INFOSYM

An Integrated Approach to Facilitate the
System Requirements Definition Process

by

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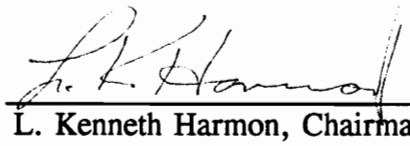

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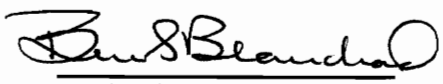

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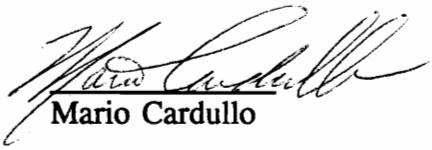

Mario Cardullo

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Industrial and Systems Engineering

(ABSTRACT)

Too often, when information systems development projects are completed and delivered, the systems are put on the shelf and never used. Maybe this was acceptable in the past, however, with the reduction in defense related contracts and shift towards the more competitive commercial market, it is imperative that information systems development organizations deliver systems that meet the needs and expectations of the customer to ensure their future survival. This paper presents an integrated approach to solving this problem by providing a formal, comprehensive method of establishing and validating quantitative system requirements. Described in detail, is a tool called INFOSYM, which not only facilitates the system requirements definition process, but also provides a standard method of recording and tracking a majority of the data required for systems design and development. Organizations can build a repository of this data for all systems development projects to establish a library of reuse data and to estimate costs and resources of future projects more accurately.

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1.0 Introduction

When developing computer systems, the goal of the systems engineer is to transform the needs and expectations of the user into an elegant and functional system. As the life-cycle of the system progresses, requirements are established by the customer, and from this, the system is designed, design reviews are carried out and accepted, and the software and hardware are produced and assembled to create the system. In theory, once delivered, the system should meet the needs and expectations of the customer. However, in too many cases, this does not happen, and in fact, systems are put on the shelf and never used operationally. How do we fix this problem? Tell the customer to make sure his needs and wants are reflected in the requirements? This would be the easy solution since that would put the blame on the customer rather than the engineers.

We must take responsibility for this dilemma and find a method for ensuring that the customer's needs and expectations are met in the delivered system. One way to accomplish this is to ensure that this information is included in the requirements and eliminate to the extent possible, the misinterpretation that may occur throughout the conceptual, preliminary, and detail design processes. In computer systems development projects, the original requirements of the customer are translated into requirements specifications, which are in turn re-translated any number of times into design specifications. The design specifications are then again translated into software. Each time one of these translations occurs, the result is slightly different. If the customer is involved throughout this process to establish quantitative and comprehensive requirements and to validate these requirements throughout system design, any misinterpretation that may occur can be eliminated. There are a few tools available which allow for customer participation, such as entity-relationship diagrams, data model diagrams, and function decomposition diagrams. However, these tools focus primarily on the functionality and interfaces of the system, and in some cases, are overwhelming to the customer. While helpful, these tools are not sufficient to establish requirements and design the system. There is a dire need for an integrated tool that encourages and allows for customer input of the data necessary for conceptual and preliminary design to establish comprehensive

and quantitative requirements. This tool must also provide feedback during detail design in order to validate and verify the requirements prior to system development. The purpose of using this tool for information systems' development projects is to ensure that the system meets the needs and expectations of the customer.

2.0 Approach

Although the integrated tool described above is not a system, all of the system engineering life-cycle activities can be applied as follows:

- Identification of the need
- Planning
- Research
- Design
- Construction
- Evaluation
- Use and logistic support

The project completed the first five activities and the results are documented in this paper. However, due to time constraints, the evaluation and use and logistic support activities were not performed.

3.0 Identification of the Need

There is a need for an integrated tool that aids in defining system requirements during the conceptual and preliminary design phases of the systems engineering life-cycle and validates the requirements during the detail design phase. Use of this tool in systems development will ensure that the system delivered meets the needs and expectations of the customer.

4.0 Planning

Advanced planning was performed to develop an implementation schedule for completing the project and report. Additional assumptions and constraints were identified to establish a clear boundary for the project and are listed below:

1. The tool is developed specifically for information systems development projects.
2. The tool requires systems engineer input with a skill level equivalent to a systems analyst.
3. The tool requires customer input with a skill level of at least a GS-11 or equivalent.
4. The evaluation and use and logistic support activities will not be performed.

5.0 Research

Applied research was performed to accomplish four goals:

1. To determine whether a tool currently exists that meets the stated need, thus nullifying the need.
2. To determine what the typical characteristics are of information systems are in order to develop a tool that can be used by all information systems development projects.
3. To determine what the deliverables are for the conceptual, preliminary, and detail design phases of information systems development projects.
4. To analyze the various tools available for systems analysis and design and determine if and how they can be incorporated into the integrated tool.

Extensive library research was performed to accomplish the first goal. The result is that there are various tools and techniques available that aid in performing discrete steps in the design processes; however an integrated tool does not exist, thereby validating the need.[7]

Interviews and document reviews were performed to accomplish the second goal. Program managers, software development managers and systems analyst/programmers

who worked on information systems development projects were interviewed to get their input on the features or characteristics of information systems that must be considered throughout the systems engineering life-cycle.

Various deliverables associated with existing information systems were reviewed to accomplish the third goal. For the most part, the deliverables conformed to military standard 2167A, or some tailored form of 2167A. The tool will be designed to allow for input of the data into military standard 2167A specifications, requirements and design documents.[11]

Extensive library research was performed to accomplish the fourth goal. There are an abundance of tools available that aid in the systems' design process. The tools were analyzed for their ability to enhance and focus interaction between the customer and the systems engineer in order to retrieve the information necessary for system conceptual, preliminary, and detail design and to provide input to the associated military standard 2167A deliverables. The N^2 chart, entity-relationship diagram, and maintenance and operational flow diagramming techniques were selected for inclusion in the integrated tool and are discussed in more detail in Section 7.0.

6.0 Design

The design of the integrated data collection tool for information systems, INFOSYM, has evolved through the steps outlined below:

1. Identifying the characteristics of information systems
2. Determining what customer-based information is needed for each characteristic for conceptual, preliminary, detail design and the associated deliverables
3. Identifying the relationships between the characteristics
4. Determining how to incorporate all of the above information into an integrated tool that utilizes a top-down approach to systems development.

6.1 Information System Attributes

All information systems have the following characteristics or attributes:

- Functions - the mission related and support activities to be performed by the system
- Interfaces - the system's external and internal interfaces
- Distribution - the location of all system and maintenance facilities
- Performance - the behavior of the system
- Security - the access control to the system's data and processes
- Software - the computer-executable program modules which provide the system functionality and support
- Hardware - the equipment used to process, store, display, communicate, and maintain system data and software
- Data - the information required to perform, monitor, control, and evaluate the mission and support functions
- Human-Machine Interface - the means by which the users interact with the system
- Procedures - the human-oriented activities relevant to operation and control of the system to enable it to achieve its mission objectives
- Management - the control over the design, development, operations, and maintenance of the system to achieve program objectives. These objectives are the technical, cost, and schedule objectives of the system
- System support - the activities necessary for operations and maintenance of the system

Each of these system attributes must be addressed in information systems development projects. One additional attribute must be added, and although it is not an information system attribute, it is an attribute of systems development and must be considered in the system development life-cycle: test and evaluation - ongoing test and evaluation of the system throughout its life-cycle. These thirteen attributes can be grouped together by the

role they play in information systems development projects. The groupings are described in the following subsections.

6.1.1 System Definition Attributes

The system definition attributes are those which describe "what" the system is supposed to do in order to meet its objectives.[10] The functions, interfaces, security, performance, and distribution attributes formulate the system definition.

6.1.2 Implementation Attributes

The implementation attributes describe "how" the system will accomplish its objectives. The hardware, software, data, human-machine interface, procedures, and system support attributes provide the mechanisms for the system to accomplish its objective.

6.1.3 Program Control Attributes

The program control attributes monitor and evaluate information systems development projects to ensure that the implementation of the system is in line with the system definition. The management and test and evaluation attributes provide this capability.

6.2 Attribute Levels of Detail

As one proceeds through the conceptual, preliminary, and detail design phases of the system life-cycle, increasing levels of detail are required for each of the attributes described above.[6] Level 1, or the top-level of the system, identifies the "big picture", the things that tend to constitute the highest level description and requirements of the system, such as the system's mission or its external interfaces. Level 2 is the next level of detail and for the most part identifies the same information in level 1 except that it is not for the system as a whole, but for the subsystems of the system. The subsystems in this context are not the subsystems that are delivered with the system, they are further details regarding the system that the user can provide. If the user cannot provide more details about the system than the data recorded at level 1, this level would be ignored (except for the management attribute). Level 3 begins to address the building blocks of

the system; the functions the system must perform, its hardware, software, and the way the system's functionality is distributed over its physical locations are examined. The true subsystems of the system are composed from the level 3 data.

For the most part, levels 1, 2, and 3 collect the data necessary to complete conceptual and preliminary design for the system and establish the system requirements. Levels 4 through n where n depends on the complexity of the system, provide further levels of detail and collect the information necessary for requirements validation during the detail design of the system.

6.3 Attribute Relationships

Once the information to be collected was defined for each of the attributes and levels, the relationships between each attribute/level combination were examined. For example, performance requirements identified in the level 3 performance attribute are allocated in level 4 to hardware and software configuration items, data groups, procedure names, or some combination. This data is retrieved from the level 3 hardware, software, data, and procedures attributes.

6.4 Attribute Products

Once the information to be collected from each attribute/level was defined, and the relationships were identified, the product formats for each level and attribute were designed. The formats must be easy to understand and simple to use and make changes to. In addition, the data recorded must be in a format that allows for cutting and pasting into various project deliverables, i.e. requirements and design specifications.

7.0 INFOSYM

This section provides the details of how INFOSYM works. Each attribute is defined in more detail along with the information to be recorded and a description of the resulting products from each level. Figures 7-1 through 7-3 provide a summary of the information extracted from each attribute. Appendix A steps through the formats for the products in

the natural order that they would be presented to the customer. There is no specified format when the product is free-form text or where the product can use various diagramming techniques to produce the same result, i.e., an entity-relationship diagram.

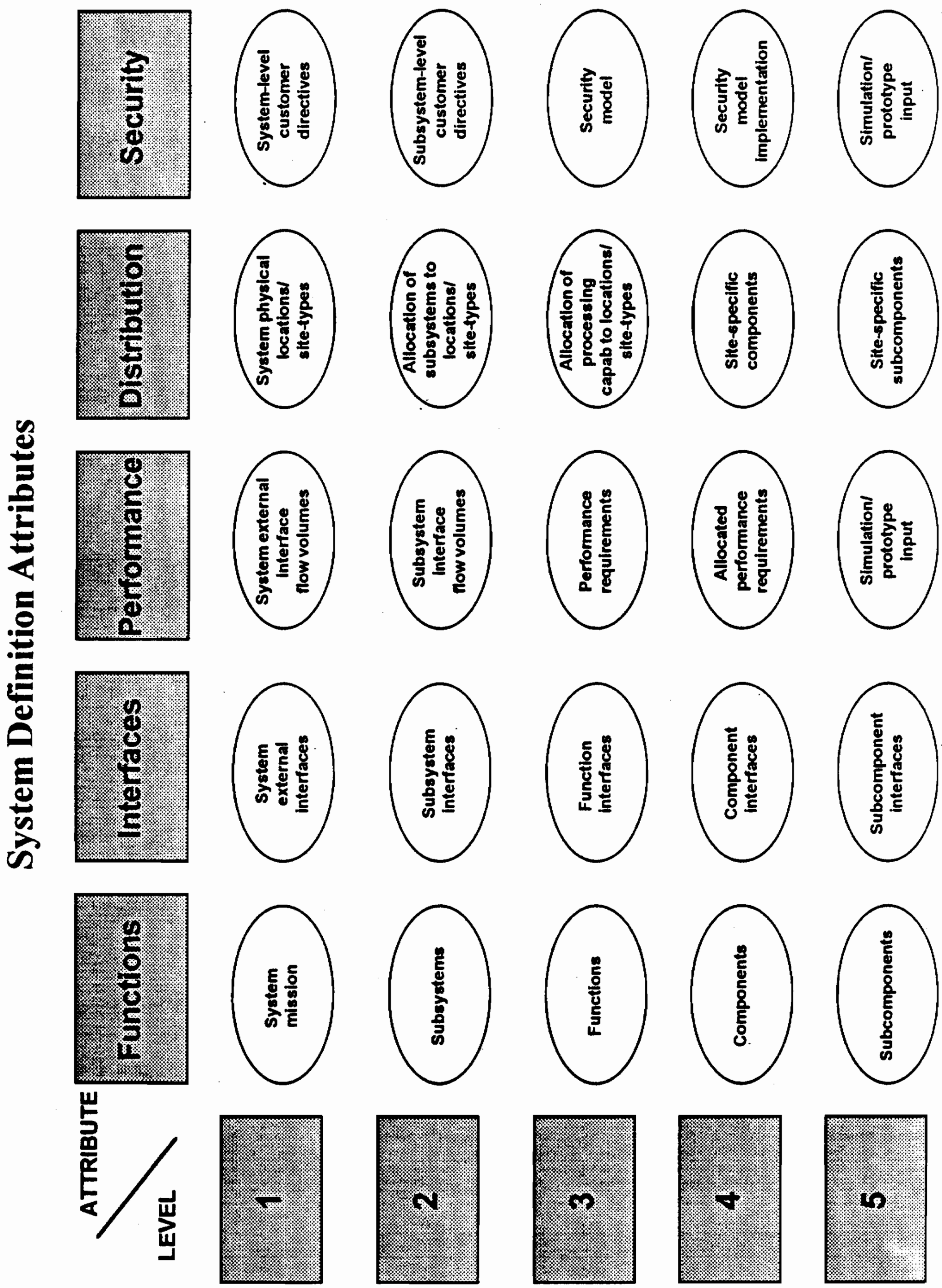

Figure 7-1. System Definition Attributes

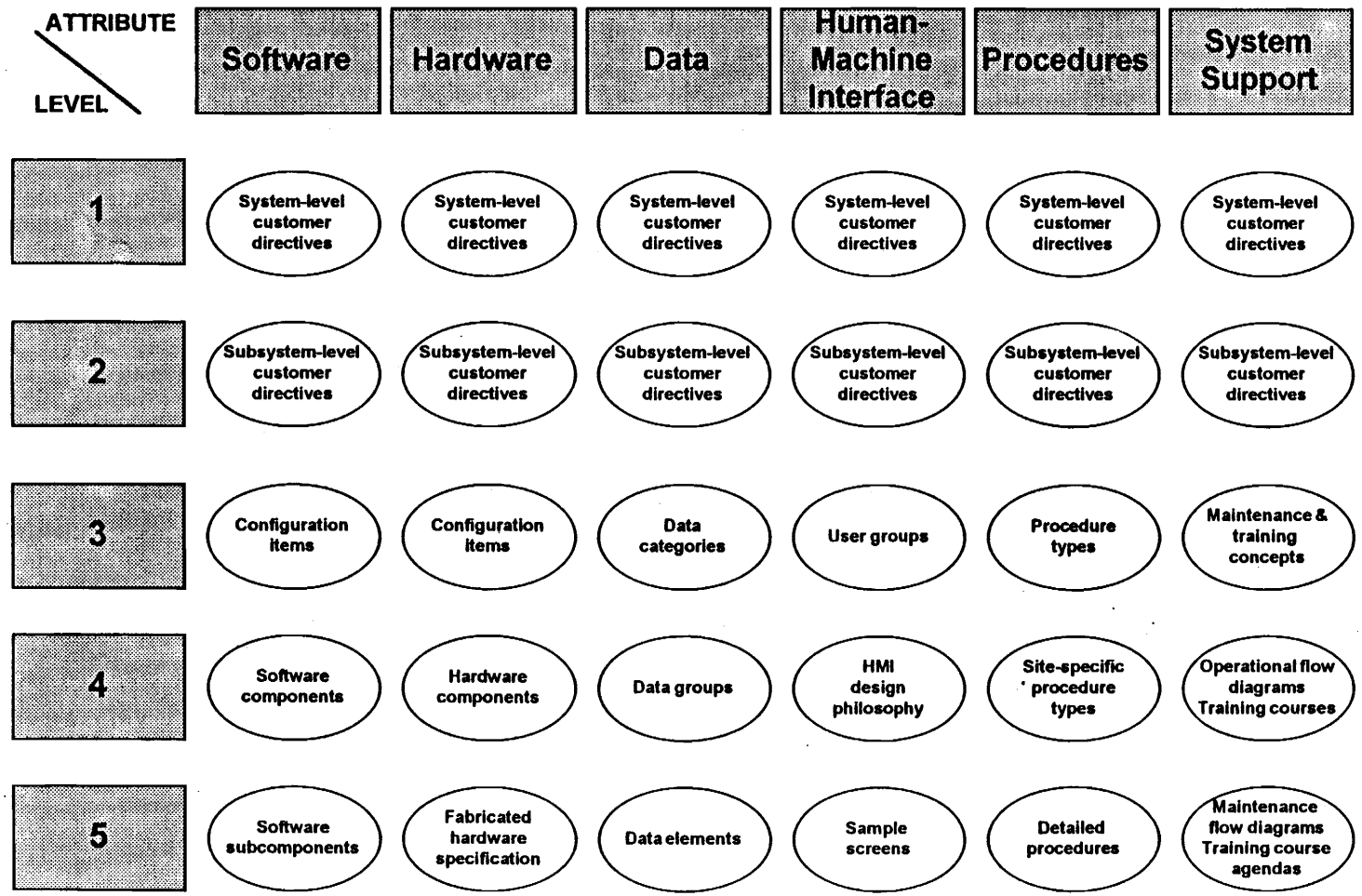

Figure 7-2. Implementation Attributes

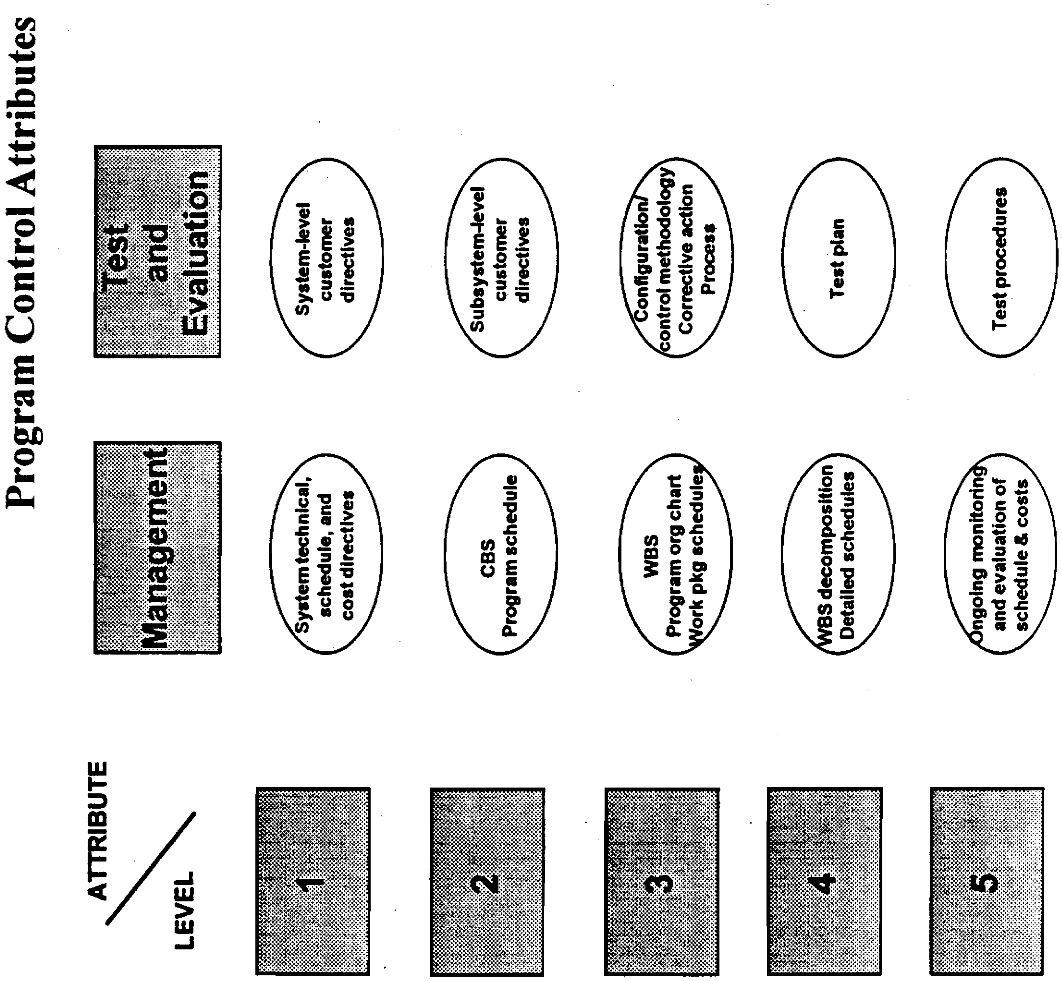

Figure 7-3. Program Control Attributes

7.1 Functions

The functional attribute describes the mission of the system and the mission-related activities or functions to be performed by the system. A functional decomposition is performed to define the functionality of the system and associated interfaces within the system.

Functions - Level 1

Level 1 describes the system mission and any alternative or secondary missions. Understanding the mission is the first step in systems development because it describes the overall objectives of the system and provides the foundation upon which the system is developed and evaluated against.

The analyst asks the customer questions regarding the mission of the system (refer to figure A-1) and documents the mission statement(s) in a free-text format (refer to figure A-2).

Functions - Level 2

Level 2 describes the subsystems of the system and their missions. Each subsystem is described in a few sentences and the major functions that each subsystem performs are defined. The mission of each subsystem is also defined and must contribute to the prime operating mission or be defined as an alternative or secondary mission.[5]

The analyst asks the customer questions regarding the subsystems of the system and their associated missions (refer to figure A-22) and documents the results in the Subsystems chart (refer to figure A-23).

Functions - Level 3

Level 3 describes the subsystems in terms of the functions required to accomplish the goals of the system. These top-level activities are shown with their interrelationships to each other. The tool used in this exercise is the N^2 chart (refer to figure A-42) which

provides a structured method for the definition of functional interactions and interfaces. The N^2 chart is simple and easy to understand, structured and methodical, top-down in nature, communicative of the design and forces a uniform level of design consistency.[9] All lines entering/leaving a box horizontally are outputs. All lines entering/leaving a box vertically are inputs. Each of the subsystems identified in level 2 is placed into the boxes on the diagonal and if there aren't any subsystems, then the major functions of the system would go into the boxes. The external inputs and outputs at level 3 are those contained on the Allocated Subsystem Interfaces chart (figure A-24). Every interface defined at level 2 must find a home on the level 3 N^2 chart; either a new box (subsystem function) must be added to the N^2 chart, or the interface will not be external once the system is developed and thus needs to be removed from the level 2 interface charts. Once the subsystem functions are identified and the external inputs and outputs are added, the interrelationships between each function is recorded on the level 3 function interface chart (refer to figure A-43). This information is contained in the Subsystem Interfaces chart (figure A-26). The analyst places the information into the N^2 chart and function interface chart formats and then meets with the customer and goes through each box to ensure all of the system functionality is captured in the level 3 boxes. Next, each possible interface (i.e., 1,2; 2,1; 1,3) is discussed to ensure the data is correct and that nothing is missing. Figures A-44 and A-45 provide a sample of how the N^2 chart works.

Functions - Level 4

The level 3 N^2 chart shows all of the top level functions of the system and their interrelationships. For each box that appears at level 3, there will be a level 4 N^2 chart that shows the decomposition of that function (refer to figure A-66). Also included are the level 4 function interface charts (refer to figure A-67). All external inputs and outputs on the level 3 N^2 chart must be used somehow in the level 4 charts.

Functions - Level 5

For larger systems, level 5 N^2 charts and function interface charts (refer to figures A-82 and A-83) exist for each box that appears on a level 4 chart. The decomposition continues to level n where n depends on the complexity of the system.

7.2 Interfaces

The interfaces attribute defines the transition points and methods for exchanging information and/or control between the system and those entities with which it interfaces as well as the interfaces among and within system components. This exchange may be a data exchange, where the information captured is the data content, format, and exchange rates, or it may be a processing exchange in the form of initiation, interaction, or control.

Interfaces - Level 1

Level 1 of the interfaces attribute identifies the environment of the system in terms of the input, output, and throughput. The entities external to the system with which the system must communicate are defined and the communication is described. The external entities may be other automated systems or non-automated information sources or recipients. The medium for the interface may or may not be electronic. The communication is described in terms of content, transmission rates, and methods/protocols.

The analyst asks the customer to identify the external interfaces (refer to figure A-3) and documents the information in the System External Interfaces chart which depicts the system as a single central box connected by arrows to each of the external entities with which it interfaces (refer to figure A-4). There are subsequent charts for each of the interfaces which describe the exchange between the system and each entity. The analyst asks the customer questions regarding the details of each interface (refer to figure A-5) and documents the results in the Information/Data Exchange chart (refer to figure A-6) and the Processing/Control Information Exchange chart (refer to figure A-7).

Interfaces - Level 2

Interfaces level 2 allocates the external interfaces identified in level 1 to one or more of the subsystems and identifies the interfaces between the subsystems.

The Allocated Subsystem Interfaces chart (figure A-24) is the same as the System External Interfaces chart except that each subsystem is placed in the center box and all of the external entities identified on the System External Interfaces chart (figure A-4) are allocated to one or more of the subsystems identified on the Subsystems chart (figure A-23). In addition, the data exchanged on the Information/Data Exchange chart (figure A-6) and the Processing/Control Information Exchange chart (figure A-7) are added to the Allocated Subsystem Interfaces chart. The second chart depicts the data exchanged between each of the subsystems. To describe the interfaces between the subsystems, the analyst asks the customer questions regarding the data exchanged between each subsystem (refer to figure A-25) and records the data on the Subsystem Interfaces chart (figure A-26).

Interfaces - Level 3

Level 3 interfaces are those that pertain to the major functions of the system and are identified in the level 3 functional attribute. When performing functional decomposition for levels 3 and below, the analyst must ensure that the interfaces described in the level above are in some manner accounted for in the subsequent levels. For example, all interfaces described in the level 2 interface attribute must be shown on the level 3 N^2 chart (figure A-44).

Interfaces - Level 4

Level 4 interfaces are defined on the level 4 N^2 charts (figure A-66).

Interfaces - Level 5

Level 5 interfaces are defined on the level 5 N^2 charts (figure A-82).

7.3 Distribution

The distribution of the system includes both the physical locations of where the system's functionality will be performed and the combinations of the system components (hardware, software, and data) that are allocated to each location. The information contained in the distribution attribute also provides the basis for installation surveys and planning.

Distribution - Level 1

The level 1 distribution attribute identifies all the physical locations of the system and categorizes them into site types where appropriate. All the sites, centers, and facilities (which includes maintenance) are recorded to the level of detail that exists. If the information system is mobile, the departure and arrival points and travel routes are highlighted.

The product is one or more maps with the physical locations plotted and travel routes highlighted. A supporting table is completed with customer input which contains location names and site types (refer to figure A-10). For mobile systems, the arrival and departure location names are recorded and a comments column is provided to record any additional details regarding the location (refer to figure A-11).

Distribution - Level 2

Distribution level 2 allocates the subsystems identified on the Subsystems chart (figure A-23) to the locations and site types defined on the Fixed and Mobile System Locations charts (figures A-10 and A-11). The resulting charts are the Subsystem Distribution - Fixed Locations (figure A-29) and the Subsystem Distribution - Mobile Locations (figure A-30) charts.

Distribution - Level 3

Level 3 examines each of the subsystems required at each location in terms of the aggregations of processing capability necessary. The level 3 hardware, software, and data attributes are examined to determine which pieces are needed at each site or for each site type.

The product of the level 3 distribution attribute is additional columns to the chart produced in levels 1 and 2. The associated hardware HWCIs, software CSCIs, and data categories required at each location or site type are added (refer to figure A-57).

Distribution - Level 4

Level 4 is a further breakdown of the components required at each location. This correlates to the aggregations of level 4 hardware and software and data required at each location. This level of detail is only required if components/data groups are to be added or deleted within the aggregations identified at level 3. The level 3 format is used to record this data (refer to figure A-57).

Distribution - Level 5

Level 5 is a further breakdown of subcomponents required a each location. This correlates to the aggregations of the level 5 hardware, software, and data provided at each location. This level of detail is only required if subcomponents or data elements are to be added or deleted within the aggregations identified at level 4. The level 3 format is used to record this data (refer to figure A-57).

7.4 Performance

System performance is the description of the behavior of the end items which comprise the system in quantitative terms.[13] Objectives for size, timing, and physical aspects of the system are in fact system constraints, and must be established early and understood throughout the research, design, development, and evaluation phases of the system life-cycle. Failing this careful monitoring, the system will almost certainly

not perform to the expectation of its users. Because actual performance cannot be measured until the system is complete, models and simulations developed during systems analysis and design propagate predictions upon which design decisions can be based.[4] At the highest level, the performance attribute documents the physical and performance requirements of the system. The performance attribute can serve as the basis of a dialogue with the customer to help establish realistic performance objectives, and then preview their impact on the system via modeling, simulation, and prototyping.

Performance - Level 1

Level 1 of the performance attribute looks at the external interfaces identified for the system and assigns associated volumes or quantity of transactions, frequency, time interval, and quantity or percent of allowable errors for each external interface defined.

The analyst asks the customer questions (refer to figure A-8) about each interface identified on the Information/Data Exchange chart (figure A-6) and the Processing/Control Information Exchange chart (figure A-7) and documents the results in the System Interface Performance chart (refer to figure A-9).

Performance - Level 2

Level 2 records the same data as level 1 for each subsystem interface. The analyst asks the customer performance questions (refer to figure A-27) about the data exchanged on the Subsystem Interfaces chart (figure A-26) and documents the results in the Subsystem Interface Performance chart (refer to figure A-28).

Performance - Level 3

Level 3 identifies the overall, high-level quantified operational, physical and performance requirements of the system. The analyst asks the customer a series of questions (figures A-46, A-47, and A-48) regarding the operational, environmental,

and performance requirements of the system and records the data in the Requirements Identification chart (figure A-49).[14] All of the questions may not apply to all information systems but it is a starting point to get the customer thinking in the right direction. After recording all the level 1 and level 2 attribute data, the analyst should be able to come up with several more questions that are more specific to the system being analyzed.

Performance - Level 4

All of the performance requirements identified in level 3 can be accomplished through either hardware, software, data, procedures, or a combination. This level allocates the level 3 performance requirements to the lowest unique levels of hardware and software components, data and procedures. A table is prepared using the data retrieved from the hardware, software, data and procedures attributes and the customer aids in assigning the performance requirements to one or more HWCIs, CSCIs, CSCs, CSUs, data groups/elements, and/or procedures (refer to figure A-80).[17]

Performance - Level 5

Level 5 contains the data derived from level 4 which would be used as input to any simulations or prototypes developed. The product is a free-text description of the data.

7.5 Security

The concern of security is of paramount importance in information systems and must be considered early in the conceptual design of the system rather than something that is imposed on the system after it is delivered. The implications of the security requirements of a system may be far-reaching, and may eliminate otherwise viable implementation alternatives and design methods. Security needs the focus that comes with having its own attribute rather than being a by-product of other attributes. The range of security requirements that can be levied against a system is broad, and more

stringent security rules can be applied as the technology of computer security advances.

Security - Level 1

The level 1 security attribute defines the overall system requirements for security. This may be identified as an Orange or Red Book trust level such as C2 or B1, or top secret. It may also be a top-level, customer-specified directive to the effect that the system will use whatever password protection is provided by the operating system or the database management system.

The analyst asks the customer questions regarding system security directives (refer to figure A-12) and documents the results in a free-text format.

Security - Level 2

Level 2 of the security attribute is the same as level 1 but applies to subsystem or site-specific security directives. The customer may specify subsystems or sites/site types to be protected in a different manner or at a different level of trust than the other subsystems or sites/site types.

The analyst asks the customer questions regarding subsystem security directives (refer to figure A-31) and documents the results in a free-text format.

Security - Level 3

The level 3 security attribute defines the differences in the manner in which the parts of the system's processes and data must be protected from the rest, or at a different level of trust. This data becomes the preliminary security model for the system. It takes an early look at the principles of trust to be used in designing the system and identifies the trust level of the processes and data of the system which are identified in level 3 of the software and data attributes.

The product is two tables indicating the data categories and CSCIs to be protected and the trust approach to be used (refer to figures A-58 and A-59).

Security - Level 4

Level 4 describes the specific implementation of the security model. Any features that need to be fabricated or developed to provide security functionality are described here, as well as the approaches to implementing the principles of trust which have been identified in level 3. Level 4 security provides input to the hardware, software, data and procedure attributes since the actual implementation will be in hardware, software, data and procedures.

The product takes what was produced in level 3 and adds data to the table indicating what hardware, software, data and procedures will be used to implement the security approach described (refer to figures A-68 and A-69).

Security - Level 5

Level 5 contains the data derived from level 4 which would be used as input to any simulations or prototypes developed. The product is a free-text description of this data.

7.6 Software

The software attribute describes the computer-executable program modules which provide the software functionality for system operation and support. This may consist of application software, service software, processing control software, or a combination.[19]

Software - Level 1

Level 1 of the software attribute represents customer directives which have been levied against the software of the system as a whole. The customer may identify a requirement to use a specified operating system, integrate a specified commercial off-

the-shelf (COTS) software package into the system, incorporate existing prototypes or non-developmental software (NDS) into the system.

The analyst asks the customer questions regarding system software directives or constraints (refer to figure A-13) and documents the results in a free-text format.

Software - Level 2

Level 2 of the software attribute is similar to level 1 in that it covers customer directives or constraints, but at level 2, the focus is their applicability to a particular subsystem or site. Thus, if the customer requires the use of a certain automated tool at a given site because it has been installed there but does not similarly constraint the other sites or subsystems, then this data is recorded here.

The analyst asks the customer questions regarding subsystem software directives (refer to figure A-32) and documents the results in a free-text format. If several anomalies exist, then the results should be provided in tabular format by location or site type. This exercise is necessary, however, the customer must be reminded of the impact of having sites with unique software. This affects the system life-cycle cost be increasing the development, test, and maintenance effort.

Software - Level 3

The software level 3 attribute describes the top level aggregations of software for the system. They are analogous to software subsystems, and are identified by examining the level 2 interface, level 3 functional and system support attributes, and levels 1-3 of the performance attribute. In a small system, these aggregations may equate to Computer Software Configuration Items (CSCIs); in a large system, they may be aggregates of CSCIs.

The product of this is a table identifying each configuration item and a description of the functionality provided (refer to figure A-54).

Software - Level 4

Software level 4 represents subdivisions or decompositions of the software entities defined in level 3 and correlate to the level 4 functional attribute data. Thus, on a small system, level 4 will correspond to the top-level computer software component (TLCSC); on a large system, level 4 may be the CSCIs themselves.[2]

The product is a table with the configuration items identified and a description of the COTS/NDS and new software required with estimated lines of code (refer to figure A-72).

Software - Level 5

Likewise, software level 5 is a decomposition of level 4, so that for a small system, level 5 is the computer software component (CSC), while on a large system, level 5 may be the TLCSC identification. The analyst must go to the level necessary to reach CSC identification. The product uses the same format as level 4 (figure A-72).

7.7 **Hardware**

Hardware is the equipment used to process, store, display, and communicate system data and software. It includes all of the equipment needed for system operation and support, including special-purpose or specially fabricated hardware, hardware required for archival and operational storage, and any special maintenance equipment required.[18]

Hardware - Level 1

As with the software attribute, the level 1 hardware attribute reflects the specific hardware requirements directed by the customer. These may include specific vendor/model requirements, hardware required for customer-directed software or prototypes, customer-furnished hardware, and any requirements to use existing equipment.

The analyst asks the customer questions regarding system hardware directives or constraints (refer to figure A-14) and documents the results in a free-text format. Also, for each of the directives identified in software level 1, determine whether associated hardware requirements exist.

Hardware - Level 2

Level 2 of the hardware attribute is similar to level 1 in that it covers customer directives or constraints, but at level 2, the focus is the applicability to a particular subsystem or site. Thus, if the customer requires the use of a certain piece of hardware at a given site because it has been installed there but does not similarly constraint the other sites or subsystems, then this data is recorded here.

The analyst asks the customer questions regarding subsystem software directives (refer to figure A-33) and documents the results in a free-text format. If several anomalies exist, then the results should be provided in tabular format by location or site type.This exercise is necessary, however, the customer must be reminded of the impact of having sites with unique software. This affects the system life-cycle cost be increasing the development, test, and maintenance effort.

Hardware - Level 3

Hardware level 3 describes the aggregations of hardware components needed to support the subsystem capabilities. The level 2 interface, level 3 functional, software, and system support attributes, and levels 1-3 of the performance attribute are examined to identify hardware components.

The product is a table identifying each hardware configuration item (HWCI) and a description of its physical components or pieces (refer to figure A-55). The results of this attribute provide input to a cost/benefit analysis.

Hardware - Level 4

Level 4 documents the results of the cost/benefit analysis to include the recommended specifics of the hardware subsystem components in terms of vendor/model identification and components to be fabricated and associated costs. The management attribute is reviewed for cost and schedule constraints and levels 1 and 2 of the interface attribute are reviewed for physical constraints when performing the cost/benefit analysis.

The product of this takes the configuration items identified in level 3 and provides the vendor model name and associated costs for recommended COTS hardware as well as an estimated cost for hardware to be fabricated (refer to figure A-73).

Hardware - Level 5

Level 5 contains the top-level specification for the hardware to be fabricated. The product is a free-text list of the specifications in bullet form for each item.

7.8 Data

The data attribute describes the information which is pertinent to the mission and support functions and may be used to perform, monitor, control, or evaluate these functions.

Data - Level 1

Data level 1 consists of specific data or database requirements directed by the customer. It includes constraints or requirements related to the way the data is defined or its accessibility.

The analyst asks the customer questions regarding system data directives (refer to figure A-15) and documents the results in a free-text format.

Data - Level 2

Level 2 of the data attribute is the same as level 1, but applies to customer direction regarding data associated with a subsystem or location/site type.

The analyst asks the customer questions regarding subsystem data directives or constraints (refer to figure A-34) and documents the results in a free-text format.

Data - Level 3

Data level 3 describes the overall categories of data that are required by the system. The level 3 functional attribute is examined to describe this data. An example of some categories of data are text, image, structured, etc.[15]

The product is a table which provides a description of each category defined (refer to figure A-56).

Data - Level 4

Level 4 describes the collections of data, or groups, within each category necessary to support the functionality described in the functional attribute level 4 or the lowest level that is appropriate. In addition, a preliminary entity-relationship diagram is developed which depicts the relationships between the data groups.[20]

The Data Groups chart is produced which provides a list of the groups associated with each data category (refer to figure A-74). Also produced is the entity-relationship diagram for the system (refer to figure A-75).

Data - Level 5

The data attribute at level 5 identifies the data elements and associated descriptions and values for the data groups defined in level 4 (refer to figure A-84).

7.9 Human-Machine Interface

The human-machine interface (HMI) is the means by which the system is presented to its users, and the mechanism for the users to interact with it. The HMI plays a crucial role in assessing the effectiveness and user acceptability of a system.

Human Machine Interface (HMI) - Level 1

HMI level 1 presents any high-level customer-directed interface requirements, such as the system shall be menu-driven.

The analyst asks the customer questions regarding HMI directives (refer to figure A-16) and documents the results in a free-text format.

Human Machine Interface (HMI) - Level 2

Level 2 of the HMI attribute is the same as level 1, but applies to customer direction regarding the HMI associated with a subsystem or location/site type.

The analyst asks the customer questions regarding subsystem HMI directives or constraints (refer to figure A-35) and documents the results in a free-text format.

Human Machine Interface (HMI) - Level 3

Level 3 defines the different types of user groups required for operation and maintenance of the system. A user group is one or more individuals who perform the same kinds of tasks i.e., system administrator, administrative support, and program management are a few that would probably exist for any information system. The functional attribute N^2 charts and the level 3 system support charts are examined to identify the user groups appropriate for the system.

The product is a table depicting the functional allocation of each user group defined (refer to figure A-60).

Human Machine Interface (HMI) - Level 4

Level 4 identifies the preliminary HMI design philosophy or the method in which the users access and use the system. It includes the rationale for such decisions as the use of multiple windows, pull-down menus, the provision of context-sensitive help, audit trails of user sessions, common look and feel requirements, or general orientations, such as workbench as opposed to toolkit. The actual implementation of the design philosophy will be performed using software and hardware. Therefore, vendor hardware and software currently available on the market which provide the philosophy specified are recorded and a cost/benefit analysis will be performed to select the vendor(s)/model(s). If additional fabrication is to be performed, then this data is recorded on the level 4 software and/or hardware charts (figures A-72 and A-73).

The User Classes chart which provides a mapping of the user groups defined in level 3 to user classes (refer to figure A-76). A user class is a collection of one or more user groups that uses the same design philosophies. Two user classes that exist for most information systems are general which would include the management, administrative support, and others that would use the same HMI techniques; and the system user class which would include groups such as the system operator, administrator, data base administrator, and maintenance specialist. The Design Philosophy chart depicts the characterization of each user class defined and the style of HMI to be used (refer to figure A-77). The characterization is whether the user class is analytic, clerical, ADP oriented, or non-ADP oriented. From the characterization defined, the HMI style can be determined (i.e., toolbox, procedural). The Design Philosophy Allocation chart lists the hardware and software products and associated vendor for each HMI style and characterization defined (refer to figure A-78).

Human Machine Interface (HMI) - Level 5

HMI level 5 provides preliminary screens for each of the user classes using the design philosophies and HMI products specified in level 4. This would identify the presentation of the top-level options available to each type of user. The product is hand-drawn sample screens.

7.10 **Procedures**

The procedural attribute of the system describes the human-oriented activities relevant to the control of the system to enable it to achieve its mission objectives.

Procedures - Level 1

Level 1 of the procedural attribute identifies any customer-directed constraints on the system's procedures. Such a directive might be that the system run without human intervention except in the case of system failure. Another might be that the system must use totally redundant hardware as its primary backup mechanism.

The analyst asks the customer questions regarding system procedural directives (refer to figure A-17) and documents the results in a free-text format.

Procedures - Level 2

Level 2 of the procedures attribute is the same as level 1, but applies to customer direction regarding the procedures associated with a subsystem or location/site type.

The analyst asks the customer questions regarding subsystem procedural directives (refer to figure A-36) and documents the results in a free-text format.

Procedures - Level 3

Procedures level 3 identifies the areas for which procedures will be required. These include at a minimum the procedures for system initialization and termination; system backup, restore, and recovery; system logging and audit; transportation and handling

of system hardware, software, and data during system initialization, operation, and maintenance, any pertinent schedules identified in level 1.

The product contains the procedures areas, associated schedule or timing information and quantities of personnel and skill levels required (refer to figure A-61).

Procedures - Level 4

Procedures level 4 describes the site or location-specific procedures that were identified in level 2.

The product is the same that was produced in level 3 with an additional column identifying the location(s) or site type(s) the procedure is applicable to (refer to figure A-79). The location/site types are those identified on the Fixed Locations (figure A-10) and Mobile System Locations (figure A-11) charts.

Procedures - Level 5

Level 5 provides the detailed step-by-step procedures and the title of the individual(s) performing each step of the procedures identified in levels 3 and 4 (refer to figure A-85).

7.11 Management

The management attribute describes the activities which have been established to control development, operations, and maintenance of the system to achieve program objectives. These objectives are the technical, cost and schedule objectives of the system, but are combined into a single management attribute.[8]

Management - Level 1

In the management attribute, level 1 identifies the constraints levied on the technical, schedule, and cost of the system. On the technical side, level 1 identifies the top-level standard under which the system is to be developed, such as 2167A, 490B,

SOID II, etc. On the schedule side, level 1 describes the program phases involved and provides a schedule for completing each phase. In a typical information system, the program phases are conceptual design, preliminary design, detail design, development, and operations and maintenance. On the cost side, level 1 contains the top level life-cycle cost budget since most all information systems projects will have cost constraints.

The analyst asks the customer questions (refer to figures A-18 and A-19) regarding system management technical, schedule, and cost directives and documents the results in free-text format.

Management - Level 2

At level 2, the program deliverables and top-level program activities are identified using the standards specified in level 1. The schedule shows the level 2 program deliverables and tasks using the schedule constraints identified in level 1. The life-cycle cost breakdown structure (CBS) is developed using the cost constraints identified in level 1 and the program activities identified on the schedule. The cost breakdown is also summarized and broken down by program year. Also, a method for managing risk throughout the life-cycle of the program is defined.[16]

The level 2 technical and schedule products are combined into the Program (program evaluation and review technique) PERT Chart indicating the program activities, milestones, deliverables and task interrelationships (refer to figure A-39).[1] The Life-Cycle Cost Breakdown provides the program activities and associated costs in tabular format with subtotals for each program phase as well as a grand total for the program (refer to figure A-40).[3] The summary costs are also included in tabular format with the program activity, cost by program year and total cost for each phase.[3] Figure A-41 depicts the cost summary format for the conceptual design phase. Similar products are produced for the remaining program activities.

Management - Level 3

Level 3 describes the program work breakdown structure (WBS). WBS Level 1 contains the system name, and WBS level 2 for most information systems contains the headings hardware, software, data, system/project management, facilities (includes maintenance) and, system test. WBS level 3 contains the work packages associated with each of the WBS level 2 elements. Levels 4 and below provide work package details. The work packages are identified by looking at the program activities identified in level 2, as well as the products of the levels 3 and below of the hardware, software, data, test and evaluation, system support, and distribution attributes and assigning tasks required to implement and integrate them. This is an iterative process in which more details are added to the WBS as tasks are better defined throughout the life-cycle of the program.

A program organization chart is prepared and the work packages are allocated to the various organizations. A mapping is also performed of the WBS work packages to the associated life-cycle costs in the Life-Cycle Cost Breakdown chart (figure A-40) and a schedule is produced for each of the work packages.

The following products are produced in the level 3 management attribute: The WBS (refer to figure A-62), the WBS to CBS Mapping (refer to figure A-63), the WBS to Organization Chart Mapping (figure A-64) and the Work Package Schedules (refer to figure A-65).

Management - Level 4

Level 4 further decomposes the WBS prepared in level 3 to additional levels of detail as necessary and provides more detailed schedules. Levels 4,5, and beyond may be necessary for large, highly complex systems.

The products are the same as the level 3 products (figures A-62 through A-65) with more details added.

Management - Level 5

Level 5 of the management attribute is the ongoing monitoring and evaluation of the program schedule and costs expended.

7.12 Test and Evaluation

Test and evaluation is the process of testing and evaluating all aspects of the system to ensure that the system meets the stated requirements and thus fulfills its mission. System test includes testing of the computer software units (CSUs), computer software components (CSCs), CSCIs, HWCIs, components and assemblies for fabricated hardware, and the system as an integrated whole.

Test and Evaluation - Level 1

Level 1 of the test and evaluation attribute identifies any customer-directed constraints on the system's test approach or procedures; for example, the customer may direct the use of a "black box" approach to testing.

The analyst asks the customer questions regarding system test and evaluation directives (refer to figure A-20) and documents the results in a free-text format.

Test and Evaluation - Level 2

Level 2 of the test and evaluation attribute is the same as level 1, but applies to customer direction regarding test and evaluation associated with a subsystem, location/site type, item of equipment, software, or data.

The analyst asks the customer questions regarding subsystem test and evaluation directives (refer to figure A-37) and documents the results in a free-text format.

Test and Evaluation - Level 3

Level 3 describes the configuration control methodology to be used for the program as well as the corrective action process for handling problems detected in the items

under configuration control. A description of how and when items are placed under configuration control and how configuration control is to be conducted is defined here.

The product of the attribute is a description of the configuration control methodology and the corrective action process for the program. If automated tools will be used to aid in these activities, then the documentation for the tools is included here. The analyst reviews the methodologies and tools used in other similar programs to determine if they are appropriate for the system being analyzed and documents the results in a free-text format. If appropriate, then the information is reviewed with the customer for approval.

Test and Evaluation - Level 4

Level 4 looks at each phase within the system life-cycle and develops a plan to test the requirements during the preliminary design, detail design, development, in-house test, and FQT. The testing techniques to be used, test classes (i.e., timing tests, erroneous input tests, maximum capacity tests), test levels (i.e., CSCI, CSCI to HWCI, system level), evaluation criteria, anticipated output, schedules, test environment, facilities, equipment and personnel required are provided for each testable item.

The product is a series of tables for each phase of the system life-cycle containing the data described above (refer to figure A-81).

Test and Evaluation - Level 5

Level 5 contains the actual test procedures to be used for each testable item specified in level 4. The product is a table containing the testable item and the associated test procedures (refer to figure A-87).

7.13 System Support

System support includes all of the elements necessary to ensure the system operates in an efficient and effective manner. It includes transportation and handling of system products, training of personnel to operate and maintain the system, and maintenance of the system throughout its operational life.

System Support - Level 1

Level 1 of the system support attribute identifies any customer directives or constraints on maintenance and training for the system.

The analyst asks the customer questions regarding system support directives (refer to figure A-21) and documents the results in a free-text format.

System Support - Level 2

Level 2 of the system support attribute is the same as level 1, but applies to customer direction regarding system support activities associated with a subsystem, location/site type, item of equipment, software, or data.

The analyst asks the customer questions regarding subsystem support directives (refer to figure A-38) and documents the results in a free-text format.

System Support - Level 3

Level 3 describes the maintenance and training concepts for the system. The concepts are developed early on in development life-cycle and are refined throughout the design process.

Maintenance Concept

The maintenance concept defines how the system will be supported throughout its operational life. As with any system there are different types or degrees of

maintenance to be performed. User, Specialist, and Producer maintenance are typical categories of maintenance for an information system.

User Maintenance - maintenance operations to be performed by the system users. This includes visual inspections of the system components, operational checkout, and executing diagnostics.

Specialist maintenance - maintenance and repair operations to be performed by software and hardware specialists at the customer's site. These individuals should also be users of the system. This includes limited software and hardware debugging and correction.

Producer maintenance - repair operations to be performed by the producers of the hardware and software at the producer's site. In the case of mobile information systems, there may be depots assigned to perform these functions. This includes major software and hardware debugging and correction.

Although information systems will for the most part have these 3 categories of maintenance, the hardware debugging and correction feature in specialist and producer maintenance will only apply where there is fabricated or non-vendor supported COTS hardware. Figure A-50 contains a Typical Maintenance Concept for information systems which does not include maintenance of COTS hardware and software. Figure A-51 is a sample Atypical Maintenance Concept for an information system which includes fabricated or non-vendor supported hardware. The concept which applies to the system being analyzed should be reviewed with the customer for accuracy, completeness and input of timing constraints (refer to figure A-52).[3]

Training Concept

At level 3, the training concept looks at the user groups and classes defined in levels 3 and 4 of the HMI attribute and levels 3 and below of the data, software, hardware,

security, procedures, and test and integration attributes and provides a bulletized list of the types of training required.

The product is the Training Concept which contains a list of training required for each user group/class (refer to figure A-53).

System Support - Level 4

Level 4 builds on the maintenance and training concepts produced in level 3 and provides the operational flow diagrams and training courses required for the system. The N^2 charts for levels 4 and below are examined to determine what the various modes of operation are and the customer provides information regarding the sequence of processing that occurs within each mode to develop operational flow diagrams. The training required for each user group/class is examined by the analyst to determine what vendor provided training courses are needed as well as the training courses that must be developed.

The products are the Operational Flow Diagrams (refer to figure A-70) and the Training Courses chart (refer to figure A-71).

System Support - Level 5

Level 5 contains the maintenance flow diagrams for the system (refer to figure A-86). The maintenance flow diagrams provide the corrective action steps necessary when the operation described in a particular box on the operational flow diagram cannot be accomplished (refer to figure A-70).[3] Each box on the level 4 operational flow diagrams is examined to determine the corrective action steps necessary for non-success. For example, one operational mode of an information system is user logon. If successful, then the user selects a menu option, if unsuccessful, the user tries again, and if unsuccessful again, the system administrator is called.

Level 5 also contains more details regarding the training courses identified in level 4. An agenda is provided for each course identifying the topics to be covered by day in a free-text format.

8.0 Mapping of Product Data to Design Deliverables

The project research included documentation reviews of deliverables associated with the conceptual, preliminary, and detail design phases of the system engineering life-cycle. INFOSYM was designed to allow for the products to be "cut and paste" into the deliverables. A mapping was performed of the data contained in the attribute products to the appropriate section in the following Military Standard 2167A documents[12]:

- System Specification
- Software Development Plan
- Software Requirements Specification
- Interface Requirements Specification
- System Design Document
- Software Design Document
- Interface Design Document
- Software Test Plan

The results are contained in Appendix B.

9.0 Conclusion

INFOSYM is an integrated approach to facilitate the system requirements definition process in information systems development projects. It provides a mechanism for the customer and the systems engineers to interact early in the system development life-cycle and ensures that the system delivered meets the customer's needs and expectations. INFOSYM provides a standard approach to gathering and recording system requirements during the conceptual and preliminary design phases of the system life-cycle and validating the requirements during the detail design phase. This validation is critical in order to make an early assessment of design changes and provide feedback prior to systems development. Design changes implemented prior to system development minimize the project cost and schedule impacts. Although INFOSYM has been developed for information systems, it can be easily modified to aid in the design and development of any type of system.

10.0 Future Uses

Once automated, INFOSYM would be an excellent Computer-Aided Software Engineering (CASE) tool for use throughout the system life-cycle. It can be used initially to define and validate the system requirements. However, INFOSYM's use can be expanded to include the following:

- o Determine the overall system impact due to design changes during development - Design changes during development can be very costly and must be assessed accurately so as to minimize the schedule and cost impact
- o Monitor and track system development and operations costs
- o Evaluation of alternative projects

Tracking of system costs is beneficial for resource and cost estimation of future systems development projects. Once automated, INFOSYM can build a repository of cost data for systems developed, thus providing more accurate estimation of future similar projects.

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Appendix A
INFOSYM Product Formats

Functions - Level 1

System Mission Questions

1. What is the prime operating mission of the system?
2. What are the alternative or secondary missions?

Functions - Level 1

IRS' Training System Mission

To provide training to all IRS employees to enable them to perform their job in a productive and efficient manner

Interfaces - Level 1

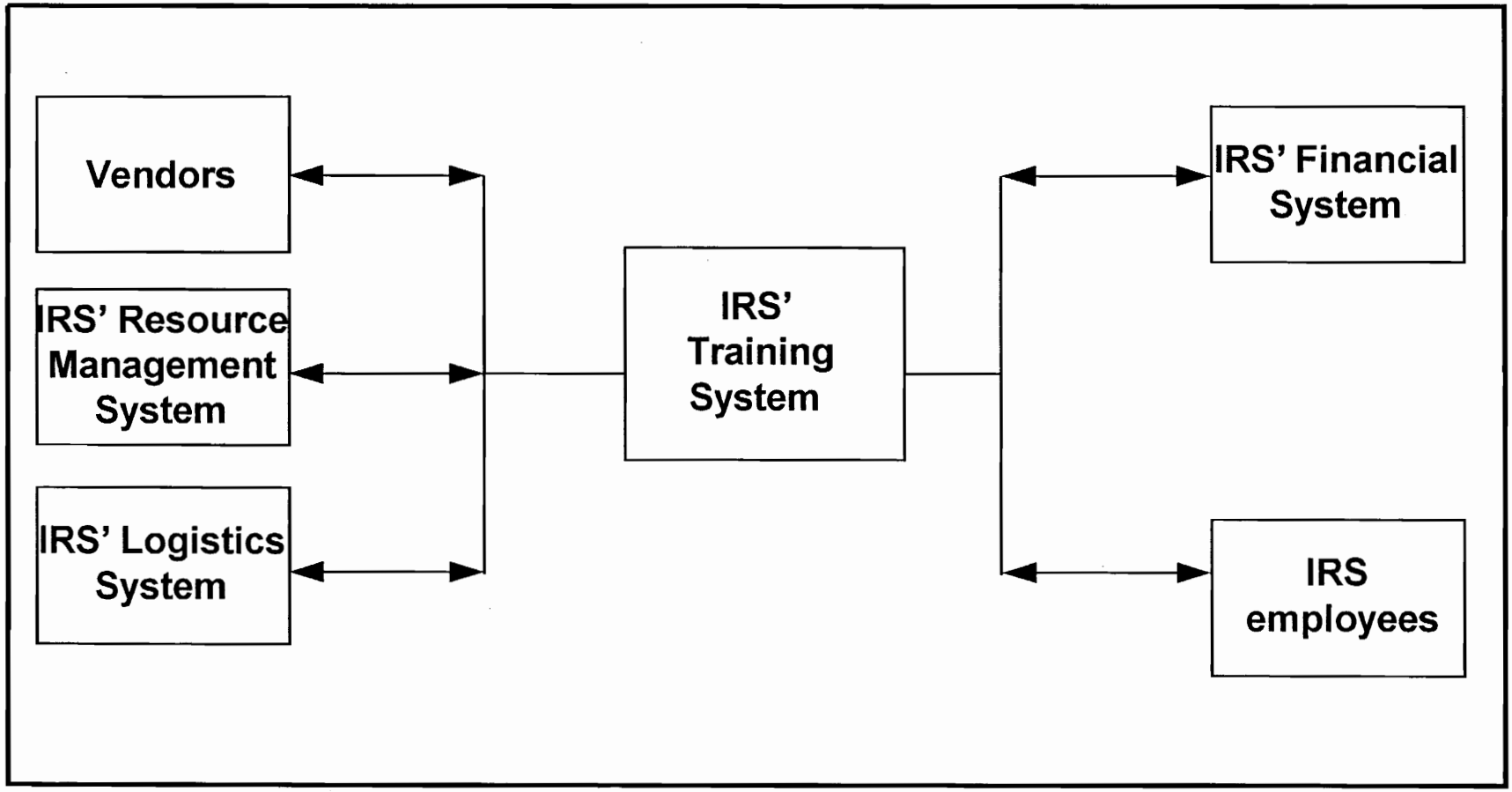
System External Interfaces Questions

1. What external organizations, systems, individuals, or other sources does your system receive information/data/processing control from?

2. What external organizations, systems, or individuals or other recipients receive information/data/processing control from your system?

Interfaces - Level 1

IRS' Training System
External Interfaces



Interfaces - Level 1

External Interface Detail Questions

These questions apply to each entity/organization defined on the System External Interfaces chart (figure A-4).

1. **Is the exchange information/data? If so, identify the content, format, and exchange rate and protocols where appropriate.**

2. **Is the exchange processing or control information? If so, identify the interaction or control that takes place as well as the event (i.e., unit of time, keystroke, query, etc.) that causes the exchange.**

Interfaces - Level 1
Information/Data Exchange

Vendors			
CONTENT	**FORMAT**	**EXCHANGE RATE**	**PROTOCOL**
Training Catalogs	electronic/ASCII non-electronic/ hard copy	N/A	N/A
Request for training	ASCII		

Interfaces - Level 1
Processing/Control Information Exchange

Organization Name	
Initiation/Event	**Interaction/Control**
Press F4	**Automatically send training report to IRS' financial system**

Performance - Level 1

System Interface Performance Questions

These questions apply to each interface defined on the Information/ Data Exchange chart (figure A-6) and the Processing/Control Information Exchange chart (figure A-7).

1. What is the volume of data in terms of number of records, messages, or transactions per exchange?

2. What is the frequency in terms of number of occurrences per time interval (seconds, hours, days, years, etc.)?

3. What is the quantity of allowable errors or percentage of allowable errors per exchange of data?

Performance - Level 1
System Interface Performance

SYSTEM INTERFACE	VOLUME	FREQUENCY*	TIME INTERVAL	ALLOWABLE ERRORS
Training Catalogs	10		biannual	
Request for Training	750		quarter	
Emp Position Des	100,000		biannual	
Emp Trng History	100,000		year	
Emp Perform App	100,000		year	
Space Availability	1,000		year	
Equip Availability	3,000		year	
Funds Availability	3,000		year	
Course Costs	3,000		year	
Training Needs	100,000		year	
Instructors	500		year	
Course Catalog	1		year	
Course Schedule	1		quarter	
Training materials	300,000		year	

*Frequency default is once per time interval

Note: the above figures are based on 100,000 employees and each employee receives three course per year

Distribution - Level 1
Fixed Locations

SITE LOCATION	SITE TYPE
Washington, D.C.	National Office
Manhattan, New York	Regional Office
San Francisco, California	Regional Office
Philadelphia, Pennsylvania	Regional Office
Cincinnati, Ohio	Regional Office*
Atlanta, Georgia	Service Center
Ogden, Utah	Service Center
Austin, Texas	Service Center*
Dallas, Texas	District Office
Buffalo, New York	District Office
Richmond, Virginia	District Office*
Arlington, Virginia	Post of Duty
Phoenix, Arizona	Post of Duty*

* Note that this indicates that there are more sites with this site type

Distribution - Level 1
Mobile System Locations

SITE LOCATION	SITE TYPE	DEPARTURE/ ARRIVAL	COMMENTS
Portland, Oregon	Loading Bay	Departure/Arrival	
Austin, Texas	Loading Bay	Departure/Arrival	
San Diego, CA	Command Ctr	Departure	
Richmond, VA	Command Ctr	Arrival	

Security - Level 1

System Security Directives

1. Is there an overall security requirement for the system?
2. Are there different levels of security required for the system?
3. Are the security features inherent in the system hardware/ software sufficient?

Software - Level 1

System Software Directives

1. Are there any COTS packages that are required to be used when developing the system?

2. Is there a specified operating system to be used (i.e., UNIX, VMS)?

3. Is there a specified development language to be used (i.e., Ada, Pascal)?

4. Are there any existing pieces of software or non-developmental software (NDS) that are to be used? If so, what software language is it developed in and does it contain COTS?

Hardware - Level 1

System Hardware Directives

1. Are there hardware vendors that must be used? If so, what are the model numbers?
2. Is there government-furnished hardware that must be used?
3. Are there requirements to use existing equipment?
4. Are there hardware requirements associated with any of the software directives listed on the software - level 1 chart?

Data - Level 1

System Data Directives

1. Are there any specific data requirements for the system?
2. Is there existing data that must be used? If so, what format is it in?
3. Are there requirements for accessing the data?

Human-Machine Interface (HMI) - Level 1

System HMI Directives

1. Are there any specific HMI requirements for the system?
2. Is there an existing interface that must be used or replicated?

Procedures - Level 1

System Procedures

1. Are there procedures that must be used for system initialization?
2. Are there procedures that must be used for system phase out and termination?
3. Are there procedures that must be used for system backup, restore, and recovery?
4. Are there procedures that must be used for system logging and audit?
5. Are there procedures that must be used for transporting and handling system hardware, software, and data for system initialization, operational use, and maintenance?
6. Are there schedules or timing considerations that apply to items 1-5?

Management - Level 1
Technical and Schedule Directives

System Management Technical Directives

1. What is the standard under which the system is to be developed (i.e., 2167A, 490B, etc.)?

2. If no standards apply, then are there specifications that must be used? Documents that must be produced? What are the deliverable outlines?

System Management Schedule Directives

1. When is the system needed? Can it be delivered in phases?

2. What is the expected operational life of the system?

Management - Level 1
Cost Directives

System Management Cost Directives

1. Are there cost constraints on the system?
2. Are there cost constraints on the research and development and production costs or initial cost?
3. Are there cost constraints on the operation and maintenance support costs?
4. Are there overall system life-cycle cost constraints?
5. What method must be used to measure task progress?

Test and Evaluation - Level 1

System Test and Evaluation Directives

1. Is there a specified test approach or procedures to be used for testing?
2. What are the testable items in addition to the system requirements spec?
3. Who will perform final qualification testing (FQT) or customer acceptance testing? Someone within the developing contractor's organization?
4. What will FQT consist of? Each CSCI, CSC, CSU, HWCI, (component and assemblies for fabricated hardware), subsystem and system tests?
5. If certain conditions exist, will a retest phase be performed? If so, what are the conditions or provisions?
6. Is there a specific corrective action process to be used ?
7. Is there a configuration control methodology/tool to be used?
8. What deliverables must be placed under configuration control prior to delivery?

System Support - Level 1

System Support Directives

1. What are the anticipated transportation, handling, and/or storage modes for the system?

2. How will the system be handled in transit?

3. What will the system be subjected to during operational use and for how long?

4. When the system becomes obsolete, what are the requirements for disposal?

5. What are the effects on the environment?

6. Will maintenance be provided via service contracts with the vendor for all COTS hardware and software?

7. Are there any directives regarding training of personnel for system installation/checkout, operation, transporting, and maintenance?

Functions - Level 2

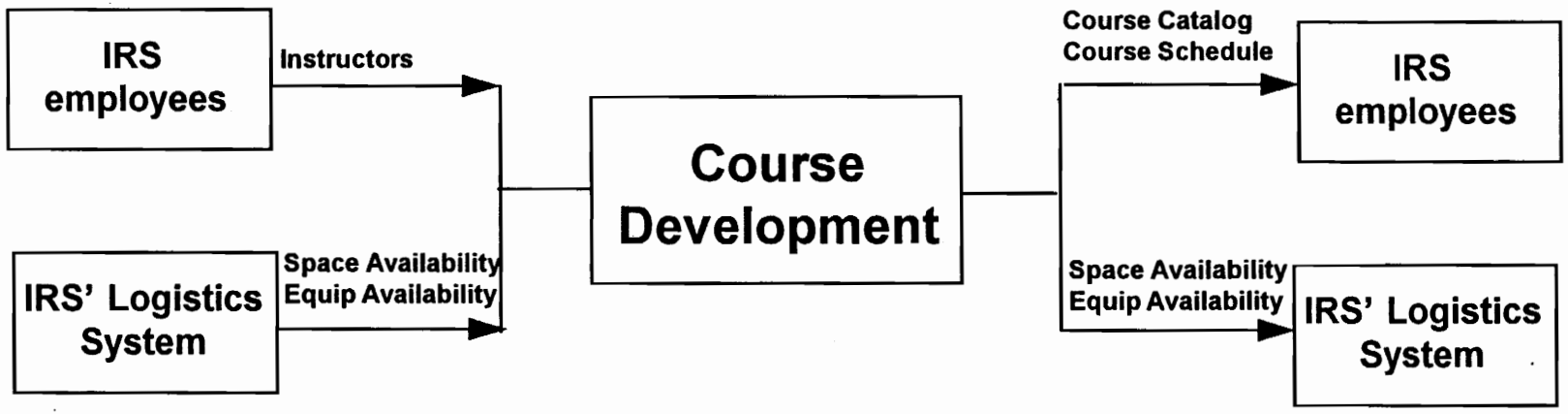
Subsystem Mission Questions

1. What are the subsystems of the system?
2. What is the mission of each subsystem?
3. How does the mission contribute to the prime operating mission?

Functions - Level 2
Subsystems

SUBSYSTEM NAME	DESCRIPTION	MISSION
Training Needs	Captures training needs and determines how to satisfy the need	Provide a mechanism for receiving and responding to training needs
Course Development	Develops and revises courses	Develop and revise courses and course materials to meet the training needs
Course Delivery	Delivers courses and course evaluations	Provide a means for presenting the training materials and evaluating the effectiveness of tng
Training Library	Maintains on-line training materials	Provide employees and instructors with training materials

Interfaces - Level 2
Allocated Subsystem Interfaces

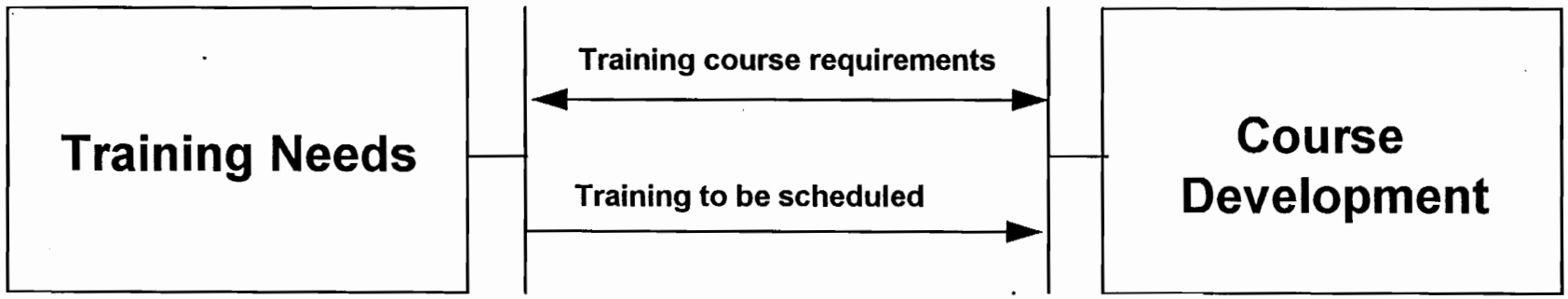


Interfaces - Level 2

Subsystem Interface Questions

1. Which subsystems exhange information/data with each other?
2. What data is exchanged between the subsystems?

Interfaces - Level 2
Subsystem Interfaces



Performance - Level 2

Subsystem Interface Performance Questions

These questions apply to the data exchanged on the subsystem interfaces charts.

1. What is the volume of data in terms of number of records, messages, or transactions per exchange?

2. What is the frequency in terms of number of occurrences per time interval (seconds, hours, days, years, etc.)?

3. What is the quantity of allowable errors or percentage of allowable errors per exchange of data?

Performance - Level 2
Subsystem Interface Performance

SUBSYSTEM INTERFACE	VOLUME	FREQUENCY	TIME INTERVAL	ALLOWABLE ERRORS
Training course requirements	50,000	1	Year	3
Training to be scheduled	100,000	1	Quarter	2

Distribution - Level 2
Subsystem Distribution - Fixed Locations

SITE LOCATION	SITE TYPE	SUBSYSTEMS
	National Office	Training Needs Course Development Training Library
	Regional Office	Training Needs Course Delivery Training Library
	District Office	Training Needs Training Library
	Post of Duty	Training Needs Training Library

Distribution - Level 2
Subsystem Distribution - Mobile Locations

SITE LOCATION	SITE TYPE	DEPARTURE/ ARRIVAL	SUBSYSTEMS
Portland, Oregon	Loading Bay	Departure/Arrival	Subsystem A
Austin, Texas	Loading Bay	Departure/Arrival	Subsystem A
San Diego, CA	Command Ctr	Departure	Subsystem A
Richmond, VA	Command Ctr	Arrival	Subsystem B

Security - Level 2

Subsystem/Site Security Directives

1. Are there site-specific security requirements?

2. Are there different security requirements for the subsystems of the system (refer to figure A-29/A-30)?

Software - Level 2

Subsystem/Site Software Directives

The following questions apply to each of the subsystems of the system as well as to each site or site-type (refer to figure A-29/A-30).

1. Are there any COTS packages that are required to be used when developing?

2. Is there a specified operating system to be used (i.e., UNIX, VMS)?

3. Is there a specified development language to be used (i.e., Ada, Pascal)?

4. Are there any existing pieces of software or non-developmental software (NDS) that are to be used? If so, what software language is it developed in and does it contain COTS?

Hardware - Level 2

Subsystem/Site Hardware Directives

The following questions apply to each of the subsystems of the system as well as to each site or site-type (refer to figure A-29/A-30).

1. **Are there hardware vendors that must be used? If so, what are the model numbers?**

2. **Is there government-furnished hardware that must be used?**

3. **Are there requirements to use existing equipment?**

4. **Are there hardware requirements associated with any of the software directives listed on the software - level 2 chart?**

Data - Level 2

Subsystem/Site Data Directives

The following questions apply to each of the subsystems of the system as well as to each site or site-type (refer to figure A-29/A-30).

1. **Are there any specific data requirements?**
2. **Is there existing data that must be used? If so, what format is it in?**
3. **Are there requirements for accessing the data?**

Human-Machine Interface (HMI) - Level 2

Subsystem/Site HMI Directives

The following questions apply to each of the subsystems of the system as well as to each site or site-type (refer to figure A-29/A-30).

1. **Are there any specific HMI requirements?**

2. **Is there an existing interface that must be used or replicated?**

Procedures - Level 2

Subsystem/Site Procedures

The following questions apply to each of the subsystems of the system as well as to each site or site-type (refer to figure A-29/A-30).

1. Are there procedures that must be used for system initialization?
2. Are there procedures that must be used for system phase out and termination?
3. Are there procedures that must be used for system backup, restore, and recovery?
4. Are there procedures that must be used for system logging and audit?
5. Are there procedures that must be used for transporting and handling system hardware, software, and data for system initialization, operational use, and maintenance?
6. Are there schedules or timing considerations that apply to items 1-5?

Test and Evaluation - Level 2

Subsystem/Site Test and Evaluation Directives

The following questions apply to each of the subsystems of the system as well as to each site or site-type (refer to figure A-29/A-30).

1. Is there a specified test approach or procedures to be used for testing?
2. What are the testable items in addition to the system requirements spec?
3. Who will perform final qualification testing (FQT) or customer acceptance testing? Someone within the developing contractor's organization?
4. What will FQT consist of? Each CSCI, CSC, CSU, HWCI, (component and assemblies for fabricated hardware), subsystem and system tests?
5. If certain conditions exist, will a retest phase be performed?
6. Is there a specific corrective action process to be used ?
7. Is there a configuration control methodology/tool to be used?
8. What deliverables must be placed under configuration control prior to delivery?

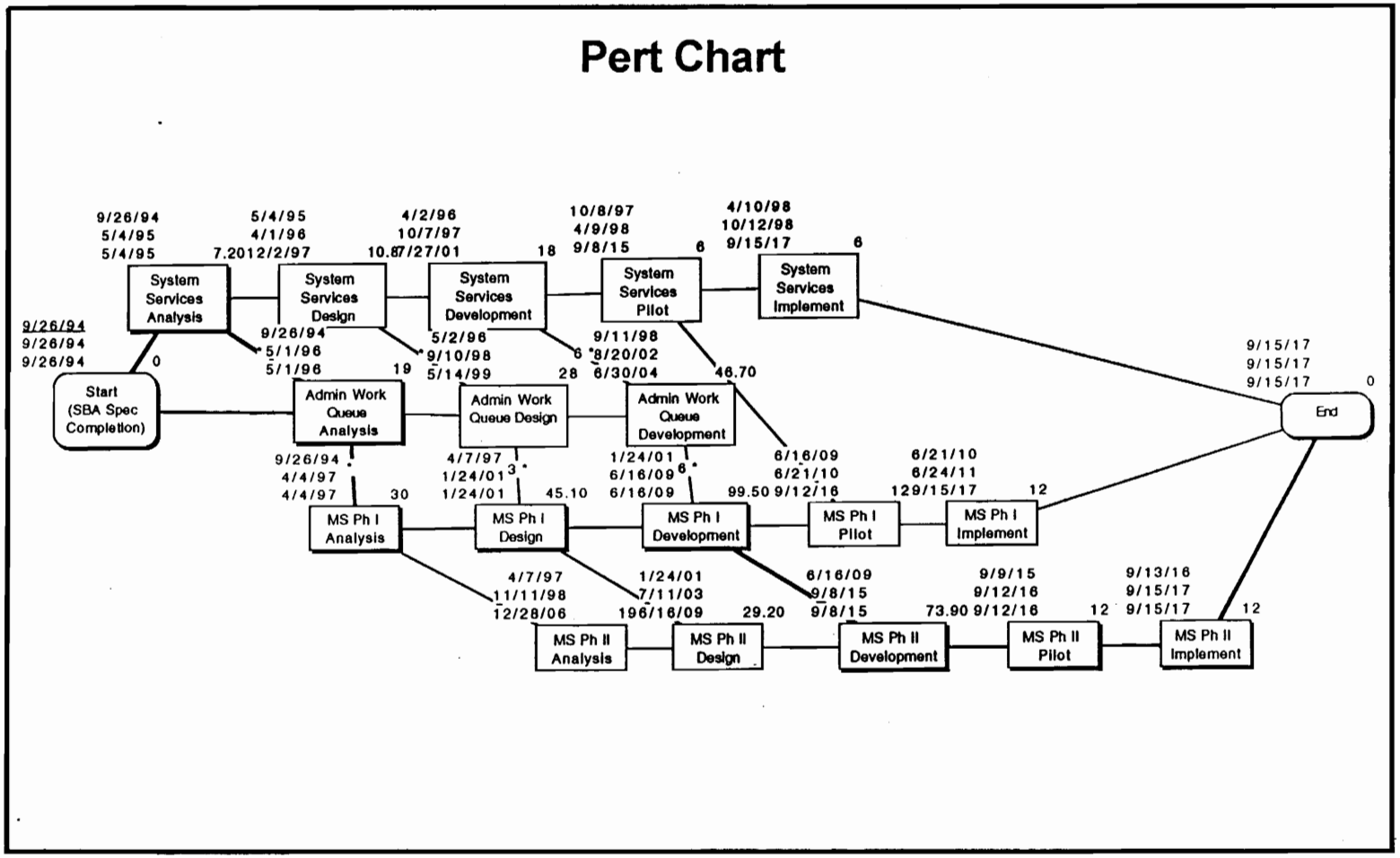
System Support - Level 2

Subsystem/Site Support Directives

The following questions apply to each of the subsystems of the system as well as to each site or site-type (refer to figure A-29/A-30).

1. What are the anticipated transportation, handling, and/or storage modes of the system?
2. How will the system be handled in transit?
3. What will the system be subjected to during operational use and for how long?
4. When the system becomes obsolete, what are the requirements for disposal?
5. What are the effects on the environment?
6. Will maintenance be provided via service contracts with the vendor for all COTS hardware and software?
7. Are there any directives regarding training of personnel for system installation/checkout, operation, transporting, and maintenance?

Management - Level 2
Program Pert Chart



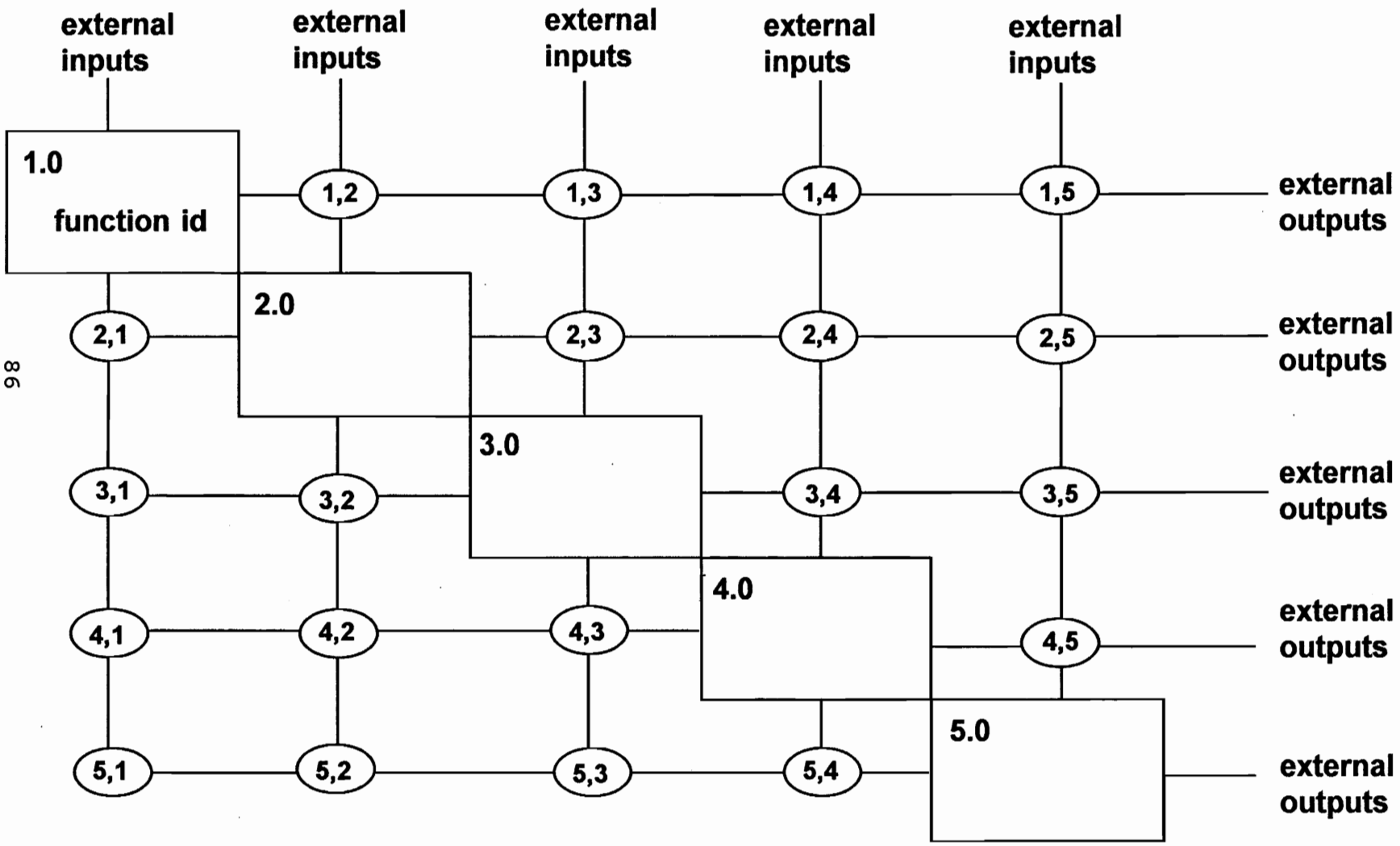
Management - Level 2
Life-Cycle Cost Breakdown

PROGRAM ACTIVITIES	COST($)	PERCENT CONTRIBUTION(%)
1. Conceptual design (a) system management (b) planning (c) research	300,000	30
2. Preliminary design (a) system management (b)	300,000	30
3. Detail design (a) system management (b)	200,000	20
4. Development (a) system management (b)	200,000	20
Grand total	1,000,000	100

Management - Level 2
Conceptual Design Cost Summary

PROGRAM ACTIVITIES	COST BY PROGRAM YEAR					TOTAL ACTUAL COST
	Year 1	Year 2	Year 3	Year 4	Year 5	
(a) System Management	80,000	20,000	20,000	20,000	20,000	160,000
(b) Planning	10,000	20,000	20,000	20,000	20,000	90,000
(c) Research	10,000	10,000	10,000	10,000	10,000	50,000
(d)						
(e)						
(f)						
Total Conceptual Design Cost	100,000	50,000	50,000	50,000	50,000	300,000

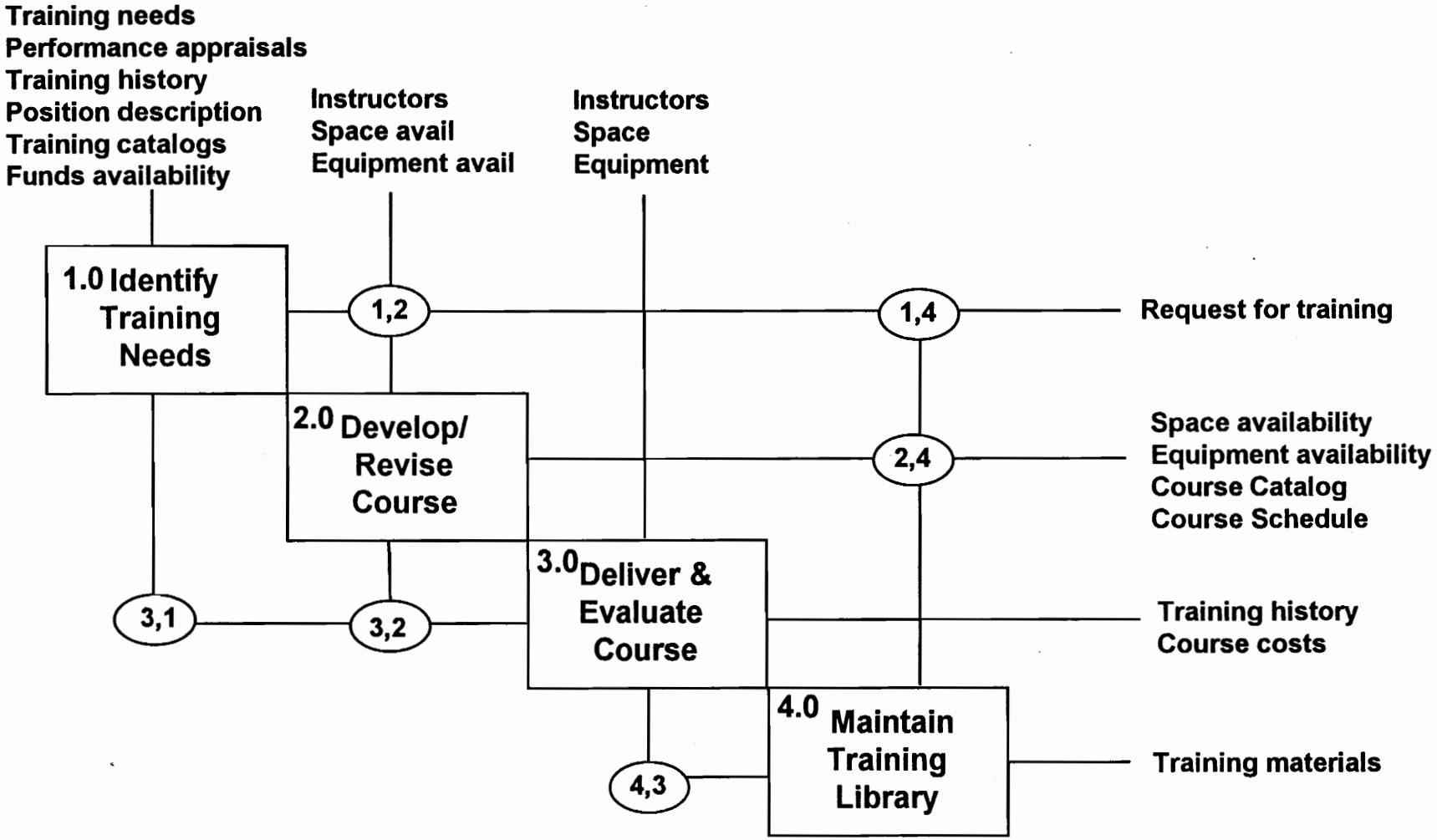
Functions - Level 3
N^2 Chart



Functions - Level 3
Function Interfaces

PROCESS ID	DESCRIPTION
1,2	
1,3	
1,4	
1,5	
2,1	
2,3	
2,4	
2,5	
3,1	
3,2	
3,4	
3,5	
4,1	
4,2	
4,3	
4,5	
5,1	
5,2	
5,3	
5,4	

Functions - Level 3
N^2 Chart



Functions - Level 3
Function Interfaces

PROCESS ID	DESCRIPTION
1,2	Training Course Requirements Training to be Scheduled
1, 4	Request for Materials
2,4	Course Materials
4,3	Course Materials
3,2	Evaluation Data
3,1	Evaluation Data

Performance - Level 3

Operational Requirements Questions

1. How is the system utilized in terms of hours of operation per day?

2. Are there on-off cycles daily, weekly, monthly, etc.?

3. What effectiveness requirements should the system exhibit?
   a. cost effectiveness?
   b. system effectiveness?
   c. availability?
   d. dependability?
   e. reliability?
   f. maintainability?
   g. supportability?
   h. transportability?

4. What are the auxiliary storage requirements?

Performance - Level 3

Environmental Requirements Questions

1. What are the environmental requirements for the system in terms of:
   a. temperature? (enter a range)
   b. humidity? (enter a range)
   c. shock and vibration? (note that this is applicable to mobile systems)

2. What environmental conditions is the system required to operate in? check those that apply:
   a. arctic
   b. tropics
   c. mountainous terrain
   d. ground (flat terrain)
   e. airborne
   f. shipboard

Performance - Level 3

Performance Requirements Questions

1. What is the allowable number of errors per hour, day, etc. or % of errors permitted per transaction?

2. What is the response time required for producing a report?

3. What is the response time required for producing the results of a query?

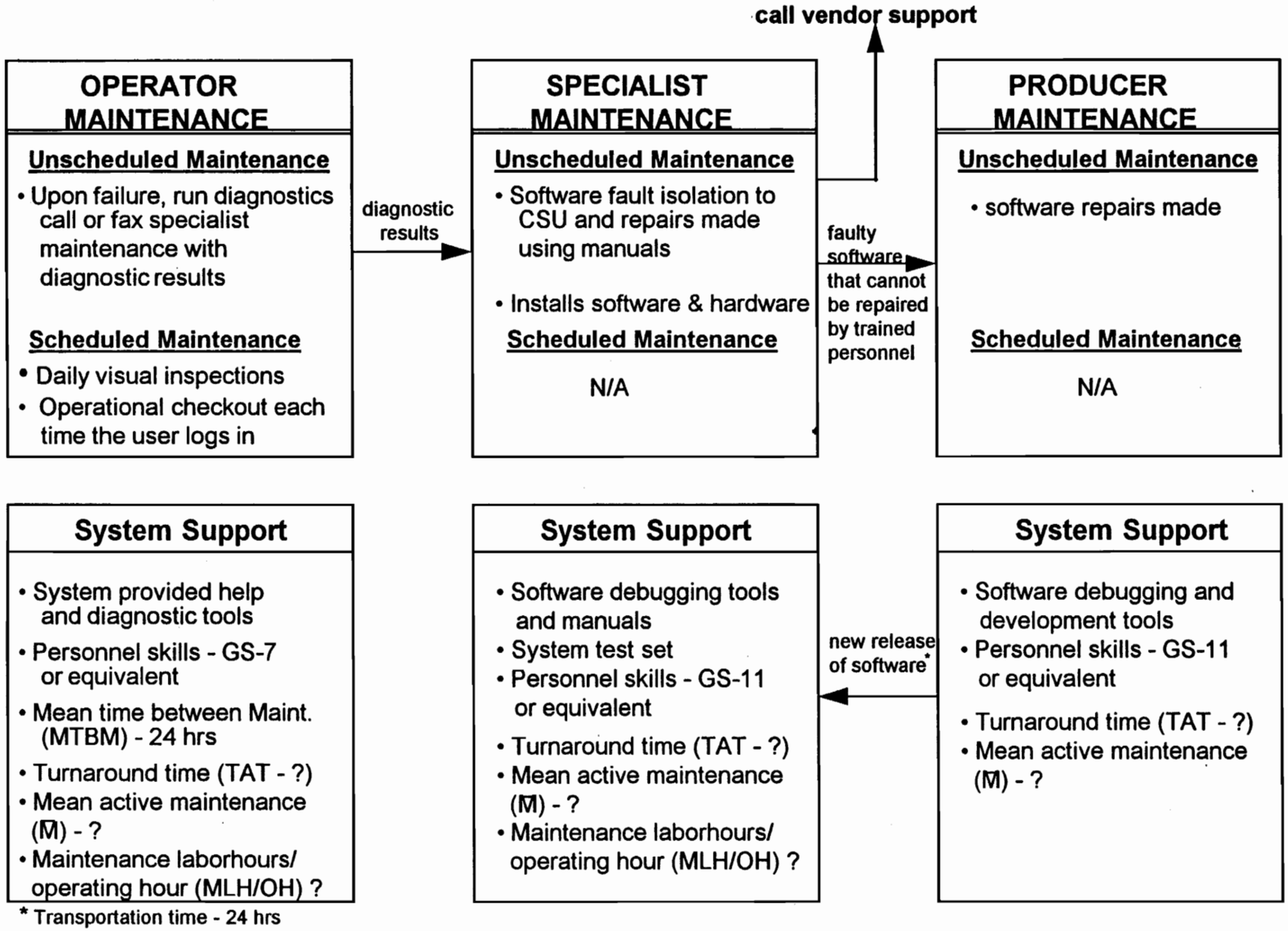
4. How long is data required to be stored (i.e., one month, year, etc.)? Are there different requirements for different types of data?

5. Are there any other performance requirements?

Performance - Level 3
Requirements Identification

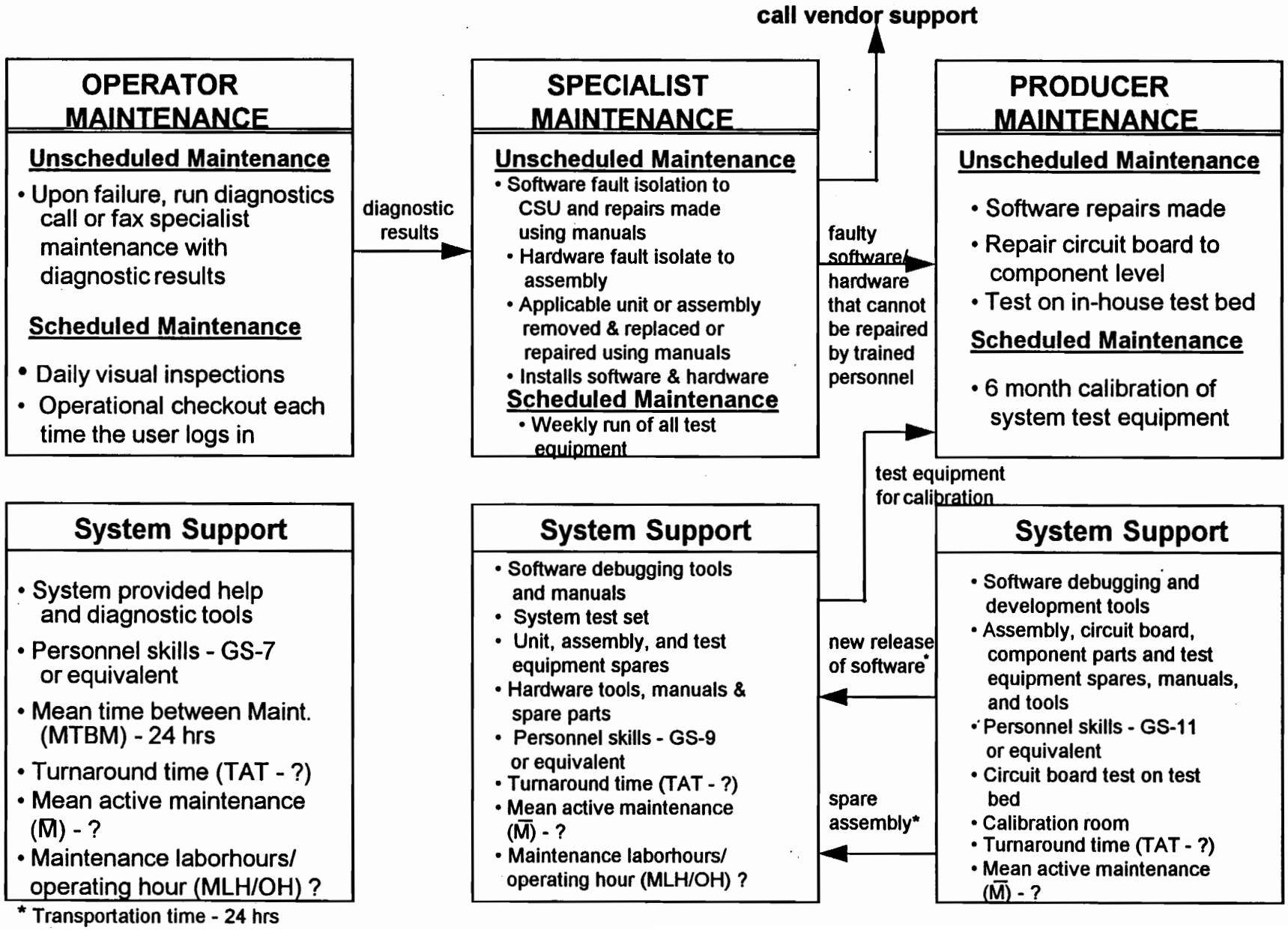
REQUIREMENT ID	REQUIREMENT DESCRIPTION
1	The system shall provide a response to a training need request within 24 hours
2	All training materials shall be on-line

System Support - Level 3
Typical Maintenance Concept



* Transportation time - 24 hrs

System Support - Level 3
Atypical Maintenance Concept



* Transportation time - 24 hrs

System Support - Level 3

Maintenance Concept Questions

1. What are the required turnaround times for specialist and producer provided maintenance?

2. What are the limits on the mean active maintenance time for all three categories of maintenance?

3. What are the limits on the maintenance labor hours per operating hour for all three categories of maintenance?

System Support - Level 3
Training Concept

USER CLASS	USER GROUPS	TRAINING REQUIRED
General	IRS Manager IRS Employee	Use of the Training System
System	System Operator System Administrator Data Base Administrator	System Hardware System Software DBMS
Training Specialist	Course Scheduler	Scheduling Techniques Logistics
	Course Developer	Technical Writing Train the Trainer
	Training Needs Analyst	Analysis Techniques
	Instructor	Instructor

Software - Level 3

CONFIGURATION ITEM	DESCRIPTION
Training Needs	Enter data on training needs form Receive other thraining needs info Analyze training needs Forms processor
Course Development	Creates and Revises courses Schedules courses Calendar Word processor Scheduling software Computer-based training (CBT) software Calendar
Course Delivery	Presents course materials Word processor CBT software
Course Evaluation	Evaluates course evaluation forms software tabulation software
Training Library	Maintains an on-line respository of trng materials Forms processor DBMS

Hardware - Level 3

CONFIGURATION ITEM	DESCRIPTION
Course Development Workstation	Workstation w/high-image display Scanner Laser printer Modem Storage Devices
Course Delivery Workstation	Workstation w/high-image display Modem
Training Request Workstation	Workstation w/non-image display Printer Modem
Communications Network	LAN wiring LAN servers Modem pool

Data - Level 3

DATA CATEGORY	DESCRIPTION
Text	Contains most of course material data
Image	Contains course material graphics
Structured	Contains the training needs data, library data, and evaluation data

Distribution - Level 3

SITE LOCATION	SITE TYPE	HARDWARE	SOFTWARE	DATA
	National Office	Course Devlpmt workstation Comm network	Course Devlpmt Training needs Training library	Text Structured Image
	Regional Office	Course Delivery workstation Comm network	Course Evaluation Course Delivery Training needs Training library	Text Structured Image
	District Office	Training request workstation Comm network	Training needs Training library	Structured
	Post of Duty	Training request workstation Comm network	Training needs Training library	Structured

Security - Level 3
Trust Approach for Data

DATA CATEGORY	TRUST APPROACH
Text	Top secret
Image	Secret
Structured	Top secret

Security - Level 3
Trust Approach for Software

CONFIGURATION ITEM	TRUST APPROACH
Training Needs	Proprietary
Course Development	Proprietary
Course Delivery	Proprietary
Course Evaluation	Top Secret
Training Library	Proprietary

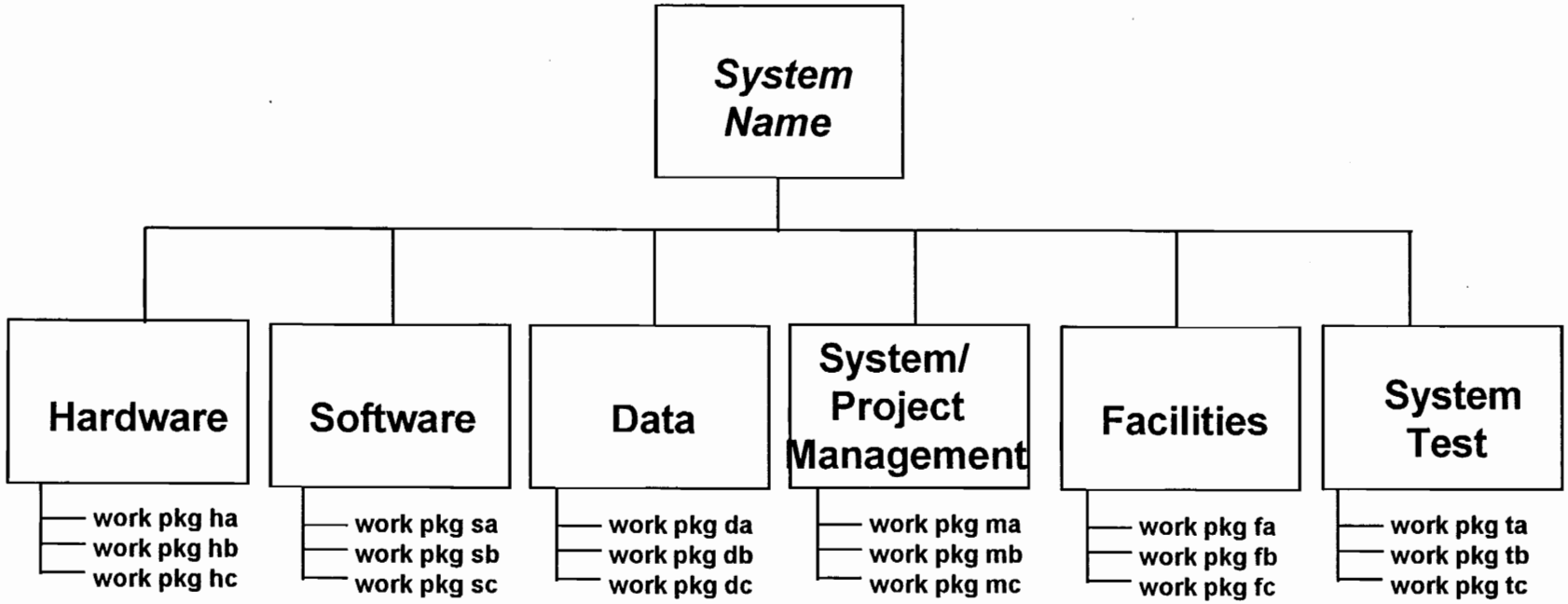
Human Machine Interface (HMI) - Level 3

USER GROUP	Identify Training Needs	Analyze Training Needs	Develop Course Materials	Deliver & Evaluate Course	Maintain Training Library
IRS employees	X			X	X
Training system administration	X	X	X	X	X
Training specialist		X	X	X	X

Procedures - Level 3

PROCEDURE	SCHEDULE/ TIMING	QUANTITY OF PERSONNEL	SKILL LEVEL
Initialization	N/A	4	GS-9 or equiv
Termination	N/A	4	GS-9 or equiv
Backup	1/Day	1	GS-7 or equiv
Restore	On-demand	1	GS-7 or equiv
Recovery	On-demand	1	GS-7 or equiv
System logging	Each transaction	1	GS-7 or equiv
System audit	1/Month	2	GS-11 or equiv

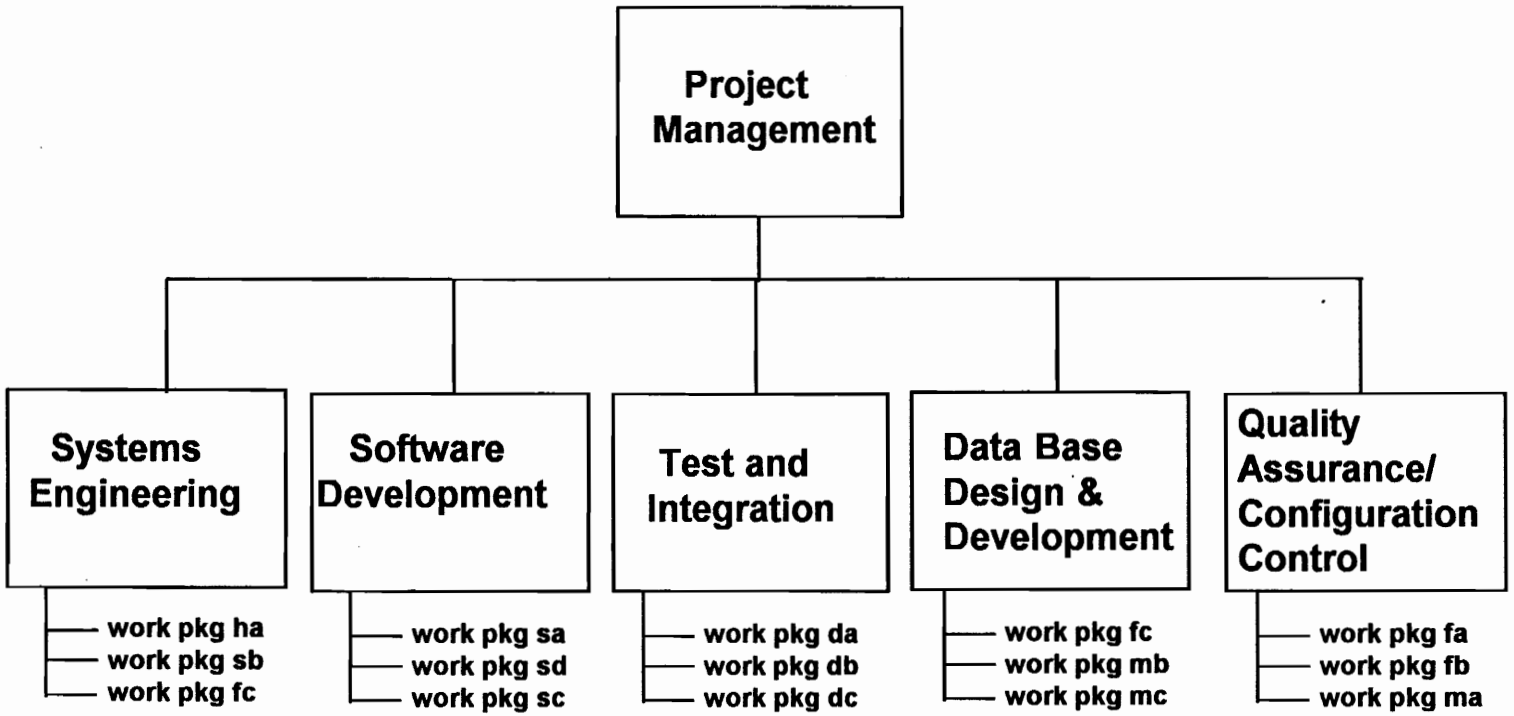
Management - Levels 3 & 4
Work Breakdown Structure



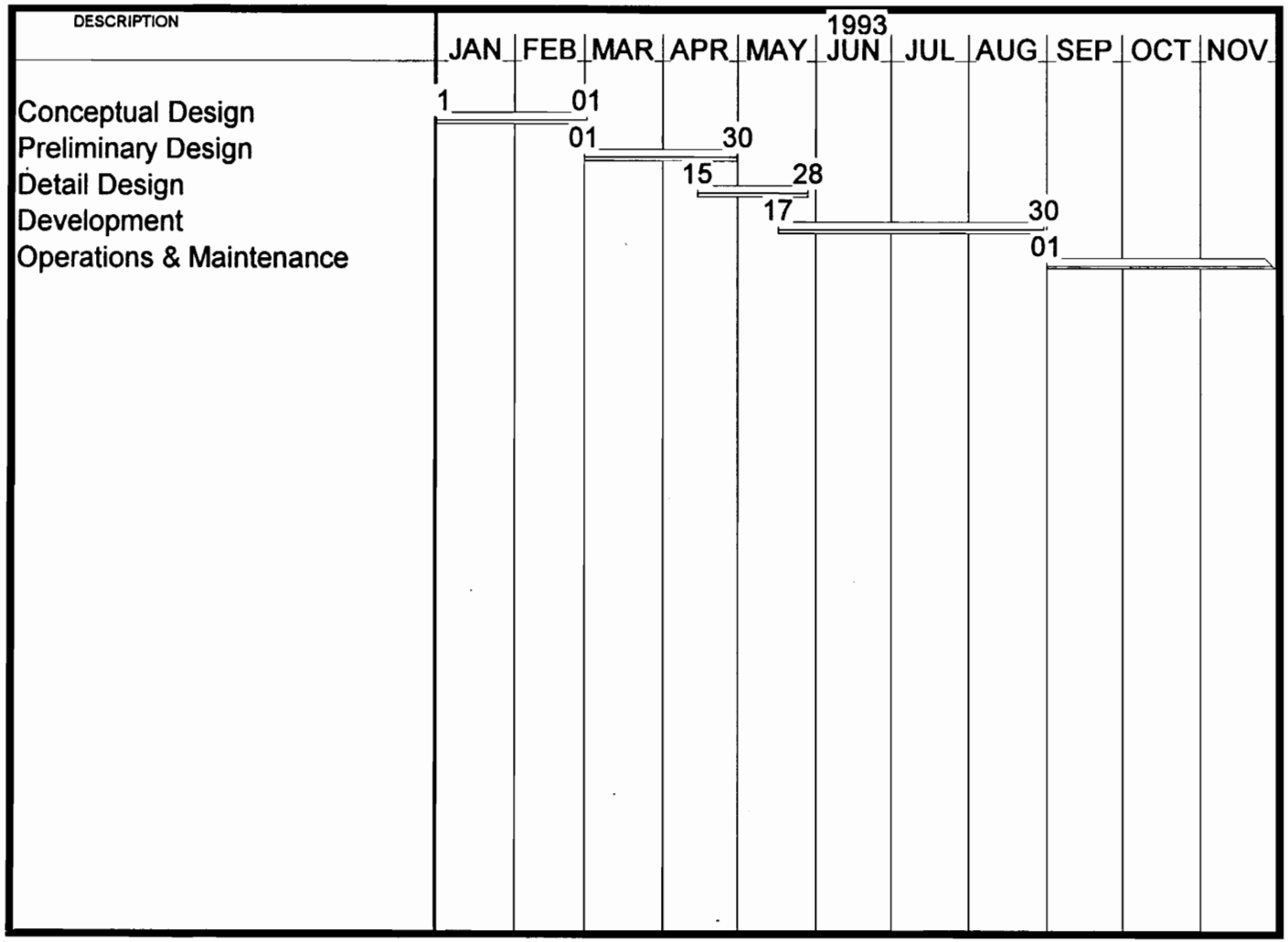
Management - Levels 3 & 4
WBS to CBS Mapping

PROGRAM ACTIVITIES	COST($)	PERCENT CONTRIB	WBS ITEM	PERCENT
1. Conceptual design (a) system management (b) planning (c) research	300,000	30	work pkg ma work pkg ta work pkg tc	10 10 10
2. Preliminary design (a) (b)	300,000	30	work pkg da work pkg db work pkg fb	10 10 10
3. Detail design (a) (b)	200,000	20	work pkg sc work pkg tc work pkg hc	10 5 5
4. Development (a) (b)	200,000	20	work pkg sa work pkg sb work pkg dc	5 10 5
5. Operations & Maintenance (a) (b)	N/A	N/A	N/A	N/A
Grand total	1,000,000	100		100

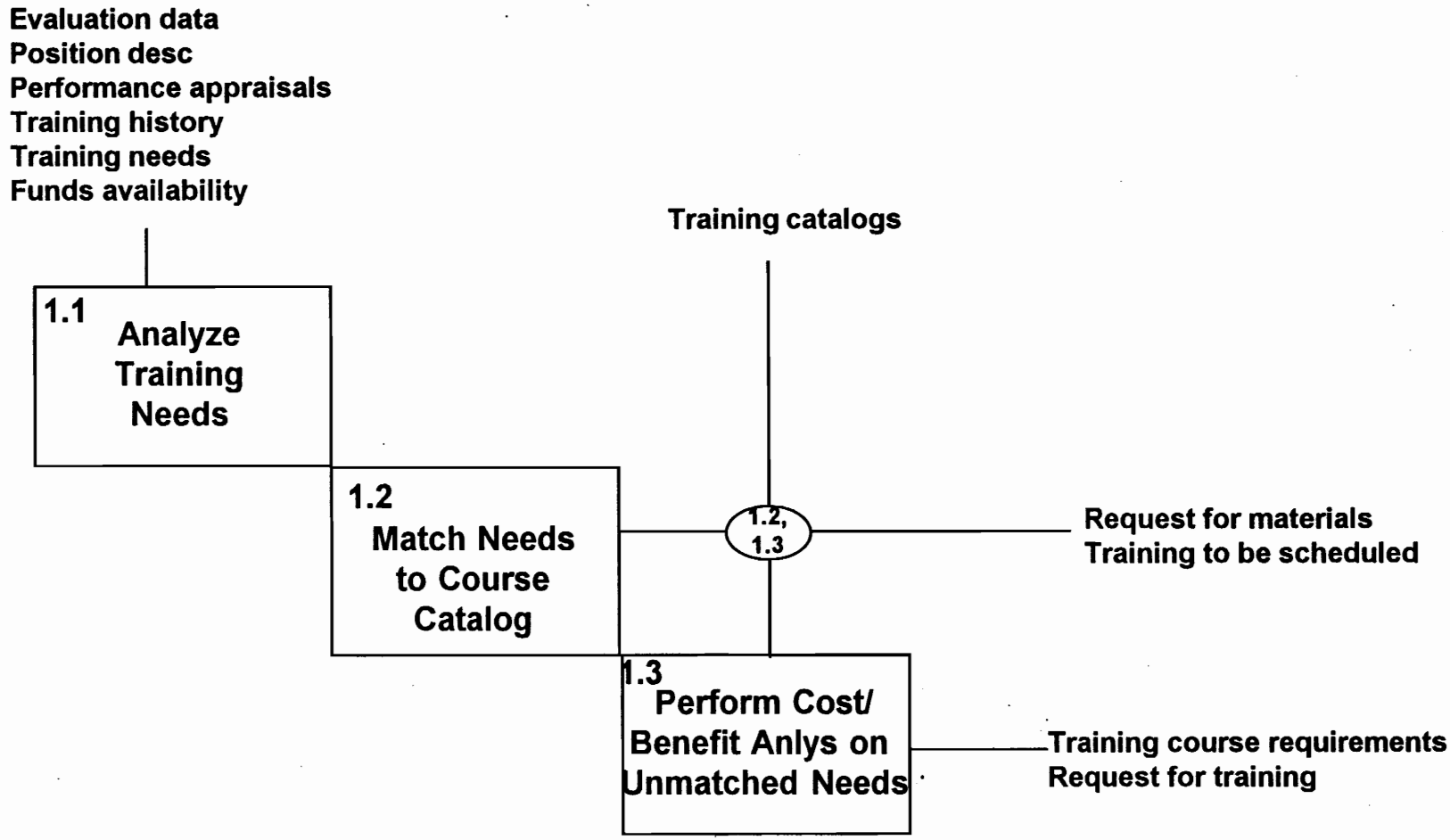
Management - Levels 3 & 4
WBS to Organization Chart Mapping



Management - Level 3 & 4
Work Package Schedule



Functions - Level 4
Identify Training Needs



Functions - Level 4
Identify Training Needs Interfaces

PROCESS ID	DESCRIPTION
1.2,1.3	Unmatched Needs

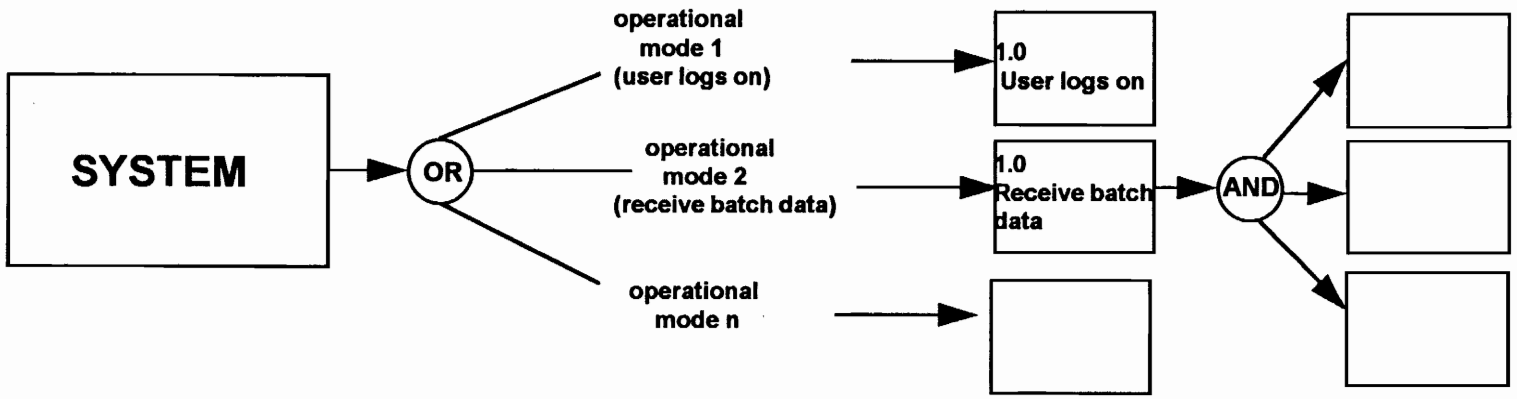
Security - Level 4
Data Implementation

DATA CATEGORY/ TRUST APPROACH	HARDWARE	SOFTWARE	DATA	PROCEDURES
Text	All HWCIs	All CSCIs	Materials data	System logging Audit
Image	Course Dev Wkstn Course Deliv Wkstn Comm Network	Course Dev Wkstn Course Deliv Wkstn Comm Netwk	Materials data	System logging Audit
Structured	All HWCIs	All CSCIs	Library data Evaluation data Needs data	System logging Audit

Security - Level 4
Process Implementation

CONFIGURATION ITEM/ TRUST APPROACH	HARDWARE	SOFTWARE	DATA	PROCEDURES
Training Needs	File server	User authentication		
Course Developmt	File server	User authentication		
Course Delivery	File server	User authentication		
Course Evaluation	File server	User authentication		
Training Library	File server	User authentication		

System Support - Level 4
Operational Flow Diagram



System Support - Level 4
Training Courses

USER CLASS	USER GROUPS	TRAINING REQUIRED	COURSES
General	IRS Manager IRS Employee	Use of the training system	Intro to training Using the tng lib Using the tng needs form
System	System Operator System Administrator Data Base Administrator	System Hardware System Software DBMS	System operator System admin Data base admin

Software - Level 4

CONFIGURATION ITEM	COTS/ NDS	NEW SOFTWARE REQUIRED	ESTIMATED LINES OF CODE
Training needs analysis	Desktop publishing DBMS On-line forms	Analysis software	50,000

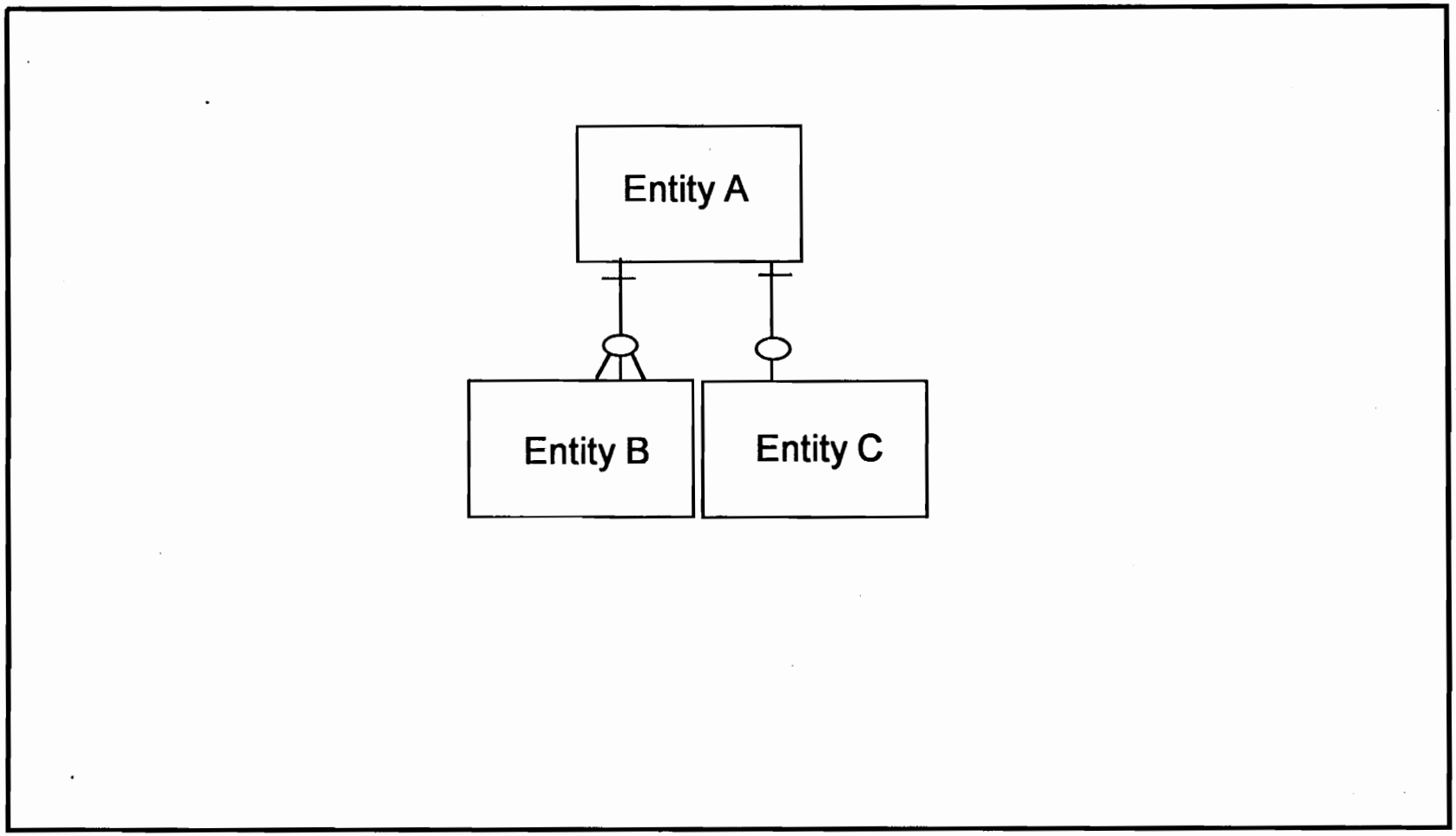
Hardware - Level 4

CONFIGURATION ITEM	DESCRIPTION	VENDOR/ MODEL	FABRICATED COMPONENTS	COSTS
Workstation w/ high image display	386 IBM compatible PC 9 mb RAM 85 mb hard disk 14" SVGA monitor	IBM 386	N/A	25,000

Data - Level 4
Data Groups

DATA CATEGORY	DATA GROUPS
Structured	Training needs data Forms Templates Editing & validation data

Data - Level 4
Entity-Relationship Diagram



Human-Machine Interface (HMI) - Level 4
User Classes

USER CLASS	USER GROUPS
General	IRS Manager IRS Employee
System	System Operator System Administrator Data Base Administrator

Human-Machine Interface (HMI) - Level 4
Design Philosophy

USER CLASS	CHARACTERIZATION	STYLE
General	Mixed: Analytic Clerical ADP Non-ADP	Mixed: Toolbox Procedural
System	Analytic ADP oriented	Toolbox

Human-Machine Interface (HMI) - Level 4
Design Philosophy Allocation

CHARACTERIZATION	STYLE	HARDWARE/ VENDOR	SOFTWARE/ VENDOR
Mixed: Analytic Clerical ADP Non-ADP	Mixed: Toolbox Procedural	IBM PC or compatible	Motif
Analytic ADP oriented	Toolbox	IBM PC or compatible	Motif

Procedures - Level 4

PROCEDURE	SCHEDULE/ TIMING	QUANTITY OF PERSONNEL	SKILL LEVEL	SITE LOCATION/ TYPE
Initialization	N/A	4	GS-9 or equiv	All
Termination	N/A	4	GS-9 or equiv	All
Backup	1/Day	1	GS-7 or equiv	District Office
Restore	On-demand	1	GS-7 or equiv	District Office
Recovery	On-demand	1	GS-7 or equiv	District Office
System logging	Each trans	1	GS-7 or equiv	Regional Office District Office
System audit	1/Month	2	GS-11 or equiv	Service Center

Performance - Level 4

REQUIREMENT ID	HARDWARE COMPONENT	SOFTWARE COMPONENT	DATA GROUP	PROCEDURE
1	Workstation w/high image display	Training needs analysis	Forms Training needs data Templates Editing & Valid	N/A

Test and Evaluation - Level 4

TESTABLE ITEM	TEST CLASS	TEST LEVEL	TESTING TECHNIQUE(S)	EVALUATION CRITERIA
Requirements Specification	Timing tests Erroneous input tests	System level	Inspection	Traceability to document

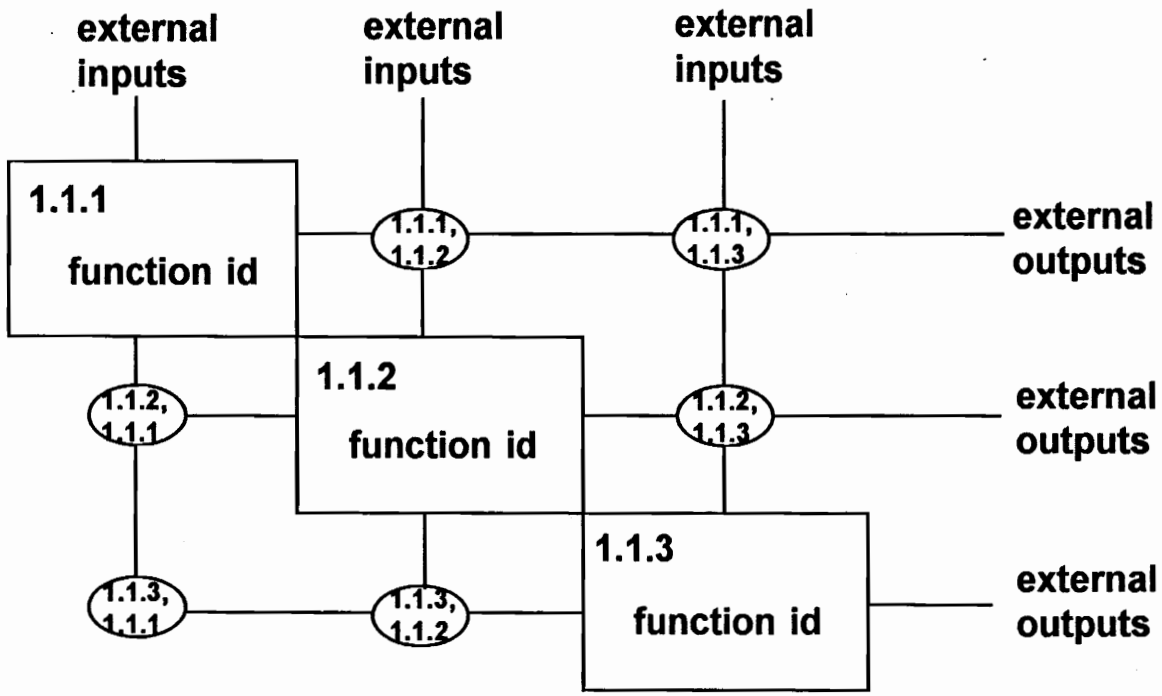
Test and Evaluation - Level 4 (cont'd)

TESTABLE ITEM	ANTICIPATED OUTPUT	SCHEDULE
Requirements Specification	Various	2/93 - 3/93

Test and Evaluation - Level 4 (cont'd)

TESTABLE ITEM	TEST ENVIRONMENT	FACILITIES/ EQUIPMENT	PERSONNEL REQUIRED
Requirements Specification	Separate test environment at developing contractors site	Target H/W in test env.	3 GS-9 or equiv

Functions - Level 5
N^2 Chart



Functions - Level 5
Function Interfaces

PROCESS ID	DESCRIPTION
1.1.1,1.1.2	
1.1.1,1.1.3	
1.1.2,1.1.3	
1.2.1,1.1.1	
1.1.3,1.1.2	
1.1.3,1.1.1	

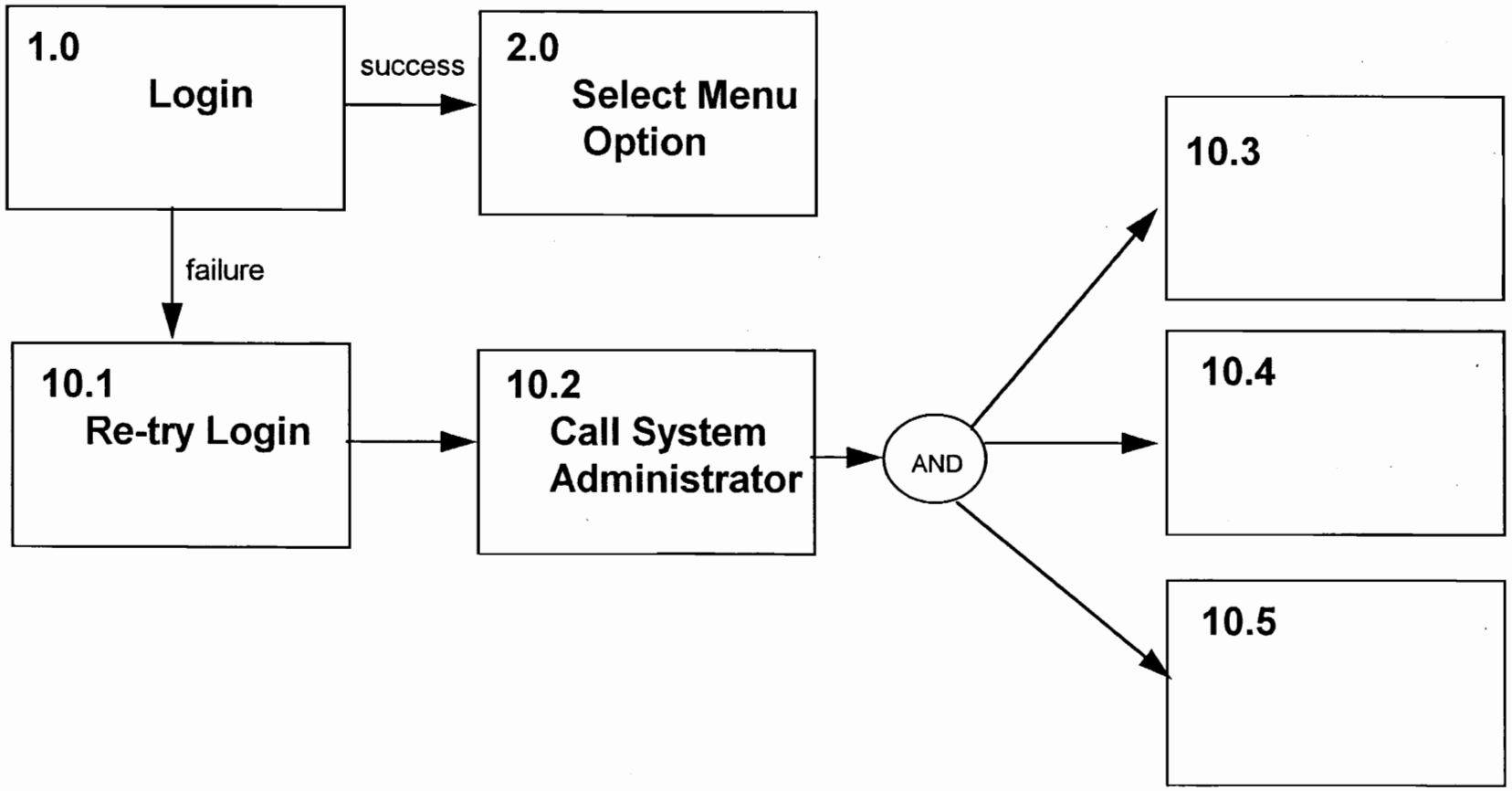
Data - Level 5

DATA GROUP	DATA ELEMENTS	DESCRIPTION	VALID VALUES
Training needs data	Employee ID	Employee's SSN	NNN-NN-NNNN
	Manager ID	Emp Manager's SSN	NNN-NN-NNNN
	Course ID	Course Identification	Alphanumeric
	Schedule	Course date requested	Date

Procedures - Level 5

PROCEDURE	STEP-BY-STEP DESCRIPTION	PERFORMING INDIVIDUAL
Initialization	1. Turn hardware on	System operator
	2. Run self-diagnostics	System operator
	3. Logon to database	Data base admin

System Support - Level 5
Maintenance Flow Diagrams



Test and Evaluation - Level 5

TESTABLE ITEM	TEST PROCEDURES
Requirements Specification	Training need query Training need update Training need delete

Appendix B

INFOSYM Products to Military Standard 2167A Mapping

				System Specification									
Section Name	Functions	Interfaces	Distribution	Performance	Security	S/W	H/W	Data	HMI	Procedures	Management	Test&Eval	Support
System definition	X												
Performance characteristics				X									
System capabilities	X												
Capability relationships	X												
External interface description		X											
External interface physical char		X											
Reliability				X									
Maintainability				X									
Availability				X									
Environmental conditions				X									
Transportability				X									
Additional quality factors				X									
Portability													X
Human engineering									X				
System security					X								
Government property usage						X	X						
Documentation											X		
Logistics			X										X
Personnel											X		
Training													X
Segment Identification	X												
Special tests												X	
Preparation for delivery			X										X

				Software Development Plan									
Section Name	Functions	Interfaces	Distribution	Performance	Security	S/W	H/W	Data	HMI	Procedures	Management	Test&Eval	Support
Project org & resources											X		
GFE/GFS						X	X						
Organization structure											X		
Personnel											X		
Schedule activities/milestones											X		
Activity network											X		
Source identification						X	X			X			
Risk management											X		
Security					X								
Corrective action process												X	
Problem/change report												X	
Software standards						X					X		
Design standards						X					X		
Coding standards						X					X		
Non-developmental software						X							
FQT organization & resources											X	X	
Test approach/philosophy												X	
Test planning assump & cnstrnt												X	
Software product evaluations											X	X	
Software configuration mgt												X	

				Software Requirements Specification									
Section Name	Functions	Interfaces	Distribution	Performance	Security	S/W	H/W	Data	HMI	Procedures	Management	Test&Eval	Support
CSCI external interface rqmts		X	X	X									
CSCI capability rqmts	X					X							
CSCI internal interfaces	X												
CSCI data element rqmts								X					
Installation dependent data			X					X					
Operational parameters				X									
Sizing and timing rqmts				X									
Security rqmts					X								
Design constraints	X	X	X	X	X	X	X	X	X	X	X	X	X
Human performance rqmts				X					X				
Requirements traceability				X									
Qualification methods												X	
Special qualification rqmts												X	
Preparation for delivery			X										X

				Interface Requirements Specification									
Section Name	Functions	Interfaces	Distribution	Performance	Security	S/W	H/W	Data	HMI	Procedures	Management	Test&Eval	Support
Interface diagrams		X											
Interface requirements	X	X											
Data requirements		X						X					
Preparation for delivery		X	X										X

				System Design Document									
Section Name	Functions	Interfaces	Distribution	Performance	Security	S/W	H/W	Data	HMI	Procedures	Management	Test&Eval	Support
Primary mission	X												
Secondary mission	X												
Support concept													X
Support facilities													X
Supply													X
System architecture	X												
HWCI identification							X						
CSCI identificaiton						X							
Manual operations identfication										X			
Internal interfaces	X												
Processing resources				X									
Quality factor compliance												X	
Requirements traceability				X									

				Software Design Document									
Section Name	Functions	Interfaces	Distribution	Performance	Security	S/W	H/W	Data	HMI	Procedures	Management	Test&Eval	Support
CSCI architecture						X							
System states and modes													X
CSCI design description						X							
CSC identification						X							
CSU identification						X							
Data structures								X					
CSCI data								X					
Requirements traceability				X									

				Interface Design Document									
Section Name	Functions	Interfaces	Distribution	Performance	Security	S/W	H/W	Data	HMI	Procedures	Management	Test&Eval	Support
Interface diagrams	X	X											
Interface data elements		X						X					
Interface message descriptions		X											
Communications protocol		X											

				Software Test Plan									
Section Name	Functions	Interfaces	Distribution	Performance	Security	S/W	H/W	Data	HMI	Procedures	Management	Test&Eval	Support
Software test environment												X	
Installation, testing, & control			X									X	X
FQT identification												X	
Test classes												X	
Test levels												X	
Test name												X	
Test schedule												X	
Data recording/analysis												X	