreements by the negotiating parties includes a variety of strategies they use to face the constraints that the very social structure imposes upon their own cooperative efforts. These strategies involve not only an adaptative process but, the more

important, ways of taking advantage of organizational ambiguity. As new opportunities and problems emerge, the negotiating parties may act alternatively as strategists, opportunists, problem solvers, or may even withdraw from the negotiations. His view of the social order as organized in terms of continuous sets of negotiations is based on pragmatic assumptions, namely that the structural context of this process will remain favorable enough as individuals to find ways of overcoming conflict. In short, he assumes social (structural) change induces social agents to negotiate, but for negotiations to be possible, change must occur at a pace that can be handled by the negotiating parties. Change in turn would account for the temporary and unstable features of the negotiations' outcomes. 12/

12.- See, in particular, Anselm L. Strauss, Negotiations (San Francisco: Jossey-Bass, 1978); idem, "Interorganizational negotiation," Urban Life 11 (1982): 350-367. The interactionist school, also known as the Chicago School, evolved as a distinctive sociological tradition associated with the work of Everett C. Hughes (Sociological Eye [Chicago: Aldine, 1971]) and Herbert Blumer (Symbolic Interactionism [Englewood Cliffs, NJ: Prentice-Hall, 1969]). The negotiated order perspective was an offshoot of this tradition, as a result of the work of Anselm L. Strauss et al (Psychiatric Ideologies and Institutions [Glencoe: Free Press, 1964]), Barney G. Glaser and Anselm L Strauss (Awareness of Dying [Chicago: Aldine, 1965]), Howard S. Becker et al (Boys in White [Chicago: Chicago University Press, 1961]), David R. Maines ("Social organization and social structure in symbolic interactionist thought," Annual Review of Sociology 3 [1977]: 235-259), and Lawrence Busch ("History, negotiation and structure in agricultural research," Urban Life 11 [1982]: 368-384), among others. For some recent critical perspectives

Strauss provides at least one important exception in his own argument about the instability and temporary nature of negotiations' outcomes: The case of negotiations aimed at building permanent structures like N.A.T.O. and Benelux. 13/ His account of both sets of negotiations shows that the search for a common, explicitly stated, long-term objective by multiple parties frames the whole negotiation process in terms of multiple, sequential and linked sets of agreements. Strauss' description of the ways these negotiations proceed suggests a similar pattern as those typical of standards committees. The negotiating parties meet repeatedly (often at stated intervals) and (re)interpret their successive agreements as "steps" in the light of multiple contingencies. The process becomes routinized though not the matter under negotiation, that involves novel elements upon which new

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on the interactionist school and the negotiated order approach, see, e.g., Joan H. Fujimura, Susan L. Star and Elihu M. Gerson, "Méthodes de Recherche en Sociologie des Sciences: Travail, pragmatisme et interactionisme," Cahiers de Recherche Sociologique 51 (1987): 9-29; Adele E. Clarke and Elihu M. Gerson, "Symbolic interactionism in science studies," in Symbolic Interactionism and Cultural Studies, ed., Howard S. Becker and Michael McCall (Chicago: University of Chicago Press, 1990), pp. 179-214; Susan L. Star, "The sociology of the invisible: The primacy of work in the writings of Anselm Strauss," in Social Organization and Social Processes, ed., David Maines (Hawthorne, NY: Aldine de Gruyter, 1991), pp. 265-284; Gary A. Fine, "Agency, structure, and comparative contexts: Toward a synthetic interactionism," Symbolic Interaction 15 (1992): 87-107.

13.- Strauss, Negotiations, pp. 86-91, 157-186.

decisions must be made. The sessions can become quite technical in nature, with experienced negotiators as representatives of the parties, but the focus is on a continuous appraisal of "how things have turned out." 14/ In contrast with other forms of negotiations analyzed by Strauss, the process of building a permanent structure does not induce opportunistic or adaptative attitudes among the negotiating parties. On the contrary, the emphasis is on developing shared problem definitions, problem solving and consensus building. 15/ Though withdrawal is always possible, the costs could become very high as the process evolves. In his view, the chief argument for aggressive players is not withdrawal

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14.- Ibid., p. 173.

15.- Dean G. Pruitt ("Strategic choice in negotiation," American Behavioral Scientist 27 [1983]: 167-194) analyzes, from a social psychology perspective, the extent negotiators may structure the process in terms of problem-solving approaches. He features bridging and logrolling as the typical strategies adopted by multiple parties in multiple and linked sets of agreements. Both of them include trust as a crucial element in the continuity of the negotiations. The importance of trust and positive emotions is also emphasized, from a social exchange perspective, by Edward J. Lawler and Jenkoo Yoon ("Power and the emergence of commitment behavior in negotiated exchange," American Sociological Review 58 [1993]: 465-481). The likelihood and relevance of positive attitudes increases, according to Howard Raiffa (Art and Science of Negotiation [Cambridge: Harvard University Pres, 1982], p. 274), with the complexity created by multiple issues and parties, who "are not clear about what is in their own interest, and their knowledge about the interests of others is likewise vague."

but their ability to infringe harm on the other, weaker parties.

For all its merits, the negotiated order perspective, at least as developed by Strauss, has two major limitations in accounting for sequential sets of negotiations. The first difficulty is its inability to provide a satisfactory account of the involvement of groups and organizations with members whose level of long-term commitment as representatives of these groupings should remain, in terms of this approach, unspecified. While the possible lack of long-term commitment may seem unproblematic in case of negotiators who face a short-term problem or constraint, it is unclear what keeps the negotiating teams in the process when a long-term approach is required. These teams, described by Strauss as part of a negotiation machinery, show a remarkable but largely unexplained endurance in dealing with unforeseen contingencies and the diversity of short-term concerns typical of complex negotiations. In his account of the development of both permanent structures (N.A.T.O. and Benelux), Strauss simply remits the reader to an initial and seemingly unchallengeable decision made before the start of the actual negotiation process. This difficulty dissipates, however, as soon as this common long-term objective is regarded as part of the shared interests of the negotiating parties.

The second and more serious limitation of Strauss' view of the negotiated order concerns his inability to account for the broader context in which a long series of negotiations is said to occur. This broader setting, which Strauss called "structural context", may define the kind of negotiations that are likely to take place or even the extent to which negotiations themselves are possible. In his view, this structural context acts as both a challenge and a constraint from the "outside" of the negotiation process. 16/ As pointed out above, he describes the contingencies taking place in this "outside" as cumulative sets of events that may compromise the ultimate viability of negotiations. Thus, the emphasis of the negotiated order approach on diversity and a nondeterministic stance to negotiations' outcomes relies to an important extent on a shifting but largely unexplicated context. A possible solution to this conceptual difficulty is, as pointed out by Dingwall and Strong, to describe the fixed character of this context and its constitutive entities as a product of agents' constructions. This could include objects whose nonnegotiable character remained unexplicated under the negotiated order framework. The proposed description of the context in terms of agents' constructions and reifications involves a conflation of practice and discourse that remains operative as

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16.- Strauss, Negotiations, pp. 98-101.

long as the analyst confronts the need to account only for agents' short-term aims and concerns. 17/ This approach, however, has shown serious conceptual and methodological liabilities in attempting to describe large-scale settings and the practical implications of collective decision making beyond social agents' discourse. 18/

Busch proposes an alternative solution. He argues that to account for the social structure the analyst must first

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17.- Robert Dingwall and Phil M. Strong, "Interactional study of organizations. A critique and reformulation," Urban Life 14 (1985): 205-231. This approach has been favored from a Science and Technology Studies perspective in particular by Steve Woolgar ("On the alleged distinction between discourse and praxis," Social Studies of Science 16 [1986]: 309-317).

18.- These liabilities become particularly visible when the analyst decides to introduce causal arguments in his or her narrative. For a discussion on the advantages and limitations of causal arguments in the social studies of technology, see, e.g., Rob Kling, "Audiences, narratives and human values in studies of technology," Science, Technology and Human Values 17 (1992): 349-365. His discussion was part of an exchange of criticisms that started with Kling ("Computerization and social transformations," Science, Technology and Human Values 16 [1991]:342-347). See also Steve Woolgar and Keith Grint, "Computers and the transformation of social analysis," Science, Technology and Human Values 16 [1991]: 368-378; Grint and Woolgar, "Computers, guns and roses: What's social about being shot?," Science, Technology and Human Values 17 (1992): 366-380; Kling, "Reply to Woolgar and Grint: A preview," Science Technology and Human Values 16 (1991): 379-381; idem, "When gunfire shatters bone: Reducing socio-technical systems to social relationships," Science, Technology and Human Values 17 (1992): 381-385.

adopt a sufficiently long temporal dimension throughout which some of the negotiations' outcomes can be observed as extending beyond their local context and adopting more stable and permanent institutional features. He shows how the history of the American agricultural research system, for instance, can be fruitfully examined in terms of negotiations among disparate interests such as those of urban agrarians, farmers, and scientists. His account includes a brief description of the differing interests of these groups in the meaning and aims of agricultural research and their evolving perspective on how problems related to the proper place of research in the social order should be defined and solved. He calls these problems structural problems and describes them as initially ambiguous enough as to remain temporally open for negotiation; but once the negotiating parties agree on particular outcomes these become institutionalized, or to use Busch's own terms, they become "sedimented into structure". As a result, new organizational structures emerge (e.g., land-grant colleges, experiment stations, agricultural sciences), and become themselves new parties in a variety of negotiations that arise as a result of the need to face and solve more specific problems. In his view, negotiations are the ways social agents can accommodate both their short-term and long-term concerns within a broader structural context that is

largely a reified outcome of previous negotiations 19/.

According to Busch, the very recontextualization of negotiations into new, more permanent, organizational settings often redefines the issues and choices of problems under negotiation, which tend to become more narrowly focused, specialized, and the preferred domain of experts. In other words, as the issues become more specific but also more complex and esoteric, negotiations themselves tend to adopt a more restrictive profile. 20/ Busch and Lacy further elaborate on the ways these negotiations take place in the case of agricultural research. In their view, current research problem choice in the agricultural sciences is a result of continuous and complex sets of negotiations not only among the various groups directly involved (i.e., scientists and research administrators) but also with various client groups that provide support and legitimacy to certain research priorities and outcomes. Busch and Lacy emphasize, in contrast with Strauss, the negotiating parties' problem-solving efforts as crucial in the reduction of costly organizational ambiguities (rather than merely attempting to

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19.- Busch, "History, negotiation and structure," pp. 368-384; idem, "Structure and negotiation in the agricultural sciences", Rural Sociology 45 (1980): 26-48.

20.- Busch, "History, negotiation and structure," pp. 378-381.

take advantage of them). They suggest that the shared interests of the parties in reducing these ambiguities tend to confer a sense of direction to the negotiation process; in other words, the process becomes structured as a search for reliable and permanent solutions to particular problems. They assume nonetheless that this search, at least in the case of agricultural research, does not extend beyond defining a more permanent role for research as a solution of broader structural problems. In short, Busch and Lacy describe the negotiations aimed at solving these structural problems (i.e, improvements in agricultural productivity) as structured in terms of a search process, though still "external" with respect to the more specific problem-solving content of scientists' practices 21/.

Now we are in condition to return to the problem of how a negotiated perspective of standards setters' deliberations can be related to the ways they agree on a common design approach and the role of their successive agreements in the process. Standards setters' use of a long series of draft

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21.- Lawrence Busch and William B. Lacy, Science, agriculture and the politics of research (Boulder, Colo.: Westview, 1983), pp. 22-36; Lawrence Busch, William B. Lacy and Carolyn Sachs, "Perceived criteria for research problem choice in the agricultural sciences," Social Forces 62 (1983): 190-200.

amendments to agree on ways of defining product safety problems may seem paradoxical in the light of their own problem-solving aims, since only a clear industrywide problem formulation can provide a consistent basis for a correspondingly uniform solution. Because many solutions are possible, according to the ways a problem is defined, the search for an industrywide solution to a product safety problem entails a consensus view of what the problem is. Contrary to the conventional wisdom, however, this agreement needs not emerge as a previous and entirely separate stage in committee deliberations, independently from participants' own problem-solving aims; both of them, a problem definition and the sketch of a solution may and often precede consensus building, which standards setters may then negotiate through a long series of refinements (i.e., amendments) to the proposed design changes. Defining problems may include, accordingly, lengthy deliberations in which small groups of standards setters provide drafts or tentative solutions to design problems whose formulation is then slightly redefined in the process.

Standards setters' draft amendments, besides their critical role in defining the problems on whose solution they agree to cooperate, also entail, I argue, continuous negotiations about participants' access to the knowledge

content of the provisions under discussion. Since sharing this knowledge is the very basis upon which committee deliberations can possibly shape a single problem-solving approach, committee members may not only consider an anticipated access to this knowledge as a good reason for their participation, but also concur in the maintenance of a cumbersome and hierarchical system of consultations with the providers of this knowledge and other committees to which they submit and resubmit the draft documents under discussion. The role of earlier agreements (i.e., rules) seems crucial here, as these may define not only the scope and pertinence of the knowledge being shared (e.g., on a project-by-project basis), but also the timing and rate of diffusion of this knowledge through various committees until final approval. Conversely, the very complexity and cumbersome features of the approval process favor situations, I contend, in which this information tends to become clustered in sets of provisions that, over time, standards setters tend to take for granted as only subsequent, but often unlikely, lengthy negotiations are capable of removing. 22/ The view of standards setters'

22.- Busch and Lacy (Science, agriculture and politics, pp. 12-19) emphasize the orderly features of negotiations, with negotiating parties' early concern with their own status as negotiators and the terms and conditions under which they negotiate. Accordingly, the longer their expected involvement in the process the more rule-abiding is likely to become their behavior and the stronger their

deliberations as negotiations explains in sum how they may regard participation and an early access to information as interchangeable items; it cannot account, however, for the ways this knowledge becomes relevant or useful for them and the organizations they represent.

DEFINING AND REDEFINING PROBLEMS

In this section I discuss the ways standards setters' agreement on problem definitions may increase the utility of the knowledge shared in the process as these interact with a dominant product design. A dominant design, I contend, is not only a specific product or system configuration (e.g., an airplane, a cargo ship, a farm tractor, etc.) that standards setters regard as typical of their industry, but also the embodiment of shared knowledge and cost minimization assumptions and practices that provide support, uniformity and stability to this configuration over time. 23/ These shared

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commitment to earlier agreements.

23.- The notion of dominant product design was introduced by William J. Abernathy (Productivity dilemma [Baltimore: Johns Hopkins Press, 1978]) and further developed by Kim B. Clark ("Interaction of design hierarchies and market concepts in technological evolution," Research Policy 14 [1985]: 235-251), and Michael L. Tushman and Lori Rosenkopf ("Organizational determinants of technological change: toward a sociology or technological evolution,"

assumptions and practices easily accommodate, I argue, the efforts of standards setters and their employers to promote, via their own agreements, the knowledge content of their own problem definitions and to adapt their design decisions, at the level of the firm, to standards' likely contents. By ensuring themselves a sufficient level of influence as problem definers, standards setters and the firms that employ them may, for instance, either promote their preferred approaches or at least take advantage of the knowledge traded in the process and use it for a timely and therefore more cost-effective implementation. This mixture of promotional and adaptative strategies often becomes, I contend, a crucial element in these firms' search for competitive advantages, even if competitive pressures ultimately force them to transfer these benefits to consumers. I end the chapter with a brief discussion on how these problem definitions, despite their cost advantages and the authority that standards-setters' consensus confers them, may find unexpectedly scant support among some groups affected by a dominant design (e.g., consumers, foreign manufacturers) but who have little or no

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Research in Organizational Behavior 14 [1992]: 311-347), among others. For a good account of how the supporters of a dominant design (i.e., the aircraft piston engine) stick to its cost advantages against a promising but less known technology, see Edward W. Constant, Origins of the Turbojet Revolution (Baltimore: Johns Hopkins Press, 1980), pp. 117-150.

interest in becoming part of the deliberations.

A dominant product design and the cost minimization strategies that sustain and stabilize it emerge, I argue, as a consequence of an extended and systemlike gathering of specialized knowledge and problem-solving practices. These practices include, as Abernathy and other students of technology have shown, a wide range of domains, such as management, design, production engineering, maintenance, and marketing, all with a common preference for predictability, planning, coordination, and risk minimization approaches. Managers at established firms' often assume, for instance, that by supporting a dominant design they can take advantage not only of their employees' growing knowledge of the product, but also of the scale economies provided by the uniform and highly integrated methods and processes used in the manufacture of the product or system and its components, their assembly, and marketing of output. As pointed out by Abernathy, "the product is defined by the process rather than the process by the product... Change is costly because in such integrated system product and process innovations become linked so that an alteration in any single feature has ramifications in many others." 24/

24.- Abernathy, Productivity, p. 69. See, in addition to the

The social agents that commit themselves to the cost reduction assumptions of a dominant product design are likely to develop similar incremental approaches and resist sudden changes to which they may find difficult to adapt. These approaches include, I argue, at least three distinctive though somewhat overlapping and highly complementary forms of interfirm knowledge exchanges and cooperation. First of all, corporate managers, engineers and other specialists working in differing firms of the same or similar industries often engage, as a growing body of empirical research shows, in informal pairwise forms of technical information trading. Anne Carter, in particular, has termed this kind of trading a form of atomistic cooperation and emphasized its benefits for all concerned, including individual traders, their employers, and final users. As she puts it:

> (A)tomistic cooperation between pairs may improve the profitability of participants temporarily but, as in the case of an industrywide collaborative

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authors mentioned in the previous note, Nathan Rosenberg, Inside the Black Box (New York: Cambridge University Press, 1982), pp. 120-140; Devendra Sahal, "Technological guideposts and innovation avenues," Research Policy 14 (1985): 61-82; and Rebecca M. Henderson and Kim B. Clark, "Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms," Administration Science Quarterly 35 (1990): 9-30. For an interesting discussion of how individual firms' problem solving becomes routinized as negotiated outcomes within their own corporate cultures, see Nelson and Winter, Evolutionary theory of economic change, pp. 107-112.

> research agreement, participants may be forced by competition to pass on their savings to consumers. On the other hand, a trader cannot unilaterally improve its position by refusing to trade. His abstinence does not control the behavior of other trading pairs and hence does not remove the competitive pressure that may come from the improved performance of those who do take advantage of the benefits of information sharing. 25/

Second, interfirm cooperation may also include a diversity of collective initiatives or tacit agreements aimed at reducing an industry's exposure to major economic, legal, or regulatory uncertainties. When these uncertainties become too large for the established firms to handle them on an individual basis, they may conclude that it is informal collective action, rather than individual competitive strategies, which holds the key to a more viable readjustment to a turbulent environment or unfriendly regulatory

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25.- Anne P. Carter, "Knowhow trading as economic exchange," Research Policy 18 (1989), p. 161. See also Eric Von Hippel, "Cooperation between rivals: informal knowhow trading," Research Policy 16 (1987): 291-302; Stephan Schrader, "Informal technology transfer between firms: cooperation through information trading," Research Policy 20 (1991): 153-170. For a good discussion on how professional societies, trade associations and other nonprofit groups facilitate this kind of trading, see David C. King and Jack L. Walker, "The provision of benefits by interest groups in the United States," Journal of Politics 54 (1992): 394-426. A good description of corporate concerns with the release of proprietary information in standards committees is in Thomas J. McNamara, "Company participation in external standards activities," in Standards Management, ed., Robert B. Toth (New York: ANSI, 1990), esp. pp. 253-257.

initiatives. Under these circumstances, collective action, as set out among others by Kenis, is more likely to occur, at least when "an intermediate structure either exists or develops which accommodates communication" among participants. 26/ Given the prevailing legal constraints (e.g., antitrust liability) and uncertain distribution of benefits among participants, interfirm collective action is generally short-

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26.- Patrick Kenis, Social Construction of an Industry (Boulder, Colo.: Westview Press, 1992), pp. 31-32. See also idem., "Preconditions for policy networks: some findings from a three-country study on industrial restructuring," in Policy Networks, ed., Bernd Marin and Renate Mayntz (Boulder, Colo.: Westview Press, 1991), pp. 297-330. European interfirm cooperation, the subject of Kenis's study, does not face the same ideological stigma nor have antitrust laws the severe informational implications typical of the U.S. Probably as a result of this, the role of American trade associations in industry self-regulation and interfirm cooperation is, by contrast, far less well documented. Among the few studies I could trace are, e.g., Louis Galambos, Competition and Cooperation (Baltimore: Johns Hopkins Press, 1966), passim; Theodore A. Smith, "Industrial associations: reflections of an insider," Journal of Voluntary Action Research 1 (1972): 8-12; Ian Maitlan, "Limits of business self-regulation," California Management Review 27 (Spring 1985): 132-147; Michael S. Hunt, "Trade associations and self-regulation: major home appliances," in Regulating the Product, ed., Richard E. Caves and Marc J. Roberts (Cambridge, Mass.: Ballinger Publishing Company, 1975), pp. 39-56; Udo Staber and Howard Aldrich, "Trade association stability and public policy," in Organizational Theory and Public Policy, ed., Richard H. Hall and Robert E. Quinn (Beverly Hills: Sage, 1983), pp. 163-178. For an overview of Canadian trade associations as instruments of interfirm collective action, see William D. Coleman, Business and Politics (Montreal: McGill-Queen's University Press, 1988), esp. pp. 18-77.

lived (though its consequences may last over a longer period) and may range, Kenis argues, from tacit forms of intervention in the market to extended negotiations through one or various intermediate organizations (e.g., trade associations, professional societies, etc.), invoke a wide variety of rhetorical strategies, and redraw, on an ad hoc basis, the boundaries of companies' intervention. It is, accordingly, the amount of resources that participant firms are willing to mobilize, negotiate and commit to these enlarged crisis-management strategies which ultimately defines the scope of their cooperation, its legitimacy, and participants' likely role in the process. These forms of collective action may surge under diverse circumstances and serve many purposes, such as attempts to re-define competition along well defined parameters for end-product safety or quality, forestall government regulations or make them more palatable, or even generally unsuccessful tying tactics aimed at leaving aside major innovators. 27/ The most salient feature of these

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27.- For studies in how interfirm cooperation may focus on ways of reducing marketing and regulatory uncertainties affecting all concerned (including nonparticipant firms) see, e.g., E. Raymond Corey, Development of Markets for New Materials (Boston: Graduate School of Business, Harvard University, 1956), pp. 135-183; Hunt, "Trade associations and self-regulation," pp. 39-56. Interfirm cooperation may also vary from flagrant violations of antitrust laws to mere defensive tactics against rivals protected, for instance, by patent rights. For an interesting case in the farm equipment industry, see,

strategies is, as pointed out by Kenis, the shared perception by participant firms of their industry as both a means and the target of their intervention. 28/

Third, interfirm cooperation may also extend beyond atomistic or short-term approaches and concentrate on how to formalize, via voluntary standards, documented solutions to the recurring problems of a dominant product design. Among the benefits participant firms may expect from the knowledge shared in the deliberations is the extent they can accommodate their own investment and competitive strategies to the collective industrywide design practices sanctioned in the process. Individual companies' appropriation of these benefits depends, accordingly, on the extent each firm can take advantage of this knowledge for a timely and more useful implementation. As in the case of pairwise atomistic cooperation, both individual standards setters and their companies may expect these informational benefits to increase the earlier their access to this knowledge. As in the case of

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e.g., Robert T. Kurdle, "Regulation and self-regulation in the farm machinery industry," in Regulating the Product, ed., Caves and Roberts, pp. 65-67; Robert C Williams, Fordson, Farmall and Poppin' Johnny (Chicago: University of Illinois Press, 1987), pp. 101-107. See also note 14 in Chapter 2.

28.- Kenis, Social Construction, pp. 28-36; idem., "Preconditions for policy networks," pp. 316-325.

interfirm short-term cooperative efforts, the informational benefits from standards setters' agreement depend on, and tend to grow with, the broadest possible implementation. In contrast with these two other, rather informal, forms of cooperation, standards setters' slower search for agreement favors a long-term focus on the recurring and more specific problems of a dominant design. The extent their problem definitions can accommodate the development of a dominant design is therefore essential in their efforts to seek, via voluntary compliance, ways of increasing the utility of the knowledge shared in the development process. 29/

These differing forms of interfirm knowledge exchanges and cooperative support for a dominant design interact in diverse and complex ways. From standards setters' perspective, the impact and likely consequences of the other

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29.- Though essential, standards setters' agreement on problem definitions does not ensure, per se, an increase in the utility of the knowledge shared in the process. Moreover, though firms' close involvement often contributes to developing cost-effective standards, not all of them are invariably so. As pointed out, among others, by Walt Crawford (Technical Standards, 2d ed. rev. [Boston: G. K. Hall & Co., 1991], pp. 79-93) and Joseph Farrell and Garth Saloner ("Coordination through committees and markets," Rand Journal of Economics 19 [1988]: 235-252), some voluntary standards may be defective and therefore difficult or impossible to implement, while others developed without taking into account the commercial interests of the firms that have to comply with them.

two forms of interfirm cooperation tend to vary according to their focus on recurring problems, their level of specificity, their expected impact on the profitability of participant firms, and the extent these problems are definable in sufficiently uniform terms compatible with, and ultimately supportive of, a dominant design. The greater the initial investment outlays or the larger the sunk investment costs, for instance, the more likely is that writing the first draft standard, revising an existing standard, or re-defining the scope and conditions of its implementation includes some kind of high-level interfirm contacts and consultations, tacit forms of intervention in the market, or even lengthy negotiations with third parties about specific issues, generally developed on an ad hoc basis. Conversely, as pointed out by Cheit, the less expensive the proposed changes in a dominant design, the more likely is that decisions (including problem definitions and draft proposals) are deferred to standards setters' professional judgment. 30/ In the latter

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30.- Ross E. Cheit, Setting Safety Standards (Berkeley: University of California Press, 1990), pp. 149-163. The importance of high-level interfirm contacts increases the higher the stakes in product development as frequently occurs, for instance, in the area of compatibility and interchangeability standards. For a good account of how these standards become part of the product development process, see Mostafa H. Sherif and Duncan K. Sparrell, "Standards and innovation in telecommunications," IEEE Communications Magazine 30 (July 1992): 22-28. For a detailed case study that illustrates the hectic and

case the whole development process may overlap and partly coincide with the atomistic pairwise forms of information trading and cooperation described above.

For all the promise of long-term benefits for all parties that have a stake in a dominant design, some of them may regard standards setters' deliberations as too far removed from their most pressing concerns. These groups, such as consumers, regulators foreign manufacturers, etc., may consider the issues as too esoteric and/or specialized, or feel that their own status as foreigners leaves them without legitimate grounds on which take part in the deliberations. Over time, however, these groups may reassess the value of the knowledge and information standards-setters use in their agreements, and strive to include this or similar knowledge under alternative and often conflicting problem definitions. What follows is an account of how standards setters' definitions of tractor safety in the farm equipment industry interacted with other groups' problem definitions, and the ways this interaction shaped manufacturers' collective design decisions, with an even greater level of uniformity than that envisaged by any of these interacting groups.

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unpredictable nature of these contacts, see Marvin A. Sirbu and Laurence E. Zwimpfer, "Standards setting for computer communication: the case of X.25," IEEE Communications Magazine 23 (March 1985), esp. pp. 38-40.

CHAPTER 4
DEFINING THE PROBLEM

The problem of overturning tractors causing serious injury or death of their operators had been a recurring topic of discussion among American tractor makers' engineers since the 1920's. Their definition of this problem and their contribution to the search for a solution compatible with the dominant tractor design underwent drastic changes in the early 1960's. A small group of tractor makers' senior engineers felt it necessary, in the midst of government agencies' growing safety activism in the area of tractor design, to mobilize all the resources at their disposal to promote their own version of rollover protection for farm tractor operators. The aim of these efforts was to formalize an industry- wide approach which, they expected, could not only spare their companies from disparate and costly forms of intervention in the farm tractor market, but also minimize interference with other features of the dominant tractor design. This chapter examines the shifting commitments of tractor makers' engineers to overturn protection, and how the implementation of their proposed design changes came to depend on the extent they could make these changes compatible with the tractor dominant design.

Until the late 1950's, there was wide agreement among

farm equipment engineers and agricultural extension specialists that the problem of tractor tipovers was a behavioral problem. The origin of this problem resided, most of them agreed, in tractor operators' lack of judgment or experience as these often drove their machines carelessly, without taking into account their limitations as inherently unstable artifacts. This instability was, from the farm equipment engineers' viewpoint, an unfortunate but inevitable result of their own search for greater tractive efficiency and the need to heighten tractor's center of gravity in order to provide sufficient clearance for its passage through farm crop rows. Repeated studies showing, for instance, tractors' remarkable propensity "to rise in front" had related this phenomenon to designers' decision to base the tractive force of the machine on two large wheels at the rear. This arrangement seemed fully justified on the grounds of economy and performance, even as it left tractor operators exposed to situations in which this tractive force, if unable to move the machine forward, could suddenly tip it backwards. In addition to this risk, tractor lateral instability was also an inevitable consequence, according to these studies, of the need for an adequate level of clearance for farm cultivation tasks. 1/

1.- A Farm Equipment Institute survey on tractor accidents

The prevailing approach among both tractor makers' engineers and extension specialists underlined the practical difficulty in designing an efficient, mass-produced machine and, at the same time, making it accident proof. Farmers' rejection of alternative designs, which could increase the cost of farming, seemed to corroborate engineers' cost minimization approach as tractor sales crucially depended on customer acceptance. Farmers' acceptance of tractor dominant design was, accordingly, a clear indication of their recognition that a high recurrence of overturn accidents was

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described, for instance, a total of 152 overturn accidents as related to circumstances such as running over steep banks, driving on steep hillsides, taking too short turns, excessive speed, or having the wheels locked or stuck in mud, namely as a result of operator's error. Not even a single accident was seemingly related to faulty design. See "Farm machine and tractor accidents, 1937-1945," FEI (Chicago, August 1945), cited in John B. Sevart and D. E. Berry, "Tractor runovers -History and solutions," American Society of Agricultural Engineers (henceforth ASAE), Paper No. MCR-86-106 (St. Joseph, Mich., 1986), p. 3. See also Wayne H. Worthington, "Evaluation of factors affecting the stability of wheel tractors," Agricultural Engineering 30 (1949), pp. 121, 179-183; E. G. Kibben, "Kinematics and dynamics of the wheel type farm tractor," Agricultural Engineering 8 (1927), pp. 119-122; A. H. Hoffman, "Tendency of tractors to rise in front: Causes and remedies," California Agricultural Extension Circular No. 276 (June 1923), pp. 1-3. See also Hans W. Sack, "Longitudinal stability of tractors," Agricultural Engineering 37 (1956), pp. 328-333; E. McCormick, "Some engineering implications of high speed farming," Agricultural Engineering 22 (1941), pp. 165-167; George W. Pakala, "Some of the dynamic characteristics of rearward tractor tipping when improperly hitched," Purdue University Ag. Engineering Dept., Topical Paper (February 1955).

attributable to operator carelessness and unsafe behavior. Farm equipment engineers' assumption was that, once sold in the market, tractors were under farmers' control and it was their responsibility to drive them carefully and avoid situations that could cause their machines to tip over backwards or sideways. The designer duties were, at most, to make sure that the operator remained aware of the risk this arrangement entailed and to reject the use of

> devices that w[ould] give the operator a false sense of security. For example, it is unwise to try to prevent the tractor from overturning by attaching a device that will cut off the ignition at a predetermined tilt angle. It's been proved that the flywheel of the engine will carry the tractor past the safety point after the ignition is cut off. 2/

The only preventive strategy that could reduce the frequency of rollover accidents consisted, according to the prevailing view, in educating farmers and persuading them of changing their behavior. This was the task of a handful of state extension agents, who had organized, since the late 1940s, a host of induced tractor overturns in hundreds of demonstrations in the Midwest and California. The aim of

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2.- Martin Ronnig, "FEI seeks safer farm equipment," SAE Journal 43 (Dec. 1955), p. 104. For an interesting description of farmers' preferences in buying agricultural equipment, see, e.g., Alexander Segall, Farmers' attitudes to farm machinery purchases, Royal Commission on Farm Machinery Study No. 4 (Ottawa, 1969), esp. pp. 17-28.

these demonstrations was to show farmers how easy was to tip over a farm tractor and the consequences of operating it unsafely. The organizers found that they could better impress their audiences and improve "the effectiveness of their demonstration by stuffing a coverall that was strapped to the seat, and placing a glass jug on its head filled with water and catsup. When the tractor overturned the glass jug broke and the dummy was crushed." 3/ Extension specialists' general assumption was that the farmer, once educated, would voluntarily restrain from incurring in unsafe driving practices. 4/

A small group of engineers organized for the first time a technical session to share experiences on an alternative approach in the Winter Meeting of the American Society of

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3.- Arnold B. Skromme, "History of rollover protection for farm tractors," ASAE Paper IAS-86-111 (1986), p. 7. See also James F. Arndt, "Rollover protective structures for farm and construction tractors -A 50-year review," Society of Automotive Engineers (henceforth SAE), Paper No. 71-0508 (Warrendale, Pa., 1971), p. 2.

4.- My description of the prevailing view of safety among American engineers until the early 1960s draws heavily on Michael Guarnieri, "Landmarks in the history of safety," Journal of Safety Research 23 (1992), pp. 151-158. A somewhat less rosy description of some participants' role in the formulation of American engineers' new injury reduction strategies is in Joel W. Eastman, "'Doctors orders:' The American medical profession and the origins of automobile design for crash protection," Bulletin of the History of Medicine 55 (1981), pp. 401-424.

Agricultural Engineers (ASAE) in Chicago in December 1962. Each of the three papers read in the session provided a differing design version of two-post frames which, if properly attached to the top of a tractor, could offer, the authors claimed, a considerable degree of protection to its operator in case of an overturn. The first speaker in the session, an Agricultural Engineering professor at Michigan State University, stated that the annual death toll in tractor accidents had climbed over the years to "approximately 1200 farmers [with] many more thousands... injured." 5/ He urged tractor manufacturers to define the overturn protection problem in ways compatible with farmers' willingness to buy practical and inexpensive devices and depicted his design as a utility-roll bar, with a threefold aim. This consisted in providing sun shade, a convenient means of lifting and carrying goods at the rear of the tractor and, according to rollover tests carried out by the speaker, a satisfactory degree of operator protection, at least in case of sideways overturns. Tractor makers could, as a result, regard the utility-roll bar as an effective means of overcoming farmers' reluctance to buy something in which they saw little practical value. In addition to these advantages,

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5.- Wesley F. Buchele, "The utility roll bar," ASAE Paper No. 62-632 (1962), p. 1.

> (t)ests indicated that... the utility-roll bar didn't interfere with the operation of the tractor or mounted implements. In case of plowing, the roll bar had to be tilted to the left to level the plow for the first round when opening a new land. 6/

The second speaker described his and his colleagues' efforts at the University of California, Davis, aimed at establishing minimum design requirements for operator protection by means of "a simple, inexpensive design." 7/ The speaker started by lamenting the "lack of accident awareness by U.S. engineers, [their failure] to provide the farmer with a tractor designed to minimize human injury [and] callous indifference to the hundreds of annual deaths [related] to inadequate design." 8/ He traced the overturn frame project at Davis to California insurance companies' interest "in reducing the number of [tractor] fatalities." 9/ He went into further detail in depicting the field tests carried out at Davis in 1956 and how they measured and calculated the impact velocity and energy absorbed by the protective frame when striking the soil. Their tests also included, he told the

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6.- Ibid., p. 4.

7.- Lloyd H. Lamouria, Coby Lorenzen, and Ralph Parks, "Design criteria for a driver-safe tractor frame," Transactions of ASAE 7 (1964), p. 418 (read in the ASAE Winter Meeting of 1962 as Paper No. 62-633).

8.- Ibid. (emphasis in the original).
9.- Ibid.

small audience, "(a) 170-lb-dummy driver... fastened into the bucket-type seat with an aircraft-type seat belt." 10/ Besides the high energy levels the frame pipe could successfully withstand, the data from the tipping tests indicated an exceedingly short time involved in a tractor overturn (from 1.5 to 2.6 seconds), which, he claimed, put beyond question the advantage of seat belt restraints against giving the operator the remote possibility of jumping clear. "The authors urgently recommend," he concluded, "that every manufacturer's design include at least the minimum protection of a safety belt and roll bar similar to those used in sports cars." 11/

The third speaker, Warren I. Hanson, a North Dakota Highway Department safety engineer, described the design and implementation of a shop-built tractor frame program for the state 190-tractor fleet of mowers used in highway maintenance. Hanson, probably the only non-member of ASAE present in the session, emphasized the encouraging results of the program, with "no material failure of any of these installations" and "only two 'lost time' injuries, resulting from tractor tip-overs." 12/ The four-feet-wide two-post frames were, in his

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10.- Ibid., p. 419.
11.- Ibid.
12.- Hanson, "Anti-roll bars of wheel tractors and mowers: The

view, more properly defined as anti-roll bars, namely as "an attachment installed on a wheeled tractor in order to prevent the machine from turning completely over in case the machine should upset." 13/ This single design objective did not preclude, however, a diversity of design approaches. As he put it:

> The North Dakota Highway Department did not decide on any particular type of bar as there were many makes of wheeled tractors, instead each of our seven Highway Districts was instructed to use materials available and to come up with their own design. As was expected, we ended up with seven types of installations constructed from pipe, angle iron and even I-Beam material. 14/

The fourth and last speaker, a senior engineer from Oliver Corporation, a major tractor maker, made a two-page commentary on the three papers. He pointed out, with deep skepticism, that prospective purchasers could see the tractor roll bars as providing too remote benefits to buy them, to fasten the seat belts if installed, or not to remove the frames should these interfere with the use of some implement. Individual farmers' behavior, he added, could vastly differ from that typical of "specialized operations such as highway mowing with equipment owned and controlled by a highway

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North Dakota picture," ASAE Paper No. 62-658 (1962), pp. 2-3.

13.- Ibid. See also "'Anti-roll bars' on tractors save lives," Journal of the ASSE 7 (May 1962), p. 7.

department." 15/ He also referred briefly to a new law "passed in Sweden whereby all new tractors delivered after July 1, 1959 shall be equipped with a safety cab or roll over bar." 16/ His company, he claimed, was introducing "a new line of tractors... designed with roll bars as a primary consideration with regard to operator's area. In other words, the door was left open for all possible approaches that we could anticipate." 17/

A few months later, in June 1963, a safety engineer from Deere & Company, reported that the use of protective canopies, cabs and frames was becoming more frequent not only in distant countries like Sweden, but also in the logging districts of California, Oregon, and Washington. In the logging industry, he pointed out, "there are legal requirements for a protective canopy over the top of the tractor and over the driver. Its purpose is twofold: to prevent falling branches or trees from striking the operator, and to protect him in case of an overturn." 18/ He briefly referred to the Tractor Roll Bar

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14.- Hanson, "Anti-roll bars," p. 2.
15.- Thomas H. Morrell, "Prepared discussion for ASAE Meeting, December 13 -Symposium Tractor Roll Bars," in ASAE Paper No. 62-658 (1962), p. 1.
16.- Ibid.
17.- Ibid., p. 2.
18.- Carlton L. Zink, "Anti-roll bars. Can they reduce tractor fatalities?" Agricultural Engineering 42 (1963), p. 308.

session in the ASAE Meeting in Chicago and stated that despite some disadvantages in the use of these frames, as discussed in the session, all tractor makers could and should afford to provide some protection. This protection should follow, in his view, the anti-roll bar design concept proposed by Warren Hanson, rather than assuming "the indefinite rolling common to racing or sports cars." He went so far as to suggest that "(t)he time [wa]s ripe for a combined ASAE and industry action to study the adaptation of anti-roll bars and/or cabs to present and future tractor design." 19/

These comments left other tractor manufacturers wondering about Deere engineers' next move in the area of overturn protection. Three years earlier Deere had taken the whole industry by surprise when it replaced its forty-year-old small engine line of tractors as its engineers staged a major assault upon the American average tractor market. A farm tractor magazine had featured the event in which Deere exhibited its new line of four and six-cylinder tractors to its own dealers and to the public as

> truly an introduction only. It was a premiere, an unveiling, of the best kept industrial secret the business.
> The new tractors... are a radical departure; a new

19.- Ibid.

> design conceived and executed as an integral unit by a corps of designers and engineers who had $ 50 million, six years and a clean drawing board. 20/

The extensive durability and performance tests that preceded the new line of tractors had provided Deere engineers at the Tractor Engineering Center in Waterloo, Iowa, with first-hand knowledge about the hazards of driving farm tractors. Among these hazards, as they had found in earlier research in the 1950s, was the bucket-type seat, which they regarded as "physiologically unsound," since it contributed "to muscular fatigue and body cramps." 21/ Given the long hours of tractor use in the peak farming season, operator weariness and lack of comfort, they reasoned, could ultimately lead to situations likely to result in an accident. They soon realized, however, that their decision to furnish Deere test tractors with a new deluxe seat design, if desirable from the operator standpoint, was largely ineffective in preventing overturn accidents. These accidents, which included a few

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20.- George H. Seferovich, "Deere's engineered new line of tractors," Implement & Tractor 75 (17 Sept. 1960), p. 67 (emphasis in the original). See also George W. Wormley, "Brand new line of tractors," Farm Journal (Oct. 1960), p. 44; Merlin Hansen, "Engineering a new line of tractors," Agricultural Engineering 42 (1961), pp. 602-605.

21.- Charles S. Morrison and Roy E. Harrington, "Tractor seating for operator comfort," Agricultural Engineering 43 (1962), esp. pp. 633 and 635. See also Seferovich, "Deere's new line of tractors," p. 69.

fatalities affecting personnel at all levels in the company, prompted a small group of Deere engineers, notably those involved in the new seat project, to design and test a protective roll bar prototype with seat belts in 1959. Senior engineers at the Tractor Engineering Center praised the effort, but regarded the project as too risky to include it in its new line of tractors and decided to postpone its implementation for a future occasion. 22/

In the early summer of 1963, after a three-year round of checks for tractor breakdowns and other customer complaints, Deere engineers felt confident enough to initiate the commercial development of antiroll bars. Their commitment to the project was based on the assumption that, under the appropriate circumstances, a sufficient number of prospective buyers could choose overturn protection devices for their

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22.- Skromme, "History of rollover protection," p. 16. See also "ROPS is dedicated as ASAE historic landmark," Within ASAE (Dec. 1986), p. 3. The proponents of the tractor frame project were aware both of the Swedish testing experience of the 1950s and the frame tested in 1956 by the group of agricultural engineers at the University of California, Davis. Moreover, Deere engineers' views on tractor safety evolved probably under the influence and in close working relationship with Henry Dreyfuss, an industrial design consultant and early critic of the safety record of the American automobile industry. See, e.g., Dreyfuss, "The car Detroit should be building," Consumer Reports 23 (July 1958), pp. 351-355; Joel W. Eastman, Styling vs. safety (Boston: University Press of America, 1984), pp. 148-176.

tractors. Deere engineers believed that they could modify their customers' buying behavior by means of comfort features such as protective canopies, even as their buyers regarded their ultimate safety benefits as unimportant. As Merlin Hansen, chief engineer at Deere Tractor Engineering Center, put it:

> We at John Deere have reached the conclusion that there is a need for incentives in addition to personal safety to encourage the voluntary use of roll-over protective devices. Combining other desired features with roll-over protection provides one method for making the overall package more attractive to potential purchasers. 23/

Deere engineers regarded this combination of features as a design and engineering problem requiring a cost-effective method of evaluating the protection afforded by these frames. A promising route towards the development of this method, they concluded after a preliminary study, was the tractor frame testing program at the National Testing Institute for Agricultural Machinery (NTIAM), in Uppsala, Sweden. The program, organized in the mid-1950s in close coordination with the Swedish Workers' Protection Board, had developed a full-scale laboratory testing approach to evaluate the strength of tractor frames and cabs. NTIAM test procedure included two

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23.- Hansen, "Roll Gards for Tractors," SAE Paper No. 66-0583 (1966), p. 4.

successive two-ton steel pendulum blows, one from one side and another softer blow from the rear of the frame, while the tractor remained firmly anchored onto the testing station floor. The test procedure involved a systematic way of relating

> the experience and conclusions arrived at in the overturning tests with pendulum impact tests. By means of theoretical calculations and, above all, comparative impact tests on trial frames identical with those used in the overturning tests it was possible to ascertain the line of impact and the level of energy required to match the stresses occurring during the... overturning tests. 24/

In addition to the pendulum blows, NTIAM testing officers had considered imperative to include a subsequent vertical loading test. This requirement, they thought, was needed to ensure that the deformed cab would not collapse in case of a multiple rollover. As a NTIAM engineer put it:

> As there is always the possibility of the tractor rolling onto and around the cab roof or ending up resting on it during an accident, it was considered a necessity to add a compression test in which a static load is applied vertically to the top of the cab in such a manner that the crushing force is distributed among all the supporting members so as

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24.- Harold A. Moberg, Tractor Safety Cabs. Test methods and experiences during ordinary farm work in Sweden (Uppsala, Sweden: NTIAM, 1964), pp. 6-8. See also idem, "Dynamic testing of tractor protection cabs -Development of method, practical experiences," SAE Paper No. 73-0761 (1973), esp. pp. 1-5; J. Sigfrid Bjerninger, "Swedish safety frame saves lives," Hoard's Dairyman 110 (1965), pp. 782-783.

> to simulate a likely real-accident situation. The static load was set to be equal to twice the weight of the tractor in order to ensure a fully adequate safety margin. 25/

While Deere engineers saw important merits in the use of the NTIAM testing approach, they regarded it as unsatisfactory on at least two counts. First, it was "based on assumptions which can result in a stronger and consequently heavier and more expensive structure than is necessary;" secondly, the procedure failed to "give any information as to what can or does happen to an operator during an actual vehicle upset." 26/ These shortcomings, from Deere engineers' viewpoint, made gaining customer acceptance impossible or at best unlikely, and any failure to provide adequate protection to an operator a likely source of litigation against their company. Moreover, by contrast with Swedish small farms and inclement weather, American farmers were continuously looking for more powerful and heavier tractors to which they could attach a wide variety of rear and front-mounted implements, rather than the use of all-weather cabs in possible need of improvement. As a result, Deere engineers felt that the very commercial

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25.- Moberg, Tractor Safety Cabs, p. 12.

26.- Hansen, "Roll Gards," pp. 6-7. See also David Bucher, "Design and evaluation of a protective canopy for agricultural tractors," ASAE Paper No. 66-625 (1966), pp. 9-11.

success of their overturn protection project depended on "a more efficient use of material" and the extent the designer could "minimiz[e] interference with implement attaching points on the tractor." 27/ Deere engineers concluded, in sum, that before they could consider any further use of the NTIAM testing experience they had first to re-examine it in the light of actual rollover tests.

The following two years the team in charge of Deere anti-roll bar project designed and built an arch-like frame prototype for one of their larger tractor models and submitted it to an extended series of rollover tests. As these proceeded, the team members introduced a number of design changes, such as the strengthening of both the rear axle housing and the frame attaching points at the axle. The tests also included an anthropomorphic manikin on the operator seat, which they considered crucial to measure and determine acceptable frame deformation. The team's aim was to evaluate the frame according to the presumptive level of injury inflicted upon the manikin during the upset, and to examine the protection afforded after successive design changes. As a signal of support for the ongoing testing program, Deere

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27.- Interview with David Bucher; Bucher, "Design of canopy," p. 2.

senior engineers led by Merlin Hansen ordered the installation of anti-roll bars first in all test tractors in Waterloo and later in various company facilities in other locations. The anti-roll bar project evolved as another chapter in Deere's proven record of industrial secrecy, even as it attracted the attention of other engineers at the Tractor Engineering Center. Some thirty years later, one of them recalled the testing program in the following way:

> I was not directly involved, but I was there and I could see what they were doing. There were movies and you could see the rollovers....
> [These took place] as somebody was driving the tractor from a pickup and then induced the overturn on a slope, first by driving it towards the slope and then turning it as if willing to get out....
> It was highly empirical, a trial and error process. We couldn't take any chance; we had to be sure that these frames wouldn't fail.... 28/

A member of the anti-roll bar team claimed, by contrast, that theirs

> was the first design [in the U.S.] in which steel was expected to bend (or deflect) in order to absorb energy of the roll. Up until that time, the formulas for steel designs were for rigid structures that retained their shape. 29/
> This idea was first developed by the Swedish, but we explored it further. 30/

28.- Interview with Wendell Van Syoc. See also Skromme, "History of rollover protection," p. 17.

29.- "ROPS dedicated as ASAE landmark," (statement of David Bucher), p. 3.

30.- Interview with David Bucher.

Deere engineers' acceptance of energy absorption criteria was based on their belief that taking advantage of designs that could bend, but not collapse, in an actual rollover was the best approach to make the frames available at a lower cost. This approach was deemed fully compatible with "portions of the NTIAM test procedure," in particular the pendulum test method, which they increasingly put into use "when it was not practical to damage an experimental vehicle in an actual rollover." 31/ Deere engineers' confidence in this method increased as they found that it could give "reproducible results for checking the impact strength of a particular design, or for determining differences in impact strength that result from design changes." 32/ After more than one hundred tipovers they found, for instance, that " (t)he lateral deformation at the top of the roll structure was 1" greater in the actual rollover test than under pendulum test conditions, 4.5 versus 3.5 inches." 33/ Their omission of other portions of the Swedish test code, in particular the static load requirement, suggests, by contrast, that they regarded operator protection in case of multiple rollovers as incompatible with their stated cost reduction aims.

31.- Bucher, "Design of canopy," p. 5.
32.- Hansen, "Roll Gards," p. 6. See also David Bucher, "Protective canopy for farm tractors," Agricultural Engineering 48 (1967), p. 506.
33.- Idem, "Design of canopy," p. 7.

Other tractor manufacturers' engineers, while unaware of Deere testing program, also began to consider the development of some kind of overturn protection for their nonfarm clientele. Many of these companies were long-established farm equipment manufacturers that were diversifying their operations to take advantage of a booming suburban market for light industrial tractors. Companies such as International Harvester, White, Ford, and J. I. Case had found that this market, despite having similar design and engineering problems, was made up of customers with a differing view of product use and performance. Buyers of this equipment, for instance, were looking for specialized applications, rather than versatility, and relied entirely on hired labor to operate it. Tractor manufacturers' engineers realized that at least in some of these applications, such as logging operations and highway maintenance, there was a trend towards an increasing use of protective canopies and anti-roll bars. Diverse government agencies like, for instance, the U.S. Army Corps of Engineers, the U.S. Forest Service, the accident commissions of the states of Oregon and Washington, California Industrial Safety Division, and the highway departments of North Dakota and Illinois, were requiring these devices to protect their own employees, their contractors' employees, or those of companies operating in the Western Coast logging industry. As worrisome as the added costs to the customer was

the growing number of agencies involved and the lack of uniformity in design criteria and performance requirements, each agency with a set of criteria in conflict with the others. 34/

The new focus of tractor manufacturers on the specific problems of the nonfarm market prompted organizational changes in some trade associations to which these companies were affiliated. The Farm Equipment Institute, for instance, ultimately recognized the growing importance of this market for its member companies and in the summer of 1964 changed its name to Farm and Industrial Equipment Institute (FIEI). In early 1965 the FIEI Advisory Engineering Committee decided to reorganize its standards-writing work and split into three sections, an Engineering Section, an International Section,

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34.- The heavy duty canopies built according to U.S. Corps of Engineers requirements sold for $950 apiece. See, e.g., "Tractor canopies -start of a trend?" Western Construction 34 (Feb. 1959), p. 30. See also John R. Prosek, "SAE's role in ROPS criteria and continued development," SAE Paper No. 80-0936 (1980), p. 1; Ernest C. Carlson, "Tractor roll-over protection frames," National Safety News 97 (Mar. 1968), pp. 64-66; George F. Kuhns, "Illinois Highway Dept. study shows that tractor anti-roll bars really work," Implement & Tractor 81 (Aug. 1966), pp. 30, 50; C. Lepitre, "Cabines de protection a chenilles," Bois et Forets des Tropiques 57 (1958), pp. 31-35; David V. MacCollum, "Tractor canopies," Pacific Builder & Engineer 64 (Oct. 1958), pp. 98-99; "Tractor canopies," American Pulpwood Association, Tech. Release No. 65-R-5 (New York, 1965); Arndt, Protective Structures," p. 4.

and a Light Industrial Section. The newly organized Industrial Section appointed a special subcommittee on Industrial Safety to work on the problem of overturn protection and

> to prepare and propose a recommendation for tractor safety frames. To avoid duplication of effort, both agricultural and industrial tractors were covered by the proposal. 35/

In August 1965 the California Division of Industrial Safety introduced major changes in its regulations for the construction industry and decided to include rollover protection among them. The pieces of equipment covered by the new operator protection requirements consisted of about 57 thousand crawler tractors, bulldozers, motor graders, scrapers, and large front-end wheel-type loaders. A Division engineer noted years later that "(m)onths had passed before a good start had been made in establishing approval criteria.

35.- Carlson, "Tractor Roll-over," p. 66. By 1965, an International Harvester spokesman claimed years later, there were already twenty manufacturers with combined sales of $ 800 million a year in light industrial equipment represented in FIEI. See Bill Fogarty, "FIEI in Disney World," Implement & Tractor 89 (21 Nov. 1974), p. 68. For good accounts of FIEI engineering committees' previous work in the area of safety in agricultural equipment, see, e.g., Thomas H. Morrell, "Industry standardization of farm equipment," Standards -A Vital Tool in Engineered Agriculture, FIEI-ASAE Symposium held in Chicago (St. Joseph, Mich.: ASAE, 1965), pp. 19-20; Edwin W. Tanquary, "Standardization of farm equipment," Agricultural Engineering 38 (1957), pp. 606-609; Bill Fogarty, "Conversation with Doug Hewitt," Implement & Tractor 88 (15 July 1973), pp. 17-18.

Preliminary meetings had come with a factor of three times the vehicle weight as perhaps the proper static load for which roll protective devices should be designed." 36/ After much hesitation, California safety officers finally decided to grant approval to the new canopies and frames on a case-by-case basis under the general performance requirement of "roll bars and supportive attachments [being able] to support not less than two times the weight of the prime mover." 37/ The impact of these regulations was considerably greater on manufacturers and users of earthmoving equipment than on the producers of light industrial equipment, but the latter realized that it was the first time in the U.S. that overturn protection was required outside the logging industry.

By early 1966, the FIEI Industrial Safety Subcommittee had already acquainted itself with American experiences on overturn protection, existing regulations, and "reviewed

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36.- Vincent L. White, "Roll over protective structures," ASSE Journal 16 (July 1971), p. 17.

37.- "California decree aims at safer construction equipment," National Safety News 94 (Nov. 1966), p. 50 (emphasis in the original). See also Paul P. Shapiro, "How front-end loader operators become casualties," National Safety News 100 (Sept. 1969), p. 60. For a useful account of the evolution of California safety regulations since the late 1940s, see, e.g., Clifford W. Farmer, "California's development of safety standards for heavy earthmoving equipment," SAE Paper No. 71- 0695 (1971).

Swedish and British test codes to determine their acceptability. It was felt that they were not adaptable... [as] they were limited to four-post design and to small tractors." 38/ The document being developed by British standards setters closely followed the NTIAM test code, but the British had changed the provision of entrusting test station officers with the authority to determine permissible levels of frame deformation, and replaced this provision with a more uniform criterion defined in terms of a zone of clearance. This zone, according to a FIEI Subcommittee member, "dictate[d] the design of a box-like or cab-shape safety frame... [with] a dimensional size sufficient to protect the operator from crushing or striking the ground during a test or an actual upset, and provide[d] that no structural member w[ould] deform into the zone." 39/ British standards setters regarded the clearance zone as a solution to the problem of how "to standardise and define precisely the method to be used. This is a 'must' if this method is to be adopted as a National or International standard and so be usable by widely differing types of testing personnel." 40/

38.- Arndt, "Protective structures," p. 5
39.- Carlson, "Tractor Roll-over," p. 67.

40.- T. C. D. Manby, "Safety aspects of tractor cabs and their testing, Journal and Proceedings of the Institution of Agricultural Engineers 20 (Feb. 1964), p. 56. For a good description of the differing assumptions of the British

The British approach, if superior to the NTIAM test code, was still unacceptable for FIEI member companies, as it required a four-post safety frame that infringed on tractor attachment points for implements widely used in American farms, among them front-mounted cultivators and corn and cotton pickers.

Deere engineers, meanwhile, were reassessing the prospects of their secrecy and go-alone strategy in the light of an increasingly unfriendly regulatory environment. Their dilemma was that a low profile participation in FIEI and ASAE standards committees, while seemingly appropriate to protect their investment vis-a-vis other competitors, also precluded their contribution to industrywide efforts aimed at forestalling government regulations. Moreover, Deere engineers' efforts either as a single company or as committee members seemed fruitless and increasingly risky as long as other companies' engineers remained divided along "a multiplicity of strong opinions based on local conditions," and could only coincide in rejecting "(w)ork done elsewhere... [since] no proposal seemed completely acceptable." 41/

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and Swedish approaches to rollover protection testing, see, e.g., E. M. Watson, Structural Testing of Tractor Safety Frames, New Zealand Agricultural Engineering Institute, Research Publication R/1 (Canterbury, New Zealand, 1967), pp. 3-6, 21- 22.

41.- Carlson, "Tractor Roll-over," p. 66. As part of Deere

Contributing to this quandary was the problem that "(i)t seemed neither possible nor desirable to develop a single test procedure and performance-requirement document to cover all the many different models, types and sizes operating in all climatic conditions." 42/ To Deere engineers' dismay, tractor makers' own disagreement was leaving the industry exposed to regulatory agencies' preference for simpler, but still costly and confusingly diverse, static load requirements as a way of solving the problem. Unless Deere engineers acted without delay and shared their knowledge with other manufacturers' engineers, the adoption of a uniform industrywide energy absorption approach seemed increasingly unlikely.

In March 1966 the FIEI Safety Subcommittee convened a closed-door meeting in Park Ridge, near Chicago, to exchange experiences with farm equipment manufacturers' engineers and seek their support in the formulation of a common approach.

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low-profile promotional efforts, Robert H. Tweedy, Tractor Engineering Center senior engineer and ASAE Tractor Committee chairman, had appointed in early 1965 a special Roll-Over Protection Subcommittee "(t)o develop a bibliography of related material..., compile material provided by the National Safety Council [and] obtain data from research being carried on by manufacturers." Page Bellinger, "Progress Report," Agricultural Engineering 46 (1965), p. 518.

42.- David L. Stevenson, "Operator protection," National Safety News 99 (April 1969), p. 73.

The session was crowded as nearly forty engineers from various tractor manufacturers, cab makers and other producers of agricultural equipment were in attendance. The first two speakers were Warren Hanson, safety coordinator of North Dakota Highway Department, and George Kuhns, safety supervisor of Illinois Division of Highways. Both of them reported a steady record of success in the use of anti-roll bar equipped tractors in highway maintenance work. Before reading his paper, Merlin Hansen, the third and last speaker, ran "(a) Deere movie of the Roll-Over Bar saving the life of a dummy tractor operator...." 43/ Then he provided some figures that, in his view, justified the treatment of injuries and fatalities from rollovers as an industrywide design problem. These figures were included in five separate tables that ranged from a ten-year record of accidents and fatalities in U.S. farms to more detailed estimates of fatal tractor accidents in Wisconsin by type, based on newspaper clippings and other information gathered by the University of Wisconsin

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43.- Arnold B. Skromme, "Growth of ASAE and the farm equipment industry," Agricultural Engineering 51 (1970), p. 183. See also Kuhns, "Illinois Highway study," pp. 30, 50; Arndt, "Protective structures," p. 4; B. T. Stephanson, "Tractor operator roll-over protection," Canadian Agricultural Engineering 10 (May 1968), p. 26. For a brief description of the state of the art in the design of shop-built anti-roll bars in the mid-1960s, see, e.g., E. D. Suino, "Tractor operation and anti-roll bars," National Safety News 94 (Sept. 1966), pp. 50d-51.

Extension Service. He pointed out that these figures consistently revealed that tractor accidents "account[ed] for about half of the total off-highway farm accidents, and [that] over half of the fatal accidents involving tractors [we]re associated with tractor upsets." 44/

Merlin Hansen proceeded with a brief

> presentation on the history of overturn protection in Sweden and what Deere & Company was doing. He pointed out that they did have a roll bar available. Someone in the crowd asked the question of cost. Merlin's reply was a question. 'Are you thinking of one or a carload?' This caught the group by surprise.... Deere did not have overturn protection available on all [tractor] models, [but] they were moving toward that end. 45/

In Hansen's view, the new regulatory trends in the U.S. made imperative for manufacturers to seek an alternative to standards patterned along the Swedish and British approaches, which were incompatible with American farmers' frequent use of front-mounted implements. Further, he told the audience, the wide differences in operating conditions of U.S. tractors and

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44.- Hansen, "Roll Guards," p. 2.

45.- Rollin D. Schnieder, "An overview of ROPS related accidents, 1965-1990," ASAE Paper No. 90-1640 (1990), p. 2. Cf. Carlon Zink ("Safety accomplishments on agricultural equipment" SAE Paper No. 80-0941 [1980], p. 44) and Skromme ("History of rollover protection," p. 19), both former Deere employees. They provide a slightly differing versions of the meeting.

variations in the likelihood of vehicle upset made unadvisable "to require all owners to bear the expense of roll-over protection." 46/ He concluded with the following remark:

> It is my sincere hope that the combined efforts of tractor manufacturers and tractor users, on a voluntary basis, will result in a substantial reduction in accident and fatality rates with the tractors we manufacture. A secondary important benefit might be that the present trend for legislation at either state or federal levels defining the design and requiring the use of such devices can be avoided. 47/

Other tractor and cab manufacturers' engineers considered that they were not in position to decline or ignore Deere's challenge. The likelihood of federal safety regulations in the automobile industry was increasing by the day, and no one could predict their scope or the types of vehicles included; the day after the FIEI meeting, the Chicago Tribune reported that General Motors "denied participating in any harassment or intimidation" of Ralph Nader, but acknowledged it had conducted a routine investigation "to determine Nader's qualifications in view of his 'extreme criticism' of G.M.'s Corvair car." 48/ The executives of the auto industry had

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46.- Hansen, "Roll Guards," p. 4 (emphasis in the original).

47.- Ibid., p. 7 (emphasis in the original).

48.- Chicago Tribune, 10 March 1966, p. 2

made, as a whole, a poor impression about their concern with traffic safety in Congressional hearings held the previous year, and were facing a backlash from the most liberal Congress in a decade. Even the National Safety Council, a traditional supporter of private voluntary efforts in the area of safety, felt it prudent, when called to testify, to urge the federal government "to establish progressively higher standards for all necessary safety devices on the motor vehicles which it purchases, and thus give leadership to the entire nation." 49/

By the early summer of 1966, FIEI Safety Subcommittee members had already agreed to structure their work in terms of a three-phase schedule. The schedule closely followed Deere's own overturn protection program as it aimed at setting performance requirements first for the simpler and most economical two-post frame design, then for the four-post canopies that provided overhead protection and maximum visibility, and finally for the most complete all-weather cabs. "Those alternatives," according to a FIEI Subcommittee

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49.- Harry N. Rosenfeld, "Wire from Washington," National Safety News 93 (Mar. 1966), p. 66. See also Elizabeth B. Drew, "Politics of auto safety," Atlantic Monthly 218 (Oct. 1966), pp. 95-99; John D. Graham, Auto Safety (Dover, Mass.: Auburn House Publishing Co., 1989), pp. 22-29.

member, "would provide the customer with a choice of protection based on his particular requirements, including the economical aspect, yet consistent with adequate safety requirements." 50/ The subcommittee also discussed the use of a more uniform terminology for the simpler two-post design, and "(t)he early name of anti-roll bar was replaced, as some people thought that the name, anti-roll bar, might connote that the tractor would not overturn." 51/ "Considerable conversation resulted, and the name 'Protective Frame' was adopted." 52/ Its "purpose... [wa]s clearly defined as to minimize the possibility of operator injury resulting from accidental upsets during normal operations." 53/

While the FIEI Safety Subcommittee deliberations proceeded, International Harvester engineers led by David L. Stevenson were developing an hydraulic test method which, they

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50.- Carlson, "Tractor roll-over protection," p. 69. For a description of cab makers' growing interest in Deere's approach to overturn protection, see, e.g., John A. Egging, "Cabs for farm tractors," ASAE Paper No. 66-626 (1966), pp. 2-3.

51.- Schnieder, "Overview of ROPS," p. 3.

52.- David L. Stevenson and William E. Gustin, "Development of a protective frame and cab recommended practice for agricultural and light industrial tractors in the U.S.," ASAE Paper No. 68-110 (1968), p. 5

53.- Ibid., p. 7.

expected, would allow them to promptly introduce their own two-post frame design. International Harvester engineers' confidence on the use of hydraulic jacks had grown after a decade of experiences in accelerating the overall speed of their testing programs intended to ensure that their new tractors could perform satisfactorily in service. By late 1965 International Harvester engineers had a systematic way of measuring the impact loads and stresses they expected these vehicles should withstand, rearranging these loads in faster and more uniform sequences not exceeding actual peak loads, and making use of hydraulic jacks in lieu of traditional torture and durability tests in order to identify design problems and correct them. 54/ They soon realized that the use of hydraulic rigs could provide a fruitful way of administering energy loads over a tractor frame gradually, which decelerated its deformation and allowed for a more detailed evaluation of performance. A slower frame deformation would permit designers to diagnose problems early in the process and determine the energy the frame and its mountings

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54.- David Stevenson and Eugene R. Whitacre, "Accelerated testing of loaders and backhoes," SAE Paper No. 65-0703 (1965), esp. pp. 2-3; Robert P. DeGraff and David L. Stevenson, "Testing and development of garden tractors and implements," ASAE Paper No. 65-649 (1965), pp. 3-9. For an overview of the use of accelerated testing by other manufacturers, see, e.g., Arnold B. Skromme, "Accelerated testing of farm machinery," Agricultural Engineering 41 (1960), pp. 154-157.

could absorb before collapsing. The use of hydraulic jacks in lieu of the pendulum test method required complex calculations performed by means of a computer program. This program, as an International Harvester engineering team recalled a few years later, allowed only for a linear analysis of frame members' displacement while deforming, which made it necessary to regard frame deformation as if a linear process and to utilize

> a piece-wise linearized process with an incremental loading.... Some plastic deformation criteria of a beam cross-section had to be assumed. The incremental loadings were done manually. It was very tedious, nevertheless the results were very helpful in evaluating the behavior of the structure and identifying the necessary changes. 55/

As soon as FIEI Safety Subcommittee members became aware of two alternative test methods, they decided to evaluate and compare them in the light of promoter companies' own data. As a retired engineer from International Harvester put it:

> The opinions of the members were split. The pendulum test was strongly favored by Deere because of the Swedish background work and their opinion that it was a dynamic test that included shock loading similar to that experienced in actual rollovers.
> International Harvester favored the development of a new static test because it would provide more detailed information about the behavior of the [two-

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55.- Rudolph E. Yeh, Yuan Huang, and Edward Johnson, "Analytical procedure for the support of ROPS design," SAE Paper No. 76-0690 (1976), p. 2.

> post] structure during incremental loading throughout the test up to full energy absorption level...
> The committee decided that both lab test procedures should be investigated with correlations to actual rollovers. Deere agreed to do further development field rollover correlations with the pendulum procedure. IH agreed to attempt to develop a new static type of test procedure with field rollover correlations also... Most of other companies were undecided as which way to go, so they attended the frequent committee meetings to monitor the progress of these two major programs and offer suggestions for overcoming difficulties as they arose. 56/

During the late fall of 1966, FIEI engineers learned that a group of European engineers working within the Organization for Economic Cooperation and Development (OECD) had submitted a proposal with new test requirements for tractor safety cabs and frames. The OECD, an international treaty organization, was an outgrowth of earlier efforts by European governments to ensure long-term economic growth by means of closer coordination of economic policy and the promotion of international trade. Among its chief programs, the OECD Scheme for the Testing of Agricultural Tractors was replacing national testing codes for tractor power and performance in Western Europe. FIEI representatives at the OECD working

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56.- Herbert Sullivan to the author, 21 Feb. 1994. For similar, though somewhat less detailed accounts, see, e.g., Carlson, "Tractor Roll-over," pp. 69-70; Stevenson and Gustin, "Development of protective frame," pp. 8-9.

groups had long regarded with suspicion European delegates' search for test provisions that were incompatible with practices and procedures long established in the U.S. The new requirements for safety cabs and frames represented, in the view of FIEI member companies, not only a further step in the OECD Scheme divergent path with respect to U.S. practice, but also the formalization of a safety test procedure that the FIEI Subcommittee already considered unacceptable. The new OECD test provisions were, from FIEI engineers' standpoint, incompatible with "many pieces [of] mounted accessory equipment in the U.S. [since] configuration and space requirements of the implements d[id] not permit the addition of the framework required for an all-weather safety structure." 57/ Among the worst provisions was "a very rigid zone of safety that was not accepted by many foreign countries," and the proposal's failure to "require the use of seat belts," even though "actual roll-over tests by various

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57.- Carlson, "Tractor Roll-over," p. 68. By the mid-1960s, OECD membership included all West European countries plus Canada, Greece, Japan, Portugal, Spain, Switzerland, Turkey, and the US. For useful accounts of the evolution of the OECD Tractor Test Code, see, e.g., T. C. D. Manby and J. Mathews, "Development and operation of OECD Tractor Test Code," SAE Paper No. 73-0762 (1973); Lester F. Larson et al, "Tractor testing worldwide," ASAE Paper No. 67-502 (1967). See also OECD Mechanism for International Coordination in Agriculture (Paris: OECD, 1970), esp. pp. 17-22, 32-33; William E. Splinter et al, "Nebraska Tractor Test -Program and philosophy," SAE Paper No. 73-0763 (1973), pp. 3-4.

manufacturers" in the U.S. had shown seat belts were "necessary with all types of rollover protection devices to prevent or lessen the severity of injury -particularly with the two-post design." 58/

FIEI engineers felt that while the new provisions were probably justified for the European dominant tractor design their inclusion in the OECD Scheme, even on an optional basis, was a likely step towards its development as a worldwide standard. The presence of European farm equipment manufacturers in the International Organization for Standardization (ISO) had grown over the previous decade, and the Subcommittee considered that, unless it could write an alternative document without delay, OECD optional requirements for overturn protection were already in process of becoming the ISO standard. Since the process was, as pointed out by John H. Zich, FIEI Subcommittee chairman, "a lengthy one, requiring substantial amount of time and foreign travel on the

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58.- Stevenson, "Operator protection," p. 76 (emphasis in the original). The countries mentioned by Stevenson were probably Canada and New Zealand. The latter had only accepted OECD safety provisions on an interim basis, while her own groups developed a national standard. For a brief description of the new provisions, see, e.g., Sverker P. E. Persson, "European experiences with operator protection frames and cabs," ASAE Paper 66-624 (St. Joseph, Mich., 1966), p. 10. See also "Test for safety cabs is added to OECD Tractor Code," FATIS 14, No. 2 (1967), pp. 49-51.

part of [ISO] working group members," FIEI late involvement was ill-advised, "for once a proposed standard reache[d] the point of formal distribution to all member countries, there [wa]s often a reluctance to... propose [and accept] amendments that might extend discussion and delay final approval." 59/ Only two large FIEI member companies, Massey-Ferguson and Ford, had a major stake in the American-European farm tractor trade, but FIEI Subcommittee members felt that only a prompt submission of an alternative proposal could spare them from a likely deterioration in the market position of their companies in third countries, particularly in Latin America. 60/

During the spring of 1967 the contest between Deere and International Harvester as promoters of two alternative test

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59.- John Zich, "Importance of worldwide standards," ASAE Paper No. 67-506 (1967), pp. 5-6.

60.- By 1965, only Massey-Ferguson and Ford were seeking full interchangeability for their farm tractors on a world-wide basis, but they were more successful shipping tractors from their European plants to the U.S. than otherwise. See, e.g., John H. Boll and Charles E. McKeon, "New world-wide line of tractors," ASAE Paper 65-104 (St. Joseph, Mich., 1965); Cyril F. Fowler, "Interchanging parts -on a world basis," Implement & Tractor 80 (21 Nov. 1965), pp. 42-44. See also George H. Seferovich, "Tractors: Surge in imports," Implement & Tractor 75 (28 May 1960), pp. 28-30; "The English tractor import question," Implement & Tractor 84 (21 Dec. 1969), pp. 12-13; David Schwartzman, Oligopoly in the farm machinery industry (Ottawa: Royal Commission on Farm Machinery, 1970), pp. 11-16, 115-126; "Foreign trade in farm machinery," Implement & Tractor 80 (21 Nov. 1975), pp. 45-47.

methods intensified as the two rival programs proceeded. Having to show the merits of their new static test method, International Harvester engineers devised new "telemetry systems... to radio impact stresses during an actual roll-over. Receivers recorded the data on tapes that could then be played back in the laboratory for analysis." 61/ Their aim was "to obtain the greatest loads imposed on the protective frame and its mountings." 62/ The use of this equipment was, accordingly, essential to "give the design engineer basic development data and... confidence the protective frame w[ould] adequately withstand the actual roll-over tests." 63/ The final word and also the largest commitment of resources "was [nonetheless] in conducting field rollovers on preproduction tractors which were fantastically expensive to build in a prototype shop." 64/ Deere engineers also ran additional field overturn tests and concluded, by contrast, that NTIAM test data for the pendulum test blows were in need of revision as "energy levels developed during a rear upset

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61.- Carlson, "Tractor Roll-over," p. 69. See also "Planned catastrophe," Implement & Tractor 82 (April 1967), p. 80; "Accelerated testing," Agricultural Engineering 48 (1967), p. 340

62.- Stevenson and Gustin, "Development of protective frame," p. 8.

63.- Ibid.

64.- Herbert Sullivan to the author, 21 Feb. 1994.

were higher than those outlined in the early procedures." 65/ Both "companies... made the data and film available to the committee for their analysis." 66/

In June 1967 the FIEI Engineering Advisory Committee approved the two draft documents written by its Safety Subcommittee and submitted them to ASAE Power and Machinery Standards Committee and to the Tractor Technical Committee of the Society of Automotive Engineers (SAE). Merlin Hansen, then Power and Machinery Committee chairman, featured the first single-page draft document as "a 'systems document,' which list[ed] general considerations..., [while] (t)he second document define[d] detailed testing procedures applicable to the [two-post] protective frame." 67/ The first document was aimed, accordingly, at bringing together, under a general description, the three types of frames and enclosures the FIEI

65.- Carlson, "Tractor Roll-over," p. 69. Norwegian test officers had arrived at a similar conclusion in 1963. See, e.g., Birger Molna, Tractor accidents and factors increasing or decreasing the risks of such accidents, Norwegian Institute of Agricultural Engineering Report No. 8 (Vollebeck, Norway, 1964). See also Moberg, "Dynamic testing," p. 7; Olle Nordstrom, "Safety and comfort test program -Swedish approach," ASAE Paper No. 70-105 (1970), p. 5.

66.- Stevenson and Gustin, "Development of protective frame," p. 8.

67.- From Merlin Hansen to ASAE Power & Machinery Committee, 13 July 1967, ASAE, St. Joseph, Mich.

Subcommittee had considered within the scope of its task; the second document corresponded only to the first of FIEI's three-phase schedule. In the second, more detailed four-page document were specified two out of three definite tests which all two-post frames had to pass. These tests consisted in an induced rollover the tractor-mounted frame had to withstand within specified levels of frame deformation, plus a full-size laboratory test. The latter could either follow a two-blow pendulum test procedure patterned on the NTIAM test code or the new static test procedure developed by International Harvester. Approval criteria for all the three tests rested upon energy absorption assumptions for tractors driven at a maximum speed of 12 miles per hour which overturned into a six-feet embankment. In contrast with the European test procedures, the proposal established a seat belt requirement and a stronger pendulum blow from the rear, similar to the sideways blow, but the document did not mention any zone of clearance, it set a generally greater allowable frame deformation, and no static load over the deformed frame was included. 68/

68.- "Protective frame performance requirements," ASAE Recommendation R306.1, adopted in August 1967, ASAE Yearbook (St. Joseph, Mich., 1968), also published as SAE Recommendation J334, approved in April 1968, SAE Handbook (Warrendale, Pa., 1969); "Specification for the safety requirements and testing of safety cabs and safety frames for agricultural tractors," British Standards

By April 1968, both engineering societies, the SAE and ASAE, had ratified with minor amendments the documents covered in the first phase of the FIEI rollover protection program. The treatment of the FIEI documents differed markedly from one society to the other. There was within ASAE Power & Machinery Committee a small group of well-informed senior engineers that closed ranks behind the proposal. 69/ In the summer of 1967, the committee chairman, Merlin Hansen, sought and obtained the prompt approval of FIEI documents by the Power & Machinery Committee. This approval, he asserted, would "materially aid in the successful introduction of roll over protective devices... being readied for production by all tractor manufacturers in the U.S... [and] substantially strengthen our U.S.A. position in our negotiations with overseas groups

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Institution, BS 4063 (London, 1966). See also "Operator protection for industrial and light industrial tractors," ASAE Recommendation R305.1, adopted in August 1967, ASAE Yearbook (1968), also published as SAE Recommendation J333, approved in April 1968, SAE Handbook (1969).

69.- Among this core of supporters was Edwin W. Tanquary, former ASAE President and Farm Implement coordinator for International Harvester, who, according to one of my interviewees, acted as "a sort of middleman between Deere and International Harvester." Another key supporter was John H. Zich, manager of standards for Ford Tractor Division. For brief profiles of Zich and Tanquary and their role in FIEI and ASAE committees, see "John Deere medal was awarded to Edwin Tanquary," Agricultural Engineering 44 (1963), pp. 383, 389-390; "FIEI award to John Zich," Implement & Tractor 81 (Jan. 1966), p. 82.

during the ISO deliberations." 70/ In August 1967, barely two months after their submission by the FIEI, the Power & Machinery Committee ratified both documents with minor amendments. 71/

In contrast with ASAE speedy approval, SAE Tractor Technical Committee was much slower to agree on the FIEI documents. Most Tractor Committee members, though concerned with European safety activism within the OECD Tractor Scheme, regarded the ASAE-approved documents only as two among at least nine documents dealing with various problems of the farm and nonfarm tractor industry they had under consideration. These documents included the five-page Agricultural Tractor Test Code, two tractor lighting documents, and four documents submitted for approval by its own Tractor Tire Subcommittee. These four documents, each written for tractors of a differing size, purpose and horsepower, reflected the growing diversity of approaches, concerns and priorities the Tractor Committee

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70.- Hansen to Power & Machinery Committee, 13 July 1967. On FIEI subsequent negotiation of ASAE documents with European delegations at ISO meetings, see, e.g., Stevenson, "Operator protection," pp. 75-76. See also "ISO Tractor Implement Committee hold first meeting in the U.S.," Agricultural Engineering 48 (1967), p. 600; Nordstrom, "Safety and comfort," pp. 4-6.

71.- For a brief description of some of these amendments, see, e.g., Russel Hahn, "Progress Report," Agricultural Engineering 49 (1968), p. 41.

had to accommodate. Though the Committee had since 1964 a permanent liaison with ASAE Power & Machinery Committee, several months elapsed after ASAE approval of the FIEI proposal, and this became merely the fourth among the backlog of documents pending for approval in SAE Tractor Committee since the early fall of 1967. 72/

Another factor that probably came to decrease SAE Tractor Committee confidence on the FIEI proposal was paradoxically the approval in November 1967, by a separate SAE committee, of a static testing procedure for protective frames and cabs of self-propelled scrapers. This two-page document, written by SAE Subcommittee 12, or Subcommittee on Vehicle Test Codes, was aimed at "provid[ing] the testing agency with a means of testing for adequacy of a Roll-Over Protective System (ROPS) design." 73/ The Subcommittee choice for a static testing

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72.- The FIEI Subcommittee probably considered important to have a prompt approval by ASAE only. According to earlier experience, once FIEI proposals had the approval of one engineering society, it was most likely a matter of time before the other society would also ratify them and treat the documents as part of their own standards. Moreover, having the endorsement of ASAE was probably enough for FIEI representatives to present both documents as American standards before European delegations in the ISO meetings taking place in mid-1967.

73.- "Minimum performance criteria for roll-over protective system for rubber-tired, self-propelled scrapers," SAE Recommended Practice J320, SAE Handbook (1969), p. 1159.

procedure, while based upon advice from farm equipment engineers, also followed practical and cost minimization criteria. An engineer from Deere Construction Division compared each testing method in the following way:

> [Whereas] several hundred upset tests have been run on smaller tractors..., the cost is considerably greater to upset large construction machines. The cost of dynamically rolling individual machines, which are of large size and complexity, prohibits this method as a standard testing procedure.... The pendulum test also becomes undesirable and dangerous because of the size of the mass and the height from which it has to swing. 74/
> Static tests, on the other hand, are less costly and [seem] just as dependable. 75/

Having agreed in August 1967 on a tight work schedule with California Safety Division engineers, SAE Subcommittee 12 attempted to strike a balance between its members' limited experience with protective frames and canopies and their aim to ensure "reasonable protection... without hampering normal [machine] use with massive structures." 76/ However, the

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74.- Arndt, "Protective structures," p. 6.
75.- Ibid. Interestingly, the very role of SAE Subcommittee 12 in developing the standard created an initial sense of perplexity among a few committee members who, despite having first-hand information from the farm equipment industry, remained uneasy about the costs and feasibility of writing a test procedure for large machines and, according to a Deere engineer, "had difficulty understanding it was a performance standard and not a design standard."
76.- George L. Klose, "Engineering basics for rollover protective structures," SAE Paper No. 69-0569 (1969), p. 2021.

document they submitted for approval to SAE Construction and Industrial Committee was, they soon realized, a defective standard. As a Subcommittee member put it:

> We still did not have any experience with actual roll-over tests of large tractors.... (O)ur first code was based on the absorption of... energy by the ROPS. Criteria were developed by calculation. The [Sub]committee had a deadline and time was up. The code satisfied the deadline, but did not establish realistic requirements.
> The first two or three actual machine rolls disproved [the document]. We found that... ROPS strength was not very well balanced in relation to the attachments to the vehicle frame. The mounting brackets, material and corner braces were very weak links in the system.
> After improvements in this area [and] evaluat[ion] under laboratory conditions..., (w)e found that [the] requirements were not achieved [even] on roll-proven structures. 77/

Having failed to find a satisfactory solution, Subcommittee 12 members realized that they had to rewrite without delay their ROPS document in terms suitable for California Safety regulators. At stake was not only SAE engineers' credibility as experts and problem solvers, but also the growing risk that regulatory agencies could start again developing their own requirements, probably based on static load criteria, as a way of solving the problem. Though at least a small group of middle-rank engineers within the

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77.- Jacob E. Staab, "Development of ROPS criteria for construction and industrial vehicles," SAE Paper 71-0693 (Warrendale, Pa., 1971), p. 2402.

committee remained cautiously committed to the energy absorption approach, this group realized that

> first-hand information from actual roll-overs was required. The most obvious and expedient means of securing this information was to enlist the support and cooperation of manufacturers. This was obtained in the form of machines to be rolled, site preparation, instrumentation, and manpower to conduct roll-over demonstrations witnessed by committee members. 78/

During early 1968, as the machine rolls took place,

> the [Sub]committee better appreciated the magnitude of the assignment. We not only had large and small vehicles of each configuration. We soon realized that what applied to small-wheel loaders did not necessarily apply to large-wheel loaders, and that it probably did not apply to large track-type tractors. 79/

78.- Prosek, "SAE's role in ROPS," p. 2. Among the early advocates of an energy absorption approach within the committee were George Klose and Jacob Staab (Caterpillar), John Prosek and Richard Dethorne (International Harvester), Frederick Main (General Motors Earthmoving Equipment Division), and Raymond Gessel (Westinghouse Air Brake Co.). Their names are in a SAE plaque of recognition as Subcommittee 12 pioneers, engraved in 1988. According to Staab ("Development of ROPS," p. 2404), there were at least eleven earthmoving equipment manufacturers represented in the committee. Most of them were nonetheless slow to commit resources to rollover demonstrations and, by the early summer of 1968, only Caterpillar and International Harvester were active in rolling machines. See, e.g., William P. Macarus, "Design and testing of rollover protective structures in accordance with SAE J395," SAE Paper No. 71-0509 (1971), pp. 1-2. For a brief description of the Construction Industry Manufacturers Association role in initiating the SAE-California Safety Division liaison, see, e.g., H. T. Larmore, "Manufacturers' approach to construction equipment safety," SAE Paper No. 69-0351 (1969), p. 3.

79.- Staab, "Development of ROPS," p. 2404.

> Movies were taken of all experimental rolls, but the best evaluation was on-the-spot observation of the violence and sounds of the impacts during a roll. 80/

With this roll experience, the Subcommittee gained confidence on the potential of a modified energy absorption approach. A roll proven protective structure was, the members of the Subcommittee concluded after comparing laboratory test data with those from machine rolls, one that exhibited "both acceptable energy imparting and energy absorbing behavior." 81/ In other words, they reasoned,

> (w)hen the roll occurs on material which is relatively soft..., a stiff ROPS is desirable as it will penetrate the ground..., [the roll will] place high stresses on the ground and... (l)ow stresses [on the protective structure] leave [it] better able to withstand any subsequent loading..., [but] (w)hen the ground stiffness... is quite high and... [it] is a poor energy absorber the ROPS needs to be a good one. 82/

As the field and laboratory tests proceeded, the Subcommittee also found that even roll proven protective structures frequently failed when the tests took place at low temperatures. These failures occurred, according to metallurgists called in for advice, because there was a sub-

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80.- Ibid., p. 2403. See also Klose, "Engineering basics," pp. 2029-2031.

81.- Klose, "Engineering basics," p. 2023.

zero "temperature at which steel loses its ability to flow plastically in the presence of a sharp crack like defect... At... [this temperature] a brittle cleavage would initiate from this defect when yield point stresses [we]re reached.... Once initiated, the brittle fracture c[ould] propagate easily through regions of the structure... [even if] subjected to low levels of applied stress." 83/ Consequently, as the committee chairman put it:

> It was deemed essential that ROPS structural members be fabricated of material possessing meaningful resistance to brittle fracture.... Obviously some other means than conducting tests at sub-zero temperatures was desirable. Metallurgists were consulted and after considerable study the [American Society for Testing and Materials] Charpy 'V' notch test was agreed upon.... 84/

82.- Ibid., pp. 2022-2023. Staab ("Development of ROPS," p. 2402) concurred in setting out that the Subcommittee had mistakenly "required the ROPS to absorb all the energy of a roll, [but] experience indicated that most parts of the machine and the ground also absorb energy."

83.- Macarus, "Design and testing," p. 1.

84.- Prosek, "SAE's role in ROPS," p. 2. The problem of brittle fracture in large steel structures and its relationship with temperature and alloy content had been the subject of extensive research since World War II. By the mid-1960s, most metallurgical research groups considered that Charpy testers, i.e., small pendulum impact testing devices, were among the most reliable and inexpensive instruments to evaluate and compare the energy absorption behavior of differing steel alloys at low temperatures. In 1968 the American Society for Testing and Materials Committee E24 on Fracture Testing agreed to include a new Charpy V-notch testing procedure in its A-370 standard "Methods and definitions for

The Subcommittee considered that it could save precious time by using the preceding ROPS document as a draft on which to rewrite similar but separate documents, each one setting individual energy absorption requirements for each machine type. This arrangement avoided further deliberations as it ratified the classification of rollover protection requirements according to types of dominant tractor design within the earthmoving industry (e.g., scrapers, crawler tractors, rubber-tired loaders and dozers, and motor graders). The use of common format also permitted the committee to focus on the specific correlations between vehicle weight and energy absorption data for each machine type, thus providing a means of "plotting a curve from the measured data" for each configuration. 85/ Once "the committee established a uniform

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mechanical testing of steel products." For detailed, though somewhat fragmented, accounts of the evolution of research leading to the standardization of this test procedure, see, e.g. Arthur F. Landry, "Charpy calibration program: Its history and importance," in What does the Charpy test really tell us? ed., A. R. Rosenfeld et al (Metals Park, Ohio: American Society for Metals, 1978), pp. 1-10; "Structural failures in welded ships," Welding Journal 32 (1953), pp. 342s-346s; S. L Holt, "Notched-bar testing -Theory and practice," in Symposium on Impact Testing, ASTM Special Technical Publication No. 176 (Philadelphia, 1956), pp. 3-9; J. A. Kies et al, "Historical note on the development of fracture mechanics by G. R. Irwin," in Linear Fracture Mechanics, ed., G. C. Sih, R. P. Wei and F. Erdogan (Bethlehem, Pa., Euro Publishing Co., 1975); pp. 1-27; C. L. Kobrin, "Stepping up the fight against fracture and fatigue," Iron Age 198 (20 Oct. 1966), esp. pp. 133-135.

85.- White, "Roll-Over Protective Structures," p. 18.

format..., [it] assigned ad hoc committees to various vehicle configurations... [and a special ad hoc committee to revise the characteristics of a common] critical zone." 86/ "Since the operator's space d[id] not change with machine size [or configuration], a decision was made to base the static test protected zone on the dimensions of... [an envelope which] provided for some relative movement between parts of the body..., [but that] actually constituted a limit on the allowable deflection...." 87/

In the spring of 1969 the Subcommittee was working in the final drafts of four separate ROPS documents and a single-page critical zone document. The four ROPS documents, while retaining a quite similar layout as that of the preceding SAE document, included a host of major and minor deletions and additions. The most visible changes were in the documents' figures, which presented more detailed if still sketchy drawings of static testing setups for each vehicle configuration and revised graphs showing the dependance of the new energy absorption requirements on machine weight. Other less noticeable changes in the text included the removal of three subsections, one describing the characteristics of the

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86.- Staab, "Development of ROPS," p. 2405.

87.- Prosek, "SAE's role in ROPS," p. 2.

critical zone, and the other two showing the steps for a proper application of test loads and the evaluation of results. Among the additions was a new description of where and how to apply test loads and how to plot them in accordance with the new energy absorption requirements set for each vehicle configuration. Shorter but important additions to the text were a disclaimer on the maximum slope for which overturn protection was ensured (45 deg. for crawler tractors and 30 deg. for scrapers, rubber-tired dozers and loaders, and motor graders), and the citation of both the Subcommittee's own document on ROPS critical zone and the American Society for Testing and Materials document describing the Charpy V-notch test procedure to evaluate the low temperature performance of steel products. 88/

The five documents, submitted for approval in the late spring of 1969, met favorable opinion not only in the SAE Construction and Industrial Committee, but also, once

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88.- "Minimum performance criteria for roll-over protective structure," SAE Recommended Practices J320a, J394, J395, J396 (for scrapers, rubber-tired loaders and dozers, crawler tractors, and motor graders, respectively), and "Critical zone," SAE Recommended Practice J397, all of them approved in July 1969, SAE Handbook (1970), pp. 1152-1160. For an excellent description of SAE Subcommittee 12 static test procedure, see, e.g., Bernard Ross and Michael DiMartino, "Rollover protective structures, their history and development," Professional Safety 27 (May 1982), esp. pp. 20- 21.

released, among California Safety Division engineers. Some tractor and canopy makers' representatives, however, were quick to point out that little had been gained to avoid regulators' rigid design specifications if, after all, the new SAE documents included an even more rigid material specification. Years later, the Subcommittee chairman related this "storm of protest and criticism" to issues such as a scarcity of "(s)uppliers of steel meeting this requirement... and [that] domestic steel producers were reluctant to produce this quality steel unless assured quantity orders, [that] ROPS fabricators were concerned that they would not be able to purchase such steel from their usual sources, [and even] some metallurgists contended that the [Charpy test] results were not truly indicative of final performance..." 89/ Another Subcommittee member felt it necessary to invoke the Subcommittee first-hand knowledge of the subject and to remind the critics that even though

> (s)everal months were required before the committee was able to think in terms of a performance code..., during our work sessions on ROPS... we had a general agreement that our final code should be a Performance Standard -not a Design Standard. 90/

89.- Prosek, "ASAE's role in ROPS," p. 2. For more detailed accounts on the reception of SAE ROPS documents by California Safety officials, see, e.g., Farmer, "California safety standards," pp. 2-3; White, "Rollover Protective Structures," pp. 18-20.

90.- Staab, "Development of ROPS," p. 2400.

The Subcommittee decision to include the material requirement was justified, accordingly, as it was the only practical means of dealing with

> one of the significant differences between small and large structures (8,000 - 120,000 lb). Structures and material that were performing satisfactorily in small vehicles were not totally satisfactory for large vehicles. The ROPS structure of approximately the same dimension was required to absorb 10 times more energy on the large vehicles... This pointed out the importance of... this material requirement....
> Much discussion with various company metallurgy specialists was carried on before this material specification was added to the criteria. Again, the [Sub]committee tried to be consistent with our objective a performance standard -not a design standard. While the material specification can be called a design standard, in the mind of the committee the need for cold temperature performance was necessary. 91/

Meanwhile, by the time SAE Subcommittee 12 was initiating its roll evaluations, the FIEI Safety Subcommittee had already drafted an early version of the document embodying the third phase of its overturn protection program. The emphasis of this single-page document was, according to FIEI Safety Subcommittee chairman David L. Stevenson, on "(f)lexibility... [to] allow the designer and manufacturer to build an enclosure around a two-post design, install an existing cab over the

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91.- Ibid., p. 2407-2408. See also note 84 above.

frame, [or] build the frame as an integral part of the cab." 92/ These differing arrangements had also to accommodate diverse "tractor [safety] requirements [that] var[ied] tremendously throughout the United States. Some users ha[d] narrow tread, extra wide tread, dual rear tires, large high flotation tires, single front wheel, dual tricycle, wide adjustable front wheels, rear tire liquid and cast iron ballast, front end ballast, and many other combination of components." 93/ Despite these differences in tractor weight and configuration, there were, he cautioned, "certain constructional details... important in ensuring that the protective frames and cabs [could] fulfill their primary function." 94/ These details, however, if likely to remain "the same as phase two with the addition of glazing and exit provisions," were not yet available to the public "as the committee ha[d] not completed this [new] phase." 95/

Other Subcommittee members, notably Lawrence Hodges, director of Product Planning & Programming at J.I. Case, were looking for ways of making their low profile participation compatible with an anticipated compliance with the FIEI

92.- Stevenson, "Operator protection," p. 74.
93.- Stevenson and Gustin, "Development of protective frame," p. 10
94.- Ibid., p. 12.
95.- Ibid.

proposal. Having embarked on a secret venture to engineer a factory installed cab for one of the largest models of their new line of farm tractors, Case engineers were attempting to match the constructional details of their new cab design with the provisions of the FIEI documents. Years later, Hodges recalled his personal involvement in the cab project as stemming from a corporate decision taken "in August 1966 [that] transferred ROPS from Research to Product Engineering and authorized the Eng[ineering] Project to develop ROPS frames and cabs for commercial use." 96/ Since Case engineers "didn't want to be behind anybody else," they decided, according to Hodges, "to put a man in an environmental enclosure that could [also] protect him from other factors, such as dust, noise, and the like...." 97/ An anticipated compliance with the standard was nonetheless the most demanding task; it was like "shooting a moving target." 98/

In August 1969 Case introduced a new line of farm tractors that included, for the first time in the U.S., a factory installed cab in which overturn protection was

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96.- Hodges, "ROPS history; personal recollections," (Notes written in 1984, enclosed in correspondence with the author, 11 Feb. 1994). See also Max R. North, "Case 1970 Agri-King tractors," SAE Paper No. 69-0589 (1969), pp. 1-3, 6.
97.- Interview with Lawrence Hodges.
98.- Ibid.

integral with cab design. While Case smaller tractor models included, in common with other major tractor manufacturers, two-post frames as optional pieces of equipment, the new cab design combined comfort features with "the roll protection prompted by good safety practices in preventing injuries from accidental turnover." 99/ As part of Case new line of tractors, the cab installed model "(e)mphasized... new styling, rubber mounted operator's platform, quiet-design cab, nylon fuel tanks and comfort/convenience features." 100/ The new "operator environment..., human engineered for the comfort and convenience of the operator," was important, according to Case engineers, not only to "increase farmer comfort [but also] for more efficient field operations." 101/ The new cab was aimed in sum at making safety concurrent with "the utmost consideration for the driver's comfort and ease of operation." 102/

By the early summer of 1970, both ASAE Power & Machinery Committee and SAE Tractor Committee had agreed to ratify, with a few editorial changes, the four overturn protection

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99.- North, "Agri-King tractors," p. 9.

100.- "From J. I. Case Co.," Implement & Tractor 84 (21 Sept. 1969), p. 15.

101.- North, "Agri-King tractors," p. 9.

102.- Ibid.

documents as revised and submitted by the FIEI. The documents, all of them elevated to the category of standards, defined their scope of application to wheel type tractors "of more than 20 engine horsepower" used either in agricultural tasks or "in operations such as landscaping, construction services, loading, digging, grounds keeping, and highway maintenance." 103/ The protective devices included in the standards were cabs and two-post of four-post frames "for the protection of operators on agricultural and industrial tractors... [that] minimize[d] the possibility of operator injury resulting from accidental upsets... [or, in the case of frames including overhead cover,] overhead hazards during normal operation." 104/ Among the new additions to the documents, obviously under the influence of Subcommittee 12 findings, was the provision that "(m)aterial and design combination used in the structure... [had to] meet all

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103.- "Operator protection for wheel type agricultural and industrial tractors," ASAE Standard S305.2, adopted in August 1967 and last revised in Feb. 1970, Agricultural Engineers Yearbook (1970), p. 243, also published as SAE Standard J333a, approved in April 1968 and revised in July 1970, SAE Handbook (1971), p. 1097. See also Russell Hahn, "Progress Report," Agricultural Engineering 51 (1970), p. 425.

104.- "Protective frame with overhead protection -Test procedures and performance requirements," ASAE Standard S310.1, adopted in June 1968 and revised in Feb. 1970, Agricultural Engineers Yearbook (1970), p. 249, also published as SAE Standard J167, approved in July 1970, SAE Handbook (1971), pp. 1101-1103.

prescribed performance tests at 0 deg. F." 105/ Interestingly, in stark contrast with the two-weight static load requirement prescribed in the document on overhead protection, the document on protective cabs treated these alike the two-post frames and left to the manufacturer's discretion to decide "(w)here... [the] protective enclosures sh[ould] meet the [test] requirements specified in [the] standard... [on] Overhead Protection...." 106/

With the approval of the four standards proposed by the FIEI, most engineers from the farm equipment industry believed that a uniform and reliable solution to the overturn protection problem had been found. With a few exceptions, however, their mood was far from celebratory. The reasons for their uneasiness were varied, but tended to coincide on issues of costs and a growing difficulty in complying with the documents' provisions. Cab makers' engineers, for instance, regarded

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105.- "Protective frame -Test procedures and performance requirements," ASAE Standard S306.2, adopted in August 1967 and last revised in Feb. 1970, Agricultural Engineers Yearbook (1970), p. 248, also published as SAE Standard J334a, approved in April 1968 and revised in July 1970, SAE Handbook (1971), p. 1101.

106.- "Protective enclosures -Test procedures and performance requirements," ASAE Standard S336, adopted in Feb. 1970, Agricultural Engineers Yearbook (1970), p. 251, also published as SAE Standard J168, approved in July 1970, SAE Handbook (1971), p. 1103.

> the costs involved in cab safety tests as outlined in... the ASAE-SAE standards [as prohibitive]. Considering that not only the cab but an expensive tractor could be extensively damaged in the vehicle overturn portion of the test procedure, most of the independent cab makers... fe[lt] that having their cabs tested with the different tractors on which the cabs could be mounted was economically unfeasible. 107/

A growing number of safety specialists and tractor makers' engineers also began to resent their unexpectedly difficult role as promoters of the two-post protective frames whose test provisions they had helped to standardize. As a Deere engineer put it:

> (T)he need for roll protection on farm... tractors has been emphasized by... creating standards, and by getting it installed on tractors. Economics and lack of operator acceptance have made the latter very difficult.
> Various promotional programs have been attempted by leading manufacturers of agricultural tractors. One such program gave half a million dollars worth of roll-over bars to customers. Many companies have used movies made up of upset testing with mannequins to emphasize the benefits f[rom] roll protection and the desirability to have it. [These programs were needed as] (o)ver and over again, the lifesaving capabilities of rollover protection have been demonstrated. 108/

107.- Charles S. Floyd, "Cab makers confer on DOT manifesto," Implement & Tractor 86 (21 June 1971), p. 13.

108.- Arndt, "Protective structures," p. 6. Another former Deere engineer recalled years later that "(a)s Waterloo engineers developed overturn protection, movies were taken of certain phases of their work. These movies were made available through our office in Product Planning for a nominal sum: $30.oo -35.oo, for about 9½ minute

Case engineers, by contrast, regarded the sudden and probably unexpected booming sales of their new cab-equipped tractors as the most encouraging response from the more affluent farm tractor clientele to their human engineering approach. Other agricultural equipment manufacturers began to consider Case commercial success with crush resistant cabs as a tacit invitation for them not only to introduce factory installed cabs of their own, but also to redefine the old cab-implement compatibility problem in terms supportive of the new American dominant tractor design. Further, most manufacturers' engineers regarded the new description of the overturn protection problem as part of a broader trend towards a faster and more powerful dominant tractor design. Engineers' task was, accordingly, "to redesign the tractor-drawn implements to perform efficiently at these higher speeds... (s)o that the man in the cab, out of heat and dust, away from the noise and relieved of the vibration, w[ould]

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movie... (A)ll who wanted to stimulate interest in reducing tractor overturn [fatalities] were logical purchasers, and users. Not all farmers grasped the idea eagerly. Indifference has long kept some from trying new ideas. Cost can be a factor. 'It can't happen to me,' was sometimes heard." Carlton Zink to the author, 13 Feb. 1994, p. 4 (emphasis in the original). See also Skromme, "History of rollover protection," p. 18; Paul Courter, "Unpopular lifesavers: roll bars," Michigan Farmer (6 July 1968), p. 24; Bill Fogarty, "Dealers and the safety selling mission," Implement & Tractor 84 (21 Jan. 1969), pp. 18-21.

also be able to monitor every important phase of agricultural operations from an instrument panel...." 109/ Others were less optimistic and cautioned that only "(w)hen both tractors and implements [we]re designed to permit installation of cabs without the problem of cab-implement interference, the true era of the tractor cab w[ould] have arrived." 110/

109.- Curry W. Stoup, "Farm machinery in the 70s," Automotive Industries 142 (15 June 1970), pp. 51-52. See also Tom Russell, "Selling safety, selling comfort," Implement & Tractor 85 (21 Sept. 1970), pp. 16-17, 20; Charles S. Floyd, "Big tractors in the big states," Implement & Tractor 86 (21 March 1971), pp. 24-26.

110.- Charles S. Floyd, "Making the cab compatible with the system," Implement & Tractor 86 (21 July 1971), p. 18.

CHAPTER 5
LEGALITY v. CONSENSUS

> "A standard must be unequally unfair to all parties...."
> T. Knowles et al, 1987. 1/

The consensus that tractor makers' engineers had built during the development of the first standards on rollover protection for farm tractors in the mid-1960s began to crumble after 1968. Some participants in the standards-setting process, like for instance, extension safety specialists, regulatory agencies' representatives, and cab makers' engineers, began to contest tractor manufacturers' commitment to rollover protection or the expense of the testing procedures established in these standards. Nonparticipant groups with a stake in the dominant product design, such as tractor dealers, manufacturers' marketing departments, tractor users, and even trial lawyers, also started to put in question the definition of overturn protection problem embodied in these documents and depict them as inadequate or difficult to implement. The disparate and conflicting objections of participant and nonparticipant groups ranged from the cost or quality of the proposed solutions to the voluntary status of implementation and the prospective, rather than retroactive, character of these solutions. Even more disruptive was the increasing willingness of some of these groups to resort to the benefits of the legal system, in particular the courts and regulatory

agencies' hearings. 2/ The initial response of tractor makers' engineers to these changes was to seek a solution along the formal and informal consultations and information exchanges on which they had based their earlier agreements. Over time, however, they realized that the credibility and success of their cooperative efforts crucially depended on the extent their companies could reconcile their individual product marketing strategies with a greater industrywide uniformity than that initially intended. This chapter examines the efforts of tractor makers' engineers to meet the challenge of the participant, but dissenting, groups, and how their employers' collective intervention in the tractor market became instrumental in making their design changes compatible with the safety demands of the other, nonparticipant, groups.

In June 1967 the American Society of Agricultural Engineers (ASAE) and the Canadian Society of Agricultural Engineering held a joint meeting in Saaskaton, Canada. The three-day program included three general sessions, 35 technical sessions, 180 technical papers, and more than 800

1.- T. Knowles, J. Larmouth and K. G. Knightson, Standards for OSI (Oxford: BSP Professional Books, 1987), p. 10.

2.- My view of legality as a resource draws heavily on Richard O. Lempert ("Mobilizing private law," Law & Society Review 11 [1976], pp. 173-189). For a somewhat similar perspective, see Marc Galanter, "Why the 'haves' come out ahead: Speculations on the limits of legal change," Law & Society Review 9 (1974), pp. 347ff.

registered participants. The featured speaker at one of the general sessions was a human factors engineering professor at the University of Ontario. He depicted engineers' growing concern with the safety of tractor operators in the following way:

> Man is an essential element in everything which we design and build [including] agricultural machinery. But... engineers became [for too long] far more interested in the physical abilities of their machines than in the interaction with the user.... [Given] his adaptability (h)e can offset deficiencies in the design of machines [and] makes machines work and work well. 3/
>
> But there are limits to what a man can do in adapting to a machine. Then come the problems often logged as 'operator error.' As these accidents... mount, you take a closer look and find that they are really engineering errors.... 4/
>
> Improvement is taking place not, unfortunately, because engineers have realized their basic ethic, but because the products of their skills have become too powerful and fast-acting for man to continue the role of adaptative element. 5/

Many in the audience found merits in the speaker's approach, but disagreed with some of his claims. Some agricultural safety specialists, for instance, coincided with the speaker in depicting the problem of farm tractor accidents

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3.- E. Llewellyn Thomas, "Machine-man interface," Agricultural Engineering 48 (1967), p. 495.
4.- Mark Zimmerman, "Canadian, U.S. Ag Engineers hold Joint Annual Meeting," Implement & Tractor 82 (7 Aug. 1967), p. 16.
5.- Thomas, "Machine-man interface," p. 495.

"as basically one of exposure to an injury agent rather than of carelessness." 6/ Yet they considered, as active participants in ASAE standards committees, that the environment in which farm tractor operators performed their tasks was probably too diverse as for the designer to anticipate every hazard and operator reactions to such hazards. In their view, the relationship between machine design and operator safety was not simple nor automatic

> because of the wide job and environmental diversity associated with farming and the fact that the worker performs in a highly individualized manner. Efforts to describe the job of farming are scarce, and those who have tried are at once amazed at its nonuniformity. 7/
>
> Man and machine... are placed together in an environmental situation (road, field, farmstead, etc.) [in which] (t)he reaction of [the] machine to a changing job situation is not automatic.... The tractor is used not only to perform the customary field operations but also to act as an extra utility vehicle for between farm units, power for all sorts of 'labor saving' equipment, transport power for handling produce to the market, personal carrier, a training device for young tractor drivers, and emergency transportation when road conditions are bad. Such diverse uses of this prime mover are as possible and... impose an almost endless learning

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6.- L. W. Knapp, "Occupational and rural accidents," Archives of Environmental Health 13 (1966), p. 504. See also "A study of 789 farm tractor fatalities," Farm Safety Review (July 1967), pp. 3-6; Kenneth M. Hofmeister and Richard G. Pfister, "Interaction between man and his environment as measured by a study of farm accidents," Transactions of the ASAE 12 (1969), pp. 661-663.

7.- Knapp, "Rural accidents," p. 504.

> problem [even] for the experienced tractor operator.... 8/

Others in the audience would have liked to note that the speaker's words overlooked the role of competitive pressures in designers' decisions. As pointed out by an International Harvester engineer:

> (T)he farmer/customer often makes his final choice from available brands... much as he selects consumer goods.
> Thus, in farm equipment..., designer's efforts to optimize both appearance and function can be especially critical in competitive situations [in which] safety cannot be added as an accessory or... even as a design revision or modification. It must, of necessity, be provided in the original design [with] improvements in the man-machine relationship depend[ing] on the establishment of industry-wide standards. 9/

The featured speaker of the ASAE Summer Meeting of 1968 at Logan, Utah, was Harry M. Philo, a trial lawyer specializing in products liability and former chairman of the Safety Committee of the American Trial Lawyers Association. He defined products liability as "the liability in law to respond in damages of the engineer, the designer, the manufacturer, the retailer, the installer and the maintainer

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8.- Idem, "Man-machine relationship in tractor accidents," Transactions of the ASAE 9 (1966), pp. 178-179.

9.- T. H. Koeber, "Agricultural equipment," Machine Design 39 (June 1967), pp. 189-190.

of a product which causes injury." 10/ In stark contrast with the featured speaker at the previous Summer Meeting, Philo described product safety design as a problem beyond the grasp of engineers as individuals or as a group, a problem that only trial lawyers and juries could ultimately solve. As he told the audience:

> Only by establishing liability do you achieve accident prevention. We have been 30 or 40 years behind the times in the development of liability. And because we have not developed the law, we have not forced industry to spend the kind of money it must to get reasonable safe design.
> But now the law is starting to respond to the needs of society and there is liability for negligent design, that liability has to be part of the cost graph. Now the [company's] board of directors must take a different approach.
> The better companies can compete in the field of accident prevention or safety just as they compete in any other area. The companies that will not do the research and will not develop safe products are going to go out of business because of the large damage claims that they can expect against them. 11/

Besides forcing manufacturers to design safer products, Philo claimed, the growing number and size of jury awards were showing that the technical competency of many engineers and standards setters in accident prevention was inadequate. As he boasted before the audience:

10.- Mark Zimmerman, "ASAE Summer Meeting," Implement & Tractor 83 (7 Aug. 1968), p. 42.
11.- Harry Philo, "Legal liability of the agricultural engineer," Agricultural Engineering 49 (1968), p. 518.

> You have not become sufficiently sophisticated in the field of accident prevention in engineering school... to recognize that this is an entirely separate discipline. Human factors engineering, ergonomics or safety engineering are entirely separate from other engineering disciplines. Engineers and architects are beginning to be sued for malpractice.... If you have no expertise..., you'd better not undertake tasks in the field of accident prevention. The better companies have design teams that include human factors engineers or safety engineers. Other companies do not include such persons on the design team.
> A jury determines whether or not... there was reasonable care. While the standards of an industry have some relevance because these may establish evidence of due care..., a jury is not bound by the negligent standards of a negligent industry. The jury determines whether or not the state of the art was that advanced as it should be. 12/

Two years earlier Philo had speculated about an increasingly frequent use of voluntary safety standards in products liability suits. He depicted attorneys' growing interest in these documents as related to their significance in supporting specific claims on the manufacturer's behavior prior to accident. From plaintiff's perspective, these documents were important, for instance, to counter the manufacturer's frequent argument on the unavailability of a remedy or in helping to determine, before the trial, the competency of defendant's expert witnesses. Plaintiff's attorneys should remain aware that voluntary safety standards generally fell short of proper diligence as these documents

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12.- Ibid.

"represent[ed] a low-level consensus of the combined interest groups" that approved them. 13/ Conversely, manufacturers' expert witnesses would eventually increase the use of these documents in the courtroom as supporting evidence for their claims "since many industries [we]re adopting codes, complying with them and seeking to convince courts and juries that compliance constitutes due care." 14/

Safety specialists writing in Agricultural Engineering, the ASAE journal, started to warn that product liability litigation was part of a new national policy on product safety. A safety specialist pointed out, for instance, that this policy and "new knowledge in the technological fields [would] impose on industry a burden of learning new concepts at increasingly accelerating rate [and the need] to critically examine each piece of equipment... to see that it is properly designed to do the job with minimum exposure to injury to the operator or to others." 15/ Since trial lawyers like Philo were "succeeding in rewriting court concepts on product liability," he wondered for how long would "safety devices and

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13.- Idem, "Problems and potentialities of safety standards in tort litigation," Trial 2 (June 1966), p. 26.
14.- Ibid., p. 27.
15.- T. David McFarland, "On-farm accidents," Agricultural Engineering 49 (1968), pp. 581, 614. See also Howard Pyle, "Safety; its demands and rewards," Agricultural Engineering 49 (1968), esp. pp. 236-237.

equipment be able to pass as optional." 16/

Another safety specialist recommended manufacturers to prepare themselves to deal with many issues at the same time. "(K)eeping with the times," he pointed out, required a major change in attitudes at all levels of each company, since "(n)o other industry produces equipment for such complexity of tasks... to be used under conditions more difficult to control." 17/ He warned, however, that manufacturers' stigma would not start to wane until they began to

> avoid countering every suggestion by citing the need for a research program necessitating a long-term delay. Common sense may indicate what can and will happen over and over again.
> As a matter of fact it is amazing that simple data collection projects have been sufficient to trigger action.... (R)eports [on] tractor fatalities were potent enough to persuade manufacturers to make protective frames available as optional equipment. Now we'll urge that some type of overturn protection be standard. 18/

The editor of Implement & Tractor, a farm equipment trade magazine, also cautioned American manufacturers about a devastating report on their product safety record published by the Canadian Royal Commission on Farm Machinery. Besides some

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16.- McFarland, "On-farm accidents," p. 581.

17.- William Johnson, "Product safety and the agricultural engineer," Agricultural Engineering 48 (1967), p. 553.

18.- Ibid., p. 599.

generally unwarranted assumptions on manufacturers' alleged complacency, the report, according to the magazine's editor, made more specific remarks on tractor design, in particular on tractor makers' slow introduction of safety frames and crush resistant cabs, insufficient attention to braking effectiveness, and their unwillingness to deal with the problem of operator's hearing loss as a result of excessive tractor noise. The magazine's editor reminded his readership that the report was likely to inspire court decisions, legislators and regulators on both sides of the U.S.-Canada border. As he put it:

> It doesn't matter that the book talks about farm machinery safety matters mainly in a Canadian context...; both nations' farms are supplied for the most part by the same equipment manufacturers. The U.S. doesn't have any Royal Commissions, but we have Congress, congressional subcommittees with investigating staffs, state legislatures.... We [also] have trial lawyers, certain trends in court decisions on product liability, and increasingly militant farm groups. 19/

The initial response of FIEI engineers to these warnings was a mixture of exasperation and candid declarations of social responsibility. This responsibility, they insisted, went far beyond bona fide compliance with safety regulations and concern with the increasing premiums of product liability

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19.- Bill Fogarty, "A book you won't enjoy reading; don't miss it," Implement & Tractor 84 (21 Feb. 1969), p. 51

insurance. An International Harvester senior engineer complained, for instance, that safety specialists rhetoric was based on "misconceptions... regarding standards and standardization [as if] any standard originating from a technical society or from a trade association [were] intended for protection of the manufacturer rather than for any consideration of the operator or user." 20/ Deere engineers, by contrast, chose to emphasize the varied and highly specific nature of industry voluntary efforts "under Farm and Industrial Equipment Institute auspices to develop standards... that w[ould] offer still further protection against operator neglect [with] industry... moving toward general adoption of a safety frame to limit overturns [and showing] interest in stronger cabs that will support tractor weight." 21/ Besides these industrywide efforts, Deere engineers were stressing not only "comfort and convenience in

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20.- Edwin W. Tanquary, "Implications of safety legislation on equipment design," Society of Automotive Engineers (henceforth SAE) Paper No. 69-0440 (Warrendale, Pa., 1969), p. 6. Three years earlier Tanquary had set out that "true accident reduction in the farm equipment will come about by the realization that... the farmer cannot always be expected to follow safe practices or specified safety rules... and it is a challenge to all of us to determine how we can help him and assist him in every way possible ("Safety in the farm equipment industry," SAE Paper No. 66-0582 [1966], p. 10).

21.- Carlton L. Zink, "Safety in farm equipment: The manufacturer's concern," Agricultural Engineering 49 (1968), pp. 74-75.

operator stations of tractors and self-propelled implements," but also new concepts that would "consider emergency situations and provide the operator with controls compatible with his natural and acquired reactions." 22/

Competitive pressures were running high among farm equipment dealers and tractor manufacturers' marketing departments, with a shared distrust towards expensive and inconvenient items like anti-roll bars. The editor of Implement & Tractor pointed out, for instance, that many dealers had "traditionally steered clear of stressing optional safety equipment or discussing safety practices, presumably because of a desire not to alarm the customer about the product." 23/ When the magazine's editor explored dealers' attitudes towards anti-roll bars, one of them said that "(w)ith a list price of about $250, I'd say the customer g[ot] his money's worth, but most customers claim[ed] the price [a]s

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22.- Page L. Bellinger, "Man-machine compatibility," Agricultural Engineering 50 (1969), pp. 17-18.

23.- Bill Fogarty, "Dealers and the safety selling mission," Implement & Tractor 84 (21 Jan. 1969), p. 19. The opposition of major tractor makers' sales departments to the two-post frame in the late 1960s and early 1970s was ratified by three of my interviewees. See also Arnold B. Skromme, "History of Rollover Protection for Tractors," American Society of Agricultural Engineers (henceforth ASAE) Paper IAS 86-111 (St. Joseph, Mich., 1986), pp. 16-19.

the reason they [we]re'nt buying." 24/ Another dealer answered as follows:

> I own and manage the business but do not work on sales myself. It was and still is my feeling that safety frames should be sold in our area, but I have been unable to convince any of the four salesmen that I am right. We have a couple in stock but do not get them sold. The idea of not wanting to alarm the customer is no doubt a big factor. Also, I am told by my sales department that the price is too high to interest our farmers. 25/

By late 1969, Benson J. Lamp, manager of Ford Tractor's Marketing Plans Department and then Technical Vice-President of ASAE, devised a way of ending this wave of mutual recriminations and enlisting ASAE membership into an ambitious safety program. At the Winter Meeting of 1969 he urged ASAE Safety Committee to develop a specific plan to reduce fatalities by fifty percent over a ten-year period. His request had an enthusiastic reception in ASAE Safety Committee that readily agreed to it and appointed a special subcommittee in charge of the organization of ASAE efforts. In the fall of 1970 an ASAE staff member featured the subcommittee activities in the following way:

> [The] subcommittee has been meeting almost monthly to systematically develop a comprehensive ten-year plan to meet this goal by 1980. The next step will be a two-day workshop October 13 and 14 at ASAE headquarters in St. Joseph. Approximately 20

24.- Fogarty, "Dealers and safety," p. 20
25.- Ibid., p. 19.

> specialists with diverse safety backgrounds and interests will meet to develop detailed lists of known and potential problem areas; develop specific courses of action; establish priorities; a timetable for execution of each recommended course of action. 26/

Meanwhile, in the late spring of 1970 ASAE membership learned that the U.S. Department of Transportation (DOT) had been directed by Congress "to conduct a study on agricultural tractor accidents and to report on the extent, causes and means of preventing such accidents on both public roads and farms by January 1, 1971." 27/ In August 1970 ASAE staff members rephrased in a questionnaire format the issues raised in a DOT letter sent to ASAE headquarters and distributed the questionnaire among members of four committees considered as having qualified opinions on these issues. With the respondents' answers at hand, a task force made up by the chairmen of the four committees consulted plus Vice-President Lamp and Lawrence Hodges, then ASAE Power & Machinery Director, met the following month to write a final report submitted to the DOT on September 28. The report, entitled

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26.- Russell H. Hahn, "Progress Report," Agricultural Engineering 51 (1970), p. 610. See also Charles S. Floyd, "ASAE Target: Cut accidental death toll by half," Implement & Tractor 86 (7 Jan. 1971), pp. 24-26, 32. For an outline of the plan, see "ASAE 10 Year Plan for Agricultural Safety," Agricultural Engineering 52 (1971), p. 17.

27.- Hahn, "Progress Report," Ibid., Vol. 51 (1970), p. 672.

Improving Safety in Agricultural Tractors, emphasized "(t)he concern and activities of ASAE for agricultural tractor and equipment safety [and] Safety Committee [efforts] to develop a plan for 50 per cent reduction in agricultural accident fatalities by 1980." 28/ On the issue of how desirable were federal standards for farm tractors, the report stated as follows:

> ASAE should not, formulate or promote a position on questions of this type.... If Congress determines that federal regulations are necessary in some areas..., ASAE and other organizations with similar concerns and capabilities can provide a ready resource of talent to define technically and economically feasible and practicable standards. ASAE experience with safety-related standards indicates that they are most effective when they are reasonable, not only for the manufacturer, but especially for the user.... ASAE standards are generally sensitive to the needs and habits of the user -in this instance, the farmer. Such sensitivity is essential whether developing voluntary performance standards of federal regulations. 29/

On September 17, 1970, while ASAE task force was drafting the report, DOT officials organized a one-day meeting in St. Louis, Missouri. At the meeting, University of Nebraska professor George Steinbruegge, an unscheduled speaker and

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28.- U.S. Department of Transportation, Agricultural Tractor Safety on Public Roads and Farms, Report to Congress, Jan. 1971, p. A150. See also Robert E. Stewart, Seven Decades that Changed America (St. Joseph, Mich.: ASAE, 1979), p. 397.

29.- DOT, Tractor Safety, pp. A148-A149.

well-known participant in ASAE and SAE standards committees, briefly referred to his interest in testing protective cabs as chairman of Nebraska's tractor testing program. This program, he explained, was set up in 1919 to comply with "a state law which requires that a tractor be tested and passed upon by a board of engineers at the University in order to receive a permit to sell a tractor in that state." 30/ He also pointed out that besides University of Nebraska Tractor Test Laboratory concern with

> performance tests related to things like horsepower and torque and wheelslip and so forth..., we set out about four years ago to acquaint ourselves with tipping tractors over...
> We have tipped tractors over flat surfaces, on into ditches and have used this Swedish pendulum test, which is part of the safety standards recognized by ASAE and SAE and FIEI....
> (O)ur tests show this standard to be inadequate, that the forces and the deflections which cabs and rollbars may be expected to withstand are much greater than the forces and the deflections which the cab may have to withstand if it was being tested according to these standards.
> I ask this Committee holding this meeting be careful about just accepting the present standard in total. I would suggest that they attempt to write a new standard based on more complete research and with representatives of the public on the standard-writing committee. 31/

30.- Ibid., p. B53 (statement of George Steinbruegge). See also Bill Fogarty, "Industry engineers have their say about tractor safety," Implement & Tractor 85 (21 Oct. 1970), pp. 38-40. On the role and procedure of Nebraska Tractor Testing Program, see Lester F. Larsen and Louis I. Leviticus, "Thirty years of Nebraska Tractor Testing," ASAE Paper No. 76-1045 (1976).

31.- DOT, Tractor Safety, pp. B53-B54.

Subsequently, Lawrence Hodges, speaking on behalf of the Farm and Industrial Equipment Institute (FIEI), seized the opportunity to put in doubt both the accuracy and validity of Steinbruegge's assertions. Hodges disputed Steinbruegge's claims in the following way:

> When the major companies in this industry began... the development of rollover protective systems..., we learned rather quickly that the protective frame criteria developed in... Sweden, were totally inadequate for the larger and more powerful tractors for use on the U.S. farms. On this point about the Swedish standards, we agree wholeheartedly with Professor Steinbruegge. However, our experience on testing against the recently adopted ASAE standard is in violent disagreement with his statement regarding the inadequacy of the U.S. standards. The significant investment of our company in the design and testing of a protective enclosure or a cab which conforms to the present standard is dramatically portrayed in a short movie which I would like to show.... As you look at this movie, keep in mind that it deals only with the protective enclosure which is one protective device, and the same expensive and design test program had to be undertaken or had to be duplicated just to provide the protective frame. 32/

The audience, made up for the largest part of tractor makers' engineers, remained in a tense silence among "those who were unhappy with Professor Steinbruegge's comment." 33/ However, and in spite of other speakers' obvious reluctance to refer directly to the issue,

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32.- Ibid., pp. B60-B61.
33.- Rollin D. Schnieder, "Overview of ROPS related accidents, 1965-1990," ASAE Paper No. 90-1640 (1990), p. 4.

> engineers present at the meeting from the major manufacturers said they would like to get more data from Steinbruegge concerning his findings. 34/

Late in the afternoon, Carlton Zink, ASAE Agricultural Safety Committee chairman and former employee of Deere & Co. and the University of Nebraska Tractor Test Laboratory, made a last-ditch effort to reconcile the far apart views of Steinbruegge and FIEI engineers. As Zink said before the audience:

> Communications can be a problem.... (A)fter talking with George Steinbruegge this morning, this noon, he was talking about standards which apply to overturn protection. He bewailed the fact that he might not said what he should have said in the way he said it, not that he failed to say what he meant, but some people may have not interpreted it in that fashion. I will gamble on trying again for George. I used to occupy a position there. As I remarked, I spent 12 years in that institution.... Actually, if they elect to check the crush resistance of cabs at Nebraska and judge them against the standard, if I interpret George's remarks correctly, he feels that the cabs currently offered by the tractor manufacturers far exceed the requirement of the standards.
> George's philosophy, as I say, to these people that work up to standards, take another look, won't you, please, and at least raise the standards for the cabs up to the standards that they are.
> I see him nodding his head up and down.... Well, thank you George, for my trying..., I hope I didn't mislead you and say something you did not want me to say. I went on to say that George fears that cabs... that barely meet the standard will not

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34.- Fogarty, "Industry engineers," p. 39.

adequately protect the driver under adverse or severe accident conditions. 35/

During the spring of 1971 cab makers' engineers learned that the DOT Report to Congress had urged the farm equipment industry "to phase out the sale of cabs and canopies that d[id] not meet ASAE-SAE safety standards, but instead serve[d] to crush or trap operators when a tractor overturn[ed]." 36/ In contrast with the self-congratulatory mood of tractor manufacturers' engineers as a result of being spared from the widely expected establishment of federal safety standards, cab makers' engineers felt that the costs of complying with the SAE-ASAE standards, as specified in the DOT Report, were unacceptably high. They were particularly troubled with the costs of the vehicle overturn portion of SAE-ASAE test procedure. After learning of a DOT letter "requesting that FIEI follow up on actions relative to the report," cab makers organized a series of FIEI-sponsored meetings in which they debated the problems of compliance. 37/ They soon realized that their ultimate ability to comply depended on helping to

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35.- DOT, Tractor Safety, p. B137

36.- Harry N. Rosenfeld, "Wire from Washington," National Safety News 103 (March 1971), p. 144. See also Charles S. Floyd, "Cab makers confer on DOT manifesto," Implement & Tractor 86 (21 June 1971), p. 12.

37.- Floyd, "Cab makers confer," p. 12. See also Russell H. Hahn, "Federal safety standards for tractors?" Agricultural Engineering 52 (1971), p.108.

rewrite some of the test provisions in ways that complying with the standard would damage "only the cab itself... in the test procedure [thus] eliminating costly damage to a tractor... in the overturn tests." 38/

The revision of the four SAE-ASAE standards on Roll-Over Protective Systems (ROPS) gathered momentum during the fall of 1971, when FIEI Industrial Safety Subcommittee members began to consider the imminence of new ROPS regulations. After their successful duel with DOT, FIEI engineers felt confident that, as long as they remained united around a single standard proposal, regulatory agencies like the Occupational Safety and Health Administration (OSHA) would regard their ROPS proposal as the most workable alternative, thus avoiding impractical and unreasonable regulations that could stifle the progress of the farm equipment industry. 39/ Cab makers' participation in

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38.- Floyd, "Cab makers confer," p. 14.

39.- See, e.g., Merlin Hansen, "Evolution of tractor design and safety features on farm tractors," DOT, Tractor Safety, pp. A83-A106; James F. Arndt, "Rollover protective structures for farm and construction tractors," SAE Paper No. 71-0508 (1971), pp. 5-7; DOT, Tractor Safety, pp. B138-140 (statement of Arnold B. Skarjune). See also Randall C. Swanson, "Trends in product safety and liability," ASAE Paper No. 71-546 (1971), pp. 2-3; Glenn Hensley, "Hear an update on industrial safety," Farm & Power Equipment 54 (July 1972), pp. 26-27; Lawrence Hodges, "75 years of progress through standardization," ASAE Paper No. 82-5549 (1982), p. 12. For a good description of FIEI's role in promoting

FIEI Safety Subcommittee deliberations seemed nonetheless to complicate matters, given their insistence in removing the field overturn test portion of the standard. Most tractor manufacturers saw little advantage in deleting this portion as they regarded it not only as a step in the development of factory installed cabs and frames, but also as one of their best arguments against criticisms such as those of Steinbruegge. A continued discussion of the problem led the FIEI Subcommittee to an extensive review of European standards for farm tractors and American ROPS documents for construction equipment, numerous refinements in terminology and definitions, additions of concepts borrowed from other standards, and a vast array of editorial changes. As the focus of the Subcommittee deliberations was on the standard on protective cabs, this document underwent extensive changes, from a mere single-page extension of the two-post frame test provisions to a separate five-page document with a similar format as that of the protective frame standard. Interestingly, and probably as a result of the growing irrelevance of these documents for the construction industry regulations, the FIEI Subcommittee agreed to drop any further

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a united front vis-a-vis government regulatory agencies, see, e.g., Bill Fogarty, "FIEI at 80: Just getting started," Implement & Tractor 88 (15 July 1973), pp. 17-18.

reference to light industrial tractors and to limit the scope of its revised standards to wheeled agricultural tractors only. 40/

On 26 July 1972 a fifteen-member OSHA Advisory Committee on Agriculture appointed by the Department of Labor held its first meeting in Washington, D.C. A farm magazine described it as "(a) well-balanced committee [with] four employers, four employees, two [representatives] from state agencies, three from technical and professional organizations, and two from other government agencies." 41/ At this first meeting the Committee members were informed that another 25-member Advisory Safety Committee for the U.S. Department of Agriculture had proposed to include rollover protection as one of the five top priorities of the newly formed OSHA Advisory

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40.- The revision of SAE-ASAE standards was completed and released to the public in Dec. 1972. See, e.g., Russell H. Hahn, "Progress Report," Agricultural Engineering 54 (Feb. 1973), p. 29. Cf. "Protective enclosures, test procedures and performance requirements," ASAE Standard S336, Agricultural Engineers Yearbook (St. Joseph, Mich., 1970), p. 251. The revised ASAE Standard S336.1 was later published as SAE Standard J168a, after being adopted in Feb. 1974, SAE Handbook (Warrendale, Pa., 1975), pp. 1056-1509.

41.- "Regulations and legalities," Farm Quarterly 27 (Fall 1972), p. 46. See also "Safety Advisory Committee in Action," Farm & Power Equipment 54 (Nov. 1972), p. 48; Schnieder, "Overview of ROPS," pp. 6-7; Russell H. Hahn, "Progress Report," Agricultural Engineering 53 (Sept. 1972), p. 34.

Committee. On 20 December 1972 the OSHA Advisory Committee, chaired by Rollin D. Schnieder, ASAE Agricultural Safety Committee member and agricultural safety specialist from the University of Nebraska, met for the third time and unanimously agreed to recommend a federal ROPS standard for all new tractors driven by employees. In contrast with other OSHA regulations for the construction industry, the Advisory Committee did not commit itself to any retrofitting decision and agreed that the issue would "be referred for further study." 42/ After the meeting, the Advisory Committee recommendation

> went to the solicitors for labor. It is their job to write and rewrite the standard so it conforms to legal description as set by the Department of Labor. They try to do this as not to change the meaning as suggested by the advisory committee. 43/

A few days before OSHA Advisory Committee met to decide on its operator protection recommendation, ASAE Power & Machinery Committee had already ratified, with minor

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42.- Standards Advisory Committee on Agriculture (20 Dec. 1972), pp. 66, 76-77 (this document is available at the OSHA docket, Washington, D.C.). See also Rollin D. Schnieder, "Function and status of DOL's Agricultural Standards Advisory Committee," ASAE Paper No. 73-5535 (1973), p. 1; 40 C.F.R. 18,254 (1975); Donald V. Koenig, "OSHA Update," Farm & Power Equipment 55 (May 1973), p. 18. For OSHA retrofitting rules for construction machines, see 37 C.F.R. § 1926.1000 (1972).

43.- Schnieder, "DOL's advisory committee," p. 2.

amendments, the four ROPS documents as revised and submitted by the FIEI. Interestingly, despite FIEI goal of simplifying the test provisions, the text of these documents was full of jargon and casual explanatory notes, such as that of a "(c)rush test procedure... not [being] specified in this standard as tests have indicated that protective structures that comply with [it] have a crush resistance of at least 1 W." 44/ Sanctioning the new test provisions was, according to an ASAE staff member, not only among the "major actions taken during the December 1972 Winter Meeting of ASAE," but also a way of preparing the terrain for OSHA Advisory Committee standard. 45/ As he put it:

> The revisions are of prime importance to tractor manufacturers and tractor cab manufacturers. Since rollover protection is one of the priority areas designated by the OSHA Agricultural Advisory Committee, these revisions will likely be reviewed by the appropriate OSHA subcommittee.
> One major change in the test procedure for protective frames is that the field upset test may be omitted if the laboratory energy absorption test results meet energy absorption specifications by 115 percent or more. 46/

44.- "Protective frame for agricultural tractors," ASAE Standard S306.3, and "Protective enclosures," ASAE Standard S336.1, both in Agricultural Engineers Yearbook, pp. 271 and 278. Both standards were also published as SAE Standards J334a and J168a, respectively.

45.- Russell H. Hahn, "Progress Report," Agricultural Engineering 54 (Feb. 1973), p. 29.

46.- Ibid.

Cab makers' engineers regarded ASAE revised standards as offering a complex and demanding test procedure but at least at a cost that allowed them to stay in business. A cab manufacturer engineer, for instance, described compliance with the ASAE static test procedure as follows:

> (A)ll ROPS designs for new equipment must be tested for compliance, prior to manufacture. Test bays are arranged to provide... the side/load energy requirement... at the top edge of the structure -the worst possible location in terms of stress.
> [This] load is applied in steps which result in lateral deflections of 0.5 in. Incremental energy absorbed for each step and totaled. Ideally the force and energy absorption requirements are met simultaneously. Often, however, the ROPS is stiffer than anticipated, so much greater force is required to deform the structure beyond its elastic limit and produce permanent plastic deformation. The structure is then considered to exceed standards. After the horizontal [side] load/energy test..., the structure is subjected to a horizontal force from the rear as well.... The rear force is also exerted at the top of the structure.
> Most agricultural ROPS are made of mild steel. Because this steel is stronger under rapidly applied loads than under much slower application, the load applied to any agricultural structure of mild steel is increased by 1.3 to accurately simulate the shock of a real roll over. 47/

Meanwhile, Steinbruegge's objections to the adequacy of SAE-ASAE pendulum test procedure were growing louder. In a paper presented with L. Dale Baker, a graduate student at the University of Nebraska, Steinbruegge had argued in the ASAE

47.- Daniel A. Lockie, "OSHA says roll-overs must be safe," Machine Design 46 (21 March 1974), pp. 200-201.

Winter Meeting of 1972 that the comparison between a cab smashed in an actual overturn accident and the near success of a similar cab during a pendulum test following ASAE-SAE standards created serious doubts about the adequacy of these standards. As Baker and Steinbruegge put it:

> The rate of pendulum energy absorbed by the soft cab that was tested was very high during the initial portion of the impact. There was relatively little pendulum energy left as the cab reached the point of rejection. A slightly wider cab may have passed this test. A similar cab was totally crushed during an actual upset under conditions that were not unduly severe. A cab that is barely able to pass the ASAE pendulum test could run a serious risk of failure during an upset. 48/

Steinbruegge's focus on cabs was based on the assumption, shared by many U.S. agricultural safety specialists, that protective cabs rather than unpopular two-post frames provided the actual solution to the overturn accident problem. His concern with the adequacy of SAE-ASAE pendulum test procedure had originated, as he recalled it a few years later, in a brief conversation with a Nebraska farmer at a safety demonstration. Shortly after a pendulum test presentation at the University of Nebraska, the farmer asked: "If you substitute the pendulum impact for rolling into a ditch, how deep a ditch does the pendulum represent?" 49/ Steinbruegge's

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48.- Baker and Steinbruegge, "A tractor overturn study," ASAE Paper No. 72-615 (1972), p. 12.
49.- Steinbruegge, "Is the ROPS standard adequate?" ASAE Paper

own inability to give any satisfactory answer puzzled him and, as he put it,

> further thought and discussion on the subject convinced [Nebraska faculty] that an answer was not available. It became evident that the adequacy of protective structures in the United States was being judged by a standard that might not itself adequate. Accordingly, our tractor rollover research emphasis was shifted from an investigation of the adequacy of rollover protective structures to the study of the adequacy of the procedures for testing such structures.
> [Our] (t)ractor rollover studies... included comparing maximum cab deflections during [actual] upsets with maximum deflections encountered during pendulum tests. Analysis of films taken during an upset on a 36* slope showed that the sideways roll of a 9,800 lb. tractor down the slope resulted in a 33% more cab to frame displacement than when struck with the pendulum.... Serious doubts of the adequacy of the SAE-ASAE pendulum test were beginning to surface. 50/

Though at least a few OSHA Advisory Committee members were aware of Steinbruegge's claims, they considered that any systematic investigation of these claims would almost certainly lead to a complete loss of control over the OSHA standard. Given the rules under which OSHA Advisory Committees made its decisions, it seemed more appropriate to

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No. 75-1578 (1975), p. 3. See also Rollin D. Schnieder, "A tractor cab may save your life," Hoard's Dairymean (25 April 1969), p. 516; Mark Zimmerman, "Celebrating 50 years of tractor testing," Implement & Tractor 84 (7 Sept. 1969), esp. pp. 33-34; Paul Courter, "Unpopular lifesavers: roll bars," Michigan Farmer (6 July 1968), pp. 24-25.

50.- Steinbruegge, "Is ROPS adequate?" pp. 3-4.

work with existing SAE-ASAE standards and manufacturers' data, rather than getting bogged with circumstantial evidence such as that offered by Steinbruegge. 51/ As Rollin Schnieder, the Advisory Committee chairman, put it:

> The committee does have to work under a deadline. We have 270 days to look at the problem and come up with some type of recommendation. If we do not, then OSHA can take the material that we have prepared and write the standard to their liking, which may not be to our liking.... By getting the standard to them on... date, they have an obligation to work with our proposal. They can make changes, however, they should not be too drastic. 52/

Other ASAE members were also unsure as to the seriousness of Steinbruegge's claims. Manufacturers regarded test data as proprietary information and refused to make them fully available to the public. In any event, his denunciations were based on the assumption that some manufacturer would seek to barely comply with the test procedure, which contradicted the most typical overdesign criteria followed in order to avoid the possibility of a costly mistake in case of failing to pass the test. Baker himself went so far as to admit that even

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51.- Interview with Richard Pfister.

52.- Schnieder, "DOL's advisory committee," p. 2. For a detailed description of Schnieder's view on the merits and limitations of SAE-ASAE standards, see, e.g., "Do-it-yourself roll bars?" Implement & Tractor 87 (21 April 1972), p. 14. See also idem, "Overview of ROPS," pp. 6-7; Rollin Schnieder and Dale O. Hull, "Occupational Safety and Health Act: How it affects ag engineers," Agricultural Engineering 52 (Oct. 1971), p. 509.

though the SAE-ASAE pendulum test procedure allowed the frame to deflect up to 14 inches in case of a 33-inch wide cab,

> (r)eports of the deflections produced from controlled upsets conducted by Deere and Company indicate that deflections of less than six inches are a common result of the tests. 53/

In June 1974 OSHA held public hearings on a notice of proposed rulemaking on overturn protection for farm tractors published four months earlier based of the Advisory Committee recommendations. The hearings, convened at four different locations in the country (Chicago, Tallahassee, Fla., Boise, Idaho, and Washington, D.C.), considered among other issues whether the proposed standard was feasible in all kinds of operations and an appropriate effective date for compliance. At the Chicago hearings, two members of the FIEI Industrial Safety Subcommittee, Newton Sacks and Herbert Sullivan, demanded flexibility in implementation and a more reasonable schedule for compliance. Newton Sacks, a senior engineer from Deere, claimed, for instance, that his company could not "order, invest in and obtain additional materials and facilities for ROPS production without having first the specific and finalized requirements of the standard, and...

53.- L. Dale Baker, "Analysis of 36 tractor upsets in Nebraska," (Master's thesis, University of Nebraska, 1972), p. 37.

request[ed] the standard be revised to require ROPS on agricultural tractors manufactured no earlier than 20 months after the effective date of the standard." 54/ Herbert Sullivan, an International Harvester engineer, stated that even though "production of cabs without ROPS ha[d] been discontinued..., a minimum lead time of 24 months from the date of final rules w[as] required to prevent a chaotic supply situation for farmers at the time of the compliance date." 55 Sullivan went further to argue that overturn protection was not necessary in the case of tractors with "mounted corn pickers and mounted cotton strippers [since] they [we]re not prone to rollover accidents." 56/ Exemption to overturn protection requirements should also include, he added, tractors used in low-clearance operations, such as orchards, for which even "a low profile ROPS [according to] research... in the Industrial Safety Committee of FIEI, could create greater safety hazards than the rollover hazard it eliminate[d]." 57/

54.- Bill Fogarty, "ROPS Hearing," Implement & Tractor 89 (15 July 1974), pp. 33, 55; Harry N. Rosenfield, "Wire from Washington," National Safety News 110 (July 1974), p. 116.

55.- Fogarty, "ROPS Hearing," p. 33.

56.- Ibid., p. 32

57.- Ibid. See also Howard J. Martin, "Dilemma of the low-profile ROPS," Agricultural Engineering 55 (July 1974), pp. 44-45.

In April 1975, after a long succession of minor amendments and editorial changes, the OSHA ROPS standard for agricultural tractors was finally ready for publication in the Federal Register. Despite covering only about 11 percent of all tractors, the new OSHA standard was, in the view of tractor makers' engineers, a de facto regulation of the entire farm tractor market, as they had to make sure that rollover protection was available for all tractor models of more than 20 hp. An ASAE staff member described the requirements set in the OSHA standard as follows:

> The long awaited regulations require ROPS on two- or four-wheel drive, wheeled or track-type agricultural tractors of more than 20 engine hp manufactured after Oct. 25, 1976. ROPS shall be provided by the employer for all such tractors operated by an employee.... Low profile tractors are exempt from the ROPS requirement while they are being used in orchards, vineyards, hop yards, inside farm buildings, greenhouses, etc. Also tractors with mounted equipment such as cornpickers and cotton strippers are exempt.
> The regulations require that ROPS be labeled by the manufacturer to indicate manufacturer's name and address, ROPS model number..., and that the ROPS was tested in accordance with OSHA regulations. Test procedures and performance requirements specified in the OSHA regulations conform to ASAE and SAE voluntary standards. 58/

58.- Russell H. Hahn, "Progress Report," Agricultural Engineering 56 (June 1975), p. 42. See also 40 C.F.R. § 1928.51 (1975); John G. Steiger to U.S. Secretary of Agriculture Earl Butz, undated letter published in Agricultural Engineering 55 (Jan. 1975), p. 16.

Meanwhile, Steinbruegge's determination to find the maximum depth of a ditch into which a tractor cab could safely roll over if it barely passed the ASAE pendulum test procedure had grown with ASAE decision to make the field upset portion of the test optional. By the fall of 1975, a few months after the OSHA standard was published, his research project was near completion and he could conclude that for a 39½-inch wide cab which barely complied with the SAE-ASAE-OSHA standards the maximum depth it could roll over without being crushed was only 18 inches. He described the behavior of the experimental cabs used in his study as follows:

> Th[e first] cab was designed to be adjustable with regard to strength and deflection. Vertical steel bars joining the upper and lower frames of the cab structure could be varied in size and number to give the desired characteristics of strength and deflection. It was found that 24 mild steel bars, 3/4 inch in diameter, would give the transverse strength necessary for the cab to meet the 115% energy absorption requirement of the SAE-ASAE performance standard for the weight of the tractor used....
> A cab was then built identical to the one which was adjusted in strength and deflection to stay within the SAE-ASAE standard's limits of acceptability. This second cab was mounted on the tractor and used to evaluate the standard in terms of response to an actual overturn. The cab and tractor weighed 10,490 lbs. The tractor with cab, was overturned sideways by a forklift into a grassy roadside ditch 42 inches deep with a 3-to-1 side slope. A 1972 analysis of 36 tractor upsets in Nebraska showed that 73% of side rollovers occurred in ditches deeper than 42 inches.... The tractor rolled 180* into the bottom of the ditch and the cab was smashed to such extent that the tractor's steering wheel was also bent.
> An unmodified cab with was built and mounted on the tractor and rolled sideways into a 30 inch ditch.

> It too smashed flat to the level of the steering wheel.
> Another similar cab was built and mounted on the tractor and rolled into an 18 inch ditch. The cab did not smash flat, but movies of the overturn showed that instantaneous maximum deflection was very nearly the same as that of the original cab when tested with the pendulum. 59/

Steinbruegge's findings, presented in a session on ROPS a the ASAE Winter Meeting of 1975, met a far more receptive audience than his earlier denunciations. Wilburt O. Gipp, a J. I Case senior engineer and chairman of the newly created FIEI ROPS Committee, went so far as to recognize the seriousness of Steinbruegge's ROPS research, even if the validity of his findings was limited to unusually soft cabs. Gipp ventured to say that since tests run at J.I. Case on soft cabs similar to those built by Steinbruegge had shown that these only supported 80 percent of the tractor weight, there was need to revise the SAE-ASAE standards to consider a crush test that eliminated the possibility of such cabs passing the tests. Rollin Schnieder, also present in the session, recalled years later that, as a result of this discussion and a subsequent request by OSHA, Gipp and Steinbruegge agreed to meet the following months to consider ways of improving the SAE-ASAE ROPS standards. These deliberations were

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59.- Steinbruegge, "Is ROPS adequate?" pp. 4-7.

instrumental, as Schnieder put it,

> in bringing the ASAE standard to a point where all involved could be comfortable with the function of the standard. George Steinbruegge['s work] on determining the energy in an overturn... was the basis for further work [with] W. O. Gipp from J. I. Case... in the upgrading of the standard.... 60/
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> After considerable testing and numerous meetings, the standard was strengthened and those involved were in agreement that it was 'state of the art'. 61/

During the fall of 1976, after lengthy negotiations, the FIEI ROPS Committee agreed with Steinbruegge that "a crush load 1,5 times the gravity force of the tractor mass [would become] part of the ROPS test requirements." 62/ Besides negotiating this new test provision with Steinbruegge, the FIEI ROPS Committee also decided to simplify the documents and remove the most repetitious clauses that had resulted from its earlier negotiations with the cab makers. Having concluded that the test requirements for cabs and two-post frames were similar, the ROPS Committee sought to stress the common

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60.- Schnieder, "Overview of ROPS," p. 7

61.- Ibid., p. 4. See also Herbert D. Sullivan, "Structural strength tests for protective cabs for agricultural tractors using static methods," Off-highway Vehicles, Tractors, and Equipment (London: The Institution of Mechanical Engineers, 1976), p. 52.

62.- Russell H. Hahn, "Progress Report," Agricultural Engineering 58 (July 1977), p. 29. The FIEI Agricultural ROPS Committee was created in early 1975, with Wilburt Gipp as its first chairman.

character of all types of overturn protection and to collapse ROPS performance requirements into a single document that could combine three out of the four existing standards. The combined ROPS draft proposal had a good reception in ASAE Power and Machinery Committee, where it was approved with editorial changes in March 1977, and by SAE Tractor Committee in June 1977. 63/

The efforts of tractor makers' engineers to accommodate the demands of cab makers, Steinbruegge, and OSHA, though successful, still fell short of satisfactory results as long as partial implementation left their companies exposed to legal actions initiated by injured parties. These parties' willingness to recourse to the courts to settle their grievances put in evidence the serious disadvantages of partial compliance with the ROPS standards tractor makers' engineers had helped to develop. While full implementation

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63.- See "Roll-over protective structures (ROPS) for wheeled agricultural tractors," ASAE Standard S383, Agricultural Engineers Yearbook (1978), pp. 278-282, also published as SAE Standard J1194, SAE Handbook (1978), pp. 40.49-40.54. The approach followed by the FIEI ROPS Committee was similar to that adopted by SAE Subcommittee 12, that early in 1972 decided to combine its four ROPS standards into a single document for all types of machines. See "Performance criteria for rollover protective structures (ROPS) for earthmoving, construction, logging and industrial vehicles," SAE Recommended Practice J1040, SAE Handbook (1975), pp. 1647-1658.

was becoming largely unproblematic in the case of tractor cabs, the two-post frame concept continued to meet reluctant buyers and the hostility of tractor makers' marketing departments. Stiff competitive pressures, in the view of most tractor salesmen, made it ill-advised to promote unpopular design features, even on an optional basis. Even though they shared with tractor makers' engineers a common fear that tractor rollover accidents, if too frequent, could tarnish their companies' reputation, the claims arising from these accidents were, in their view, a legal and insurance problem, rather than a marketing-related problem. Over time, as the costs of product liability suits continued to climb, tractor makers' engineers started to consider persuading their companies of the need to seek ways of changing their marketing policies and the voluntary status of implementation to make them compatible with the new legal environment.

In November 1977 the FIEI convened for the first time a two-day workshop in Arlington Heights, near Chicago, to the specific purpose of discussing "the industry's more persistent problem: the increasing number and escalating costs of product liability [suits]." 64/ With attendance of nearly 200 top

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64.- "FIEI Conference tackles product liability," Agricultural Engineering 59 (Jan. 1978), p. 18.

industry engineers and other representatives of the farm equipment business, the workshop focused on specific issues, such as growing jury awards, growing insurance premiums, when to settle out of court, accident prevention, pre-litigation defense practices, record keeping, defense preparation, dealers' role in the process, and legislative involvement. Among the most pressing concerns was, as pointed out by an insurance industry speaker, the problem of not being "quite sure what the dimensions of product liability are [with] insurance carriers [in need of] building an 'X' factor into their premium structure." 65/ He noted that, given the prevailing uncertainties, it was "to the carriers' credit that they ha[d] not withdrawn from the field." 66/ Another insurance industry representative emphasized that since virtually all farm equipment accidents took place in remote locations, but generally near the area where the equipment was bought, dealers were in the best position to get first hand information and to bring an independent engineer

> into the case at the earliest possible time. This expert has several tasks to complete. He must consult with your attorney; examine the equipment, site, photographs, and accident reports; review applicable codes and standards; plan for and, when possible, conduct any tests required, and finally, develop a report based on the advice of your

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65.- Ibid., p. 19.
66.- Ibid.

attorney. 67/

Other scheduled speakers emphasized the need for manufacturers' collective involvement at the highest possible level, including lobbying in federal and state legislatures and changes in industry marketing policies. Lawrence Hodges, Vice-President of J. I. Case and FIEI's Safety Policy Committee chairman, cautioned that controlling litigation costs had become an industrywide problem which companies could no longer afford to leave in hands of their chief engineers, lawyers, dealers, or insurance carriers. He warned that "a safe product defined in engineering terms may not be a safe product as defined by the 'law'," and urged other executives to "stop 'subsidizing' product liability costs by reaching into the corporate kitty, and start adding product liability costs directly into the price of the product." 68/ "(E)very company," he suggested, had to take into account not only the financial costs of litigation but its impact on its own reputation and "be committed to product safety in writing." 69/ Before the close, a group of corporate lawyers and FIEI's Legislative Policy Committee members outlined the main points

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67.- "Product liability gets up-date and review," Farm & Power Equipment 65 (Jan. 1978), p. 32.

68.- "FIEI Conference," p. 18.

69.- Ibid.

of FIEI efforts to reduce product liability costs through legislative reform. The proposed FIEI guidelines for reforming product liability law included time limitations to the age of the equipment from which claims arose and restrictions to the types of admissible evidence against the manufacturer. 70/

The FIEI workshop, if unusual for its exclusive concentration on product liability, was among the growing number of seminars, special sessions, and even mock trials arranged by the SAE, ASAE and FIEI. In these seminars tractor manufacturers' engineers learned that product liability had evolved from an affordable burden to their industry into a crisis-proportion problem whose explosive growth, if continued unabated, could seriously undermine the financial strength of their employers. A speaker in a products liability session at the 1976 SAE Off-Highway Meeting in Milwaukee, Wisc., warned, for instance, that "current trends... caused insurance premiums to rise in some cases from 400% to 600% in one year,

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70.- Ibid., pp. 19-20. Insurance industry representatives favored a somewhat similar approach, but their emphasis was on limiting the amount of jury awards and the regulation of attorneys' fees. See, e.g., "Product liability: Insurer's point of view," Agricultural Engineering 58 (Jan. 1977), pp. 11, 13. See also "Are dealers concerned about product liability?" Implement & Tractor 94 (21 March 1979), pp. 24-26, 32.

and in other cases coverage was not available at al." 72/ A panelist at the ASAE Winter Meeting of 1976 in Chicago stated that a decision by Florida Courts of Appeals against a tractor manufacturer made this state one of the "thirty-five states [that] had adopted the doctrine of strict liability in tort and [expected] many states [to] follow that lead in the near future." 71/ In 1974 the SAE President Wilson A. Gebhardt claimed that product liability litigation was not only a "monster industry [with] (t)he number of cases increasing at an alarming rate," but also "one of the most serious and rapidly growing problems facing American business." 73/ As he put it:

> (J)ury-awarded damages are increasing to fantastic figures. In 1960 in Cook County, Illinois, the county seat for Metropolitan Chicago, there were only three decisions returned in favor of plaintiffs, with total awards of $ 4200, an average of $ 1400 each. In 1965 there were seven product

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71.- Robert D. Tomlinson, "Product liability: Its effects on the manufacturer-distributor relationship," SAE Paper No. 76-0702 (1976), p. 3, also published in Automotive Engineering 84 (Oct. 1976), pp. 30-32, 74.

72.- Franklin A. Morse and David R. Melton, "Product liability and the design of agricultural products: A lawyer's view," ASAE Paper No. 76-1547 (1976), p. 1. See also Robert O. Diedrichs, "Product liability: Some background and a team approach to defense," ASAE Paper No. 76-1550 (1976), pp. 5-6; Frank Buckingham, "ASAE Seminar, session on Product Liability," Implement & Tractor 92 (7 March 1977), pp. 19-20, 32.

73.- Gebhardt, "Product liability: Let the seller's engineers beware," SAE Paper No. 74-0641 (1974), p. 1.

> liability cases awarding plaintiffs a total of $ 269,150, an average of about $ 38,500 each. In 1966 eight verdicts awarded $ 906,640, or a average of over $ 113,000 each. Today, million d o l l a r awards for a single death are not uncommon. In one case $ 2.5 million was awarded for the very severe injury of one person. 74/

In 1976 Robert L. Barrett, a Deere attorney with over twenty years of experience in the courtroom, warned in a FIEI meeting in Key Biscayne, Florida, "that a defentant's difficulty in court [wa]s often the result of a defensive position he can support." 75/ He contended that given plaintiff's privileged access to evidence, adding safety features to a product had become a sound corporate investment, since it was "better to spend costs now improving a product than... to pay millions later in a law suit." 76/ In his

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74.- Ibid.

75.- Glenn Henseley, "System approach is used to counter PL problems," Farm & Power Equipment 63 (Feb. 1977), p. 24. See also "ICED gathers at Key Biscayne," Implement & Tractor 92 (21 Jan. 1977), p. 20.

76.- Henseley, "System approach," p. 24. Barrett's view of product safety as a good corporate investment reflected Deere safety policy rather than personal views. As Keith L. Pfundstein, a Deere senior engineer, put it: "(T)oday's climate of product liability is such that deliberate action to correct safety problems can be justified on an economic basis.... (T)he higher cost of liability insurance or higher deductible limit resulting from a poor corporate accident record would be enough to offset much of the expense of corporate product safety efforts" ("Corporate product safety for farm and industrial machinery," Agricultural Engineering 52 [1971], p. 311).

view, besides being forced to deal with multiple cases with a late and slippery access to all pertinent details of each accident, the defendant also faced rules of discovery that put within plaintiffs' reach product safety information normally available only to the manufacturer. As he had put it a few years earlier:

> This is not a 'Perry Mason' day and age. Judges insist that they shall have no surprises developed by defense in a trial. In pursuit of that purpose, they are very firm in saying to the defendant: 'Tell this man, this plaintiff, anything he asks about your entire operation relative to this product. Tell him in writing what he needs to know.'
> Along with these interrogatories, plaintiff will ask you to produce documents -drawings, test reports, description of production methods and inspection procedures- documents that have even the least bearing on the product.
> Plaintiff's counsel can come to your office and pore through everything you have. In the process -perhaps in examining your warranty claims- he will come with supportive evidence he never thought of, evidence that will be helpful in his case against you.
> You can seldom claim successfully that some document is irrelevant because in many jurisdictions the judges are very liberal. They'll say: 'This is discovery, and we want plaintiff to understand your entire setup so that he can perfect his lawsuit against you. 77/

Other tractor makers' attorneys felt, by contrast, that it was companies' inability to provide a credible account of the accident, rather than plaintiff's free access to

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77.- Clare E. Wise, "Carnage in the courtroom," Machine Design 44 (4 May 1972), pp. 21-22.

companies' product safety information, which was the most troublesome aspect of litigation. Serious flaws in defendant's account often took place, as a Massey-Ferguson lawyer lamented, when paid experts did not fulfill their obligations and gave "their testimony 'off-the-cuff,' without researching the area of design involved, or applicable standards and regulations." 78/ Once the paid expert made his deposition prior to trial or an oral testimony in the courtroom, it was "up to the jury to weigh his opinion-testimony for whatever it [wa]s worth, and... up to the defense to disprove his testimony." 79/ An International Harvester lawyer advised other companies not only to "develop your own in-house experts for testifying in the courtroom [but also an] (e)arly feedback from your field organizations... to ascertain the condition of your manufactured product at the time of accident." 80/ An

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78.- James W. Klock, "The engineer as paid witness," Agricultural Engineering 55 (April 1974), p. 27. For a good description of the expected behavior of the expert witness from the plaintiff's perspective, see Harry M. Philo and Linda M. Atkinson, "The expert witness," Trial 14 (Nov. 1978), pp. 37-41. See also Thomas F. Talbot, "Your day in court," Machine Design 47 (6 Feb. 1975), pp. 68-72; Charles C. Bowman, "Expert witness fees for agricultural engineers," Agricultural Engineering 60 (Jan. 1979), pp. 22-24.

79.- Klock, "Paid witness," p. 27. See also Carlton Zink, "On the engineer as paid witness," Agricultural Engineering 55 (April 1974), p. 22.

80.- Paul C. Nelson, "Defense against product liability lawsuits," Agricultural Engineering 55 (July 1974), pp. 12-13. For similar statements see, e.g., Morse and

Allis-Chalmers attorney cautioned, however, that the lack of strict compliance with voluntary standards could seriously compromise the job of tractor makers' expert witnesses and recommended manufacturers to conform to "(s)tandards... accepted or promulgated by industry or professional organizations such as ASAE... if you expect to successfully defend a lawsuit where standards might become an issue." 81/

The outcome of legal actions against manufacturers of tractors involved in rollover accidents relied heavily on how juries might interpret conflicting testimonies, with verdicts uncertain and settlements showing wide fluctuations from case to case. Tractor manufacturers' expert witnesses, in growing numbers enlisted from companies' own engineering and design departments, worked in close contact with companies' attorneys to provide an account of the accident which often related it to operator misuse or failure to order rollbars when operating conditions made it advisable to purchase them. These claims were highly successful when plaintiff's evidence was deemed insufficient to show that a remedy was available at the time

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Melton, "Design of agricultural products," pp. 8-13; Gary A. Roberts, "Products liability: The engineer's role," ASAE No. 75-1552 (1975), pp. 4-7; Diedrichs "Background and team approach," pp. 6-11.

81.- John F. Friedl, "Products liability: A corporate lawyer's point of view," Agricultural Engineering 58 (Jan. 1977), p. 7.

of manufacture or that it was the tractor maker, rather than the farmer, who had failed to provide it. Circumstances such as bad weather, driving on steep slopes or slippery surfaces, operator's inexperience, poor judgment, behavior prior to accident or awareness of similar tractors with rollover protection were often sufficient for summary dismissal of plaintiff's claim. The job of tractor makers' expert witnesses was generally more difficult in liberal jurisdictions like California and New York, and manufacturers' lawyers made every effort to avoid them. Tractor makers' search for more favorable settlements or verdicts against plaintiff was also more difficult when facing a combination of claims on defective design and other legal theories, such as breach of contract or manufacturers' failure to warn. 82/

82.- Prior to the advent of products liability in the mid-1960s, courts customarily dismissed any legal action against tractor manufacturers for injuries sustained in overturn accidents. See, e.g., "Evidence held insufficient..." in Foster v. Ford Motor Co., 246 P. 945 (1926); "Negligence... held not established" in Ford Motor Co. v. Wolber, 32 F.2d 18 (1929). For a few successful suits, see, e.g., Hubner v. International Harvester Co., Calif. Alameda Cty. Super. Court, No. 415,444, Jan. 1974 ($ 150,000 for plaintiff); Kujawinski v. Clark Equipment Co., Ill., Cook County Circuit Court, No. 73L10214, Oct. 20, 1978 ($ 750,000 settlement). For a few unsuccessful actions, see, e.g., "(T)ractor manufactured in 1946 [was not] defective in that it did not have such safety features as roll bars or safety belts," Gates v. Ford Motor Co., 494 F.2d 458 (1974); "(P)laintiff... not entitled to recover..., evidence having raised neither a question of design conformity with established standards nor risk of injury that would

By the late 1979, however, tractor makers' engineers learned of three adverse court decisions ruling that it was the manufacturer, rather than the operator, who was clearly in a better position to reduce the risk of injury in an overturn. In Wagner v. International Harvester Co., a Minnesota jury awarded $ 1.6 million to a severely injured operator after a small crawler tractor overturned and crushed him while attempting to ascend on a moderate slope. In addition to the lack of overturn protection, the Model 500C tractor, manufactured in 1971, had a hot transmission fluid pipe with a breather cap located in front of the operator's seat, which spilled causing severe burns to the operator pinned beneath the crawler. As the Appeals' judge put it:

> In his lawsuit Wagner claimed breach of warranty, negligence and strict liability chiefly with respect to the instability of the crawler, the absence of rollover protection, and the design and placement of the transmission fluid filler pipe and breather cap. The jury... determined that the crawler was in defective condition when it left IHC's control because it was not equipped with a rollover protective device as standard equipment, and it found that the type or location of the transmission fluid filler cap and breather cap was a design defect.
> IHC failed to conduct certain tests that may have been relevant to the crawler's stability....

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have not readily perceived by plaintiff's husband," Owens v. Allis Chalmers Co., 268 N.W.2d 291 (1978); "(N)o danger inherent... but rather danger increased or lessened according to job and site for which the equipment was purchased and used," Biss v. Tenneco, Inc., 409 N.Y.S.2d 874, 875 (1978).

> Moreover, one of the plaintiff's witnesses testified that smaller crawlers like the 500C were less stable than large ones, and that consequently they could tip over more easily. A second expert witness echoed this testimony and stated that the diminished stability of a small tractor made rollover protection imperative. 83/

On appeal International Harvester attorneys argued, to little purpose, that "misuse was the proximate cause of Charles Wagner's injuries." 84/ Further, they contended that because overturn protection was available as optional equipment and "the danger of rollover and resulting injuries was within the contemplation of the ordinary consumer or crawler operator, [IHC] should not be held liable." 85/ The Court of Appeals dismissed the misuse argument countering that International Harvester "should have reasonably foreseen use of the 500C by operators having limited training and experience." 86/ The Court also rejected the other two contentions of International Harvester and ruled that

> The record reflects... that approximately 30,000 tractor operators had been crushed in rollover accidents since 1971. Although most of these accidents involved less stable wheeled tractors, the jury could consider that evidence and draw from it The conclusion that IHC should have foreseen rollovers of Model 500C crawlers.
> a manufacturer is liable not only for defects that cause accidents, but also for defects that

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83.- 611 F.2d 224, 228-229 (1979).
84.- Ibid., p. 229.
85.- Ibid., pp. 229-230.

> predictably enhance resultant injuries.
> In 1971, IHC did not offer a rollover protective structure satisfying Society of Automotive Engineers (SAE) standards as optional equipment on the 500C. We note in passing that IHC offered such rollover protective structures as optional equipment on all of its larger crawlers. The absence of such protection for the more vulnerable 500C supports the jury findings of... defective design....
> In sum, appellee Wagner presented testimony of expert witnesses together with other evidence from which the jury could conclude that... the 500C crawler [was] defective because it was sold without rollover protection. 87/

The second decision was the reversal, by the Arizona Courts of Appeals, of a summary judgement for the manufacturer in Chavarria v. Ford Motor Co. The summary judgment followed an Arizona Court decision entered a year earlier for the manufacturer of a 20-ton scraper which overturned, after plaintiff failed to show evidence that the absence of rollover bars rendered the scraper, made in 1961, defective and unreasonably dangerous. 88/ In Chavarria, however, the Arizona Court of Appeals held unanimously that evidence was probably sufficient for a jury to determine that the lack of a rollover protective system was both a design defect and the proximate cause of the death of a young operator of a farm

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86.- Ibid., p. 230.
87.- Ibid., pp. 230-231.

88.- Chavarria v. Ford Motor Co., 602 P.2d at 827 (1979). The decision invoked in Chavarria was Vineyard v. Empire Machinery Co., Ariz. App., 581 P.2d 1152 1978).

tractor manufactured in 1970. The Court of Appeals judge went so far as to claim that plaintiff's expert testimony clearly showed that the tractor involved in the accident had

> a dangerous propensity to overturn and to overturn quickly, leaving the operator no chance to escape. [The expert] believed that the tractor was so dangerous that a roll-over protection system should be included as standard equipment. He further stated that had the tractor been so equipped, he doubted the operator would have been killed.
> An eyewitness stated in her deposition that she saw the tractor traveling north on Harrison Road in the north-bound lane about 8 a.m. The weather was clear and dry. As she observed it traveling slowing down the street, the front end began to turn to the left. The tractor jackknifed, flew up in the air and then threw the driver to the pavement where he was crushed when it fell on him. The turning of the tractor, from her view of the accident, was not caused by the driver. Nothing untoward in the use of the tractor appears in her account.... (T)he 'jackknifing' of the tractor in the instant case seems inexplicable except for the inherent propensity of the tractor to overturn as stated by appellants' expert. This same expert stated in his affidavit that the tractor was unreasonably dangerous because an operator would not appreciate its propensity to turn over and the consequent necessity of a roll-over protection system.
> Based on the lack of a roll-over protection system and the evidence of the security provided by such a system, coupled with the propensity of the tractor to overturn, we find a genuine issue of material fact concerning the existence of a defect rendering the tractor unreasonably dangerous. 89/

The third decision was the reversal, in Caterpillar Tractor Co. v. Beck, of a reduced jury award for plaintiff

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89.- 602 P.2d at 827 (1979). No further published records follow after this case, which was most likely settled for an undisclosed amount.

based on what, according to the Alaska Court of Appeals, were improper instructions to the jury. In the view of the Court of Appeals, in these instructions neither defective design nor the contributory negligence of a purchaser-operator of a front-end loader which overturned was properly defined. After defining design defect according to a cost-benefit approach, the Court of Appeals ruled that "the manufacturer could not absolve himself of liability by expecting the purchaser to provide safety features." 90/ As the Court judge put it:

> If the focus is on the nature of the product as defective, and the jury has found the lack of safety device to render the product defective, it is inconsistent to turn around and reduce the user's recovery merely because he bought and used the product as marketed....
> Caterpillar was in a better position than the Beck family business to ascertain the risks and the means to avoid such risks. Caterpillar had access to

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90.- 593 P.2d at 891 (1979). According to the Alaska Court of Appeals, the problem of determining whether or not there was a design defect in cases such as the front-end loader, manufactured in 1964, had been subject to differing interpretations and doctrinal controversies until 1978, when a more consistent cost-benefit approach emerged in Barker v. Lull Engineering Co. (573 P.2d 443). For more details of this controversy, see, e.g., John Wade, "On product 'design defects' and their actionability," Vanderbilt Law Review 33 (1980), pp. 600-606; Page Keeton, "Product liability and the meaning of defect, St. Mary's Law Journal 5 (1973), pp. 30-39; Jerry J. Phillips, "Standard for determining defectiveness in products liability," University of Cincinnati Law Review 96 (1977), pp. 101-121; U.S. Department of Commerce, Interagency Task Force on Product Liability, Final Report, Nov. 1977, pp. II8-II12.

> statistics which afforded it the opportunity to balance risks and costs. Beck's business was family run with very little business sophistication. They operated with large deficits and lacked sufficient objectivity to evaluate whether their own expense in installing ROPS would be warranted....
> (C)omparative negligence cannot be used when the plaintiff's negligence was nothing more than knowledge of the defect. This is especially true when there is a large used equipment market. The buyer in that market is even less likely to have the data on the dangers of operating without ROPS and the means to forestall such danger. 91/

From FIEI engineers' perspective, courts' new focus on their companies' design decisions, rather than operator responsibility, was a likely source of unreasonably large jury awards and increased defense costs and damage to their companies' reputation. Even more troubling than tractor makers' enlarged responsibility was courts' increasing reliance on defendant's subsequent product improvements as evidence of design defect at time of manufacture. Tractor makers' attorneys often sought, to little avail, to persuade judges that, if the focus of products liability was on design decisions, post-manufacture knowledge was irrelevant and it was therefore unreasonable to use it as a yardstick of proper care. In Caterpillar Co. v. Beck, for instance, the Court of Appeals held, against Caterpillar arguments, that

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91.- 593 P.2d 871, 891-892 (1979).

> evidence of postmanufacture accidents... is admissible....
> Alaska Rule of Evidence 407... provides that in a products liability action evidence of subsequent changes is admissible toward the feasibility of alternative designs as well as defective conditions. Rule 407 is consistent with the majority of jurisdictions.... (T)he public policy assumptions justifying this evidentiary rule are [that] the normal defendant manufactures tens of thousands units of goods [and] will [not] forego improvements in its product, and risk innumerable additional lawsuits and the attendant adverse effect upon its public image....
> Evidence about the character of the product, as reflected in subsequent modifications or accidents, is highly probative in strict liability cases, and therefore is not excludable on relevancy grounds. We therefore hold that evidence of post-injury accidents and design changes is admissible as authorized by the trial court. 92/

FIEI engineers viewed the use of postmanufacture knowledge in litigation as economic nonsense and a clear abuse of the American legal system. They were particularly troubled with the speculative grounds on which courts determined design defects in old but still useful equipment, the wasteful nature of search for evidence, and the unpredictability of jury verdicts. As a Fiat-Allis senior engineer put it:

> It takes three to five years of very expensive effort by many people to close a single case, either in the courts or by negotiation. Product litigation [is] diverting a very large segment of our country's resources from productive endeavor into a costly, traumatic, adversary conflict that cannot continue

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92.- 624 P.2d 790, 793-794 (1981). The public policy assumptions invoked in Beck II are based on an earlier ruling, Ault v. International Harvester Co., 117 Cal.Rptr 812 (1975). See also note 90 above.

> to be afforded by the injured, the producer, or the public.
> One injured party will be denied recovery while another will be favored with a high settlement or verdict....
> More often than not settlements are related to the skill, thoroness, perseverance and luck of the attorneys involved in the case.... A great deal of time and effort are consumed in meticulous search thru mountains of data and documents for details attorneys feel are necessary under the name of Discovery in the search for facts and counterfacts. Our system for justice is now being used... to administer a system of reallocation of wealth from those who benefit from the machines (all of us) to those who are injured by machines (some of us). Gentlemen, the scales have been tipped too far. 93/

Most American tractor manufacturers' engineers took comfort in the belief that jury awards and settlements on overturn accidents would soon start to decline, if not in size, at least in number. Among the two major reasons for this belief was the growing number of large tractors with crush-resistant cabs their companies were producing and farmers eager to buy. A senior engineer from White Farm Equipment, a FIEI member company and major tractor manufacturer, claimed, for instance, at the ASAE Winter Meeting of 1980 in Chicago that "one million ROPS ha[d] been sold in the U.S. to date." 94/ While this claim included both

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93.- J. B. Codlin, "Hazard control," SAE Paper No. 80-0674 (1980), pp. 7-8. For similar statements see, e.g., Keith L. Pfundstein, "Incentives v. demands in offroad machinery safety," SAE Paper No. 80-0693 (1980), pp. 3-4.

94.- Frank Buckingham, "ASAE's accident reduction program ten years later: Progress and opportunities," Implement & Tractor 96 (7 Jan. 1981), p. 11.

protective cabs and the far less popular two-post frames, it was a typical expression of confidence on the declining number of overturn fatalities after a decade of participation in the ASAE voluntary program to reduce the agricultural death toll by half. Having missed their target, they remained nonetheless self-assured that the trend was definitely downwards. Other ASAE members and active standards setters, in particular agricultural safety specialists, were more cautious and felt that the huge population of old tractors without overturn protection left little room for complacency. They were also less sure about the commitment of tractor makers' sales departments and farm equipment dealers. As Rollin Schnieder put it:

> (S)ome well-trained farm equipment dealers do an excellent job of selling safety features... and make an honest effort to inform potential buyers. Other dealers have been much less effective in this area, and some manufacturers have been equally slow or reluctant to become involved in safety training for their dealers and customers.... 95/

The second reason for FIEI engineers' timid optimism was the enactment, by a number of state legislatures, of statutes setting time limitations ranging from six to twelve years

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95.- Ibid. See also "Engineering a safer food machine," Agricultural Engineering 61 (Oct. 1980), pp. 46-47; "A search for realistic safety concepts," Ibid., Vol. 62 (Jan. 1981),pp. 22-23; Richard G. Pfister, "Do tractors last too long?" Ibid., Vol. 54 (May 1973), pp. 12-13.

after product sale in which product liability claims could arise. Passed in a dozen states by 1982, these statutes of limitations constituted the most visible result of intense lobbying by chambers of commerce and trade associations like the FIEI. The most frequent reason invoked in their enactment was the need to spare manufacturers from litigation uncertainties related to products and equipment whose extended life span made them subject to extensive repairs and postmanufacture changes. Besides the clear advantage of reducing the risks of litigation to the more recent and therefore more traceable pieces of equipment, tractor manufacturers' engineers regarded these statutes as a much needed protection against courts' tendency to rely on postmanufacture knowledge to determine design defects. 96/

96.- At least some of the drafters of these statutes viewed time limits as complementary, rather than opposed to, the risk-utility balancing approaches increasingly favored by the courts. As Richard A. Epstein, one of the drafters of the New Hampshire statute, put it: "The cost-benefit formulations of product defects... ha[ve] led to an indeterminacy of outcome that makes categorical judgments about defects difficult, if not impossible, to sustain.... (A) jury (whose discretion, de jure and de facto, is broad) may routinely disapprove... the design adopted.... No one can say with confidence what warning or design would be sufficient unto the day to ward off liability.... The logic behind the statute is that [it] shortens the time frame, reduces the level of error, reduces the need to examine the conduct of intermediate parties, and clarifies the incentives upon the party in possession" ("Temporal dimension in Tort Law," University of Chicago Law Review 53 [1986], pp. 1202-1203, 1209). See also Gary T. Schwartz, "New products, old products,

In the late summer of 1982, however, FIEI engineers learned that their companies' lobbying efforts to reduce their increasing legal exposure to suits on old equipment had failed. To their dismay, a growing number of courts were striking down the statutes as unconstitutitional on the grounds of arbitrary deprivation of some citizens' right to equal access to the courts. In Lankford v. Sullivan, Long & Hagerty, for instance, the Supreme Court of Alabama unanimously overruled an Alabama statute that established that product liability suits could only "be brought within 10 years after the manufactured product is first put into use by any person or business entity." 97 In the view of Alabama Supreme Court, the statute was not only harsh and arbitrary, but also unwarranted even from a risk-utility balancing perspective, since detailed studies in insurance carriers' potential losses related to old products had "indicated that only 2.7 percent of the products involved in products liability actions were purchased more than six years prior to the injury-causing

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evolving law, retroactive law," New York University Law Review 58 (1983), pp. 842-852; Francis McGovern, "Variety, policy and constitutionality of product liability statutes of repose," American University Law Review 30 (1981), pp. 579ff; "On limiting product liability suits," Agricultural Engineering 57 (July 1976), p. 46; "FIEI in Washington," Implement & Tractor 92 (June 1976), p. 34.

97.- 416 So.2d at 999.

event." 98/ The court, however, pointed out that the harshness of the statute was even greater and more difficult to justify in the few cases of products whose useful safe life clearly exceeded the ten-year limit set in the statute. As an example, the court referred to a "study [which] revealed that 50 percent of all [farm] tractors surveyed had a life-span of more than ten years." 99/

For FIEI engineers, the new trends in product liability constituted an added economic uncertainty in the midst of a woeful situation created by the severe economic downturn of 1980. Most of them suddenly realized, amid a severe and seemingly endless recession, that their shared enthusiasm with the wealthiest and till then most dynamic segment of the

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98.- Ibid., p. 1002. Similar views were held by the Supreme Court of New Hampshire, which noted in Heath v. Sears, Roebuck & Co. that "a significant number of legislators expressed skepticism about the fairness of a State products liability law and about its effectiveness in stabilizing insurance rates for New Hampshire manufacturers" (464 A.2d at 293). The new Hampshire Court went further in pointing out "(t)he unreasonabliness inherent in a statute that eliminates a plaintiff's cause of action before the wrong may reasonably be discovered [and] denies equal protection of the laws under the New Hampshire Constitution" (464 A.2d at 295 and 298). See also Bolick v. American Barmag Corp., 293 S.E.2d 415 (N.C. 1982). For a skeptical view of the reasons invoked by both detractors and advocates of these statutes, see McGovern, "Policy and Constitutionality," esp. pp. 588-621.

99.- 416 So.2d at 1003.

American tractor market, while highly profitable in good times, left them exposed to a ruinous situation in times of recession. Deere chairman William A. Hewitt depicted the recession as "one of the most serious declines in recent history. The extreme high levels of competitors' inventories," he said, "has further aggravated the situation, leading to heavy price discounting." 100/ A few months later, a European marketing consultant visiting a Management and Marketing Convention in Las Vegas noted that "(t)he general concensus was that interest rates were unbearably high and cash flow hopelessly inadequate with dealers de-stocking and farmers holding back on purchases." 101/ Despite the general gloom, he added,

> European manufacturers' experience has proved they have an important advantage over the American producer. The USA chose to do things on a gigantic scale. Their farms are big, their tractors are big and so are their crops. But there are plenty of smaller farms not adequately catered for by the domestic industry. So long as the US manufacturer overlooks the smaller farms, British industry can step in to good advantage. 102/

100.- "Deere & Company reports income up by 10 percent in 1981," Farm & Power Equipment 73 (Feb. 1982), p. 17. See also Bill Fogarty, "How do major inventories look today?" Implement & Tractor 97 (21 April 1982), pp. 10-11, 22.

101.- John Colman, "A look at the North American market," Agricultural Engineer 37 (Summer 1982), p. 71.

102.- Ibid. For a good description of American tractor makers' expectations before the recession, see George McConeghy, "A fearless forecast of farm machinery in the 1980s," Implement & Tractor 92 (21 Jan. 1977), pp. 12-16.

As troubling as the prospect of foreign companies' growing dominance of the small tractor market was cash strapped farmers' preference for aged but still useful equipment. In early 1983 a Columbia University Business School professor addressed nearly 200 senior engineers and industry executives at a FIEI meeting in Naples, Florida. "In endgame," she told the audience, "strong firms possess the ability to re-position themselves to serve the most attractive market niches, since they have identified how demand will decline." 103/ Then she asked whether her listeners considered that their companies might find sensible a serious reduction of forces typical of an endgame business environment. Amid the growing pessimism, the majority of respondents felt inclined to agree they might. 104/ Most domestic tractor makers had to recognize that small Japanese and European tractors sold better than the typically larger U.S. brands. Further, their own marketing deals with foreign tractor makers to distribute small and more attractively-priced units and heavy price discounts on larger equipment had created a vicious circle of recurring losses, while leaving unaffected the huge mountain of inventories of old but much

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103.- Bill Fogarty, "Contemplating ag policy, impact of P-I-K, endgame strategies," Implement & Tractor 98 (March 1983), p. 14

104.- Ibid.

cheaper equipment. As a result, they became resigned spectators when many farmers began to turn to such equipment even though it was slower and less comfortable to operate and did not include overturn protection as the newer but more expensive tractors. As a manufacturer senior engineer put it:

> During the 1960's and 1970's, when the economy was expanding and farming was a profitable enterprise, the luxurious tractors were a viable means of inducing the purchase of integral safety features. However, as the economy became depressed in the early 1980s, many farmers reactivated the 'old reliables' produced in the 40's and 50's, which are more economical to operate and were also lacking many of the current technological safety features. 105/

In the summer of 1984 Deere top management started to reassess its long held policy of offering the two-post frame as an optional piece of equipment in its line of smaller tractors. As in the case of other major tractor makers, Deere's partial implementation of ROPS standards had long been a divisive issue in the company, with engineers and marketers offering opposing views on the merits and disadvantages of this policy. The long-term benefits of rollover protection as

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105.- W. C. Jackson, "A historical review of the evolution of farm tractors...," SAE Paper No. 85-1498 (1985), p. 11. See also Glenn Henseley, "What is the situation at the auctions?" Implement & Tractor 99 (April 1984), pp. 12-15; Scott R. Nesbit and Bill Fogarty, "volume is up but it is still a buyer's market," Ibid., Vol. 98 (July 1983), pp. 26-27, 41; "Tractors from Japan," Ibid., Vol. 94 (21 April 1979), pp. 8-10; "Ford aims at 30-90 hp market," Ibid., Vol. 97 (21 Jan. 1982), pp. 8-10.

standard equipment had been stressed by ASAE Safety Committee members for many years, but tractor manufacturers' marketing departments had fiercely opposed anything more than a voluntary commitment to promote it on an optional basis. This time, however, Deere marketing department objections, typically based on the prospect of slower sales, seemed unusually weak in the midst of a sales slump without precedent since the 1930s and the still escalating costs of litigation. 106/

The Deere announcement in November 1984 of its new marketing policy decision to sell all its tractors with overturn protection in place took the industry by surprise. After some hesitation, however, all other tractor manufacturers had decided by early March 1985 that they were ready to follow Deere's lead. Their shared determination to include overturn protection in all tractor models allowed no exceptions as even all smaller imported tractors of no less than 20 horsepower were included, and tractors sold for use in orchards and low clearance situations were also equipped with fold-down options. 107/ The decision, though posted as an

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106.- Arnold B. Skromme, "History of rollover protection for farm tractors, ASAE Paper IAS-86-111 (1986), pp. 16-17, 20; "Deere opts for ROPS all the way," Agricultural Engineering 65 (Dec. 1984), p. 31.

107.- Skromme, "History of rollover protection," p. 20. See

individual marketing policy by each company, was a collective admission that despite the still severe competitive pressures in the farm tractor market, no manufacturer could any longer afford to assume further legal responsibility for unprotected drivers. As a result of the tractor makers' collective decision, overturn protection became a uniform and permanent feature of the U.S. tractor dominant design.

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also Schnieder, "Overview of ROPS," p. 8; Lawrence Hodges, "ROPS history, personal recollections," manuscript enclosed in letter, Hodges to the author, 11 Jan. 1994.

CHAPTER 6
REDEFINING THE PROBLEM

In the early 1970s American tractor manufacturers' engineers began to re-examine the problem of rollover protection in the light of worldwide changes in the dominant tractor design. These changes originated not only in a continuous expansion of the international tractor trade, but also in the creation of foreign subsidiaries by a number of major American and European producers. Companies with plants on both sides of the Atlantic soon realized they shared a growing difficulty in taking advantage of interchangeability of parts and equipment and related economies of scale as long as a host of compatibility problems that plagued their North American and European operations remained unsolved. Among the problems American tractor makers' engineers had found the most difficult to tackle was the incompatibility of U.S. and European testing approaches to determine tractor safety and performance. Prior efforts under the auspices of the Farm and Industrial Equipment Institute (FIEI) to negotiate a common U.S.-European approach to test procedures and mutually acceptable ways of certifying results had failed amid disagreements on a range of intractable issues, such as the admissibility of voluntary compliance, the relative costs, practicality and reliability of the FIEI and European approaches, and the role of government agencies' in the

standards-setting process. FIEI engineers remained nonetheless convinced that only by redefining the scope of the rollover protection problem in terms compatible with overseas standards could they remove a nontariff barrier to a growing and mutually beneficial international tractor trade. 1/ This chapter examines FIEI engineers' shifting assumptions in their drive towards worldwide tractor test compatibility, and how their own promotional strategies led them to negotiate and ultimately commit themselves to test provisions and an implementation approach they had previously considered unacceptable.

In late October 1975 Herbert Sullivan, an International Harvester senior engineer and member of the FIEI Agricultural

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1.- On the rank of rollover protection standards and international trade in the priorities of U.S. major tractor manufacturers, see, e.g., "FIEI in Disney World," Implement & Tractor 89 (21 Nov. 1974), pp. 66-67. For an overview of the overseas production and marketing strategies of major American manufacturers till the early 1970s, see, e.g., Robert Kurdle, Agricultural Tractors (Cambridge, Mass.: Ballinger Publishing Co., 1975), esp. pp. 171-182. On the European approach to overturn protection tests, see, e.g., Harald A. Moberg, "Dynamic testing of tractor protection cabs: Development of method, practical experiences," Society of Automotive Engineers (henceforth SAE) Paper No. 73-0761 (Warrendale, Pa., 1973), pp. 5-10. See also Franklin C. Walters, "Agricultural, construction and industrial machinery organizations involved in international standards," SAE Paper 70-0104 (1970); T.C.D. Manby and John Matthews, "Development and operation of OECD Tractor Test Code," SAE Paper No. 73-0762 (1973).

ROPS Committee, traveled from Chicago to London to present a paper at a Conference organized by the British Institution of Mechanical Engineers. FIEI engineers regarded Sullivan's visit to London as an opportunity for the U.S. to persuade some key members of the European delegations to the International Organization for Standardization (ISO) that the technical superiority of the American approach to overturn protection warranted "international acceptance of the ASAE-SAE static procedure as an optional test standard." 2/ An earlier FIEI attempt, also made by Sullivan at an ISO meeting in Rome in 1972, had faced general European skepticism and objections raised by Swedish delegates concerning "the apparent lower energy specified compared to the energy available in the pendulum and the lack of performance experience with ROPS tested to the ASAE-SAE standard." 3/ This time, however, the occasion seemed more propitious, as all FIEI ROPS Committee members, including Deere engineers, had become firm supporters of the use of static test methods, especially in the case of large equipment. Further, they had learned, a few months prior to the London Conference, that Swedish engineers at the

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2.- Sullivan, "Structural strength tests for protective cabs for agricultural tractors using static test methods," Off-Highway Vehicles, Tractors and Equipment (London: The Institution of Mechanical Engineers, 1976), p. 51.

3.- Ibid.

National Testing Institute for Agriculture and Earthmoving Machinery (NTIAEM) were already running tests along the U.S. static test procedure and comparing results with the pendulum test procedure of the Organization of Economic Cooperation and Development (OECD). 4/

Another reason for FIEI ROPS Committee's cautious optimism was the expected impact of ISO new voting rules on the worldwide authority of ISO International Standards. Under the old rules, revoked in 1971, "for an ISO Recommendation to become an ISO Standard, no dissenting vote should have been cast by a Member Body during its circulation for acceptance by the organization." 5/ Given the wide economic and political differences among the 56 national member bodies represented in

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4.- Interview with Herbert Sullivan. Deere engineers's full acceptance of the static test method took place sometime in the early 1970s. As William J. Teaford, a senior engineer from Deere & Co, put it: "Based on my employer's early testing, our test option selection included a maximum of dynamic, low temperature testing... and a -18 *C field upset test.... We departed from that option only when tractor size became so large, and the pendulum mass remained restricted to 2t. To provide the required energy for large tractors the necessary lift height of a 2-t pendulum results in such high impact velocity that it is no longer a credible roll-over simulation.... For these large tractors our test option consisted of... a 115% energy static test" (Roll-over protective structures [ROPS] for wheeled agricultural tractors, ASAE Distinguished Lecture Series No. 18 [St. Joseph, Mich., 1993], p. 8).

5.- Lal C. Verman, Standardization (Hamden, Conn.: Archon Books, 1973), p. 157.

ISO, these rules had favored a situation in which ISO was issuing about 350 ISO Recommendations per year, each approved by a majority of 60 percent or more, but there were no ISO Standards. Under the new rules, the unanimity principle was abandoned, ISO Recommendations would cease to exist, and existing ISO Recommendations could become ISO Standards with a majority of 75 percent of national members' vote. The expected result of these changes was a more dynamic, effective and productive organization without the cumbersome approval procedures followed by international treaty organizations like the OECD. 6/

Sullivan's paper consisted in a detailed account of the American experience with static test methods with emphasis on the reliability and proven record of the U.S. testing approach. His audience, made up of 170 British engineers and about 20 delegates from other European countries, listened attentively as he provided a comparative view of the development of the static and pendulum test procedures in the previous decade. As a result of this experience, Sullivan pointed out, FIEI engineers had found

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6.- Ibid. See also Brian D. Wakefield, "Will ISO Standards bring U.S. to its knees?" Iron Age 215 (7 April 1975), pp. 43-45. For a comparative view of ISO and OECD workings, see Walters, "Ag machinery international standards," p. 1-8.

> the static test procedure to have the following advantages over the pendulum test:
> (1) Repeatability is improved with the elimination of variables such as lashing technique, tyre construction, inertia of cab assemblies when equipped with air conditioning equipment.
> (2) Range of tractor sizes suited to static testing is much broader....
> (3) Design data for ROPS development is more complete [as] the exact load at which a specific type of failure starts can be determined during testing of a frame. The test can be stopped at that point and design changes can be made before proceeding with additional loading. This type of development is not possible with the pendulum impact test procedure. 7/

Besides these practical advantages, Sullivan argued, FIEI engineers' confidence on the static test method had grown over the years with the remarkable consistency of their experimental results. This consistency defied, in his view, the relevance of some European contentions concerning the lack of reliability of this test procedure, based in particular on the admittedly much lower energy levels involved in this test method relative to those required in the pendulum test procedure. After readily recognizing that a full account of the differences in energy requirements for the two test methods was not available, he went further to emphasize that the best approach to overcome these objections and doubts consisted in "testing identical ROPS frames by both methods to

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7.- Sullivan, "Structural strength tests," p. 51.

correlate results." 8/ He documented a few severe accidents with cabs tested to the SAE-ASAE static test procedure, and claimed that in none of these accidents had the actual energy absorption by the cabs challenged the adequacy of the static test procedure. Sullivan concluded that, in view of this experience, it was sensible to assume that "approximately fifty percent of the total potential energy of the pendulum is absorbed by a conventional ROPS or cab structure during testing to the OECD code." 9/

The first commentary from the audience came from a NTIAEM engineer, who depicted Sullivan's paper as a contribution "of the greatest importance when dealing with the problem of how to create and internationally agreed method on static testing of ROPS." 10/ He also pointed out that practical experience in Sweden was indicating the inadequacy of the pendulum test method in the case of large construction machines. As he put it:

> Legal requirements for ROPS in that category of machines have existed in Sweden since 1 January 1975. The strength testing is at present carried out in accordance with the dynamic method. This method, however, creates problems when testing ROPS to heavy machines. The strain on buildings and test equipment can be high and cause safety problems

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8.- Ibid.
9.- Ibid., p. 53.
10.- "Discussion," Off-Highway Vehicles, p. 186

> during the test procedure. It is therefore desirable to replace the dynamic testing by a static procedure.
> A test rig for static testing has been constructed at our station in South Sweden at a place called Alwerp near the City of Malmö. The rig has been designed to meet the requirements for testing ROPS to machines up to a mass of 100,000 kg, which is equal to 220,000 lb.... The studies have concentrated to giving answers to the questions which arise when considering replacing of the dynamic procedure by the static one.... A report of the studies... will be available in English in the first two months of the next year. 11/

John Matthews, a British delegate from the National Institute of Agricultural Engineering (NIAE), also made a brief commentary emphasizing, by contrast, the divergent design approaches involved in the FIEI and European views of rollover protection. If adopted, he said, the FIEI proposal before ISO for a static test procedure would offer an inferior level of operator protection than existing OECD test provisions. At stake was, in his view,

> the policy to be adopted in relation to damage to the structure in the test. We are going into a situation where we have two very different policies -the policy... in relation to the [proposed] ISO code at least if there is any sort of damage, provided the energy is at fault- and the policy in the [European] pendulum tests which so far has been essentially to say that multiple rolls are a possibility and after the three blows which simulate one roll -in fact one rear turn and one side turn- when the structural integrity of the cab should be pretty much well unaffected and therefore we have strict limits about the cracks and tears which

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11.- Ibid.

arise. 12/

Two weeks earlier, Matthews had confidently predicted in a paper delivered to a NIAE Conference that it was only a matter of time before the static test procedure was adopted as part of OECD and ISO test codes. "Difficulties preventing immediate acceptance of existing codes," he said, "will be overcome and static testing will be accepted ultimately." 13/ These difficulties dictated, in his view, the need for additional research in areas such as "the correspondence between energy levels absorbed by the cab in pendulum tests and those specified in static tests, bearing in mind the sharing in the pendulum test between cab distortion and cab movement." 14/ As soon as these differences in energy absorption were determined, OECD Tractor Test stations using a recognized static procedure would ultimately offer an added level of operator protection

> since the static force may be applied beyond the minimum required to pass the test [and] it can be

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12.- Ibid., p. 188. On NIAE experience with antiroll bars and multiple rollovers see T. C. D. Manby, "Safety aspects of tractor cabs and their testing," Journal & Proceedings of the Institution of Agricultural Engineers 20 (Feb. 1964), pp. 56-59.

13.- Matthews, "Ergonomics of tractor design with regard to work-place environment," Agricultural Engineer 30 (Winter 1975), p. 105.

14.- Ibid.

> assured that the [cab] structural stiffness does not decrease significantly near the test limits and therefore lead to a risk of failure in a multiple rollover situation. 15/

European researchers' confidence on the energy assumptions of the OECD pendulum test procedure had declined as they concluded that it was severe enough only for small tractors. Despite these doubts, European delegates to the OECD and ISO continued to reject the FIEI suggested introduction of the SAE-ASAE theoretical notion of mass, related to both vehicle weight and power. This notion was, from the European perspective, a too eclectic and unscientific formula as to become any serious proposition on the basis of which to determine the level of protection afforded, especially in case of multiple rollovers. 16/ A group of NIAE

15.- Ibid.

16.- Contributing to this conclusion was undoubtedly the denunciation of University of Nebraska professor Steinbruegge concerning the inadequacy of the SAE-ASAE ROPS standards for tractor cabs. On the other hand, European researchers' skepticism about the SAE-ASAE theoretical notion of mass has not faded and still holds today, as Edward Fritz, FIEI ROPS Committee chairman, told me in an interview. This skepticism, however, prevailed against the background of European tractor makers' own concerns with the excessive complexity of OECD Tractor Test Code and its delays in terms of the approval procedure. See, e.g., R. Gueguen, "Les essais officiels de tracteurs agricoles selon le code O.C.D.E.," Bulletin d'Information du CNEEMA, No. 251 (Dec. 1978), esp. 53-54.

researchers, in close cooperation with Deere engineers from the U.S., had completed by 1973 an extensive study in the energy involved in tractor rearward overturns. They had found that "energy levels used so far in the test work may be sufficient for the smaller types of agricultural tractors but are inadequate for the heavier types of tractor now in common use." 17/ This conclusion, however, did not induce NIAE researchers to change their position on the SAE-ASAE formula for the pendulum rear impact, but to seek instead an alternative formula

> based on the weight of the tractor but also on the rotational energy generated during rearward overturning of the tractor.
> The formula... contains the value of the tractor wheelbase..., and gives considerably greater energy values for the heavier types of tractor than those specified in the current OECD code. The values proposed in the new OECD and ISO drafts... are calculated from the data provided by these studies. 18/

During the late fall of 1976 the FIEI ROPS Committee learned that a European ROPS Study Group had also recommended a new formula for uniform energy criteria for farm tractors of all sizes. The ROPS Study Group Report, written for the Commission of the European Economic Community (EEC), relied on simulation models and experimental work for the types of

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17.- Moberg, "Dynamic testing," p. 7.
18.- Ibid. See also Matthews, "Ergonomics," p. 105.

overturning accidents considered the worst in terms of the energy absorbed by the protective frames or cabs. By the time of their involvement in the EEC project, the ROPS Study Group members had already developed computer-run mathematical descriptions of tractors falling off steep banks and multiple rollovers on a uniform slope from a high initial speed, and regarded these two accident types as the severest for European conditions. Having run a limited series of multiple rollovers of experimental tractors with detailed measurements of impact force and displacement, the ROPS Study Group advised the EEC Commission of the use of a simplified energy/tractor mass formula of 1.75 Joules per Kg as the basis for a uniform EEC approach to static tests for rollover protection structures. 19/

FIEI engineers had good reasons to view cautiously

19.- C. J. Chisholm, "Effect of parameter variation on overturning and impact behaviour," Journal of Agricultural Engineering Research 24 (1979), p. 436; idem, "Mathematical model of tractor overturning and impact behaviour," Ibid., Vol. 24 (1979), p. 378. See also H. Schwanghart, "Experimentelle Untersuchung von Stossvorgängen im Boden und die Anwendung bei Berechnung eines am Hang seitlich Uberrollenden Fahrzeuges," Proceedings of 5th International Conference of International Society for Terrain-Vehicle Systems held in Detroit, Mich. (June 1975), vol. 3, pp. 811-830. On the extent FIEI engineering committees kept current of European regulatory trends, see, e.g., Bill Fogarty, "Conversation with Doug Hewitt," Implement & Tractor 88 (15 July 1973), p. 18.

European researchers' search for differing energy determination criteria than those American engineers believed were adequate. There was talk among members of U.S. delegations to some ISO Technical Committees (TCs) of an increasing difficulty in having their proposals duly considered when "EEC countries get together at informal meetings to write the standards which they present at an ISO meeting with six to 10 votes already in the bag." 20/ A senior engineer from a major U.S. farm tractor maker warned in a FIEI meeting that unless American delegates found ways of countering the European practice of bloc voting at ISO meetings and U.S. companies overcame their reluctance to adopt the metric system, the prospects of American standards being accepted in ISO would dim. As an example, he told the audience that "European tire manufacturers, dominating the ISO committee on tire standards, [we]re striving to get load rating standards for combines adopted that would mean an increase of at least 40 percent in the size and cost of S-P combine tires above what our experience in the U.S. found to be satisfactory." 21/ He went further to argue that

> (a)n indispensable portion of an engineer's... language is that of measurement, and in this regard

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20.- Wakefield, "Will ISO standards?" p. 46.
21.- Bill Fogarty, "Looking at research needs, the economy..." Implement & Tractor 90 (15 July 1975), p. 75 (statement of Lawrence H. Skromme).

> the U.S. is falling rapidly behind. The rest of the world is rapidly changing to a metric measurement system based on SI (Systeme International) units, with the U.S. the only major nation staying with the outmoded inch-pound system.
> (W)orldwide standardization... is based on metric SI units. European countries, with their long tradition of cartels, see this as an effective means of standardize the U.S. right out of their markets, which ultimately means all markets outside the U.S.
> (O)ur industry, FIEI and ASAE have all taken a passive approach to the metric changeover situation, (which) can prove disastrous to all our overseas business. 22/

Meanwhile, a simplified FIEI ROPS standard proposal was under consideration in both the SAE Tractor Committee and ASAE Power & Machinery Committee. The document, a proposed condensation of three existing SAE-ASAE standards on rollover protection was a result of FIEI ROPS Committee efforts to accommodate not only the demands of domestic tractor manufacturers and cab makers, but also of regulatory agencies, such as the Occupational Safety and Health Administration (OSHA), and the University of Nebraska Tractor Test Laboratory. FIEI engineers expected that the imminence of the document's approval and the broader domestic consensus on the technical merits of the upcoming standard would strengthen the U.S. position in ISO. 23/

22.- Ibid. p. 74-75.

23.- Individuals involved in the OSHA-Nebraska attempt to upgrade the SAE-ASAE ROPS standard were, as seen in previous chapter, University of Nebraska professors

During the early summer of 1977 both engineering societies, the SAE and ASAE, approved and released to the public a slightly amended version of the eight-page ROPS document submitted to them by the FIEI. Besides having a simplified format compared to that of the three standards it superseded, the new ROPS document included three major additions. These were a new static crush test somewhat analogous, though based on differing tractor mass assumptions, to that specified in the OECD test code, a clearly defined zone of clearance, and provisions for a Seat Reference Point defined in terms fully compatible with those of ISO Draft Standard 3462. 24/ A fourth important, even if seemingly minor, change was the low-profile use of inch-pound units of measurement, written in parentheses after the more prominent figures written in metric system units, which laid down all test requirements set in the new standard. An ASAE staff member referred to the advantages of the new standard compared

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George Steinbruegge and Rollin D. Schnieder and FIEI ROPS Committee chairman Wilbert Gipp. By 1975 the Nebraska ROPS research program organized by Steinbruegge was well under way, and had already enlisted the support of at least the majority of government employees and agricultural safety specialists serving on the OSHA Advisory Committee for Agriculture, appointed in 1972.

24.- The text of the SAE standard included a footnote pointing out that "consideration is being given to adopting the ISO definition when it is approved" ("Roll-over protective structures [ROPS] for wheeled agricultural tractors," SAE Standard J1194, SAE Handbook [1978], p. 40.48).

to the three documents it replaced in the following way:

> ASAE Standards on roll-over protective structures (ROPS) for wheeled agricultural tractors originally adopted in 1967 have been revised and combined as ASAE Standard S383....
> The new combined Standard includes a crush load of 1.5 times the gravity force of the tractor mass as part of the ROPS test requirements.... S383 is expected to be more acceptable internationally and more readily understood. The standard was proposed by the Agricultural ROPS Committee of the Farm and Industrial Equipment Institute and will be published by ASAE and the Society of Automotive Engineers (SAE). 25/

In the interim, however, FIEI ROPS Committee efforts aimed at bridging its differences with European delegates on the pendulum test procedure had come to a halt as a result of a new EEC Council directive. The directive, issued in the summer of 1977, ratified almost every provision of the existing OECD ROPS standard and prompted a de facto closure of negotiations between the FIEI and European delegations on the pendulum test method. While Council directives did not oblige EEC members to enforce them, unless they already had national regulations to the purpose, none of the existing or new regulations could contradict a Council directive once enacted. Despite these limitations, the directive, merely one among more than thirty implementing directives pending after an

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25.- Russell H. Hahn, "Progress Report," Agricultural Engineering 58 (July 1977), p. 29.

earlier general directive on tractor safety issued in March 1974, was a clear signal of a high level of policy consensus among EEC members, as the approval of any such directives could not take place over the objections of a single member country. For FIEI engineers EEC harmonization efforts covering European national tractor safety regulations even before these were enacted constituted a pathetic case of overregulatory zeal, which they were proud of having staved off in the U.S. To the FIEI ROPS Committee's comfort, the directive included tractors only in the range of 1500 to 4500 kg, which still left room for compromise on a common static test procedure for heavier tractors. 26/

26.- American tractor makers' engineers were not alone in their anxiety about EEC Council regulations. For a critical comment on the EEC harmonization and the market distortions it encouraged, see, e.g., B. Welz, "Müssen wir mit den Wettbewerbsverzwrrungen etwig leben? Vorschrichten und Normen bei Schleppern und ihren Geräten auf EG-basis," DLG Mitteilungen (6 Jan. 1977), pp. 18-19. See also Council of the European Communities, "Council directive of 28 June 1977 on the approximation of the laws of the Member States relating to the rollover protection structures of wheeled agricultural or forestry tractors," Official Journal of the European Communities 20 No. L220 (1977), esp. p. 3; idem, "Council directive of 4 March 1974 on... type approval of wheeled agricultural and forestry tractors," Ibid., Vol. 17, No. L84 (1974), pp. 10-24. On American engineers' views of European regulations for farm tractors, see, e.g., G. K. Heldt, "European requirements for tractor design," American Society of Agricultural Engineers (henceforth ASAE) Paper No. 79-1554 (St. Joseph, Mich., 1979), pp. 4-5; John A. Starkey, "Government requirements and voluntary standards -International considerations," SAE Paper No. 83-0386 (1983).

By the late spring of 1979 the FIEI delegation to ISO was disenchanted by the perceived delay in reaching compromise on any ROPS document for large tractors. There was, besides the ISO Draft Standard 3463, patterned along the OECD pendulum test procedure (for tractors up to 6000 kg.), only one ROPS-related document ("Seat Reference Point, ISO DIS 3462) which they could possibly consider as useful in defining a common zone of clearance for tractor cabs and frames. Given the European refusal to consider the American static test method as formulated in the SAE-ASAE standard, progress only seemed to occur, albeit slowly, as a result of earlier contacts by delegates of EEC member countries who met informally prior to the ISO meetings. The Secretariat of ISO Technical Committee on Tractors and Machinery for Agriculture (ISO/TC 23) had been held by a member of the French delegation since 1947, and the Secretariat for the Subcommittee on Safety and Comfort of the Operator (SC3) held by the British delegation since its inception in the early 1950s, a practice common to all ISO Technical Committees (TCs), whose secretariats usually remained firmly in hands of a particular country. In common with other ISO TCs having a steady record of annual meetings, the Working Group on ROPS (WG3) of ISO/TC 23/SC3 had submitted two successive versions of ISO DIS 3463 to the ISO Central Secretariat in Geneva, Switzerland, but to the satisfaction of the FIEI delegation, each version failed to gather the needed

75 percent of the votes from ISO member countries for it to become an ISO International Standard. The FIEI ROPS Committee was confident that, given the European failure to produce any alternative test procedure suitable for heavier tractors, the European delegation at ISO would ultimately have to settle for the U.S. superior technology. 27/

During the summer of 1979 two seemingly contradictory events upset FIEI ROPS Committee expectations on the inevitable success of the static portion of the SAE-ASAE ROPS standard. The first occurrence, to all appearances favorable, was the passage by U.S. Congress of the Trade Agreement Act of 1979. The new law was the culmination of a decade of multilateral negotiations of the U.S. government and its main trading partners, with all signatory parties in agreement that only a full recognition of ISO Standards could initiate a new

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27.- Interview with L. Dale Baker. By the late 1970s ISO standards-writing activities encompassed over 150 TCs, about 500 Subcommittees (SCs), and nearly one thousand Working Groups (WGs). The level of activity, productivity and complexity of each TC, SC and WG varied considerably from case to case. For a good account of ISO standards-making process from an ISO/TC 23 perspective, see Allen R. Dedrick, "Progress through standards: Its dynamic future national and international," ASAE Paper 82-5544 (1982), pp. 3-7. On accounts of the process based on other ISO TCs, see, e.g., Starkey, "Government requirements," p. 5; Wakefield, "Will ISO Standards?" pp. 43-47; Walt Crawford, Technical Standards (Boston: G.K Hall & Co., 1991), 2d. ed., pp. 116-120.

era of worldwide dismantlement of all technical barriers to trade. As former ASAE President Lawrence Hodges put it:

> "The act committed the US to join with many of the other industrial nations in a treaty commonly referred to as GATT (General Agreements on Tariffs & Trade). Section 413 of that act details actions to comply with the standards code of GATT. Since the US does not have nor do we want a Federal mechanism for the adoption of International Standards into the US National System, we must rely on the Standards programs of organizations such as ASAE, to provide the mechanism for recognition and adoption of International Standards into our National Standards. Th[is helped to] mature the ASAE standards development program and placed it squarely in the global arena." 28/

The second event was the approval by the EEC Council of a new directive establishing an alternative static test procedure for farm tractors. The test requirements of the directive presented major differences with respect to the static test portion of the SAE-ASAE ROPS standard. Among the greater and soon obviously unsurmountable disparities was a new energy/tractor weight formula based on the EEC ROPS Study Group recommendation, a higher zone of clearance (defined in accordance with both the British and OECD test code specifications), and the stipulation that "all structural members, joints, attaching brackets and parts of the tractor which transmit the loading force shall be free from cracks and

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28.- Hodges, "75 years of progress through standardization," ASAE Paper No. 82-5549 (1982), p. 15.

tears detectable by visual inspection." 29/ Other minor differences, such as the Council use of tractor weight, size and track width, rather than power, to describe the range of tractors included in the directive, and the use of differing specifications for beam size, surface covered and load location from those in the SAE-ASAE standard, were glaring signs of the limited degree of cooperation between FIEI engineers and European researchers. 30/

Having secured other EEC delegations' support for a new static test proposal, British delegates submitted a modified version of the 1979 EEC directive along with two other ROPS documents for consideration in the ISO deliberations in the summer of 1979. Only one of the three documents, the ISO Draft Standard on Seat Reference Point (ISO 3462), had the full backing of the American delegation. The other two proposals, a third version of ISO 3463 patterned along the

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29.- Council of the European Communities, "Council Directive of 25 June 1979 on... rollover protection structures of wheeled agricultural or forestry tractors (static testing)," Official Journal of the European Communities 22 No. L179 (1979), p. 4. Cf. "Rollover protective structures..." SAE Standard J1194, SAE Handbook (1978), pp. 40.48-40.54. See also Edward Fritz and William G. Switalski, "Small agricultural tractor ROPS -New operator protective zone," SAE Paper No. 91-1782 (1991), p. 8.

30.- Council of EC, "Directive of 25 June 1979," pp. 11-22. Cf. "Rollover protective structures," SAE Standard J1194, pp. 40.50-40.51.

OECD pendulum test procedure and the new document entitled "Protective Structures -Static Test Method" (ISO 5700), were slightly amended versions of the EEC directives of 1977 and 1979. While ISO 3462 was circulated among ISO national member bodies and approved in 1980 without FIEI objections, British delegates proposed to defer further consideration of ISO 5700 and ISO 3463 to the SC3 meeting of 1980, thus providing time for other delegations to determine the merits of ISO 5700 in the light of tests conducted in their own countries. In 1981, to the surprise of FIEI delegates, the EEC delegations had won the support of Eastern European countries and therefore sufficient votes as to obtain the approval of both documents as ISO Standards. "Our problems in ISO," lamented one of my interviewees, "started when we thought that we had a standard and expected that other countries would accept it; otherwise it would cost us money." 31/

31.- Interview with L. Dale Baker. Herbert Sullivan, another of my interviewees, hinted that they should not have been taken by surprise. In his view, both Eastern and Western European delegates at ISO shared similar views. Researchers from government agencies, he said, "were numerous in the U.K. delegation and about half of them in the German delegation. Only one third of French delegates were company people. In the Iron Curtain one hundred percent of the people come from the government.... They tend to disregard costs and... work in 'ivory tower' labs... In the U.S. [by contrast] the engineer is responsible to the industry and to the consumer."

Three years before the approval of ISO static test procedure (ISO 5700), C. J. Chisholm, a NIAE Tractor Department researcher and former member of the EEC ROPS Study Group, had completed an extended study in the behavior and impact sustained by overturning tractors. His research, funded by the EEC Commission and conducted in close coordination with the other two former members of the EEC ROPS Study Group, combined mathematical models and experimental work on tractors overturning sideways from a bank, one of the two worst types of rollovers singled out in a NIAE survey on tractor accidents in the U.K. His approach consisted in "the development of a mathematical model for overturning and subsequent impact... and experiments... to validate this model through the overturning of tractors fitted with experimental frameworks on which impacting forces and energies together with vehicle motions parameters could be measured." 32/ Chisholm's mathematical study soon evolved into computer-run simulation models based on earlier work developed in particular by researchers from Eastern Europe and in German and U.S. Universities. In his view, the combination of simulation models and experiments was the most reliable and expedient means of providing

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32.- "Tractor Ergonomics," Agricultural Engineer 29 (Spring 1974), p. 19

> standards committees, legislators and manufacturers with strength and deformation criteria likely to ensure a high level of protection for drivers in overturning accidents.... Simulation is needed to cover a wide range of conditions and to study the detailed effect of parameter changes. Experiments alone would have been too costly and time-consuming, and insufficiently reliable to meet these requirements. 33/

To Chisholm's surprise, his findings failed to corroborate the long held European assumption that single overturns were invariably less severe than multiple rollovers. After a round of 30 tractor rollover experiments conducted at NIAE, Sisloe, U.K., he concluded in the summer of 1978 that the safety frame of an experimental tractor of 3000 kg could absorb considerable levels of energy when it fell vertically onto a flat surface after overturning from a ramp similar to a 2 m-high bank. Chisholm reluctantly admitted that his findings could be interpreted as if undermining the validity of the EEC energy/tractor weight formula based on advice from the ROPS Study Group, and was quick to suggest that European large zone of clearance could make up for small inconsistencies in the EEC formula, especially in the case of smaller narrow-track tractors. As he put it:

33.- Chisholm, "Mathematical model," p. 375. See also idem, "Experimental validation of tractor overturning simulation," Journal of Agricultural Engineering Research 24 (1979), pp. 395-397, 412-413; idem, "Tractor overturning accidents and safety cab strength," Agricultural Engineer 36 (Spring 1981), p. 17.

> If a statistically reliable distribution of accident bank height existed it would be possible to choose a value to assure any given value of protection.... Accidents of the severity for which protection is required are so rare, however, that the parameters in this study are based on rather crude estimates. Impact energy in strength tests is related to protection only through the criterion of acceptable deformation, and it is unlikely that [European] standards committees would allow a significant reduction in the generous zones of clearance adopted at present.
> With these limitations it seems reasonable to take the linear regression through all data points as the basis of sideways energy criterion in strength tests. The energy/mass relationship of 1.80 J/Kg is surprisingly close to the value of 1.75 J/Kg recommended by the EEC study group partly on the basis of simulations of [multiple] overturns on a uniform slope. Since the two [accident] types produce characteristics with opposing curves, their combination in a single linear function appears to be logical, and the choice of a mean line rather than a maximum is justified by the factor of safety inherent in the zone of clearance. 34/

In the case of heavier tractors, according to Chisholm, the severity of certain types of multiple rollovers over a uniform slope could also increase in line with factors such as tractor weight and power or initial speed. Further consideration of a theoretical combination of these factors, as suggested in the SAE-ASAE formula, was nonetheless out of question, since European standards committees had

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34.- Idem, "Effect of parameter variation," p. 436. See also idem, "Experimental validation," pp. 411-412; idem, "Tractor overturning accidents," p. 20.

> shown an understandable reluctance to base ROPS strength test criteria on complicated formulae involving many parameters. The simplest analysis shows that several parameters are likely to influence overturning behaviour and the amount of energy absorbed in the ROPS, but only the tractor mass is included in the present formulae. The only exception is the [NIAE developed] formula for rear impact or loading, which takes into account the pitch moment of inertia or an estimate of it based on the wheelbase. 35/

Meanwhile, FIEI engineers were considering ways of broadening the scope of their deliberations as to formulate a common ISO strategy that included all relevant aspects of tractor testing. Having suffered a major defeat in ISO, the FIEI ROPS Committee felt it necessary to initiate information exchanges with other FIEI technical committees in order to build a more consistent American approach to ISO-OECD-European codes and regulations on tractor safety and performance. At the FIEI discussions, they learned that ISO adoption of the SAE-ASAE Test Code on tractor performance had failed to persuade European tractor testing authorities to make changes in their national codes or to promote changes in the OECD Tractor Test Code to accommodate the provisions of the ISO-SAE-ASAE test code. While both the SAE-ASAE and OECD test codes on tractor performance had a common origin in the testing program organized by the University of Nebraska in

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35.- Idem, "Effect of parameter variation," p. 417. See also "Tractor overturning accidents," pp. 19-20.

observance of a law enacted by the Nebraska Legislature in 1919, the Nebraska-SAE-ASAE test code and the OECD code had taken divergent paths since the late 1950s. To FIEI engineers' dismay, European growing support for the OECD test procedures, even as these differed markedly from the ISO-Nebraska test code, would continue to make test results in Nebraska and Europe impossible or difficult to compare. 36/

FIEI engineers' discussions extended for months, as they explored various alternatives to overcome test duplication and the problems created by the overlapping functions of ISO and OECD test codes. At the meetings, Franklin C. Walters, a senior engineer from Deere & Company and Secretary of ISO TC 23/SC 2 on Common Tests, argued that, despite the staunch support of European testing authorities for the OECD Test Code, the FIEI had to stick to ISO standards. He further contended that FIEI committees had to work in closer contact with European trade associations, in particular CEMA (European Committee of Associations of Manufacturers of Agricultural

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36.- Russell Candee and Franklin C. Walters, "History of SAE Agricultural Tractor Test Code," SAE Paper 80-0930 (1980). See also Herbert D. Sullivan, "Role of the U.S. tractor industry in OECD testing," ASAE Paper No. 88-1508 (1988), p. 3; Lester F. Larsen and Louis I. Leviticus, "Thirty years of Nebraska tractor testing," ASAE Paper No. 76-1045 (1976), esp. pp. 10-12; Manby and Matthews, "Development of OECD Test Code," passim.

Machinery), to persuade European national authorities to recognize not only the ISO ROPS Standards but also

> Agricultural Tractor Test Code ISO 789 as it now exists or as revised. The present situation involves testing to various national and technical codes. This duplication results in unnecessary expense to the customer and utilization of resources that could be used more advantageously. Increasing world tractor trade continues to add complexity to the situation.
> There should be reciprocity in acceptance of test results between test stations and government bodies. Testing to a common ISO code to which all interested groups have had opportunity to make input... could be the basis for reciprocity of acceptance of test results. 37/

Walters' support for ISO standards had the backing of most FIEI engineers who regarded ISO procedures preferable to those of treaty organizations like OECD not only on the grounds of a shared voluntaristic ideology, but also because ISO could make better use of companies' technical competences. As a nongovernmental organization, they argued, ISO technical committees were in position to make sense of both manufacturers' concerns and the challenge of coping with an increasingly specialized knowledge. As the FIEI Engineering Policy Advisory Committee chairman had put it three years earlier:

37.- Candee and Walters, "History of SAE Code," p. 6.

> Fifteen years ago, technical standards development was much simpler.... Participants... were well qualified technical persons with a high degree of knowledge about the entire machine.... Today's standards activities involve skilled engineering and often legal persons plus specialists like an hydraulics person....
> The voluntary system... assures that the most knowledgeable skilled people for each of our companies can contribute expertise in the development of good technical standards.... 38/

And again:

> Worldwide standardization is on a rocket going straight up, in both numbers of [ISO] international standards and importance.... In the coming five years..., our current involvement must be at least doubled.... 39/

By late 1981, FIEI ROPS Committee members concluded that the whole process of rewriting the SAE-ASAE ROPS standard to make it ISO compatible only made sense if it could also ensure an end to tractor test duplication in U.S. and Europe. At stake were not only existing discrepancies between the ISO-Nebraska test rules and OECD Test Code on tractor performance, but also how to overcome EEC regulatory agencies' refusal to accept American manufacturers' self-certification practices.

38.- Bill Fogarty, "FIEI Marketing and Management Conference," Implement & Tractor 93 (March 1978), pp. 12-13 (statement of John H. Zich).

39.- Ibid., p. 12. For similar statements see, e.g., J. E. Reed, "Worldwide Standardization -Commonality and Economy," Agricultural Engineering 50 (May 1978), pp. 22-23.

In contrast with both OECD tests on tractor safety and performance and Nebraska tractor tests on tractor performance, which took place in government laboratories (and results certified by an official agency), the implementation of SAE-ASAE ROPS test procedure was voluntary and, when undertaken, manufacturers' entire responsibility. Given U.S. product liability laws, however, no manufacturer of tractors would dare to pretend compliance with SAE-ASAE ROPS standard, and the risk of litigation had already become an effective means of enforcement, at least in the case of tractor cabs. The lack of similar liability laws in Europe created nonetheless a serious credibility problem for American self-certification claims in EEC tractor markets. 40/

As the ISO-related talks proceeded, it also became clear that overcoming the reservations of some FIEI member companies on making changes to the existing SAE-ASAE ROPS standard was more difficult and time-consuming than anticipated. The farm equipment industry was facing the severest economic downturn since the 1930s and all major tractor makers felt compelled to engage in harsh cost cutting to curtail losses and avoid bankruptcy, in some cases to little avail. Many FIEI

40.- See, e.g., Heldt, "European requirements," pp. 4-5; Sullivan, "Role of tractor industry," pp. 3-4; Starkey, "Government requirements," pp. 2-5.

engineers started to consider that the ways "this industry's farmer-customers [had to] operate in the 1980s w[ould] remain vastly different from that to which we became accustomed in the 1970s." 41/ With bloated inventories and highly uncertain prospects for exports, some financially troubled companies were hostile to the adoption of new costly test provisions which they regarded as a low priority and should wait till better times. FIEI President Emmett Barker also started to worry about the impact of early retirements on FIEI committees' ability to promote a long-term perspective of industry problems and to negotiate effectively with other groups and organizations. Early retirements, he pointed out, were

> causing us to lose key people who possess the 'lore' of the industry. Their unique contributions cannot be replaced with younger people no matter how well trained in current technologies. This is not easily understood until an appreciation is gained on how complex the interrelationships are between FIEI and many other groups who have programs impacting our vital interests, e.g., ASAE, SAE, ISO.... 42/

41.- Bill Fogarty, "The seventies are over," Implement & Tractor 98 (July 1983), p. 30.

42.- Idem, "In good health to face important challenges," Implement & Tractor 96 (Feb. 1981), p. 21. On large and small companies' attitudes to the recession, see, e.g., Jill Betner and Lisa Gass, "Planting deep and wide at John Deere," Forbes (14 March 1983), pp. 119-122; "Is the choice consolidation or cataclysm?" Implement & Tractor 98 (May 1983), pp. 5-6.

In the summer of 1984 the OECD Council approved the adoption of a static test procedure which, as FIEI ROPS Committee expected, was a slightly amended version of the ISO Standard. The OECD Council decision was in close correspondence with an EEC directive, approved two years earlier, that authorized EEC members to "prohibit the entry into service of tractors on which the rollover protection structure does not comply with provisions of this Directive." 43/ Having changed their strategy from hostility towards EEC and OECD test codes to a cautious support for ISO 5700, the FIEI ROPS Committee realized that OECD ratification of ISO ROPS standards added a sense of urgency to the difficult task of writing and promoting an ISO-compatible standard. While a handful of senior engineers representing global players, such as Massey-Ferguson, International Harvester, John Deere, J.I. Case, and Ford became strong advocates of a new ISO compatible standard, earlier proposals by the drafting committee had faced the hostility of FIEI engineers representing smaller companies, who favored the existing standard and submitted

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43.- EC Commission, "Commission Directive of 15 Dec. 1982 adapting to technical progress Council Directive... relating to the rollover protection structures of wheeled agricultural or forestry tractors," Official Journal of the European Communities 25 No. L386 (1982), p. 31. See also OECD Standard Codes for the Official Testing of Agricultural Tractors (Paris: OECD, 1988), pp. 9, 141ff.

numerous negative votes. These votes often included detailed rationales that slowed down the process as these compelled the drafting committee members to negotiate amendments before resubmitting the draft to the higher levels of the FIEI hierarchy of technical committees. "Harmonization was difficult," told me two of my interviewees. 44/

While the drafting committee persevered in its efforts to overcome internal objections to its new ROPS proposal, parallel discussions at FIEI on how to deal with the discrepancies between ISO and OECD test codes continued. Participants in these discussions, led by Herbert Sullivan and Franklin Walters, were concerned with the growing worldwide recognition, even among non-OECD members, of the OECD tractor test codes on both tractor performance and rollover protection. They concluded that, in the light of this recognition and the lack of acceptance of ISO-Nebraska tractor tests in many important markets outside North America, the FIEI had little choice but to promote the participation of U.S. as a full member of the OECD Tractor Test Scheme. To

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44.- Interviews with Herbert Sullivan and L. Dale Baker. With considerably less R&D than the first SAE-ASAE standards on overturn protection the development of the ISO compatible standard went, according to Sullivan, through six or seven FIEI drafts compared to three in the first ROPS standards of the 1960s. See also Fritz and Switalski, "Small agricultural tractor ROPS," p. 1.

this purpose, they agreed to constitute

> the FIEI Third Party Review Task Force to develop a system for conducting and certifying OECD performance and ROPS tests at manufacturers' tests facilities. Our intent was for the U.S.A. to participate actively in the OECD testing program. We met several times with John Lien of the U.S. Department of Commerce to work out details and obtain the full support of the U.S. government. We negotiated back and forth to find common ground between U.S. test organization proposals and acceptance conditions of Common Market officials in Brussels whenever we were in Europe for ISO or OECD meetings. 45/

Meanwhile, the status of the SAE-ASAE-ISO 789 test code on tractor performance was being challenged in other ways. The significance of this code had been its use as the basis for the official rules of the University of Nebraska tractor testing program, which certified whether each tractor tested to this code met its advertised claims. Until the early 1980s, Nebraska Test Laboratory officials had confidently depicted the tests as having reached such worldwide preeminence that it was common practice of some countries to "import tractors only if accompanied by a test report." 46/

45.- Sullivan, "Role of tractor industry," pp. 3-4. Other FIEI engineers who participated in the Third Party Review Task Force were Max North of J.I. Case, Art Tobiassen of Ford, Williard Jenkins of Deere, Donald Painter of Massey-Ferguson and Marvin Pribyl of Deutz-Allis. See also Kenneth von Bargen et al, "Nebraska Tractor Testing Beyond 1985," ASAE Paper MCR- 86-109 (1986), p. 3.

46.- Louis I. Leviticus, "Sixty years of tractor testing," Farm, Ranch and Home Quarterly (Feb. 1980), p. 14. See also Larsen and Leviticus, "Thirty years," pp. 3-11.

With increasing tractor imports to the U.S., however, foreign manufacturers felt that the costs of having their tractors tested in Nebraska in terms of test fees and delays in bringing a new model to the U.S. market were unwarranted when the same model had already been tested to the OECD code. As more foreign tractors kept coming to the U.S., Nebraska Test Laboratory officials felt they were in an increasingly vulnerable position vis-a-vis the claims of irrelevance made by manufacturers with tractors tested to the OECD code. "Of the tractors sold in the United States," they had to recognize, "most small tractors are manufactured in Japan, most mid-sized tractors are manufactured in Europe while only some of the larger two-wheel and four-wheel drive tractors are still manufactured in the United States and Canada." 47/ Further, in contrast with OECD-related tractor test regulations which were nationwide or even multinational in scope, Nebraska sales permits were circumscribed to a small portion of the North American tractor market, since Nebraska was "the only state in the US with a requirement that agricultural tractors have a power and fuel consumption test." 48/

47.- Von Bargen et al, "Nebraska Tractor Testing," p. 2.

48.- Ibid., p. 3. See also Gary Burchfield, "New role for Nebraska Lab," Implement & Tractor 106 (Nov. 1991), p. 1, 23.

In April 1985 the Nebraska Legislature passed Resolution 99, which called for a review of the Tractor Test Law to determine its possible repeal or changes in the statutes that could accommodate manufacturers' most pressing concerns. For the FIEI Third Party Review Task Force the perceived indecisiveness of Nebraska legislators was a suitable occasion to redefine the tractor testing problem in terms of worldwide uniformity based on the OECD codes. As Herbert Sullivan, then FIEI Task Force chairman, put it:

> The complete review (Resolution 99) of the Nebraska test law, we thought, presented an opportunity to... revise the law to accommodate an OECD test scheme in the U.S. With full FIEI Board approval, our task force negotiated with the University of Nebraska and the State Legislature to achieve our goal of eliminating the costly and time-consuming duplication of testing in the U.S. and Europe. 49/

The rapidly declining proportion of world tractors being produced in the U.S. added a sense of urgency to FIEI Task Force efforts to promote the implementation of all OECD codes, including ROPS. For these codes to remain a cost-effective choice vis-a-vis the SAE-ASAE standards on tractor safety and performance, the FIEI had nonetheless to first find a way of

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49.- Sullivan, "Role of tractor industry," p. 4. For similar but considerably less detailed accounts of these negotiations, see Von Bargen et al, "Nebraska tractor testing," pp. 2-4; Kenneth von Bargen et al, "Tractor testing at the University of Nebraska," ASAE Paper 88-1510 (1988), pp. 2-3.

certifying test results that was both credible and acceptable to EEC regulatory agencies. Among all foreseeable alternatives, the most attractive was to enlist the support of University of Nebraska testing program. Herbert Sullivan described FIEI engineers' negotiations on the utilization of the program facilities and personnel as follows:

> Several meetings were held with the University and Legislature officials to assist them in working out the enabling legislation that would be needed. The result was Legislative Bill 768 which was signed into law April 18, 1986. During the rest of 1986 FIEI and the University negotiated test fees and procedures. Those were our most challenging times. The proposed fees were too high and the rules were too restrictive in the opinion of the industry. Further, the role of FIEI as the 'Designated Authority' [of the U.S. at the OECD] was being contested by the University of Nebraska. Matters were complicated by the news media moving in to cover the disputes with some very yellow journalism. They escalated the disputes by creating a perception of all-out war.
> The industry, having no alternatives, made it known we were negotiating an agreement with other agencies (such as SAE) to witness and certify our testing at manufacturers' test sites. The University threatened, through its friends in the Legislature, in the form of a proposed bill, to do away with the OECD recognition and to reinstate the old Nebraska test requirements. The amendatory legislation eventually was withdrawn.
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> Both sides knew that all options and appeals had been fully investigated at state, federal and international levels. Having reached a point where there appeared to be essentially no mutually acceptable alternatives, all parties began to negotiate point-by-point in earnest. In the following year, 1987, an agreement was reached, although many thought it would never become a reality. It was subject to final review by the FIEI Board of Directors, the U.S. Department of Commerce and the University of Nebraska. The final documents

> [were] signed by FIEI and the University on August 5, 1987.... 50/

While the FIEI-University of Nebraska negotiations proceeded, the SAE Tractor Committee had already under consideration an ISO-OECD compatible ROPS proposal submitted by the FIEI. The twelve-page proposal, entirely written in metric terminology, was intended to replace the existing eight-page SAE-ASAE ROPS standard in most applications, except in low profile tractors and tractors with rear wheels' tread of less than 1115 mm (or about 3 ft 8 in). 51/ Among the most contentious provisions was the requirement for a considerably higher clearance zone, which prescribed major changes in long-established design practices for cabs and protective frames. This clearance zone, patterned on the British ROPS standard written two decades earlier, was intended to provide full protection without requiring the operator to use a seat belt. 52/ In contrast with the existing SAE-ASAE ROPS standard it

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50.- Sullivan, "Role of tractor industry," pp. 4-5. For Deere engineers' perspective of what was accomplished, see Page L. Bellinger, "Improving product safety and productivity through standards," ASAE Paper No. 87-5530 (1987), p. 5. See also Von Bargen et al, "Nebraska Tractor Testing," pp. 4, 6.

51.- "Roll-over protective structures (ROPS) for wheeled agricultural tractors," SAE Standard J2194, approved in Dec. 1987, SAE Handbook (1989), p. 39.53.

52.- Paul D. Ayers, Monte Dickson and Steve Warner, "Model to evaluate exposure criteria during Roll-Over Protective Structures (ROPS) testing," Transactions of ASAE 37

was aimed at replacing, the proposal also established three rather than two optional test procedures, any of which would suffice as a condition for acceptance. These included a dynamic (pendulum) test procedure or a static laboratory test, in addition to a separate field upset test procedure. The proposal, however, also cautioned that the new standard was only ISO-compatible to the extent that "(a)ny ROPS meeting the performance requirements of ISO 5700 (Static ROPS Test Standard) or ISO 3463 (Dynamic ROPS Test Standard) meets the performance requirements of this SAE standard." 53/ Given major tractor manufacturers' reservations about the costs and reliability of the field overturn test procedure, its inclusion as an optional test procedure seems a likely concession to some manufacturers that remained unconvinced of the ISO-OECD formulae. In any event, American tractor makers' engineers were confident on the superiority of the FIEI proposal with respect to ISO 5700 and ISO 3463, as these would conform to the proposal only "if the ROPS temperature/material

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(1994): 1763-1764. See also Fritz and Switalski, "Small agricultural tractor ROPS," p. 1; Trudy Karlson and Jay Noren, "Farm tractor fatalities: The failure of voluntary safety standards," American Journal of Public Health 69 (1979), esp. p. 148.

53.- "Roll-Over Protective Structures," SAE Standard J2194, p. 39.52.

and seat belt requirements of this SAE standard are also met." 54/ The FIEI standard proposal was finally approved, with minor amendments, by the SAE Tractor Committee in December 1987.

Having secured SAE approval for the new ROPS standard and a certification approach compatible with OECD test rules, the FIEI ROPS Committee expected that ASAE subsequent ratification would strengthen the case for OSHA recognition. Some extension safety specialists and active members of ASAE standards committees joined FIEI ROPS Committee's optimism and celebrated the efforts to create an ISO-compatible standard as evidence that American professional societies were "moving from the isolationism of the United States to world standardization." 55/ ASAE approval, however, was slow to come, and similar complaints as those encountered at FIEI resurfaced. Among the objections were the confusion and likely implementation problems created by two parallel ASAE ROPS standards, the entire metric orientation of the new proposal, and its redundant character given the proven record of the existing ROPS standards. 56/ The proposal was

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54.- Ibid.

55.- Rollin D. Schnieder, "Future direction of agricultural safety," ASAE 87-5531 (1987), p. 5

56.- These complaints were still voiced in various committee

approved by the ASAE Power & Machinery Committee in March 1990, nearly a decade after the first ISO-compatible draft proposal prepared for the consideration of the FIEI ROPS Committee. 57/

After the ASAE approval, FIEI engineers turned their attention to finding ways of persuading OSHA to recognize the ISO compatible standard. Having tested their tractors to the ISO ROPS standards at companies' facilities witnessed and certified by University of Nebraska Testing Laboratory officials since 1988, FIEI engineers felt they had good arguments to convince OSHA of the unneeded costs for American farmers created by test duplication in the U.S. and Europe. FIEI engineers had found that, despite its earlier reputation for adversarial attitudes towards business, OSHA was following a consistent policy of updating its standards for technical progress, wherever possible in accordance with existing voluntary standards. In the summer of 1990, a senior engineer from Deere & Company initiated, on behalf of the FIEI and the SAE and ASAE technical committees, a formal request indicating

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meetings two years after the standard approval. I was present at these meetings when I concurred to the ASAE Summer Meeting of 1992 in Nashville, Tenn.

57.- "Roll-over protective structures (ROPS) for wheeled agricultural tractors (ISO compatible)," ASAE Standard S519, ASAE Standards (1991), pp. 305-315. See also Fritz and Switalski, "Small agricultural tractor ROPS," p. 1.

the need for OSHA to adopt the new SAE-ASAE ISO-compatible standard in order to update OSHA's own ROPS standard. The new ROPS standard, as he wrote in a letter to OSHA,

> provide[s] for protection at least equivalent to the 1975 OSHA standards.... Unfortunately, since the OSHA standard is not in harmony with... ASAE/SAE and ISO (international) standards, manufacturers in the U.S. and other countries must also conduct the unique OSHA test for rollover protective structures for tractors to be used in U.S. worksites covered by OSHA. That adds unnecessary time and expense to the development of operator protection. The OSHA standard... creates a barrier to trade and increases the cost of safety devices to U.S. farmers.
> Please initiate action to issue and distribute an administrative letter which... harmonize[s] the OSHA standard with worldwide standards for tractor rollover protection structures.... 58/

OSHA officials' response to FIEI engineers' request was receptive, but they conditioned acceptance upon receiving further information against which to compare and evaluate FIEI claims of equivalent protection. FIEI ROPS committee members agreed to make this information available and arranged a series of tests for three differing tractor models according to both the new and the old standard, correlated results and

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58.- Page L. Bellinger to Gerald F. Scannell and Robert A. Mosbacher, 25 June 1990. See also Sullivan, "Role of tractor industry," pp. 6-7; Jimmy L. Butt, "Place of standards in agricultural engineering," Literature of Agricultural Engineering, Carl W. Hall, ed. (Ithaca, N.Y.: Cornell University Press, 1992), esp. p. 205.

submitted the data to OSHA. Months elapsed without response, till late 1991, when Edward Fritz, FIEI ROPS Committee chairman received the long awaited favorable reply. In the letter, OSHA officials pointed out that for administrative reasons farm tractor makers' request for equivalency

> required an evaluation of the new standards by OSHA to assure that the requirements for agricultural wheeled tractor ROPS continue to be acceptable.... The assessment has shown that the current ROPS structures... provide superior safeguarding of exposed workers compared to the previous requirements of the SAE or the OSHA standards. The test results and supporting data reflecting the required ROPS modifications, provided by three principal manufacturers of tractors in the United States, were most convincing. In every case, the tractor ROPS which could withstand the qualifying tests for OSHA/SAE J1194 approval failed when tested against the new requirements. Also, in every case, the solution for acceptance under the new standards required that the rear-most structural portion of the ROPS be strengthened significantly. 59/

Having accomplished a full recognition, by U.S. regulatory agencies, of the ISO ROPS standards as an optional test procedure, American tractor makers' engineers could feel that their collective investment was warranted. They had succeeded not only in negotiating an overturn protection approach that was compatible with the worldwide dominant tractor design, but also in persuading their domestic audiences of the virtues of their new global perspective. Yet

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59.- Patricia K. Clark to Edward A. Fritz, 5 nov. 1991.

the price they had paid in their drive towards ISO-OECD compatibility was heavy. They had agreed to subject themselves to the rules of a multinational regulatory scheme whose complexity and lack of practicality they once abhorred, and whose implementation in the U.S. was a de facto recognition of the end of their role as independent decision makers they had prided themselves in a nonregulated industry. Even though the new SAE-ASAE ROPS standard was compatible with overseas standards based on worldwide consensus, in many respects this document had also become a mandatory-like standard, rather than a voluntary standard.

CHAPTER 7
THE POLITICS OF SECRECY AND PRODUCT DESIGN COMPATIBILITY. CONCLUSIONS

Standards setters' deliberations constitute a both a form of knowledge sharing and a collective commitment to solve the compatibility problems of a dominant product design. Despite the twists and turns of these forms of collective commitment, there were in the case of the deliberations leading to rollover protection standards three main elements that exhibited remarkable continuity through the period under study. The first was the hierarchical character of the exchanges of knowledge which participants used to agree on industrywide changes in product design; the second was participants' systematic withholding from nonparticipant groups all the particulars of their deliberations to the purpose of ensuring both an orderly search for agreement and the industrywide character of their proposed changes in product design. The third constant was the steady shift of focus from the problem of ROPS-implement compatibility to the problem of how to make the dominant tractor design more compatible with a changing legal order. This shift took place in the background of overall changes not only in the average size and power of the American farm tractor, but also in the scope and nature of the international tractor trade.

The first constant feature in the process of developing American standards on rollover protection was the hierarchical character of knowledge sharing. The higher the rank of participants the more frequent and comprehensive were their knowledge exchanges and the greater their likely impact on the dominant tractor design. Considerable knowledge sharing, for instance, took place initially at the level of the drafting committee while its members were seeking a common, though still rough, description of the overturn protection problem and a tentative definition of the scope and terms of the proposed design changes. Committee members regarded knowledge sharing as the basis on which to agree on an initial description of the overturn protection problem that could accommodate their companies' disparate concerns with the marketing and cost implications of the proposed changes. Information exchanges followed an exploratory pattern and were project-oriented in the sense that

> members [were willing to] bring to the committee their experiences, the literature at their disposal, and tests they ha[d] been conducting.
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> The Committee reviewed Swedish and British codes to determine their acceptability. [But] they were not adaptable; owing to their lack of inclusion of technical information, they were limited to a four-post design [which] infringed on several implement mounting points on Unites States tractors.
> The Committee reviewed all available test and accident literature pertaining to tractor upsets. Several manufacturers run upsets tests on their own tractors to determine various factors that play a role in design and testing....

From the many tests, a proposal for a standard emerged. 1/

Once a proposal was available or the standard up for revision, however, the document became the basis for further knowledge trading. High-level participants learned not only about most of the assumptions and some of the facts embodied in the new proposal as portrayed by its promoters, but also about other parties' concerns. Knowledge sharing became issue-oriented, rather than project-oriented, and frequent changes in the proposal, according to how issues were resolved, created shifting expectations among individual participants on the ultimate benefits of their activity. By having access to the proposal, all of them could strive to amend it in ways that could accommodate individual or corporate concerns without unduly compromising their confidence on its reliability. Despite the shifting expectations created by participants' intervention, however, the more frequent their attendance to meetings, the more likely it was that they could use the knowledge released in the deliberations to their own advantage at crucial times when

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1.- James F. Arndt, "Roll-over protective structures for farm and construction tractors -A 50-year review," Society of Automotive Engineers (henceforth SAE) Paper No. 71-0508 (Warrendale, Pa., 1971), p. 5.

making some of their most sensitive decisions. A clear example of how participants could benefit from this knowledge was the role of continued membership in the Farm and Industrial Equipment Institute (FIEI) in providing J. I. Case senior engineers with the opportunity to anticipate the likely content of the SAE-ASAE standard for protective cabs. Having the occasion to assess this document long before it was issued, Case engineers could develop their new factory installed protective cabs in full compliance with the standard.

Making use of a somewhat cumbersome and hierarchical process to develop and approve a proposal was, from FIEI engineers' standpoint, not only a matter of corporate gain but also an effective way of ensuring the most reliable solution. In their view, engineers' unique problem-solving abilities were the best suited to make of a proposal "the solution that always works." 2/ Though seemingly minor and time-consuming, the long series of amendments that preceded its approval was also, in their view, an important means of perfecting this solution as "(i)t takes time and participation to write a good standard." 3/ FIEI engineers regarded the benefits all who

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2.- Interview with Herbert Sullivan.
3.- Lawrence Hodges to the author, 11 Jan. 1994.

have a stake in the dominant product design could expect from engineers' industrywide agreement as even greater in the case that test requirements and performance criteria, rather than specifications for design, were preferable. In their view,

> (t)he people who are most adept at designing performance standards are engineers who are trained in, and are indeed active in, the design profession. The engineer generally has at his disposal supplemental tools such as computers, test instruments, and machine shops for constructing experimental designs. In addition, he knows which of projected designs need to be accommodated. 4/

Engineers seeking to initiate or amend a proposal could find, however, that the extent of their influence was most likely related to their own access to their employers' testing facilities and a relevant engineering budget. This access was, in the case of the ROPS standards examined above, almost invariably in the hands of tractor makers' senior engineers serving in relevant committees of the FIEI, the American Society of Agricultural Engineers (ASAE), and the Society of Automotive Engineers (SAE). Individuals like, for instance, Merlin Hansen, David L. Stevenson, Lawrence Hodges, and Herbert Sullivan strived and, most of the time, succeeded in mobilizing their companies' resources to the purpose of initiating FIEI ROPS proposals or making major amendments to

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4.- Arndt, "Roll-over protective structures," p. 5.

existing SAE-ASAE documents. Knowledge sharing, in their view, was most useful at the top of FIEI member companies' hierarchy, where they could take best advantage of this knowledge to "write a superior proposal that w[ould] be well received by technical societies." 5/ As representatives of FIEI member companies and active members of SAE and ASAE committees, they were in a privileged situation to persuade other participants in these committees of the merits of the proposals they were submitting for approval. To their advantage, they were viewed in the standards committees of both engineering societies not only as credible sources of knowledge, data, and written contributions based on their employers' most sensitive information, but also as high-level negotiators in position to make important decisions and act on their companies' behalf. Given their prerogatives as members of FIEI drafting committees and representatives of their companies, they could exert in sum greater influence on the content of the documents they wrote than the other, more numerous, SAE and ASAE committee members. 6/

5.- Herbert Sullivan to the author, 21 Feb. 1994.

6.- FIEI-SAE-ASAE interinstitutional cooperation, which is typical of the development of all SAE-ASAE standards concerning major tractor design and engineering problems, clearly precedes ROPS. A careful reading of the SAE Handbook and ASAE Standards reveals, for instance, that 19 out of 25 SAE-ASAE standards have been drafted, proposed and revised by the FIEI in the last thirty years. Nine of these documents were safety or safety-

FIEI engineers' continuous efforts to restrict or delay the diffusion of the knowledge shared in their deliberations partly revert the terms of the problem of the intended use of this knowledge in the standards-setting process. Rather than sharing it solely for the purpose of perfecting their ROPS proposals, FIEI engineers sought to concentrate their most sensitive knowledge exchanges at the level of the drafting committees, and then, once this knowledge was embodied in a proposal, to use the document as a powerful promotional tool. Having to disclose only part of the knowledge embodied in a ROPS proposal, FIEI engineers could protect and stabilize its prescriptive content and limit the ability of other members of SAE and ASAE committees to challenge it or to produce competing problem definitions. Having before them the proposal, but not the supporting data and information to which its content was related, most of the SAE-ASAE membership had little option but to exercise their voting rights and professional judgment to challenge only the document's most obvious inconsistencies. 7/ Any attempt to question a

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related standards, with 8 of them drafted and revised by FIEI technical committees. Over the years, most standards setters have even come to see FIEI engineers' influence as a natural state of affairs. "It's a one-way street," as an ASAE staff member told me in an interview.

7.- This right, however, is often used with extreme circumspection. One of my interviewees, a self-employed engineer and critic of the process, said that despite some engineers' reservations about FIEI proposals they

proposal in terms other than those under which it was drafted (e.g., negative votes based on aspects the proposal failed to cover) was considered, according to SAE-ASAE long-established balloting rules, as nonpersuasive and technically irrelevant. FIEI engineers' prerogatives in handling the most sensitive interfirm knowledge exchanges became, in short, the basis for promoting major tractor design changes whose industrywide implementation, they expected, would support the projected development of the dominant tractor design.

The second constant feature in the period under study was participants' continuous use of their access to the successive versions of a ROPS proposal to bolster both the authority and prescriptive content of the final document. By supporting, with or without amendments, the design changes prescribed in the proposals, participants sought to take advantage of an early access to their contents to amend or ratify them while agreeing on tight limits to the diffusion of the knowledge and criteria used in their production. This combination of collective secrecy and supportive strategies was aimed at both increasing their own influence and curbing the ability of

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would still vote in favor of them as they "are in fear of losing their jobs." He went further to state that he had seen "an engineer favoring a proposal and then voting against it because his boss told him to do so."

nonparticipants to challenge portions or aspects of a proposal on which participants had already agreed. By limiting outsiders' access to the knowledge and criteria shared in the deliberations, standards setters sought in sum to ensure both the orderly pace of their deliberations and the authority, stability and as-broad-as-possible implementation of their proposed changes in product design.

A darker side of standards setters' secrecy and restrictive forms of knowledge sharing was the extent they could use them to ignore or trivialize certain problems excluded from, or peripheral to, their proposed design changes. Until the early 1960s, for instance, tractor manufacturers' reluctance to recognize that there was a tractor safety design problem was clearly related to is cost implications, rather than to any difficulty in assessing the need or likely benefits from a solution. Even as they started to develop this approach under the title of a SAE-ASAE standard, its intended implementation was limited to tractors over 20 horsepower, and was optional and prospective, rather than retroactive. Though products liability litigation may have induced changes in manufacturers' policy on the optional character of tractor safety, large awards and settlements have been less effective in persuading them, or tractor owners, to seek overturn protection for tractors of less than 20 hp or to

retrofit all tractors in use. 8/ Further, discovery rules may have even increased FIEI engineers' preference for secrecy as they often invoked the fear of being sued as a good reason to withhold data or information others could use against them in the courtroom.

The use of restrictive forms of knowledge sharing in the standards-setting process is even more worrisome in the light of regulatory agencies' frequently blind adoption of voluntary standards as the basis of their safety regulations. This kind of adoption sanctions and legitimates, via the regulatory process, the status of standards setters' shared knowledge as proprietary information to which even these agencies have often limited access. While Steinbruegge's bid to challenge

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8.- The only exceptions to date are J. I. Case and Deere & Company, that have retrofitting programs at owners' expense for all their tractor models in use since 1965. Older tractors are excluded, since Case and Deere engineers believe that their rear tractor axle to which the frame is attached is not strong enough and may collapse in an overturn. On the other hand, promoting a standard with added costs for the consumer but without benefits the consumer can readily grasp is a problem for manufacturers that goes well beyond my ROPS case study. This difficulty often results either in manufacturers' delay or reluctance to deal with certain issues or in technological choices that make users' adoption unavoidable. For a good example in the telecommunications industry, see Marvin Sirbu and Lawrence Zwimpfer, "Standards setting for computer communication: The case of X.25," IEEE Communications Magazine 23 (March 1985), pp. 35-45.

the SAE-ASAE standard may illustrate the fragility of FIEI engineers' monopoly of expertise, U.S. regulatory agencies' practice of free riding on standards setters' expertise denied him credibility vis-a-vis FIEI engineers until he could produce findings of his own that proved his case. Far more troubling than U.S. regulatory agencies' role in sanctioning standards setters' secrecy are the access problems faced by anyone attempting to examine the criteria used in setting international standards under the auspices of the International Organization for Standardization (ISO). Arguably more political than the U.S. standards-setting process, ISO deliberations are likely to have greater potential implications for unrepresented parties, given manufacturers' growing reliance on ISO standards in an increasingly global economy. For nonparticipants, however, the minutes of ISO deliberations remain beyond reach. As one of my interviewees put it:

> We keep records for only five years. This is a legal requirement. For the dynamic [overturn protection] test we probably have them, but they are not public information. 9/

These concerns may obscure the fact that the success of tractor makers' engineers in shaping the outcome of the

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9.- Interview with George Bowen.

process has been far from absolute. Individuals or groups with access to appropriate testing facilities could, and in fact did, challenge the approach embodied in the ROPS documents written by FIEI engineers. Steinbruegge's successful bid to contest the quality of SAE-ASAE ROPS standards is a case in point. European regulatory agencies went even further and made use of the knowledge embodied in these documents to successfully develop, through their testing facilities, an alternative ROPS document of their own. In contrast with Steinbruegge's claim on the inadequacy of these documents in FIEI engineers' own terms, European standards setters argued that the FIEI approach was unlikely to protect the tractor operator in case of a multiple rollover. In other words, they put into question the SAE-ASAE standard not in terms of its intended function, but because it was written following an incomplete definition of the rollover protection problem. Against these objections, FIEI engineers' belief on the technological superiority of their testing method became a presumptuous underestimation of European regulatory agencies' ability to solve the problem in their own, well-defined, terms. FIEI engineers, unwilling or unable to accommodate European concerns, played a solo strategy that proved self-defeating in terms of the international credibility of their design approach. As a result, when the European document, rather than the FIEI proposal, became the

new ISO-OECD ROPS standard, FIEI engineers had little option but to support it as a new feature of the worldwide dominant tractor design.

The third and most constant element in the efforts to develop ROPS standards was the continuously changing ways of defining the relationship between rollover protection and the American dominant tractor design. The first concern of tractor makers' engineers attempting to solve the overturn protection problem was how to make it compatible with the other utility dimensions of the dominant tractor design. The crucial role of implements in farm tractor design presented them with the difficult task of finding cost-effective ways of integrating overturn protection features within the tractor-implement system as a whole. As an International Harvester engineer put it:

> (I)n real life, the tractor is only a source of power. It must be used with an implement or some other tool to bring a return on the farmer's investment, so safety should always be viewed in light of the entire system, i.e., the tractor and implements. 10/

FIEI engineers' initial choice of a simple two-post frame

10.- U.S. Department of Transportation, Agricultural Tractor Safety on Public Roads and Farms (Washington, D.C.: U.S. Government Printing Office, 1971), p. B-87 (statement of Richard N. Coleman).

design, rather than a four-post frame or cab, was aimed not only at a more efficient use of material, but also at minimizing its interference with several tractor-implement attaching points. Their early rejection of the European four-post frame design took place not only on the basis of cost considerations, but also, as pointed out by an International Harvester senior engineer, because

> many pieces [of] mounted accessory equipment in the U.S. and configuration and space requirement of the implements do not permit the addition of the framework required for an all-weather safety structure. 11/

Once rollover protection standards were available for both the two-post frame concept and tractor cabs, tractor makers' engineers found that some of the SAE-ASAE test provisions were incompatible with cab makers' demands for economy and simplicity. These demands, raised at a series of FIEI meetings, met the sympathetic response of tractor makers' engineers, even though both cab makers and tractor manufacturers were tough competitors in the farm tractor market. Acting with the common aim of forestalling Federal safety regulations, all participants in FIEI meetings agreed to reduce

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11.- Ernest C. Carlson, "Tractor Roll-Over Protection Frames," National Safety News 97 (March 1968), p. 68.

> the costs involved in cab safety tests as outlined in the... SAE-ASAE standards. Considering that not only the cab but an expensive tractor could be extensively damaged in the vehicle overturn portion of the test procedure, most of the independent cab makers expressed their feeling that having their cabs tested with different tractors on which the cabs could be mounted was economically unfeasible. (A) representative of a tractor manufacturer [said] that the over-turn tests [had been] necessary to find out how the cab-structure would withstand the impact forces of an upset [but] acknowledged that enough information from such tests h[ad] already been obtained and the expense of continuing to over-turn tractors as the method of testing cabs was probably unjustified now. 12/

FIEI engineers' initial attempt to implement ROPS standards on a voluntary basis also proved incompatible with courts' interpretation of product safety. Further, their own efforts to develop these standards, they soon realized, left them exposed to litigants' use of their own knowledge against their companies in court. As tractor upsets repeated over and over again, they found themselves enlisted in increasing numbers as expert witnesses with the duty to claim, even against their inner beliefs, that it was the tractor operator, rather than the manufacturer, who was at fault. In violent contrast with their typically low-key exchanges of knowledge in standards committees, they felt discovery rules forced them to surrender their knowledge to unfriendly hands ready to use

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12.- Charles S. Floyd, "Cab Makers Confer on DOT Manifesto," Implement & Tractor 86 (21 June 1971), p. 13.

it to bid for the highest possible jury award. Over time, they came to the conclusion that only a full implementation of SAE-ASAE ROPS standards could spare them and their companies from this ordeal, at least in the event of future upsets with new equipment. Yet their ability to influence their companies' marketing practices was limited as long as the burden and inconvenience created by products liability litigation seemed affordable. Their chances to effect a change in these practices only improved after the severe economic downturn of the 1980s, when tractor makers developed a shared concern with reducing litigation uncertainties rather than relying on the then far more uncertain prospect of increased tractor sales.

The last and more important compatibility problem faced by FIEI engineers was how to reconcile the contents and implementation of their ROPS proposals with European standards and regulations. FIEI engineers' early search for support from the SAE and ASAE committees to develop ROPS proposals they thought suitable for American tractors was, for instance, highly successful. Over time, however, they realized that their disagreement with European and OECD standards and divergent interpretations of tractor safety were less important than the burden of test duplication and related compatibility problems associated with the increasing

international tractor trade. As knowledge of protective cabs became more widespread and new knowledge on mathematical models for the evaluation of the protection afforded by these frames also became available, European researchers (i.e., the EEC ROPS Study Group) felt they could use their testing facilities to research alternative approaches. Ultimately, FIEI engineers lost the control over the ROPS proposals in ISO, had to relinquish their role as problem definers, and resort to adaptative strategies including the renegotiation of the voluntary status of implementation, at least for the tractors their companies sought to introduce in the world market.

The three constant elements discussed above illustrate the extent standards setters' deliberations, despite taking place in the midst of restrictive forms of knowledge sharing, have become more responsive to the safety demands of the social order. This responsiveness may have even changed the character of the process of setting voluntary product safety standards in the U.S. to the point of transforming it into an increasingly involuntary form of cooperation. As the financial risks of products liability suits have steadily increased over the years, corporate managers often consider that making available at least part of the company time and bearing most of the travel and lodging expenses of sending

their engineers to standards committee meetings is no longer an investment, but a matter of survival. As a result, standards committee meetings dealing with safety matters tend to attract crowds even in the case of shrinking industries like the production of farm equipment. Further, the issues and approaches adopted in the deliberations have become increasingly political as participants painstakingly ponder the legal and financial implications of the proposals' wording and the extent of its proposed changes in the dominat product design.

The increasingly involuntary character of setting and implementing industrywide safety standards may have also changed the ways standards setters relate themselves to government agencies and the courts. As a result of large jury awards and the unpredictable features of tort litigation, tractor makers' engineers have often come to regard regulatory agencies as allies, rather than foes, in the midst of the increasingly uncertain world of retrospective product design responsibility. Their own willingness to cooperate in the establishment of new safety standards may have evolved from a hesitant and at times ill-defined support for a dominant tractor design into a highly structured search for ways of protecting their companies in the courtroom. Under these circumstances, they no longer regard federal regulatory

agencies' adoption of voluntary safety standards and the transformation of these into mandatory regulations as a matter of contention. Rather, they tend to look at this adoption as a badly needed mechanism to enhance the authority of their own documents which they see as one of the few defenses available to their employers in a lawsuit. The mandatory-like character of voluntary standardization may have in sum changed standards setters' distrust towards government intervention and lessened the importance of earlier distinctions between regulated and nonregulated industries.

American standards setters' shifting commitment to an increasingly mandatory-like standardization illustrates the importance of third parties' action in effecting change. The role of nonparticipant parties (e.g., tractor purchasers, overseas standards setters) in redefining not only the ways a group of standards setters agrees but also the voluntary character of its cooperative efforts broadens the perspective of the analyst on the limitations of narrowly defined studies in how knowledge producers negotiate and resolve disputes. All too often controversy scholars have presented the resolution of disputes between experts as depending solely on participants' rhetorical maneuvers, namely as if nonparticipants' silence condemned the latter to the role of passive spectators. My case study clearly shows that third

parties, if directly affected by these disputes, may exhibit a remarkable ability to mobilize alternative resources and even to find ways of using experts' proposed solutions against the very producers of these solutions. The consequences and importance of this occurrence constitute a potentially new research dimension of Science and Technology Studies worth of further investigation.

Another aspect of the case study susceptible of some cautious generalization concerns the extent standards setters' willingness to cooperate includes inter-industry compatibility problems beyond the scope of a dominant product design. Setting quality standards, for instance, may contribute to a better functioning of certain key components of highly composite products like farm tractors; yet the development of these standards may also have an equally important impact on the producers of commodities like steel, lubricants, and other materials. While agreeing on quality standards for these products is often viewed, from the perspective of the agricultural equipment industry, as a way of solving some of the recurring problems of the dominant tractor design, this agreement almost invariably includes participants who represent the interests of the producers of these commodities. Contributing to the development of these standards, from the perspective of the latter, may still make sense not only as a

way of avoiding costly confusion in the markets, but also to the extent these documents may become forms of promoting a greater inter-industry compatibility.

The active role of corporate interests in promoting inter-industry cooperation also helps to put the links between standards committee deliberations and interfirm diffusion of technological knowledge in a broader perspective. Individual companies' willingness to contribute to the process and share knowledge and proprietary information may depend not only on how high is the in-house cost of producing this information, but also on how limited are its direct benefits for each firm. Conversely, the greater the direct benefits a company may expect from the knowledge it produces the more likely it is that this company regards this knowledge as sensitive information and shows greater reluctance in releasing it in standards committees. Deere engineers' initial hesitation in divulging their knowledge on how to test the two-post frame is a case in point for it shows the limits of voluntary cooperation. Once, and if, companies like Deere see sufficient merits in interfirm cooperation and knowledge sharing, they are likely to become not only promoters, in standards committees, of a particular design approach, but also custodians of a slow-as-possible diffusion of this knowledge. For these companies the temporary advantages

conferred by their role in promoting an appropriate pace for the diffusion of this knowledge are as important as the industrywide or inter-industry compatibility approaches they aim to promote. The politics of releasing this information in ways that contribute to negotiating design compatibility is in sum the politics of collective secrecy and a slow-as-possible release of the technological knowledge upon which they rely to promote their preferred approach to compatibility.

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APPENDIX A.

LIST OF INTERVIEWS

I include all interviews that lasted at least thirty minutes. About one third took place at ASAE or SAE meetings. Only five of them were telephone interviews. All the other interviews took place in the offices or homes of the interviewees, sometimes for several hours.

Nagaprakash N. Babu, Caterpillar, East Peoria, IL.

L. Dale Baker, J I Case, Hinsdale, IL.

George Bowen, staff member, American National Standards Institute, New York.

Wesley Buchele, Agricultural Engineering Professor, Iowa State University, Ames, Iowa.

David H. Bucher, John Deere, Des Moines, Iowa

John H. Crowley, Equipment Manufacturers Institute, Chicago, IL.

Edward A. Fritz, J I Case, Hinsdale, IL

Dale Galliart, John Deere, Mouline, IL.

Wilbert Gipp, retired (formerly at J I Case), Racine, Wisc.

Russel H. Hahn, staff member, ASAE, St. Joseph, Michigan

Lawrence H. Hodges, consultant (formerly at J I Case), Racine, Wisconsin

Richard Pfister, Ag. Engineering Professor, Michigan State University, East Lansing, Michigan.

John R. Prosek, retired (formerly at Int. Harvester), Glen Ellyn, Illinois.

Henrietta Scully, staff member, American National Standards Institute, New York.

John B. Sevart, Advance Technology, Wichita, Kansas.

Randall L. Sierk, Ford New Holland, New Holland, PA.

Herbert Sullivan, consultant (formerly at Int. Harvester), Savannah, Georgia.

William J. Teaford, John Deere, Waterloo, Iowa.

Wendel Van Syoc, retired (formerly at John Deere), Moline, IL.

James Woodward, Massey Ferguson, Des Moines, Iowa

Carlton Zink, consultant (former member of the Nebraska Tractor Test Laboratory Board of Engineers, and also at John Deere), Moline, IL.

APPENDIX B.

PERIODICALS, MAGAZINES AND TECHNICAL PAPERS CONSULTED

The publications and papers listed below were systematically reviewed for the period under study. They are not listed in the bibliography.

- Agricultural Engineer
- Agricultural Engineering
- ASAE Standards/ASAE Yearbook
- Farm and Power Equipment
- Farm Safety Review
- Health and Safety Science Abstracts
- Implement and Tractor
- Journal of Agricultural Engineering Research/Journal & Proceedings of the Institution of Agricultural Engineers
- Journal of ASSE/Professional Safety
- Journal of Safety Research
- Machine Design
- Magazine of Standards
- Materials Research & Standards/ASTM Standardization News
- National Safety News
- SAE Handbook
- SAE Journal/Automotive Engineering
- Standards Engineering
- Transactions of ASAE

- **ASAE Technical Papers** (1960-1990). Copies of these papers are available in microfiche from the headquarters of the American Society of Agricultural Engineers (ASAE), St. Joseph, Michigan. They are issued in five to six digit series at both national and regional level, with the two first digits indicating year of publication. In the case of regional papers these two digits come after an three-letter abbreviation that specifies the region to which the paper is ascribed.

- **SAE Technical Papers** (1965-1990). Organized in six-digit series and available in microfiche from the headquarters of the Society of Automotive Engineers (SAE), Warrendale, Pennsylvania. As in the case of ASAE papers, the two first digits indicate year of publication.

APPENDIX C.
ABBREVIATIONS

AESC - American Engineering Standards Committee.

ANSI - American National Standards Institute (formerly USASI and ASA).

ASAE - American Society of Agricultural Engineers.

ASA - American Standards Association (formerly AESC).

ASME - American Society of Mechanical Engineers.

ASTM - American society for Testing and Materials.

EEC - European Economic Community,

EMI - Equipment Manufacturers Institute (formerly FIEI)

FEI/FIEI - Farm (& Industrial) Equipment Institute.

IH/IHC - International Harvester (Company).

ISO - International Organization for Standardization.

NIAE - National Institute of Agricultural Engineering (United Kingdom)

NISO - National Information Standards Organization.

NTIAM/NTIAEM - National Testing Institute for Agricultural (and Earthmoving) Machinery - (Sweden).

OECD - Organization for Economic Cooperation and Development.

ROPS - Roll-Over Protective Structures

SAE - Society of Automotive Engineers.

USASI - U.S.A. Standards Institute (formerly ASA).

VITAE

Rafael Jorge Balderrama
911 University City Boulevard # A7
Blacksburg, VA 24060

EDUCATION Ph.D., Science & Technology Studies, August 1996
Virginia Polytechnic Institute & State University

Diplôme d'Etudes Supérieures (Graduate Studies in Management of Urban Technical Services.
- Université de Technologie de Compiègne, France (March-November 1985).

M.S. Science & Technology Policy, Dec. 1983.
- Manchester University (United Kingdom).

Sociologist, Dec. 1976.
- Universidad Central de Venezuela, Caracas.

FULL-TIME APPOINTMENTS: Researcher and Graduate Instructor at Center of Development Studies (CENDES), Caracas, Venezuela (1984-1990).

Duties:

Initially under contract. Responsible of a survey on R&D projects in the area of alternative energy sources in an oil producing country like Venezuela. This research was part of a major research project, "Latin American Technology Prospective," funded by the IDRC (International Development Research Council), a Canadian agency with close links with developing countries. The project had also the support of UNU (United Nations University) in Tokyo. The IDRC-UNU project included close cooperation of academic centers in Latin America: CENDES, Universidade de Campinas (Brazil), UNAM (Mexico), and Fundación Bariloche (Argentina). There was, as a result of this larger project, a number of research reports with limited circulation (see among them infra, section of unpublished reports).

- Nominated by the Center of Development Studies to a government fellowship for a graduate course on town administration and technical urban services management at the Université de Technologie de Compiègne, France, 1985.

- From December 1985 to August 1990. Researched and taught at CENDES Master's program on Development Studies, option Science & Technology. Advisor of two students who successfully completed their Master's theses (one of them on how the Venezuelan agricultural research system handled a cattle disease, the other on Venezuelan agricultural policies and their impact on the development of an impoverished area in Venezuela). Researched the evolution of Venezuelan agricultural research networks, conducted first with funds from the Consejo de Desarrollo Científico y Humanístico of the Universidad Central de Venezuela. From mid-1986 this project was expanded to study agricultural scientists' participation in the policy making process. The new project had the support of the Venezuelan science agency, CONICIT (Project S1-1833). There are various publications as a result of this project (see below).
Organized a Cendes-Fundación Polar Symposium on the evolution and performance of Venezuelan R&D Centers (June 1990).

University Instructor (undergraduate courses) in Statistics and Social Science Methodology at Facultad de Medicina, Universidad Central de Venezuela (1977-1980)
Duties:
- Taught large groups of freshmen students (90-110 students), with practical exercises and discussions in smaller groups.
- Prepared mimeographs, handouts and selected other teaching material as required in the courses (emphasis on deficiency diseases and other public health issues).
- Two courses taught alternately (1) 1st semester, fundamentals of Social Science Methodology, (2) 2nd semester, Statistics.

PART-TIME POSITIONS:

Spanish Instructor, Department of Foreign Languages and Literatures, Virginia Tech (Jan. 1995-Aug. 1995)
Duties:
Taught undergraduate courses. Participated in other faculty activities as required.

Graduate Research Assistant, Sociology Department, Virginia Tech (Aug. 1991-May. 1992; Aug. 93-May 94)
Duties:
- Classified and evaluated information from newspapers published in U.S. rural towns as the basis for comparative studies of the ways American rural communities position themselves with respect to sustainable agriculture. Worked on a selected number of states, i.e., Iowa, Minnesota, and Virginia.
- Prepared a report on a comparative study of two rural communities in Iowa (Harlan and Denison).
- Prepared a questionnaire on farmers' voluntary use of BMPs (Best Management Practices) in Virginia and their willingness to contribute to reducing nonpoint pollution.

FIELDWORK: Cultural and socioeconomic study of the indigenous Baniva community of Maroa, Venezuelan Southern Amazon, 1973 (in Spanish).

Technoeconomic study of sesame production in Turén, Venezuela (this study was part of my undergraduate Sociology Thesis), 1974 (A summary in English is available).

Gestion municipale et agriculture periurbaine: le cas de Périgny-sur-Yerres, Paris, France, 1985.

Un projet d'investissement non conventionnel: la commune rurale de Vieure, Moulins, France, 1985.

UNPUBLISHED WORK:
- "El potencial científico-técnico venezolano en fuentes alternas de energía". UNU-IDRC Paper, CENDES, Caracas, January 1985.

- "STS in Latin America: Globally irrelevant?," Center for the Study of Science in Society, Virginia Tech, March 1993 (43 pages).

- "A comparative view of two agricultural communities in Iowa: Harlan and Denison." Sociology Department, Virginia Tech, Blacksburg, Dec. 1993 (40 pages).
- Questionnaire on farmers' voluntary

implementation of BMPs (Best Management Practices) in Virginia, Department of Agricultural Engineering, Virginia Tech, Blacksburg, May 1994.

PUBLICATIONS:

- Ciencia y política agroalimentaria en Venezuela: La experiencia de los últimos 60 años. (CDCH-Fondo Editorial Acta Científica Venezolana), book, 1993 195 pp.

- Transferencia internacional de tecnología y modernización en el sector público: El caso CIDIAT", Ciencia, Tecnología y Desarrollo [1988] 12(1-4): 283-300; a modified version was published in Licha, I. et al (eds.), Capacidad de Gestión de Centros de Investigación en Venezuela [1994] (Caracas: Ediciones CDCH).

"Agricultural research priorities and farm modernization in Venezuela", Science and Public Policy [1988] 15(3): 163-169.

- "Papel de la investigación agronómica en la modernización de la agricultura venezolana, 1937-1960", Estudios Rurales Latinoamericanos [1987] 10(1): 95-123.

- "Los primeros doce años del Ministerio de Agricultura y Cría", in TEXERA, Y and FREITES, Y (eds.), La ciencia en Tiempos de Crisis, 1936-1948 (Caracas: Fondo Editorial Acta Científica Venezolana), 1993, pp. 119-152.

- "América Latina ante la avalancha de las nuevas tecnologías" (LICHA, Isabel, co-author), David y Goliat [1987] 17(51): 39-42.

- "Estado actual de la ID en fuentes alternas de energía en Venezuela y algunas opciones para su valorización", Revista CIV [1987] 94(341): 21-27; a modified version was published in Cuadernos del CENDES [1988] No. 7: 93-104.

- "Institucionalización de la planificación de la investigación agrícola en Venezuela, 1959-1975", Acta Científica Venezolana [1988]: 39(1): 84-89.

SYMPOSIA AND SEMINARS:

"Finalization and valorization of agricultural research: The case of Venezuela, 1959-1975." Paper at the Derek de Solla Price Seminar on The Dynamics of Scientific Disciplines in the Periphery, organized by Hebe Vessuri and Yakob Rabkin in February 1987 in San José, Costa Rica. Support for the travel and expenses was provided by the Venezuelan scientific agency, CONICIT, Project S1-1833.

"Recent development of Venezuelan agricultural research", paper (in Spanish) at the Atelier-Seminar on The Administration of R&D Services in Venezuela, organized by O.A.S (Organization of American States) and Fundacite, October 1987, Barquisimeto, Venezuela.

"Transferencia Internacional de Tecnología y Modernización en el Sector Público: El caso CIDIAT", paper presented in the Fundacion Polar-CENDES Seminar on The Management of R&D Centers in Venezuela, organized by I. Licha, R. Balderrama, and L. Yero in June 1990, Caracas, Venezuela. The Proceedings were published in a volume edited by I. Licha (Caracas: Ediciones CDCH), 1994.

"The politics of agricultural research and food self-reliance in an oil producing country: The case of Venezuela", paper presented at 4S Annual Meeting of the Society for Social Studies of Science, held at the Cambridge Center Marriot, Mass., November 1991.

"Negotiating Uniformity: Collective agency, public goods and the setting of engineering standards," Seminar at the Center for the Study of Science in Society, Virginia Tech, Blacksburg, April 1995.

"Setting Technical Industry-Wide Standards: Some Public Policy Dilemmas." Paper at The STS Meeting & Eleventh Technology Literacy Conference, Arlington, Virginia, February 1996.

"New Economic Trends in Latin America." Talk at Círculo Hispánico, Virginia Tech, Blacksburg, Virginia, April 1996.

"Social Construction of Uniformity: Setting Safety Standards for Agricultural Equipment," Paper at ISTA 96 International Symposium on Technology and Society, Princeton University, Princeton, June 1996.