UPGRADE HUMAN-MACHINE INTERFACE, PROVIDE ADDITIONAL ANALYSIS TOOL, AND UPGRADE AND MIGRATE SCHEDULING CPCI IN EXISTING MAJOR COMPUTING SYSTEM

Submitted by D. L. Andrex

Project and Report submitted to the Faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

MASTERS OF SCIENCE
IN
SYSTEMS ENGINEERING

APPROVED:

Dean Benjamin Blanchard, chair

Kenneth Harmon

Lois Hennis-Crawford

September 1996

Blacksburg, Virginia

Keywords: Human-machine, HMI, MMI, Upgrade, Computer, Schedule, Management

UPGRADE HUMAN-MACHINE INTERFACE, PROVIDE ADDITIONAL ANALYSIS TOOL, AND UPGRADE AND MIGRATE SCHEDULING CPCI IN EXISTING MAJOR COMPUTING SYSTEM

Submitted by D. L. Andrex

Dean Benjamin Blanchard, chair
Systems Engineering

Abstract

This project was inspired by an ENG 5004 session that explored how humans process information coupled with a complaint in my workplace about how difficult it was to analyze our management data. The workplace problem lay in the technology in use: character based terminals presenting data in tabular format regarding schedule data for work on maps. This data tends to be graphically and geographically related, and more easily processed visually as symbols by humans.

The challenge in this project is that it attempts to engineer a business process and implement it in software (in an existing and operating system). The conceptual solution is to provide a graphical user interface (GUI) which presents schedule elements graphically (GANTT, PERT, and Resource Use Charts) in the visual paradigm with which managers are familiar. Further, the scheduled work is geographically based, so a graphical device that shows where a job is located is useful, especially when adjacent jobs that contended for data at their borders are also shown. And finally, given the graphic tools for reporting and analysis, the capabilities to use these tools to create and implement schedules would provide managers with greatly improved efficiency.

The conceptual solution indicates an evolution in technology for this customer. A move from the mainframe driven operations and character based display to more distributed processing and graphically based displays is indicated. The capability required is a small subset of the existing system which is not to be disturbed during integration and installation.

The solution to be implemented is to migrate the needed functions to a PC based terminal running a graphical user interface. The desired applications are hosted locally on the PC which is connected to the mainframe through existing networks. An application on the PC provides the interface to the mainframe for data extraction, and later, a data interface. Scheduling, database, and Geographic information systems (GIS) are resident on the PC, and are integrated to support customer use. The PC is then the Integrated Management Workstation (IMWS).

The interface and database elements are essentially invisible to the manager. It is the manager's job to strategize and implement work plans, not worry about the inner workings of the computer system. The scheduling and GIS applications are represented to the manager who interacts, analyzes, and decides. The manager is the last and decisive element in the system, and uses the new capabilities to help manage the work.

This project defines the problem, provides the conceptual solution, and provides the engineering management plans and system requirements to implement the solution. This project does not build anything and no code is written. These tasks are to be accomplished by the team that implements this project according to the guidance and stipulations contained in the project documents.

Acknowledgements

To the A-Course, especially Bev Carpenter, for assitance in overcoming my many disruptions.
To Lois Hennis-Crawford, A-course supervisor when I started the program, now my manager, and project committee person, who goaded me to complete this project.
To Benjamin Blanchard who had the wisdom, clear view, and power to help me overcome obstacles and disruptions to accomplish this project.
To Ken Harmon, a last minute participant in this project which I am sure was an unexpected and unscheduled addition to his incredible workload.
To Loretta Tickle of the wonderful name and voice who knows everything, who is the glue of the university, and to whom I owe an enormous debt because she provided me with the connections and opportunities I needed to finish this project.
And to my wife, Ann Christine, who tolerated my many hours diverted and insisted that I get some sleep.

I thank you all.

1. PROJECT BACKGROUND 1

2. PROBLEM DESCRIPTION 3

2.1. Introduction 3

2.2. The Existing Digital Production System 3
2.2.1. General Description 3
2.2.2. DPS Current Life Cycle Status 5
2.2.3. The Production Management Assignment Process 5
2.2.4. The Production Process 6
2.2.5. The Extraction Task 6
2.2.6. The Extraction Task/Subtask Network 10
2.2.7. Changes and Change Management 13
2.2.8. Existing Subtask Scheduling Method 14
2.2.9. Existing Interface Concepts, Operation, and Support 15
2.2.10. Existing Subtask Assignment Change Management Methods 16
2.2.11. Existing Maintenance Support and Plan 17
2.2.12. Lost Production Time 17

2.3. Data Display and User Interface 17

2.4. Simultaneous Adjacent Extraction Problem Definition 18

2.5. Extraction Subtask Management 20

2.6. Simultaneous Adjacent Extraction White Paper 21
2.6.1. World Changes 21
2.6.2. Workstation Environment 22
2.6.3. Maintenance 22
2.6.4. Queued Task Scheduler 22
2.6.5. Comments 23

2.7. Human Role in the System 25

2.8. User Survey 26

3. PROBLEM ASSESSMENT 31

3.1. Risk Assessment 31
3.1.1. Risks Regarding the IMWS with SAEAT 31
3.1.2. IMWS, QSS implementation 32
3.1.3. General 33

3.2. Risk Mitigation 33
3.2.1. Interface Design, Development, and Support 33

3.2.2. Data Interface 34

3.3. Maintenance Plan 35
3.3.1. Software Maintainability 36
3.3.2. Maintenance Regions 37
3.3.3. Maintenance Terminals 37
3.3.4. Configuration Management 37

3.4. IMWS Top Level Operations Concept 38
3.4.1. Phase 1 Operations Concept - Simultaneous Adjacent Extraction Analysis Tool (SAEAT) 38
3.4.2. Phase 2 Operations Concept 39
3.4.3. Phase 3 (QSS) Operations Concept 41

3.5. IMWS Top Level Functional Requirements 42
3.5.1. IMWS Phase 1 Top Level Functional Requirements 43
3.5.2. IMWS Phase 2 Top Level Functional Requirements 44
3.5.3. IMWS Phase 3 Top Level Requirements 44

3.6. Solution Approach 46
3.6.1. Three Phase Program 47
3.6.2. Three Phases Justified 47

4. RECOMMENDED SOLUTION 48

4.1. Mission Statement 48
4.1.1. SAEAT Mission 48
4.1.2. QSS Mission 49

4.2. Solution Concept 49
4.2.1. Phase 1: Provide IMWS Infrastructure and Preliminary SAEAT Capability 52
4.2.2. Phase 2: Added SAEAT Data and Granularity 53
4.2.3. Phase 3: Subtask Scheduler 53
4.2.4. Mission Summary 54

5. PROJECT ENGINEERING MANAGEMENT 55

5.1. Project Strategy 55
5.1.1. Engineering Management Personnel 56
5.1.2. Dependencies on Customer Initiatives 56
5.1.3. The IMWS Project Events and Dependencies 56
5.1.4. Customer Interface and Participation 58

5.2. Work Breakdown Structure 58
5.2.1. WBS Dictionary 58

5.3. Project Schedule Issues 62
5.3.1. Phase 1 Delivery Schedule 62
5.3.2. Phase 2 Delivery Schedule 63
5.3.3. Phase 3 Delivery Schedule 64

5.3.4. Production, Operation, and Maintenance 66

5.4. Configuration Management Plan 66
5.4.1. Installations and Discrepancy Process 67
5.4.2. IMWS CM Environment 68
5.4.3. Build Process 68

5.5. Development Plan 71
5.5.1. Customer Initiatives 71
5.5.2. Acquisition 72
5.5.3. Three Phase Development 74
5.5.4. Development Methodology 74
5.5.5. Incremental Development 74

5.6. Interface Control 77
5.6.1. Internal Interfaces 77
5.6.2. External Interfaces 80
5.6.3. Hybrid Interfaces 83
5.6.4. Interface Implementation 84

5.7. Implementation Plans 84
5.7.1. Phase 1 Development 85
5.7.2. Phase 2 Development 92
5.7.3. Phase 3 Development 95

5.8. Training 101
5.8.1. Maintenance Training 101
5.8.2. User Training 101

5.9. Test & Transition Planning 101

5.10. Cost Analysis 102
5.10.1. Phase 1 103
5.10.2. Phase 2 105
5.10.3. Phase 3 107
5.10.4. Following O&M Costs 109

6. PRELIMINARY DESIGN 111

6.1. IMWS Detailed Operations Concept 111
6.1.1. Phase 1 (SAEAT) Operations Concept 111
6.1.2. Phase 2 (SAEAT) Operations Concept 113
6.1.3. Phase 3 (QSS) Operations Concept 113

6.2. IMWS Functional Requirements 117
6.2.1. Phase 1 Functional Requirements 117
6.2.2. Phase 2 Requirements 124
6.2.3. QSS Detailed Functional Requirements 124

6.3. IMWS Requirements Matrix 137

6.3.1. Phase 1 (SAEAT) Functional Requirements....139
6.3.2. Phase 2 Functional Requirements....143
6.3.3. Phase 3 (QSS) Detailed Functional Requirements....144

7. CONCLUSIONS AND OBSERVATIONS....150

8. APPENDIX: COST BACKUP....151

TABLE OF FIGURES

FIGURE 2.2-1 DPS SEGMENTS LOGICAL CONFIGURATION ... 4
FIGURE 2.2-2 DPS SEGMENTS PHYSICAL CONFIGURATION ... 4
FIGURE 2.2-3 JOB STRUCTURE ... 6
FIGURE 2.2-4 DPS PRODUCTION PROCESS FLOW ... 7
FIGURE 2.2-5 TYPICAL DPS END TO END PROCESS FLOW ... 8
FIGURE 2.2-6 ADJACENT EXTRACTION JOBS SHOWN GEOGRAPHICALLY ... 9
FIGURE 2.2-7 EXTRACTION PROJECT JOB NETWORK ... 10
FIGURE 2.2-8 EXTRACTION SUBTASKS SHOWN GEOGRAPHICALLY WITHIN THE TASK ... 11
FIGURE 2.2-9 EXTRACTION SUBTASK GANTT CHART SCHEDULED BY LWU ... 12
FIGURE 2.2-10 EXTRACTION SUBTASK NETWORK PERT CHART ... 13
FIGURE 2.2-11 DPS COMMUNICATIONS PROTOCOL ... 16
FIGURE 2.4-1 ACHIEVABLE EXTRACTION PROGRAM (FIRST TIER) ... 19
FIGURE 2.4-2 DESIRED EXTRACTION PROJECT ... 20
FIGURE 2.8-1 USER FORM REGARDING PM/S SCHEDULING ... 27
FIGURE 2.8-2 USER SURVEY FORM REGARDING PM/S GUI AND QSS ... 29
FIGURE 2.8-3 USER SURVEY RESULTS REGARDING SCHEDULING ... 30
FIGURE 2.8-4 USER SURVEY RESPONSES TO GUI & QSS CONCEPT ... 30
FIGURE 3.3-1 IMWS MAINTENANCE PLAN ORGANIZATIONAL ELEMENTS ... 36
FIGURE 3.4-1 PHASE 1 DISPLAYED ELEMENTS - L2 PERSPECTIVE ... 39
FIGURE 3.4-2 PHASE 2 DISPLAY ELEMENTS - L3 PERSPECTIVE ... 40
FIGURE 3.4-3 PHASE 3 DISPLAY ELEMENTS - L5 PERSPECTIVE ... 42
FIGURE 3.5-1 IMWS PHASE 1 TOP LEVEL FUNCTIONAL FLOW ... 43
FIGURE 3.5-2 PHASE 3 TOP LEVEL FUNCTIONAL FLOW ... 45
FIGURE 4.2-1 IMWS PHASES AND RESPONSIBILITIES ... 50
FIGURE 4.2-2 IMWS FUNCTIONAL ELEMENTS ... 51
FIGURE 4.2-3 IMWS FUNCTIONAL ELEMENTS IN THE DPS ENVIRONMENT ... 52
FIGURE 5.1-1 IMWS PROJECT FLOW CHART ... 57
FIGURE 5.2-1 IMWS WORK BREAKDOWN STRUCTURE ... 59
FIGURE 5.3-1 IMWS PHASE 1 PROJECT SCHEDULE ... 62
FIGURE 5.3-2 IMWS PHASE 2 PROJECT SCHEDULE ... 64
FIGURE 5.3-3 IMWS PHASE 3 PROJECT SCHEDULE ... 65
FIGURE 5.3-4 IMWS PROJECT LIFE CYCLE SCHEDULE ... 66
FIGURE 5.4-1 CM DISCREPANCY AND WORKOFF PROCESS ... 67
FIGURE 5.4-2 DR BUILD PROCESS FLOW THROUGH THE IMWS ENVIRONMENTS ... 69
FIGURE 5.4-3 CM BUILD PROCESS FLOW ... 70
FIGURE 5.6-1 IMWS INTERNAL INTERFACES (PHASES 1 & 2) ... 79
FIGURE 5.6-2 IMWS INTERNAL INTERFACES (PHASE 3) ... 80
FIGURE 5.6-3 IMWS EXTERNAL INTERFACES ... 81
FIGURE 5.6-4 EXISTING PM/S INTERFACES IMPACTED BY THE IMWS ... 82
FIGURE 5.7-1 PHASE 1 INCREMENTAL DEVELOPMENT SESSION ISSUES ... 86
FIGURE 5.7-2 QUERY INTERFACE TO THE PM/S M204 DATABASE PROCESS FLOW ... 88
FIGURE 5.7-3 IMWS INTEGRATION SIMULATOR CONFIGURATION ... 92
FIGURE 5.7-4 PHASE 2 SESSION ISSUES ... 93
FIGURE 5.7-5 PHASE 3 SESSION ISSUES ... 96
FIGURE 5.10-1 PHASE 1 AGGREGATE EXPENDITURE RATE ... 105
FIGURE 5.10-2 PHASE 2 AGGREGATE EXPENDITURE RATE ... 107
FIGURE 5.10-3 PHASE 3 AGGREGATE EXPENDITURE RATE ... 109

Figure 6.1-1 Desired SAEAT Display 112
Figure 6.1-2 QSS Session Initial Conditions 114
Figure 6.1-3 QSS Session First Assignment Actions 115
Figure 6.1-4 QSS Session with New Additional Assignment 116
Figure 6.1-5 QSS Session Subtask Completes 116
Figure 6.1-6 QSS Session with Reassignment and Resource Change 117
Figure 6.2-1 P1.2 Query Process Flow 120
Figure 6.2-2 Saved Query Process Flow 122
Figure 6.2-3 QSS Entry Options 126
Figure 6.2-4 Create Query Flow Diagram 128
Figure 6.2-5 Get Saved Query & Run Query Flows 129
Figure 6.2-6 Save Query & Report Flows 130
Figure 6.2-7 Create Assignments Flow 131
Figure 6.2-8 Change Assignments Flow 134
Figure 6.2-9 Manage Resources Flow 136
Figure 6.3-1 IMWS Internal Interface Requirements 138
Figure 6.3-2 IMWS External Interface Requirements 139

TABLE OF TABLES

Table 5.2-1 Modules to be Included by Phase 61
Table 5.5-1 IMWS Component Allocation to SAEAT and QSS Applications Critical Items 74
Table 5.5-2 IMWS Tasks Reviewed for Incremental Development 75
Table 5.6-1 IMWS Internal Interfaces and Relationships 78
Table 5.6-2 IMWS Hybrid Interfaces and Relationships .... **Error! Bookmark not defined.**
Table 5.7-1 Incremental Sessions Planned per Phase 85
Table 5.7-2 Phase 1 Session 2 Required Data Structures 86
Table 5.7-3 Phase 1 Session 3 Required Data Structures 87
Table 5.7-4 IMWS Database Equivalents to the PM/S M204 Database 89
Table 5.7-5 Integration Requirements Verification Checklist 90
Table 5.7-6 Phase 2 Session 1 Required Data Structures 93
Table 5.7-7 IMWS Database Equivalents to the PM/S M204 Database (Phase 2) 94
Table 5.7-8 Phase 3 Session 1 Required Data Structures 97
Table 5.7-9 IMWS Database Equivalents to the PM/S M204 Database (Phase 3) 98
Table 5.10-1 Software Packages to Support Development and Transition 102
Table 5.10-2 Labor Classes and Hourly Rates 103
Table 5.10-3 Phase 1 Summary Costs 103
Table 5.10-4 Phase 2 Cost by WBS Element 104
Table 5.10-5 Phase 2 Summary Cost 105
Table 5.10-6 Phase 2 Cost by WBS Element 106
Table 5.10-7 Phase 3 Summary Cost 107
Table 5.10-8 Phase 3 Cost by WBS Element 108
Table 5.10-9 O&M Costs for Discrepancy Resolution 109
Table 5.10-10 Maintenance Upgrade and Inventory Management Costs 110
Table 5.10-11 Site License Expenses 110
Table 5.10-12 O&M Summary Costs 110
Table 6.1-1 Possible Phase 1 SAEAT Report on Project Shown in Figure 6.1-1 112
Table 6.3-1 Codes Used to Identify Allocated Components 137

TABLE 6.3-2 PHASE 1 REQUIREMENTS MATRIX 140
TABLE 6.3-3 PHASE 3 REQUIREMENTS MATRIX 144

1. PROJECT BACKGROUND

This project was inspired by an ENG 5004 session that explored how humans process information coupled with a complaint in my workplace about how difficult it was to analyze our management data. The workplace problem lay in the technology in use: character based terminals presenting data in tabular format regarding schedule data for work producing maps. This data tends to be graphically and geographically related, and more easily processed visually as symbols by humans. An opportunity existed to plan a migration to more current technology which could display the data in a more consumable and manipulable manner.

It is my contention that systems engineering methodology can be used to impose an engineering discipline on a project that encompasses a wide range of technologies, can identify and allocate functions to most appropriately utilize the technologies, and can control the development and integration of these technologies and functions into a useful and useable capability.

The challenge in this project is that it attempts to engineer a business process and implement it in software (in an existing and operating system). I see software as a largely undisciplined industry employing little methodology to create its products. The result is distrust, especially by information system managers, especially of software driven systems and their capabilities. In many cases the cost to operate and maintain the system eroded the value of the information that was being managed. The operating costs exceded expectations due largely to lack of engineering to cosider operation and maintenance costs when the system was begun. This situation was improving at the time this project was drafted, and has continued to improve since.

The academic requirement is to create a project which demonstrates the application of systems engineering methodology to solve an identified problem. There is a process which I, the engineer, must follow, during the creation and execution of the project. I have chosen to create a systems engineering project which provides the engineering guidance to upgrade an existing system. This project defines the problem, provides the conceptual solution, and provides the engineering management plans needed to implement the solution, and provides the initial design elements. Life cycle concerns are are discussed in the conceptual solution and engineering guidance sections, and is necessary for context of any contemplated design. This project does not build anything and no code is written. These tasks are to be accomplished by the team that implements this project according to the guidance and stipulations contained in the project documents.

The work to create the project included the following tasks, and can be interpretable as a WBS:

1. **Project Definition**
   - Define the problem
   - Determine the Problem Scope
   - Review the Scope for Feasibility
   - Refine the Scope
2. **Create the Project**
   - Problem Definition
   - Problem Assessment
   - Recommended Solution
   - Project Engineering Management
   - Initial Design
3. **Close the Project**
   - Submit Draft

Collect Comments and Incorporate
Defend
Collect Comments and Incorporate
Submit Final Document

Item 1 is the formulation and bounding of the problem and was conducted with Dr. Jeff Woldstad. The scope of this project had to be curtailed when it became clear that it would require several people half a year to accomplish the proposed work. It was during that time that the project took shape as primarily an engineering management plan.The conceptual solution indicates an evolution in technology for this customer.

Item 2 is the engineering plan, the written project. In includes the elements of engineering methodology required by the implementers to create the desired capabilities and satisfy the identified requirements. It is the actual work done to create a project to satisfy the acedemic requirements.

Item 3 is the closure plan, and arguably the most difficult part. Here is where the peer review and scrutiny is applied, and where the commitment is met. An action plan of loose ends is developed, attacked, and finally satisfied. The book is then put on the shelf.

The project addresses both technilogical issues and somewhat wider systems issues. Technologically, a move from the mainframe driven operations and character based display to more distributed processing and graphically based displays is indicated. The capability required is a small subset of the existing system which is not to be disturbed during integration and installation.

Wider themes, which should not be overlooked in the process are presented in the final paragraphs of this Section. Two major concepts are themes of this projects: first, the human user is an integral part of the system, and second, the user needs to participate in the system development process. There is a "spiral design methodology" being proposed and defiend by industry (by the Software Engineering Institute) which attempts to impose an engineering discipline ona rapid prototyping sort of paradigm. I have spent some time in the project describing which elements are suitable for such design, and identified these as design sessions. I recommend exercising some care when using a "spiral" type methodology. It can be abused to avoid engineering process and discipline which consumes schedule and budget, especially in the early phases of the project. There are great bonuses to be realized, however, when the user contributes directly to the development: the fielded system will be faimiliar, work as expected, and be already supported by the user.

The human manager is the last and decisive element in the system, and uses the new capabilities to help manage the work. The human is considered an important element of the system. The human provides data and sesisions to the system which then processes these data and returns the results to the human. No actions are taken or enforced without the human review and confirmation. In the end, the human makes the decisions.

2. PROBLEM DESCRIPTION

2.1. *Introduction*

The problem investigated in this section defines functional shortcomings in a very large computer system. The deficiency causes are a combination of ingredients. The procurement process is very slow compared with the creation of new technology. The system being examined was fielded this year after seven years in development. As a result, the system is technologically obsolete at the time it is put into production. Although much time was spent dotting the engineering i's, many decisions seem to have been made in haste or according to expediencies other than engineering judgment. Finally, the operations concept was based on assumptions of the world order that have been radically altered. These issues conspire to create major operational deficiencies that must be identified and corrected.

2.2. *The Existing Digital Production System*

The Digital Production System (DPS) produces maps and charts using interconnecting computer systems and entirely digital processes. The system procurement cycle has been on the order of seven or eight years, with a heritage system whose design was conceived yet a decade earlier. The result is that the technology employed in some instances is antiquated, and the operational concepts have been modified by world events. The fielded system, therefore, has some unforeseen shortcomings, and the customer is interested in pursuing corrections.

The man machine interface needed to plan and manage work is character based and tabular. A graphics based interface is desired. The method to schedule the work is cumbersome and inefficient, and the customer is inquiring whether it is feasible to modify the scheduling method and its man machine interface.

This is a two part problem, but there is synergy between the parts. A phased solution may be possible that provides the customer the planning man machine interface at a fairly low risk and also provides the platform and environment to develop upgraded scheduling capabilities.

This project explores and defines the customers needs, identifies solution concepts and their attendant risks, develops requirements, and selects a candidate solution. The high level functional design is then developed.

This project is in fact a case study, and interactions with the customer are presented. In the field, the problem is still being scoped, and the solution has been neither selected nor adopted. In fact, in the current fiscal environment, feasibility is still in question. It is hoped that the investigations in this project are of use to the subject case in fact.

2.2.1. General Description

The total system must be described to provide the problem context. The digital production system (DPS) takes digital and non-digital source materials, converts them all to a digital form, then applies various cartographic processes, all by humans operating computer tools, to produce the maps and charts in the formats specified by the customers. The DPS consists of the following segments, which are illustrated in Figures 2.2-1 and 2.2-2:

Source Acquisition Segment (SA/S), Data Services Segment (DS/S), Production Management Segment (PM/S), Source Preparation Segment (SP/S), Data Extraction Segment (DE/S), Product Generation Segment (PG/S).

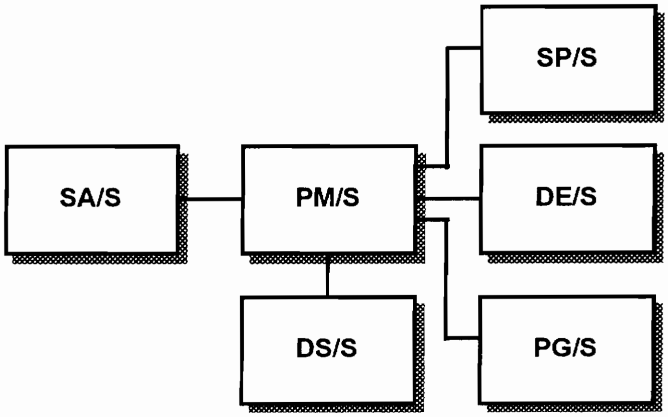


Figure 2.2-1 DPS Segments Logical Configuration

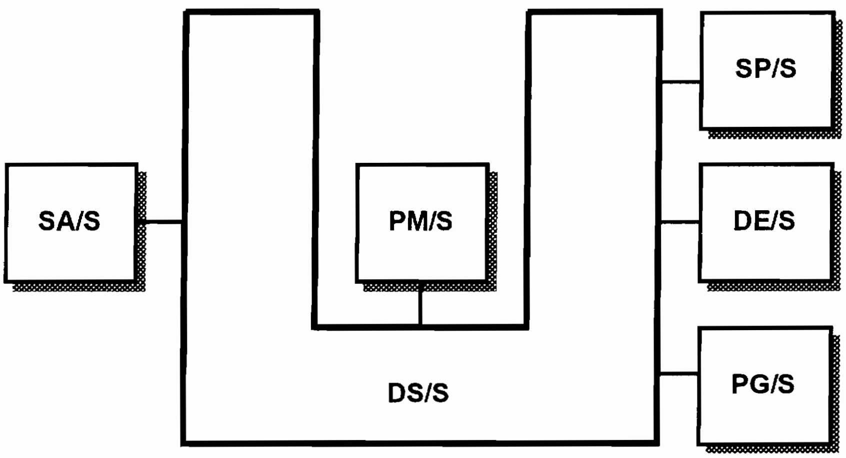


Figure 2.2-2 DPS Segments Physical Configuration

The SA/S manages and stores digital image source data. The SP/S locates and reviews source holdings, including non-digital sources, such as existing maps or photographs, and determines whether there is enough suitable source to produce each desired product. Additionally, the SP/S may digitize non-digital source materials to support the production effort. Finally, the SP/S performs geopositioning; the measurement corrections needed such that all sources can be related to a common grid. The DE/S processes the digital image data and identifies features found. The features are catalogued in a working database, and include elevations, rivers and drains, roads and bridges, and other customer specified items of interest. When the feature set has been extracted from the digital image, the PG/S symbolizes the features and produces the digital and/or hard copy products specified by the customer. The PM/S provides management tools and is responsible for job and data flow and control. The DS/S provides the communications media and provides storage for many data types used during the production effort.

Each segment contains a major computer system, and to accomplish the tasks within each segment's charter requires immense compute power. Each computing system must communicate with all the others. Several million digital sources can exist, each consuming perhaps hundreds of megabytes of data space. Several million digital products also exist which are maintained in another data store. The simple statements contained in this paragraph are meant to indicate the DPS scope and complexity through order of magnitude: this is a complex and ambitious system.

2.2.2. DPS Current Life Cycle Status

The DPS is currently being activated, and system actual usage is being discovered as the system is exercised. There are considerable discrepancies between the original operations concept (OPS CON) and how the users are operating the system. To the system's credit, it has shown remarkable flexibility to adapt to the current needs. The changing world socio-political climate is changing rapidly, and these changes drive changes in the customer requirements, which in turn drive changes concerning how the system is operated. The iron curtain has fallen, there have been major volcanic eruptions and other natural disasters, there is conflict in central Asia and Africa, all of which affect various customers mapping needs, and the ability to meet those needs.

The activation process has included integration, checkout, and test (IC&T) of segments individually, and then as a system in a series of "demos." The Demos were highly constrained and generated lessons learned. During the Demos, support transition was begun from "factory" development staffs to site located operations & maintenance staffs. Next, exercise and rehearsals (E&R) were conducted by the users and customer production management staffs, supported by the fledgling O&M staffs. E&R is concluding as this paper is written, and limited production, called production start-up (PSU) is underway.

2.2.3. The Production Management Assignment Process

This project concerns the PM/S, and to explain the problem, the typical job process flow must be understood. Management of any production effort contains similarities: there is a defined workload, there are available and needed resources, the resources are committed to the work which is in turn accomplished, and performance data is collected to determine schedule adherence and cost. The PM/S is the computer tool that helps perform these functions in the DPS. The Operators are the DPS production managers, educated and trained in business and management, perhaps experienced cartographers, but not necessarily computer oriented. There are five management levels identified, one through five, one being the most responsible.

The level one (L1) manager is responsible for project and job planning and supervises a department (designated by two initials). The L1 has a wide perspective, long term view of production goals and needs, and is responsible for department performance. The level two (L2) manager is responsible for scheduling and managing at the project and job levels, and supervises the department (designated by three initials). The L2 commits the jobs to the schedule and is responsible for the job performance. The level three (L3) manager is responsible for scheduling and managing at the task level, and is the adjutant to the L2. The schedule is committed to the branch (designated by four initials). The L3 commits the tasks to the schedule and is responsible for the task performance. The L4 is currently inert. The level five (L5) manager is responsible for scheduling at the subtask level, the point at which the actual work is committed to a machine and an operator for a defined time slot. The L5 supervises the branch, which includes the production people operating computers. The L5 supervisor is a very busy person. There may be several L5s working on a job, typically one to supervise the work done in each production segment (SP/S, DE/S, or PG/S).

2.2.4. The Production Process

Figure 2.2-3 shows the structure of a job. The job occupies a time slot, and is divide into time slots defined by tasks. The illustrated job has a serial network of four tasks. Task one contains two subtasks worked in parallel. Task 2 contains two subtasks worked serially. Figure 2.2-4 is a simplified process flow diagram that illustrates the production process described in this section.

Managers plan jobs according to customer requirements and source availability. Once the job is planned by the L1 manager, it is committed to the schedule by the L2 manager, then each task in the job is reviewed and placed on the schedule by the L3 manager. In the typical job, there is a task set each for the SP/S, DE/S, and PG/S, often in that order. Figure 2.2-5 shows a typical job flow through the production segments.

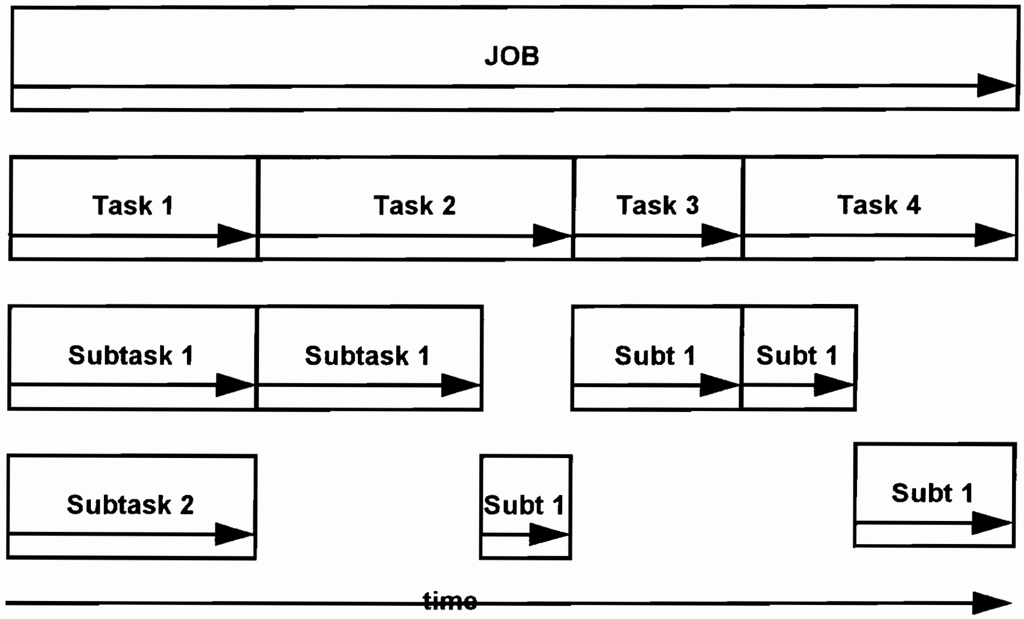


Figure 2.2-3 Job Structure

Once the task has been placed on the schedule, the L5 must schedule all subtasks to machines and operators to accomplish the actual work. When the L5 has made all assignments and reviewed all necessary ancillary data and special instructions, a data package, called the Task Implementation Plan (TIP) is sent electronically via the DS/S to the production segment. The production segment typically has a central controlling machine which receives the TIP, allocates the designated machine, and provides the subtask data required. The operator then performs the functions demanded until the assigned subtask is completed. When completed, the operator initiates a production status (PRSTAT) message which is electronically sent to the PM/S. Interim PRSTAT messages are sent to the PM/S typically at the end of each shift, and contain actuals and an estimated time needed to complete.

2.2.5. The Extraction Task

The extraction task has a number of management challenges. Defined in each job are the coordinates of interest for a particular job. A geopositioning job may contain (and define) several extraction areas. Once geopositioning has been accomplished, the extraction jab may be scheduled. The extraction job contains the coordinates of the area to be extracted. Prior to the extraction task, several tasks are performed to prepare the source data to be extracted. The extraction task is then scheduled, and it contains coordinates that are the same as the job coordinates.

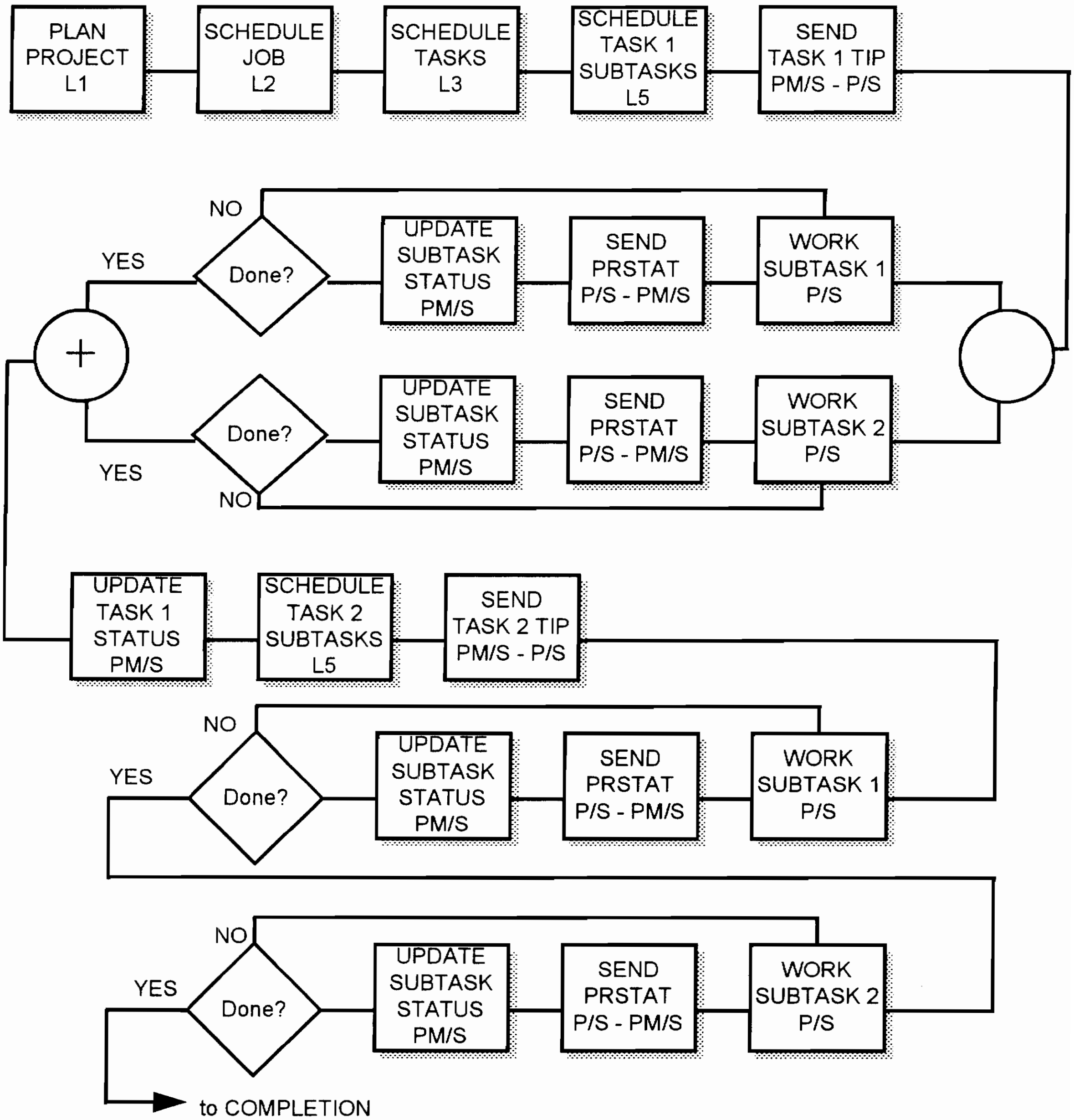


Figure 2.2-4 DPS Production Process Flow

Extraction job and task managers have similar needs. They need to see the array of their jobs or tasks (which are geographically coincident) and their statuses - planned, scheduled, in work (with an estimate to complete, hopefully in work hours), or finished. There may be geographic areas that are not planned for extraction, and therefore have no status. The extraction task is very lengthy and contends for data at the borders of the task area. The extraction project must be planned carefully to avoid very long project production timelines.

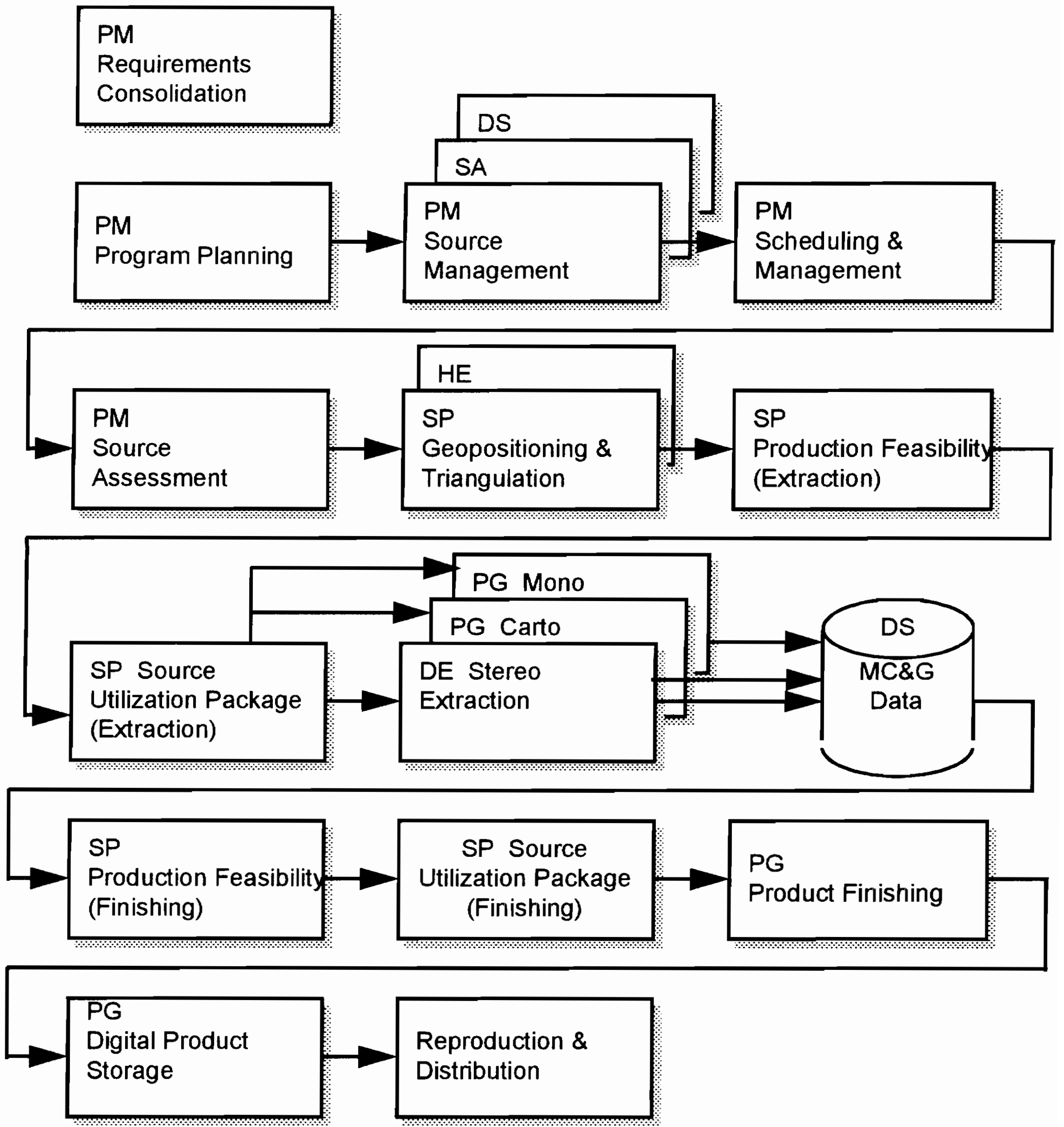


Figure 2.2-5 Typical DPS End to End Process Flow

The work to be scheduled and done can be related at the job, task, and subtask levels to particular coordinate sets. Figure 2.2-6 shows 16 extraction jobs with an index relating the jobs and extraction tasks to geographic location. The extraction task has a one to one relation with the job.

The geographic data is maintained in what is known as the MC&G database. The existing operations concept dictates that the extraction task accesses the data by coordinate, and the MC&G database is locked while the data is being operated on. Once extraction is completed, the extracted data is stored back to the MC&G database which is then unlocked. When the data is retrieved for extraction, an extra fringe is also taken. This allows accurate extraction up to the edge of the assigned area. If this fringe were not taken, then extrapolation techniques would have to be used to extract to the edges of the assignment area, and this has been deemed unacceptable by the customer.

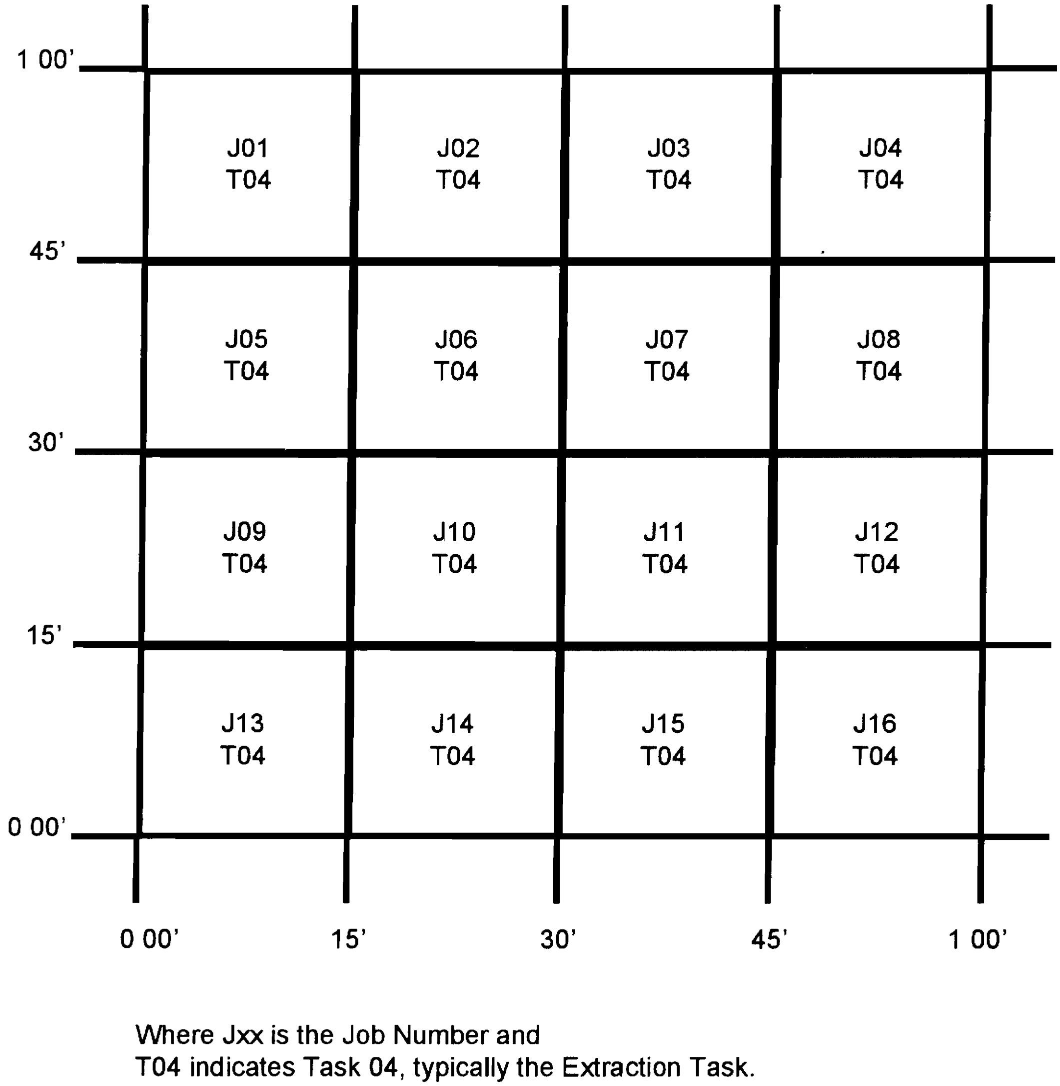


Figure 2.2-6 Adjacent Extraction Jobs Shown Geographically

The effect is that adjacent assignment areas cannot be extracted at the same time. In order to extract the planned one degree by one degree area shown in Figure 2.2-6, the planner may set up a job network as shown in Figure 2.2-7. This plan sidesteps the adjacent simultaneous extraction issue by building job dependencies: job J02 extraction cannot begin until J01 and J03 extractions are complete. Assuming that all 16 extraction tasks take approximately the same time, this network is fairly efficient. It should be noted that the extraction task may take from 600 to 2000 hours - four months to a year! For the network shown in Figure 6, extraction may take one to three years.

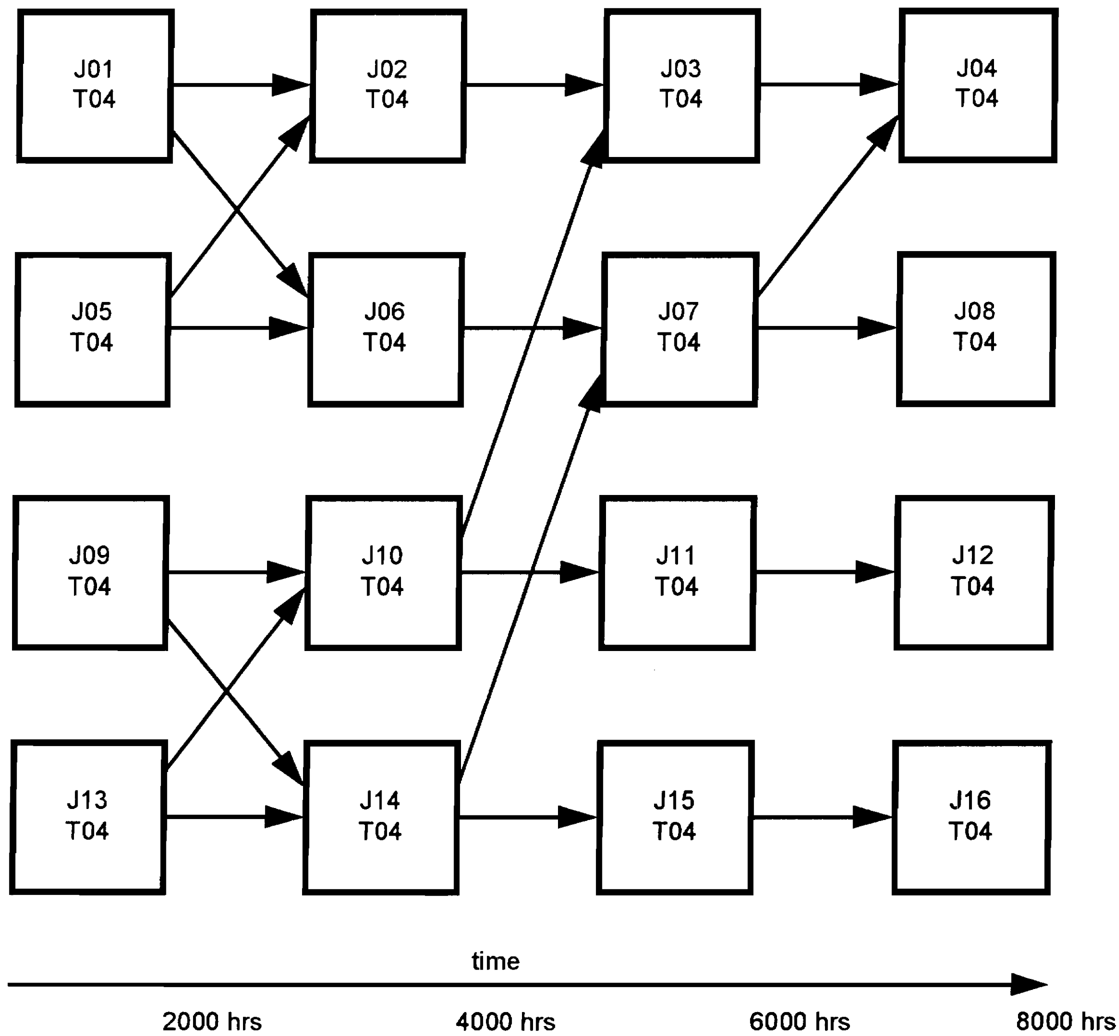


Figure 2.2-7 Extraction Project Job Network

2.2.6. The Extraction Task/Subtask Network

Special challenge is provided to the L5 by the spatial structure of the extraction task. Feature extraction is performed on digital or digitized image data. Features include elevation contours, bodies of water and shore lines, roads, railways, rivers and drains, and other items of interest such as particular or significant buildings. Geographic Information Systems (GIS) is an emerging technology which, among many other things, performs this sort of feature extraction.

Each extraction area is divided into smaller geographic parcels. This is to provide more manageable sized areas for the cartographer to work on. Even with computer assistance, there is only so much that a human can maintain at a time. The product intended is known when the job is scheduled, and therefore the level of detail to be extracted is also known. The size of the actual work areas, called logical work units (LWU) is driven by the expected complexity: the more complex, the smaller the LWU.

The extraction task operates on the data contained in the extraction area. See Figure 2.2-8 for the breakdown of the work within the extraction task area. The extraction area is divide into what the Extraction segment unfortunately calls models. For the purpose of this paper, the extraction models will be referred to as E-Models, as opposed to the job process flow models in the PM/S, which will be referred to as M-Models. The E-Models coincide with selected imagery, and tend to run latitudinal across the extraction area. The E-Models are comprised of one or more logical work units (LWUs).

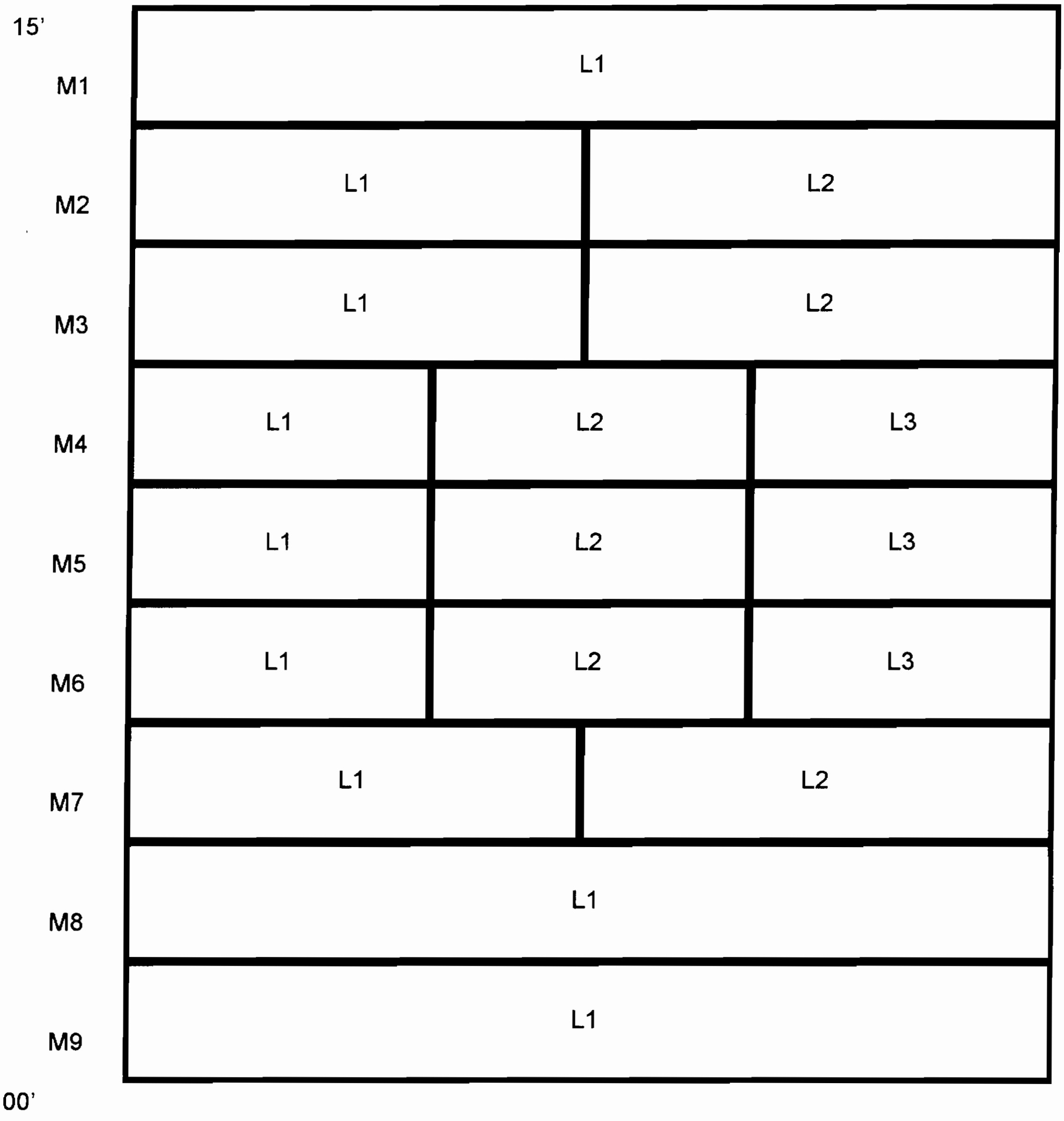


Figure 2.2-8 Extraction Subtasks Shown Geographically within the Task

The PM/S builds subtask schedules that support extraction LWU by LWU. Each LWU contains three subtasks, extraction, QA, and rework. Let's identify the subtasks as 100 for extraction, 110 for QA, and 120 for rework for ease of tabulation and illustration. Subtasks map to LWUs on a three to one basis: each three subtask set applies to a particular, geographically unique LWU. Current evidence is that the typical LWU is scheduled to consume three weeks schedule time.

There is another issue for managing extraction subtask schedules. Refer to Figure 2.2.6-1, which shows the E-Models and LWUs for a particular extraction task. No two models can be extracted simultaneously because this causes contention for data at the border. Models are typically defined with some overlap. In theory, the first model worked captures all data at the borders, extracts the features to the edge, then returns the data to the database. The next model is then extracted, but the border region has already been extracted, and the cartographer extracting the second model does not need to re-extract at this border. Should two cartographers extract a border area simultaneously, each would be operating on the same data at the same time, without the benefit of the knowledge of each other's updates. Rather than adjudicate this contention, the concept is to avoid it through judicious scheduling. This concept is similar to the extraction job scheduling strategy.

Each extraction task is divided into the E-Models, and these models are grouped in sets of three. One cartographer is assigned to each set of three E-Models, and works from north to south through the E-Models. By the time the cartographer working the northernmost set of E_Models is ready to begin the third, the cartographer working the next set should, at the very least, have completed the first assigned E-Model of that set.

This scheme is controlled by the P-Model chosen when the job is initially scheduled. An extraction scheduled with this P-Model may produce a schedule similar to that shown in the GANTT chart of Figure 2.2-9. The subtask network, shown in Figure 2.2-10, contains parallel as well as serial elements.

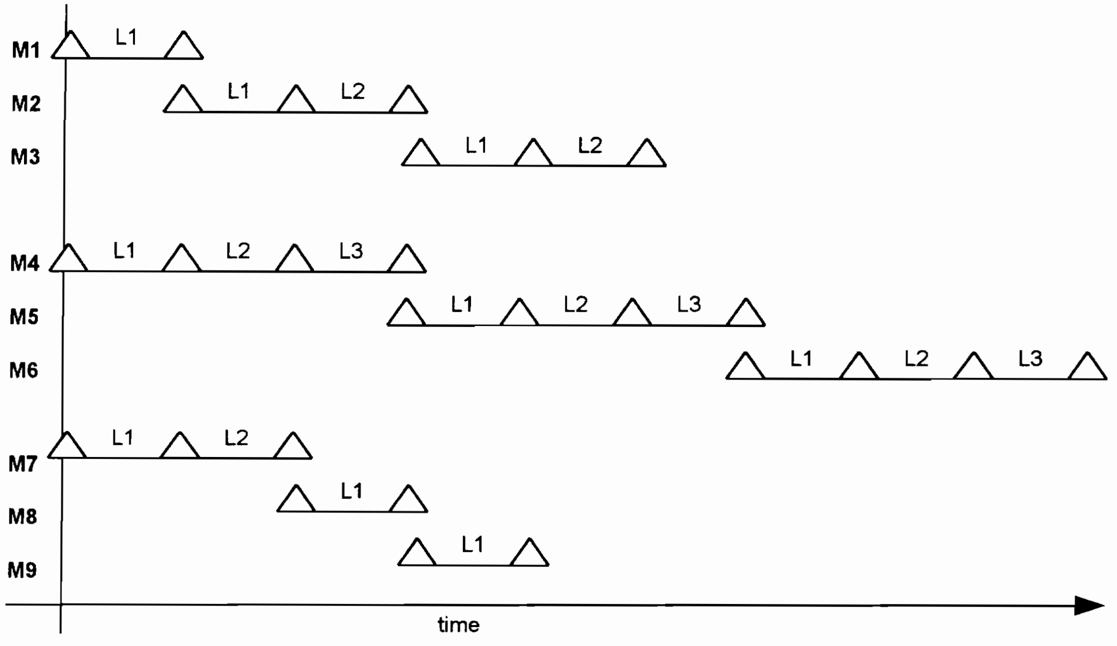


Figure 2.2-9 Extraction Subtask GANTT Chart Scheduled by LWU

Another method is available should there be extreme schedule pressure. To shorten the total production time, more cartographers may be assigned, and more E-Models may be worked in parallel. The P-Model for such an extraction allows each subtask to be scheduled in parallel. The onus and complete responsibility then shifts to the L5 manager and that person's scheduling skill. Typically, two E-Models are assigned to each cartographer, shortening overall production time. There is increased risk for data contention, or perhaps for idle time if contention is foreseen.

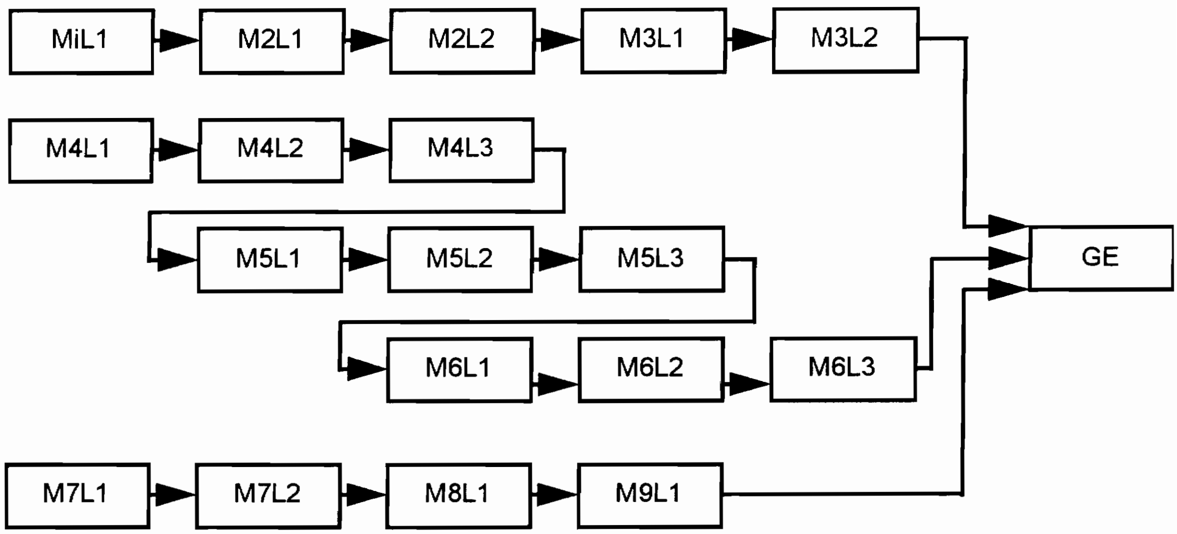


Figure 2.2-10 Extraction Subtask Network PERT Chart

2.2.7. Changes and Change Management

Change can be introduced into job schedules in many ways, similar to forces that drive changes in many business enterprises.

Customers change their minds which drive production requirements changes.
Customer's priorities change which may make a job ore or less urgent.
Sources might not be available, or may be available according to a changed schedule.
Unassessed source data may be found to be inappropriate, incorrect, or corrupted.
Work done on the floor may be done incorrectly and need rework.
Machine errors may occur which lose or corrupt data and require maintenance or rework.
Machines may go down and be unavailable for scheduled production time.
Workers may become sick or leave the production organization causing unscheduled resource shortfalls.
Scheduled work may be finished early allowing schedule acceleration.

Within the project scope, changes due to equipment availability, operator availability, schedule overrun, and early finish are considered. These issues concern mainly subtask level issues, and are especially critical because they affect activity in the production environment directly. Other change management issues also need review and perhaps correction, but must be the subject of other inquiries.

Change within an enterprise continually occurs, and the tools used to schedule events must therefore recognize and adjust to, or otherwise manage, the changes. If a machine goes down, the manager is not likely to allow the operator to do nothing (and charge idle time or overhead) while the machine is being repaired. The manager will assign another task to the operator while corrective maintenance is performed. The methods to manage change in the existing system are discussed later, after the method to schedule and assign work at the subtask level is presented.

2.2.8. Existing Subtask Scheduling Method

All customer requirements are expressed in terms of the product desired, and all product production processes are modeled in the PM/S database. Models exist from history for most products, but sometimes a new model must, and can, be built. The model contains, for scheduling purposes,

the job and product types,
the task sequences (their precedence networks),
the subtask sequences needed to accomplish the tasks,
the resource types, skilled people and special purpose workstations,
and expected durations needed to complete each subtask and task.

The model contains all possible tasks needed for the production process. Some tasks may be optional and not needed for each job.

One model can possibly support multiple products and multiple jobs. From the model a job base standard is derived which is tailored to specific jobs. The base standard is a subset of the product model. Base standards may include optional tasks. Whether or not these tasks may need to be performed are determined by run time conditions. Each job when it is scheduled creates a job specific standard (JSS) from the base standard. The JSS is used to govern all scheduling activities for the specific job. The JSS will be updated during job execution to meet run time conditions.

Job and task schedules are created from the JSS, and ultimately create time windows when production work is expected to be accomplished. The L5 manager makes these assignments using the PM/S.

At the L5's disposal is the item specific resource pool and knowledge of existing assignments (contained in the PM/S database). Reports are generated on a resource by resource basis, i.e., on person or piece of equipment at a time. The PM/S uses "first best fit" to create assignments. The machine will automatically choose resources from the pool and search for availability (non assigned times) for those resources that coincide with the specified schedule interval. If found, the assignment is made, and (in some cases) fed back to the L5 for approval. Upon approval, the assignments are stored in the PM/S database, and the resource pool availability is updated. If a match can be only partially made, the partial assignment is created, but conflicts also are created. The L5 manager may approve such an assignment, but an inherent management challenge is accepted: the assignment is being made with less time than predicted to accomplish the work.

The task becomes available for subtask scheduling when the task schedule is approved, typically by the L3. It is at this time that the Task Implementation Plan (TIP) is created as an entity. The task schedule approval implies sufficient resources to accomplish the planned task. The newly created TIP is called the Reference TIP, and when reviewed by the L5, contains the computers best guess at a specific assignment set.

Usually, the L5 manager then specifies the equipment and operator desired for a subtask (often different from the automatically calculated choices), and the machine makes the assignments. At this point the TIP is referred to as a Candidate TIP. If all subtasks within that task are fully assigned, the TIP may be approved, then sent to the production segment.

The effect is that each subtask assignment must satisfy a three dimensional matrix: time interval, equipment availability, and operator availability. Calculations must be performed for each subtask assigned.

There are assignments that cannot be completely fulfilled because sufficient resources do not exist during the expected time frame. What resources are available will be assigned, but shortfalls exist. The L5 may approve such an assignment, but understands the management challenge to essentially do more with less. Any time a subtask cannot be completely assigned, a conflict exists with the chosen resources, and a report is generated for the L5 review.

It should be noted that effective scheduling is based on accurate subtask duration estimates in the model, which in turn are based on knowledge and subtask performance history.

2.2.9. Existing Interface Concepts, Operation, and Support

When the L5 has made the assignments and committed them in the PM/S data store, the data must then be communicated to the production segment. The assignment information is invoked in the production segment, and details who will do what work on which machine, and on what data. The message is packaged in the PM/S according to the DPS interface control document (ICD) and sent to the production segment on the DPS local area network, operated by the DS/S. The communications protocol is specific to the customer, and as far as I know, has no equivalents in commercial industry. □□The assignment message is named the TIPLAN, most likely named to denote the TIP dataset that is sent over the DPS local area network (LAN). The communications process is currently three steps, and is shown in Figure 2.2-11: first, the PM/S assembles the TIPLAN and transmits it to the LAN (the TIPLAN contains sender and receiver information); second, the DS/S delivers the TIPLAN to the addressee and notifies the PM/S that the TIPLAN has been delivered; third, the receiving segment notifies the DS/S that the TIPLAN has been received, and the DS/S relays this final status to the PM/S. There are several error conditions that return error status messages to the PM/S. Typically, when the PM/S receives these error messages, the TIPLAN is reset, then resent until a successful transaction is completed.

The transaction processing, host machine to host machine, is fairly reliable, but, as can be seen from Figure 2.2-11, there is no feedback from the production peer application to the PM/S application. The message content is not validated as part of the message transfer process, and this creates one of the serious problems. Although a valid transaction occurs, a valid communication, peer application to peer application, may not

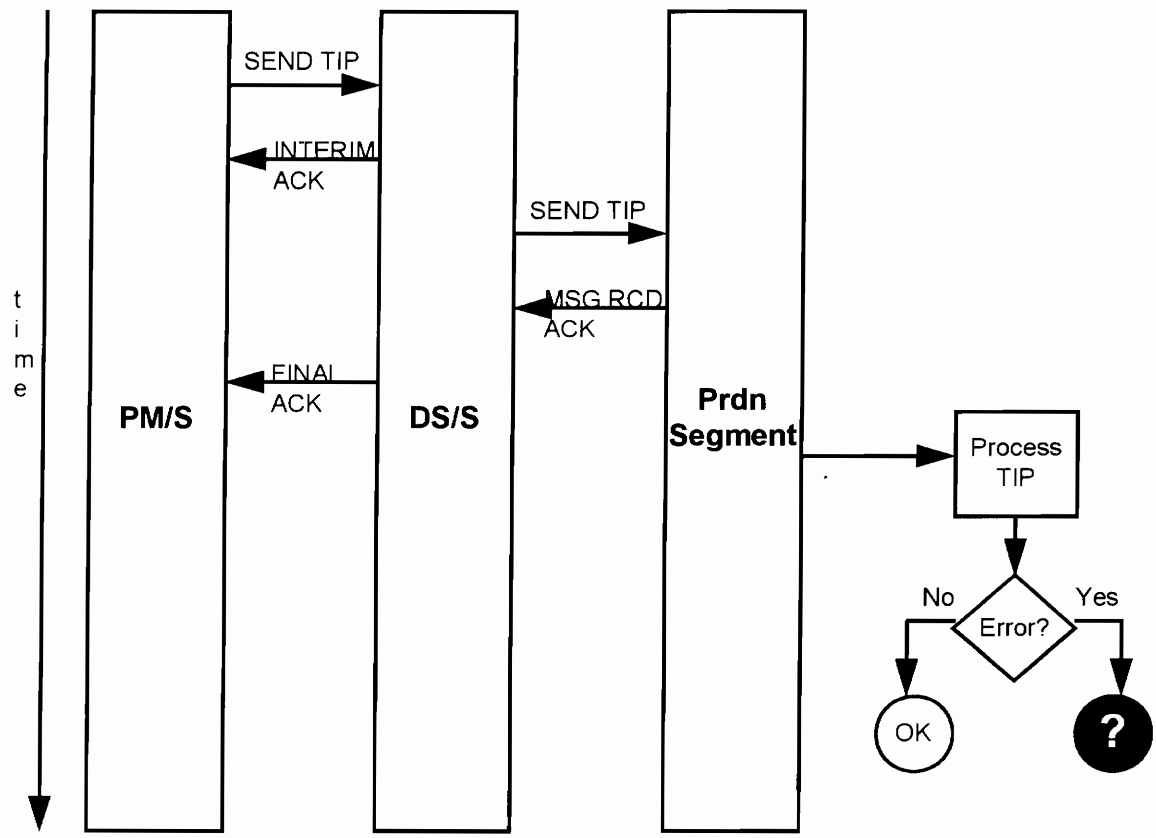


Figure 2.2-11 DPS Communications Protocol

2.2.10. Existing Subtask Assignment Change Management Methods

To cope with run time changes in a task, the L5 may modify assignments in the Task Implementation Plan. The L5 may change an operator, a piece of equipment, or, within constraints of the task time window, alter the subtask schedule. The change method is popularly called TIP MODs. In short, the L5 makes the desired changes. When the desired new assignments are made, the resources chosen are checked against the resource pool for conflicts. Conflict and approval processing works as for the initial assignments. When the modified assignments are approved, with or without conflicts, a TIP message containing all task data including the changes is assembled in the PM/S, then sent to the production segment. Special fields are designated in the TIPLAN to denote the modifications. The production segment processes the new TIP, and proceeds on the production task.

There are four other modification options, usually invoked in situations more drastic than schedule or resource adjustments:

1. Cancel, keep allocations

Cancel the task in production, but keep the resource allocations on the books. This anticipates near term correction, and in effect, reserves the resources for this particular task.

2. Cancel, return allocations

Cancel the task in progress and return the allocations. The resources are returned to the availability pool for use on other tasks. The canceled task is not expected to be put back into work soon, so the resources are not needed.
3. Interrupt & continue
Interrupt the task in progress, but finish those subtasks in work. Do not start any new subtasks. This makes room for a higher priority task while preserving the work already done.
4. Interrupt immediately
Interrupt the task in progress, stop all subtasks immediately. This makes room for a higher priority task immediately, but the consequence is that work already done may be thrown away.

2.2.11. Existing Maintenance Support and Plan

In fact, I have never seen the DPS Maintenance Plan. I will speculate based on observations from a couple year's maintenance work on this system during transition. There is no measure for system availability, and no requirement levied against the maintenance contractors to maintain a certain level of availability, measured any certain way. There is no tolerance specified for failure rate, but there are dozens of Discrepancy Reports (DRs) written every day.

Each segment is maintained through an operations and maintenance (O&M) contract. The staffing plans are requested rather than specified. The onus is on the contractor to tell the customer what it takes to operate and maintain the delivered system. I would have thought that the maintenance specifications would have predicted an expected staffing effort, and the customer would require the contractors to explain deviations from that staffing plan. In fact, the staffing plans seem to be driven purely by the budget with little regard to other factors. Maintenance is managed by the surprise. If certain capabilities are too (and Unexpectedly) expensive to fix, degraded operation and deferred maintenance is accepted.

The system is so large and complex that it is not feasible to simply start over. Too much is invested, and production requirements can't wait. In all, it is quite a paradox.

2.2.12. Lost Production Time

During the first two years of operations, more than 100 discrepancy reports (DRs) were written against the DE/S-PM/S interface. DRs are written when the discrepancy impacts production time. Neither the method to calculate system availability nor the method to determine the number of lost hours has been formalized, so it is somewhat difficult to determine the true scope. The production segment, in this case the Data Extraction Segment, has an interest to make the impact appear as large as possible while the Production Management Segement has an interest to limit the apparent damage introduced into the system. The PM/S estimate is on the order of thousands of lost hours whereas the DE/S estimate is in the tens of thousands of lost hours. With no absolute scientific reckoning, it can be observed that a lot of discrepancies have caused an unacceptability large amount of lost time. Difficult to calculate is the knock on effect of the following processes which must change their production plans.

2.3. Data Display and User Interface

The Production Management Segment in the DPS is built on a heritage product named the Data Interface Segment (DI/S). It was believed at the beginning of the DPS acquisition cycle that the most cost effective strategy was to add the new PM/S functions on top of the DI/S baseline (one notable new function was scheduling at the subtask level). The DI/S is hosted on an IBM mainframe running the MVS operating system. The central processor adjudicates time slices for multiple users. The users are connected to the central processor via a token ring fiber optic LAN. The procurement cycle was begun in the early eighties, using that vintage technologies and philosophies. The acquisition method locked the design technology, and made response and improvement to more modern technologies difficult and expensive.

Technical decisions were made before windows technology was established, before graphics presentations were common or affordable. Therefore, the heritage technology drove the continued use of the IBM terminal for the user interface. The IBM 3720 terminal is widely in use in the system. This terminal is character based, and displays 23 lines and 80 columns. These constraints drive all data presentation. Due to the screen limitations, one information screen at a time is available, and the user must thread sequentially through the screens.

The desired data exists and is managed. The presentation method is very constrained, and in many cases difficult to use. To operate on the data, many users print the desired reports and spread them out on a table to do their analysis. The message is that the paper presentation is better than the direct human machine interface. Further, some reports are inadequate, and the users have come to the maintenance staff to generate ad hoc reports. This style of data management works, but one would rather have the capability in the user's domain.

2.4. Simultaneous Adjacent Extraction Problem Definition

This section discusses changes to operational and production requirements that drive new needs.

During the DPS transition the final activity was Exercises and Rehearsals (E&R). E&R was a customer run activity that exercised DPS functions against operational requirements for the first time. Up to this point, activities were geared towards requirements verification and segment sell off by the contractors. At the conclusion of E&R, the E&R director conducted a lessons learned briefing. Two slides, reproduced here as Figures 2.4-1 and 2.4-2, capture the essence of the simultaneous adjacent extraction (SAE) problem. Figure 2.4-1 shows the actual plan that was executed (actually, the first tier - the boxes not shaded were extracted in subsequent passes), and Figure 2.4-2 shows what was desired. All segments were compliant with their requirements and the existing system concept of operations. The desired work could not be accomplished because there is the restraint that presents extraction work on two areas that share an edge. This prevents two operators from updating the same data at the same time without benefit of the knowledge of each other's updates.

Is it a problem because an executive in the customer's executive corps thinks so? Maybe. Certainly as one engineering contractor, the complaint should be evaluated. As a contractor, the decision must be made: is there sufficient support to justify some research?

The problem was further investigated by the customer's engineering shop. The results were published in a white paper titled "Implementing SAE and QTS in a DPS Mod.0 Baseline." Comments regarding SAE are provided here, comments about the "QTS" are provided later, and a more complete White Paper review is provided in Section 2.6.

In the white paper, the existing extraction method is defined as the "alternating checkerboard method." This is as described and illustrated in the existing system operation section of this paper. The white paper asserts that "production managers are using non-DPS means to track the progress of working on the alternating checkerboard ..." This can be seen from the E&R director's slides: this information is not a report from the PM/S, but a collection of reduced PM/S data formatted on a Mac!

The white paper observes "Prior to the demise of the USSR, the (customer) strategic needs and objectives for extraction were both geographically stable enough and temporally long term enough such that it was possible to allow the alternating checkerboard ... design to be used in production. ... given the new world order where extraction needs are neither geographically stable nor temporally long term, the notion of the existing alternating checkerboard design becomes fully unacceptable." And further, "The (customer) Planning and Programming (PP) Directorates across all ... production components and Headquarters have asked that the alternating checkerboard approach be abandoned..." PP is staffed by Level 1 and Level 2 managers.

The white paper takes a definitive stance: there is a problem. Faced with only this much evidence, the responsible engineering support contractor must pay attention. The issues are management methods and tools, and therefore the PM/S should address this issue.

There is no restraint imposed by the PM/S on when which extraction jobs can be scheduled. Technically, from the PM/S perspective, it is possible to schedule simultaneous extractions. The human manager must make the decisions. This is not necessarily a problem. There is, however, no PM/S tool to produce the reports that contain the data shown in Figures 2.4-1 and 2.4-2.

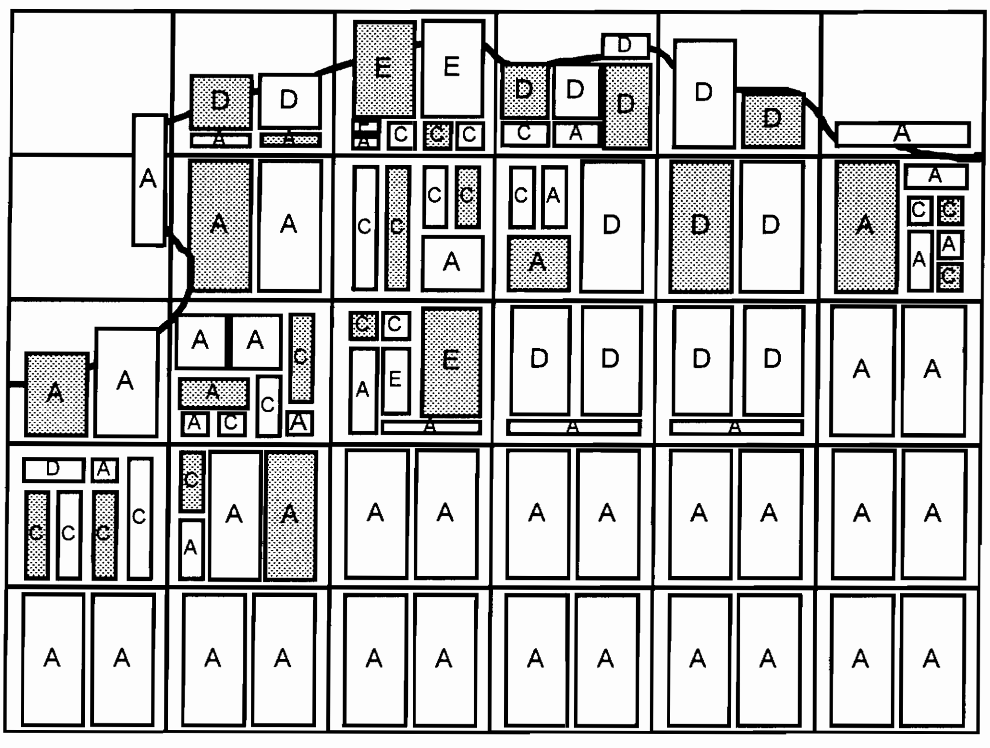
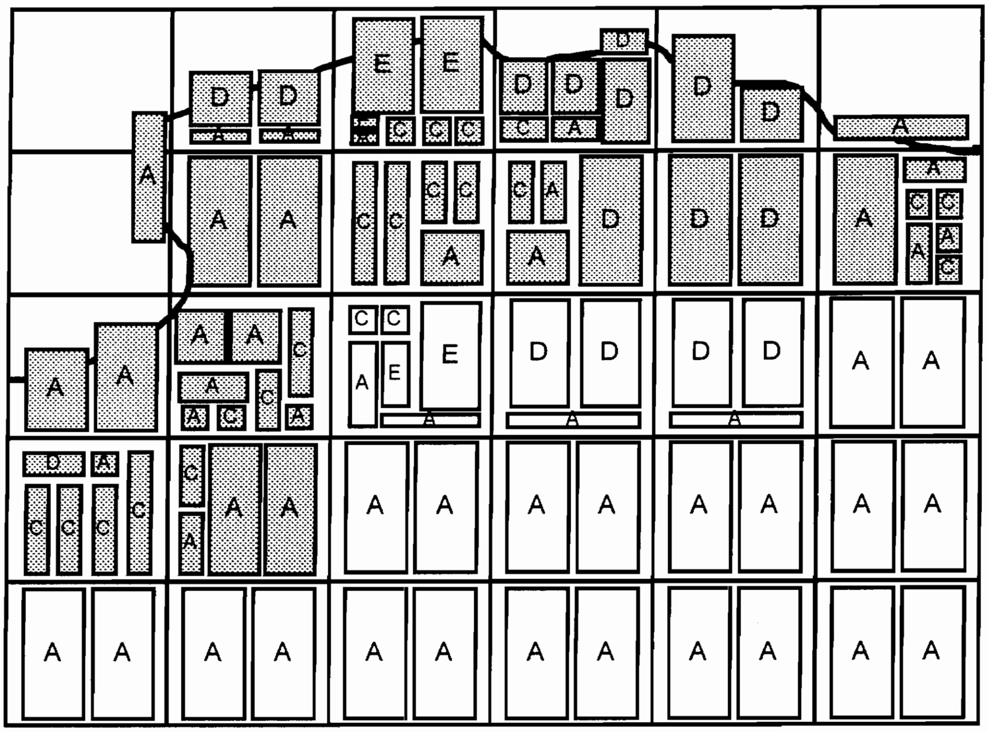


Figure 2.4-1 Achievable Extraction Program (First Tier)



Product	Job Count
A MPO2	48
C MPO5	23
D DFAD1	16
E DTED1	5

Figure 2.4-2 Desired Extraction Project

2.5. *Extraction Subtask Management*

Change management in the PM/S is implemented by the ability to modify TIPs and restart tasks. In the fifteen months that followed delivery of the TIP MOD capability, one hundred one discrepancy reports (DRs) have been written against extraction TIPs. In many cases, both the PM and DE segments are compliant with their specifications, yet the interface is not effective.

There are several reasons for the failures.

The first is that production segments consider schedule dates and times as absolute and require adjustment from the PM/S any time an assignment starts earlier or later than planned. In some cases, the production segment needs an adjustment when an assignment completes early, and nearly always when an assignment runs late. Schedules are, by nature, informed estimates, and actual start and completion dates and times vary from those planned to some degree. This implies that a TIP modification will be required for each assignment, and therefore, each original TIP sent. The more messages are sent, the more there is an opportunity for an error.

The second is that the TIP is a complex message and contains a lot of interrelated data extracted from the database at a particular moment in time. A successful message transaction requires that the data be correct and complete. Data changes with time, and the more messages are sent, the greater the opportunity for data between segments to become unsynchronized.

The third is that there are few recovery methods after a message fails or data becomes unsynchronized. The usual procedure is to write a very high priority Discrepancy Report against the production scheduling process and manually intervene to make corrections. This is very time consuming and costly.

A number of these discrepancies have been assigned to me for investigation and comment. As the PM/S maintenance contractor, I am constrained to the PM/S functional requirements. This leads to discrepancy reports found to be not discrepant, even though the ultimate DPS operation is not achieved. This in turn leads to both customer and contractor frustration because the system doesn't work as desired.

As the PM/S operations contractor, however, there is latitude to provide broader comments. The operations perspective is more concerned with making things work than with requirements compliance. Ultimately if there is no existing requirement for desired capability, the requirement(s) must be identified, scoped, and funded. The customer frustration peaked in one DR and I was assigned to make a recommendation, which follows.

2.6. *Simultaneous Adjacent Extraction White Paper*

The customer's engineering shop issued a white paper titled "Implementing SAE and QTS in DPS MOD.0 Baseline" where SAE is the Simultaneous Adjacent Extraction and QTS is the Queued Task Scheduler. In this paper, the QTS devolves into the Queued Subtask Scheduler (QSS) as the task queues are defined by L3 task scheduling in the existing DPS operational environment. References to this customer document for the remainder of this paper will be the "SAE White Paper."

The document cannot be reproduced herein in whole, nor can it be cited as reference because it is not obtainable, but this section synopsizes the important concepts. The SAE White Paper is strong evidence defining operational problems, and provides some guidance for possible solutions. It also shows the customers preference for certain technologies. The following are points illuminated in the SAE White Paper.

2.6.1. World Changes

When the DPS design was conceived, the world order was defined by the Cold War. The East-West relationship was stable, if uncomfortable, and cartographic needs were fairly predictable. The method to extract features and digitally catalog them relied on this stability, and is referred to as the "alternating checkerboard method" described in the Extraction Task section earlier. The alternating checkerboard method provides a fairly simple data management scenario: only one owner of the data at one time, and only the owner can update.

The world order dramatically changed with the fall of the iron curtain and the destabilization of the Eastern Bloc. Coincidentally, other areas of the world have become destabilized and volatile. The alternating checkerboard method no longer is an appropriate extraction method because too much time is consumed waiting for a neighboring area to be completed. A typical extraction can take six months, and a product could wait a year for neighboring extractions to be completed. An operation such as Desert Storm in Iraq could not stand such a delay.

The SAE White Paper charges the DS/S with creating a new method for data management such that adjacent areas may be updated at the same time, and the PM/S with creating an analysis tool that can help plan for and contain simultaneous adjacent extractions.

2.6.2. Workstation Environment

In the SAE White Paper, the systemwide upgrade to FDDI is assumed. Although not yet operational, the work is underway. Although running behind schedule, there is every reason to believe the upgrade will eventually be accomplished. The customer is committed to the upgrade. The plan is to connect all segment hosts through the FDDI, running a communications protocol such that peers should be able to communicate. TCP/IP appears to be one protocol to be installed. Such an environment can support a sort of distributed processing responsibility. From the PM/S perspective, the CPU does not need to service each terminal with a logical connection; the CPU can download a requested subset of applications responsibility, the workstation can process independently and update the main data store as appropriate through the communications system.

The customer has embarked on a program to procure a low cost, standard workstation. The SAE White Paper names the Intel based 486 running a DOS/Windows environment as a leading candidate, but does not rule out other solutions. The White Paper illuminates the Object Linking Environment (OLE) available through Windows as desirable. It envisions creating icons with attributes supplied from a local data store, and establishing relations between the icons to implement SAE analysis tools and a form of scheduling tool. The language used is Object Oriented Programming (OOP) terminology, and the customer thinks this is an appropriate technology to pursue for the workstation.

The customer envisions a distributed workstation population that communicates with the PM/S IBM mainframe host. The workstations present data to the user in graphical formats. Icons are selectable and maneuverable through point, click, and drag operations.

2.6.3. Maintenance

The customer intends to support the workstation hardware and software with in house resources as much as possible. The customer is relying on contractor support to develop and install the FDDI upgrade, to select and procure the standard workstation, and to create the software that runs on the workstation. The software must be developed in such a way that the in house resources can maintain it. The customer recognizes that the in house programmers are quite junior, but anticipates that the OO technology will help support such maintenance.

2.6.4. Queued Task Scheduler

In the SAE White Paper, the customer cites several issues that are viewed as deficiencies in the PM/SW scheduling capability.

First, there is lost time due to the inability to send timely change information to the production segment. The paper states that "as much as thirty percent of a task time may be spent trying to reschedule..."

Second, system implementation interprets schedules generated in the PM/S and invoked upon the production segments as entirely deterministic. Start and finish dates and time are cast in concrete, and only rescheduling (new dates/times cast in concrete) effects a change. This results in managers constantly updating schedules and sending data across a fragile interface. This is viewed as an inefficient and inappropriate use of the managers' time, and exposes the system to excessive technical risk. The customer states the desire to interpret task schedules as queues, with the schedules probabilistic in nature. The effect is, there are only two issues of concern: what work is currently being done, and what work is next. When the current work is completed, start the next work. Thus the absolute dependence on start and stop dates and times is broken, and far less traffic is envisioned across the PM/S to production segment interface.

Third, it is difficult for the scheduling manager to get the whole picture needed to perform his/her job. The scheduling manager needs to visit several different screens through several different functions, form queries and generate reports for each, collect the paper reports (all tabular), then prepare the scheduling strategy. The customer has been exposed to simple widows based commercial off the shelf (COTS) schedulers that present all similar information in one display. The customer states the desire to drive the PM/S to a similar environment and display mode.

2.6.5. Comments

Comments regarding the major issues in the SAE White Paper are presented. They are generated from the PM/S O&M perspective, and tend to combat the notion that the PM/S software implementation is deficient while acknowledging the valid customer concerns.

2.6.5.1. Workstation Environment

The distributed workstation environments a new concept in the DPS. It seeks to take advantage of technologies that have matured in the last several years. The DPS procurement cycle started in the early eighties, and design assumptions did not include workstations. The large computer system procurement process seems not to have been able to adjust to changes in technology, and as a result, technology a generation or two (or more) old is being fielded. The SAE White Paper is an attempt to update the DPS even while it is becoming operational. This is a daunting task, but it does recognize that the procurement method needs to be dealt with creatively, and it does provide a path to solution for new operational requirements and perceived functional deficiencies.

2.6.5.2.SAE

In the distributed workstation environment, it is unclear to which segment the simultaneous area extraction analysis belongs. Perhaps these management workstations comprise a separate new segment. Unique functionality suites will be installed, and interfaces to all existing segments will be designed and implemented. Such characteristics physically and technically could define a separate segment.

The SAE analysis will be performed by the extraction managers, who are members of the Production Management Segment. Because the managers will be performing analysis that supports production decisions, it is natural to functionally allocate the SAE analysis tools (SAEAT) within the PM/S technical suite. It should be noted that the PM/S maintains all data necessary to support the SAEAT. The PM/S contractor is therefore the most appropriate to produce the needed software.

2.6.5.3.Queued Task Scheduler - lost time

Several issues regarding the QTS require some debate, including lost time, DPS maintenance, interface operations concept, the notion of queued tasks (deterministic vs. Probabilistic), and use difficulty. Lost time and DPS maintenance are discussed together and the other issues are addressed singly.

Lost Time
The DPS Maintenance Plan does not provide guidance on how to calculate down time. It specifies that systemwide a "95% confidence factor" should be achieved. Specifics of downtime in one segment affecting another, of one function affecting multiple jobs, or on job being delayed for specific reasons are not defined. Further, downtime for various reasons other than technical performance are not specified. Such reasons could include shortage of magnetic tape or paper, power or cooling system failure, shortage of operators or other workers. In short, any quantified downtime statement must be scrutinized.

Further, training was not provided to the managers who operate the system. Training was informal, ad hoc, and on the job. The lack of training is identified as a major contributor to downtime.

Production time has been lost, but to attribute it solely to the PM/S is a harsh conclusion. In fact, the DPS concept of operations does not address change management in any sufficient detail, and further, interface implementation regarding schedule change management has been reactionary rather than planned. The method that the PM/S generates schedules is not debated, and is in fact recognized as compliant. The method that the schedule information is conveyed to the production segments, via Task Implementation Plan (TIP) messages that contain the human and machine assignments, also is not debated, and is also recognized as compliant. That the production segments accept the TIPs and the associated assignments is further considered compliant. That the production segments consider the scheduled assignment start and stop dates and times as absolute is further considered compliant. The only result that arises is that the customer has found fault with the DPS specifications the customer itself drove. The PM/S developer and maintainer, as a contractor, must point out that discovered operational deficiencies are beyond any scope and requirement that can be levied. Recognizing that, the PM/S contractor can agree that time has been lost trying to exercise the interface between the PM/S and the production segments trying to effect schedule changes. The PM/S contractor is willing to provide any required analysis and support solutions that improve operations. However, any plan for improvement must contain system engineering considerations must be applied, such as interface operation definition and enforcement, maintenance planning, including training, and thorough risk assessment.

Interface Operations
Interface operations was mentioned as a downtime contributor. Interface development and management, and enforcement, must serve system needs. All DPS software segments appear to be reasonably compliant with their interface specifications, yet the interfaces do not operate in a manner that serves the DPS operational goals. That the production segments interpret start and stop dates and times as absolute has caused problems. The PM/S collects actuals against plan and schedule, so there is little room for adjustment there, either. That most COTS schedulers can schedule tasks on an ASAP (as soon as possible) basis seems to have been neglected. ASAP scheduling relies on dependency knowledge to start the next task when its successor has completed. Scheduling products, including the PM/S scheduler, must have predecessor/successor knowledge to function. That the customer requests such capability is belated, but needed.

Queued Tasks
The customer desires a queued system rather than the manager generated task list constrained by start and stop dates. The customer has in fact already created a queued system, but the control mechanism has been found to be inappropriate. The customer has decided how much work will be planned, has developed a standard that contains estimated typical durations, and has acquired a specific number of production workstations and workers to accomplish the work. These are the elements of a queued system, regardless of how the system was planned. The planned work translates to the arrival rate, the standard durations the service time, and the number of workstations the service channels. The problem arises because the

control mechanism is the schedule start and completion date for a given task or subtask. An assignment is sent to a workstation on a designated date, regardless of the workstation status.

When the DPS was conceived, it was thought that the L5 supervisor would tell the production segments what to do on a moment by moment basis, although jobs and tasks would be scheduled based on months and/or years. This placed the burden on the L5 to mechanically update Á□schedules in the software daily or even hourly to remain current with actuals. It has been discovered that this mechanical tinkering distracts the manager from managing, creates some lost time while assignments are being adjusted, and further introduces errors into the system. The concept was that the L5 would be a micromanager, hourly directing the cartographers and production workforce. Such micromanagement is not now considered essential, or even productive.

The arrival rate control to the service channel can be changed to a dependency type algorithm: what is the workstation assignment current status, what is next. The L5, the human in the system can build the queues according to plan priorities. In fact, the human judgment and intuition for such a task is more efficient and as effective as any mechanism that can be reasonably developed.

The customer request to migrate to a queued task system is reasonable in the current operational environment. It is not appropriate to lay the operational schedule management inadequacy entirely on the development contractor. It should be noted that the scheduling problems being encountered are at the assignment level, which in the DPS is at the subtask level. What is needed is a method to queue assignments, as assignments are what is sent to the production segments.

PM/S Scheduling Use Difficulty
The PM/S design and approach was based on a heritage product. The hierarchy and serial process through panels was specifically required by the customer (departures had been proposed). It was deemed more cost effective to use the existing structure and add to it rather than create a new system. Subtask assignment and scheduling was a new function implemented in the DPS, and utilized the serial thread process. The process was subjected to normal development reviews and built in compliance with the customer's specifications. Although there is agreement that the system is difficult to use, it was the desired system. Further, it may be agreed that multiple windows displayed, point and click to select, and drag to manipulate is an easier method, the technology was not available at the time the design choices were made. If at this time the customer is committed to such a concept and design change, it can be supported, but only if the system engineering elements listed above are also addressed.

2.7. Human Role in the System

The Production Management Segment is the customer organization that plans and then manages the work. The software, also identified as the Production Management Segment (PM/S), provides the tools that the human managers use to create the plans, make the planned assignments, track the actual progress against those assignments, make adjustments to the plans, and collect the actual costs. This distinction is important and often overlooked. It is easy to assume that the software tool is the segment, and then attribute all requirements and performance to the software. It is, however, the human that makes the decisions and takes the actions. Further, it is necessary to understand that the Production Management Segment is responsible for the production decisions in the customer's overall organization, and functional requirements that fall within the management charter need to be allocated to this segment. Whether the functional requirements should also be included in the PM/S software tool is a matter for case by case review.

Figure 2.7-1 expresses the basic elements in the user feedback system. The crucial issue to support SAE is what data is displayed to the human, and how understandable is it. A first design task is to understand what the human needs to see, then design how to show it. The presentation should be designed for human consumption rather than mechanical ease from the machine perspective. It is true that the mechanically facile design is cheaper in the short run (in the development phase), but operational costs and losses will more than offset the development savings. That this project has become necessary is a case in point. Screen presentations to the user have been designed constrained to the limitations of the IBM 370 terminals and the tabular reports available from the database. These have, in operations, proven inadequate, and redesign is now required.

The DPS produces cartographic products, by nature graphical and visual. The human thinks, analyzes, and strategizes in terms of the images being manipulated. A list of coordinates is no substitute for a simple map when conducting analysis. The human, when no other options remain, will draw/obtain a map and superimpose the coordinates of interest, then conduct analysis. The existing problem is that there is no such management tool in the system.

In the case of SAE, the system could present graphical data similar to that shown in Figures 2.4-1 and 2.4-2. In seconds the human can understand the desired area of interest and its components to be extracted. It would take some more time to create the plan needed to limit simultaneous extractions, but the human can accomplish this to a myriad of requirements in a manageable amount of time. Elements shown in these figures are a very simple backdrop map, areas to be extracted, the extraction spec for each of the areas, areas to be assigned, and those neighboring areas not of interest. Each area is easily identified by coordinates. The customer team that generated these figures have a good feel for the presentation needed to manage SAE. Their purpose was, in fact, to investigate SAE management. The elements the customer chose to illustrate the problem were selected to communicate the idea to other humans quickly and concisely. These are among the elements that would be useful to the human managing SAE in the production environment.

2.8. User Survey

Instituted as part of the O&M support is the PM/S User's Group (PMUG). Meetings are sponsored about every six weeks to review topics of interest and present new material. After the customer generates the SAE white paper, the customer requested that the users be informed of the SAE issue and brought into the development communications loop. In addition to the SAE, the customer was concerned about the scheduling tool's effectiveness. To bring the user population into the process, two questionnaires and presentations were developed. The first questionnaire queried user satisfaction with the existing scheduling tool, and the first presentation provided the concept that a graphics based interface could be provided, and job related data could be displayed, indexed on a base map by coordinates. The second presentation showed an icon base point and click selection process for schedule manipulation. The second questionnaire polled the users as to the necessity of the graphical user interface (GUI) concept.

The first user survey, shown in Figure 2.8-1, was devised and distributed on two occasions, at two consecutive meetings, one in February, one in April. The reason for two distributions was to gauge a shift in user attitudes. The survey was designed to target the three active layers of management, and provides the opportunity to isolate particularly weak areas. Analysis can also be provided in a general way, judging overall customer satisfaction.

The PMS User Survey allowed the users to rank each question on a scale of one to five, one being good, and five being bad. The first five questions are aimed primarily at the L2 supervisors, the next three at the L3 supervisors, and the remainder at the L5 supervisors. Figure 2.8-2 shows the aggregate results from

12 Feb 1993

RC PM/S USER SURVEY

RECENT ACTIVITIES HAVE EXERCISED STANDARDS, JOB AND TASK SCHEDULING, AND TIP PROCESSING CAPABILITIES. THE FOLLOWING QUESTIONS ARE TO PROVIDE FEEDBACK TO HELP FOCUS ON PRODUCT IMPROVEMENT. PLEASE ANSWER THESE QUESTIONS AND RETURN THE QUESTIONNAIRE TO DAVE ANDREX, ROOM T597 (X5612R). COMMENTS WELCOME, PLEASE PROVIDE ON REVERSE SIDE.

I AM _LEVEL 2 _LEVEL 3 _LEVEL 5 SUPERVISOR

ACTIVITIES I SUPPORT: _PSU _E&R _STE _OTHER

SEGMENTS WHERE I HAVE MANAGEMENT RESPONSIBILITY: _SP/S _DE/S _PG/S

PLEASE ANSWER THE FOLLOWING QUESTIONS USING THE RELATIVE SCALE SHOWN TO THE RIGHT. THESE ARE YOUR PROFESSIONAL OBSERVATIONS.	GOOD EASY				BAD DIFFI CULT
STANDARD MANIPULATION TO SUPPORT MY JOB IS					
STANDARD MAINTENANCE IS					
INITIAL JOB SCHEDULING IS					
JOB SCHEDULE MAINTENANCE IS					
INITIAL TASK SCHEDULING IS					
TASK SCHEDULE MAINTENANCE IS					
RESOURCE POOL MANAGEMENT IS					
RESOURCE POOL REVIEW IS					
INITIAL TIP PROCESSING IS					
INITIAL SUBTASK SCHEDULING IS					
TIP STATUS REVIEW IS					
TIP CHANGE MANAGEMENT IS					
SUBTASK CHANGE MANAGEMENT IS					
THE PM/S AS A TOOL TO DO MY JOB IS					

Figure 2.8-1 User Form Regarding PM/S Scheduling

40 respondents. The February results are luke warm with only 20% of the respondents in the easy category, and only half expressing satisfaction with ranks of one or two. As the maintenance contractor, such a report indicates the need to improve. Half the user population is NOT happy with the product. Further, the environment for the O&M contracts is very competitive, and such a response indicates market vulnerability.

It gets worse. The repeat survey run in April shows a shift towards dissatisfaction. Only 25% of the respondents rank the PM/S scheduling tool as a one or two, indicating fully three fourths of the user population is NOT happy with the product. The customer's comments in the SAE/QSS white paper are born out. The results from these two surveys clearly indicates a problem from the user's perspective Figure 2.8-1. User Survey Form Regarding PM/S Scheduling Performance.

The second survey, presented in Figure 2.8-3, is divided into two categories, Graphic User Interface and Subtask Scheduler. The users are provided the opportunity to rank from Don't Care (1) to Need (5). Aggregate results are presented in Figure 2.8-4 in two categories, L5 supervisors (who are primarily interested in the subtask scheduling issues) and L2/3 supervisors. The results clearly indicate user support for the graphic user interface with more than three fourths of the respondents in the Want to Need categories. The underlying assumption is that the respondents are professionals who know what is needed to perform their jobs, and that therefore, the survey results are valid

12 Feb 1993

RC PM/S USER SURVEY

RECENT ACTIVITIES HAVE EXERCISED STANDARDS, JOB AND TASK SCHEDULING, AND TIP PROCESSING CAPABILITIES. THE FOLLOWING QUESTIONS ARE TO PROVIDE FEEDBACK TO HELP FOCUS ON PRODUCT IMPROVEMENT. PLEASE ANSWER THESE QUESTIONS AND RETURN THE QUESTIONNAIRE TO DAVE ANDREX, ROOM T597 (X5612R). COMMENTS WELCOME, PLEASE PROVIDE ON REVERSE SIDE.

I AM _LEVEL 2 _LEVEL 3 _LEVEL 5 SUPERVISOR

ACTIVITIES I SUPPORT: _PSU _E&R _STE _OTHER

SEGMENTS WHERE I HAVE MANAGEMENT RESPONSIBILITY: _SP/S _DE/S _PG/S

PLEASE ANSWER THE FOLLOWING QUESTIONS USING THE RELATIVE SCALE SHOWN TO THE RIGHT. THESE ARE YOUR PROFESSIONAL OBSERVATIONS.	DON'T CARE 1	2	WANT 3	4	NEED 5
GRAPHICAL USER INTERFACE CONCEPT					
WINDOW BASED					
MANIPULATE GRAPHICS TO MODIFY DATA					
DATA UPDATED IN BACKGROUND					
MESSAGES PROCESSED IN BACKGROUND					
MESSAGE STATUS PROVIDED ON SCREEN					
SUBTASK SCHEDULE CONCEPT					
QUEUE BASED ON NEXT WS AVAILABLE, NEXT SUBTASK TO DO					
DATES ARE ESTIMATES					
OPERATORS ASSIGNED BY L5 ON THE FLOOR					
ABILITY TO ALTER SUBTASK NETWORK					
ABILITY TO DESIGNATE THE NEXT LWU					

Figure 2.8-2 User Survey Form Regarding PM/S GUI and QSS

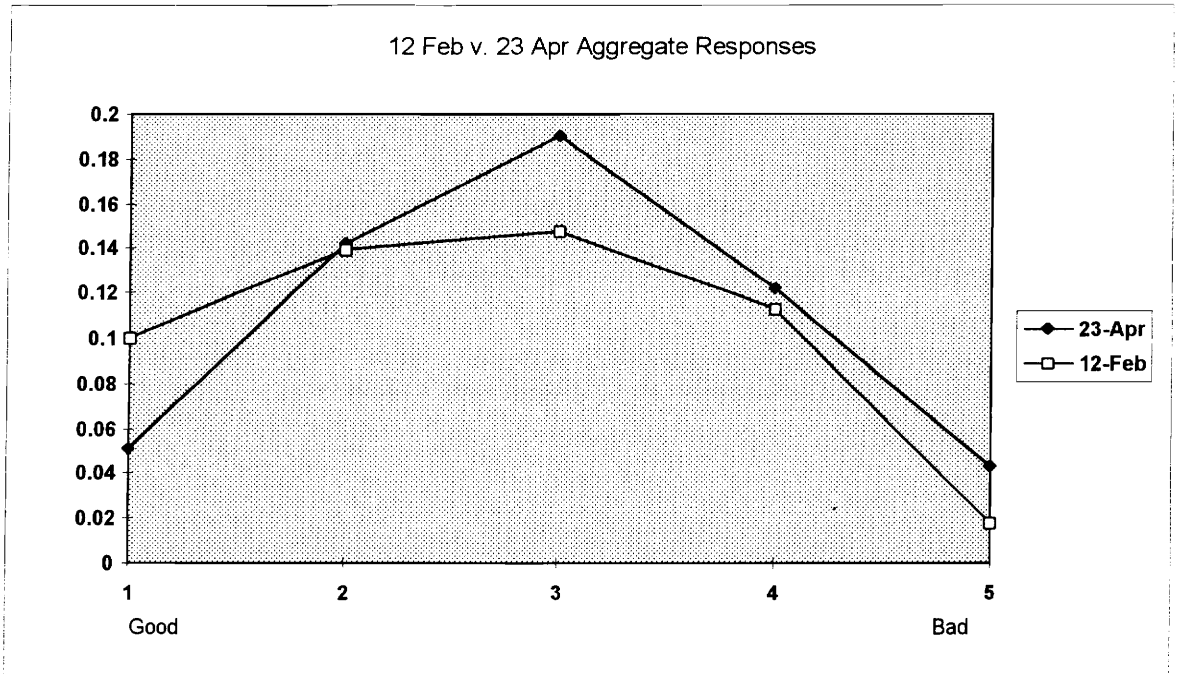


Figure 2.8-3 User Survey Results Regarding Scheduling

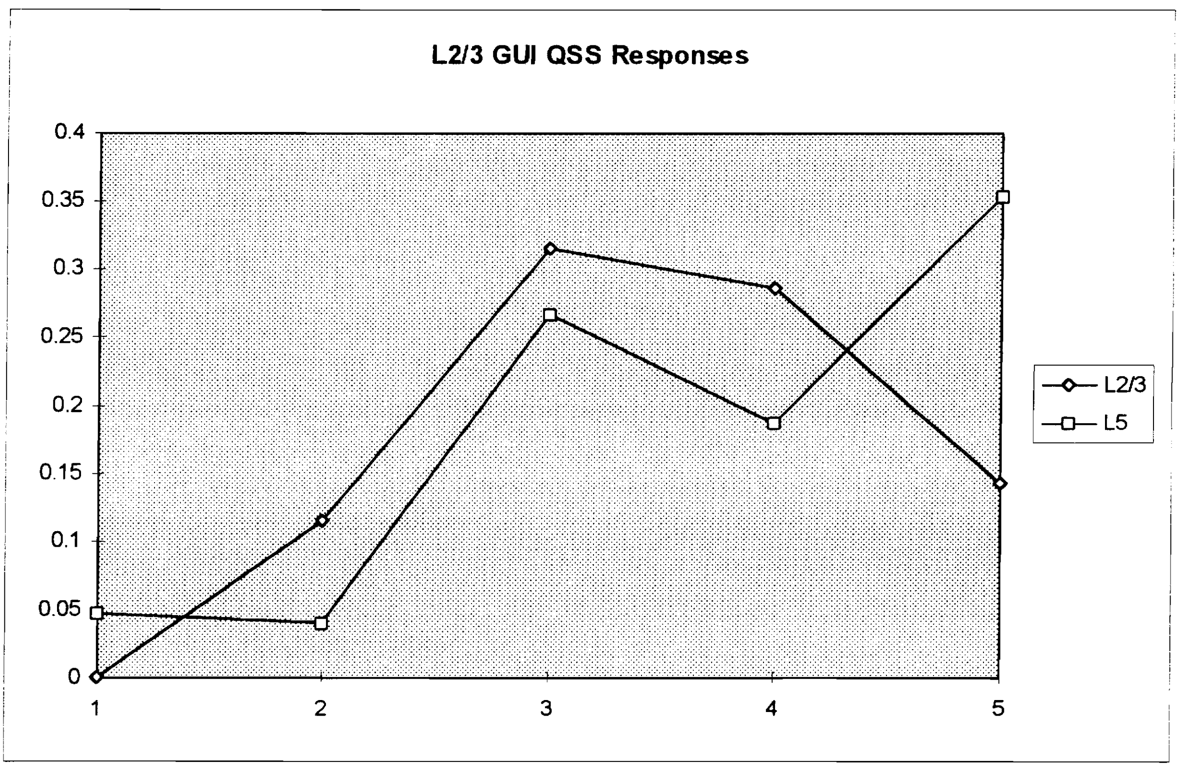


Figure 2.8-4 User Survey Responses to GUI & QSS Concept

3. Problem Assessment

This Section reviews aspects of the problem in an engineering context. It identifies aspects which must be analyzed, then either proceeds with the analysis and solution, or defines the plan which must be followed to implement the solution. Included is the review of risks, maintenance and operations concepts, top level functional requirements, and an implementation approach.

3.1. Risk Assessment

This section catalogs the potential risks associated with adding the IMWS with the SAEAT and QSS to the existing DPS architecture. It includes the risks associated with migrating the subtask scheduling functions from the PM/S to the IMWS.

The customer's interest is expressed in the SAE white paper and in the PSU Director's assessment. The SAE particularly is needed, despite what risks may be encountered.

Competitors also have interest. As a DPS life cycle cost issue, there is a known operational strategy to reduce the number of maintenance contractors. Consolidating the maintenance force under two banners, one for data management, one for production, for instance, reduces the price to contract management and offers cost savings through elimination of duplication. The risk here is not technical but business based. The contractor that supports the selected SAE approach gains an advantage. Vulnerability to competition is an issue.

3.1.1. Risks Regarding the IMWS with SAEAT

3.1.1.1. Added Complexity

An analysis tool that has its own set of interfaces, potentially to all segments. From an interface perspective, the IMWS looks like a new, separate segment.

3.1.1.2. Interface Design, Development, and Support

A considerable portion of the existing problem stems from the current interface support: it is very poor. There are several reasons worth exploring to avoid similar problems. The final question that must be answered is whether the effort be expended to develop the new interfaces needed to support the new user interface, or whether the existing interfaces should be strengthened.

The risk to interface support distills to a lack of commitment. When the system was initially developed, the customer's organization was not of a single mind, and there were competing philosophies on how the interfaces should operate. To further complicate the issues, there was no prime contractor responsible for turnkey system delivery. Each contractor was motivated to support the interfaces in the way that developed the most revenue for its development contract. This goal diverges in many cases from the system Goal; support an operational interface. As a result, the interface operations are being determined at run time by customer adjudication, discrepancy by discrepancy. Of course, the solution for one discrepancy is not always the system solution, so the same issue is sometimes visited and resolved several times before a satisfactory solution is reached.

Interfaces must be added between the PM/S and the IMWS, and the existing communications architecture must be modified. The implementation will be accomplished on a live, operational system, and must be accomplished with no disruption or degradation to the production effort. This presents technical and operational risks

3.1.1.3. Data Transfer

The phase 1 task, SAEAT implementation, requires read only capability, and therefore minimizes data integrity risks. The process must be created that accesses the PM/S data store, retrieves the data, and translates it into the format compatible to the IMWS data store. The risk here is minimal, in and of itself, but when integrated into the DPS, must not disrupt or degrade production activities.

3.1.1.4. Customer Furnished Facilities

Two major initiatives are underway that create direct dependencies for IMWS implementation: the LAN upgrade to FDDI and the workstation hardware choice.

The existing communications media has become outdated, and the protocols are unique. The Network Systems Corporation (NSC) proprietary HYPERchannel with a customer developed protocol is currently in use. The migration to FDDI appears sensible, but impacts cannot yet be determined.

The customer is determining a basic PC based workstation configuration. The choice is not known at this time. The customer intends to host future capabilities on the standard workstation. The implication is that the IMWS functionality will have to exist on a not yet known platform.

3.1.2. IMWS, QSS implementation

3.1.2.1. Operational and Functional Concepts

Should the added complexity and interface issues be resolved and be deemed manageable, the operational and functional concepts must be clearly defined. Normally, these are given issues in design development, but in this case, Functionality is being migrated, and the impact of the migration must be addressed. Failure to do so will present major unresolved technical and operational issues.

The central issue is how to best utilize the existing system while providing the desired IMWS QSS benefits. Certain portions of the existing system (in the PM/S) will have to be decommissioned. How much, and how difficult, are determined by the operational and functional concepts

3.1.2.2. Operational Impact

The DPS will be fully operational at the time the IMWS QSS will be installed. Impact to production performance must be limited as much as possible, and managed in a fully visible and accountable way. This risk must be addressed in the integration and implementation planning.

3.1.2.3. Data Integrity

The QSS on the IMWS accepts data from the PM/S, operates on that data with resulting updates, and writes the resultant updates back into the PM/S data store. The data process between the PM/S and the IMWS must manage these updates and maintain the data quality. This represents significant technical risk.

3.1.2.4. Decommission Existing Subtask Scheduler

To build the QSS is only part of the problem. Existing PM/S functionality is moving from the PM/S mainframe to the IMWS. The existing subtask scheduler must be decommissioned. This presents high technical risk. The existing subtask scheduler is integrated into the PM/S package, and the problem is to define what the boundaries are. Previous comments regarding system disruption and degradation apply.

3.1.3. General

3.1.3.1. Funding

To proceed with the IMWS program, there must be adequate customer commitment expressed by available funding. Current trends indicate much less funding is expected to be available. The trade of the customer's expected gain versus cost versus operational loss must be made. This may be a difficult risk to quantify as there is as yet no good statistical basis.

3.1.3.2. Competitor's Interests

There is strong evidence that competitors desire the IMWS development task: each has approached the customer with unsolicited offers. To date, the customer has viewed these Offers with some skepticism. However, in light of the funding environment, marketeers may make unrealistic claims (in the name of competition) which may appear attractive. After all, the first step is to obtain the work. If this is determined to be a real risk, it must be combated by demonstrating, through engineering analysis and discipline to the customer, the shortcomings of cheap and dirty solutions. The lack of up front study and planning are easily eliminated for the sake of meeting cost goals, but this has been shown to be an unsound practice.

3.2. Risk Mitigation

The presented risks must be evaluated. Whether the risk is manageable and whether that management is worth the effort must be determined.

3.2.1. Interface Design, Development, and Support

These issues represent high technical risk. IMWS success depends on thoughtful enforced working interfaces. Elements beyond the IMWS development and deployment scope contribute to the interface success. The lack of management accountability for interface operation must be recognized and managed by the customer.

Even if the IMWS contractor had the authority to enforce interface performance, there is little of consequence that could be levied against a competing contractor to enforce that performance. Consider a competing contractor who would like to obtain or take over the IMWS contract. If the existing contract does not meet its stated goals, that weakness can be exploited. To create such a weakness, non-cooperation regarding the interface implementation would be a credible tactic. It is very easy to claim poor or ambiguous direction.

Because the interface success is beyond the scope of the IMWS contractor, and because there is no way to determine the customer's enforcement method, and because the IMWS success depends directly upon the interface effectiveness, this constitutes a major risk category. Should the customer agree to proceed with the IMWS, the customer must convene and chair an interface working group that defines and enforces the interface operations concept and all interface control documents.

3.2.2. Data Interface

IMWS phased implementation helps manage the data interface problems. The first phase, the SAEAT, requires read only capabilities, and therefore simplifies the data interface. The SAEAT poses little data contamination risk.

SAEAT data interface development provides the infrastructure to transfer data from the PM/S to the IMWS. This infrastructure can later be exploited when the QSS is implemented. The QSS must update data and write it back to the PM/S. Separating this activity narrows the data interface scope for each phase, and therefore makes the task more manageable. The QSS data contamination risk must be managed with careful functional design which defines interface operation.

3.2.2.1. Operational and Functional Concepts

These represent manageable risks and contain basic design trades. Subsequent discussion explores possibilities, and a recommendation is offered. Operational requirements are presented in Section 2.3 and 4.8, and functional requirements in 2.4 and 4.9. These requirements drive to achievable systems.

3.2.2.2. Customer Furnished Facilities

This issue is entirely beyond the control of the IMWS developers. Until the communications upgrade is substantially complete, no IMWS can be installed, even in a test configuration, with testable interfaces. A direct schedule dependency exists, and therefore a major schedule risk also exists.

Development of the software design can proceed with some assumptions. Depending on the level of detail, operational and functional concepts can be developed, the implementation, test, and installation plans started, and requirements written. To begin prototyping incurs some risk because some hardware must be selected to host the development software, and operating system software and development tolls must be acquired. Hardware investment and software development tool investment may be at risk. The prototype, however, is to provide proof of concept, and prototype results may be portable. This risk is somewhat manageable by communication with the customer. The customer's preference may be determined even before the engineering studies are complete. Also, the customer can be invited to share this risk, once it is clearly explained.

3.2.2.3. Implementation Planning and Strategies

There are a number of high risk elements in the IMWS concept. This does not mean the project should not be attempted, only that a strategy should be developed to contain the risks and provide contingencies for worst case results.

To contain the risks, the project must be divided into several phases, each with distinct deliveries. Within each phase, employ an incremental development methodology. With this approach, high risk items regarding interfaces can be attacked immediately, and SAEAT functionality delivered as soon as possible. This approach further mitigates some schedule risk because the SAEAT may be delivered and put into operation quite some time before the entire project is completed. Meanwhile, the challenges of QSS can be somewhat deferred. The results discovered during earlier phases can be incorporated into the QSS solution. Three phases are recommended, and are explored in detail in subsequent sections. Phase 1 creates the infrastructure and architecture for the IMWS. It adds functionality to provide job and project granularity for the SAEAT. Phase 2 focuses on the SAEAT application, provides more features and granularity. Phase 3 is devoted to the QSS.

Within each phase, deliverable components will be developed incrementally. The process is discussed more in the Development Plan and Implementation Plan sections. The risk mitigation success will depend on the quality of these plans, and the alertness and commitment of the people who execute them.

3.2.2.4. Funding

Control of funding risk is beyond the authority and capabilities of the IMWS project, but this risk is mitigated by the phased approach. Each phase delivers needed products. Should funding become unavailable in the midst of the project, it is probable that a usable delivery can be made, or may have been made.

3.2.2.5. Competitor's Interests

The best method to control this risk is to provide a complete project plan that provides for the customer's needs and subjects the risks to the clear light of day. The customer's funding position is difficult, so the need to provide the engineering to scope the problem is more evident than ever, and the customer's sensitivity is greater than ever.

3.3. Maintenance Plan

Elements of the Maintenance Plan are shown in Figure 3.3-1.

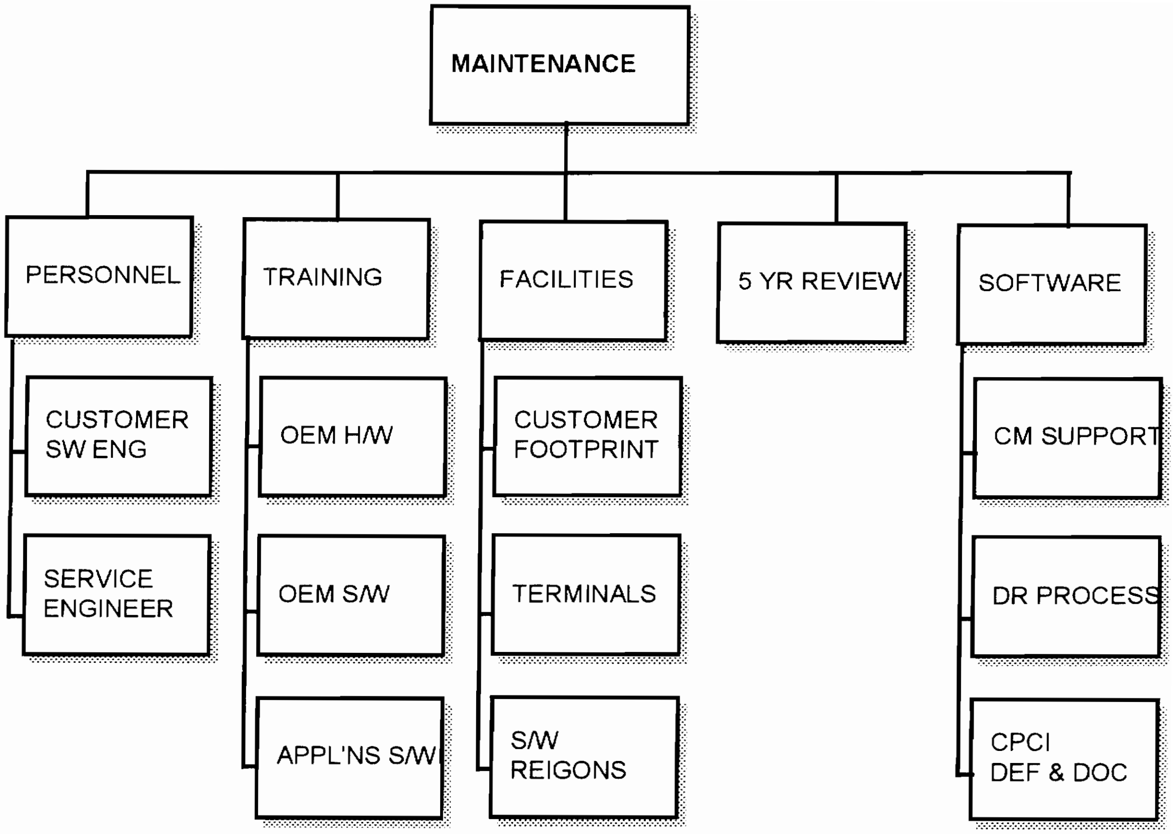


Figure 3.3-1 IMWS Maintenance Plan Organizational Elements

3.3.1. Software Maintainability

The IMWS is to be maintained by customer programmers who are already known. They are junior, and do not have the developed skill sets necessary for efficient IMWSmaintenance. Therefore, a training program in the technology selected will be required. Additional training specific to both IMWS SAEAT and QSS phases is also required. Customer programmers are on the customer payroll, and on the customer site.

In addition to the customer's maintainers, "factory" support will be available. It is not clear whether the customer requires (or desires) on site "factory" support.

Because the maintainers are junior, the actual software will have to be well documented and commented. Programmers handbooks must be developed for each software module written, and must include the program descriptive language (PDL) and functional flow charts.

The software must be designed such that a user with the maintainer's access can edit the code. Security considerations must not lock the maintainer out.

The IMWS lifetime is considered to be ten years, with a complete review after five years to determine the suitability and usefulness at that time. The five year review is intended to measure the IMWS effectiveness against alternate technical solutions that may have been created in the intervening five years. The technology growth pace is such that this review is advised.

It is recommended that the software be generated with computer assisted software engineering (CASE) tools, or other code generating tool. The tool is to be delivered with the IMWS software to be used for subsequent maintenance. With such a tool, the maintainer may be effective with functional knowledge as opposed to the detailed code knowledge. Further, such a tool provides a consistent means to create refinements and enhancements to the delivered product.

3.3.2. Maintenance Regions

Three regions, each with a copy of the IMWS software, must be provided. Whether the software is physically kept in the mainframe DASD or on board the workstation is to be determined. Entry into a particular region is by operator selection at the beginning of the session. A banner is to be provided on screen stating which region the operator is using (this is especially useful to maintainers).

The three regions are the production (P) region, the test and verification (V) region, and the maintenance (M) region. The P region contains the latest released software, and is the software used operationally. The V region contains the P software with additional fixes and/or enhancements that need to be exercised for validation. The M region contains the production software, but is modifiable for experimentation and problem resolution. Modifications in the M region deemed suitable for use are moved to the V region for test and verification, and then to the P region. This migration is controlled by a configuration management (CM) process.

The arrival of PC terminals, each loaded with its native software, adds complexity to the environment. It is expected that the PCs will have removable hard drives which helps simplify the maintenance and security problems, but uncreases the CM comlexity. Ultimately, in the production environment, each hard drive containing IMWS software would be configuration controlled. When a change is delivered, the old hard drives would be physically collected and replaced. This adds an inventory burden on the CM organization. A second method would be to electronically survey the terminals on the network, and propagate changes from the CM host to the workstations. A tool to manage and accomplish this operation must be bought or built. This is a task to be studied in the design phase of the project.

3.3.3. Maintenance Terminals

Included in the system will be a sufficient number of IMWS terminals that each designated maintainer have access to a WS full time. It is expected that one programmer will be required full time for real time phase one operations support and necessary maintenance. It is expected that two programmers will be required full time for real time phase two operations support and necessary maintenance. Each terminal must be capable of provided at least three logical sessions, one to access the production region, one for the test and verification region, and one for the maintenance region.

3.3.4. Configuration Management

Software when created will be placed under configuration management (CM). The CM plan is presented in Section 4.

3.4. *IMWS Top Level Operations Concept*

The section provides the basic operations concept derived from the customer needs, and provides the framework for the project design. IMWS requirements are divided into three phases. The first provides the IMWS infrastructure and SAEAT minimal capability. The second expands the SAEAT. And the third provides subtask scheduling and resource management.

3.4.1. Phase 1 Operations Concept - Simultaneous Adjacent Extraction Analysis Tool (SAEAT)

There are about fifty managers at any DPS site, all of whom are likely to need the SAEAT. Three sites have been commissioned, one is being activated, one more is being planned. The IMWS will be provided and distributed throughout each site on the sites network. The number of users does not impact the SAEAT's functionality, but may be a loading factor for the network implementers and operators to consider.

The IMWS will host the SAEAT. The manager logs on to an IMWS session and selects the SAEAT. The manager may then select QUERY, DISPLAY, REPORTS, or UTILITIES. QUERY provides the manager with the ability to build and run queries against the PM/S data. For Phase 1, queries are constrained to job level related data only. DISPLAY provides the interface to the manager. DISPLAY accepts the query results and puts them on the screen. The results may be displayed in a manner similar to that shown in Figure 3.4-1. DISPLAY also allows the manager to select parameters concerning how the data is to be displayed. REPORTS provide the manager the ability to tabulate the query results and send them to an output device or into a file. UTILITIES provide the manager a measure of control over terminal and session parameters.

Figure 3.4-1 shows how query results might be displayed. Note that the manager doesn't care what software did to generate this display, only that she has it for analysis. There is a geographic display showing a coastline and the job footprints are overlaid. The jobs are grouped into three sets in response to query parameters, likely predecessor job. Each of the sets may have been pre-processed by a unique geopositioning job, and prepared to be extracted to a designated specification. Windows are also presented showing project GANTT and PERT charts. J13 is selected in the geographic window, and the J13 data is highlighted in the GANTT and PERT charts. Two status bars are provided at the bottom of the screen (they can be anywhere the user prefers), one to provide feedback regarding message traffic and status, and one to provide system health. These bars are to provide the user with some information about the needed infrastructure and some comfort that the actions are being completed.

The human manager reviews and analyzes the provided data. The manager may manipulate the display to provide different information for consideration. The SAEAT provides the data, the human acts on it. The SAEAT will not alter data in and of it self. It is an analysis tool in the PM/S suite. The human manager will develop strategies and decisions based on analysis done during the SAEAT session and enact those decisions through the existing PM/S job scheduling capabilities.

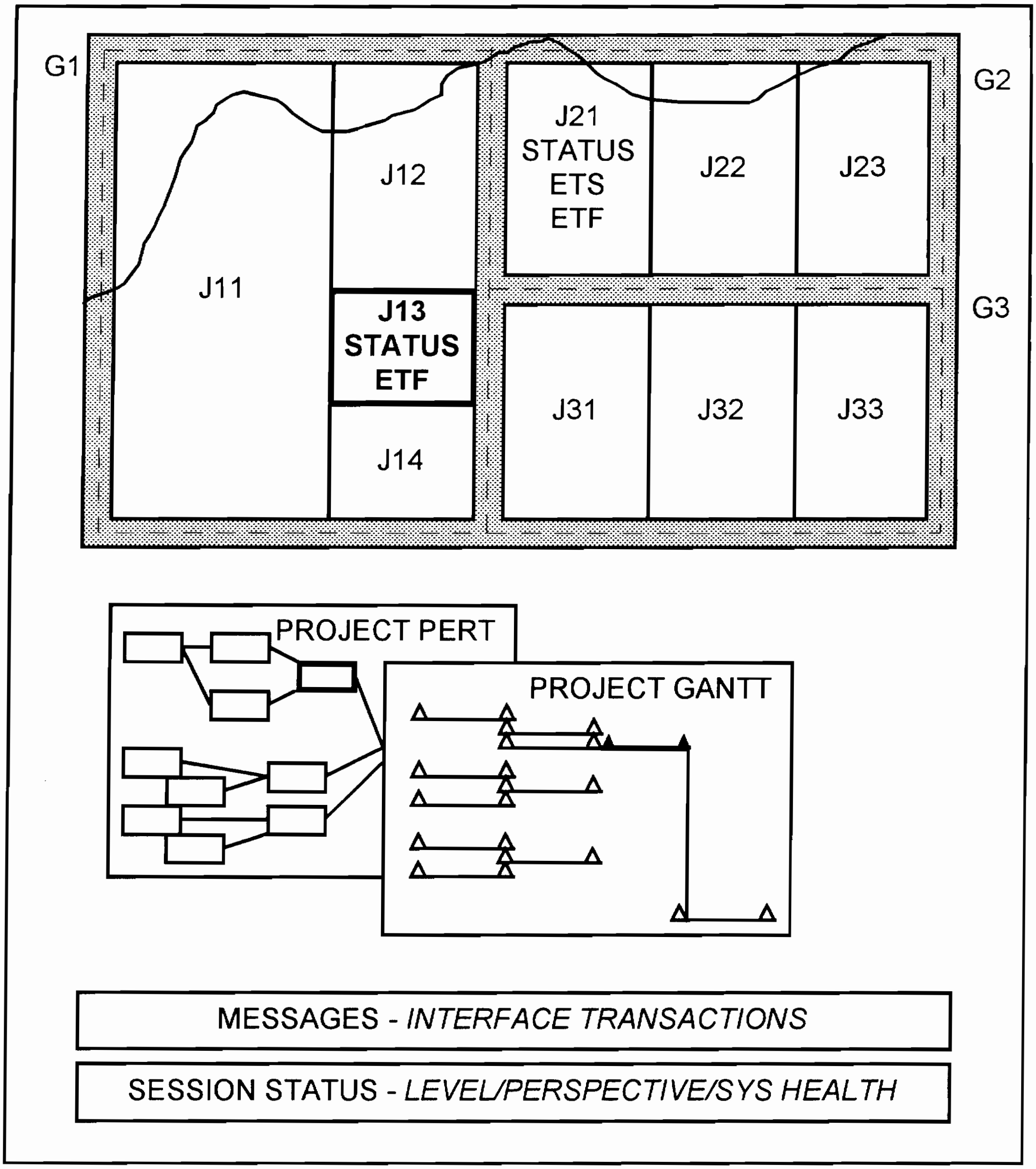


Figure 3.4-1 Phase 1 Displayed Elements - L2 Perspective

3.4.2. Phase 2 Operations Concept

Phase 2 adds to the scope and data available to the SAEAT. The operating infrastructure provided by the Phase 1 development continues to be used. The object of the Phase 2 development is to provide SAEAT data detail to the task level. This provides the human manager more detail for analysis and is especially helpful for run-time conditions. In addition to the view provided by Phase 1, Phase 2 provides a view similar to that shown in Figure 3.4-2.

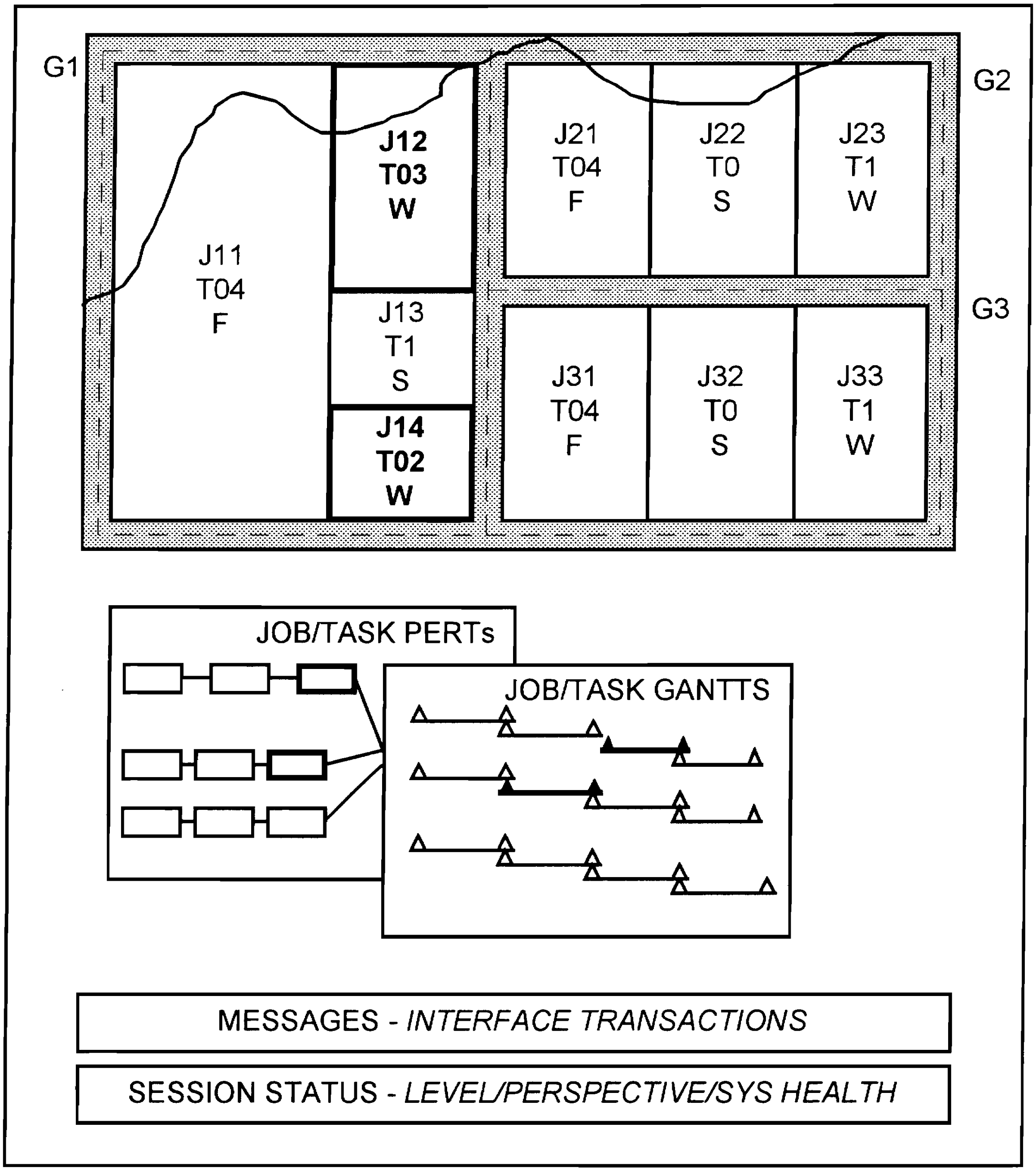


Figure 3.4-2 Phase 2 Display Elements - L3 Perspective

The REPORTS capability is also expanded to include the schedule performance monitor. The schedule performance monitor option includes job and task level analysis. The manager may set performance thresholds, and when a job or task duration exceeds the set threshold, a report is generated and returned to the manager. These reports tend to indicate work running longer than expected and the manager may need to apply corrective action.

3.4.3. Phase 3 (QSS) Operations Concept

Phase 3 capability uses the infrastructure developed in the previous phases. The logon, communication, and display are all utilized. The data and functions are expanded, and menu choices are added.

The Phase 3 goals are to provide a view similar to that shown in Figure 3.4-3, and to create assignments and manage resources in the IMWS environment. The view allows the scheduling manager to graphically and geographically survey the land over which the work is being performed at the subtask level to help form plans and strategies. The customer desires to accomplish subtask scheduling in a manner more sensitive to the probabilistic nature of a schedule. Pools of work (subtasks) are arranged in queues at resources (the production workstations). As one subtask is finished, the next occupies the workstation, and all subtasks move one position closer to the workstation.

The customer has defined the queues in a defacto mode. The number of production workstations has already been bought, and the amount of work has already been identified. To my knowledge, no service channel type analysis has been done, so I don't know what the expected results are. Service channel times are predicted in the PM/S models and standards. The tool proposed herein allows the L5 manager to manage run-time conditions.

The new menu choices provide the capability to create and change assignments and to manage resources. The manager can select these options and then manipulate the display by selecting an object (a subtask or a resource), and either moving on the screen to establish new relationships, such as assignments, or change attributes through data entry.

The schedule performance monitor option is also expanded to include subtask level analysis. The manager may set performance thresholds, and when a subtask duration exceeds the set threshold, a report is returned to the manager. These reports tend to indicate work running longer than expected and the manager may need to apply corrective action.

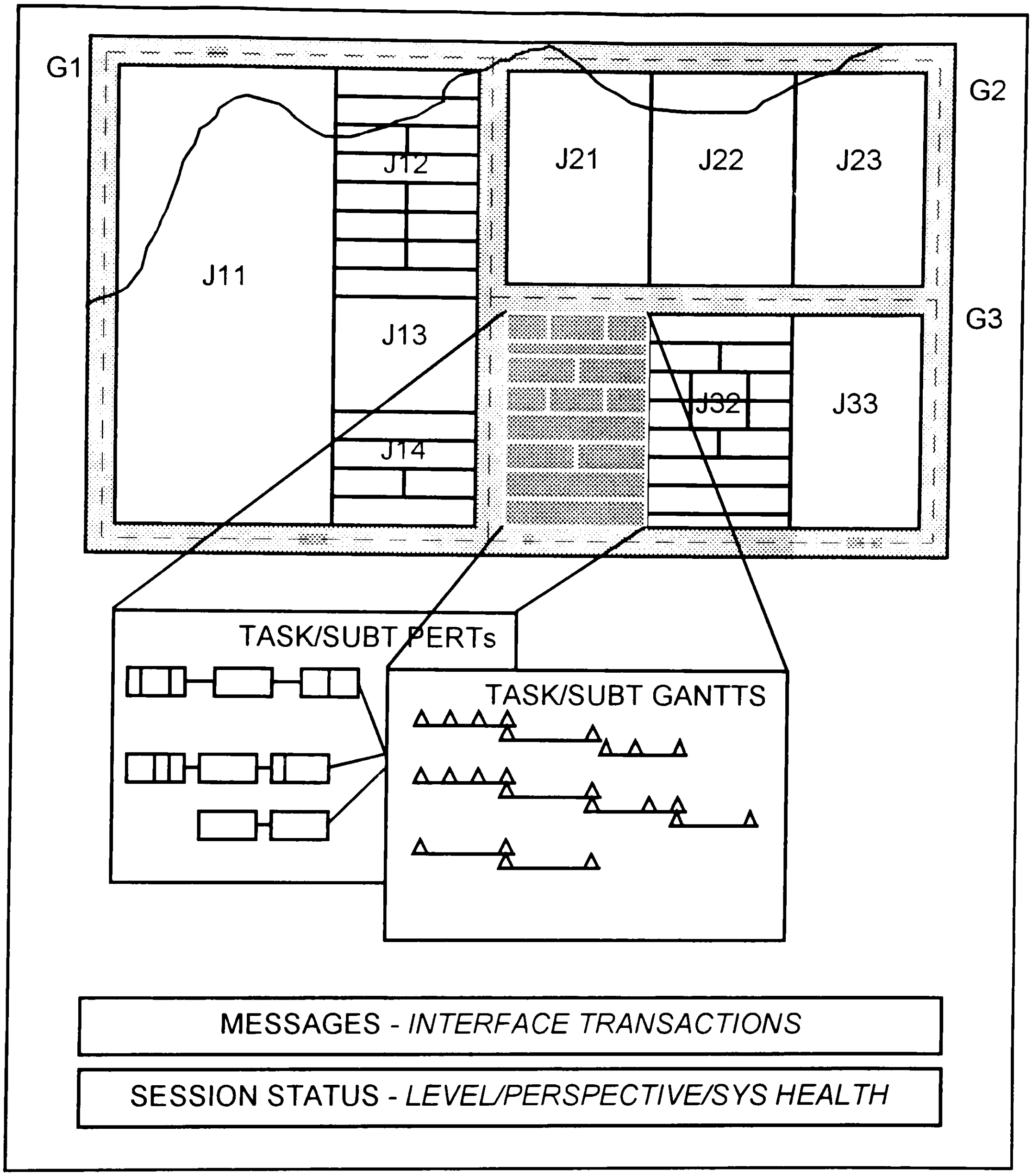


Figure 3.4-3 Phase 3 Display Elements - L5 Perspective

3.5. IMWS Top Level Functional Requirements

This section presents the IMWS top level functional requirements. IMWS requirements are divided into three phases. The first provides the IMWS infrastructure and SAEAT minimal capability. The second expands the SAEAT. And the third provides subtask scheduling and resource management.

3.5.1. IMWS Phase 1 Top Level Functional Requirements

The top level functional flow is shown in Figure 3.5-1. Each functional box is numbered for indexing purposes. In the following text, the paragraphs are numbered and correspond to the figure. The first two characters indicate the phase the requirement belongs to.

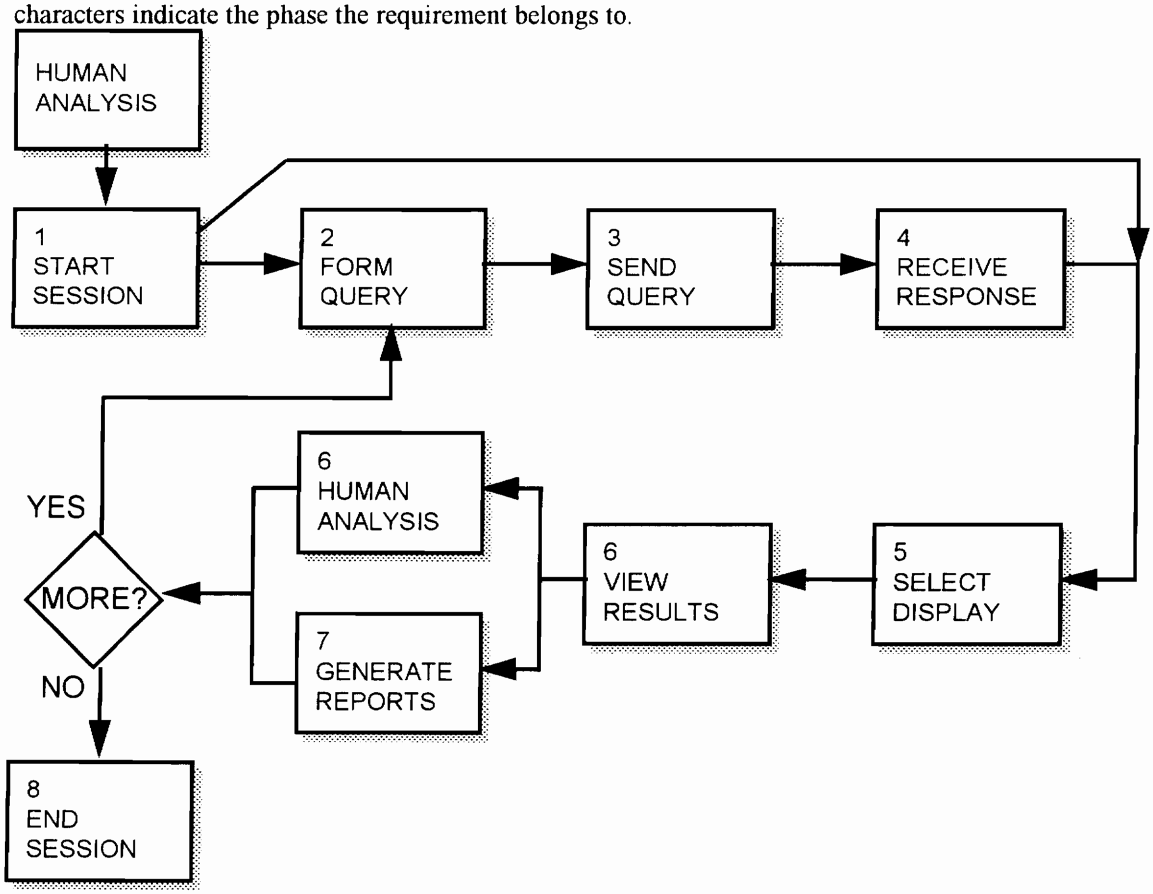


Figure 3.5-1 IMWS Phase 1 Top Level Functional Flow

P1.1 Start Session

The manager logs on to an IMWS session. The logon procedure provides any saved data the manager may have created during previous sessions, including queries, reports, and default parameter sets. The top IMWS screen is displayed and allows the operator to select SAEAT or QSS. QSS is not available for Phases 1 or 2. The manager selects SAEAT and the Phase 1 choices are then displayed. Figure 3.5-2 shows the Phase 1 Menu selection.

The functional flow shown in Figure 3.5-1 illustrates the Query flow only. That function is discussed first, then the other selections follow.

P1.2 Form Query

The Query function presents the Phase 1 parameters and accepts values from the manager for those parameters. When the data is committed, the query is constructed, then translated into a format compatible with the PM/S and it's M204 database. The query includes whether the results are to be stored or sent to the screen. The manager is provided the options whether to run or store the query.

P1.3 Send Query
When the query is run, it must be sent through the IMWS communications and the DPS network to the PM/S. The PM/S receives, recognizes, and processes the query. The PM/S then formulates the response and returns it to the IMWS. Communications processes during the transaction monitor the transaction status and correct errors. If errors cannot be corrected, a message is sent to the IMWS screen for the manager who can then institute corrective action.

P1.4 Receive Results
The IMWS receives, recognizes, and processes the query results. Processing includes translating the M204 results into the IMWS local database format and loading the data. The IMWS then returns a message to the screen indicating the operation is complete. If the results have been directed to the screen, and when display parameters have been selected, then they are displayed.

P1.5 Select Display Parameters
Display parameters must be selected to display any data. Display parameters include object and attribute selection in accordance with available data. All objects and some attributes may be shown graphically. Any attribute may be shown as text values. Figure 3.4-1 shows an example of display parameter selections. The job displayed by coordinates is a selected object while status is the graphically represented attribute. Other attributes are shown as text notes.

P1.6 View and Analyze Results
This is the human participation. The tool provides the data, the human the analysis. The human may redefine the display during the session.

P1.7 Reports
The Reports function allows the manager to format available data and capture that data in a file or send it to the screen.

P1.8 End Session
End Session is actually a Utilities selection. When End Session is selected all stored queries, parameters, and report data are store in the PM/S and logoff procedures are implemented to disconnect the IMWS and the user from the system.

Other Utilities selections include terminal and session control.

3.5.2. IMWS Phase 2 Top Level Functional Requirements

The Phase 2 functional requirements are essentially the same as those for Phase 1. The difference is in the data and analysis scope. Data to the task level is included. Using the developed infrastructure and utilities, that data is displayed, reported, and analyzed with the same functions that were provided in Phase 1.

3.5.3. IMWS Phase 3 Top Level Requirements

The distinction defining Phase 3 is that data updates are included in the provided capabilities. Phase 3 implements the QSS on the already developed IMWS infrastructure. Figure 3.5-2 shows the QSS Phase 3 functional flow.

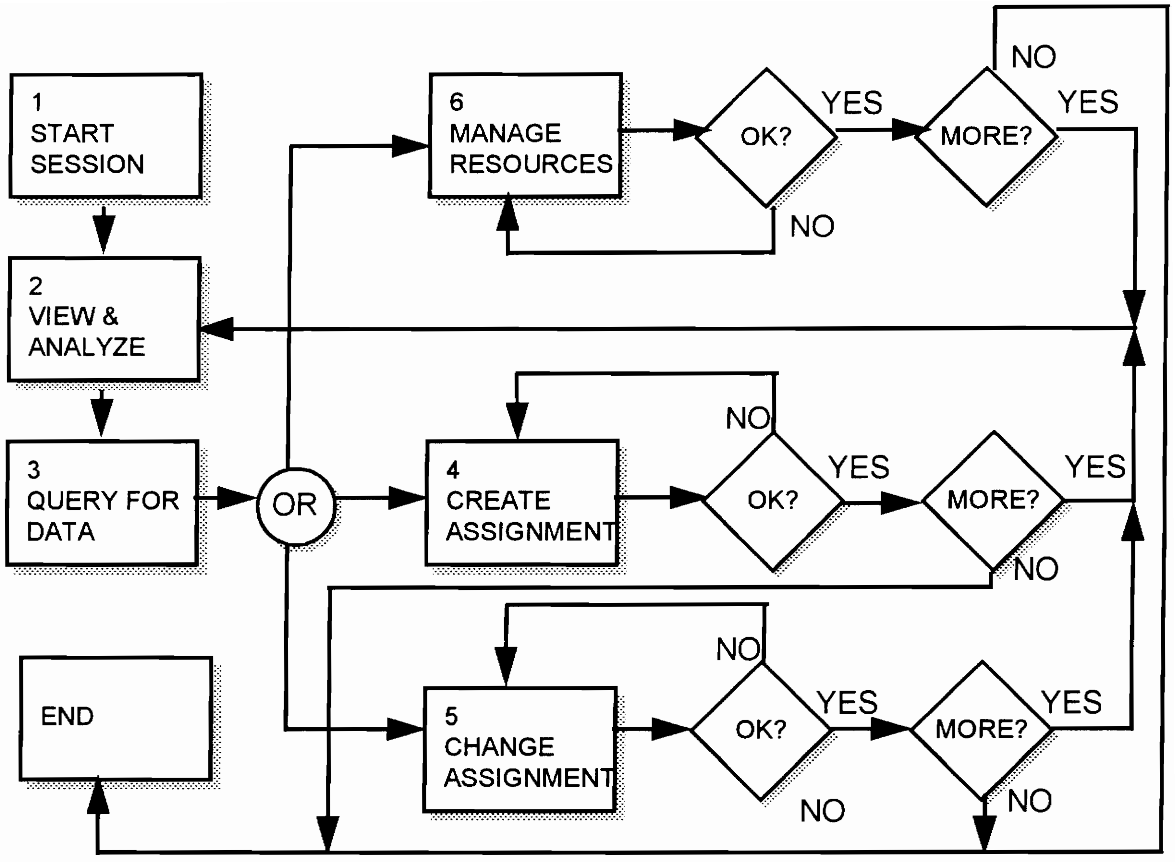


Figure 3.5-2 Phase 3 Top Level Functional Flow

P3.1 Start Session
In addition to requirements for Phase 1, Phase 3 logon procedures must recognize the initiating manager's organization to control read and write privileges. Existing PM/S logon procedures will be used. The data that belongs to the initiating manager's organization is allowed to be updated. All other data that may be retrieved from the PM/S is read only, and will be protected from attempts to write.

The top screen is presented and QSS is selected.

P3.2 Display
The main QSS screen shows all the options available for the SAEAT with additions for Create Assignments, Change Assignments, and Manage Resources.

Display parameters are added in Phase 3 to show subtasks, resources, and assignments. Assignments are the subtask-equipment pairing. Windows are defined for the work pool (unassigned subtasks) and the resource pool (equipment and their assignments. Objects defined are the subtasks and the equipment.

P3.3 Query
The QSS Query function uses the functions developed in Phase 1 to construct and send the query, then receive, store, and display the results. The query ability is expanded to include the subtask data.

P3.4 Create Assignments
Assignments are created by selecting the unassigned subtask and connecting it to an idle workstation, or to the queue of an assigned workstation. Creating the connection creates the assignment, and supporting data is simultaneously creating defining the assignment. Assignment data must include subtask start and end dates, subtask predecessor and successor links, and the equipment to which it is assigned. The assignment data is sent to the PM/S which updates the PM/S M204 database accordingly. The PM/S then processes the data according to existing functionality and sends the TIP to the production segment to enforce the assignment

P3.5 Change Assignments
Assignments are changed by selecting an assigned subtask, either on a workstation or in a queue, and moving it to create new relations. The new relation may be a Cancel (remove the existing assignment and make no new assignment) or a modification (MOD) (remove the old assignment and make a new one).

In the case of the Cancel, all assignment data is removed and the changes sent to the PM/S which accepts and processes the changes, then sends the Cancel TIP to the appropriate production segment to remove the assignment. All predecessor and successor links for affected subtasks in the queue are recalculated as are all scheduled start and completion dates.

In the case of the Change, all old assignment data is replaced with the new assignment data, and the changes sent to the PM/S which accepts and processes the changes, then sends the any MOD TIPs to the appropriate production segment(s) to change the assignment(s). All predecessor and successor links for affected subtasks in the queue (and new assignment queue, if used) are recalculated as are all scheduled start and completion dates.

P3.6 Manage Resources
The manage resources capability allows the equipment status to be reviewed and changed. The equipment's organization can also be changed. The changes are sent to the PM/S and it's M204 database is updated.

3.6. Solution Approach

There are three separate but related problems. First, the simultaneous adjacent extraction analysis tool (SAEAT) is required. Second, considering the desire for improved man machine interface, and the absolute inability of the PM/S hardware/architecture to provide the graphic display needed for the SAEAT, a platform can be developed implementing a new human-machine interface (HMI) philosophy and hosting the SAEAT. Third, the subtask scheduler can be implemented on the new platform as well, and builds on the functions developed to support the SAEAT. The solution approach is to use the customer agency standard workstation in the upgraded communications environment, and implement the SAEAT and QSS functions. The combination of workstation, SAEAT, and QSS is the Integrated Management Workstation (IMWS).

Operational and functional requirements are to be identified. From these requirements, the HMI elements are defined. Once defined, the development and implementation plans are executed to provide the capabilities.

3.6.1. Three Phase Program

To provide SAEAT and QSS, and to mitigate the risks identified in Section 3.1, the SAEAT and QSS will be implemented on the customer provided workstation in the upgraded communications environment in three phases.

Three phases are designated to provide visibility to the customer management, to contain technical risk by spreading it among the phases, and to allow delivery of some components as they are developed. The customer has realized (ref SAE paper) that many concepts have been undertaken without sufficient functional analysis or requirements definition, a contract has been let, and then considerable costs have been incurred with disappointing results. The three phase approach demonstrates feasibility and functionality in a visible and accountable manner. Each phase provides a manageable technical challenge with measurable goals, and limits existing system impact. It is true, even with the three phase program, that implementation planning remains key to the IMWS success.

Delivery is also phased. This allows the SAEAT to be delivered first, and this supports the customer's needs as the tool does not currently exist.

Combine the SAEAT and the HMI improvement. All data needed to support the SAEAT resides in the PM/S. Create a platform and connect it to the PM/S. This solution conforms to the customer's operational structure: the SAEAT is a manager's tool, will be operated by managers, and belongs in the management functional suite. Divide the SAEAT into two phases. The first phase provides the new needed infrastructure and modifications to the existing system as well as the minimum necessary functional capability to support SAEAT. The second phase provides more data and finer granularity for review.

All infrastructure and database structures created for the SAEAT are then the basis to create the QSS which is implemented in phase three. The QSS implementation exploits the opportunity to move segment functionality to a more modern technology and provide the trend for the next generation development.

3.6.2. Three Phases Justified

The three phase program is devised to provide visibility and control to the customer's acquisition management and help mitigate program risk. With the three phase approach, capability can be demonstrated, then implemented in measures. Adjustments to the subsequent phases can be incorporated based on lessons learned from previous phase experience. Due to the nature of the program, the phases naturally occur in series. Second phase development relies on first phase results, and third phase development likewise relies on second phase results. Each phase can therefore be managed discretely, each with their own design and review cycles. A further advantage is that if a phase suffers negative results, correction can be applied with limited impact to subsequent phases. If the results are to negative for recovery, the program can be terminated with damage limited to the phases under work. For example, if the program proves not to be feasible after the first phase, second and third phase development costs are saved. If the third phase proves not to be feasible, then the benefit of the first two phases are realized while the third phase is retired. The phased program provides a measure of contingency planning to help manage overall program risk.

4. Recommended Solution

This Section contains the Integrated Management Workstation (IMWS) mission statement and solution concept. Both are derived form an assessment of the customer needs and the risk analysis.

4.1. Mission Statement

The IMWS supports dual missions, the Simultaneous Adjacent Extraction Analysis Tool (SAEAT), and the graphically based Queued Subtask Scheduler. The SAEAT is new capability to the Digital Production System (DPS) while the QSS replaces the existing subtask scheduling function. Both SAEAT and QSS support ongoing DPS production management activities and will be used by the production managers. The SAEAT is considered the primary mission as no such capability currently exists, and the QSS is the secondary mission, leveraging IMWS advantages to upgrade an existing capability.

At any given DPS site, approximately fifty production managers are expected to be DPS users. The IMWS is to be available at all times to each manager. Both SAEAT and QSS activities can take place at any time. SAEAT is expected on an occasional basis whereas the QSS will be used by the L5 supervisors on a continuous basis. The L5 supervisors comprise about 70% of the production management staff.

4.1.1. SAEAT Mission

The SAEAT provides production managers with graphically based extraction job data for analysis to better manage simultaneous adjacent extraction occurrences.

Hosted on the IMWS, the SAEAT provide the reviewing managers with a graphical representation of extraction jobs and their attributes indexed to a coordinate system and overlaid on a simple background map. All level managers have access to the SAEAT to perform reviews from their various perspectives and to serve their various needs. The SAEAT derives all data from the existing Production Management Segment (PM/S) host database.

The manager queries the SAEAT for the desired information and the SAEAT provides the results to the screen. The manager can review attributes of any presented job or can manipulate the display such that chosen attributes are graphically displayed. The manager then formulates extraction strategies based on the presented information. The displayed information aids the manager's decisions, presumably to avoid as much as possible simultaneous adjacent extractions. The manager generates reports as needed to support the decision making process.

Note that there has been discussion to develop software that automates the decision process to avoid simultaneous extraction. The requirements for this automated function are very strenuous and must be implemented only through custom developed software. It is the view of this project that a tool to aid the human making the decision is far more feasible, reliable, and implementable than developing an automated process. In the end, the humans still make the decisions.

The SAEAT does NOT update any data, does not calculate or implement any decisions. The SAEAT is a tool used to present data in a consumable form to the human manager, and then the manager makes the decisions and implements them through the existing scheduling functions in the PM/S. The human manager is a major component in the SAEAT.

4.1.2. QSS Mission

The QSS provides improved graphically based subtask scheduling capabilities to the L5 manager, and allows review by the L2 and L3 managers. The QSS supports more consistent accurate scheduling, and also provides the L5 with an easier to use and faster to implement set of capabilities. The QSS allows the L5 manager to view a graphical representation of all work (or any selected subset of that work) to allow a much faster, accurate, and efficient analysis of the workload. The QSS allows a faster implementation of the L5 assignments and work strategies.

Hosted on the IMWS, the QSS replaces the subtask scheduling capability in the existing PM/S. The QSS graphically displays assignments and their status, resource pools, and schedules, and indexes the assignments by geographic coordinates to a simple backdrop map. The L5 manager operates the QSS, but L2 and L3 managers can view QSS data.

L5 managers manage only their organization. The QSS session is interactive; decisions made by the L5 manager create data changes and send messages to the production segments. The data updates are written to the PM/S host database. L5 managers are identified by their organization; access to the data is controlled and assignments made by organization.

Data is manipulated on the screen via point, click, and drag type operations. Such manipulation causes the appropriate data updates in the IMWS database. When the L5 is satisfied with all results, they are committed and at that time written to the PM/S host database, and required messages are sent.

4.2. Solution Concept

This solution is provided to support the IMWS mission. The solution approach is to use the customer agency standard workstation in the upgraded communications environment, and implement the SAEAT and QSS functions. The combination of workstation, SAEAT, and QSS is the Integrated Management Workstation (IMWS). This section defines how the solution approach is to be accomplished and is the solution concept.

The IMWS is developed and delivered in three phases. The first phase provides the IMWS infrastructure such as the database, utilities, program control, and communications. Also the external interfaces are established. The essential SAEAT capabilities are included. The guiding philosophies for the HMI are established. Phase 2 provides the supporting data desired for the SAEAT. Phase three implements the QSS Figure 4.2-1 shows the three phases and their responsibilities.

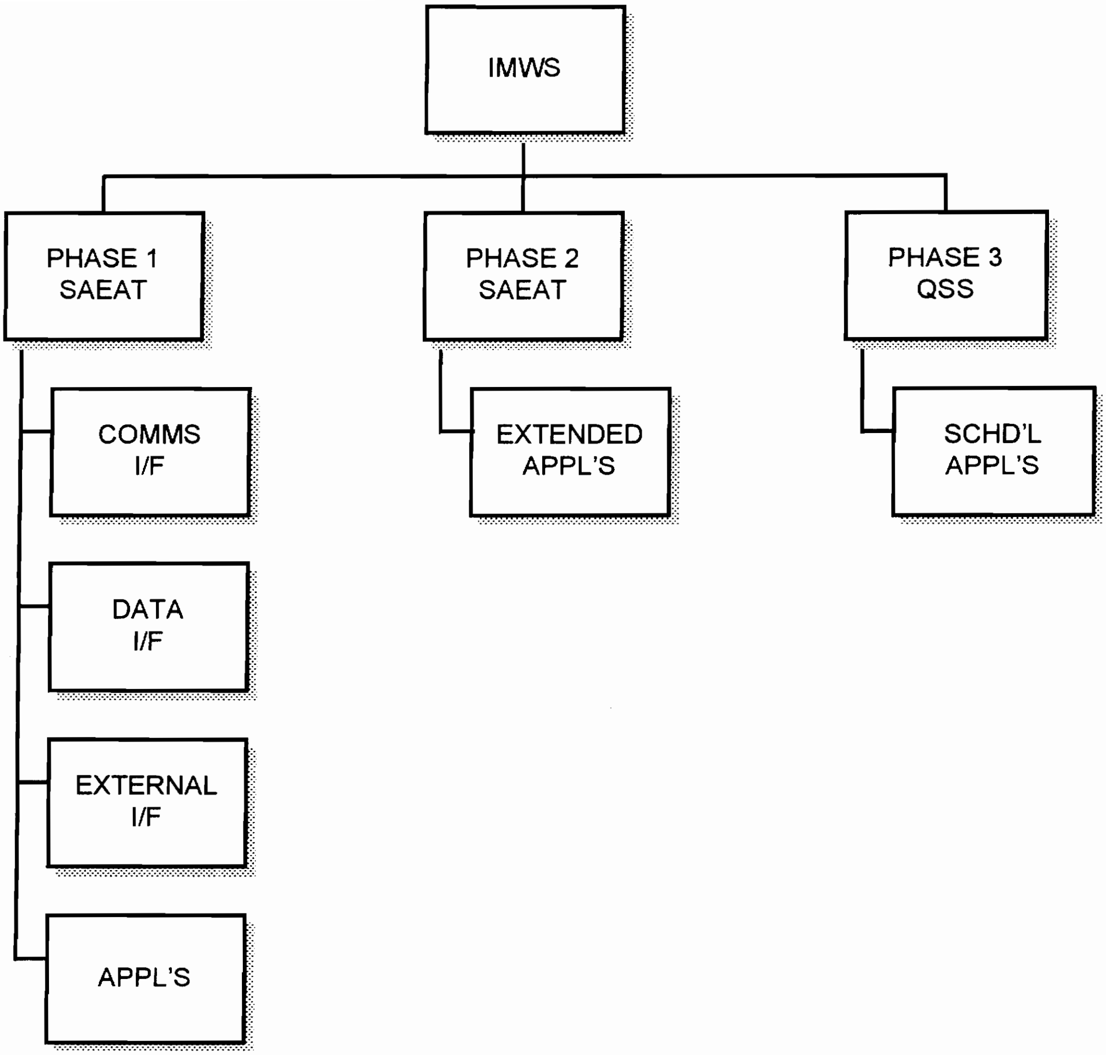


Figure 4.2-1 IMWS Phases and Responsibilities

Figure 4.2-2 shows the IMWS functional concept. The IMWS consists of the basic workstation components and special purpose applications and interfaces. The workstation contains the operating system, the DPS network communications handlers, the graphical user interface (GUI), and the operator input device(s). The workstation will be provided by the customer under a separate program. The customer is undertaking a project to buy a large quantity of general purpose workstations to be adapted to various uses.

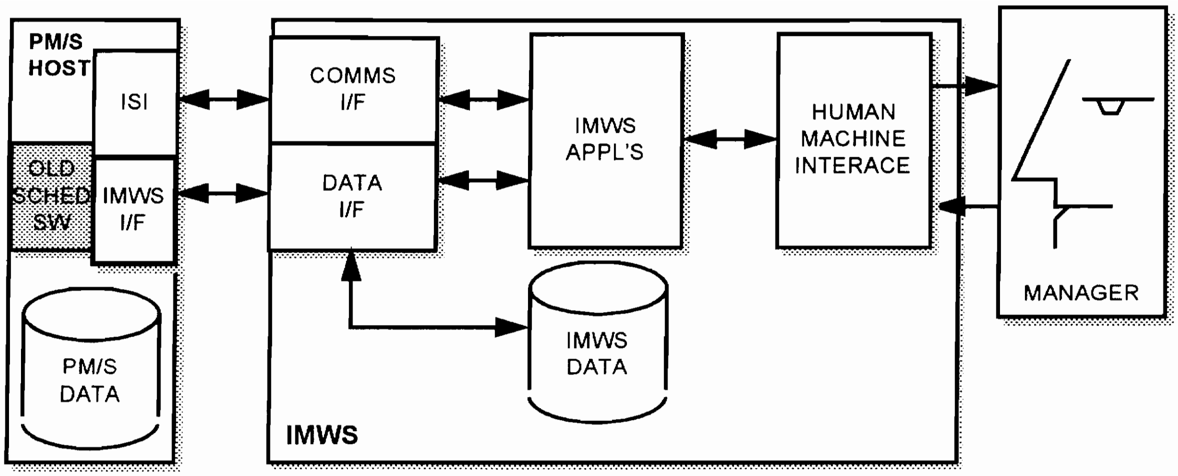


Figure 4.2-2 IMWS Functional Elements

The IMWS application requests and/or accepts data input from the PM/S (via workstation interfaces), accepts query parameters from the user, provides a local data store, and provides formatted data to the display (compatible with the GUI).

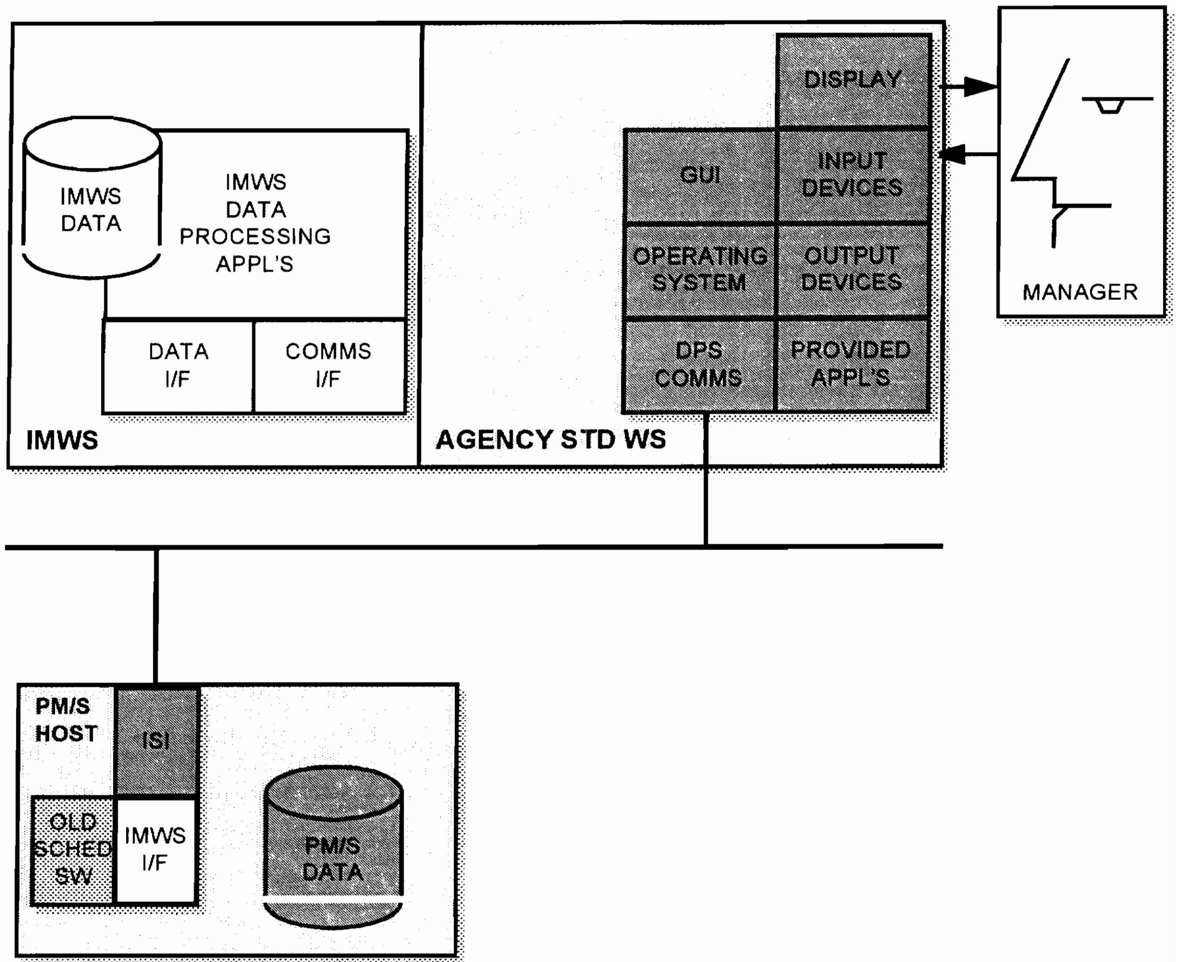


Figure 4.2-3 IMWS Functional Elements in the DPS Environment

Figure 4.2-3 shows the IMWS functional concept in the DPS environment. The shaded blocks indicate existing functions. The IMWS functions are embedded in the agency standard workstations, and also in the PM/S. External interfaces to the PM/S and to the host workstation are shown.

4.2.1. Phase 1: Provide IMWS Infrastructure and Preliminary SAEAT Capability

The Phase 1 effort creates the architecture/infrastructure needed to host the IMWS functions. It builds the query capability to extract the desired SAEAT support data from the PM/S and display it on the IMWS. It also provides view manipulation - presentation parameters such as scroll, scan, and zoom, and selection of attributes to be displayed.

Three IMWS functions must be created, a communications interface (Comms I/F), a data interface Data I/F), and an applications set.

The communications interface provides connections services to the PM/S and its data store. It may include components and modifications in the PM/S.

The Data I/F accepts queries from the applications set and returns the results from the local data store, or directs the query to the Comms I/F if the query is for PM/S held data.

The applications set accepts the user query, generates the query compatible with the PM/S, and passes the query to the Comms I/F to be sent to the PM/S. It accepts data from the PM/S and formats and stores this data in the local database via the Data I/F. Finally, the applications set will have a future (Phase 3) capability to assemble datasets that are the result of workstation activity and write these datasets into the PM/S data store.

The Phase 1 effort also provides the graphical interface necessary to support SAEAT. It shows jobs against a simple geographic background (perhaps the digital chart of the world (DCW)) indexed by coordinates. It also provides attributes at the job level to include status and schedule. No update capabilities are provided with the SAEAT. The system effectiveness includes the participating manager as an integral system component. The SAEAT provides data that is input to the manager. The manager then uses this input to develop strategies, and implements these strategies by executing new schedules or changes to existing schedules using the existing PM/S tools.

4.2.2. Phase 2: Added SAEAT Data and Granularity

The Phase 2 effort adds data structures needed to support SAEAT to the subtask level and expands query capabilities to extract this data from the PM/S. Also, it expands the display parameter selection capabilities to include the new data. This phase builds on the first phase, but does not add major new functions. It also supplies some data structures to be used in Phase 3, therefore simplifying and focusing the Phase 3 efforts.

4.2.3. Phase 3: Subtask Scheduler

The subtask scheduler is a natural augmentation to the SAEAT. It provides the interactive ability to manage resource pools, track work status, and schedule work (create Assignments) at the subtask level in the environment created to host the SAEAT. The subtask scheduler employs queuing techniques to more smoothly manage the work flow, and is named the Queued Subtask Scheduler (QSS). The data and structures created to support the SAEAT are used as the infrastructure for QSS. Data that supports the QSS already exists in the PM/S, and provides the initial conditions for a scheduling session. The scheduling session results are written back into the PM/S data store.

The QSS requires operational and functional concepts that define the IMWS queuing methods. It requires careful consideration in the data processing sections, as this function provides update capabilities, and data integrity must be preserved. This phase also provides a high degree of user interaction, and this capability must also operationally and functionally be defined. Finally, this phase represents a migration of functionality from the PM/S mainframe environment to the IMWS. As such, there is impact to the Computer Program Critical Items (CPCI) functions in the mainframe environment, and this impact must be identified, addressed, and managed. The subtask scheduling function in the PM/S will have to be largely decommissioned.

This phase is the most technically demanding and the riskiest. The first two phases can be completed, installed, and used while phase three is developed.

4.2.4. Mission Summary

In summary, the IMWS provides the environment and platform that hosts the SAEAT, and then the QSS is added. The SAEAT allows data to be displayed for human review to manage simultaneous adjacent extractions. The QSS provides a more user friendly and efficient method to create production assignments and manage schedules and resources at the subtask level.

5. Project Engineering Management

The project success is very sensitive to management and control abilities. Because the project is an addition to an existing functional system, careful planning is needed to disturb the system as little as possible. Contingent planning is needed to recover should any implementation action cause a system failure. Accountability is required to prevent unexpected actions from occurring, and to provide the authority to execute those actions that are planned. Accountability and visibility are required to provide the customer with accurate status and opportunity for propitious planning input.

The Project Engineer and Project Manager (two different positions) will supply the authority for the project. The project engineer is responsible for all technical decisions, including execution of planned activities according to the project schedule and technical plans. The Project Manager is responsible for personnel, business, and support and facilities issues. The Project Manager is the connection to the customer business apparatus for scope issues.

The Project Engineer develops and oversees the technical plan. This person provides the "big picture" perspective and makes certain that the various component parts work together. Internal and external interfaces are particularly important. Each component is likely to be well defined by a requirements set, and engineers and programmers assigned to the components are expected to be successful. The Project Engineer must be certain that the components understand their relationship to each other to insure full compliant functionality. In like manner, the project engineer must understand the external interfaces, and make certain that these requirements are met.

The Project Manager and Engineer are responsible to create, execute, and enforce the plans that will be used to create the project. The division of labor will be adjudicated by these two individuals.

The plans needed to create the SAEAT and QSS, index by sub-sections in this section are

5.1 Project Strategy, Management and Control
5.2 WBS
5.3 Project Schedule Issues
5.4 CM Plan
5.5 Development Plan
5.6 Interface Control
5.7 Implementation Plan
5.8 Test Plan

5.1. Project Strategy

Due to risk factors, especially those associated with phase three, this project strategy is devised as the main risk mitigation. The recommended solution is a three phase project. This strategy separates issues and allows needed functions to be implemented as they are completed. Further, natural checkpoints are identified and mark recovery points if needed.

5.1.1. Engineering Management Personnel

The Project Engineer and Project Manager (two different positions) will supply the authority for the project. The project engineer is responsible for all technical decisions, including execution of planned activities according to the project schedule and technical plans. The Project Manager is responsible for personnel, business, and support and facilities issues. The Project Manager is the connection to the customer business apparatus for scope issues.

The Project Engineer develops and oversees the technical plan. This person provides the "big picture" perspective and makes certain that the various component parts work together. Internal and external interfaces are particularly important. Each component is likely to be well defined by a requirements set, and engineers and programmers assigned to the components are expected to be successful. The Project Engineer must be certain that the components understand their relationship to each other to insure full compliant functionality. In like manner, the project engineer must understand the external interfaces, and make certain that these requirements are met.

The Project Manager and Engineer are responsible to create, execute, and enforce the plans that will be used to create the project. The division of labor will be adjudicated by these two individuals.

5.1.2. Dependencies on Customer Initiatives

The two most pressing and uncontrolled risks are the customer decision and delivery of the standard workstation and the delivery and implementation of the DPS communications upgrade.

The design concept provides an architecture which is workstation sensitive, but within that architecture are less sensitive elements. The database and (developed) applications are to some degree portable, and may be developed on a choice of machines. These two components may be functionally developed in an environment significantly different from the ultimately chosen host, but implemented with little problem. The program will obtain the machines thought to be currently in favor with the customer (Intel Pentium processor, SVGA, running a Windows or Windows NT environment). Essentially, early development will be in a prototype mode, and the results will be moved to whatever platform is chosen.

5.1.3. The IMWS Project Events and Dependencies

Figure 5.1-1 shows dependencies in a PERT chart that illustrates the process flow. The dependencies are Phase 1 issues, and the figure pertains to Phase 1 development. Parts of the figure that are shaded are repeated for Phases 2 and 3.

The initial project stages are dedicated to acquiring the development resources. The development workstation is selected against assumptions predicting the customer's favored choice. The software development tool set and IMWS local database must also be chosen. When the decisions have been made, the equipment and software must be purchased. Upon delivery, the development items must be integrated into a working environment.

Once the development workstation has been integrated, the Comms I/F, Data I/F and applications development can begin. When each of the development efforts has been completed, they are integrated into a complete product. Functional requirements are verified in a stand-alone test that proves the integration success.

At this time, the customer workstation must be available. It is expected that at any time there is an event or decision regarding the customer's agency standard workstation, the IMWS developers will be notified immediately. Impact to the IMWS development must be made in light of any changes in technology or delivery schedule. Adjustments are made as needed to be compatible with the customer's host. The stand-alone test is repeated, then the IMWS software is moved to a workstation in the System Test Environment (STE).

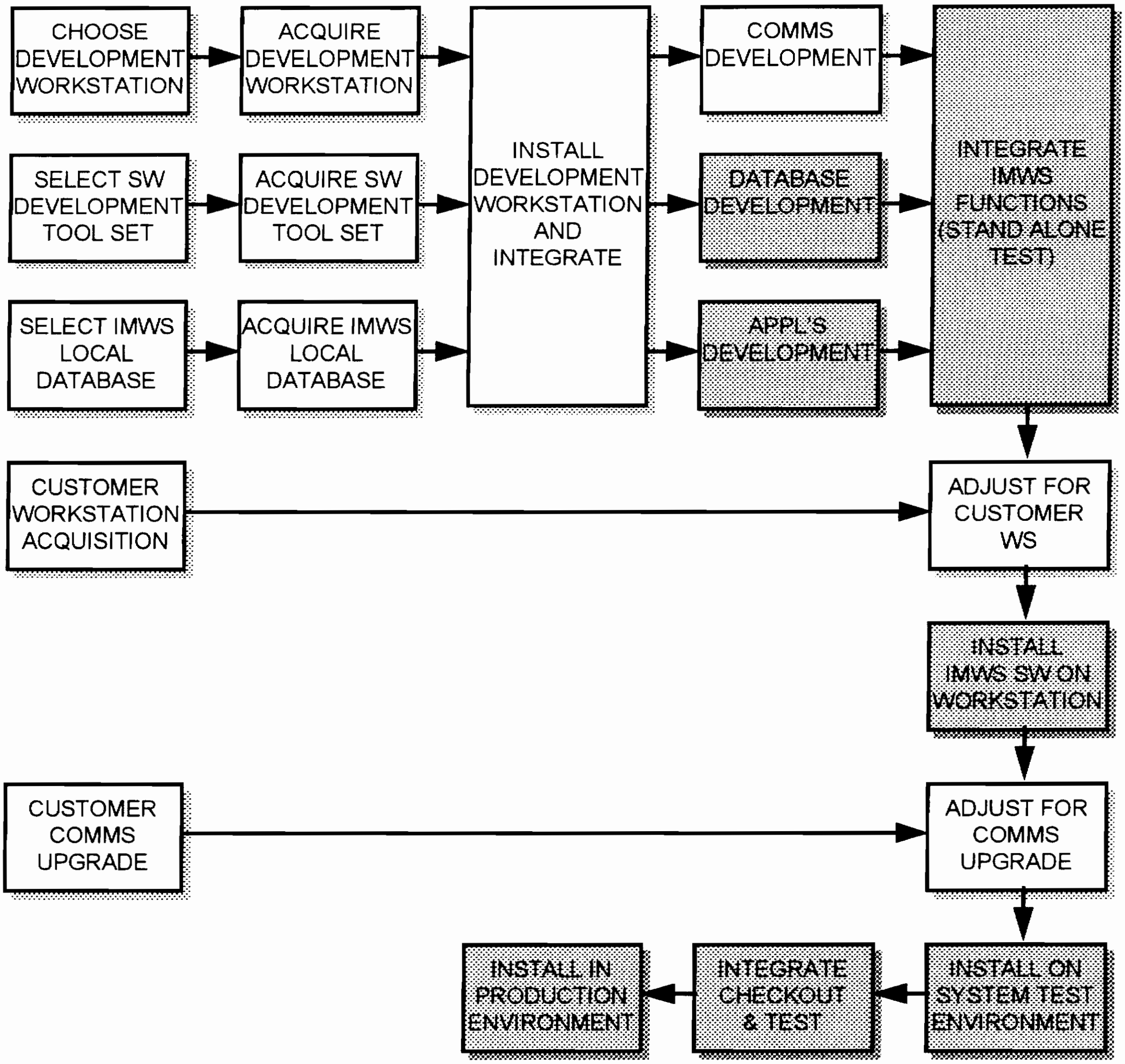


Figure 5.1-1 IMWS Project Flow Chart

At this time, the customer's communications upgrade must be in place. It is expected that at any time there is an event or decision regarding the communications upgrade, the IMWS developers will be notified immediately. Impact to the IMWS development must be made in light of any changes in technology or delivery schedule. The STE contains hosts from the production segments as well as an interconnecting communications network. The STE is purported to be the equivalent of the Production Environment. All testing done in the STE is considered a valid check for products to be installed in the Production Environment. A full function test and evaluation is conducted with the IMWS in the STE. When complete, the IMWS is migrated to the Production Environment.

5.1.4. Customer Interface and Participation

For project success, the customer's interest and participation are required. It is expected that the customer will name an acquisition manager who is the customer's counterpart to the Project Manager, and a technical lead who is the counterpart of the Project Engineer. The customer's representatives will provide the communications channels necessary to facilitate the IMWS project success. The customer's representatives will also assign the necessary and appropriate personnel to help accomplish tasks identified in the various engineering plans.

Development cycles will require customer participation. Because user interaction with the presented data is the project essence, who better than the managers who will use the system to test drive it during development? In order to provide the needed feedback system (between customers and developers), it is necessary to choose techniques that support this immediate feedback, as well as a procedure within which to work.

Test cycles also will require customer participation. Customer personnel are needed to ascertain that the delivered product meets the requirements and performs as expected.

5.2. Work Breakdown Structure

The project Work Breakdown Structure (WBS) is shown in Figure 5.2-1. The WBS defines accounts for all work to be accomplished in the IMWS project. There are three major categories: System Engineering, Software Engineering, and Management. System engineering is heavily emphasized in the IMWS WBS. The System Engineering elements provide for development planning, requirements allocation, interface management, test planning, life cycle planning, and other activities that provide cohesion to the project. Software Engineering provides the production work; software code, debug, integration and test. Configuration management is also provided. Management includes all management tasks needed to provide project continuity.

5.2.1. WBS Dictionary

These sections are numbered in accordance with the WBS Diagram shown in Figure 5.2-1.

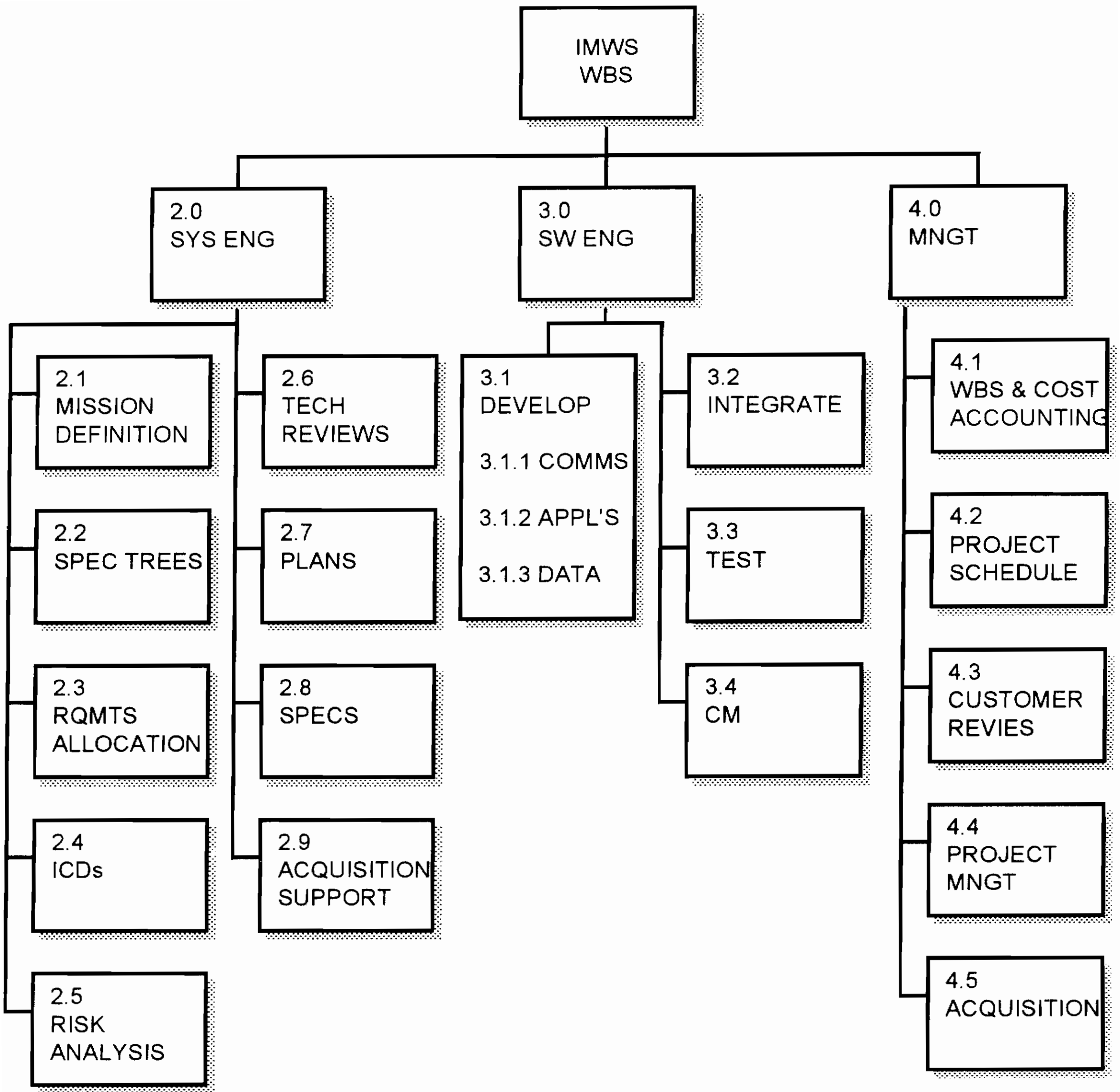


Figure 5.2-1 IMWS Work Breakdown Structure

2.0 System Engineering
Effort involved in all system engineering activities are rolled up into this element.

2.1 Mission Definition
This element contains all the effort needed to determine the customer needs, provide analysis, and distill the mission requirements.

2.2 Specification Trees
This element contains all the effort needed to produce the specification tree that defines the IMWS. Includes segment design specification and part one requirements specification.

2.3 Requirements Allocation
This element contains all the effort needed to produce the operational and functional IMWS requirements.

2.4 Interface Control Documents (ICDs)
This element contains all the effort needed to produce the interface analysis and control documents for internal software to software, user to IMWS, and IMWS to segment interfaces.

2.5 Risk Analysis
This element contains all the effort needed to perform risk review, analyze the review, and create a risk mitigation plan.

2.6 Technical Reviews
This element contains all the effort needed to prepare and present technical reviews, including the PDR and CDR for each phase.

2.7 Engineering Plans
This element contains all the effort needed to create the project engineering plans, including

Development Plan
Implementation Plan
Test Plan
Configuration Management Plan
Maintenance Plan

This element provides the aggregate Project Engineering Management Plan.

2.8 Specifications
This element contains all the effort needed to generate the specifications defined in the specification tree.

2.9 Acquisition Support
This element contains all engineering effort needed to support acquisition of the development workstation, software tools, and other items needed by the project. Includes research and trade studies.

3.0 Software Engineering
Effort involved in all software engineering activities are rolled up into this element.

3.1 Development
Software development for the three IMWS areas are collected in this element. Effort includes all effort for database, comms, and applications development, code, and debug. Three iterations, one for each phase, are defined.

3.1.1 Comms
This element contains all effort needed to create the communications interface between the IMWS and the PM/S, via the customer provide network. Effort includes work accomplished in the PM/S host to complete comms compatibility.

3.1.2 Applications
This element contains all effort needed to create the IMWS applications. Table 5.3-1 defines modules to be included.

Table 5.2-1 Modules to be Included by Phase

Phase 1	Phase 2	Phase 3
Query	Query	Query
Display	Display	Display
Utilities	Utilities	Utilities
SAEAT	SAEAT	Schedule
Interfaces	Interfaces	Resources
		Interfaces

3.1.3 Database
This element contains all effort needed to create the database structures and interfaces, and to populate the data, as well as create and analyze reports.

3.2 Integration
This element contains all effort in the IMWS integration process. All effort to exercise internal software interfaces, verify error recovery, and exercise simulated external interfaces is included. Three iterations, one for each phase, are defined.

3.3 Test & Transition
This element includes all effort to prepare procedures, data and workstation environment, execute tests, review and analyze data, and produce any reports. Also, transition activities, including planning, installation, and checkout are included. Three iterations are required, one for each phase, are defined.

3.4 Configuration Management
This element includes all effort to design, create, and apply configuration management to the IMWS during its development, integration, and test.

4.0 Management
Effort involved in all management activities are rolled up into this element.

4.1 WBS and Cost Account Management
This element includes all effort to set up and manage cost accounts, to include audits, reports, and analysis of cost performance.

4.2 Project Schedule
This element includes all effort to maintain the project schedule, to include critical path management, reports, and analysis of schedule performance.

4.3 Customer Reviews
This element includes all effort to prepare and present customer reviews, typically to include monthly project status reviews and other designated periodic reviews.

4.4 Project Management
This element includes all effort to perform project management tasks.

4.5 Acquisition
This element includes all effort to acquire workstations, software products, tools, and licenses needed to support the IMWS projects. This element also includes the costs of acquired items.

5.3. Project Schedule Issues

In the SAE White Paper, the customer stated that the SAEAT is desired by July 1994 to support the MOD.0 program. Unfortunately, the MOD.0 program has not been widely circulated and is apparently a matter of some debate. Regardless, the MOD.0 time frame cannot be met.

5.3.1. Phase 1 Delivery Schedule

Figure 5.3-1 shows the proposed IMWS Phase 1 delivery schedule. Phase 1 can be delivered in ten months from the designated start date. Four technical reviews are to be held: the Requirements Review (RR) at the end of month one; the Preliminary Design Review (PDR) at the end of month two; the Critical Design Review (CDR) at the end of month four; and the Test Readiness Review (TRR) at the end of month eight.

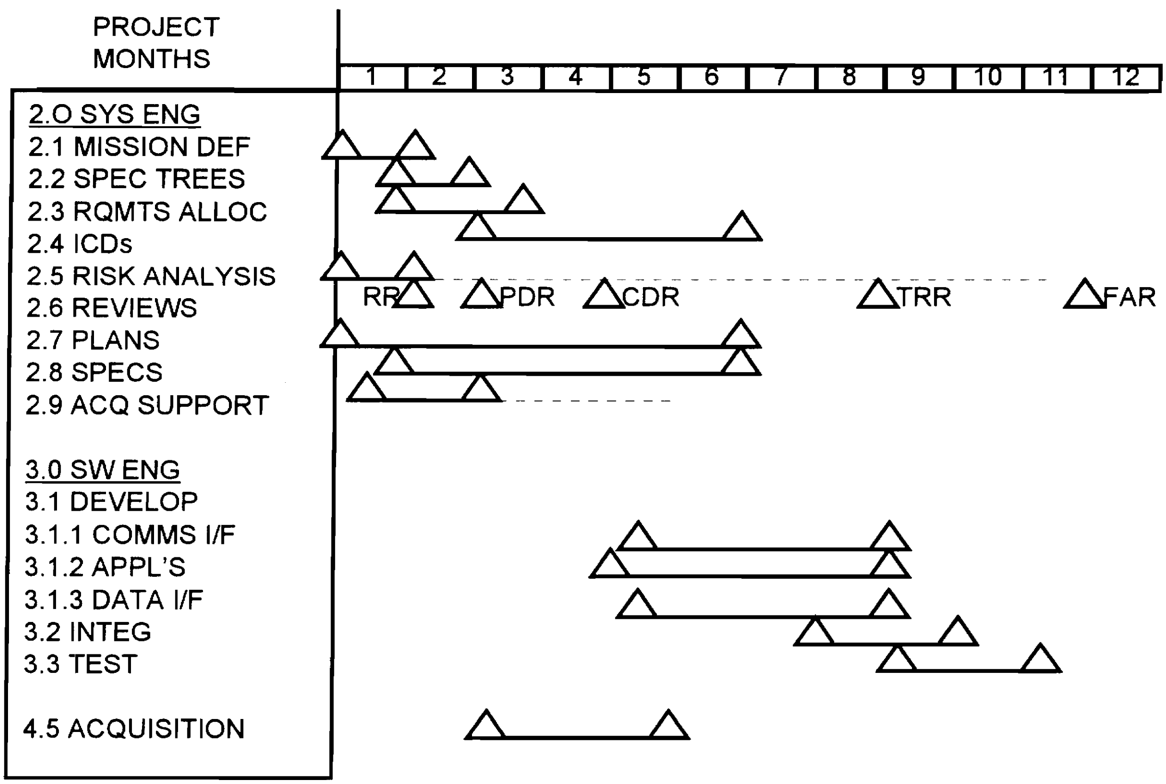


Figure 5.3-1 IMWS Phase 1 Project Schedule

To support the Requirements Review, the Mission Definition and Risk Analysis are complete, the Spec Tree and Requirements Allocation are being produced, and the various engineering plans have been started. These efforts cannot continue without a good understanding of the requirements. The Requirements Review is a feedback point from the customer to make certain the IMWS Phase 1 is properly scoped and understood. If there are deficiencies, corrective action should be identified and begun.

To support the PDR, the Spec Tree and Requirements Allocation are complete. The Interface Control Documents (ICDs) are outlined, and rough drafts of the engineering plans are available. The expected plans include:

IMWS Development Plan,
IMWS Implementation Plan,
IMWS Test Plan,
IMWS Configuration Management Plan, and
IMWS Maintenance Plan.

Acquisition support reports are also completed and contain the recommendations for the local database and the programming language(s), tools, and techniques to be used.

To support the CDR, drafts of the specs and ICDs are available. All acquisition activities are complete. Drafts of the engineering plans are available and near final form. The Development and Implementation Plans will be used to govern immediately upcoming activities. The CDR must successfully complete in order to proceed to development.

To support the TRR, all engineering plans must be complete and all development activities must be complete. The upcoming activities will be governed by the Test and CM Plans. Included in the review are all items needed to support the integration effort. This is a good time to check on the status of the customer provided facilities. If they are not ready at this point, schedule impact will be suffered as time will have to be added to transition from the development workstation to the agency workstation. If at the end of integration, measured by completion of the stand-alone test, the customer supplied facilities have not been delivered, scheduled progress will stop.

Four months are allocated to the development cycle. Choice of technology and development tools supports this time frame. One month is allocated to the integration and stand-alone test activities, and one month further test in the STE.

5.3.2. Phase 2 Delivery Schedule

Figure 5.3-2 shows the delivery schedule for the IMWS Phase 2. Because the Phase 2 delivery is simpler, and because much of the front end engineering was done in Phase 1, the Phase 2 duration is much shorter, only 6 months. Mission Definition, Spec Trees, Risk Analysis, and Acquisition were delivered with Phase 1. Requirements Allocation, ICDs, Plans, and Specs require updates and do not have to be created from the beginning.

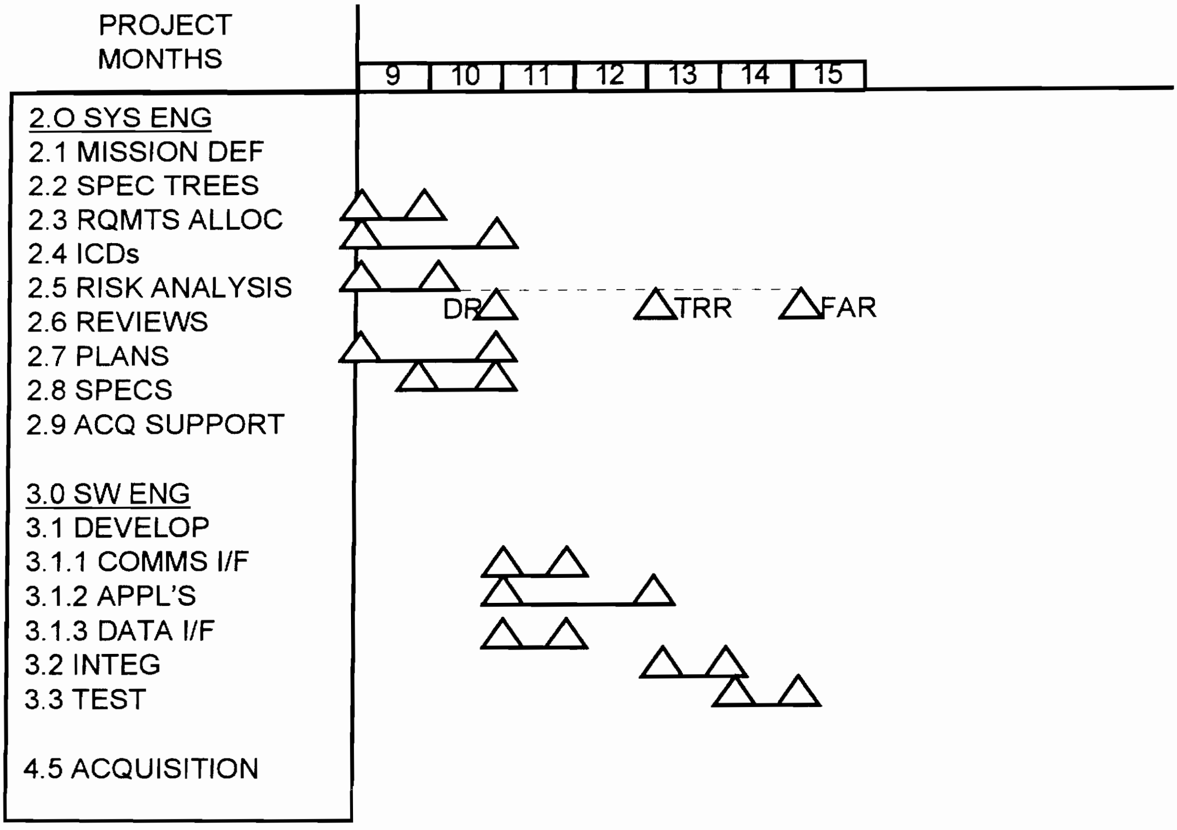


Figure 5.3-2 IMWS Phase 2 Project Schedule

Phase 2 activity starts in month 9 and overlaps Phase 1 by two months. During these two months, Phase 1 is testing and Phase 2 is primarily writing, so there should be little stress on resources.

Only two technical reviews are planned, a Design Review (DR) at the end of month 10, and a Test Readiness Review at the end of month 12. To support the Design Review, updates to the Requirements Allocation, ICDs, Engineering Plans, and Specs are complete. Beginning the development cycle depends on successful Design Review completion.

Two months are scheduled to create the Phase 2 applications. The TRR is then held to review the development effort and all other items needed to support the integration and stand-alone test. Development must be completed before integration and test can begin

5.3.3. Phase 3 Delivery Schedule

The Phase 3 requirements are somewhat more demanding, and a ten month time period is scheduled. Phase 3 activity starts in month 13 and overlaps Phase 2 by two months. During these two months, Phase 2 is testing and Phase 3 is primarily writing, so there should be little stress on resources.

Three technical reviews are planned: the PDR at the end of month 14, the CDR at the end of month 15 and the TRR at the end of month 18. Figure 5.3-3 shows the delivery schedule for the IMWS Phase 3.

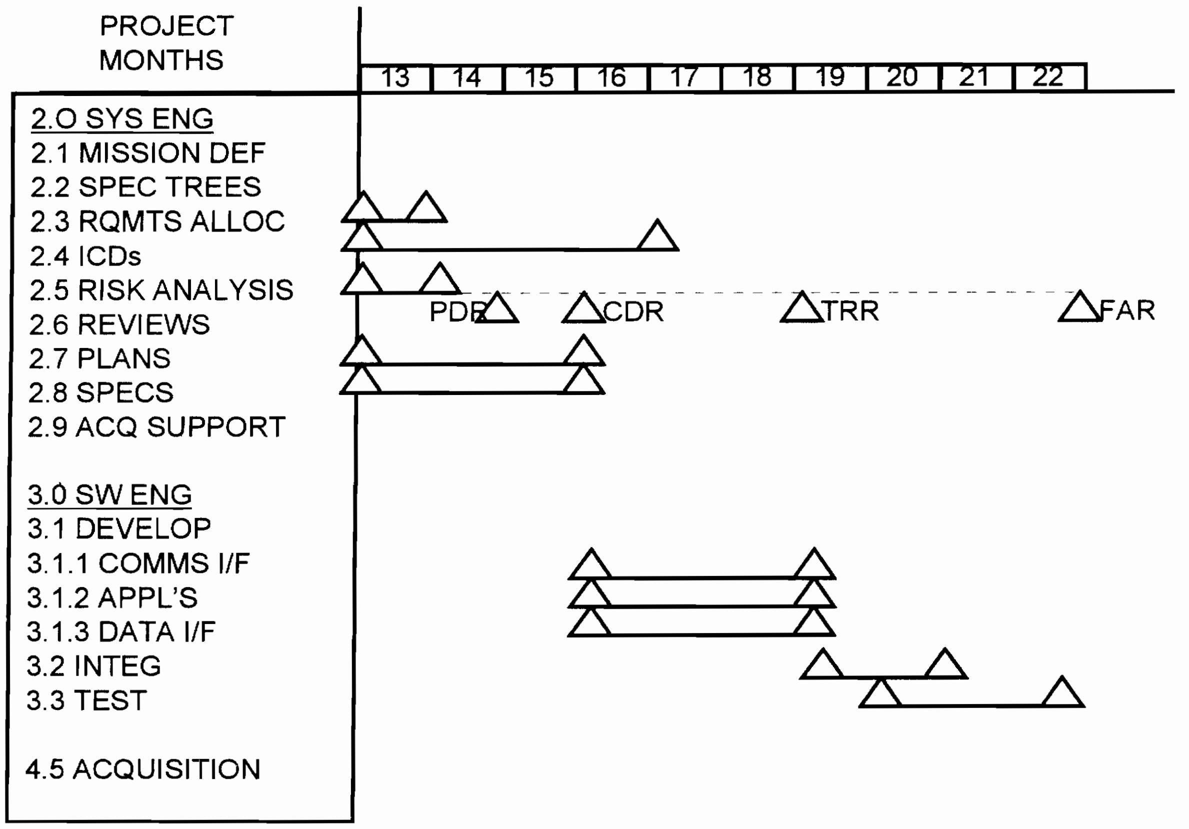


Figure 5.3-3 IMWS Phase 3 Project Schedule

To support the PDR, the Requirements Allocation is completed and drafts are available of the ICDs, engineering plans, and specs. The engineering plans are largely updates, but the specs and ICDs contain new and complex work.

To support the CDR, the engineering plans and specs are complete, and the last draft of the ICDs are available. Phase 3 development depends on successful CDR completion.

Three months is provided for the development. The applications development is incremental, and after a year on the project, developers are expected to be very proficient. The data interface is straight forward at this point, adding data structures to the existing infrastructure. The technical challenge is adding the update capability. The communications interface is expected to provide major challenge as both query and update capabilities with the PM/S are required as well as interaction with the production segments.

The TRR is held at the end of month 18. All development must be complete to support the TRR. Integration and Test depend on successful TRR.

Two months is provided for the integration and stand-alone tests. The time provides for a richer and more challenging requirements set to be exercised and verified. Two months further is provided for testing in the STE to allow for complete interface checkout.

5.3.4. Production, Operation, and Maintenance

In total, the IMWS development project spans 22 months and is considered a fairly ambitious schedule. The next three years, the IMWS is operational and subject to Operations and Maintenance (O&M) requirements. At the end of month 48, a technical review is conducted to study the IMWS effectiveness and suitability. Surveys of available technology will be conducted, and recommendations for changes and/or enhancements will be included in the report. The plans for the next five year cycle will also be included. Figure 5.3-4 shows the overall IMWS project schedule.

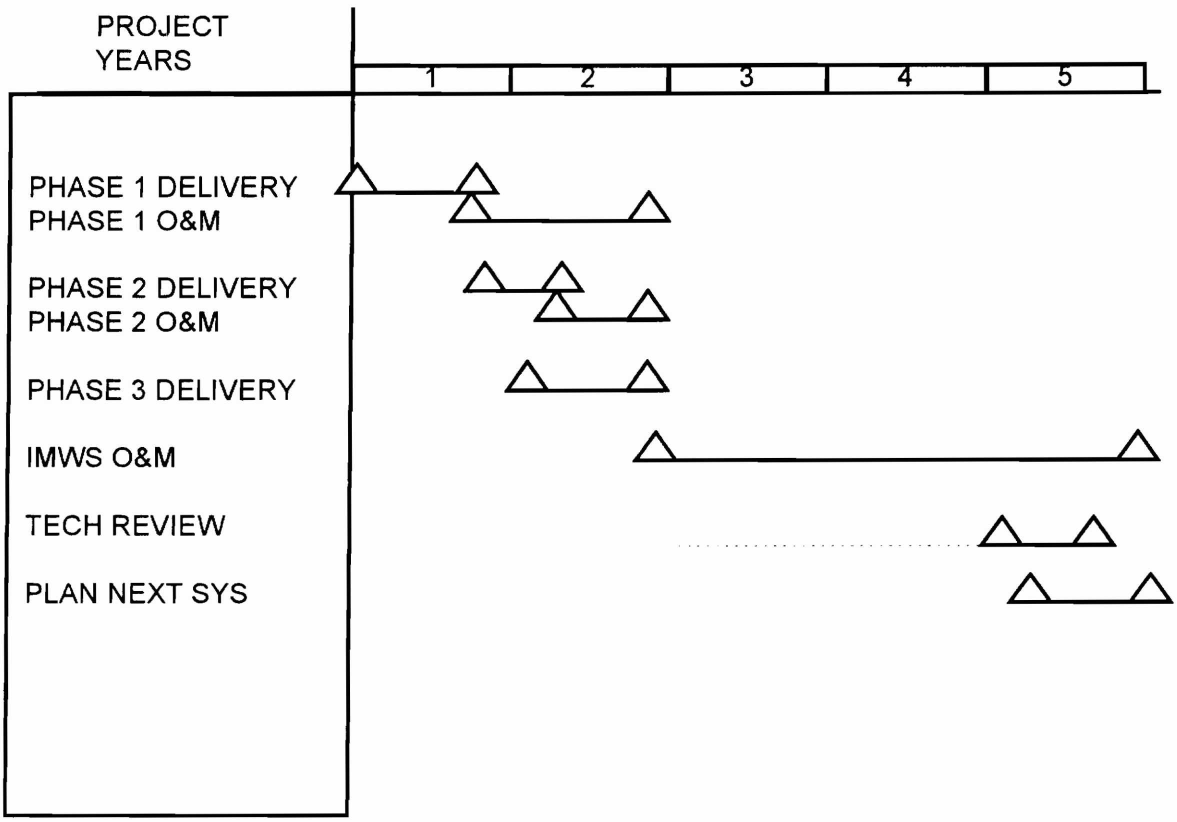


Figure 5.3-4 IMWS Project Life Cycle Schedule

5.4. Configuration Management Plan

Configuration Management (CM) will be used to control the software baseline and ensure that the available functions are known and work as expected.

CM personnel install baseline software and all changes to the baseline. No other personnel can modify baseline software. CM personnel must work in concert with the developers and later with the O&M staff to correctly install the most recent authorized changes.

5.4.1. Installations and Discrepancy Process

In this project, there are six baseline installations, two for each phase, one in the test environment, one in production. CM will assume control of the development baseline when it is installed on the workstation for stand alone test. All changes to the baseline from that point forward are governed either by the discrepancy process, or by installation of a new baseline.

The installation process is applied to major deliveries that provide new functions and meet new requirements. The software is managed as a block, rather than problem by problem. When milestones are met, the entire software package is moved to the next environment. The typical path is from the development environment to the test environment to production. The test environment may actually be several tiers to accommodate stand alone, then segment testing, depending on the delivery.

The discrepancy process is applied on a problem by problem basis. Discrepancies may be discovered during development, test, or production. The discovered discrepancy is documented in a Discrepancy Report (DR), then assigned to the appropriate expert to troubleshoot and investigate. When the best solution is derived, programmers adjust the software, then recommend test. The change is tested, and either the fix is verified as valid, or it fails and is returned for further investigation. The progress is documented in the DR. CM moves the new software at milestones designated in the DR documentation by the engineers and programmers. The process is illustrated in Figure 5.4-1. In addition to documentation, engineering, programming, and CM personnel periodically meet to discuss various issues, devise best strategies, and keep up to date.

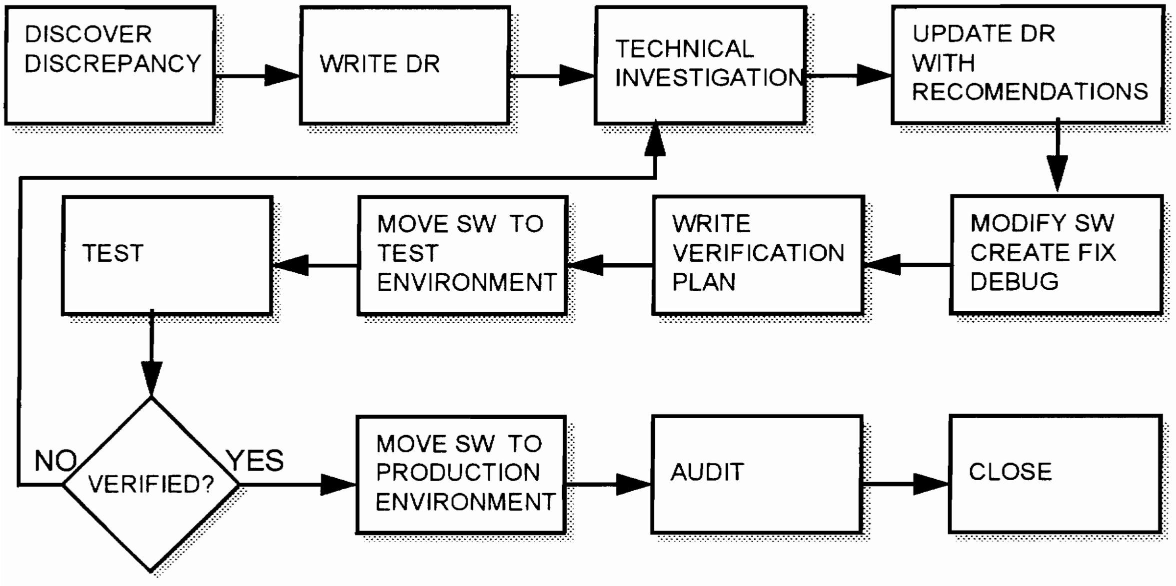


Figure 5.4-1 CM Discrepancy and Workoff Process

5.4.2. IMWS CM Environment

To control the IMWS baseline presents challenges different from the native PM/S. The PM/S is one machine (per location), an IBM mainframe. It's software baseline configuration is controlled from the Development and Test Facility (DTF), typically located at the O&M contractor's "factory" (as in this case). A number of software libraries are maintained on the DTF. The following are the needed:

One is the "gold copy," the current law of the land. The gold copy defines the valid current maintained version.

In the O&M environment, the work-off library. This software can be modified by O&M programmers to recreate problems or devise solutions. When the solution is completed, the changes are captured and moved to the Test library by CM.

The test library is the same software baseline as the gold copy with additional new changes added. The new changes are tested in this configuration. When testers verify changes produce the desired effects and/or satisfy new requirements, the captured changes are moved to the gold copy. The changes are then propagated to the sites where the PM/S software exists in production libraries. Test libraries exist at all functional sites as well as at the DTF. Configuration is identical across all installations.

Production libraries exist at each functional site. The production library is an exact copy of the DTF Gold Copy.

During product development, a development library is required. If enhancements or new capabilities are being developed, the development library exists in addition to all others. Development programmers and engineers modify and exercise software in the development library until requirements are met. At this point, the new software is captured and moved to the test library by CM.

5.4.3. Build Process

With central control and a small number of sites each running one machine, the control process appears fairly simple. But the IMWS will have 50 (TBR) machines at a site, each running a copy of the baseline. If baseline is changed, all 50 copies must be simultaneously updated. Further, the infrastructure established for electronic transfers is tailored to the PM/S, but requirements to support the IMWS maintenance must be developed. The following concept is to be used to guide the design. Refer to Figures 5.4-2 and 5.4-3.

At the DTF, a Gold Copy of the IMWS configuration is maintained by CM. Therefore, at least one IMWS must be provided to the DTF as part of the project CM support. A simulated communications link must also be provided for test and verification purposes. This link is expected to be provided as part of the development process

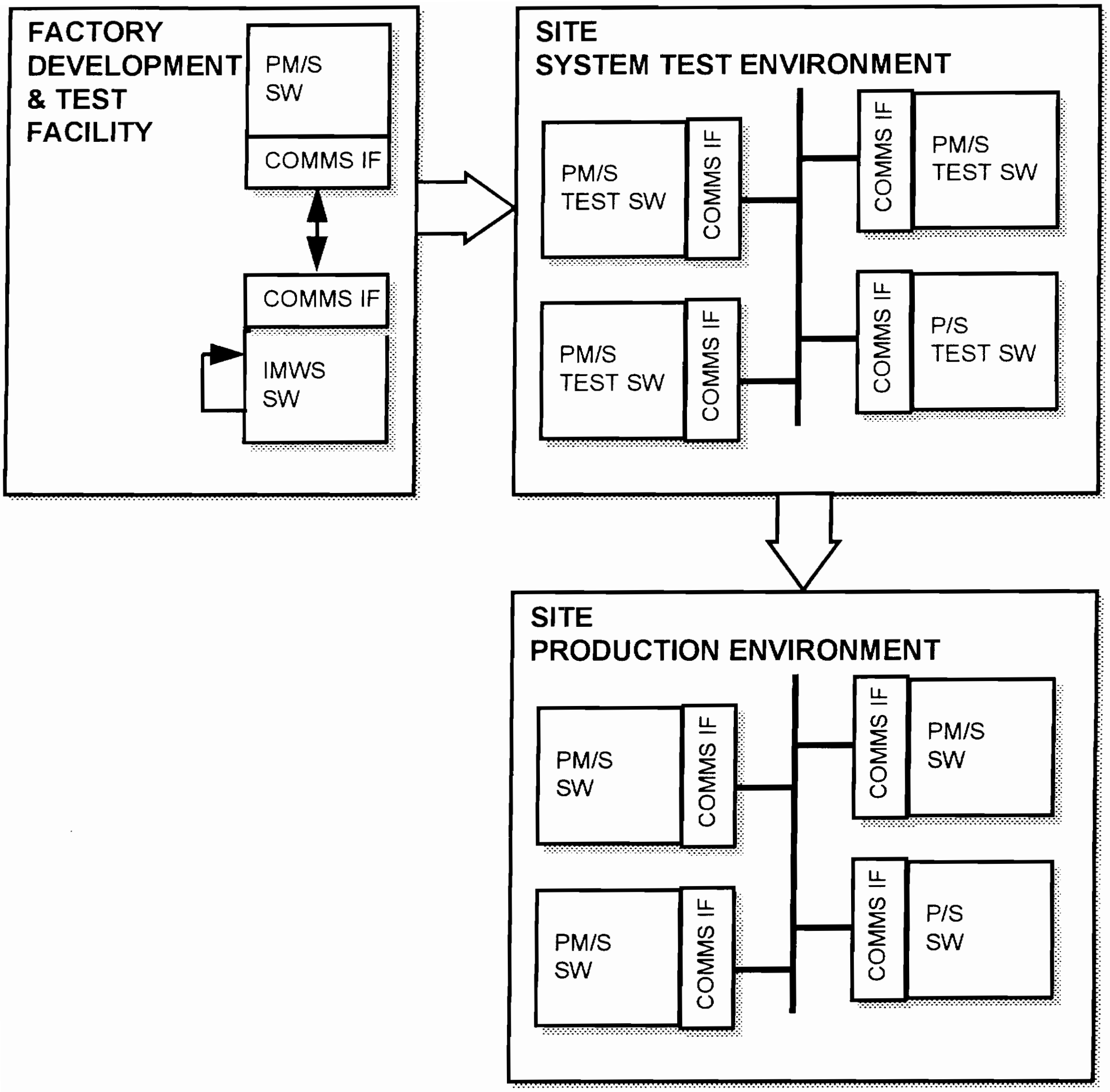


Figure 5.4-2 DR Build Process Flow through the IMWS Environments

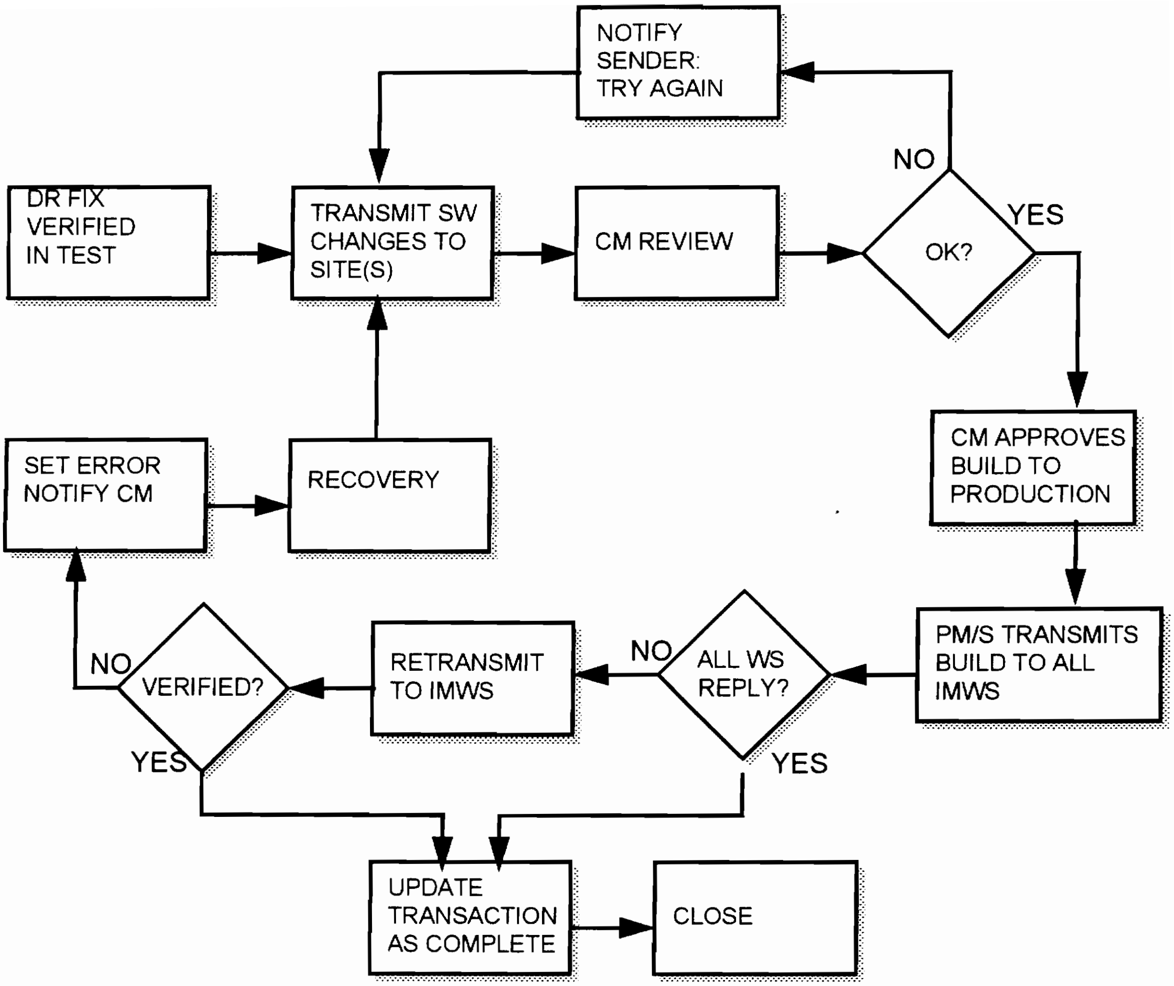


Figure 5.4-3 CM Build Process Flow

The software to be built is put in a package and sent to the operational production facility. The PM/S at the site receives and stores the package. Site CM personnel review the received CM package. If it is damaged, a message is sent to the DTF, and the package is recreated and resent. If it is okay, CM approves the package for installation into the production baseline. The PM/S then electronically transmits the package to all IMWSs. Each IMWS must acknowledge receipt. The PM/S tracks responses, and if any workstation fails to respond, a second transmission is sent. If no response continues, the PM/S sets an error condition and generates a report for review by CM. It must be CM standard operating procedure (SOP) to review error conditions after each install and make certain no error conditions exist, or take corrective action is they do. Receipt of the build package kicks off a program in the IMWS Utilities component that installs the changes contained in the build package.

This concept provides opportunities to use the existing PM/S CM tool and as much of the existing infrastructure as possible. At the least, the CM concept levies requirements against the IMWS design which must be met for the IMWS to be operationally successful. Communications between the IMWS and PM/S must be established, specified, and designed. The IMWS build installation procedure must also be specified and designed. The CM concept must be modified as the design progresses to remain compatible. □Þ

5.5. *Development Plan*

The development plan contains the strategies to create the development environment and facilities, and to produce the project software. This plan includes the dependencies from one activity to another, and further includes contingencies to cope with dependencies on customer initiatives.

5.5.1. Customer Initiatives

Two customer initiatives impact IMWS development: the decision on the customer standard workstation, and the upgraded communications system. Figure 5.1-1 shows dependencies in a PERT chart that illustrates the process flow and illustrates the project performance impact of customer provided facilities. These issues are discussed in Section 4.1. The following are technical considerations that drive the IMWS development regarding the customer provided facilities.

5.5.1.1. Work Station

Although the final development must await the customer's acquisition decision regarding the standard workstation, applications and database modules can be started. Choice of the software development suite anticipates the customer's selection of a windows environment. This is due to opinions presented by the customer's System Test Engineering (STE) office, and the Engineering office's SAE paper, that the expected choice is the Pentium based processor running a windows environment. One of the first development tasks is to select the software development suite.

5.5.1.2. Communications

The customer's communications upgrade is known due to actions by the Data Services Segment. The hardware has been procured and installed, but the implementation is lagging the planned schedule. Implementation is in fact going slowly because outstanding operational and functional issues are unresolved. It is difficult to predict when recovery will occur, or what it may look like, but the following is known.

Intersegment communications will be via the Fiber Distributed Digital Interconnection (FDDI). Each segment host will be provided with an FDDI port. FDDI hardware has been procured and installed.

The difficulty occurs defining how each host will implement its interface to the FDDI. Consistency across the system is required. Due to the existing communications system, Migration to the FDDI has caused significant potential impact to all segment's communications software. In most cases, this is special purpose software developed specifically to support the customer's unique communications system.

The current plan is to install TCP/IP in the hosts and decommission the existing comms software, but still each host must adjust it's interface to the comms, in this case, the TCP/IP.

The IMWS Comms I/F can be developed on this assumption. On the one side, the Comms I/F interfaces with the applications, an interface that can be developed in the workstation stand-alone environment. The interface to the network can be developed next, and if the network is not yet available, development can proceed against an assumption set, previously discussed here.

These initial actions support program schedule goals while mitigating risk of the customer communications choice dependency. The risk remains that the communications implementation schedule is not known. Even with the best assumption set, the IMWS cannot work without a network. On the plus side, development on the workstation assuming a TCP/IP interface can support, if not drive, the solution.

5.5.2. Acquisition

Development tools and items must be procured to support IMWS development. These include the software languages and development tools, the database, and the workstation.

5.5.2.1.Software Development Tools and Language(s)

The development language, approach, and tool set can be selected. The applications functions can be designed and created in a stand alone environment. Language and tool selection must be sensitive to the fact that the customer decision is in doubt, and that the selection may need to be compatible with several possible platforms. Further, because the maintenance programmers are expected to be less experienced junior personnel, the software needs to be fault tolerant, easy to diagnose, and supported by tools that generate code. The tools selected to create the delivered software product will be delivered with the software to support its maintenance. Not only does a software generating tool help speed development, it generates code in a consistent, if mechanical, manner. Such software tends to lend itself to re-use.

Referring to the customer's SAE White Paper, the customer desire for, if not commitment to, Object Oriented (OO) technologies is clear. The requirements descriptions are phrased in OO jargon, driving solution choices to that technology.

OO technology does support icon creation and can update supporting databases by icon manipulation. A very attractive feature is that software code can be generated directly from functional flow diagrams. This can significantly speed development, especially in a systems engineering oriented program where requirements analysis is afforded a high priority. The drawback is that OO is a nascent technology with perhaps ten implementation methodologies, each with their own specialized notation. An engineering study must be undertaken as part of the Acquisition Support task to decide which, if any, OO technology is recommended. The leading language contender is C++ which many of the code generators use to create the OO programs.

Criteria for the study include:

- Maturity. Have products been built and fielded with the candidate product.
- Support Tools. Are CASE tools and code generators available.
- Data support. Is a database technology included, available, or recommended to support the candidate product. For instance, what hierarchies are supported? When one object is appended to another, do the data relations also become appended?
- Suitability. Can the candidate product implement the IMWS requirements?
- Object Linking Environment (OLE). Does the candidate product support OLE? When a change is made to an object, or to it's data or relationships, are all other objects/data/relationships for which links have been defined updated? Is the linking technology easy to use? (Linking technology has important applications. The IMWS data, especially the QSS, can be complex and tightly coupled. Linking can help maintain operational coherence. Likewise, in development where relationships are likely to change, link driven updates help reduce time consuming and tedious searches through the system to eliminate the ricochet effect.

- Vendor Support. Is the vendor known and stable? Will the vendor be able to support the candidate product through the IMWS life cycle? How are upgrades managed?
- Developer and Maintainer Skill Levels. What skill sets are required to develop with the candidate product, and subsequently, what skills are needed to maintain programs created with it? Is vendor based training available?

Consultation with the corporate Object Oriented Core Team (OOCT) indicates that such a study would require one working month, and require about one and one half head's effort over that time. Draft requirements must be provided.

Included in this study should be a review of existing market applications. To be considered are to what degree commercial off the shelf (COTS) products satisfy the operational and functional requirements, and also how well do they fit into the desired technological OO paradigm. It could be that a program scheduler (such as the Microsoft Project) and a GIS package (such as Mapinfo) could be supported by a commercial database and the developers task is to build the inter-interfaces and the user interface. The final path chosen must satisfy the IMWS operational and functional requirements

5.5.2.2. Database

The local database must also be selected. File size and structure must be considered, and a programming capability, including a query language, must be included. The database programming capability must handle large and frequent program controlled inputs and outputs. Each time a session starts, each subsequent user query, and, in Phase 3, each scheduling action causes data to be transferred into and out of the local database. One of the first development needs is to select the local database. An engineering study must be undertaken as part of the Acquisition Support task to decide which database product is recommended.

Criteria for the study include:

- Maturity. Have products been built and fielded with the candidate product.
- Suitability. Can the candidate product implement the IMWS requirements? Is the candidate product specifically tailored to support any OO technology?
- Vendor Support. Is the vendor known and stable? Will the vendor be able to support the candidate product through the IMWS life cycle? How are upgrades managed?
- Developer and Maintainer Skill Levels. What skill sets are required to develop with the candidate product, and subsequently, what skills are needed to maintain databases and/or programs created with it? Is vendor based training available?
- Size. How many files, records, and fields are supported? It is expected that the IMWS will routinely manipulate hundreds of files in the QSS, with an upper limit of two thousand. The average number of fields is twenty per record, and average field length is 8 characters.
- Programming and Query Support. What programming or query languages are supported? The IMWS will require at least a query language support. Are any supported languages specifically OO compatible?
- Indexes and Relationships. How many indexes can be supported? How are they created? How much memory is consumed to support an index?
- Speed. How long does it take to generate query results? How is this time measured?

5.5.2.3. Development Workstation

The program must also acquire development workstations to host the initial development efforts. The workstations will be chosen anticipating the customer's choice. Due to opinions presented by the customer's System Test Engineering (STE) office, and the Engineering office's SAE paper, the expected choice is the Intel Pentium based processor running a windows environment with 500+ MB removable hard drive. An engineering study must be undertaken as part of the Acquisition Support task to decide which development workstation is recommended.

Four workstations are recommended, 3 to support each of the development tasks (Comms I/F, Data I/F, and Applications), and a fourth to support external interface development.

These initial actions support program schedule goals while mitigating risk of the customer workstation choice dependency. The risk remains that if poor technical selections are made, or if the customer has a significant change of plans, the early development effort is lost. In this worst case scenario, workstations and development tools have been acquired that can be applied to other endeavors.

5.5.3. Three Phase Development

Development is divided into three phases. The first phase provides the interfaces and infrastructure, and a minimalistic SAEAT applications set. The first phase contains the start-up risks and problems. The second phase provides wider SAEAT capabilities and expands the IMWS data structures. The third phase implements the QSS, adds database update capability, and further expands the IMWS capabilities. As discussed earlier, the three phase plan supports risk mitigation and provides separate stand alone deliveries during the project.

5.5.4. Development Methodology

Not only is the project broken into phases, but it further decomposes to critical items and components. Four critical items are identified: the communications interface (Comms I/F)), database interface (Data I/F), and applications. Applications are considered two critical items, SAEAT and QSS. Applications further decompose into components and are listed in Table 5.5-1.

Table 5.5-1 IMWS Component Allocation to SAEAT and QSS Applications Critical Items

SAEAT		QSS
Phase 1	**Phase 2**	**Phase 3**
Query	Query	Query
Display	Display	Display
Utilities	Utilities	Utilities
Interfaces	Interfaces	Interfaces
		Resource Mgt
		Assignments

5.5.5. Incremental Development

Critical items (CIs) and components (Cmps) are evaluated for their suitability for incremental development. The following tests are applied:

Is this a high risk subject?

Does this have a user interactive interface?
Is this an area of requirements uncertainty?

If the answer to even one of these questions is yes, then the incremental development approach should be considered. If the answer to two or all three is yes, strong consideration to an incremental development should be given.

Feedback is the key ingredient in an incremental development. The customer's technologists and users participate in each cycle. The scenario for incremental development may follow this model (other variations are possible, depending on the problem and the people participating):

The development contains several cycles, each with a set of goals and constraints. Solution strategies are developed within the cycles, then executed. The progress through a cycle is orderly, and follows a four activity sequence. The first activity defines the scope for that cycle. The objectives are set, constraints identified, and possible Alternatives identified. The second activity is dedicated to risk identification and mitigation. Mitigation may include modification of that cycle's objective, but an impact assessment must accompany such a change. The third activity is to implement the decisions that fulfill the objectives. The fourth phase is to measure and test the product against the objectives for that cycle. The test results are analyzed, and the degree of success determined. The results provide the foundation for the next cycle.

The number of iterations should be planned, and is constrained by time and budget. Objectives need to be judiciously chosen. The end requirements for a development are specified, and the aggregate objectives meet the requirements. Each cycle should be evaluated against the requirements for the CI OR Cmp being developed. The results should include whether the requirements can be met with the remaining planned cycles.

Customer users and technologists participate throughout the cycle. Each team will have to work out its own dynamics, but the development engineer is in charge. All team members must commit to that cycle's objectives and maintain discipline. The customer personnel bring insight to the development process that allow the product to be built more authentically. Field discrepancies and repairs are expected to be reduced, and this supports ease of maintenance and reduces life cycle support cost. Table 5.5-2 lists the CIs and Cmps in the IMWS project and provides the results for the above mentioned test. Those items that are to be reviewed are marked with one asterisk, and those items that will be developed incrementally are marked with two asterisks.

Table 5.5-2 IMWS Tasks Reviewed for Incremental Development

Phase 1: SAEAT	
Phase 1 Infrastructure	
Communications	*
Development Tool Set	*
Database	*
Phase 1 CPCIs and Components	
Database Interface	*
capabilities	*
data definition file	*
SAEAT data structures (schema)	*
Applications	**
Display	**
Icons (objects)	**
Windows	**
Backdrop	**
Menus	**

Query	**
Methods	**
Utilities	**
Terminal Control	**
Session Control	**
Reports	**
Communications Monitor	*
Schedule Performance Monitor	**
Interfaces	*
Internal	*
External	*
Phase 1 Contingencies	
Standard Workstation	*
Communications Network	*
Phase 2: SAEAT Additions	
Phase 2 Infrastructure	
Communications (expanded)	*
Database (expanded)	*
Phase 2 CPCIs and Components	
Database Interface (expanded)	*
capabilities	*
data definition file	*
SAEAT data structures (schema)	*
Applications	**
Display	**
Icons (objects)	**
Query	**
Methods	**
Utilities	**
Reports	**
Schedule Performance Monitor	**
Interfaces	*
Internal	*
External	*
Phase 3: QSS	
Database	*
data definition file	*
QSS data structures (schema)	*
Applications	**
Display	**
Icons (objects)	**
Menus	**
Query	**
Methods	**
Areas	**
Assignments	**
Resources	**

Resource Management	**
Subtask Assignment	**
Utilities	**
Terminal Control	**
Session Control	**
Reports	**
Communications Monitor	*
Schedule Performance Monitor	**
Interfaces	*
Internal	*
External	*

Development for each phase will proceed to completion, and will follow the strategies outline in this section and Section 5.1. The Implementation Plan in Section 5.7 details the incremental development sessions and integration plans.

5.6. *Interface Control*

Two interface types require attention: internal and external. Internal interfaces consist of those communications between modules within the IMWS, and external interfaces consist of communications between the IMWS application and the other DPS hosts. The external interfaces are all accomplished via communications with the PM/S host. This section provides the guidance for developing and controlling the IMWS interfaces. It's main goal is to maintain coherence among the IMWS processes during development and integration. If this is successful, the fielded IMWS interfaces are expected to work.

5.6.1. Internal Interfaces

Figure 5.6-1 shows the Phase 1 and 2 interfaces, and Figure 5.6-2 shows the Phase 3 interfaces. Arrow heads denote the interface point and direction. Dotted lines are directed toward an external interface, and are provided to show that the Comms I/F must decide if a transaction is to an internal or external interface.

The Comms I/F is the interface adjudicator. The Comms I/F must know what the transactions are, what the source is, and what is the intended destination. The Data I/F talks only to the Comms I/F and the local database. All paths to the database are from a source, through the Comms I/F, through the Data I/F which performs the actual queries and generates the results report, to the database. Data output is the reverse process. The Comms and Data I/F processes exist primarily to facilitate the IMWS interfaces.

The Display Process is supplied dynamic inputs from all other processes. The Display process contains and manages the session's display elements, and other process are calling the display Process for these elements. The Display Process has an output interface (see Figure 5.6-3) that sends the data to the workstation display (through the Comms I/F).

The Utilities Processes call the display and the local database. Likewise, the Query Processes call the display and the local database. Results are returned to the Display Process, and/or directed through an external interface such as a printer.

The Phase 3 configuration maintains all Phase 2 interfaces and adds two more processes, Assignment and Resource Management. A query provides data which Assignment and Resource Management manipulate. Changes are sent to the Display Process.

Table 5.6-1 IMWS Internal Interfaces and Relationships

Source Process	Originating Process	Destination Process	Purpose
Query	Query	Comms I/F	Query Database
Query	Query	Comms I/F	Update Display with latest action taken
Utilities	Utilities	Comms I/F	Request report or data to support production
Utilities	Utilities	Comms I/F	Update Display with latest action taken
Assign	Assign	Comms I/F	Update local databases with latest assignments
Resources	Resources	Comms I/F	Update local databases with latest resource status
Comms I/F	Query	Data I/F	Query Database
Comms I/F	Query	Display	Update Display with latest action taken
Comms I/F	Utilities	Data I/F	Request report or data to support production
Comms I/F	Utilities	Display	Update Display with latest action taken
Comms I/F	Assign	Data I/F	Update local databases with latest assignments
Comms I/F	Resources	Data I/F	Update local databases with latest resource status
Comms I/F	Data I/F	Display	Update Display with latest action taken
Comms I/F	Data I/F	Utilities	Return query results to support performance monitor
Data I/F	Query	Database	Query parameters for return to display
Data I/F	Utilities	Database	Query parameters to support reports
Data I/F	Utilities	Database	Query parameters to support performance monitor
Data I/F	Assign	Database	Assignment update data
Data I/F	Resources	Database	Resource status update data
Database	Query	Data I/F	Return query results
Database	Utilities	Data I/F	Return query results to support reports
Database	Utilities	Data I/F	Return query results to support production performance monitor
Database	Assign	Data I/F	Update display with new assignments
Database	Resources	Data I/F	Update display with new resource status
Database	Query	Comms I/F	Format and return query results
Database	Utilities	Comms I/F	Format and return query results to support reports
Database	Utilities	Comms I/F	Format and return query results to support production performance monitor
Database	Assign	Comms I/F	Format and return query results to update display with new assignments
Database	Resources	Comms I/F	Format and return query results to update display with new resource status

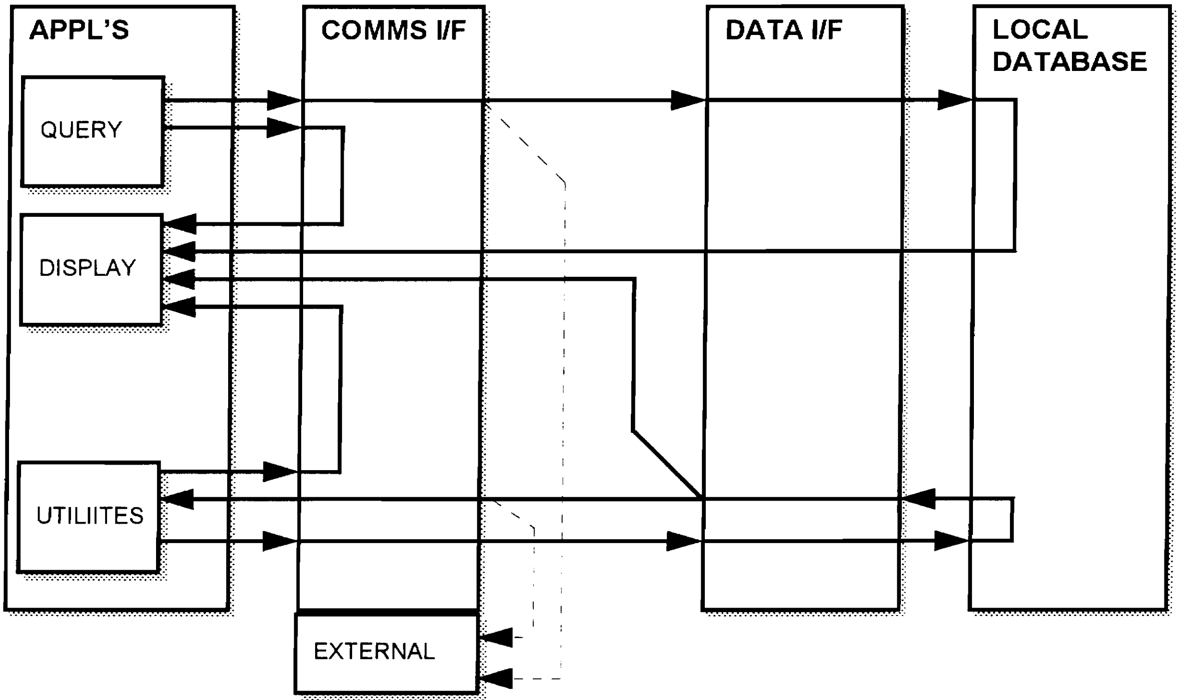


Figure 5.6-1 IMWS Internal Interfaces (Phases 1 & 2)

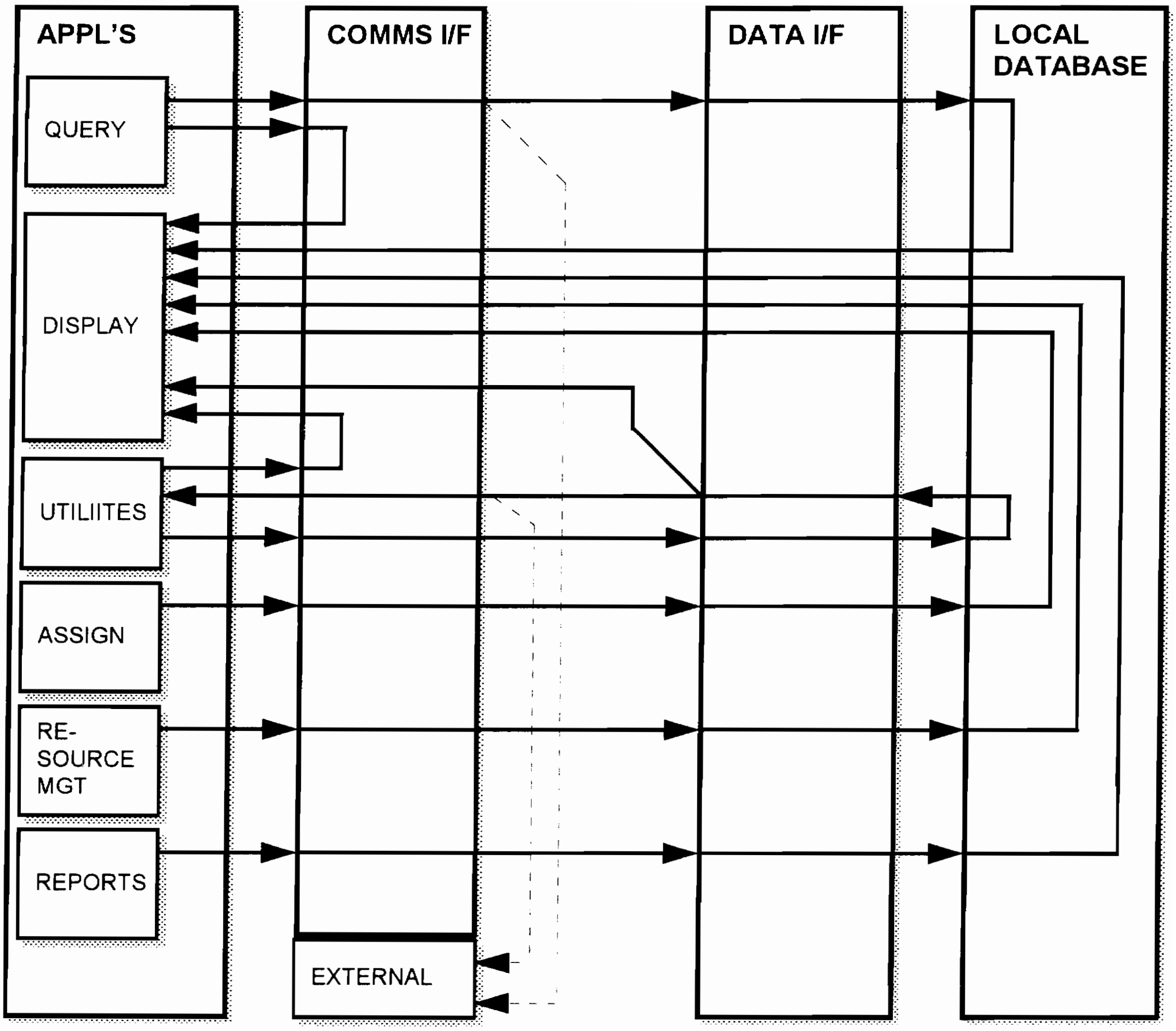


Figure 5.6-2 IMWS Internal Interfaces (Phase 3)

5.6.2. External Interfaces

Figure 5.6-3 shows the IMWS external interfaces. External interfaces are divided into two categories, those that go to the workstation environment, and those that go to the DPS network and remote hosts. All remote interfaces in this design go to the PM/S, and the PM/S in turn sends messages to other hosts as needed. Figure 5.6-4 shows existing interfaces that are affected by the IMWS.

A note regarding the existing interfaces. There is a choice: 1) either the IMWS can implement the interfaces and add to the suite of interfaces supported system-wide, or 2) the IMWS can implement a small set of interfaces with the PM/S, and the PM/S in turn uses existing interfaces to complete any required actions. Choice 1) has far reaching effects into the interfaces of each segment in the DPS. In effect, a new segment would be added to the DPS suite. All communications tables would have to be updated, and new messages and their formats would have to be defined. Further, instead of the single

PM/S host communicating with the production segment hosts, a number of IMWSs each appearing as a host, can communicate PM/S like information.

Choice 2) requires several new interface messages with the PM/S host and changes to those shown in Figure 5.6-4. Although less efficient, choice 2) has much less impact on the DPS and requires much less effort to implement. Choice 2) is accepted for this design.

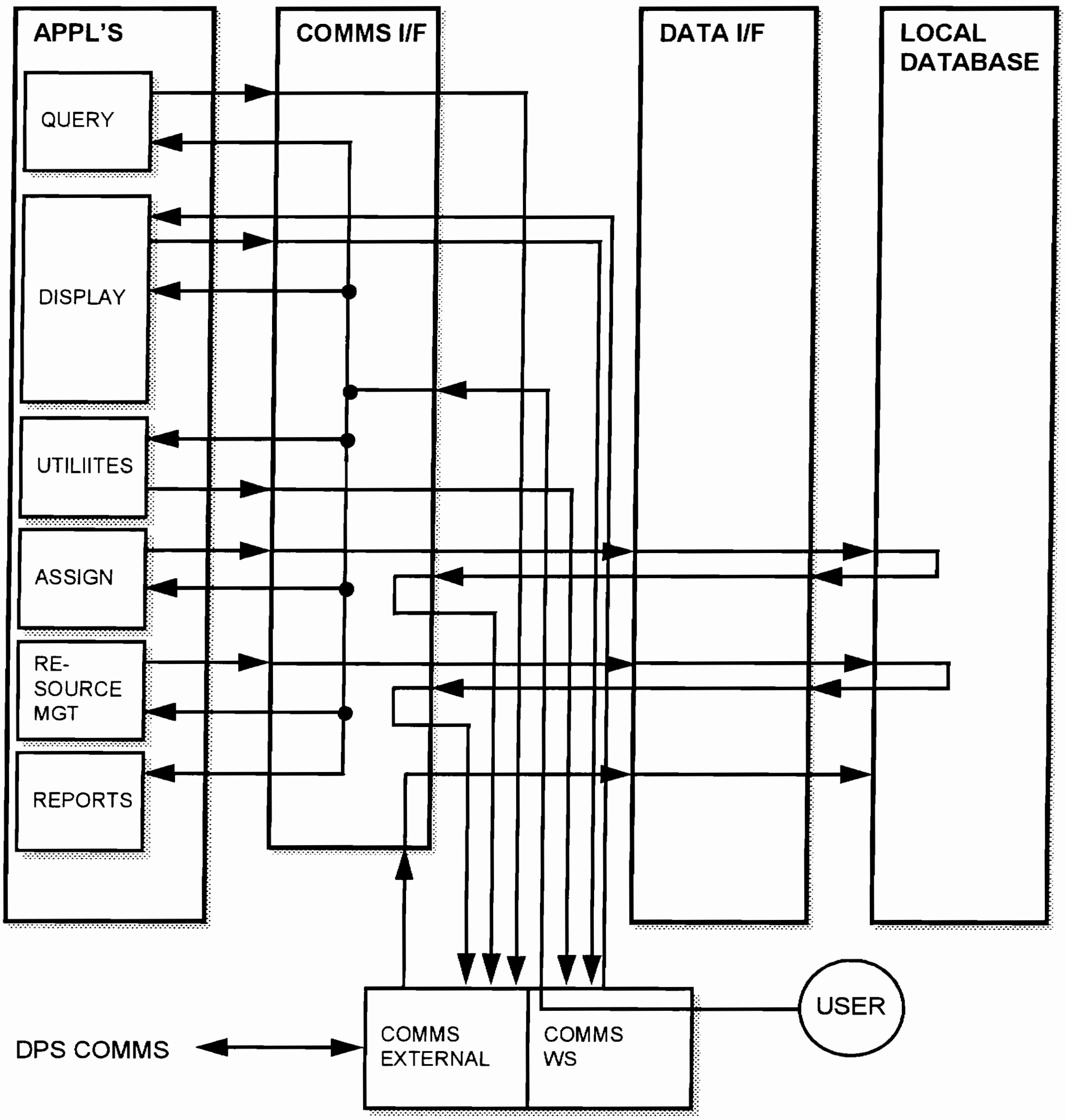


Figure 5.6-3 IMWS External Interfaces

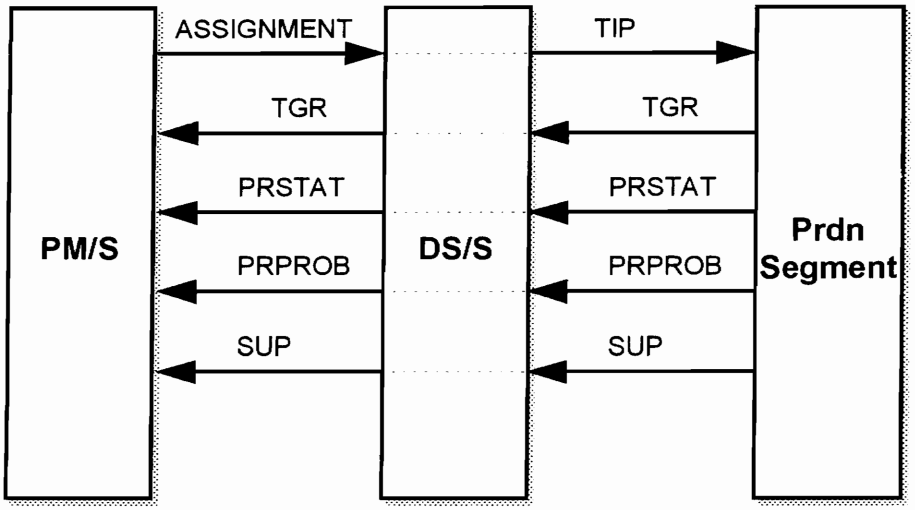


Figure 5.6-4 Existing PM/S Interfaces Impacted by the IMWS

All processes talk to the external interfaces through the Comms I/F. The Comms I/F adjudicates all traffic through the external interfaces. The Comms I/F must recognize each source, it's associated destination, and the message type. The Comms I/F accepts all inputs from external sources and directs them to the appropriate process.

The Display Process communicates with the host workstation environment to present the session activity on the host workstation CRT. The display also accepts user inputs.

Utilities communicate with the host workstation operating system for terminal and session control, and to direct reports to output devices.

The query process must communicate with the PM/S host to obtain the data the IMWS will use. It also accepts user input.

Both Assignment and Resource Management write updates to the local database which are in turn propagated to the PM/S database.

The Data I/F generates the updates for the local database, then translates the changes to the PM/S M204 data format for PM/S consumption. The Data I/F also accepts the query results from the PM/S, translates them to the format compatible with the local database, and loads the data. The local database has no direct external interfaces as that responsibility is handled by the Data I/F.

Table 5.6-2 IMWS External Interfaces and Relationships

Source Process	Originating Process	Destination Process	Purpose
Display	Display	Comms I/F	Interface to Host WS CRT
Utilities	Utilities	Comms I/F	Interface to Host WS for terminal control, session control, and report output

Source Process	Originating Process	Destination Process	Purpose
Query	Query	Comms I/F	Interface to PM/S database to obtain data
Assign	Assign	Comms I/F	Assignment data updates destined ultimately for the PM/S database
Resources	Resources	Comms I/F	Resource status data updates destined ultimately for the PM/S database
Comms I/F	Display	Host WS	Interface to Host WS CRT
Comms I/F	Utilities	Host WS	Interface to Host WS for terminal control, session control, and report output
Comms I/F	Comms I/F	PM/S	Session initiation and logon procedures
Comms I/F	Assign	PM/S	Assignment data updates destined ultimately for the PM/S database
Comms I/F	Resources	PM/S	Resource status data updates destined ultimately for the PM/S database
Comms I/F	Query	PM/S	Interface to PM/S database to obtain data
User	User	Comms I/F	User input to display
User	User	Comms I/F	User Input to utilities
User	User	Comms I/F	User input to query
User	User	Comms I/F	User input into assign
User	User	Comms I/F	User input to resources
Comms I/F	User	Display	User input to display
Comms I/F	User	Utilities	User Input to utilities
Comms I/F	User	Query	User input to query
Comms I/F	User	Assign	User input into assign
Comms I/F	User	Resources	User input to resources
PM/S	PM/S	Comms I/F	Query results for the IMWS

5.6.3. Hybrid Interfaces

Figure 5.6.3 shows some interfaces that appear to be internal, but that ultimately support a thread to an external interface. These internal/external interfaces are identified herein as hybrid. They include the interfaces between the Comms I/F and the Data I/F, and the Data I/F and the local database that particularly support data exchange with the PM/S. These interfaces are catalogued in Table 5.6-3.

Table 5.6-3 IMWS Hybrid Interfaces and Relationships

Source Process	Originating Process	Destination Process	Purpose
Comms I/F	Assign	Data I/F	Assignment data updates destined ultimately for the PM/S database
Comms I/F	Resources	Data I/F	Resource status data updates destined ultimately for the PM/S database
Comms I/F	PM/S	Data I/F	Interface to Host WS CRT
Data I/F	Assign	Comms I/F	Interface to Host WS for terminal control, session control, and report output

Source Process	Originating Process	Destination Process	Purpose
Data I/F	Resources	Comms I/F	Interface to PM/S database to obtain data
Data I/F	Assign	Database	Assignment data updates destined ultimately for the PM/S database
Data I/F	Resources	Database	Resource status data updates destined ultimately for the PM/S database
Data I/F	PM/S	Database	
Database	Assign	Data I/F	Interface to Host WS CRT
Database	Resources	Data I/F	Interface to Host WS for terminal control, session control, and report output

5.6.4. Interface Implementation

All interfaces catalogued in this section must be implemented and also documented in the Interface Control Document. It is recommended that the Comms I/F be presented with a uniform format that internal interfaces must comply with. External interfaces will have to be engineered against what the customer provides, but a uniform format is expected. The interface data must be encapsulated in at least a header record. The header must contain the source process, the destination process, the type of message, and the message length.

5.7. Implementation Plans

The implementation plans include the details for the expected incremental development, then the migration from prototype to test to production. There are three phases, each with specific goals. Each phase has it's implementation cycle. Implementation begins when the software development tools, language(s), and local database have been selected. The development scenarios are similar, regardless of the technologies chosen.

Some activities are very mechanical in nature and tend to occur in the background. As such, these activities do not lend themselves so readily to the incremental development approach. During Phase 1, the IMWS to PM/S-M204 interface must be developed. The user generated query must be translated to M204 user language, transmitted to the PM/S, the results received and loaded into the IMWS database. This task is done in a more traditional manner, building against functional requirements.

A note about incremental development. This technique is a hybrid of design review and specification writing. It is used to arrive at the best solution for the customer by incorporating customer feedback as designs and prototypes are developed. The technique takes advantage of the speed and ease with which prototypes can be developed using certain software tools and technologies. CASE tools that are code generators and can generate code from functional diagrams are necessary to support an incremental development program. It is the intent that downstream design changes and subsequent site modifications can be minimized. The great contrast is that in traditional design, the customer buys a specification at a design review, and the developer then builds to that spec with little further customer feedback or intervention. The baseline is tightly controlled, and further change is indeed expensive. The incremental method incorporates customer feedback and accepts change during the design implementation. Requested changes are reviewed for scope consistency, and response time is expected to be much quicker.

Incremental development is accomplished in a series of sessions, defined and controlled by the implementation plan. Considerable latitude is given to developers to find solutions to meet the requirements. Each session has success criteria a set of goals to be met during the session. Participants are chosen to support each session based on knowledge of the that session's issues. The session will be attended typically by three development personnel and at least two customer personnel. Development management presence at the session is provided by this plan. The development personnel include the software engineer, knowledgeable with the chosen CASE tools; the systems engineer, knowledgeable with the operational and functional requirements; and a third person of various skills to document the session and its decisions. The customer personnel should include the appropriate user, in this case the L2 supervisor, and a member of the customer's technical staff, knowledgeable with the operational and functional requirements.

Table 5.7-1 shows the sessions planned for each phase. In the discussion present below for each phase, this Figure will be decomposed to support the topics addressed in each phase.

Table 5.7-1 Incremental Sessions Planned per Phase

Phase 1	Phase 2	Phase 3
Session 1 Session 2 Session 3 Session 4 Session 5 Comms I/F Database I/F Integrate & Test Install	Session 1 Session 2 Comms I/F Database I/F Integrate & Test Install	Session 1 Session 2 Session 3 Session 4 Session 5 Session 6 Session 7 Comms I/F Database I/F Integrate & Test Install

5.7.1. Phase 1 Development

The Phase 1 goal is to create the display similar to the Level 2 view shown in Figure 3.3-1 Much of the Phase 1 development will be accomplished incrementally with customer participation. A series of four sessions will be held. The goals of each session are defined herein, and will be achieved for form, fit and function. The desired displays, the manipulations to those displays, and desired output reports will be created. Software tools will be employed during these sessions to generate the code that supports the displays and their interactions. At the end of each session, an evaluation of the session's success will be conducted. Action items will be developed for deficiencies and for additionally desired capabilities. Deficiencies will certainly be addressed as a corrective program, and desired capabilities will be reviewed for scope impact. If possible, desired capabilities can be added to future planned development sessions.

Phase 1, Session 1

The goals are quite, but deceptively, simple. Figure 5.7-1 illustrates the session issues. The workstation has been equipped with a windows based operating system, CASE tools, a local database, and a base map. The base map is expected to be the Digital Chart of the World (DCW) supplied by the Defense Mapping Agency (DMA). The first session will establish:

- logon procedures and screen appearances and messages;
- menus and selections, especially to display the base map;

- window definition/creation for the base map display;
- base map display parameters;
- the ability to "scroll" across the base map.

Phase 1, Session 2
The session 2 goals are concerned with the data structure needed to support the information to be displayed. Creation of the job icon is also included. Figure 5.7-1 illustrates the session issues. The second session will establish:
- data structures needed to support the job display;
- the ability to display the job by coordinates against the base map;
- the method to form a query.

Although these are only three issues, they are paramount to the SAEAT success. At session two, data will be created by hand by the developers and placed as needed into the database. The ability to import data is developed and demonstrated later. The necessary data structures are listed in Table 5.7-2.

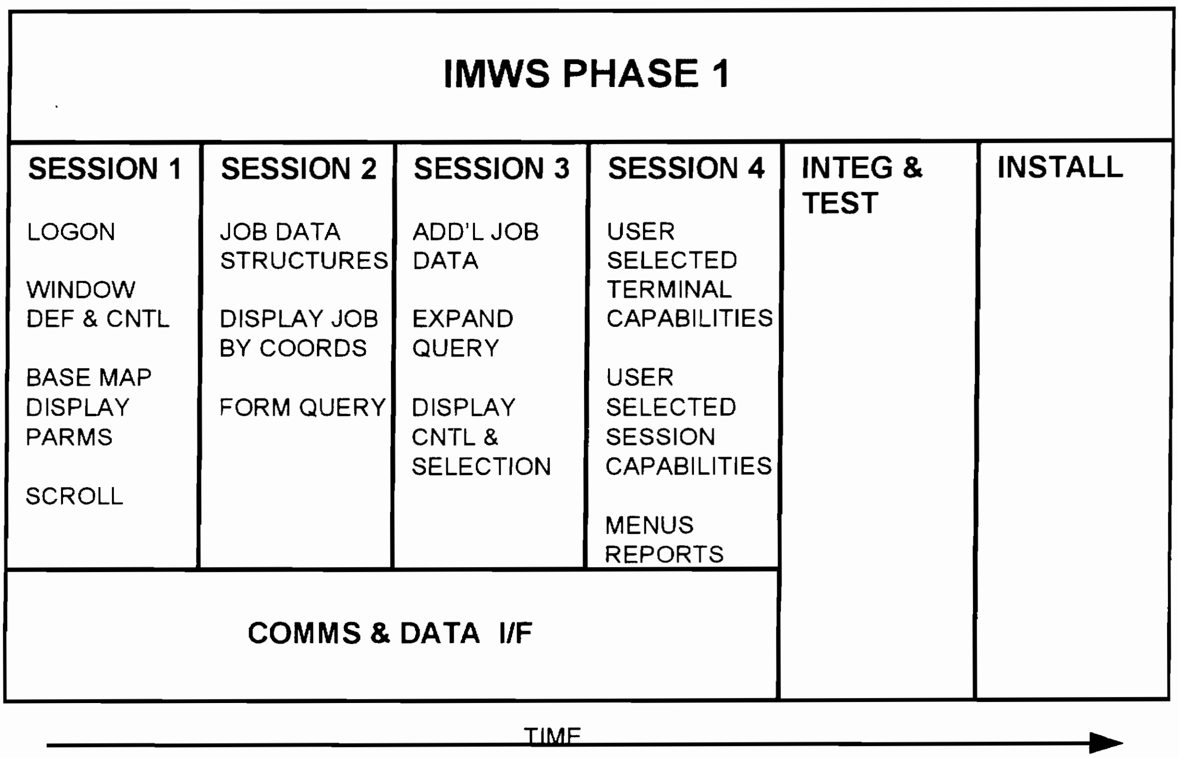


Figure 5.7-1 Phase 1 Incremental Development Session Issues

Table 5.7-2 Phase 1 Session 2 Required Data Structures

File	Field	Format	Comments
JOBSCHED	JOB_ID	CHAR, 10	Unique job identifier
	STANDARD_ID	CHAR, 11	Standard that is the basis for the job
	ADJUSTMENT_ID	CHAR, 7	Unique adjustment to the standard to support the specific job
	PROJECT_ID	CHAR, 8	Unique identifier for the family of jobs

	SW_LAT SW_LON NE_LAT NE_LON	TBD TBD TBD TBD	Latitude and longitude from opposite corners defining the assigned job area. Format will be chosen by the developers to support the greatest efficiency

Phase 1, Session 3
The session 3 goals are concerned with the data structures needed to add the desired attributes to the job and display them. Display management is another issue. Figure 5.7-1 illustrates the session issues. The third session will establish:
- the attributes to be added to the job, and their supporting data structures, listed in Table 5.7-3;
- expand the query capability to include the added data structures;
- expand the query capability to collect multiple jobs by a single coordinate set query or by a project query;
- define methods to select and display the job attributes.

In session 3, data will be created and populated by the developers on an as needed basis.

Table 5.7-3 Phase 1 Session 3 Required Data Structures

File	Field	Format	Comments
JOBSCHED	PLAN_START	YYYYMMDDHHMM	Job planned start date
	PLAN_COMP	YYYYMMDDHHMM	Job planned start date
	SCHED_START	YYYYMMDDHHMM	Job scheduled start date
	SCHED_COMP	YYYYMMDDHHMM	Job scheduled start date
	ACTUAL_START	YYYYMMDDHHMM	Job actual start date
	ACTUAL_COMP	YYYYMMDDHHMM	Job actual start date
	PERCENT_COMP	N, 2	Job percent complete
	ETC_HRS	N, 4	Job estimate to complete work hours
	STD_DUR	N, 4	Job expected duration calculated in the JSS
	JOB_STATUS	CHAR, 1	Job status codes: P = planned S = scheduled W = in work F = finished C = canceled

Phase 1, Session 4
The session 4 goals are concerned with utilities needed to manage the session. Display characteristics, session defaults, and user choices and preferences are addressed. Also, report capabilities are included. Figure 5.7-1 illustrates the session issues. The fourth session will establish:
- terminal capabilities to be user controlled, such as cursor style, auto-save, history, audit logs, etc.;
- session capabilities to be user controlled, such as windows set-ups, canned data queries, startup defaults, monitors for communications and system health, colors and shadings used to represent attributes;
- the overall menu system;

- report generation, including graphic screen prints and user formulated and formatted tabular reports.
- user display controls, including zoom and scroll

Phase 1 Traditional Development Issues
The database interface between the IMWS database and the PM/S native M204 database is the primary issue. There are assumptions that must support the database interface effort:
- the communications system and protocols have been installed and work correctly;
- the communications software includes monitoring utilities that the IMWS design can use to present communications performance/events on the IMWS display;
- that a windows based presentation manager is included in the agency standard workstation operating system.

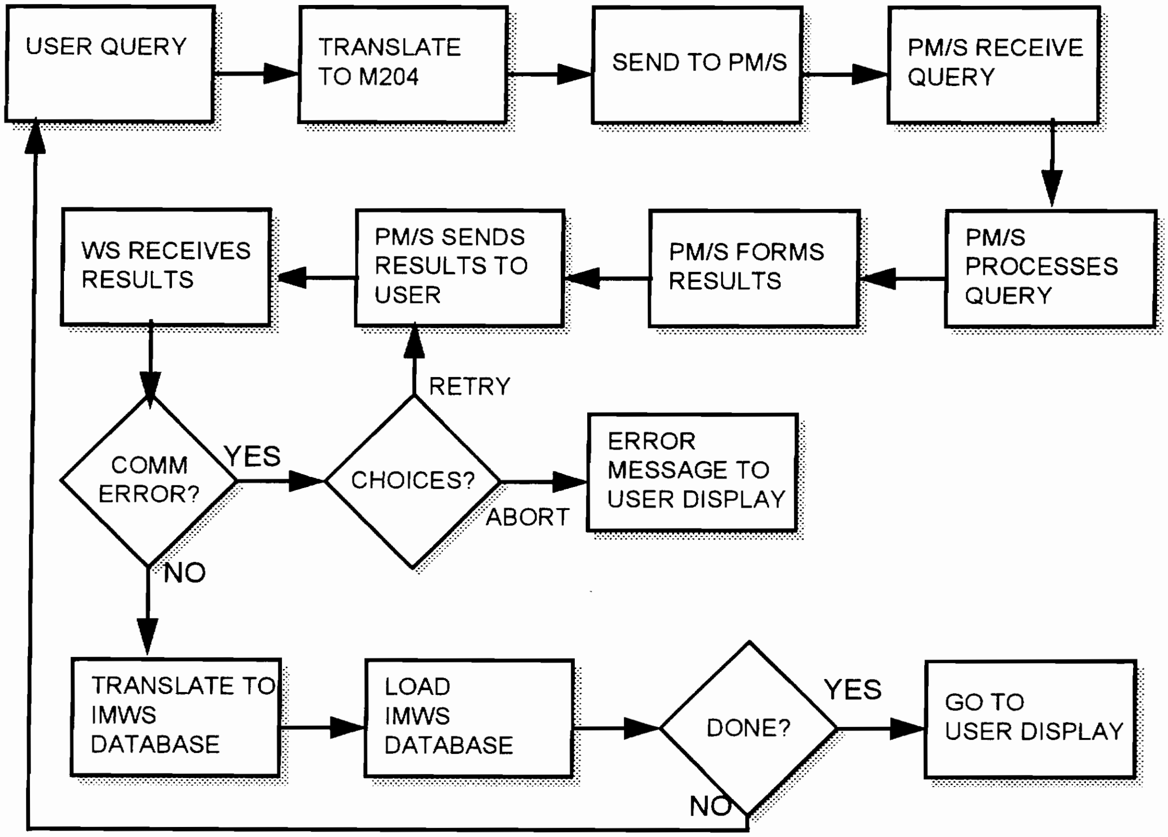


Figure 5.7-2 Query Interface to the PM/S M204 Database Process Flow

The functional flow diagram is shown in Figure 5.7-2 and supports the following functional requirements.

The database interface functional flow begins when the user has formulated the query. The query is translated to M204 user language and sent to the IMWS comms handler which delivers the query to the PM/s host. Data format is assumed valid because data choices provided to the user developed in sessions 2 and 3 are only valid choices. Content cannot be validated because it is not possible to know all future data combinations. Table 5.7-4 contains the Phase 1 IMWS data and the M204 equivalent. Also refer to Section 5.6 which discusses these interface issues.

The PM/S ICD must be changed to accept the query as valid. The PM/S Intersegment Interface (ISI) CPCI handles the incoming messages. The transmitted message must contain a header record that identifies the record type and the transmitting workstation id. New message header formats must be in accordance with the existing format: field contents must be identified with the new information. The ISI internally held message type table must be updated to include the IMWS query. The ISI internally held table of valid hosts must be expanded to include each IMWS in the system. The ISI then handles the query and assembles the results for transmission back to the sender.

Table 5.7-4 IMWS Database Equivalents to the PM/S M204 Database

IMWS		**PM/S**		
File	**Field**	**File**	**Record Type**	**Field**
JOBSCHED	JOB_ID	JOBSCHDF	JOBSW	JOB_ID
	STANDARD_ID			STANDARD_ID
	ADJUSTMENT_ID			ADJUSTMENT_ID
	PROJECT_ID			PROJECT_ID
	SW_LAT			note 1
	SW_LON			note 1
	NE_LAT			note 1
	NE_LON			note 1
	PLAN_START			PLAN_START_DATE
	PLAN_COMP			PLAN_COMP_DATE
	SCHED_START			SCHED_START
	SCHED_COMP			SCHED_COMP
	ACTUAL_START			ACTUAL_START
	ACTUAL_COMP			ACTUAL_COMP
	PERCENT_COMP			note 2
	ETC_HRS			note 2
	STD_DUR			STD_DUR_HRS
	JOB_STATUS			JOB_STATUS_CODE

Note 1. Several coordinate fields and conventions exist in the PM/S job file. The Designer will choose those fields which can be most easily manipulated b the IMWS applications.

Note 2. These fields do not exist in the PM/S database. Investigate whether to add them to the PM/S structure, or to calculate them from other PM/S held data to be used only in the IMWS.

The DPS communications system then delivers the results to the IMWS, or, in the case of a failure, delivers the error message. If an error was detected, a message is provided to the user that the error has occurred, and provides the user with the choice to retry or abandon the attempt. Retry reinitiates the process, and abandonment leads to the user back to the initial session screen.

When the IMWS receives the query results, they are translated to the IMWS database form and loaded into the database. The user is provided the message that the transaction is complete, and the query results are displayed according to the user's previously selected format.

Phase 1 Integration

When all development sessions and the traditional development have been completed, the development results must be integrated into one package on the workstation. All elements are to be installed and then exercised to demonstrate the IMWS Phase 1 functionality. Prior to executing the formal integration exercise, defined by the IMWS Phase 1 Functional Checklist in Table 5.7-5, a readiness review will be held. The readiness review will address integration completeness and define those issues controlled by notes in the checklist..

Table 5.7-5 Integration Requirements Verification Checklist

Done	Item	Activity	Comment
☐	1	Logon to session	Session initiated
☐	2	Select top menu	Top menu is displayed with choices: Terminal Control Session Control Query Reports
☐	3	Select Terminal Control	note 1
☐	4	Exercise Terminal Control options	notes 1, 2
☐	5	Exercise Session Control Options	notes 1,3
☐	6	Create and store queries	Queries include: coordinates PROJECT_ID JOB_ID
☐	7	Run query on line	Returned to the screen is the query result displayed against the backdrop map. Run queries in boolean combination, coordinates and PROJECT_ID. Notes 4 and 5.
☐	8	Run stored queries	Same as Item 7, notes 4 and 5.
☐	9	Modify displayed results presentation	Select attributes control from Session Control menu. Screen updates in accordance with user selections. Note 6.
☐	10	Resize window	Resize window, do not change displayed query results content.
☐	11	Zoom in	Select portion of display to zoom in, do not change query results content
☐	12	Zoom out	Select zoom out, do not change query results content
☐	13	Scroll display	Select scroll and modify the display. Do not change displayed query results content.

Note 1.
The screen appearance and options specified will be an output of the interactive sessions. When determined, the data will be added as an appendix to this checklist, and will be the basis for verification

Note 2.
Actual options available will be an output of the interactive sessions. When determined, the data will be added as an appendix to this checklist, and will be the basis for verification. Options must include: cursor adjustment, auto-save, session history, audit logs.

Note 3.

Actual options available will be an output of the interactive sessions. When determined, the data will be added as an appendix to this checklist, and will be the basis for verification. Options must include: window set-up capabilities, establish and demonstrate start-up defaults, monitor set-ups for system and comms health and status, attribute display settings.

Note 4.
For integration, requires simulator support.

Note 5.
The appearance of job displays is determined by interactive development sessions and defaults chosen.

Note 6.
Actual options available will be an output of the interactive sessions. When determined, the data will be added as an appendix to this checklist, and will be the basis for verification. Options must include: attribute list and display selections for each

Phase 1 Integration Environment
The integration is performed in a stand-alone mode, so a representative interface to the IMWS must be devised. Two choices exist: 1) obtain access to a network similar to DPS or 2) simulate the DPS environment.

To use choice 1), the network must be identified and must share characteristics with the DPS network (which remains undefined at this writing). The network must have resident a host which runs M204 on which the developers can obtain an account, and on which they can create their own M204 database region. Given these accomplishments, the developers would then have to create the IMWS test M204 region and its test data.

To use choice 2), the communications and data exchange must be simulated. One possible method is to define a logical host within the IMWS integration machine: that is, the IMWS and simulator will be co-hosted on the same machine. The query is sent and routed to the simulator logical address. The tester receives the query and creates a report to screen and printer. The message content is evaluated for validity, either by a test tool process or tester analysis (or both). Previously created expected responses are stored in the simulator, and the tester can select one and return it to the IMWS host which processes it as it normally would.

Choice 1) presents considerable challenge for several reasons:
- It relies on systems and environments external to the development environment. Both schedule and technical risk can be incurred, especially when the network and M204 host priorities do not coincide.
- Further is a cost factor. Typically, subscription fees would be encountered, and may not be efficient resource use.
- The configuration presents aspects that are beyond the tester's control, and can introduce variables that may influence the integration results.

Choice 1) has the advantage that the communications interface would be fully exercised.
Choice 2) also presents it's challenges:
The simulator is it's own design and implementation effort. The operator controls and capabilities must be developed in addition to the IMWS. It is expected that the software developers will create test tools during the normal development course that can be used by the integrators and testers.
- The internal communications must be designed. The development workstation is expected to be equipped with the same communications protocol as that chosen by the DPS. However, if that is not

known at the integration time, the best approximation will be used. In that the communications interface is simulated, there would be no ultimate damage through excess commitment to the integration effort.
- All content and format of expected responses must be anticipated, created, and loaded into the simulator.

Choice 2) has the advantages that it is entirely within the IMWS development domain and can be effectively managed. Further, once the simulator is developed, it can be reused for additional integration efforts. Production units will number in the dozens to hundreds, and the simulator can be used to integrate each production unit. The simulator can also be used to support the Phase 2 and 3 developments.

Choice 2 is preferred and selected to support the IMWS development. The simulator functions are driven by the integration Phase 1 checklist activities listed in Table 5.7-5 The simulator configuration is shown in Figure 5.7-3.

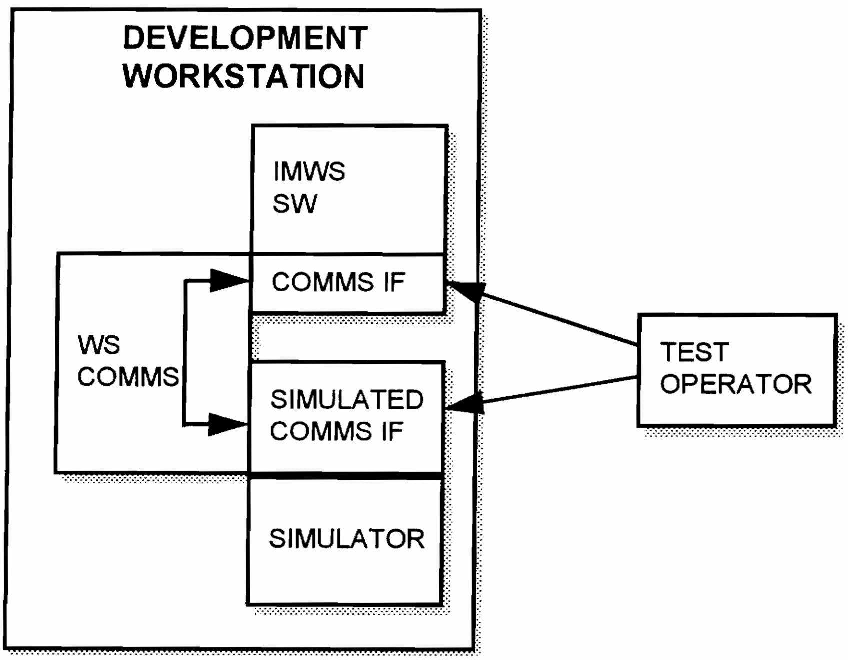


Figure 5.7-3 IMWS Integration Simulator Configuration

5.7.2. Phase 2 Development

The Phase 2 goal is to create the display shown in Figure 3.3-2 and it's supporting environment. The supporting infrastructure has been created in Phase 1, so Phase 2 only expands that infrastructure to accommodate the required Phase 2 data. The message structures created in Phase 1 support the additional content added by Phase 2 functions. Only two sessions are required to implement the Phase 2 requirements, as shown in Table 5.7-1. Figure 5.7-4 shows the Phase 2 session issues.

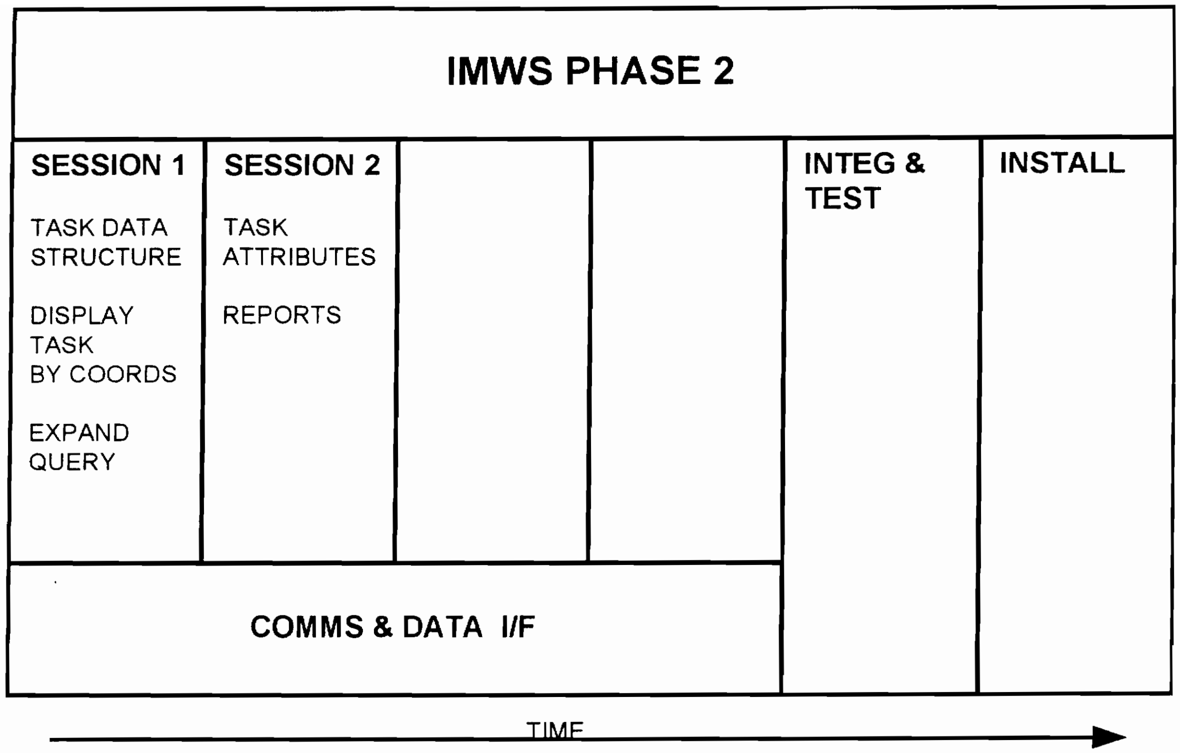


Figure 5.7-4 Phase 2 Session Issues

Phase 2, Session 1
The session 1 goals are concerned with the data structures needed to support the display shown in Figure 4.3-2. Task icon creation and connection to the data structures, and expanded query capabilities based on the new data structures are also included. The desired data structures are shown in Table 5.7-6, and the PM/S equivalents are shown in Table 5.7-7. The first session will establish:
- data structures needed to support the task display
- the ability to display tasks by coordinates
- expand query parameters

Table 5.7-6 Phase 2 Session 1 Required Data Structures

File	Field	Format	Comments
TASKSCHED	JOB_ID	CHAR, 10	Unique job identifier
	TASK_ID	CHAR, 5	Unique task identifier
	PRED_TASK_ID	CHAR, 5	Unique predecessor task identifier
	SUCC_TASK_ID	CHAR, 5	Unique successor task identifier
	PROJECT_ID	CHAR, 8	Unique identifier for the family of jobs
	T_SW_LAT	TBD	
	T_SW_LON	TBD	
	T_NE_LAT	TBD	
	T_NE_LON	TBD	Latitude and longitude from

File	Field	Format	Comments
			opposite corners defining the assigned task area. Format will be chosen by the developers to support the greatest efficiency
	T_PLAN_START T_PLAN_COMP T_SCHED_START T_SCHED_COMP T_ACTUAL_START T_ACTUAL_COMP T_PERCENT_COMP T_ETC_HRS	YYYYMMDDHHMM YYYYMMDDHHMM YYYYMMDDHHMM YYYYMMDDHHMM YYYYMMDDHHMM YYYYMMDDHHMM N, 2 N, 4	Task planned start date Task planned start date Task scheduled start date Task scheduled start date Task actual start date Task actual start date Task percent complete Task estimate to complete work hours
	T_STD_DUR	N, 4	Task expected duration calculated in the JSS
	TASK_STATUS	CHAR, 1	Task status codes: P = planned S = scheduled W = in work F = finished C = canceled

Table 5.7-7 IMWS Database Equivalents to the PM/S M204 Database (Phase 2)

IMWS		PM/S		
File	**Field**	**File**	**Record Type**	**Field**
TASKSCHED	JOB_ID TASK_ID PRED_TASK_ID SUCC_TASK_ID PROJECT_ID T_SW_LAT T_SW_LON T_NE_LAT T_NE_LON T_PLAN_START T_PLAN_COMP T_SCHED_START T_SCHED_COMP T_ACTUAL_START T_ACTUAL_COMP T_PERCENT_COMP	JOBTASKF	TASKS	JOB_ID TASK_ID PREDECESSOR_TASK_ID SUCCESSOR_TASK_ID PROJECT_ID note 1 note 1 note 1 note 1 PLAN_START_DATE PLAN_COMP_DATE PLAN_COMP_TIME SCHED_START_DATE PLAN_COMP_ TIME SCHED_COMP_DATE SCHED_COMP_ TIME ACTUAL_START_DATE ACTUAL_START_ TIME ACTUAL_COMP_DATE ACTUAL_COMP_ TIME note 2

IMWS		PM/S		
File	**Field**	**File**	**Record Type**	**Field**
	T_ETC_HRS T_STD_DUR TASK_STATUS			note 2 STD_TASK_DUR TASK_STATUS_CODE

Note 1. Several coordinate fields and conventions exist in the PM/S job file. The Designer will choose those fields which can be most easily manipulated b the IMWS applications.

Note 2. These fields do not exist in the PM/S database. Investigate whether to add them to the PM/S structure, or to calculate them from other PM/S held data to be used only in the IMWS.

Phase 2, Session 2
Session two goals are concerned with task attributes, their supporting data, and their method of display. Consideration will be given to the task display versus the job display, and how to manage both displays and still provide an orderly, analyzable visual output to the manager. Report options will be expanded to include task parameters. The second session will establish:
- identify desired task attributes
- methods to select and display task attributes, and coexist with the job display
- expand reporting capabilities

5.7.3. Phase 3 Development

Phase 3 provides the subtask perspective as shown in Figure 4.3-3 and allows the manager to create assignments and manipulate resources. The ability to update PM/S data is added in this phase, and further attention to external interfaces and the PM/S functions are required.

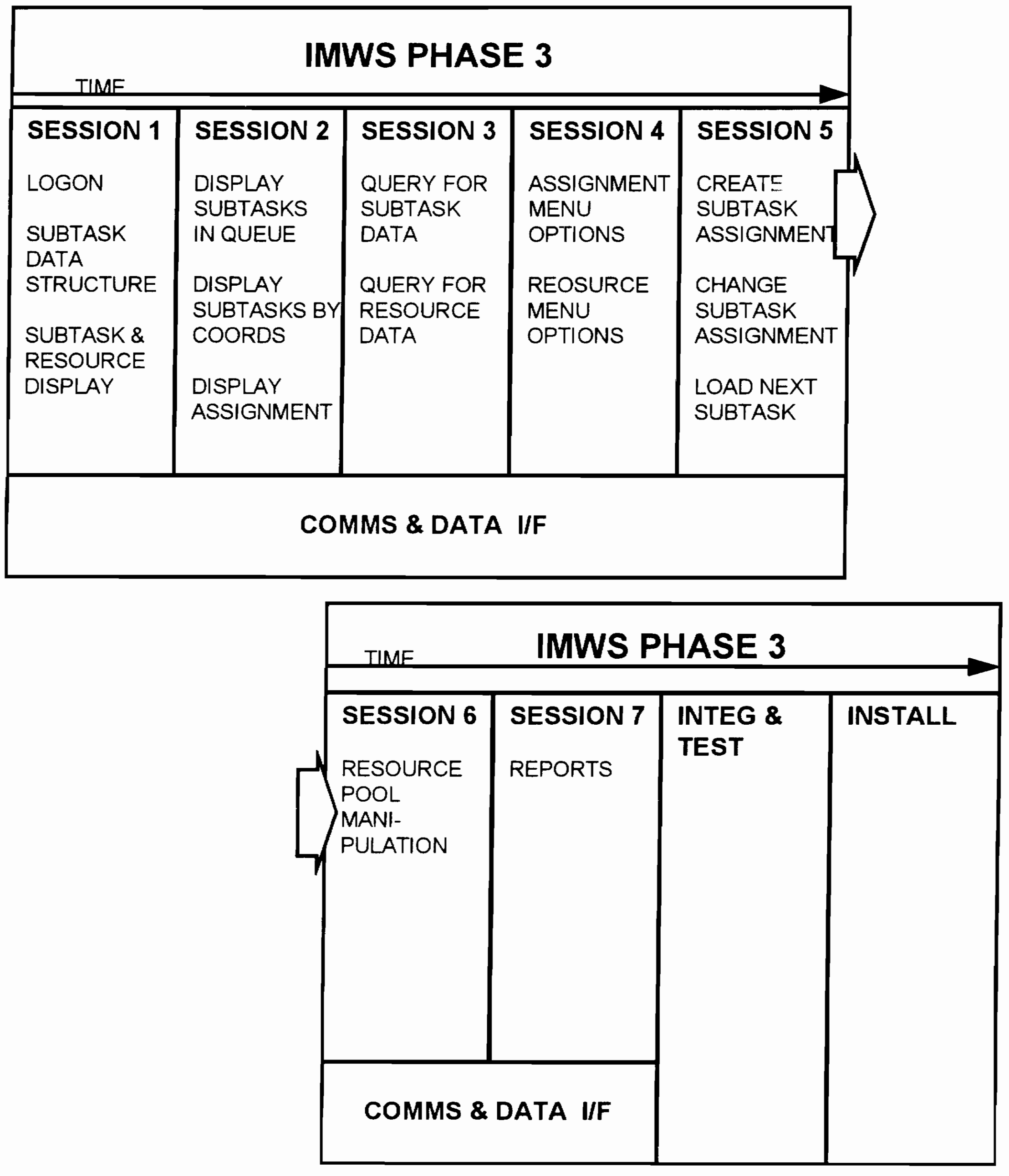


Figure 5.7-5 Phase 3 Session Issues

In Phase 3, there will be some areas where incremental development is appropriate while in others, traditional development will prevail, as discussed in Section 5.5 and shown in Table 5.5-2. Phase 3 incremental development will be accomplished in seven sessions. Issues managed by traditional development methods include additions to the Data I/F, internal and external interface development, and additions to the Comms I/F. Figure 5.7-5 shows the Phase 3 development issues.

Phase 3, Session 1
The goals of session 1 are concerned with the data structures needed to support the display shown in Figure 4.3-3. Subtask icon creation and connection to the data structures are also included. The desired data structures are shown in Table 5.7-8, and the PM/S equivalents are shown in Table 5.7-9. The first session will establish:
- data structures needed to support the subtask and resource display
- the ability to display subtasks and resources

Table 5.7-8 Phase 3 Session 1 Required Data Structures

File	Field	Format	Comments
TIPDATA HEADER			
	TIP_ID	CHAR, 28	Unique task identifier for header of TIP message sent to Production Segments. Concatenation of job_id, cal year, task_id, and sequence.
	TASK_ID	CHAR, 5	Unique TASK identifier
	SUBTASK_CT	N, 2	Subtask count
	ORG_CODE	CHAR, 5	Organization code for the organization to which the subtask is assigned; uniquely identifies one L5 (branch chief).
	T_SW_LAT	TBD	
	T_SW_LON	TBD	
	T_NE_LAT	TBD	
	T_NE_LON	TBD	Latitude and longitude from opposite corners defining the assigned task area. Format will be chosen by the developers to support the greatest efficiency
	T_SCHED_START	YYYYMMDDHHMM	Task scheduled start date
	T_SCHED_COMP	YYYYMMDDHHMM	Task scheduled start date
SUBTASK	TIP_ID	CHAR, 28	Key
	TASK_ID	CHAR, 5	Key
	SUBTASK_ID	CHAR, 3	
	SUBTASK_NAME	CHAR, 3	
	SUBTASK_SEQ	CHAR, 3	
	S_SCHED_START	YYYYMMDDHHMM	Subtask scheduled start date
	S_SCHED_COMP	YYYYMMDDHHMM	Subtask scheduled start date
	S_ACTUAL_START	YYYYMMDDHHMM	Subtask actual start date
	S_ACTUAL_COMP	YYYYMMDDHHMM	Subtask actual start date
	PRED_SUBTASK_ID	CHAR, 3	Unique predecessor subtask identifier
	SUCC_SUBTASK_ID	CHAR, 3	Unique successor subtask identifier
	S_PERCENT_COMP	N, 2	Subtask percent complete

File	Field	Format	Comments
	S_ETC_HRS	N, 4	Subtask estimate to complete work hours
	S_STD_DUR	N, 4	Subtask expected duration calculated in the JSS
	SUBTASK_STATUS	CHAR, 1	Subtask status codes: P = planned S = scheduled W = in work F = finished C = canceled
	S_SW_LAT	TBD	
	S_SW_LON	TBD	
	S_NE_LAT	TBD	
	S_NE_LON	TBD	Latitude and longitude from opposite corners defining the assigned subtask area. Format will be chosen by the developers to support the greatest efficiency
RESEQUIP			Table of equipment resources
	EQUIP_CODE	CHAR, 4	Code denoting a class or family of equipment - general equipment category
	EQUIP_ID	CHAR, 7	Unique equipment identifier
	EQUIP_ORG_CODE	CHAR, 5	Organization to which the equipment belongs
	EQUIP_STATUS	CHAR, 1	Equipment status code: U = up and unassigned (available) A = assigned N = down and not available R = reserved

Table 5.7-9 IMWS Database Equivalents to the PM/S M204 Database (Phase 3)

IMWS		PM/S		
File	**Field**	**File**	**Record Type**	**Field**
TIPDATA HEADER		TIPDATAF	T_HDR	
	TIP_ID			TIP_ID
	TASK_ID			TASK_ID
	SUBTASK_CT			
	ORG_CODE			ORGANIZATION_CODE
	T_SW_LAT			note 1
	T_SW_LON			note 1
	T_NE_LAT			note 1
	T_NE_LON			note 1

IMWS		PM/S		
File	**Field**	**File**	**Record Type**	**Field**
	T_SCHED_START			SCHED_START_DATE
				PLAN_COMP_ TIME
	T_SCHED_COMP			SCHED_COMP_DATE
				SCHED_COMP_ TIME
SUBTASK	TIP_ID			TIP_ID
	TASK_ID			TASK_ID
	SUBTASK_ID			SUBT_ID
	SUBTASK_NAME			SUBT_ACRO_NAME
	SUBTASK_SEQ			SUBT_WORK_SEQ
	S_SCHED_START			SUBT_SCHED_START_DATE
				SUBT_SCHED_START_TIME
	S_SCHED_COMP			SUBT_SCHED_COMP_DATE
				SUBT_SCHED_COMP_TIME
	S_ACTUAL_START			SUBT_ACTUAL_START_DAT E
				SUBT_ACTUAL_START_TIME
	S_ACTUAL_COMP			SUBT_ACTUAL_COMP_DATE
				SUBT_ACTUAL_COMP_TIME
	PRED_SUBTASK_ID			PRED_SUBT_WORK_SEQ
	SUCC_SUBTASK_ID			PRED_SUCC_WORK_SEQ
	SUBTASK_STATUS			SUBT_STATUS_CODE
	S_PERCENT_COMP			
	S_ETC_HRS			
	S_SW_LAT			note 1
	S_SW_LON			note 1
	S_NE_LAT			note 1
	S_NE_LON			note 1
	S_STD_DUR	STDDATAF		SUBT_DUR
RESEQUIP				
	EQUIP_CODE			EQUIP_CODE
	EQUIP_ID			EQUIP_SERIAL_ID
	EQUIP_ORG_CODE			ORGANIZATION_CODE
	EQUIP_STATUS			

Phase 3, Session 2
The goals of session 2 are concerned with subtask attributes, their supporting data, and their method of display. Two views are supported: the first geographically, the subtask indexed to coordinates; the second with the subtasks as queued objects with the current assignment bound to the resource. The second session will establish:
- the ability to display subtasks as objects in a queue
- the ability to display a current assignment as a subtask object linked to a resource object
- the ability to display subtasks by coordinates□Data coherence is needed for this session, so the data I/F development schedule must be able to support this session. The data must support subtasks with estimated

schedules as the result of a task schedule, and existing assignments. The subtask precedence network must be in place.

Phase 3, Session 3
The goals of session 3 are concerned with creating the query parameters needed to support the QSS. The manager needs to be able to query on the basis of organization for all or a subset of subtasks or assignments. The third session will establish:
- the ability to query for subtask data based on:
organization code
geographic coordinates
project, job, or task id
date range
subtask status
- the ability to query resource data based in:
organization code
equipment type
equipment status
- compound queries can be formed using the Boolean AND and OR operators

Phase 3, Session
The goals of session 4 are concerned with menu choice creation. The Assignment and Resource Management area is complex, and it is important to include desired customer options. The design anticipates these options from research and customer feedback, but improvements and additions may be forthcoming. The fourth session will establish:
- assignment options and menu selections
- resource management options and menu selections

Phase 3, Session 5
The goals of session 5 are concerned with manipulating subtask assignments. This includes assignment creation, assignment change, assignment completion and the subsequent automatic assignment of the next subtask in the queue. The fifth session will establish the ability to:
- create subtask assignments
- change subtask assignments
- automatically load the next subtask when the one in work finishes

Phase 3, Session 6
The goals of session 6 are concerned with the ability to manipulate resources. This includes adding, removing, and changing organization. This session will establish the ability to:
- add equipment to the resource pool
- remove equipment from the resource pool
- change equipment organizations

Phase 3, Session 7
The goals of session 7 are concerned with reporting capabilities. This session will expand reporting capabilities to support subtask assignment and resource managers.

5.8. Training

Training will be required for maintainers and users. The training program will have to follow the planned three phase deliveries.

5.8.1. Maintenance Training

Maintenance training is to be provided to support the three deliveries. The operational paradigm changes some as applications will be hosted on remote PC terminals as well as in the mainframe. The PCs are provided by the customer, so training associated with care and feeding for these PCs is assumed to have already been provided. Training provided by this program will be applied only for the delivered applications. If commercial off the shelf (COTS) software is provided, training will include at least an overview of the COTS package and how it is interfaced into the system.

Maintenance training will include the system overview and review of the OPSCON. Maintenance training will also include fault isolation, to include interpretation of error messages, checks for data integrity, and tracing activity through the interfaces. The goal of this training is to provide the maintainers with the knowledge necessary to fold the ability to support and troubleshoot the new applications with the same facility that they carry out their other duties.

5.8.2. User Training

User training is to be provided to support the three deliveries. The operational paradigm changes some as applications will be hosted on remote PC terminals as well as in the mainframe. The PCs are provided by the customer, so training associated with the environment and provided applications for these PCs is assumed to have already been provided. Training provided by this program will be applied only for the delivered applications. If commercial off the shelf (COTS) software is provided, training will include at least an overview of the COTS package and how it is interfaced into the system.

User training will include the system overview and review of the OPSCON. The user training will be scenario based, anticipating "a day in the life" of the user. Information gained from user participation in the incremental development should be used to generate the training scenarios. The goal of this training is to provide the managers with a level of comfort such that they can use the provided new capabilities and tools to support their everyday jobs.

5.9. Test & Transition Planning

It has been said that one tests as one goes when using the incremental or spiral development method. However, an exit mechanism is needed to exit the activities of a spiral, and a formal test or demonstration fulfills that requirement. This paragraph provides only the guidance from the engineering management perspective.

The IMWS is to be tested during each session of iterative design, and at the end of the integration of each phase. The Test Readiness Review (TRR) is required as a prerequisite for end of phase testing. Each Phase is comprised of sessions, and testing which occurs within a phase during session conduct is considered part of the development process, but it is recommended that the developers maintain engineering notes of these tests and demonstrations to design and conduct the phase tests.

When all sessions of a phase have been completed, the software is integrated on the IMWS platform. The integration process is the preparation for the TRR and the phase test, and is the dry run to be certain that the target requirements have been met for the phase. Test procedures are finalized. Note that for phase 3, the integration is the culmination for the project, and regression testing demonstrating SAEAT continues to work when integrated with QSS is necessary.

Test procedures are to be written describing the initial conditions and data needed, the goals of the test, the actions the test conductors will take, and the expected outcomes. Output data will be collected and recorded according to the test procedures. Test will verify requirements presented in Section 5.3 have been met. The test procedures will identify which requirements are being verified by which tests. A Requirements Verification Matrix is presented in Section 5.

When the test is completed, the results will be reviewed by the customer. Any issues or questions will have action plans for closure created and executed. At this point, permission is required to move the new functions into the production environment. The move will be governed and supervised by the CM processes. There will be a contingent plan to remove the new capability if catastrophic failure occurs. The new capability is used for 1 week in the production environment, and the results are reviewed at the Final Acceptance Review.

The final Acceptance Review (FAR) ascertains that all requirements have been satisfactorily addressed, and that support for operations, maintenance, and configuration management has been provided. The evaluation period demonstrates that the form and fit of the new function is satisfactory and does not degrade any existing operational capabilities. The FAR certifies that IMWS software in the customer provided workstation is viable, and that the customer is willing to assume the ownership and responsibility for the new capability. This process is repeated for each of the planned phases.

5.10. Cost Analysis

Refer to WBS in Section 4.2 which organizes the tasks needed to complete the project. The cost analysis is accomplished following the WBS structure. Costing is done for each of the three phases. Spreadsheets for both hours and cost are shown for each WBS element for each phase. The spreadsheet detail reports are provided as an appendix for reference in the hardcopy, and attached as an electronic Excel file in the softcopy submission. Summaries and charts are presented in this Section with analysis.

The only material appears in WBS element 4.5, Acquisition and consists of four Workstations for development as discussed in Section 4.5, Development Plan.

The workstations are quoted at $3000 each, $12,000 total.

Priced also will be the following software packages. These are yet to be decided, but represent a representative suite which may be used. Quoted product estimates are shown in Table 5.10-1.

Table 5.10-1 Software Packages to Support Development and Transition

Software Product	License Cost (x4)	Site License Cost (x3)
MS Project	$469 ($1876)	$11850 ($35550)
Mapinfo	$1295 ($5180)	$42450 ($127350)

Foxpro	$499 ($1497)	N/A
C++	$499 ($1497)	N/A

Software Engineering requires 4 Copies for development. then at transition an addition site license for 50 people at each of three sites will be required. Site license cost identified as N/A are needed for developemnt only.

The operating system is supplied with the workstations. The suite of office software (MS Office) is customer furnished under their site license agreement.

Labor is applied through 6 categories. Engineers (E1. E2. and E3) and Technical Support (T1. T2. T3) with rank 1 being the principle. 2 being senior. and 3 being junior. The principles are responsible as managers and decision makers. Senior staff have working system knowledge. work with little need for supervision. and are qualified through degrees and/or experience. Junior staff require supervision. but are competent in their field through degrees or other appropriate qualifying conditions. Rates are shown in Table 5.10-2.

Table 5.10-2 Labor Classes and Hourly Rates

Labor Class	Cost i $/h
E1	7
E2	5
E3	3
T1	6
T2	4
T3	2

5.10.1. Phase 1

The Phase 1 Summary costs are shown in Table 5.10-3 and the cost per WBS element is shown in Table 5.10-4. The aggregate burn rate (project cost per month) is shown in Figure 5.10-1. The supporting detail is presented in the Appendix. These three data are used for analysis to show overall trends and scale. and to be able to size feasibility.

Table 5.10-3 Phase 1 Summary Costs

SUMMARY Phase 1

Total WBS 2:	**Grand Total**
(System Engineering)	**340920** (labor)
133640	**22050** (material)
Total WBS 3:	**362970**
(Software Engineering)	
142480	
Total WBS 4:	
(Management)	
67200	
12000 (material)	

The Phase 1 cost is about $360,000. Phase 1 includes the bulk of the system engineering planning and engineering management planning required for the IMWS project. Phase 1 builds the infrastructure for communications and database and includes all required preliminary studies that support phase 2 and 3 development. The question to consider is scale. The estimate of $360,000 is a lot of money. However, the customer operating budget burn rate is $100,000 per day. The problem described in Section 1 has lead to much loss of productive time. If four days worth of enterprise wide operation can be saved over the expected 5 year life cycle of the IMWS, then the project is justified. Due to the scope of complaints, and observed lost production time (although seldom enterprise wide), the cost savings to operations will justify the project. If this were not sufficient, time saved by managers due to better tools to more efficiently and accurately do their work would be the discriminator. This project is indeed feasible. (I've seen more spent on less.)

Table 5.10-4 Phase 2 Cost by WBS Element

	2.1 Mission Def	2400
	2.2 Spec Trees	3400
	2.3 Rqmts Alloc	23200
	2.4 ICDs	25600
	2.5 Risk Analysis	9400
	2.6 Tech Reviews	6720
	2.7 Plans	32400
	2.8 Specs	25400
	2.9 Acq Support	2720
3.1.1	COMMs	29440
3.1.2	Applications	29440
3.1.3	Database	29440
	3.2 Integration	14320
	3.3 Test & Transition	14320
	3.4 CM	25520
		0

4.1 Cost Accounting	16720
4.2 Project Schedule	16720
4.3 Customer Reviews	13600
4.4 Project Mngt	15840
4.5 Acquisition	4320

And another sanity check is the graph shown in Figure 5.10-1 which illustrates the project burn rate.

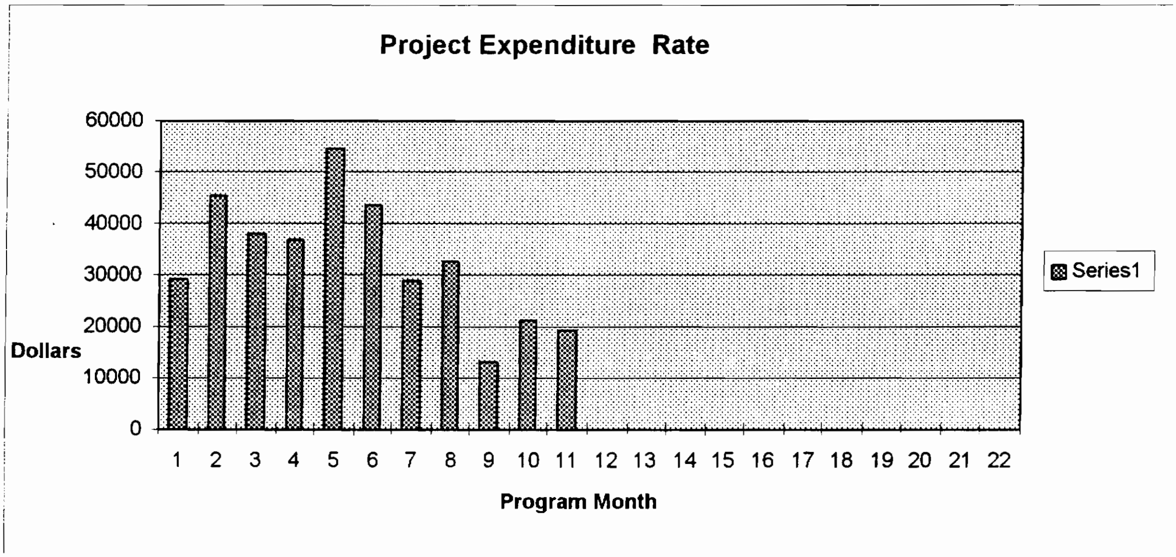


Figure 5.10-1 Phase 1 Aggregate Expenditure Rate

The graph shown in Figure 5.10-1 shows the aggregate resource level needed to support the IMWS Phase 1 development in terms of cost. Usually, to be manageable, this curve should be as smooth as possible. There is a significant peak in month five when development is underway, and a valley in month nine as transition begins. Some adjustment to the task allocation across time may be desired, or access to the labor resources may be cleverly managed. The project engineer and manager will mange these issues during the project conduct. These variations are considered manageable.

5.10.2. Phase 2

Table 5.10-5 is the Phase 2 labor cost summary by WBS rolled up category. Table 5.10-6 shows each WBS element and rolled up. The aggregate burn rate (project cost per month) is shown in Figure 5.10-2. Supporting detail is shown in the Appendix.

Table 5.10-5 Phase 2 Summary Cost

SUMMARY Phase 2

Total WBS 2:
(System Engineering)
33360

Grand Total
83920

Total WBS 3:
(Software Engineering)
35200

Total WBS 4:
(Management)
15360

Table 5.10-6 Phase 2 Cost by WBS Element

	2.1 Mission Def	0
	2.2 Spec Trees	0
	2.3 Rqmts Alloc	4400
	2.4 ICDs	6800
	2.5 Risk Analysis	4800
	2.6 Tech Reviews	5760
	2.7 Plans	6800
	2.8 Specs	4800
	2.9 Acq Support	0
3.1.1	COMMs	3120
3.1.2	Applications	6240
3.1.3	Database	5120
	3.2 Integration	6720
	3.3 Test & Transition	8320
	3.4 CM	5680
		0
	4.1 Cost Accounting	3360
	4.2 Project Schedule	3600
	4.3 Customer Reviews	4080
	4.4 Project Mngt	4320
	4.5 Acquisition	0

Phase 2 implementation is an extension of Phase 1. Although the design is known, the system engineering analyses and plans are still required. The total cost for Phase 2 is a relatively modes $84,000.

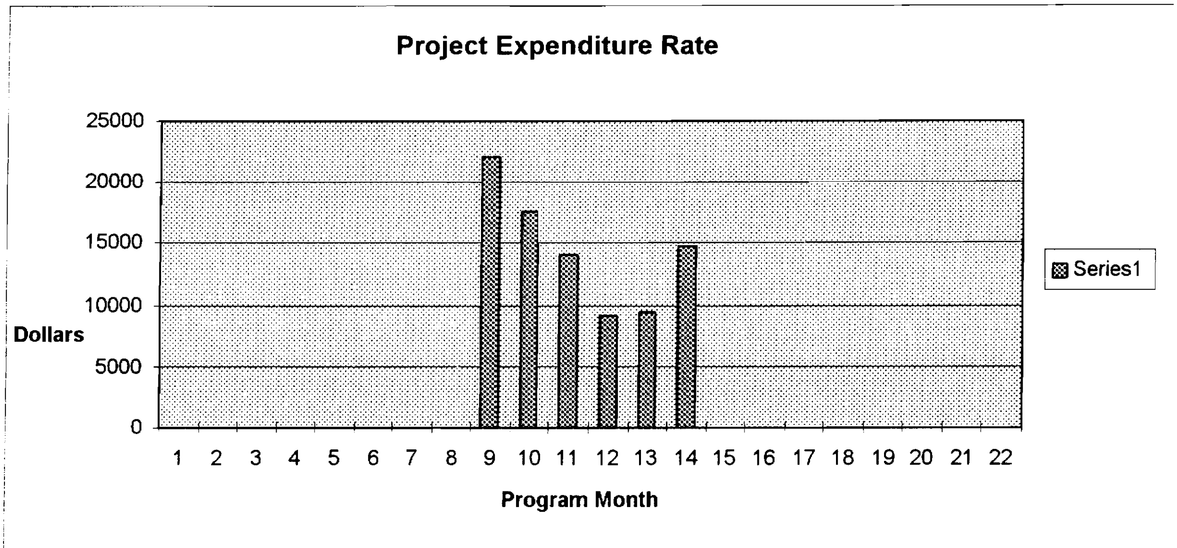


Figure 5.10-2 Phase 2 Aggregate Expenditure Rate

The burn rate shown in Figure 5.10-2 is fairly typical and manageable. Planning and engineering is front loaded, giving way to a fairly simple development.

5.10.3. Phase 3

Table 5.10.7 is the Phase 3 labor cost summary by WBS rolled up category. Table 5.10.8 shows each WBS element and rolled up. The aggregate burn rate (project cost per month) is shown in Figure 5.10-3. Supporting detail is shown in the Appendix.

Table 5.10-7 Phase 3 Summary Cost

SUMMARY Phase 3

Total WBS 2: (System Engineering) 72760	**Grand Total** 173800
Total WBS 3: (Software Engineering) 81880	
Total WBS 4: (Management) 19160	

Table 5.10-8 Phase 3 Cost by WBS Element

	2.1 Mission Def	0
	2.2 Spec Trees	0
	2.3 Rqmts Alloc	10800
	2.4 ICDs	15200
	2.5 Risk Analysis	10800
	2.6 Tech Reviews	8960
	2.7 Plans	10800
	2.8 Specs	16200
	2.9 Acq Support	0
3.1.1	COMMs	8500
3.1.2	Applications	14900
3.1.3	Database	14900
	3.2 Integration	15600
	3.3 Test & Transition	21100
	3.4 CM	6880
		0
	4.1 Cost Accounting	4320
	4.2 Project Schedule	4640
	4.3 Customer Reviews	4800
	4.4 Project Mngt	5400
	4.5 Acquisition	0

New capability is delivered with Phase 3, the ability to manage resources and write to the host database. The required level of effort is greater than Phase 2, but the infrastructure is provided. The additional $184,000 is again justifiable against the $100,000 per day operating budget. This phase implements the manager's ability to enforce the strategies that are able to be analyzed as a result of the Phase 1 and 2 implementation.

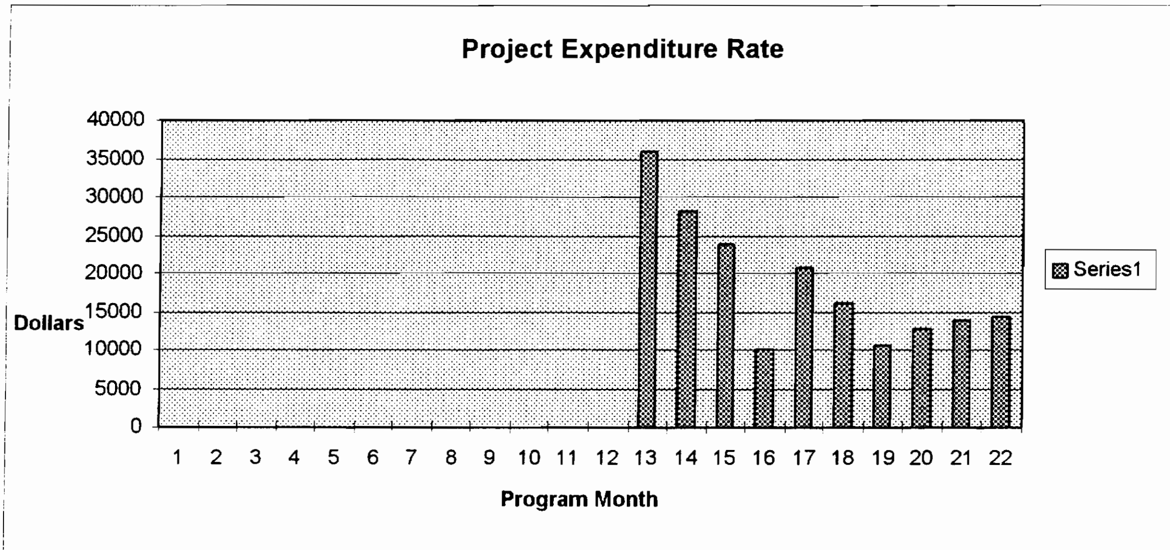


Figure 5.10-3 Phase 3 Aggregate Expenditure Rate

The burn rate shown in Figure 5.10-3 is fairly classic with a valley at month 16 when development is kicking off. This provides the managers an opportunity to accelerate the schedule.

5.10.4. Following O&M Costs

Once the IMWS is deployed, it will be controlled by the CM organization and maintained by the O&M staff. There are associated additional duties and therefore costs which the O&M budget will assume. The following are the O&M issues (which are mentioned in the Maintenance Plan and Configuration Management Plan Sections) and the expected labor and other costs associated with them.
O&M costs are shown for years two through five of the project. Year one is Phase 1 development, year 2 Phase 1 is deployed and Phase 2 and 3 are developed. Years 3 through 5 are simple operations. During year 5, the system is to be evaluated, and any extensions and associated costs will be determined at that time.

CM activity and corrective maintenance will be driven by IMWS maturity. Although a good quality product is expected, issues will surface during use that weren't addressed during development. Typically, these issues and discrepancies are discovered early in the product's lifetime. Year 2 will contain the infant discrepancies for Phase1, and Year 3 those for Phases 2 and 3. The cost to process and resolve the typical discrepancy is currently approximately $2,000. This cost includes maintenance personell analyzing the problem, softare making changes, maintenance performing verification, and CM managing the process. Table 5.10-9 summarizes the expected discrancy rate and associated costs.

Table 5.10-9 O&M Costs for Discrepancy Resolution

	Year 2	Year 3	Year 4	Year 5	Total
Discrepancies	12	18	6	3	39
Cost	$24,000	$36,000	$12,000	$6,000	$78,000

O&M will have two other tasks, managing upgrades to commercial software contained in the IMWS, and managing the software inventory in the deployed IMWS's. The effort expected is one day per month of T3 time and one day per year of T1 time. Table 5.10-10 summarizes the costs associated with upgrade and inventory management.

Table 5.10-10 Maintenance Upgrade and Inventory Management Costs

	Year 2	Year 3	Year 4	Year 5	Total
T1 (days)	1	1	1	1	4
T3 (days)	12	12	12	12	48
T1 (cost)	$480	$480	$480	$480	$1,920
T3 (cost)	$1,920	$1,920	$1,920	$1,920	$7,680
Total	$2,400	$2,400	$2,400	$2,400	$9,600

The final element of the O&M costs are the licenses for the commercial software employed in the IMWS and running on the site network. Licenses are a one time cost, but commercial software is periodically upgraded. A start-up cost must be incurred to load the needed commercial software into the system, and then one upgrade cost is estimated.

Table 5.10-11 Site License Expenses

	Year 2	Year 3	Year 4	Year 5	Total
MS Project	$35,550		$5,000		$40,550
Mapinfo.	$127,350		$5,000		$132,350
Total	$162,900		$10,000		$172,900

The summary of O&M associated costs for years 2 through 5 is shown in Table 5.10-12.

Table 5.10-12 O&M Summary Costs

	Year 2	Year 3	Year 4	Year 5	Total
DR Process	$24,000	$36,000	$12,000	$6,000	$78,000
Upgrade & Inventory	$2,400	$2,400	$2,400	$2,400	$9,600
Site Licenses	$162,900		$10,000		$172,900
Total	$189,300	$38,400	$34,400	$8,400	$260,500

The added cost to O&M over four years is less than 3 days operating budget. If the expected improvement in lost time is realized even partly, this cost is justified.

6. Preliminary Design

This section lays out the critical design elements needed to implement the IMWS project. It is beyond the intended scope of this paper to execute all the design functions required - to do so requires a team of several people over many months. This section will provide the

- operational requirements,
- functional design,
- requirements allocation to function,
- a discussion on make-buy,
- a candidate IMWS implementation, and
- a test plan

6.1. IMWS Detailed Operations Concept

This section presents the IMWS operations concepts. The IMWS is IMWS requirements are divided into three phases. The first provides the IMWS infrastructure and SAEAT minimal capability. The second expands the SAEAT. And the third provides subtask scheduling and resource management.

6.1.1. Phase 1 (SAEAT) Operations Concept

The Phase 1 goals are to create the IMWS infrastructure and a display capability that can generate a display such as that shown in Figure 6.1-1. When the manager has viewed the display, a report such as that shown in Table 6.1-1 may be desired. The manager must have these goals in mind to effectively use the SAEAT. The manager must then design the query, display parameter set, and reports to drive out a useful results set. The manager must know the area or project to be studied, and must have some schedule parameters that must be met.

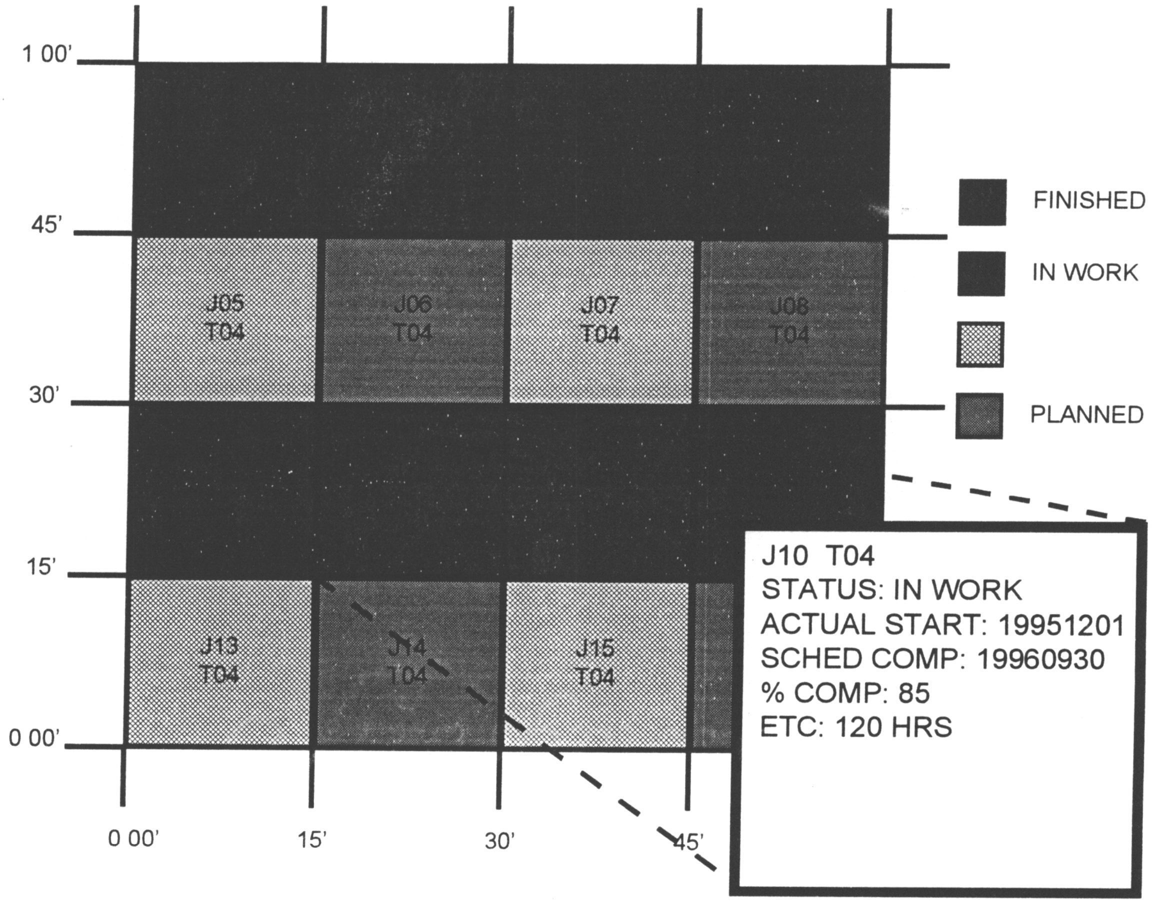


Figure 6.1-1 Desired SAEAT Display

Table 6.1-1 Possible Phase 1 SAEAT Report on Project Shown in Figure 6.1-1

JOB_ID	STATUS CODE	SCHED START	SCHED COMP	HOURS ETC
J01	F			0
J02	W	19960104	19960930	125
J03	F			0
J04	W	19960104	19960930	120
J05	S	19961001	19970401	1000
J06	P	1997 0406	19971015	1000
J07	S	19961001	19970401	1000
J08	P	1997 0406	19971015	1000
J09	F			0
J10	W	19960104	19960930	120
J11	F			0
J12	W	19960104	19960930	80
J13	S	19961001	19970401	1000

JOB_ID	STATUS CODE	SCHED START	SCHED COMP	HOURS ETC
J14	P	1997 0406	19971015	1000
J15	S	19961001	19970401	1000
J16	P	1997 0406	19971015	1000

The manager sets the display parameters to generate the type display needed. The Figure 6.1-1 display has Jobs displayed as objects geographically. The job status is shown graphically. Other selected items are shown as text when the job is selected for review.

The manager then creates a report to capture the results. Reports can contain any data active for a particular display/session. Reports can be sorted on any data field. The table shown above includes the jobs, their status, schedule and performance information. This report is sorted by JOB_ID.

Managers are expected to operate the SAEAT from any of the IMWSs distributed throughout a given DPS site. The specific workstation chosen doesn't matter. The connection is made logically to the particular manager, regardless of the workstation chosen. All workstations may be simultaneously connected, with as many as 50 managers performing queries and generating reports. In fact, the expected pattern is for the majority of managers to run a query over the area of Interest for their particular work the first hour of the shift. The use is expected to then decline sharply and continue sporadically until near the end of the shift when managers may review the job and work status.

6.1.2. Phase 2 (SAEAT) Operations Concept

The Phase 2 concept is the same as that for Phase 1. The differences are that the data is task oriented, and the analysis focus is task oriented.

6.1.3. Phase 3 (QSS) Operations Concept

Phase 3 provides the review capability for subtasks, and the concept is the same as for the previous phases. Additionally, the QSS is implemented, providing the capability to manage subtask schedules and resources.

The set of five figures, Figure 6.1-2 through Figure 6.1-6 illustrate the QSS operational requirements. Figure 6.1-2 shows the initial conditions. The extraction task has been scheduled in the PM/S which has created the Reference TIP and the initial subtask records. The manager has queried the PM/S based on the TASK_ID, and has geographically displayed the task. Within the task are the subtasks, shown as the logical work unit (LWU within the extraction model (E-model). In the figures, the model, shown in the extraction area, is designated with an M and the LWU with an L. E-models contain one or more LWUs. Each LWU represents a three subtask set, and therefore the LWU's relate directly to subtasks.

The Work Pool shows the unassigned subtasks belonging to the queried task. Only one task was selected for this example, so the TASK_ID for each subtask is not shown, although at the manager's discretion, it could be. The subtasks are referenced by their associated E-model and LWU, but, at the manager's discretion, they could be shown by SUBTASK_ID. The Equipment Pool shows the workstations available for assignment to the manager's organization. Four are available for assignment.

The first actions taken are shown in Figure 6.1-3. The manager wishes to avoid data conflicts within the task structure and elects to put the M1L1, M2L3, and M4L1 subtasks in work. The assignments are made by selecting the subtasks and connecting them with the assigned workstations. In this case, M1L1 has been assigned to WS1, M2L3 to WS2, and M4L1 to WS4. The manager has elected to show the hours estimated to complete attribute. Assume 8 hours per shift, one shift per day. Ninety six hours represent 12 work days.

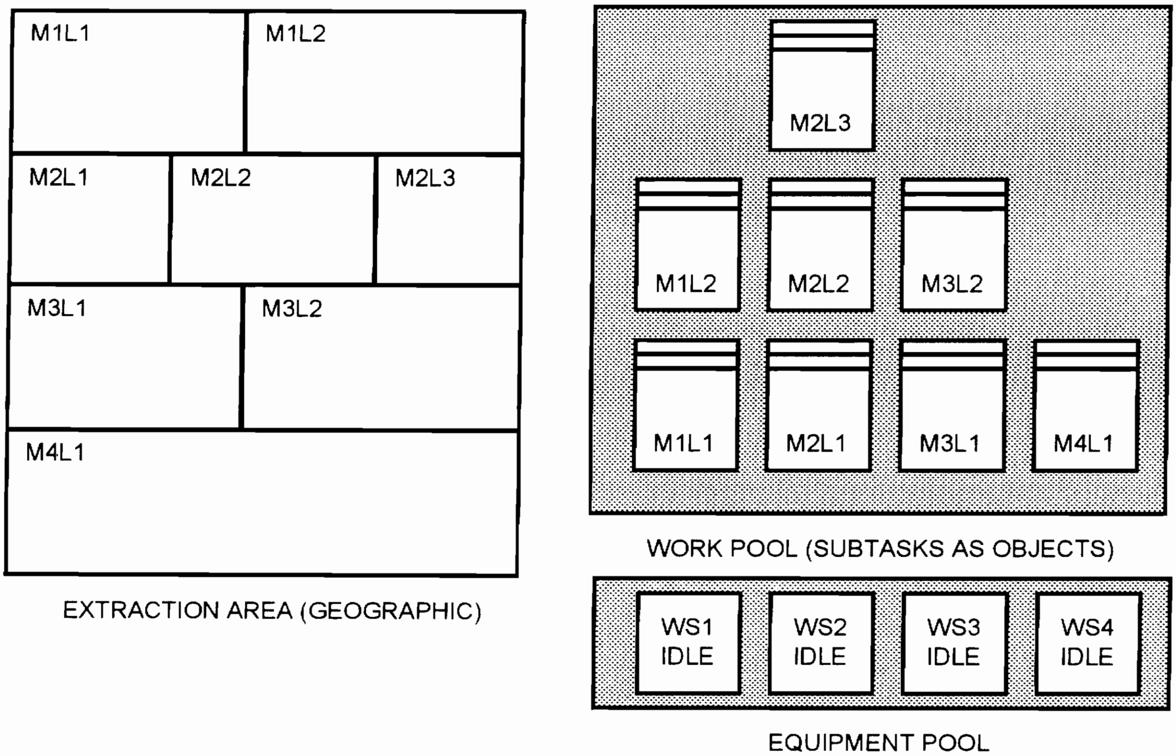


Figure 6.1-2 QSS Session Initial Conditions

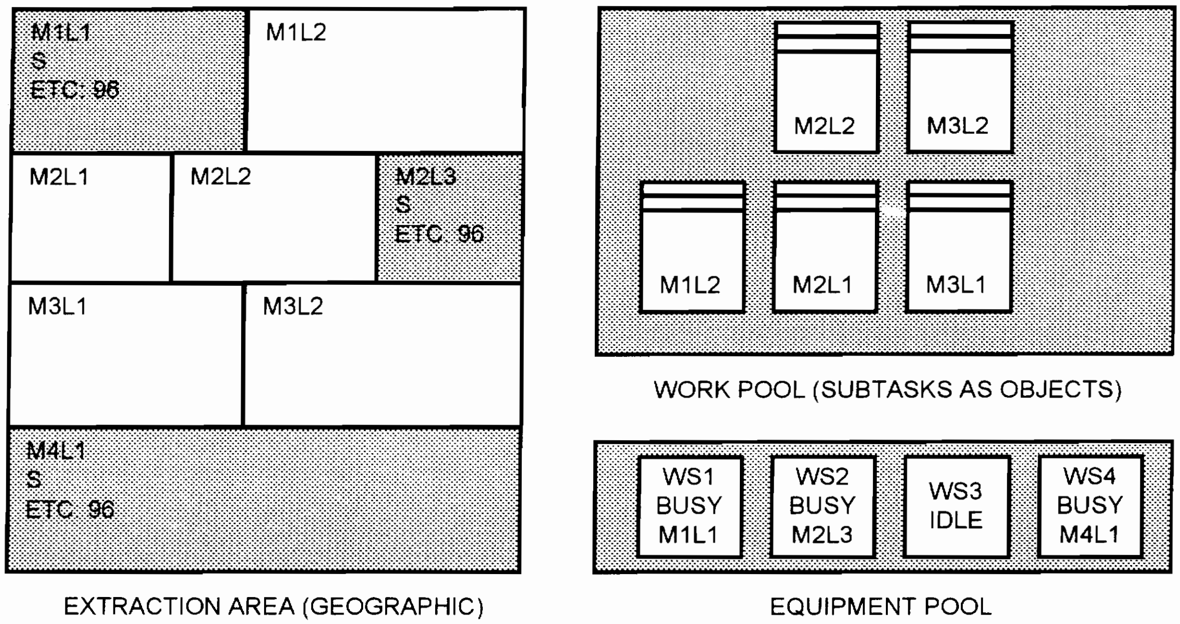


Figure 6.1-3 QSS Session First Assignment Actions

The manager commits the assignments, and the TIP is generated in the PM/S and sent to the DE/S to enforce the assignment. The extraction area display changes to the updated condition, and the assigned subtasks no longer appear in the Work Pool, but appear as assignment text attributes to the associated workstations in the Resource Pool. From prior analysis, the manager knows that the E-model 4 is sparse and expects it to complete earlier than scheduled.

Figure 6.1-4 shows the assignment condition after two shift's work have elapsed. As the manager had expected, progress on E-model 4 has been very quick. Extraction has proceeded from north to south in that E-model, so the northern border data is no longer needed by the M4L1 cartographer. The manager decides to commit the M3L1 subtask to WS3. A TIP message is generated and sent to the DE/S to enforce the assignment. The Area Display, Work Pool, and Resource Pool update according to this action.

Figure 6.1-5 shows the condition two shifts later. The M4L1 subtask has completed and left WS4, leaving it idle. There are no other assignments that can be made without creating data contention. The manager elects to wait to make the next assignment rather than manage the data contention issue. Figure 6.1-6 shows the condition another five shifts later. Workstation 2 has gone down. The manager has reassigned the M2L3 subtask to WS4. A TIP is created and sent to the DE/S to enforce the changed assignment. The manager changes the workstation status to N, down so that assignments cannot be inadvertently made to the non-functioning workstation. The displays update to reflect these events.

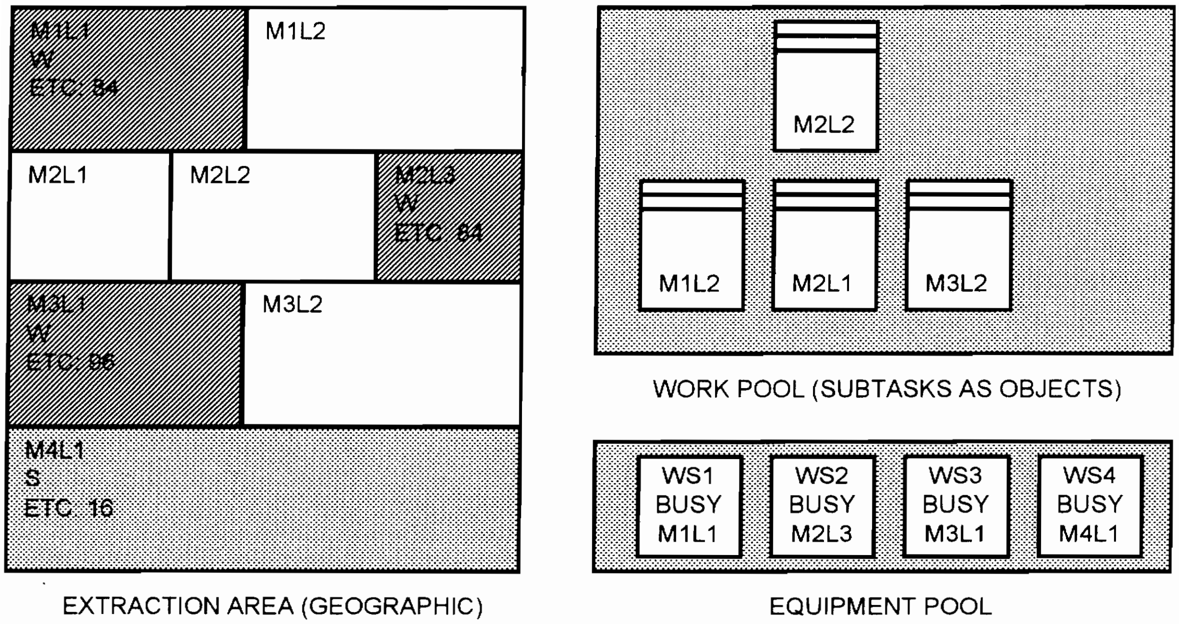


Figure 6.1-4 QSS Session with New Additional Assignment

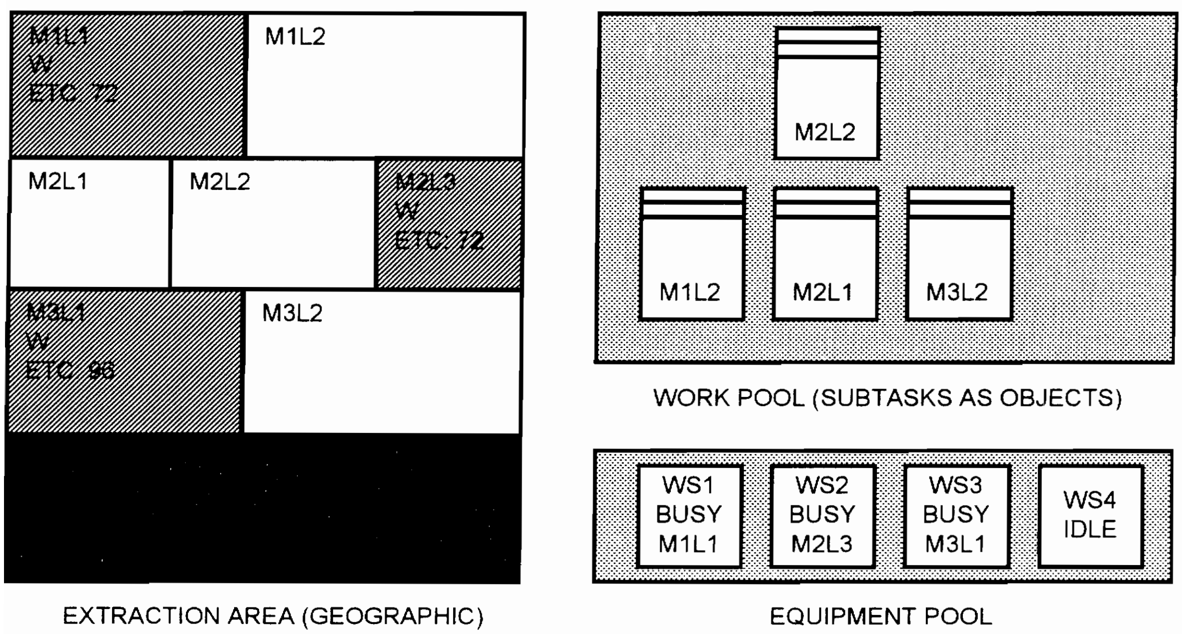


Figure 6.1-5 QSS Session Subtask Completes

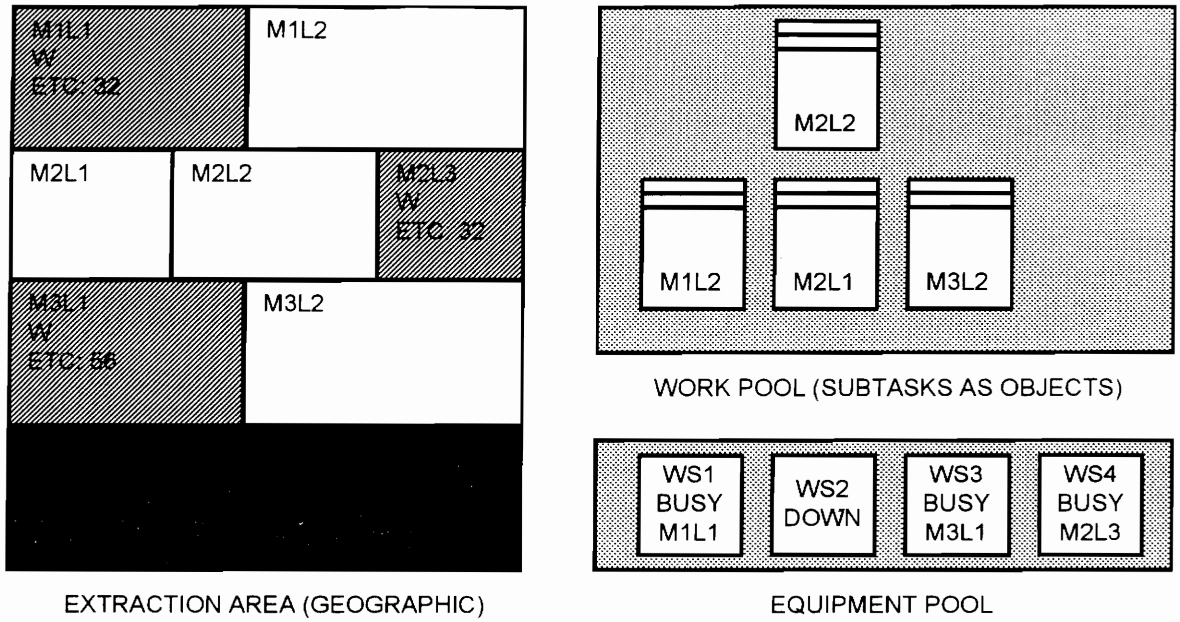


Figure 6.1-6 QSS Session with Reassignment and Resource Change

6.2. IMWS Functional Requirements

This section presents the IMWS functional requirements. Phases 1 and two implement the SAEAT and Phase 3 the QSS. Requirements are indexed for cross referencing purposes. The first two characters identify the phase and are followed by a period as a delimiter. The next character references the function as shown in Figure 3.4-1 or 2.4-2 as appropriate. This is a system perspective, and requirements are levied against the human participants as well as the product to be developed.

6.2.1. Phase 1 Functional Requirements

The IMWS Phase 1 requirements provide initial Simultaneous Adjacent Extraction Analysis Tool capability to all PM/S managers. Managers query the PM/S for particular data, the data is retrieved and displayed in geographic format for human analysis. The Phase 1 development defines the presentation and other man-machine interface issues.

Initial conditions
The IMWS initially is in a quiescent mode, no session in progress, no communications connection established or pending. The IMWS does not belong to any particular owner, and no external communication (aside from health status via system polling) is expected or provided for. The only expected action from the quiescent mode is for a PM/S manager to establish a session.

P1.1 Logon

P1.1.01

The PM/S manager requests a session with the LOGON command. All other inputs return an error message to the screen. Three erroneous inputs cause a message to be sent to the PM/S host machine for review by the console operators. The message is maintained in the PM/S system and error logs.

P1.1.02
When the LOGON command is sensed, a query for password is displayed on the screen, and the manager enters the personal password.

P1.1.03
The logon request is packaged and routed through the COMMS process to the PM/S host. The PM/S host grants the connection according to processes already in place. Additional capability must be added to recognize the IMWS host and user, and to generate and return messages to that user. An additional user profile must be added to the logon tables to identify and include the IMWS user.

P1.1.04
If the password and user are acceptable, the connection is made through the communications process, and the manager at the IMWS is notified via screen message that the session has been established.

P1.1.05
If either the password or the user are not included or defined in the PM/S host logon table, no connection is made, and a security error message is returned to the originating IMWS. Password violations are adjudicated via in place PM/S host functions.

P1.1.06
The IMWS presents a session banner that contains the date and time, the user's id, the session region, the facility id, and a line for system messages.

P1.1.07
The logon process will identify and provide to the session any saved datasets that the manager has previously created. These datasets may be saved queries, reports, or workfiles that the manager has generated. These saved sets are identified in these functional requirements.

P1.2 Query

P1.2.01
The only option provided by Phase 1 is to query the PM/s database for project/job related status.

P1.2.02
The manager selects "query" from the menu bar (or like device) and the query screen is presented. The Query screen presents two options

Create Query
Saved Query

The Create Query functional process flow diagram is shown in Figure 6.2-1.

P1.2.03
All options may be concatenated with boolean AND or OR operators. For example, a manager may query for all jobs in a specific one degree "square" whose status is "in work."

The response may show something like Figure 6.1-1 discussed in the operational requirements section. Only jobs in work are shown, indexed against the coordinate grid.

P1.2.04
The manager may query for data based on geographic requirements. All management levels use this query: L1 managers need to review planned and scheduled activities in an area to evaluate previous planning effectiveness, and to provide basis for subsequent planning. L2 and L3 managers need to see planned and scheduled extraction jobs to predict and detect possible collisions for data needs. L5 managers need to see what is planned and scheduled for neighbor regions around the assigned region to help provide strategy for ongoing extractions.

P1.2.04
From the Create Query option, the manager selects from 5 options: query by

1. Geographic co-ordinates
2. Project id
3. Job status
4. Product id
5. Free form query

The project id is an eight character string that encompasses a family of jobs. The project manager, usually the L1 or L2 manager, may to query on this parameter. The manager may include multiple projects up to (TBD) within a single query.

P1.2.06
The manager may query based on the job status. There are five possibilities:

1. P is Planned,
2. D is scheduleD,
3. W is in Work,
4. C is Canceled,
5. F is Finished.

More than one status may be included in a single query.

P1.2.07
The manager may query on a product id, usually a three character delineator specifying the end product to be produced after the extraction is done.

P1.2.08
The free form query is provided for those managers who are familiar with the query language context and specific available data. These managers can formulate and directly submit such queries without selecting any of the first four options.

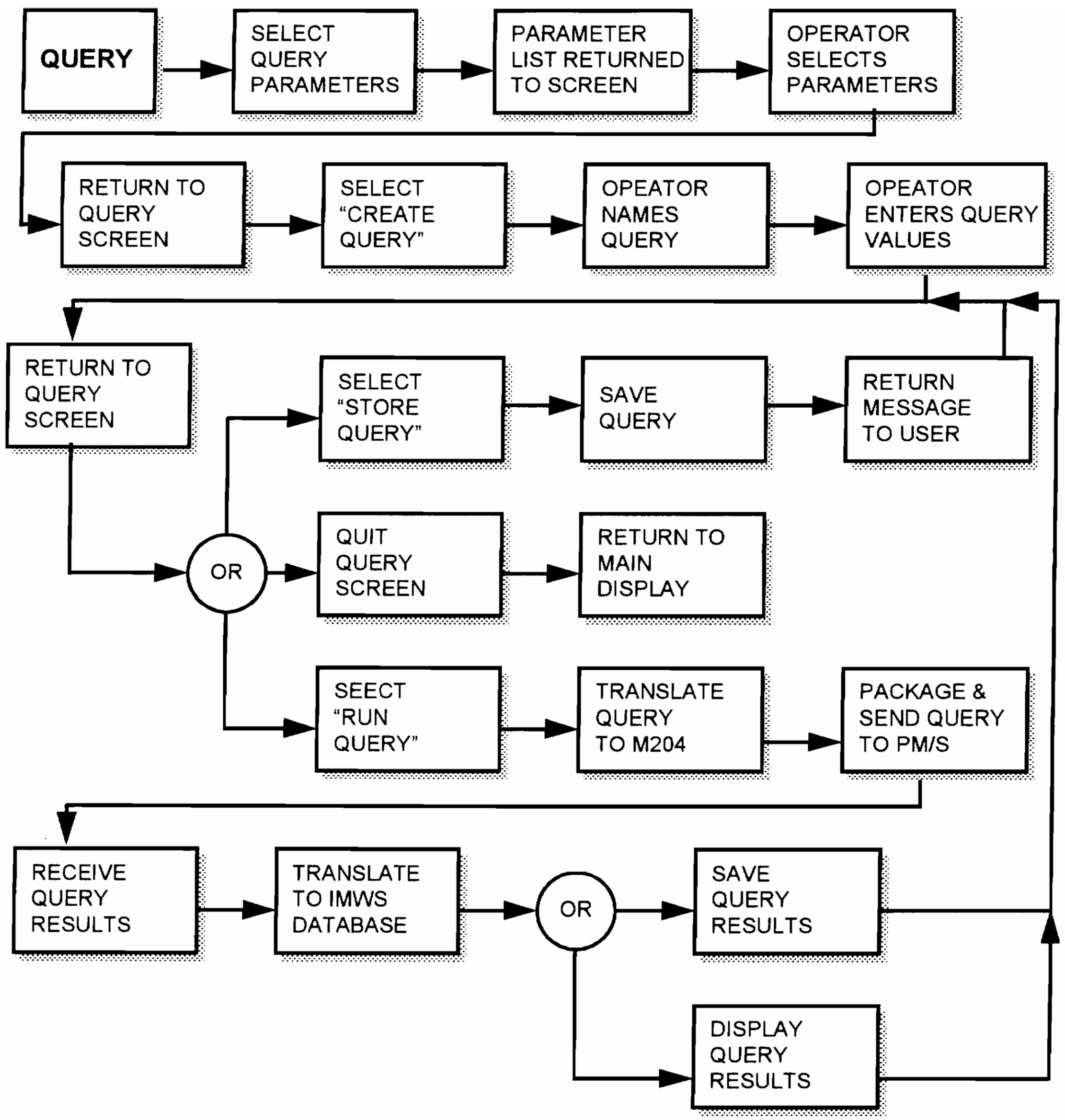


Figure 6.2-1 P1.2 Query Process Flow

P1.2.09
If the query contains an error, the IMWS application returns an error message to the operator along with the invitation to try again.

P1.2.10
Table 6.2-1 shows all data structures that may be queried. Queries on any other fields receive no response. An error message is generated for each query attempted not in the specified set and returned to the user via the screen, with the error indexed to the specific inappropriate query.

P1.2.11
The manager may then store or run the query.

P1.2.12
The manager may select Saved Query. The Saved Query functional process flow is shown in Figure 6.2-2. The Saved Query is a query which has been previously created and saved. The Saved Query is stored in the PM/S and provided to the manager's session as part of the logon process.

P1.2.13
When the Saved Query option is selected, a list of the saved queries is presented. The manager may select one saved query. The manager then has the choice to review or send the query.

P1.2.14
When the manager elects to review the query, the query parameters and values are presented on the screen. The manager may edit these values using the Create Query functionality.

P1.3 Send the Query to the PM/S

P1.3.01
When the manager has formulated and is satisfied with the query, or when the Saved Query is selected, the "SEND" command is invoked.

P1.3.02
When the "SEND" command is invoked, the IMWS application collects the query parameters and translates them into an M204 (the PM/S host's native database) query, then sends the query, via existing COMMs services to the PM/S host. The PM/S host recognizes the IMWS SAEAT query and accepts the message for processing.

P1.3.03
PM/S Processes the Query and returns the results. The PM/S recognizes the IMWS query and logs in to the M204 database as an IMWS user. The search is performed and the results are collected. Where data exists based on the query, it is copied and placed in the IMWS report. If data does not exist for a particular field, or for the entire query, a "data not found" message is returned, indexed to the particular query that had no data. The collected results are placed in a report and returned via existing COMMs services to the IMWS

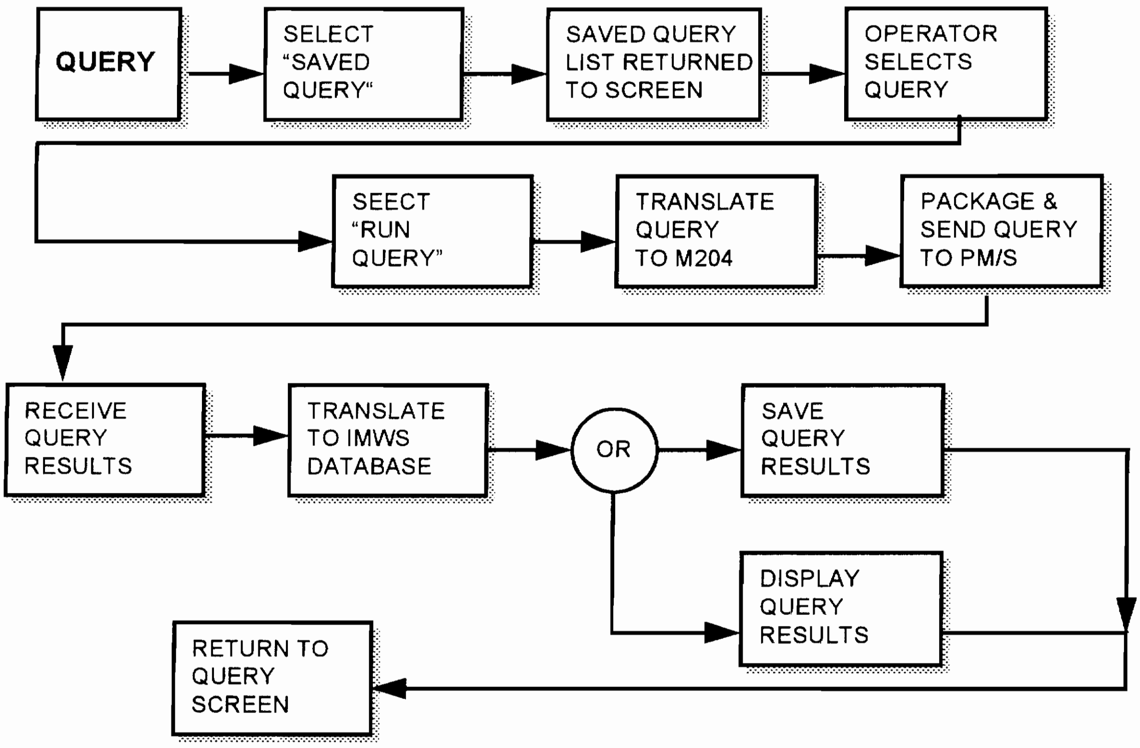


Figure 6.2-2 Saved Query Process Flow

P1.4 IMWS Processes Query Results

P1.4.01
The IMWS receives the query results, translates them from the M204 format into the IMWS local database format, and stores them in the IMWS database.

P1.4.02
The IMWS must track the query process to completion from a communications perspective. The IMWS must retain that a query has been sent and when. The existing COMMs service provides interim status of the transactions. The IMWS knows when the entire process has successfully completed because the results report is returned. Among the intermediate messages received may be error conditions. The IMWS must recognize a set of these error conditions and provide recovery methods.

P1.5 SAEAT Presentation
Once the data has been retrieved from the PM/S and stored in the IMWS database, the operator sets the display parameters. The operator can set display parameters at any time through menu selection.

P1.5.01
The SAEAT purpose is to geographically present information managers need on the screen to assist with extraction strategies. Figure 6.1-1 shows the one possible desired display.

P1.5.02
The manager sets the display parameters.

P1.5.03
The selected parameters may be saved as a default set. These parameters will be fetched and invoked as part of the logon process.

P1.5.04
The display parameters include choices for each data structure available.

P1.5.05
Display items can be defined either as objects or attributes. As an example, for Phase 1, the manager may select the job defined by coordinates as the object and status, actual start date, scheduled completion date, percent complete, and estimated hours to complete as attributes, as shown in Figure 6.1-1.

P1.5.06
Attributes may be defined such that they graphically modify the object or attached and displayed as text. In Figure 6.1-1, the job status attribute modifies the job with shading. Other attributes are attached as text and are displayed when the job is selected from the display.

P1.6 View and Analyze Results
This is the human participation. The tool provides the data, the human the analysis. The human may redefine the display during the session.

P1.7 Reports

P1.7.01
The manager may select Job Reports.

P1.7.02
Job Reports allow the manager to define the desired Phase 1 SAEAT data to be included in the report.

P1.7.03
Job Reports allow the manager to direct the report results to a dataset, to the screen, or to the designated printer.

P1.8 Logoff/Session Termination

P1.8.01
The manager may select to terminate the session.

P1.8.02
When selected, the IMWS stores any saved queries or default parameter sets to the PM/S.

P1.8.02
The IMWS and PM/S perform the necessary disconnection functions to terminate the session.

P1.9 Utilities
Not shown in the flow diagram is the utilities function.

P1.9.01
Utilities selections are

Terminal Control
Session Control

End Session

6.2.2. Phase 2 Requirements

No new capabilities are added in Phase 2. The query capability is expanded to include task level data.

6.2.3. QSS Detailed Functional Requirements

The QSS functional analysis defines operations, the methods to execute the operations, and expected results. The QSS functionality must support the operational requirements: that which the operator must be able to do to accomplish the work must be supported by the machine.

This functional analysis is supported by process flow diagrams. Tie points in the diagrams are indicated by circles that contain letters. In the text, they will be referred to as "tags," such as "tag X."

On the IMWS, PM/S subtask scheduling functionality is provided to the L5. Subtask data becomes available for update when the task is scheduled. This creates the reference TIP in PM/S and the subtask records. Subtask records in reference TIPs do not have values for schedule or resource fields. Requirements are numbered for indexing purposes.

P3.1 START SESSION

P3.1.01
The manager logs on and initiates the session as described in Section 5.2.1. QSS is selectable from the initial screen. Figure 6.2-3 illustrates the start up process.

P3.1.02
Logon sequence identifies manager by organization code. This identification limits update privileges to data belonging to that organization.

P3.1.03
The logon sequence supplies the session with any saved data (saved queries and workfiles).

P3.2 DISPLAY

P3.2.01
Initial Screen is displayed with five menu choices:

Query
Create Assignments
Change Assignments
Manage resources
Reports
Utilities

P3.2.02 Query is the default session start.

P3.2.03
Not Used

P3.2.04

Each item is selectable. 5.2-3

P3.2.05
When an operation is completed, and no destination is indicated, the program returns to the initial screen.

P3.2.06
Utilities contain a selection for display settings. Figure 6.2-3 includes the flows to access the utilities. Included are the objects and attributes which may be selected for display. The manager selects for a given session what is desired.

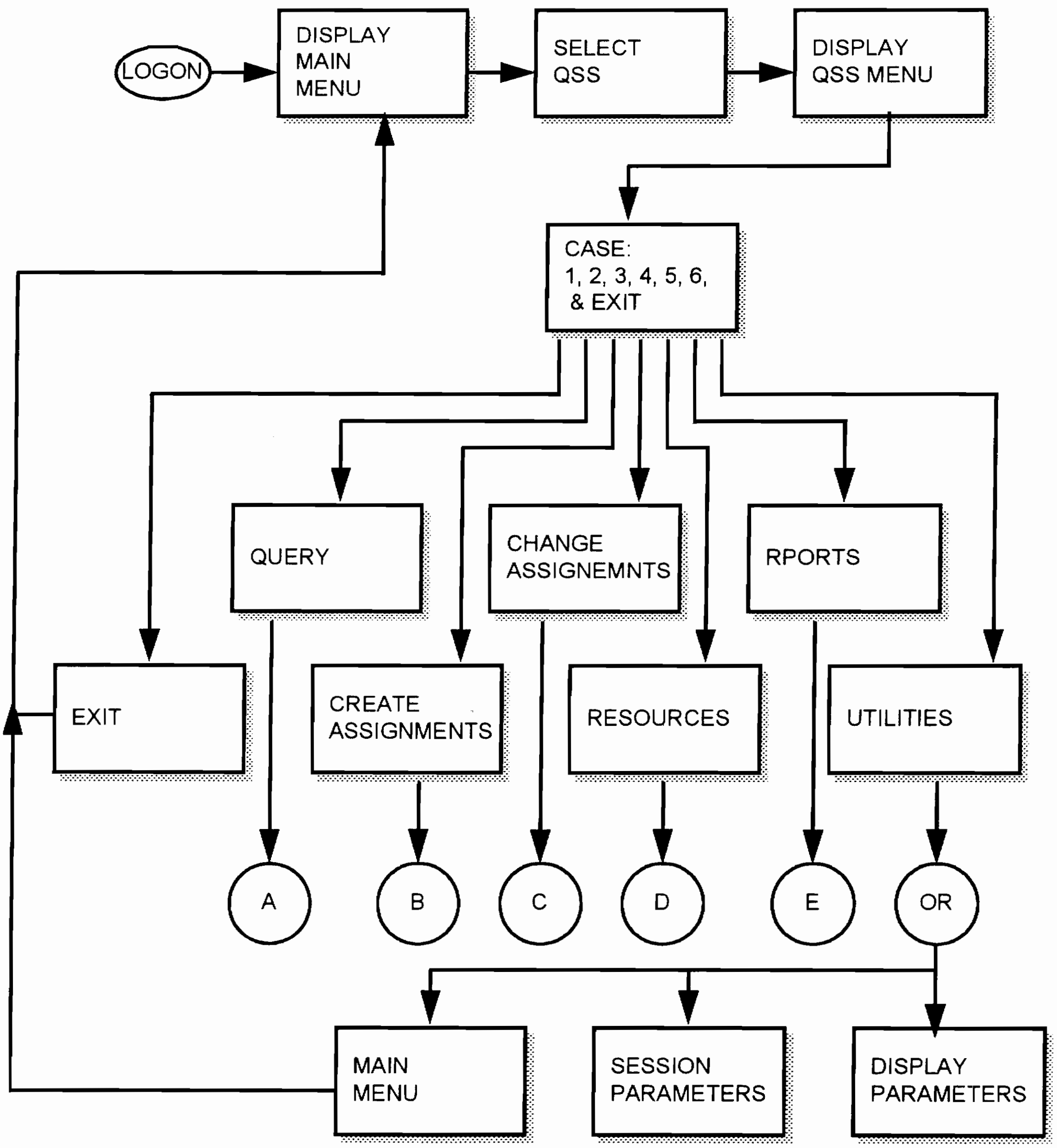


Figure 6.2-3 QSS Entry Options

P3.2.07
Objects and their attributes are:

- subtask
- resource
- project id
- organization
- job id
- equipment code
- task id
- equipment serial id
- equipment code
- equipment status
- date range
- coordinates

P3.2.08
Display defaults may be saved and automatically be put in use upon session initialization.

P3.2.09
When selected, the Resource Pool is shown. The Resource Pool contains the workstations, and their status and assignment data.

P3.2.10
The workstation with multiple assignments displays the subtask objects as a queue connected to the workstation. The subtasks are shown in the queue order. The queue order is supported by data as approved by the manager. See the assignments requirements.

P3.3 QUERY
The new query process is shown in Figure 6.2-4. Saved and Run query processes are shown in Figure 6.2-5.

P3.3.01
Query parameters are shown in the Interface Control section. The manager enters values for query parameters.

P3.3.02
When satisfied, the manager commits the query which causes the query to be translated to M204 user language or M204 SQL and then sends the query to the PM/S.

P3.3.03
The PM/S receives the query, reads the header, recognizes and accepts the query.

P3.3.04
The PM/S processes the query and assembles the results. 5.2-4 5.2-5

P3.3.05
The PM/S sends the query results back to the originating workstation.

P3.3.06
The originating workstation receives the results report and recognizes it.

P3.3.07
The IMWS translates the received data into a format compatible with the local IMWS database.

P3.3.08
The IMWS displays the query results on screen in accordance with display attributes selected.

P3.3.09
On screen manipulations cause database updates.

P3.3.10
The IMWS can undo (TBR) operations.

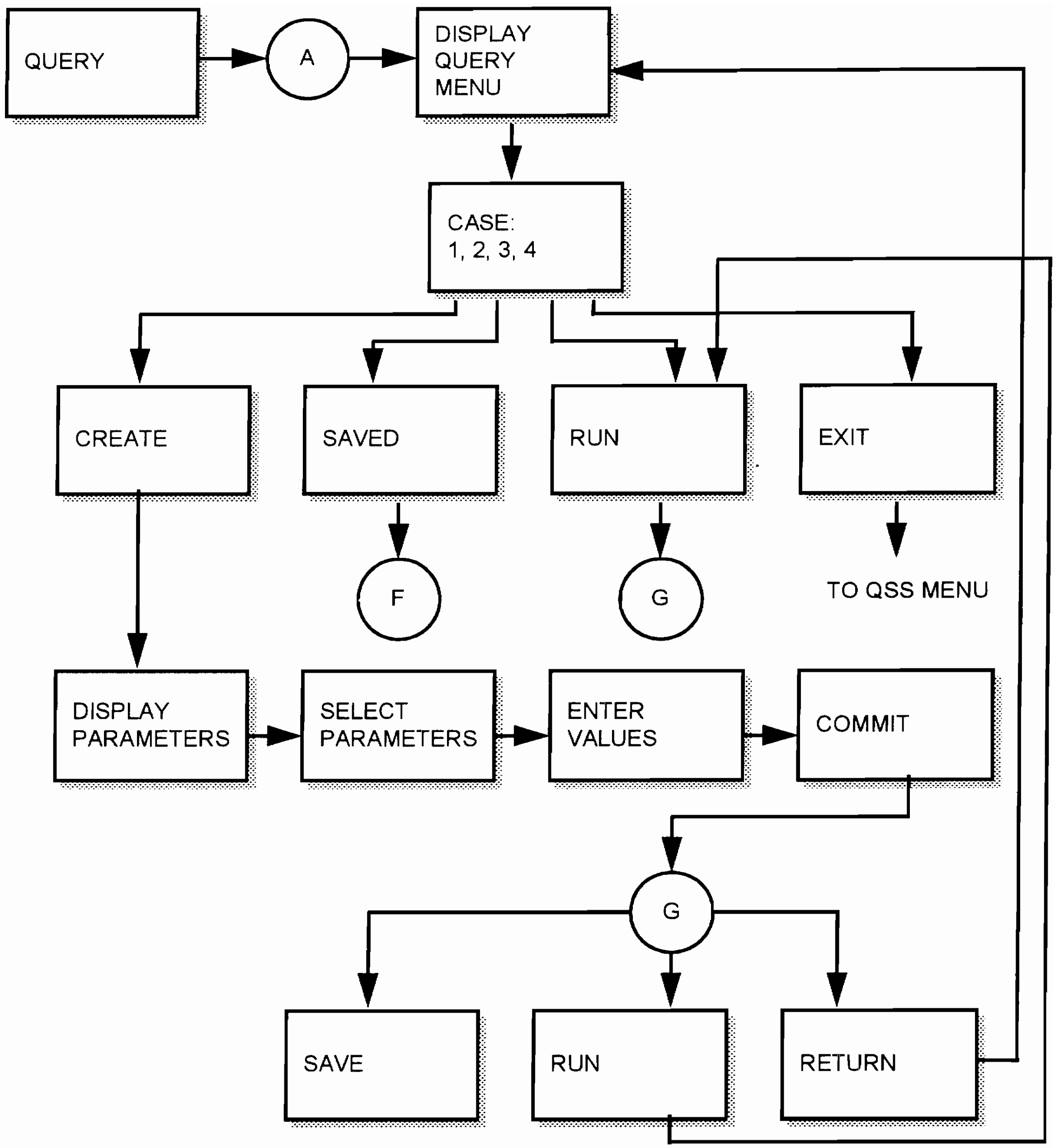


Figure 6.2-4 Create Query Flow Diagram

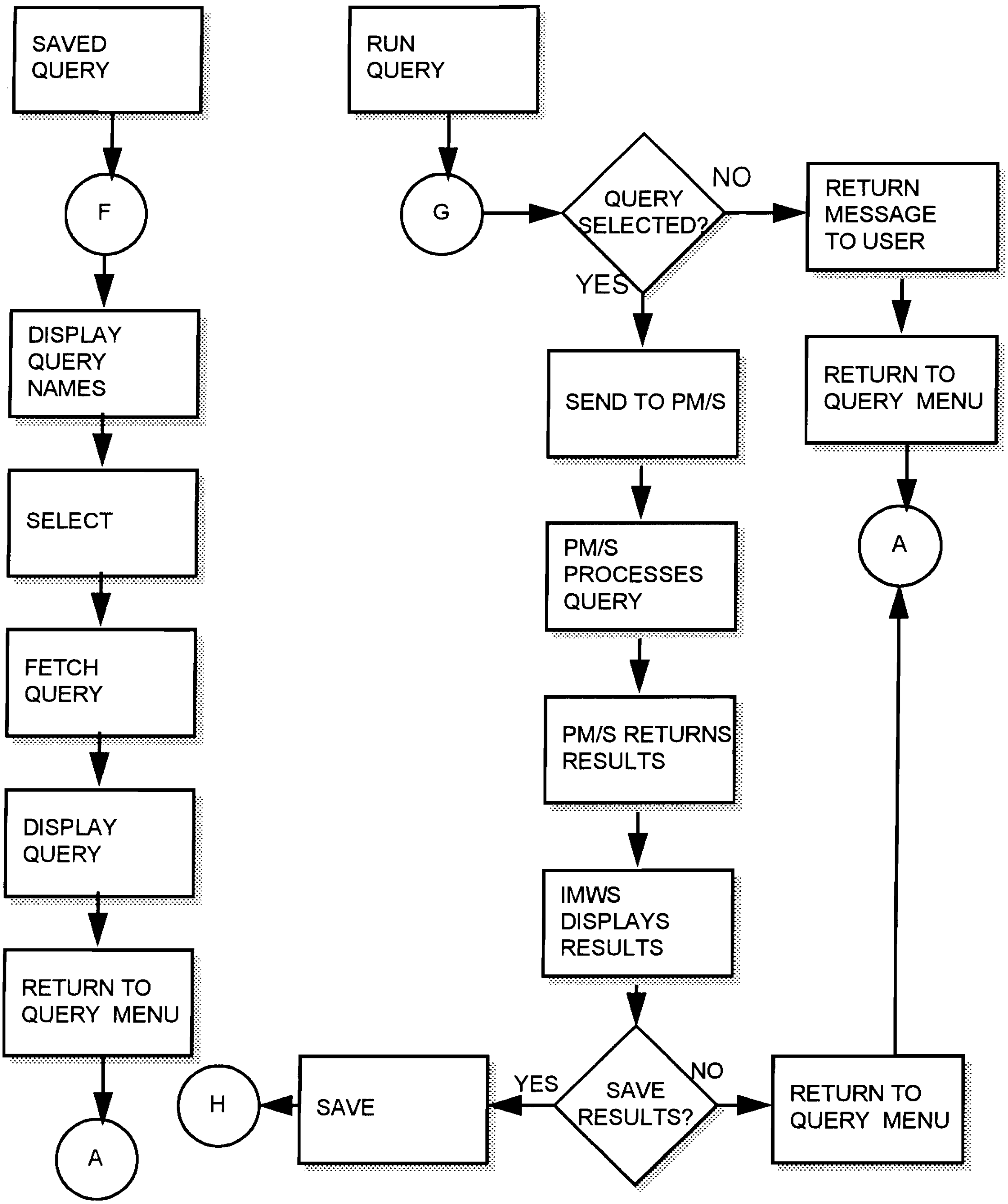


Figure 6.2-5 Get Saved Query & Run Query Flows

P3.3.11
The query may be saved with the manager's logon files to be used in a later session. Figure 6.2.6 illustrates the process. This figure also illustrates the run query process.

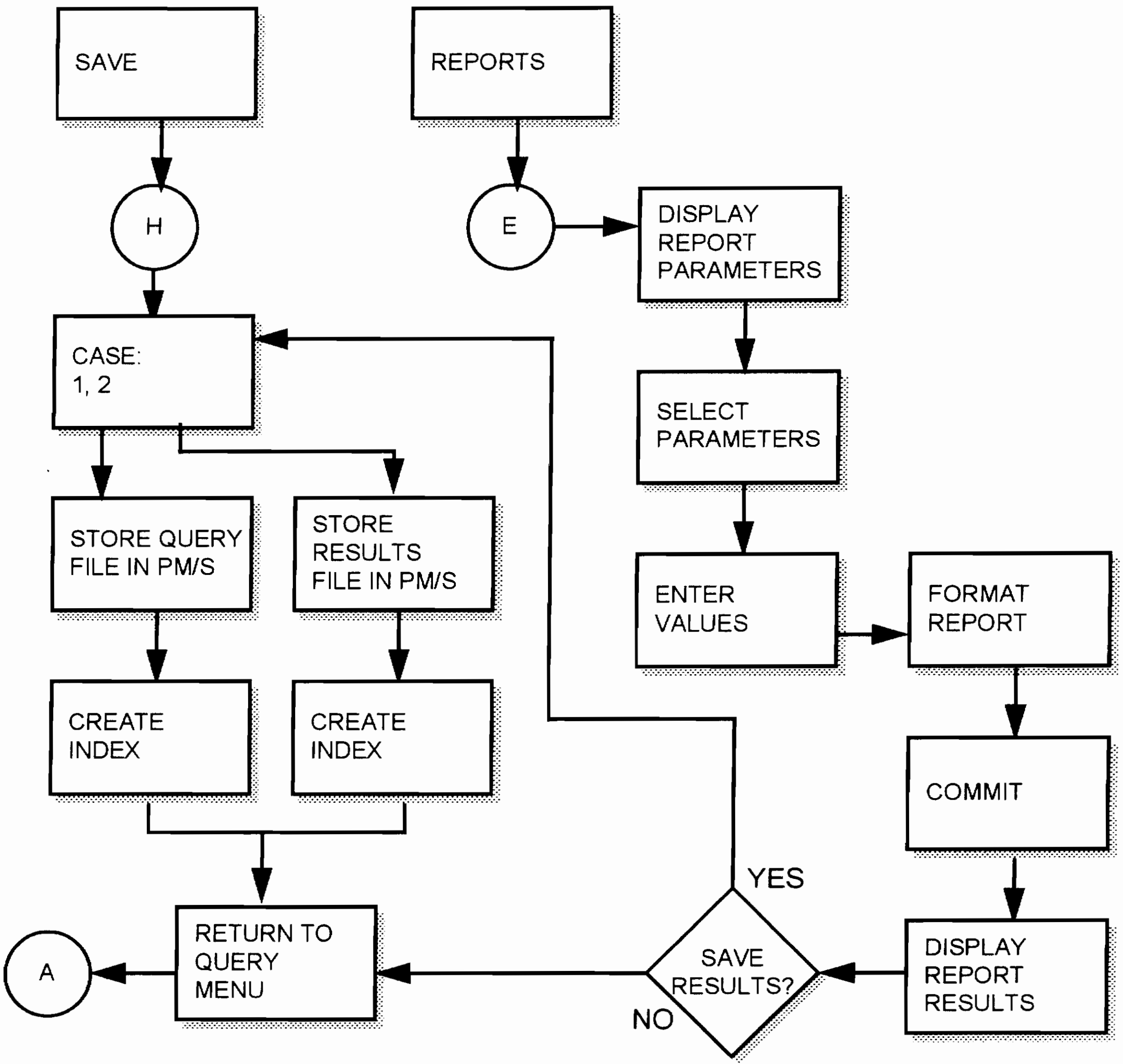


Figure 6.2-6 Save Query & Report Flows

P3.4 CREATE ASSIGNMENTS

P3.4.01
The manager may select the Create Assignments option and assign any available unassigned subtask to a workstation or a queue on a workstation. The create assignments process is illustrated in Figure 6.2-7. Subtasks are available to the workstation when the TIPDATAF/T_STK records are created for a particular task in the PM/S when the task is scheduled.

P3.4.02

When the workstation is idle (EQUIPMENT_STATUS_CODE = U), the manager creates assignments by selecting a subtask and moving it onto the workstation. A link is created between the workstation and subtask which defines the assignment. Assignment data is written to the local database. The data includes subtask scheduled start and stop dates and assigned equipment id. Workstations with status code equaling R (reserved) or N (not available) cannot accept assignments.

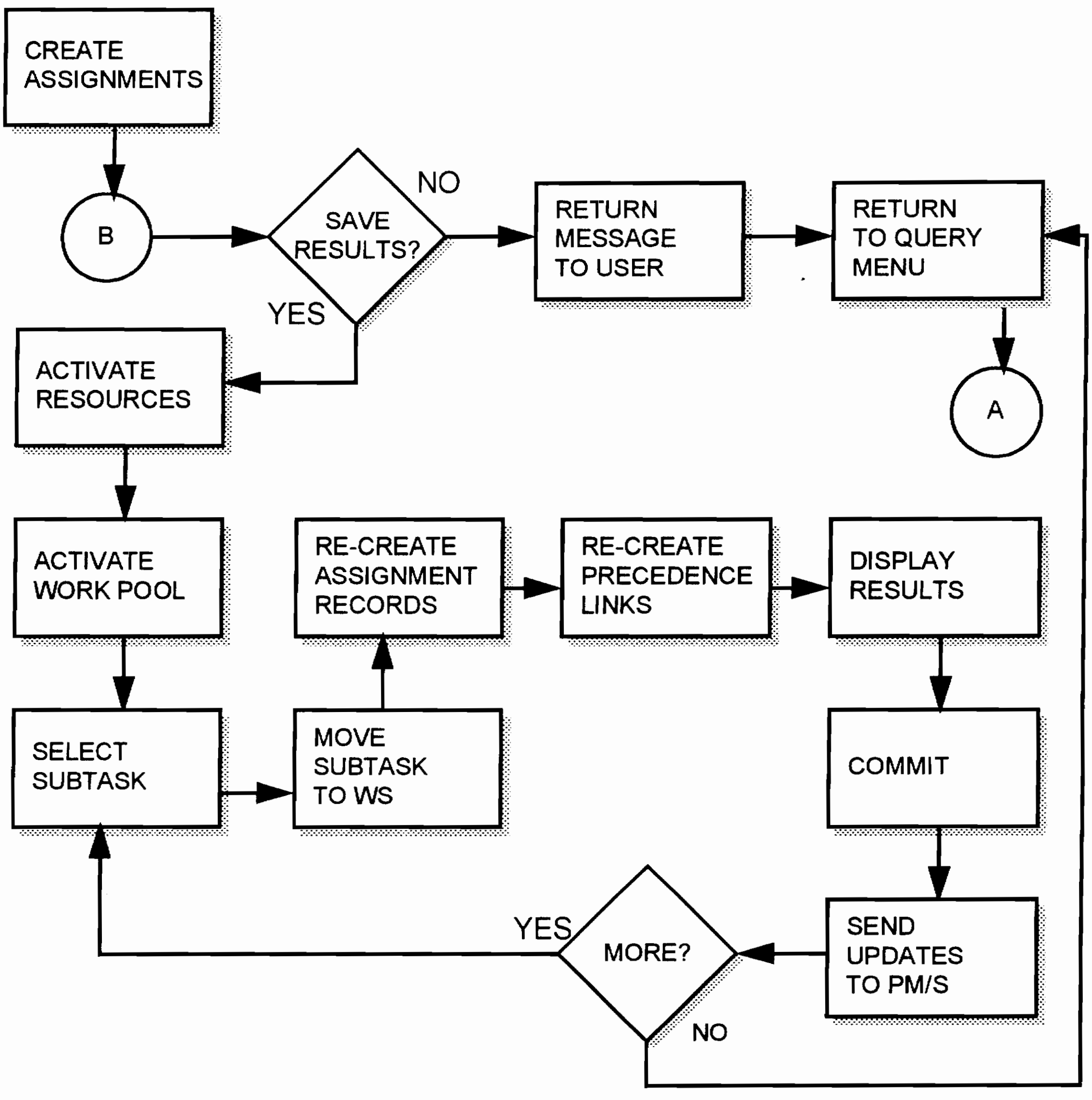


Figure 6.2-7 Create Assignments Flow

P3.4.03
When the manager has finished with the assignment(s), the assignments can be approved.

P3.4.04
The manager may decide the created assignments are not acceptable and can select the choice to return to the last point at the session where data was committed, or to the original conditions if no commitment has been made. 5.2-6 5.2-7

P3.4.05
When the manager has approved the assignment(s), the assignment data is sent to the PM/S. The assignment data is translated in the IMWS to a format compatible with the PM/S. The PM/S accepts the assignment data from the IMWS and loads the data into the M204 database.

P3.4.06
The PM/S processes and sends the TIP according to existing procedures. The requirements for data validity in the TIP must change to support the new QSS concept. The only data required to send the TIP are the schedule start date and the equipment serial id which define the assignment, and the TIP status code equals approved. The employee id is not required, nor are the schedule start and stop times. The successful TIP the TIP status code to 4 (sent) which is sent back to the IMWS.

P3.4.07
When the workstation has an assignment or several assignments (EQUIPMENT_STATUS_CODE = A), it can accept further assignments up to a maximum of 12 (TBR). If an assignment is attempted that exceeds the maximum allowed queue length, the assignment cannot be made, and a message is returned to the screen.

P3.4.08
The manager may add assignments to the queue by selecting the unassigned subtask and placing it at the end of the queue. Predecessor and successor subtask links are built as well as the schedule start and stop dates and the assigned equipment id. The schedule start date must be calculated according to the ETC hrs of the current assignment and the sum of the STD_DUR _HRS of each subtask in the queue.

P3.5 CHANGE ASSIGNMENTS

P3.5.01
The manager may select the Change Assignment option and proceed to change any existing assignment, including those in work on a workstation. Figure 6.2-8 illustrates the process.

P3.5.02
The change assignments option includes
- Cancel assignment
  - on workstation
  - in queue
- Change assignment
  - on workstation
  - in queue
    - reorder queue 5.2-8

P3.5.03
The manager may cancel the assignment on the workstation by selecting the assignment and invoking the cancel function. The assignment link to the workstation is broken. The assignment data (scheduled start date, scheduled stop date, and equipment serial id) in the TIPDATA/TSTK record is removed. In the display, the objects are separated. The update is sent to the PM/S which accepts the data and generates the Cancel TIP MOD to enforce the assignment change in the production segment.

P3.5.04
The manager may cancel an assignment in a queue by selecting the assignment and removing it from the queue. The assignment data is removed from the TIPDATA/TSTK record. The predecessor and successor links for that subtask are removed. The predecessor and successor relationships for the subtasks remaining in the queue are recalculated. The updates are sent to the PM/S. The PM/S determines whether the TIP had been sent. If yes, then the Cancel TIP MOD is sent. If not, no further action is required.

P3.5.05
Subtasks that have been canceled are returned to the Work Pool. The TIPDATA/HDR is returned to reference TIP status: it appears as if new.

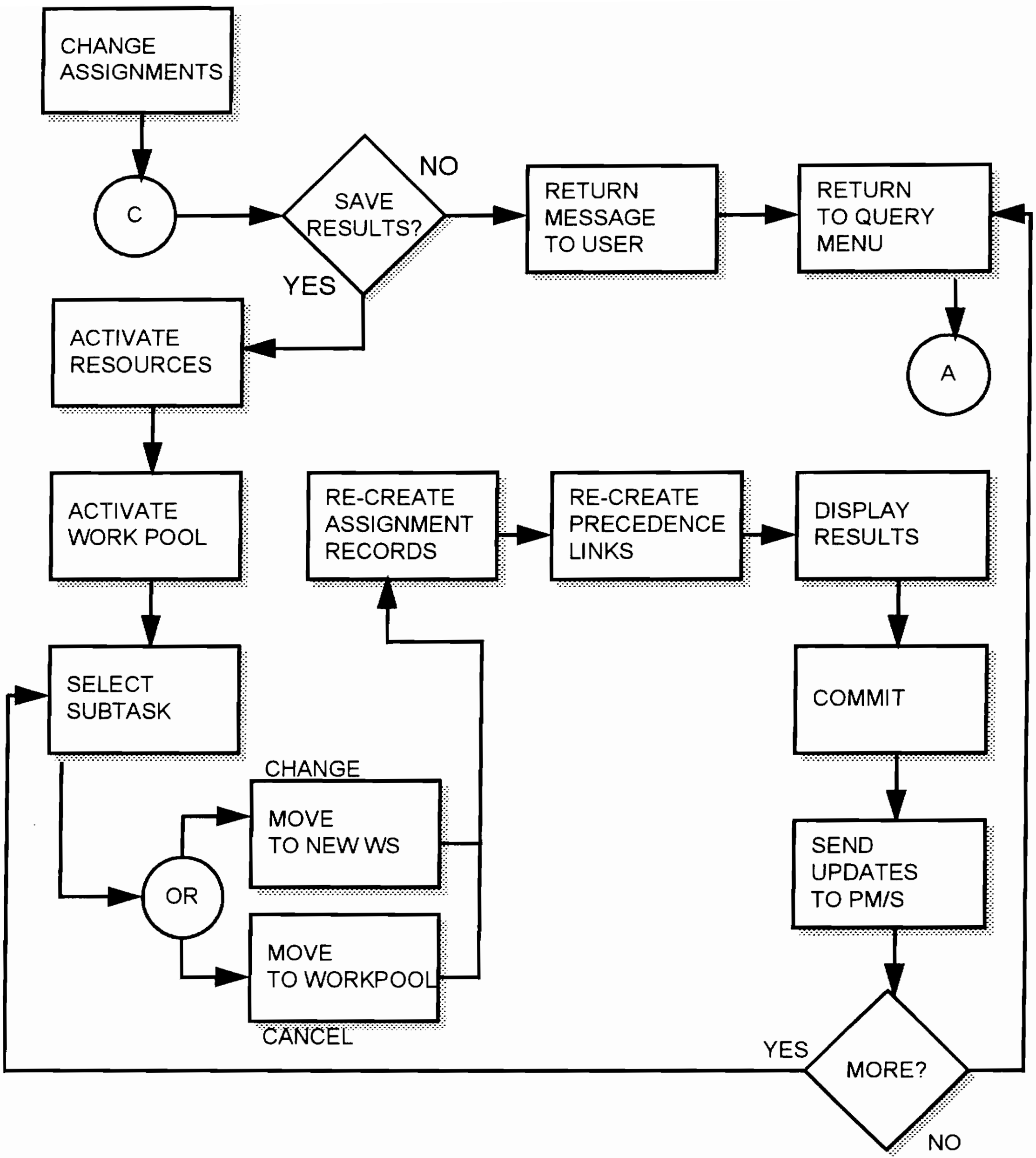


Figure 6.2-8 Change Assignments Flow

P3.5.06
The manager may change an assignment on a workstation by selecting that assignment and placing it where desired. The data that defined the initial assignment is removed and replaced with the new assignment data.

P3.5.07

The changed assignment can be placed on another workstation. The workstation status code before the assignment must be U, unassigned. When the manager approves the changes, the new assignment data is placed in the TIPDATA/STK record and sent to the PM/S. The PM/S generates the TIP MOD message with the new assignment data and sends it to the production segment to enforce the change.

P3.5.08
The changed assignment can be placed in a queue.
The manager places the assignment in the queue where desired. The new schedule start date is calculated based on the sum of the STD_DUR_HRS of each preceding subtask in the queue and the ETC_HRS of the current assignment. New predecessor and successor subtask links are built for the newly assigned subtask and it's immediate predecessor and successor. When the manager approves the changes, the data updates are sent to the PM/S. The PM/S manages any required TIP messages that need to be sent to the production segments according to the existing requirements.

P3.5.09
The manager may change an assignment in a queue by selecting that assignment and place it where desired. This essentially reorders the queue. The manager may remove the assignment from one workstation queue and place it in another. The predecessor and successor subtasks to the removed subtask have their predecessor and successor links recalculated to maintain queue continuity. All successor subtasks have their schedule dates recalculated based on the sum of the STD_DUR_HRS of each preceding subtask in the queue and the ETC_HRS of the current assignment. When the assignment is placed in the new queue (or re-placed in the same queue), the new schedule start date is calculated based on the sum of the STD_DUR_HRS of each preceding subtask in the queue and the ETC_HRS of the current assignment. New predecessor and successor subtask links are built for the newly assigned subtask and it's immediate predecessor and successor. When the manager approves the changes, the data updates are sent to the PM/S. The PM/S manages any required TIP messages that need to be sent to the production segments according to the existing requirements.

P3.5.10
When the manager approves the changes, the data updates are sent to the PM/S. The PM/S manages any required TIP messages that need to be sent to the production segments according to the existing requirements.

P3.6 MANAGE RESOURCES

P3.6.01
The manager may select the Manage Resources option. The process is shown in Figure 6.2-9.

P3.6.02
The manager may select a workstation and change it's status.

P3.6.03
A workstation with status A (assigned) cannot have it's status changed. The manager must remove all assignments before invoking a status change.

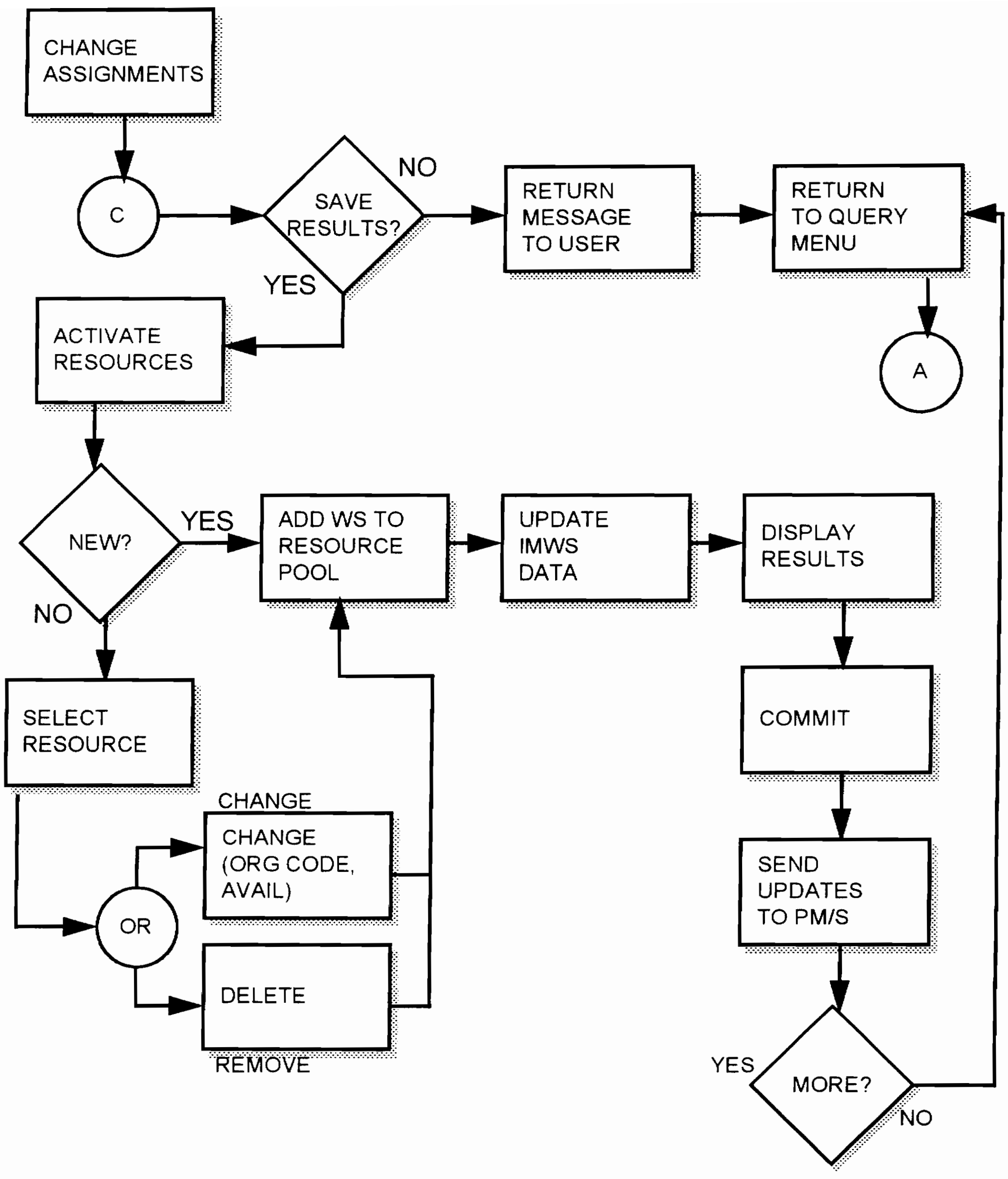


Figure 6.2-9 Manage Resources Flow

P3.7 REPORTS

P3.7.01
The manager may select the Reports option. The reports flow is shown in Figure 6.2-6.

P3.7.02
The Reports option includes
Subtask Reports
Schedule Performance Monitor

P3.7.03
Subtask Reports allow the manager to define the desired resource data to be included in the report.

P3.7.04
Subtask Reports allow the manager to direct the report results to a dataset, to the screen, or to the designated printer. 5.2-9

P3.7.05
The subtask performance monitor allows the manager to view subtask schedule performance against the expected performance which is ultimately defined in the standard and available in the TIPDATA/STK record in the STD_DUR_HRS field.

P3.7.06
The manager may select the threshold for performance measurement. For instance, the manager may select a threshold of 10%. When a subtask actual duration exceeds the threshold, a report is automatically generated and sent to that manager. If the manager has an active session at the time the report is generated, a message s sent to that session's screen. If the manager is not on the system, the report is sent to a report dataset, and a message is sent to the manager during the logon procedure for the next session.

6.3. *IMWS Requirements Matrix*

This section presents the IMWS requirements matrix. Phases 1 and two implement the SAEAT and Phase 3 the QSS. Requirements are indexed for cross referencing purposes. The first two characters identify the phase and are followed by a period as a delimiter. The next character references the function as shown in Figure 3.4-1 or 3.4-2 as appropriate. This is a system perspective, and requirements are levied against the human participants as well as the product to be developed. Requirements are allocated to the initiating function and all participants in the interface paths. Figures 5.6-2 and 5.6-3 are regenerated in this section as figures 6.3-1 and 6.3-2, respectively, with the interface paths indexed. The initiating function and interface path are shown with the requirement. Table 6.3-1 itemizes the codes used.

Table 6.3-1 Codes Used to Identify Allocated Components

Name	Explanation/Component
QRY	Query
DAT	Data I/F and Database
COM	Communications I/F
DIS	Display
UTIL	Utilities
REP	Reports
ASG	Assignments
MRS	Manage Resources
Ix	Internal interface path number
Ex	External interface path number

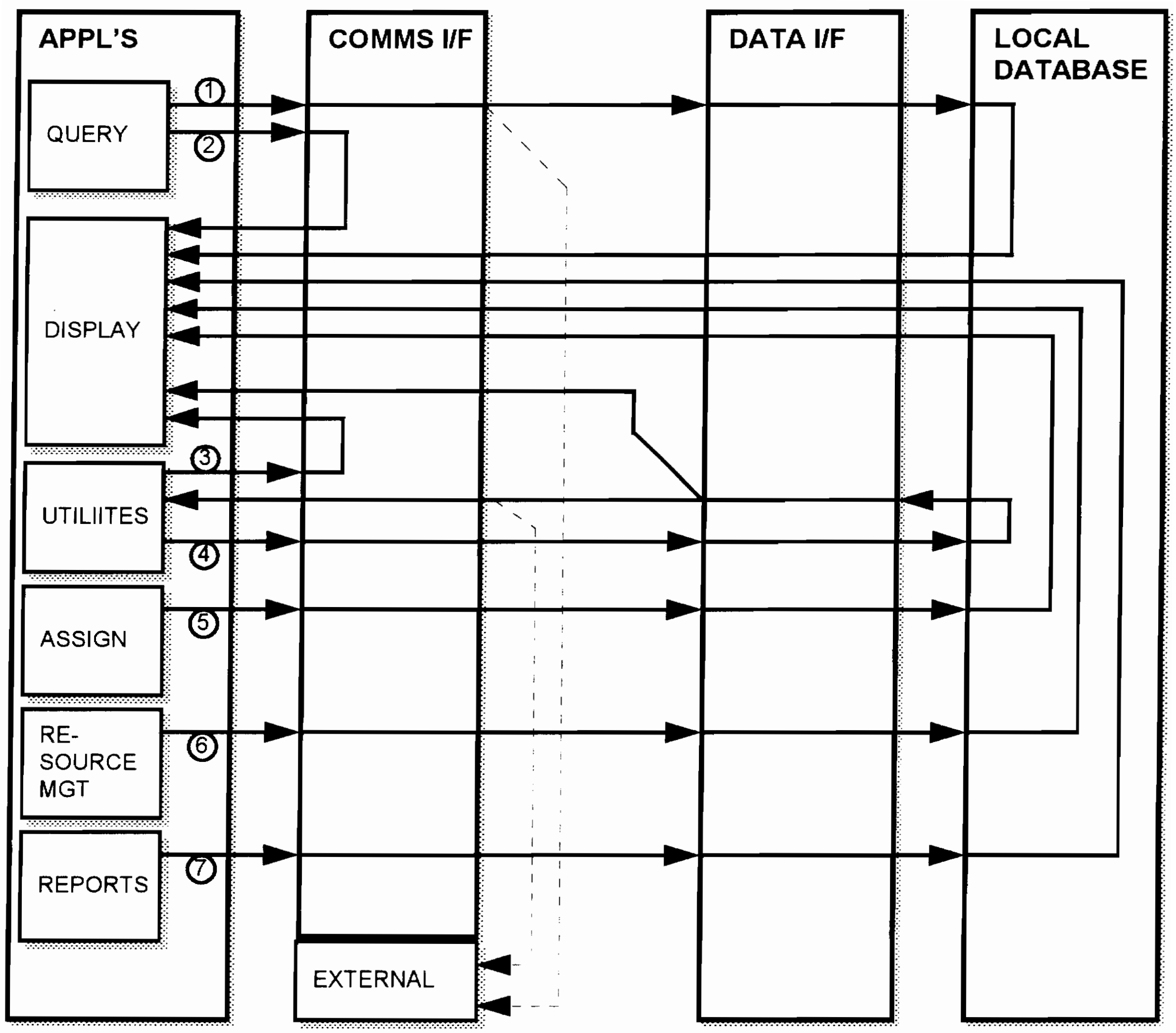


Figure 6.3-1 IMWS Internal Interface Requirements

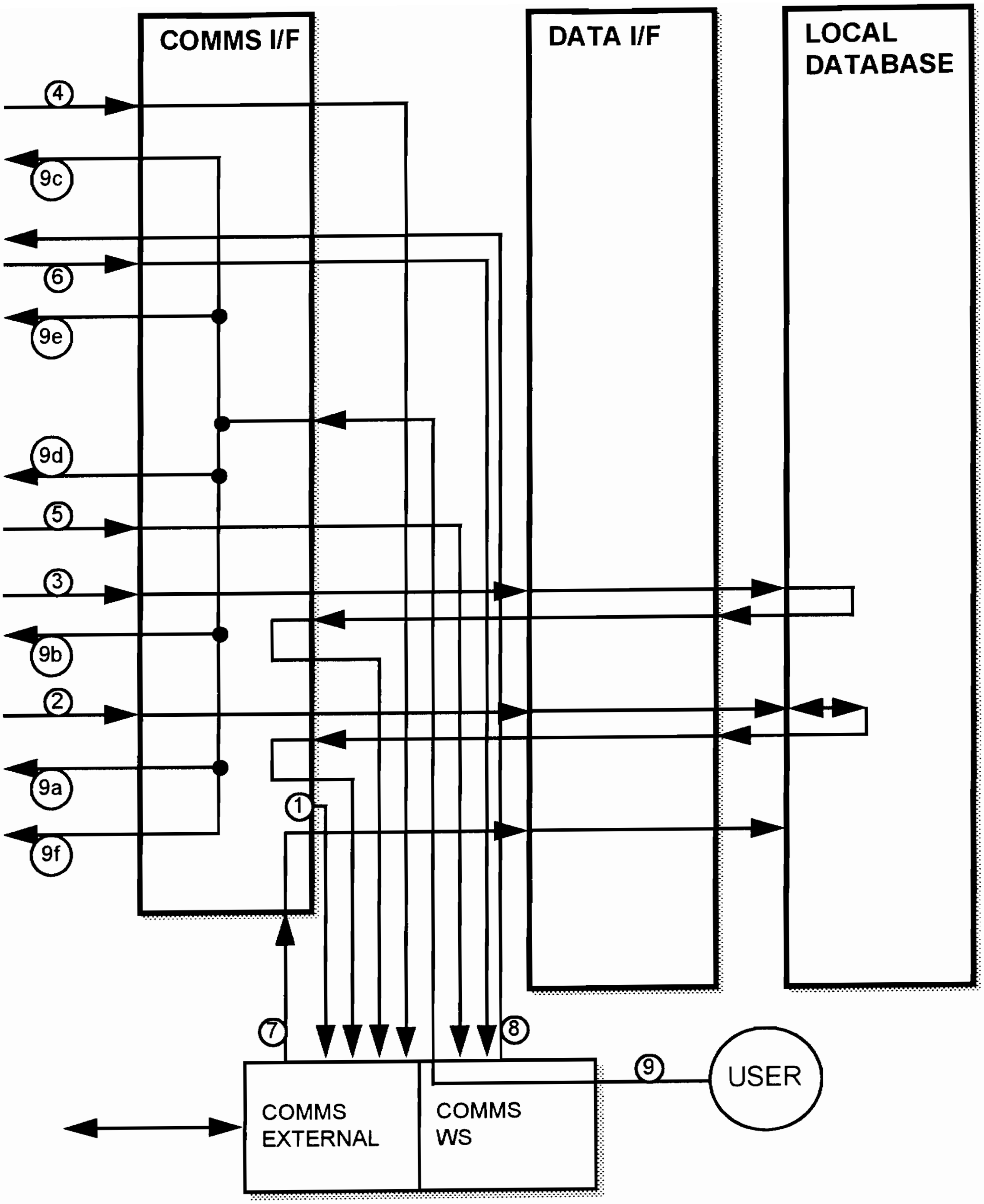


Figure 6.3-2 IMWS External Interface Requirements

6.3.1. Phase 1 (SAEAT) Functional Requirements

The IMWS Phase 1 requirements allocation identifies the components and interface paths that create the functions specified.

Table 6.3-2 Phase 1 Requirements Matrix

Index	I/F	Description
P1.1		**Logon**
P1.1.01	COM E1	The PM/S manager requests a session with the command. All other inputs return an error message to the screen. Three erroneous inputs cause a message to be sent to the PM/S host machine for review by the console operators. The message is maintained in the PM/S system and error logs.
P1.1.02	COM E8	When the LOGON command is sensed, a query for password is displayed on the screen, and the manager enters the personal password.
P1.1.03	COM PM/S E1	The logon request is packaged and routed through the COMMS process to the PM/S host. The PM/S host grants the connection according to processes already in place. Additional capability must be added to recognize the IMWS host and user, and to generate and return messages to that user. An additional user profile must be added to the logon tables to identify and include the IMWS user.
P1.1.04	COM E8	If the password and user are acceptable, connection is made through the communications process, and the manager at the IMWS is notified via screen message that the session has been established.
P1.1.05	COM E1	If either the password or the user are not included or defined in the PM/S host logon table, no connection is made, and a security error message is returned to the originating IMWS. Password violations are adjudicated via in place PM/S host functions.
P1.1.06	DIS E8	The IMWS presents a session banner that contains the date and time, the user's id, the session region, the facility id, and a line for system messages.
P1.1.07	COM E! E7 E8	The logon process will identify and provide to the session any saved datasets that the manager has previously created. These datasets may be saved queries, reports, or workfiles that the manager has generated.
P1.2		**Query**
P1.2.01	ALL	The only option provided by Phase 1 is to query the PM/s database for project/job related status.
P1.2.02	DIS E9e	The manager selects "query" from the menu bar (or like device) and the query screen is presented. The Query screen presents two options Create Query Saved Query Logon sequence identifies manager by organization code. This identification limits update privileges to data belonging to that organization.

Index	I/F	Description
P1.2.03	QRY E7 I1	All options may be concatenated with boolean AND or OR operators. For example, a manager may query for all jobs in a specific 5 degree "square" whose status is "in work." The response may show something like Figure 5.8-1 discussed in the operational requirements section. Only jobs in work are shown, indexed against the coordinate grid.
P1.2.04	QRY E9c E9e	From the Create Query option, the manager selects from 5 options: query by 1. Geographic co-ordinates 2. Project id 3. Job status 4. Product id 5. Free form query
	QRY E9c	The manager may query for data based on geographic requirements. All management levels use this query.
P1.2.05	QRY E4	The project id is an eight character string that encompasses a family of jobs. The project manager, usually the L1 or L2 manager, may to query on this parameter. The manager may include multiple projects up to (TBD) within a single query.
P1.2.06	QRY E4	The manager may query based on the job status more than one status may be included in a single query.
P1.2.07	QRY E4	The manager may query on a product id, usually a three character delineator specifying the end product to be produced after the extraction is done.
P1.2.08	QRY E4	The free form query is provided for those managers who are familiar with the query language context and specific available data. These managers can formulate and directly submit such queries without selecting any of the first four options.
P1.2.09	QRY I2	If the query contains an error, the IMWS application returns an error message to the operator along with the invitation to try again.
P1.2.10	DAT QRY E4	Table 6.2-1 shows all data structures that may be queried. Queries on any other fields receive no response. An error message is generated for each query attempted not in the specified set and returned to the user via the screen, with the error indexed to the specific inappropriate query.
P1.2.11	QRY E9	The manager may then store or run the query
P1.2.12	QRY E9e	The manager may select Saved Query. The Saved Query is stored in the PM/S and provided to the manager's session as part of the logon process.
P1.2.13	QRY E9c E9e	When the Saved Query option is selected, a list of the saved queries is presented. The manager may select one saved query. The manager then has the choice to review or send the query.
P1.2.14	QRY I2	When the manager elects to review the query, the query parameters and values are presented on the screen. The manager may edit these values using the Create Query

Index	I/F	Description
		functionality.
P1.3		**Send the Query to the PM/S**
P1.3.01	QRY E9c	When the manager has formulated and is satisfied with the query, or when the Saved Query is selected, the "SEND" command is invoked.
P1.3.02	QRY E4	Logon sequence identifies manager by organization code. This identification limits update privileges to data belonging to that organization.
P1.3.03	QRY PM/S	PM/S Processes the Query and returns the results. The PM/S recognizes the IMWS query and logs in to the M204 database as an IMWS user. The search is performed and the results are collected. Where data exists based on the query, it is copied and placed in the IMWS report. If data does not exist for a particular field, or for the entire query, a "data not found" message is returned, indexed to the particular query that had no data. The collected results are placed in a report and returned via existing COMMs services to the IMWS.
P1.4		**IMWS Processes Query Results**
P1.4.01	QRY E7	The IMWS receives the query results, translates them from the M204 format into the IMWS local database format, and stores them in the IMWS database.
P1.4.02	COM E1 E7	The IMWS must track the query process to completion from a communications perspective. The IMWS must retain that a query has been sent and when. The existing COMMs service provides interim status of the transactions. The IMWS knows when the entire process has successfully completed because the results report is returned. Among the intermediate messages received may be error conditions. The IMWS must recognize a set of these error conditions and provide recovery methods
P1.5		**SAEAT Presentation** Once the data has been retrieved from the PM/S and stored in the IMWS database, the operator sets the display parameters. The operator can set display parameters at any time through menu selection.
P1.5.01	ALL	The SAEAT purpose is to geographically present information managers need on the screen to assist with extraction strategies. Figure 6.1-1 shows the one possible desired display.
P1.5.02	DIS E9e	The manager sets the display parameters.
P1.5.03	COM E1	The selected parameters may be saved as a default set. These parameters will be fetched and invoked as part of the logon process.
P1.5.04	DIS	The display parameters include choices for each data structure available.
P1.5.05	DIS	Display items can be defined either as objects or attributes. As an example, for Phase

Index	I/F	Description
	E9e I1	1, the manager may select the job defined by coordinates as the object and status, actual start date, scheduled completion date, percent complete, and estimated hours to complete as attributes, as shown in Figure 6.1-1.
P1.5.06	DIS E9e I1	Attributes may be defined such that they graphically modify the object or attached and displayed as text. In Figure 6.1-1, the job status attribute modifies the job with shading. Other attributes are attached as text and are displayed when the job is selected from the display.
P1.6		**View and Analysis Results** This is the human participation. The tool provides the data, the human the analysis. The human may redefine the display during the session.
P1.7		**Reports**
P1.7.01	REP E9f I7	The manager may select job reports.
P1.7.02	REP E9f I7	Job Reports allow the manager to define the desired Phase 1 SAEAT data to be included in the report
P1.7.03	REP E1 I1	Job Reports allow the manager to direct the report results to a dataset, to the screen, or to the designated printer.
P1.8		**Reports**
P1.8.01	COM I1	The manager may select to terminate the session.
P1.8.02	COM E1 PM/S	When selected, the IMWS stores any saved queries or default parameter sets to the PM/S.
P1.8.03	COM E1	The IMWS and PM/S perform the necessary disconnection functions to terminate the session.
P1.9		**Utilities** Not shown in the flow diagram is the utilities function.
P1.9.01	UTIL E9d	Utilities selections are Terminal Control Session Control End Session

6.3.2. Phase 2 Functional Requirements

Phase 2 builds query capability on the infrastructure and capability provided in Phase 1. Query display capability is expanded to include the task level data.

6.3.3. Phase 3 (QSS) Detailed Functional Requirements

On the IMWS, PM/S subtask scheduling functionality is provided to the L5. Subtask data becomes available for update when the task is scheduled. This creates the reference TIP in PM/S and the subtask records. Subtask records in reference TIPs do not have values for schedule or resource fields.

Allocations are indexed to the numbered requirements in Section 5.2

Table 6.3-3 Phase 3 Requirements Matrix

Index	I/F	Description
P3.1		**Start Session**
P3.1.01	COM E1	. The manager logs on and initiates the sessions described in Section 5.2.1. QSS is selectable from the initial screen.
P3.1.02	COM E1	Logon sequence identifies manager by organization code. This identification limits update privileges to data belonging to that organization.
P3.1.03	COM E7	The logon sequence supplies the session with any saved data (saved queries and workfiles).
P3.2		**Display**
P3.2.01	DIS	Initial Screen is displayed with five menu choices: Query Create Assignments Change Assignments Manage resources Utilities
P3.2.02	DIS	Query is the default for the session start.
P3.2.03		Not used.
P3.2.04	DIS E9e	Each item is selectable.
P3.2.05	DIS	When an operation is completed, and no destination is indicated, the program returns to the initial screen.
P3.2.06	UTIL I3 E9c	Utilities contain a selection for display settings. Included are the objects and attributes which may be selected for display. The manager selects for a given session what is desired
P3.2.07	DIS I4b	Objects and their attributes are: subtask resource project id organization job id equipment code

Index	I/F	Description
		task id equipment serial id equipment code equipment status date range coordinates
P3.2.08	DIS E5	Display defaults may be saved and automatically be put in use upon session initialization.
P3.2.09	DIS I5	When selected, the Resource Pool is shown. The Resource Pool contains the workstations, and their status and assignment data.
P3.2.10	DIS I5	The workstation with multiple assignments displays the subtask objects as a queue connected to the workstation. The subtasks are shown in the queue order. The queue order is supported by data as approved by the manager. See the assignments requirements.
P3.3		**Query**
P3.3.01	QRY E9c	Query parameters are shown in the Interface Control section. The manager enters values for query parameters.
P3.3.02	QRY E9c E3	When satisfied, the manager commits the query which causes the query to be translated to M204 user language or M204 SQL and then sends the query to the PM/S.
P3.3.03	COM PM/S	The PM/S receives the query, reads the header, recognizes and accepts the query.
P3.3.04	COM PM/S	The PM/S processes the query and assembles the results.
P3.3.05	COM E7	The PM/S sends the query results back to the originating workstation.
P3.3.06	COM E7	The originating workstation receives the results report and recognizes it.
P3.3.07	DAT E7	The IMWS translates the received data into a format compatible with the local IMWS database.
P3.3.08	QRY I1	The IMWS displays the query results on screen in accordance with display attributes selected.
P3.3.09	ASG I5	On screen manipulations cause database updates.
P3.3.10	DIS	The IMWS can undo (TBR) operations.
P3.4		**Create Assignments**
P3.4.01	ASG	The manager may select the Create Assignments option and assign any available

Index	I/F	Description
	E9b PM/S	unassigned subtask to a workstation or a queue on a workstation. Subtasks are available to the workstation when the TIPDATAF/T_STK records are created for a particular task in the PM/S when the task is scheduled.
P3.4.02	ASG E9b	When the workstation is idle (EQUIPMENT_STATUS_CODE = U), the manager creates assignments by selecting a subtask and moving it onto the workstation.
	ASG I5	A link is created between the workstation and subtask which defines the assignment. Assignment data is written to the local database. The data includes subtask scheduled start and stop dates and assigned equipment id. Workstations with status code equaling R (reserved) or N (not available) cannot accept assignments.
P3.4.03	ASG E9b	When the manager has finished with the assignment(s), the assignments can be approved
P3.4.04	ASG E9b	The manager may decide the created assignments are not acceptable and can select the choice to return to the last point at the session where data was committed, or to the original conditions if no commitment has been made.
P3.4.05	ASG E9b E3	When the manager has approved the assignment(s), the assignment data is sent to the PM/S. The assignment data is translated in the IMWS to a format compatible with the PM/S. The PM/S accepts the assignment data from the IMWS and loads the data into the M204 database.
P3.4.06	ASG PM/S	The PM/S processes and sends the TIP according to existing procedures. The requirements for data validity in the TIP must change to support the new QSS concept. The only data required to send the TIP are the schedule start date and the equipment serial id which define the assignment, and the TIP status code equals approved. The employee id is not required, nor are the schedule start and stop times. The successful TIP the TIP status code to 4 (sent) which is sent back to the IMWS.
P3.4.07	ASG I5	When the workstation has an assignment or several assignments (EQUIPMENT_STATUS_CODE = A), it can accept further assignments up to a maximum of 12 (TBR). If an assignment is attempted that exceeds the maximum allowed queue length, the assignment cannot be made, and a message is returned to the screen.
P3.4.08	ASG E9b I5	The manager may add assignments to the queue by selecting the unassigned subtask and placing it at the end of the queue. Predecessor and successor subtask links are built as well as the schedule start and stop dates and the assigned equipment id. The schedule start date must be calculated according to the ETC hrs of the current assignment and the sum of the STD_DUR _HRS of each subtask in the queue.
P3.5		**Change Assignments**
P3.5.01	ASGT E9b	The manager may select the Change Assignment □option and proceed to change any existing assignment, including those in work on a workstation.
P3.5.02	ASG I5	The change assignments option includes Cancel assignment

Index	I/F	Description
		on workstation in queue Change assignment on workstation in queue reorder queue
P3.5.03	ASG E9b I5 E3	The manager may cancel the assignment on the workstation by selecting the assignment and invoking the cancel function. The assignment link to the workstation is broken. The assignment data (scheduled start date, scheduled stop date, and equipment serial id) in the TIPDATA/TSTK record is removed. In the display, the objects are separated. The update is sent to the PM/S which accepts the data and generates the Cancel TIP MOD to enforce the assignment change in the production segment.
P3.5.04	ASG E9b I5 E3	The manager may cancel an assignment in a queue by selecting the assignment and removing it from the queue. The assignment data is removed from the TIPDATA/TSTK record. The predecessor and successor links for that subtask are removed. The predecessor and successor relationships for the subtasks remaining in the queue are recalculated. The updates are sent to the PM/S. The PM/S determines whether the TIP had been sent. If yes, then the Cancel TIP MOD is sent. If not, no further action is required.
P3.5.05	ASG I5	Subtasks that have been canceled are returned to the Work Pool. The TIPDATA/HDR is returned to reference TIP status: it appears as if new.
P3.5.06	ASG E9b I5	The manager may change an assignment on a workstation by selecting that assignment and placing it where desired. The data that defined the initial assignment is removed and replaced with the new assignment data.
P3.5.07	ASG I5	The changed assignment can be placed on another workstation. The workstation status code before the assignment must be U, unassigned.
	E9b E3 PM/S	When the manager approves the changes, the new assignment data is placed in the TIPDATA/STK record and sent to the PM/S. The PM/S generates the TIP MOD message with the new assignment data and sends it to the production segment to enforce the change.
P3.5.08	ASG E9b I5 E3 PM/S	The changed assignment can be placed in a queue. The manager places the assignment in the queue where desired. The new schedule start date is calculated based on the sum of the STD_DUR_HRS of each preceding subtask in the queue and the ETC_HRS of the current assignment. New predecessor and successor subtask links are built for the newly assigned subtask and it's immediate predecessor and successor. When the manager approves the changes, the data updates are sent to the PM/S. The PM/S manages any required TIP messages that need to be sent to the production segments according to the existing requirements.
P3.5.09	ASG I5	The manager may change an assignment in a queue by selecting that assignment and place it where desired. This essentially reorders the queue. The manager may

Index	I/F	Description
		remove the assignment from one workstation queue and place it in another. The predecessor and successor subtasks to the removed subtask have their predecessor and successor links recalculated to maintain queue continuity. All successor subtasks have their schedule dates recalculated based on the sum of the STD_DUR_HRS of each preceding subtask in the queue and the ETC_HRS of the current assignment. When the assignment is placed in the new queue (or re-placed in the same queue), the new schedule start date is calculated based on the sum of the STD_DUR_HRS of each preceding subtask in the queue and the ETC_HRS of the current assignment. New predecessor and successor subtask links are built for the newly assigned subtask and it's immediate predecessor and successor.
P3.5.10	E9b E3 PM/S	When the manager approves the changes, the data updates are sent to the PM/S. The PM/S manages any required TIP messages that need to be sent to the production segments according to the existing requirements.
P3.6		**Manage Resources**
P3.6.01	MRS E9a	The manager may select the Manage Resources option.
P3.6.02	MRS E9a	The manager may select a workstation and change it's status.
P3.6.03	MRS E9a	A workstation with status A (assigned) cannot have it's status changed. The manager must remove all assignments before invoking a status change.
P3.7		**Reports**
P3.7.01	REP E9f	The manager may select the Reports option.
P3.7.02	REP	The Reports option includes Subtask Reports Schedule Performance Monitor
P3.7.03	REP E9f	Subtask Reports allow the manager to define the desired resource data to be included in the report.
P3.7.04	REP E9f I7	Subtask Reports allow the manager to direct the report results to a dataset, to the screen, or to the designated printer.
P3.7.05	REP E9f I7	The subtask performance monitor allows the manager to view subtask schedule performance against the expected performance which is ultimately defined in the standard and available in the TIPDATA/STK record in the STD_DUR_HRS field.
P3.7.06	REP E9f I7	The manager may select the threshold for performance measurement. For instance, the manager may select a threshold of 10%. When a subtask actual duration exceeds the threshold, a report is automatically generated and sent to that manager. If the manager has an active session at the time the report is generated, a message s sent to that session's screen. If the manager is not on the system, the report is sent to a report dataset, and a message is sent to the manager during the logon procedure for the next session.

Index	I/F	Description

7. Conclusions and Observations

In the time since I conceived this project, phases one and two have been implemented. However, the process was not quite what I had anticipated, and this provides an object lesson. One risk I had not identified was management buy-in from my own team. There was a political perception that to put forth this project as a proposal would be tantamount to admitting a latent defect. I could not persuade my management that providing a proactive solution for a well identified problem was the best course of action. Even so, the work described in Sections 1 and 2 was actually carried out. I briefed customers and users about the concepts of operation, demonstrated screen elements and the windowed environment. I distributed the user surveys shown in this paper, and collected and analyzed the results exactly as shown. I had thought this background would provide the evidence needed to satisfy management, but I was mistaken.

However, a fourth site was established, and I went to work the test and transition issues. The local site management (my own and the customer's) were far more interested in this project, and it was at this site that the project was implemented. The transiiton team had done a good enough job to free a considerable number of hours, so the project was produced as a management challenge at no additional cost to the trasition activity. The application and data was deployed via removeable hard drives (the more physically involved of the options sited in the paper), but even so, the O&M tax was very light and easily carried without addition to the staff. The work was primarily done by four people with occaisional help from others over a six month period, which is pretty quick. The customer had user representatives provide comments and sit in demonstrations to provide guidance on the project utility *during* the development. This participation was invaluable to the project progress. In the end, the capability was very well received by the customer and is in routine use. It works!

The object lesson is to not overlook the most obvious or take for granted the most simple circumstances. Communication between me and my management was not effective and our agendas were not aligned. I fixed this on the second try.

Phase three has not yet been implemented as it is quite complex and the skill set to do the work is no longer available. As time and technology march on, I expect the entire system to be completely replaced in the near future, and therefore no further expenditure for improvement.

In all, the engineering effort presented in this paper was a viable method to approach, analyze, solve, and implement this project.

8. Appendix: Cost Backup

This Appendix contains the labor spreadsheets that form the basis of estimate for costs to accomplish this projects. The costs are based on the task descriptions in the WBS Dictionary, and the spreadsheets follow the indices established by the WBS. These spreadsheets support the numbers discussed in the Cost Section.

Phase 1
Labor

WBS	Name	Class	Rate	Month 1	2	3	4	5	6	7	8	9	10	11
Phase 1														
2.1	Mission Def													
		E1	70	20	0	0	0	0	0	0	0	0	0	0
		E2	50	20	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				40	0	0	0	0	0	0	0	0	0	0
	Total:													
		40												
2.2	Spec Trees													
		E1	70	0	20	0	0	0	0	0	0	0	0	0
		E2	50	0	40	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	60	0	0	0	0	0	0	0	0	0
	Total:													
		60												
2.3	Rqmts Alloc													
		E1	70	0	80	80	0	0	0	0	0	0	0	0
		E2	50	0	160	80	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	240	160	0	0	0	0	0	0	0	0
	Total:													
		400												
2.4	ICDs													
		E1	70	0	0	20	20	20	20	0	0	0	0	0
		E2	50	0	0	80	80	160	80	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	0	100	100	180	100	0	0	0	0	0
	Total:													
		480												
2.5	Risk Analysis													

Phase 1
Labor

WBS	Name	Class	Rate	Month 1	2	3	4	5	6	7	8	9	10	11
		E1	70	20	0	0	0	0	0	0	0	0	0	0
		E2	50	160	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				180	0	0	0	0	0	0	0	0	0	0
	Total:													
		180												
2.6	Tech Reviews													
		E1	70	16	16	0	24	0	0	0	16	0	0	24
		E2	50	0	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				16	16	0	24	0	0	0	16	0	0	24
	Total:													
		96												
2.7	Plans													
		E1	70	20	20	20	20	20	20	0	0	0	0	0
		E2	50	80	80	80	80	80	80	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				100	100	100	100	100	100	0	0	0	0	0
	Total:													
		600												
2.8	Specs													
		E1	70	0	20	20	20	20	20	0	0	0	0	0
		E2	50	0	80	80	80	80	0	0	0	0	0	0
		E3	30	0	0	0	0	0	80	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	100	100	100	100	100	0	0	0	0	0
	Total:													
		500												
2.9	Acq Support													
		E1	70	8	8	0	0	0	0	0	0	0	0	0
		E2	50	16	16	0	0	0	0	0	0	0	0	0

Phase 1
Labor

WBS	Name	Class	Rate	Month 1	2	3	4	5	6	7	8	9	10	11
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				24	24	0	0	0	0	0	0	0	0	0
	Total:													
		48												
3.1.1	COMMs													
		E1	70	0	0	0	0	8	8	8	8	0	0	0
		E2	50	0	0	0	0	40	40	40	40	0	0	0
		E3	30	0	0	0	0	80	80	80	80	0	0	0
		T1	60	0	0	0	0	40	40	40	40	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	168	168	168	168	0	0	0
	Total:													
		672												
3.1.2	Applications													
		E1	70	0	0	0	0	8	8	8	8	0	0	0
		E2	50	0	0	0	0	40	40	40	40	0	0	0
		E3	30	0	0	0	0	80	80	80	80	0	0	0
		T1	60	0	0	0	0	40	40	40	40	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	168	168	168	168	0	0	0
	Total:													
		672												
3.1.3	Database													
		E1	70	0	0	0	0	8	8	8	8	0	0	0
		E2	50	0	0	0	0	40	40	40	40	0	0	0
		E3	30	0	0	0	0	80	80	80	80	0	0	0
		T1	60	0	0	0	0	40	40	40	40	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	168	168	168	168	0	0	0
	Total:													
		672												
3.2	Integration													
		E1	70	0	0	0	0	0	0	0	0	16	40	0
		E2	50	0	0	0	0	0	0	0	0	80	80	0
		E3	30	0	0	0	0	0	0	0	0	40	40	0

Phase 1
Labor

WBS	Name	Class	Rate	Month 1	2	3	4	5	6	7	8	9	10	11
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	136	160	0
	Total: 296													
3.3	Test & Transition													
		E1	70	0	0	0	0	0	0	0	0	0	16	40
		E2	50	0	0	0	0	0	0	0	0	0	80	80
		E3	30	0	0	0	0	0	0	0	0	0	40	40
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0	136	160
	Total: 296													
3.4	CM													
		E1	70	8	8	8	8	8	8	8	8	8	8	8
		E2	50	0	0	0	0	0	0	0	0	0	0	0
		E3	30	16	16	16	16	16	16	16	16	16	16	16
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	32	32	32	32	32	32	32	32	32	32	32
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				56	56	56	56	56	56	56	56	56	56	56
	Total: 616													
4.1	Cost Accounting													
		E1	70	8	8	8	8	8	8	8	8	8	8	8
		E2	50	0	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	8	8	8	8	8	8	8	8	8	8	8
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	24	24	24	24	24	24	24	24	24	24	24
				32	32	32	32	32	32	32	32	32	32	32
	Total: 352													
4.2	Project Schedule													

Phase 1
Labor

WBS	Name	Class	Rate	Month 1	2	3	4	5	6	7	8	9	10	11
		E1	70	8	8	8	8	8	8	8	8	8	8	8
		E2	50	0	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	8	8	8	8	8	8	8	8	8	8	8
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	24	24	24	24	24	24	24	24	24	24	24
				40	40	40	40	40	40	40	40	40	40	40
	Total:	440												
4.3	Customer Reviews													
		E1	70	16	16	0	16	0	0	0	16	0	0	16
		E2	50	0	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	16	16	0	16	0	0	0	16	0	0	16
		T2	40	16	16	0	16	0	0	0	16	0	0	16
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				48	48	0	48	0	0	0	48	0	0	48
	Total:	240												
4.4	Project Mngt													
		E1	70	16	16	16	16	16	16	16	16	16	16	16
		E2	50	0	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	16	16	16	16	16	16	16	16	16	16	16
				32	32	32	32	32	32	32	32	32	32	32
	Total:	352												
4.5	Acquisition													
		E1	70	0	0	0	0	0	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	8	8	8	0	0	0	0	0	0
		T2	40	0	0	24	24	24	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	0	32	32	32	0	0	0	0	0	0
	Total:	96												

WBS	Name	Class	Cost Rate	Month 1	2	3	4	5	6	7	8	9	10	11
P 1														
2.1	Mission Def													
		E1	70	1400	0	0	0	0	0	0	0	0	0	0
		E2	50	1000	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				2400	0	0	0	0	0	0	0	0	0	0
	Total: 2400													
2.2	Spec Trees													
		E1	70	0	1400	0	0	0	0	0	0	0	0	0
		E2	50	0	2000	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	3400	0	0	0	0	0	0	0	0	0
	Total: 3400													
2.3	Rqmts Alloc													
		E1	70	0	5600	5600	0	0	0	0	0	0	0	0
		E2	50	0	8000	4000	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	13600	9600	0	0	0	0	0	0	0	0
	Total: 23200													
2.4	ICDs													
		E1	70	0	0	1400	1400	1400	1400	0	0	0	0	0
		E2	50	0	0	4000	4000	8000	4000	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	0	5400	5400	9400	5400	0	0	0	0	0
	Total:													

	Phase 1		Cost											
				Month										
WBS	Name	Class	Rate	1	2	3	4	5	6	7	8	9	10	11
	25600													
2.5	Risk Analysis													
		E1	70	1400	0	0	0	0	0	0	0	0	0	0
		E2	50	8000	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				9400	0	0	0	0	0	0	0	0	0	0
	Total: 9400													
2.6	Tech Reviews													
		E1	70	1120	1120	0	1680	0	0	0	1120	0	0	1680
		E2	50	0	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				1120	1120	0	1680	0	0	0	1120	0	0	1680
	Total: 6720													
2.7	Plans													
		E1	70	1400	1400	1400	1400	1400	1400	0	0	0	0	0
		E2	50	4000	4000	4000	4000	4000	4000	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				5400	5400	5400	5400	5400	5400	0	0	0	0	0
	Total: 32400													
2.8	Specs													
		E1	70	0	1400	1400	1400	1400	1400	0	0	0	0	0
		E2	50	0	4000	4000	4000	4000	0	0	0	0	0	0
		E3	30	0	0	0	0	0	2400	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	5400	5400	5400	5400	3800	0	0	0	0	0
	Total: 25400													

WBS	Name	Class	Rate	1	2	3	4	5	6	7	8	9	10	11
	Phase 1		**Cost**	**Month**										
2.9	Acq Support													
		E1	70	560	560	0	0	0	0	0	0	0	0	0
		E2	50	800	800	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				1360	1360	0	0	0	0	0	0	0	0	0
	Total: 2720													
3.1.1	COMMs													
		E1	70	0	0	0	0	560	560	560	560	0	0	0
		E2	50	0	0	0	0	2000	2000	2000	2000	0	0	0
		E3	30	0	0	0	0	2400	2400	2400	2400	0	0	0
		T1	60	0	0	0	0	2400	2400	2400	2400	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	7360	7360	7360	7360	0	0	0
	Total: 29440													
3.1.2	Applications													
		E1	70	0	0	0	0	560	560	560	560	0	0	0
		E2	50	0	0	0	0	2000	2000	2000	2000	0	0	0
		E3	30	0	0	0	0	2400	2400	2400	2400	0	0	0
		T1	60	0	0	0	0	2400	2400	2400	2400	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	7360	7360	7360	7360	0	0	0
	Total: 29440													
3.1.3	Database													
		E1	70	0	0	0	0	560	560	560	560	0	0	0
		E2	50	0	0	0	0	2000	2000	2000	2000	0	0	0
		E3	30	0	0	0	0	2400	2400	2400	2400	0	0	0
		T1	60	0	0	0	0	2400	2400	2400	2400	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	7360	7360	7360	7360	0	0	0
	Total: 29440													

	Phase 1		Cost	Month										
WBS	**Name**	**Class**	**Rate**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
3.2	Integration													
		E1	70	0	0	0	0	0	0	0	0	1120	2800	0
		E2	50	0	0	0	0	0	0	0	0	4000	4000	0
		E3	30	0	0	0	0	0	0	0	0	1200	1200	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	6320	8000	0
	Total: 14320													
3.3	Test & Transition													
		E1	70	0	0	0	0	0	0	0	0	0	1120	2800
		E2	50	0	0	0	0	0	0	0	0	0	4000	4000
		E3	30	0	0	0	0	0	0	0	0	0	1200	1200
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0	6320	8000
	Total: 14320													
3.4	CM													
		E1	70	560	560	560	560	560	560	560	560	560	560	560
		E2	50	0	0	0	0	0	0	0	0	0	0	0
		E3	30	480	480	480	480	480	480	480	480	480	480	480
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	1280	1280	1280	1280	1280	1280	1280	1280	1280	1280	1280
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				2320	2320	2320	2320	2320	2320	2320	2320	2320	2320	2320
	Total: 25520													
4.1	Cost Accounting													
		E1	70	560	560	560	560	560	560	560	560	560	560	560
		E2	50	0	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	480	480	480	480	480	480	480	480	480	480	480
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	480	480	480	480	480	480	480	480	480	480	480
				1520	1520	1520	1520	1520	1520	1520	1520	1520	1520	1520
	Total: 16720													

WBS	Name	Class	Cost Rate	Month 1	2	3	4	5	6	7	8	9	10	11
Phase 1														
4.2	Project Schedule													
		E1	70	560	560	560	560	560	560	560	560	560	560	560
		E2	50	0	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	480	480	480	480	480	480	480	480	480	480	480
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	480	480	480	480	480	480	480	480	480	480	480
				1520	1520	1520	1520	1520	1520	1520	1520	1520	1520	1520
	Total: 16720													
4.3	Customer Reviews													
		E1	70	1120	1120	0	1120	0	0	0	1120	0	0	1120
		E2	50	0	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	960	960	0	960	0	0	0	960	0	0	960
		T2	40	640	640	0	640	0	0	0	640	0	0	640
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				2720	2720	0	2720	0	0	0	2720	0	0	2720
	Total: 13600													
4.4	Project Mngt													
		E1	70	1120	1120	1120	1120	1120	1120	1120	1120	1120	1120	1120
		E2	50	0	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0	0
		T3	20	320	320	320	320	320	320	320	320	320	320	320
				1440	1440	1440	1440	1440	1440	1440	1440	1440	1440	1440
	Total: 15840													
4.5	Acquisition													
		E1	70	0	0	0	0	0	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	480	480	480	0	0	0	0	0	0
		T2	40	0	0	960	960	960	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0	0
				0	0	1440	1440	1440	0	0	0	0	0	0
	Total: 4320	Burn Rate		29200		38000		54480		2888 0		13120		19200

	Phase 1		Cost	Month										
WBS	Name	Class	Rate	1	2	3	4	5	6	7	8	9	10	11
					45200		36800		43480		32720		21120	
	SUMMA													
	Total (System Engineering) 133640			**Grand 340920**										
	Total (Software Engineering) 142480													
	Total (Management) 67200													

Phase2 Labor

WBS	Name	Class	Rate	9	10	11	12	13	14
Phase 2									
2.1	Mission Def								
		E1	70	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	0	0	0	0	0
	Total:								
		0							
2.2	Spec Trees								
		E1	70	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	0	0	0	0	0
	Total:								
		0							
2.3	Rqmts Alloc								
		E1	70	20	0	0	0	0	0
		E2	50	60	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				80	0	0	0	0	0
	Total:								
		80							
2.4	ICDs								
		E1	70	20	20	0	0	0	0
		E2	50	40	40	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				60	60	0	0	0	0
	Total:								

	Phase2		Labor						
WBS	**Name**	**Class**	**Rate**	**9**	**10**	**11**	**12**	**13**	**14**
	120								
2.5	Risk Analysis								
		E1	70	40	0	0	0	0	0
		E2	50	40	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				80	0	0	0	0	0
	Total: 80								
2.6	Tech Reviews								
		E1	70	0	16	0	16	0	16
		E2	50	0	16	0	16	0	16
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	32	0	32	0	32
	Total: 96								
2.7	Plans								
		E1	70	20	20	0	0	0	0
		E2	50	40	40	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				60	60	0	0	0	0
	Total: 120								
2.8	Specs								
		E1	70	0	40	0	0	0	0
		E2	50	0	40	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	80	0	0	0	0
	Total: 80								

Phase2 **Labor**

WBS	Name	Class	Rate	9	10	11	12	13	14
2.9	Acq Support								
		E1	70	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	0	0	0	0	0
	Total: 0								
3.1.1	COMMs								
		E1	70	0	0	16	0	0	0
		E2	50	0	0	40	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	0	56	0	0	0
	Total: 56								
3.1.2	Applications								
		E1	70	0	0	16	16	0	0
		E2	50	0	0	40	40	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	0	56	56	0	0
	Total: 112								
3.1.3	Database								
		E1	70	0	0	16	0	0	0
		E2	50	0	0	80	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	0	96	0	0	0
	Total: 96								

Phase2 **Labor**

WBS	Name	Class	Rate	9	10	11	12	13	14
3.2	Integration								
		E1	70	0	0	0	0	16	0
		E2	50	0	0	0	0	80	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	40	0
		T3	20	0	0	0	0	0	0
				0	0	0	0	136	0
	Total: 136								
3.3	Test & Transition								
		E1	70	0	0	0	0	0	16
		E2	50	0	0	0	0	0	80
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	80
		T3	20	0	0	0	0	0	0
				0	0	0	0	0	176
	Total: 176								
3.4	CM								
		E1	70	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	8	8	8	8	8	8
		T2	40	0	0	0	0	0	0
		T3	20	20	20	20	20	20	40
				28	28	28	28	28	48
	Total: 188								
4.1	Cost Accounting								
		E1	70	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	4	4	4	4	4	4
		T2	40	0	0	0	0	0	0
		T3	20	16	16	16	16	16	16
				20	20	20	20	20	20

Phase2 Labor

WBS	Name	Class	Rate	9	10	11	12	13	14
	Total: 120								
4.2	Project Schedule								
		E1	70	4	4	4	4	4	4
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	16	16	16	16	16	16
				20	20	20	20	20	20
	Total: 120								
4.3	Customer Reviews								
		E1	70	0	8	0	8	0	8
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	8	0	8	0	8
		T2	40	0	0	0	0	0	0
		T3	20	0	16	0	16	0	16
				0	32	0	32	0	32
	Total: 96								
4.4	Project Mngt								
		E1	70	8	8	8	8	8	8
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	8	8	8	8	8	8
				16	16	16	16	16	16
	Total: 96								
4.5	Acquisition								
		E1	70	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	0	0	0	0	0

Phase2 **Labor**

WBS	Name	Class	Rate	9	10	11	12	13	14
	Total: 0								

	Phase2		Cost						
			Contract Month						
WBS	Name	Class	Rate	9	10	11	12	13	14
Phase 2									
2.1	Mission Def								
		E1	70	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	0	0	0	0	0
	Total:								
	0								
2.2	Spec Trees								
		E1	70	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	0	0	0	0	0
	Total:								
	0								
2.3	Rqmts Alloc								
		E1	70	1400	0	0	0	0	0
		E2	50	3000	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				4400	0	0	0	0	0
	Total:								
	4400								
2.4	ICDs								
		E1	70	1400	1400	0	0	0	0
		E2	50	2000	2000	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				3400	3400	0	0	0	0
	Total:								

Phase2 Cost

WBS	Name	Class	Contract Month Rate	9	10	11	12	13	14
	6800								
2.5	Risk Analysis								
		E1	70	2800	0	0	0	0	0
		E2	50	2000	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				4800	0	0	0	0	0
	Total: 4800								
2.6	Tech Reviews								
		E1	70	0	1120	0	1120	0	1120
		E2	50	0	800	0	800	0	800
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	1920	0	1920	0	1920
	Total: 5760								
2.7	Plans								
		E1	70	1400	1400	0	0	0	0
		E2	50	2000	2000	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				3400	3400	0	0	0	0
	Total: 6800								
2.8	Specs								
		E1	70	0	2800	0	0	0	0
		E2	50	0	2000	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	4800	0	0	0	0
	Total: 4800								

	Phase2		**Cost**						
WBS	**Name**	**Class**	**Contract Month Rate**	**9**	**10**	**11**	**12**	**13**	**14**
2.9	Acq Support								
		E1	70	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	0	0	0	0	0
	Total: 0								
3.1.1	COMMs								
		E1	70	0	0	1120	0	0	0
		E2	50	0	0	2000	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	0	3120	0	0	0
	Total: 3120								
3.1.2	Applications								
		E1	70	0	0	1120	1120	0	0
		E2	50	0	0	2000	2000	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	0	3120	3120	0	0
	Total: 6240								
3.1.3	Database								
		E1	70	0	0	1120	0	0	0
		E2	50	0	0	4000	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	0	5120	0	0	0
	Total:								

WBS	Name	Class	Contract Month Rate	9	10	11	12	13	14
	5120								
3.2	Integration								
		E1	70	0	0	0	0	1120	0
		E2	50	0	0	0	0	4000	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	1600	0
		T3	20	0	0	0	0	0	0
				0	0	0	0	6720	0
	Total: 6720								
3.3	Test & Transition								
		E1	70	0	0	0	0	0	1120
		E2	50	0	0	0	0	0	4000
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	3200
		T3	20	0	0	0	0	0	0
				0	0	0	0	0	8320
	Total: 8320								
3.4	CM								
		E1	70	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	480	480	480	480	480	480
		T2	40	0	0	0	0	0	0
		T3	20	400	400	400	400	400	800
				880	880	880	880	880	1280
	Total: 5680								
4.1	Cost Accounting								
		E1	70	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	240	240	240	240	240	240

	Phase2		Cost						
WBS	Name	Class	Contract Month Rate	9	10	11	12	13	14
		T2	40	0	0	0	0	0	0
		T3	20	320	320	320	320	320	320
				560	560	560	560	560	560
	Total: 3360								
4.2	Project Schedule								
		E1	70	280	280	280	280	280	280
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	320	320	320	320	320	320
				600	600	600	600	600	600
	Total: 3600								
4.3	Customer Reviews								
		E1	70	0	560	0	560	0	560
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	480	0	480	0	480
		T2	40	0	0	0	0	0	0
		T3	20	0	320	0	320	0	320
				0	1360	0	1360	0	1360
	Total: 4080								
4.4	Project Mngt								
		E1	70	560	560	560	560	560	560
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	160	160	160	160	160	160
				720	720	720	720	720	720
	Total: 4320								
4.5	Acquisition								
		E1	70	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0

Phase2 **Cost**

WBS	Name	Class	Contract Month Rate	9	10	11	12	13	14
		T1	60	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0
				0	0	0	0	0	0
	Total: 0		Burn Rate	22160	17640	14120	9160	9480	14760

Totals

2.0 (System Engineer-ing)	3.0 (Software Engineer-ing)	4.0 (Mana ge-ment)	Grand
33360	35200	15360	83920

Phase 3 **Labor**

WBS	Name	CI	Con-tract Month Rate	13	14	15	16	17	18	19	20	21	22
P 3													
2.1	Mission Def												
		E1	70	0	0	0	0	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0	0
	Total: 0												
2.2	Spec Trees												
		E1	70	0	0	0	0	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0	0
	Total: 0												
2.3	Rqmts Alloc												
		E1	70	40	0	0	0	0	0	0	0	0	0
		E2	50	160	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				200	0	0	0	0	0	0	0	0	0
	Total: 200												
2.4	ICDs												
		E1	70	20	20	20	20	0	0	0	0	0	0
		E2	50	20	80	120	80	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				40	100	140	100	0	0	0	0	0	0

	Phase 3		Labor										
WBS	Name	CI	Con-tract Month Rate	13	14	15	16	17	18	19	20	21	22
	Total: 380												
2.5	Risk Analysis												
		E1	70	40	0	0	0	0	0	0	0	0	0
		E2	50	160	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				200	0	0	0	0	0	0	0	0	0
	Total: 200												
2.6	Tech Reviews												
		E1	70	0	16	16	0	0	16	0	0	0	16
		E2	50	0	16	16	0	0	16	0	0	0	16
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	16	16	0	0	16	0	0	0	16
				0	48	48	0	0	48	0	0	0	48
	Total: 192												
2.7	Plans												
		E1	70	20	20	20	0	0	0	0	0	0	0
		E2	50	20	80	80	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				40	100	100	0	0	0	0	0	0	0
	Total: 240												
2.8	Specs												
		E1	70	20	20	20	0	0	0	0	0	0	0
		E2	50	20	80	80	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				40	100	100	0	0	0	0	0	0	0

Phase 3 **Labor**

WBS	Name	CI	Con-tract Month Rate	13	14	15	16	17	18	19	20	21	22
	Total: 240												
2.9	Acq Support												
		E1	70	0	0	0	0	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0	0
	Total: 0												
3.1.1	COMMs												
		E1	70	0	0	0	10	10	10	0	0	0	0
		E2	50	0	0	0	20	40	20	0	0	0	0
		E3	30	0	0	0	20	40	20	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	50	90	50	0	0	0	0
	Total: 190												
3.1.2	Applications												
		E1	70	0	0	0	10	10	10	0	0	0	0
		E2	50	0	0	0	40	80	40	0	0	0	0
		E3	30	0	0	0	40	80	40	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	90	170	90	0	0	0	0
	Total: 350												
3.1.3	Database												
		E1	70	0	0	0	10	10	10	0	0	0	0
		E2	50	0	0	0	40	80	40	0	0	0	0
		E3	30	0	0	0	40	80	40	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0

	Phase 3		**Labor**										
WBS	**Name**	**CI**	**Con-tract Month Rate**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	90	170	90	0	0	0	0
	Total: 350												
3.2	Integration												
		E1	70	0	0	0	0	0	0	20	20	0	0
		E2	50	0	0	0	0	0	0	80	80	0	0
		E3	30	0	0	0	0	0	0	80	80	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	180	180	0	0
	Total: 360												
3.3	Test & Transition												
		E1	70	0	0	0	0	0	0	0	10	20	20
		E2	50	0	0	0	0	0	0	0	20	120	80
		E3	30	0	0	0	0	0	0	0	20	120	80
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	50	260	180
	Total: 490												
3.4	CM												
		E1	70	0	0	0	0	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	4	4	4	8	8	8	8	8	8	8
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	8	8	8	20	20	20	20	20	20	40
				12	12	12	28	28	28	28	28	28	48
	Total: 252												
4.1	Cost Accounting												

Phase 3 **Labor**

WBS	Name	CI	Con-tract Month Rate	13	14	15	16	17	18	19	20	21	22
		E1	70	0	0	0	0	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	2	2	4	4	4	4	4	4	4	4
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	4	4	16	16	16	16	16	16	16	16
				6	6	20	20	20	20	20	20	20	20
	Total: 172												
4.2	Project Schedule												
		E1	70	2	2	4	4	4	4	4	4	4	4
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	4	4	16	16	16	16	16	16	16	16
				6	6	20	20	20	20	20	20	20	20
	Total: 172												
4.3	Customer Reviews												
		E1	70	0									
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	16	16	0	0	16	0	0	0	16
				0	16	16	0	0	16	0	0	0	16
	Total: 64												
4.4	Project Mngt												
		E1	70	2	2	8	8	8	8	8	8	8	8
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	2	2	8	8	8	8	8	8	8	8
				4	4	16	16	16	16	16	16	16	16
	Total: 136												

Phase 3 **Labor**

WBS	Name	CI	Con-tract Month Rate	13	14	15	16	17	18	19	20	21	22
4.5	Acquisition												
		E1	70	0	0	0	0	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0	0
	Total: 0												

Phase 3 **Cost**

WBS	Name	CI	Rate	Month 13	14	15	16	17	18	19	20	21	22
P 3													
2.1	Mission Def												
		E1	70	0	0	0	0	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0	0
	Total: 0												
2.2	Spec Trees												
		E1	70	0	0	0	0	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0	0
	Total: 0												
2.3	Rqmts Alloc												
		E1	70	2800	0	0	0	0	0	0	0	0	0
		E2	50	8000	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				10800	0	0	0	0	0	0	0	0	0
	Total: 10800												
2.4	ICDs												
		E1	70	1400	1400	1400	0	0	0	0	0	0	0
		E2	50	1000	4000	6000	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				2400	5400	7400	0	0	0	0	0	0	0
	Total:												

Phase 3 **Cost**

WBS	Name	CI	Rate	Month 13	14	15	16	17	18	19	20	21	22
	15200												
2.5	Risk Analysis												
		E1	70	2800	0	0	0	0	0	0	0	0	0
		E2	50	8000	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				10800	0	0	0	0	0	0	0	0	0
	Total: 10800												
2.6	Tech Reviews												
		E1	70	0	1120	1120	0	0	1120	0	0	0	1120
		E2	50	0	800	800	0	0	800	0	0	0	800
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	320	320	0	0	320	0	0	0	320
				0	2240	2240	0	0	2240	0	0	0	2240
	Total: 8960												
2.7	Plans												
		E1	70	0	1400	1400	0	0	0	0	0	0	0
		E2	50	0	4000	4000	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	5400	5400	0	0	0	0	0	0	0
	Total: 10800												
2.8	Specs												
		E1	70	1400	1400	1400	0	0	0	0	0	0	0
		E2	50	4000	4000	4000	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				5400	5400	5400	0	0	0	0	0	0	0
	Total: 16200												

Phase 3 **Cost**

WBS	Name	CI	Rate	Month 13	14	15	16	17	18	19	20	21	22
2.9	Acq Support												
		E1	70	0	0	0	0	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0	0
	Total: 0												
3.1.1	COMMs												
		E1	70	0	0	0	700	700	700	0	0	0	0
		E2	50	0	0	0	1000	2000	1000	0	0	0	0
		E3	30	0	0	0	600	1200	600	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	2300	3900	2300	0	0	0	0
	Total: 8500												
3.1.2	Applications												
		E1	70	0	0	0	700	700	700	0	0	0	0
		E2	50	0	0	0	2000	4000	2000	0	0	0	0
		E3	30	0	0	0	1200	2400	1200	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	3900	7100	3900	0	0	0	0
	Total: 14900												
3.1.3	Database												
		E1	70	0	0	0	700	700	700	0	0	0	0
		E2	50	0	0	0	2000	4000	2000	0	0	0	0
		E3	30	0	0	0	1200	2400	1200	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	3900	7100	3900	0	0	0	0
	Total: 14900												

Phase 3 **Cost**

WBS	Name	CI	Rate	Month 13	14	15	16	17	18	19	20	21	22
3.2	Integration												
		E1	70	0	0	0	0	0	0	1400	1400	0	0
		E2	50	0	0	0	0	0	0	4000	4000	0	0
		E3	30	0	0	0	0	0	0	2400	2400	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	7800	7800	0	0
	Total: 15600												
3.3	Test & Transition												
		E1	70	0	0	0	0	0	0	0	700	1400	1400
		E2	50	0	0	0	0	0	0	0	1000	6000	4000
		E3	30	0	0	0	0	0	0	0	600	3600	2400
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	2300	11000	7800
	Total: 21100												
3.4	CM												
		E1	70	0	0	0	0	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	240	240	240	0	480	480	480	480	480	480
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	160	160	160	0	400	400	400	400	400	800
				400	400	400	0	880	880	880	880	880	1280
	Total: 6880												
4.1	Cost Accounting												
		E1	70	0	0	0	0	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	120	120	240	0	240	240	240	240	240	240
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	80	80	320	0	320	320	320	320	320	320

Phase 3 **Cost**

WBS	Name	CI	Rate	Month 13	14	15	16	17	18	19	20	21	22
				200	200	560	0	560	560	560	560	560	560
	Total: 4320												
4.2	Project Schedule												
		E1	70	140	140	280	0	280	280	280	280	280	280
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	80	80	320	0	320	320	320	320	320	320
				220	220	600	0	600	600	600	600	600	600
	Total: 4640												
4.3	Customer Reviews												
		E1	70	0	1120	1120	0	0	1120	0	0	0	1120
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	0	320	0	0	0	0	0	0	0	0
				0	1440	1120	0	0	1120	0	0	0	1120
	Total: 4800												
4.4	Project Mngt												
		E1	70	140	140	560	0	560	560	560	560	560	560
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0
		T3	20	40	40	160	0	160	160	160	160	160	160
				180	180	720	0	720	720	720	720	720	720
	Total: 5400												
4.5	Acquisition												
		E1	70	0	0	0	0	0	0	0	0	0	0
		E2	50	0	0	0	0	0	0	0	0	0	0
		E3	30	0	0	0	0	0	0	0	0	0	0
		T1	60	0	0	0	0	0	0	0	0	0	0
		T2	40	0	0	0	0	0	0	0	0	0	0

Phase 3 **Cost**

WBS	Name	CI	Rate	Month 13	14	15	16	17	18	19	20	21	22
		T3	20	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0	0
	Total:												
		0	Burn Rate	35800	28280	23840	10100	20860	16220	10560	12860	13760	14320

TOTALS

Total 2.0 (System Engineering) 72760	**Grand** **173800**
Total 3.0 (Software Engineering) 81880	
Total 4.0 (Management) 19160	