The Gemini 8-m Telescopes Project

Gemini Software & Controls Management Plan

Version 1.

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We are continually being faced with fantastic opportunities
brilliantly disguised as insoluble problems.

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Revision Chart

Draft 1	for review within Controls Group
Draft 2	for review within Project
Draft 3	for review by Working Group
Draft 4	for general review
Version 1	under change control

Action Items

check use of operations personnel throughout document

should try to get more developers on operations staff

reviews by Gemini of Work Packages are with Gemini as customer; need to schedule reviews with Gemini as vendor and Scientists as customers

need to add draft WBS

do we need to add PDR/CDR of SDD/SRS by CCWG ?

what entity provides technical oversight of the project for AURA ?

PREFACE

This document covers the software engineering aspects of the Gemini Software and Controls Project and it is intended to be used by both Gemini and Gemini partners, e.g., universities, industries, etc., in the development of Gemini software and controls. The present document contains the following major sections:

Introduction

Project Organization

Managerial Process

Technical Process

Work Packages, Schedule, and Budget

Appendices may be provided for some specific topics and shall be considered as applicable. At the end of the document an example of the software life cycle using the Ward and Mellor methodology is given.

Must and shall are used to indicate mandatory practices, should and may are used, respectively, for recommendations and guidelines. The provisions of the SMP are applied to the whole Gemini Software and Controls, whether developed in house or by external partners.

This document follows IEEE Standard 1058.1-1987, *Software Project Management Plans*, in both its form and content.

The intent in providing this document is to enforce standard engineering practices on the development of software and controls for the Gemini Project.

1. INTRODUCTION

This section of the SMP shall provide an overview of the project and the product, a list of project deliverables, the plan for development of the SMP, reference materials for the SMP, and definitions and acronyms within the SMP.

1.1. PROJECT OVERVIEW

This subsection shall provide a concise summary of the project objectives, the product to be delivered, major work activities, major work products, major milestones, required resources, and master schedule and budget.

1.1.1. Project Objectives

The objective of the Gemini Software & Controls Project is the construction, installation, commissioning and handover of the software and control systems required for the installation, commissioning and operation of two 8 meter telescope systems together with the necessary infrastructure at Mauna Kea, Hawaii and Cerro Pachon, Chile.

1.1.2. Product Delivered

The Gemini Software & Controls Project is part of the Gemini 8-m Telescopes Project and its task is to provide the software and controls required to control and operate the telescope itself and its associated instruments both locally, i.e. at the telescope site, and remotely, for example, from Gemini headquarters at Tucson or from one of the partner countries.

1.1.3. Major Work Activities

The major work activities will be:

- requirements analysis
- work package allocation
- work package management
- acceptance testing
- installation and commissioning

1.1.4. Major Work Products

The major work products resulting from the above work activities will be:

- Specification Documents
    - Operational Concept Definition
    - Software Requirements Specification
    - System Design Document

- Work Package Agreements
- Specific Work Package Documentation
    - Preliminary Design Review documents
    - Critical Design Review documents
    - Acceptance Testing documents
- Software and Controls Packages
- Installation and Commissioning documents

1.1.5. Major Milestones

The major milestones of the project are:

- system design review
- completion of the control system simulator
- completion of the functional control system
- delivery of specification control system
- acceptance of Mauna Kea control system
- acceptance of Cerro Pachon control system

1.1.6. Required Resources

The staff resources required within the Gemini Controls Group will be a Controls Manager, System Software Engineer, Real Time Software Engineer, and a Servo Controls Engineer.

The staff resources required from the Gemini Project will be:

- support from the Gemini Documentation Coordinator for handling documents under change control,
- attendance at major reviews by the Gemini Systems Engineer,
- support from the Gemini secretarial staff
- contractual and budgetary support from the Gemini administrative staff

Staff resources for installation and commissioning will be a combination of the members of the Controls Group and those members of the operations team which are hired in advance of handover.

Staff resources from outside of the Gemini Project are detailed in the appropriate work packages.

1.1.7. Master Schedule And Budget

The master schedule for the project is show in figure 1.1 as a gantt chart. The timing of the activities on Mauna Kea and Cerro Pachon are tied to the dates that the enclosure and telescope are available for installation of the software deliverables.

The details of the budget are shown in figures 1.2 and 1.3. Figure 1.2 shows an overview with an emphasis on staff costs while figure 1.3 shows the costs of the work packages.

1.1.8. Relationship To Other Projects

1.1.8.1. External Relationships

The Gemini Project is not itself directly related to any other projects. It is recognized by Gemini that there may be cost and schedule advantages to Gemini if some of the work packages required by Gemini can be synchronized with similar work being carried out by the partner countries.

1.1.8.2. Internal Relationships

The Gemini Software & Controls Project is related to the other projects within the Gemini Project. There are specific ties to the Enclosure, Telescope, Optics, and Instrument Projects. Each of these projects requires software and controls systems to be provided with the individual mechanisms. The relationship is that the group responsible for the mechanism (which in general is <u>not</u> the Controls Group) will decide at what level the responsibility is split between their group and the Controls Group. This split can occur at the following levels of responsibility:

- actuator and sensor
    - group responsible sets control specification
    - two groups agree on appropriate actuators and sensor
    - controls group arranges delivery of system meeting specification
- subsystem
    - two groups agree on subsystem interface control definition
    - group responsible delivers subsystem which meets controls subsystem interface specification
    - controls group delivers overlying system and subsystem interface
- system
    - two groups agree on system interface control definition
    - group responsible delivers entire system which uses controls system standards

1.1.9. Official Product Requirement Document

The official statement of product requirements is version 1.1 of the Gemini Science Requirements document.

1.2. Project Deliverables

This subsection shall list all of the items to be delivered to the customer, the delivery dates, delivery locations, and quantities required to satisfy the terms of the project agreement. This list of project deliverables shall not be construed as an official statement of project requirements.

1.2.1. Deliverable Items

The Gemini Software & Controls Project shall deliver software systems, control systems, documentation, and user manuals required as well as the necessary computer, network and electronic hardware to support the software and controls functions. The specifics will be part of the individual work package descriptions.

Also included as a deliverable is acceptance testing, installation, test, checkout, commissioning and handover to the operations staff.

Sufficient spares necessary to implement the maintainability and supportability requirements of the project shall be included as deliverables.

1.2.2. Delivery Dates

All of the items shall be delivered such that successful handover to the operations staff can take place on or before:

- December 31, 1999 on Mauna Kea
- December 31, 2001 on Cerro Pachon

1.2.3. Delivery Locations

The deliverables shall be delivered to the Gemini installations associated with Mauna Kea, Hawaii and Cerro Pachon, Chile.

1.2.4. Quantities Required

There shall be quantity one of the deliverable items delivered to each of the two delivery locations.

1.3. Evolution Of The SMP

This subsection shall specify the plans for producing both scheduled and unscheduled updates to the SMP. This subsection shall also specify the mechanisms used to place the initial version of the SMP under change control and to control subsequent changes to the SMP.

1.3.1. Scheduled Updates Of SMP

The SMP shall be updated on a six month time schedule throughout the project lifetime until handover is complete. If it proves more efficient, this time schedule may change to an annual basis later in the project.

1.3.2. Unscheduled Updates of SMP

At any time that substantial revisions of the SMP are necessary then an unscheduled update will be issued. If such a revision would occur within 3 months of a scheduled update then it will the Group Manager's decision whether to delay the unscheduled update or to issue the scheduled update earlier.

1.3.3. Dissemination Of Updates

Updates will be issued by the project to a mailing list maintained by the project. The minimum membership of this mailing list will be Project Manager, Project Scientist, Project Managers, Controls Working Group members, all community groups producing software for the Gemini Project. In addition an electronic copy of the most current document, in encapsulated postscript format, shall be available for anonymous ftp transfer at all times. The cost and budget information will not be released outside of the Gemini project.

1.3.4. Initial Version Of SMP

The initial version of the SMP will undergo four drafts before coming under formal change control. The first draft shall be for review within the controls group, the second draft for review within the project, the third draft shall be for review within the control working group, and the fourth draft shall be for review within the community. Once all four drafts are finished the document will undergo formal review before coming under change control.

The formal review of the SMP shall be performed by:

- the Controls manager
- the System Software Engineer
- the Gemini Systems Engineer
- the Controls Working Group

1.3.5. Change Control of SMP

Once under change control any proposed changes must be approved by the Gemini Change Control Board. Prior to approval by this body the changes will be approved by an ad hoc committee made up of the Gemini Controls Manager, the Chairman of the Gemini Controls Working Group, and such members within and without the Controls Working Group as are interested in making comment.

1.4. Reference Materials

This subsection shall provide a complete list of all documents and other sources of information referenced in the SMP. Each document should be identified by title, report number, date, author, and publishing organization. Any deviations from referenced standards or policies shall be identified and justifications shall be provided.

1.4.1. Applicable Documents

The following documents of the exact issue shown form a part of this document to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this document, the contents of this document shall be considered as a superseding requirement.

[EDS] Gemini Electronic Design Specification - SPE-ASA-G0008

[GOALS] Goals & Requirements for Software & Controls - SPE-C-G0026

[SCP] Gemini Software Configuration Control Plan - SPE-C-G0011

[SPS] Gemini Programming Standards - SPE-I-G0009

[SRS] Gemini Software Requirement Specification - SPE-C-G0014

1.4.2. Reference Documents

The following documents are not part of this document, but are relevant to the management of the development of the Gemini Software and are referenced in the text.

Gemini Instrumentation Plan

IEEE 610.12-1990 -- Standard Glossary of Software Engineering Terminology

IEEE 730-1989 -- Standard for Software Quality Assurance Plans

IEEE 828-1990 -- Standard for Software Configuration Management Plans

IEEE 829-1983 -- Standard for Software Test Documentation

IEEE 830-1984 -- Guide for Software Requirements Specifications

IEEE 983-1986 -- Guide for Software Quality Assurance Planning

IEEE 1008-1987 -- Standard for Software Unit Testing

IEEE 1012-1986 -- Standard for Software Verification and Validation Plans

IEEE 1016-1987 -- Recommended Practice for Software Design Descriptions

IEEE 1042-1987 -- Guide to Software Configuration Management

IEEE 1058.1-1987 -- Standard for Software Project Management Plans

IEEE 1063-1987 -- Standard for Software User Documentation

P Ward and S Mellor, Yourdon Press, 1985 -- Structured Development for Real-Time Systems

1.5. Definitions And Acronyms

This subsection shall specify, define, or provide references to the definition of all terms and acronyms required to properly interpret the SMP.

1.5.1. Definitions

The whole body of software that will be present in the Gemini Project can be divided into three categories:

1.5.1.1. Vendor Software

Proprietary, off-the-shelf software such as operating systems, DBMSs, etc. This also includes community supplied and supported software such as ADAM, IRAF, MIDAS, etc.

1.5.1.2. Modified Vendor Software

Vendor software (as above) specifically adapted to Gemini's needs.

1.5.1.3. Specially Developed Software

Gemini-specific software developed either in house or by a developer at Gemini's request. The copyright and all proprietary rights relating to such software will belong to Gemini or to both parties, depending on case-specific contractual conditions.

In addition to previous classifications, the following definition identifies a particular case:

1.5.1.4. Embedded Software

Software used in the lower levels of the controlling hardware (Programmable Logic Controllers, microprocessors, etc.) and that typically resident in ROM or EPROM. No part of this software will be downloaded at start-time. This embedded software can be divided, with respect to communication with upper level software, into two categories:

- on-line: communication uses software protocols.
- stand-alone: communication is via electronic interfaces only, i.e., digital or analog signal exchange.

The embedded software can be: vendor, adapted, or specially developed.

1.5.1.5. Gemini Software And Controls Hierarchy

In the absence of a standard definition, the following terms are used to define the software hierarchy and have, therefore, Gemini specific meanings:

- Gemini Software refers to the whole Gemini Software and Controls system. The Gemini Software is divided into a number of packages.
- A package corresponds to a major subdivision of the Gemini Software. The Gemini Software Design Description organizes the Gemini Software into the following major packages:
    - Observatory Control (OCS)
    - Telescope Control (TCS)
    - Communications (COM)
    - Data Handling (DHS)
    - Instrumentation Control (ICS), covering the aspects common to all instruments.
    - one package for each Instrument foreseen in the Gemini Instrumentation Plan.

  Packages will be subdivided into modules.

- A module is a relatively large subdivision of a package which handles one of the major functional requirements of the package. Modules are divided into units.
- A unit is a group of logically or functionally related components.
- A component is the smallest identifiable software unit in the system. While no rigid definition of a component is proposed, typically it should:
    - be separately compilable, or contained in an include file
    - perform only a single function
    - consist of less than 300 lines of source code (including comments)

1.5.1.6. Software Engineering Terms

This document uses many software engineering terms, or terms which, in a software engineering context, have a restricted meaning. The definitions are taken from the IEEE Glossary of Software Engineering Terminology (IEEE 610.12-1990).

The definition of a specific term is given in the text when the term is introduced. In addition to these definitions, a list of other terms used, not defined later in the text, follows:

Acceptance Testing

Formal testing conducted to determine whether or not a system satisfies its acceptance criteria and to enable the customer to determine whether or not to accept the system. The acceptance test can occur at different levels.

Baseline

A specification or product that has been formally reviewed and agreed upon, and that, thereafter, serves as a basis for further development, and that can be changed only through formal change control procedures.

Change Control

The process by which a change is proposed, evaluated, approved (or rejected), scheduled and tracked.

Configuration

The arrangement of a computer system or network as defined by the nature, number and chief characteristics of its functional units. More specifically, the term 'configuration' may refer to a hardware configuration or to a software configuration.

Configuration Item

A collection of hardware or software elements treated as a unit for the purpose of configuration management.

Data Dictionary

A collection of the names of all data items in a software system, together with relevant properties of those items.

Data Flow Diagram

A graphical representation of a system, showing data sources, data sinks, storage and processes performed on data as nodes, and logical flow of data as links between nodes.

Validation

Correct work being performed.

Verification

Work being performed correctly.

Quality

The totality of features and characteristics of a product or service that bears on its ability to satisfy given needs.

Quality Assurance

A planned and systematic pattern of all actions necessary to provide adequate confidence that the item or product conforms to established technical requirements.

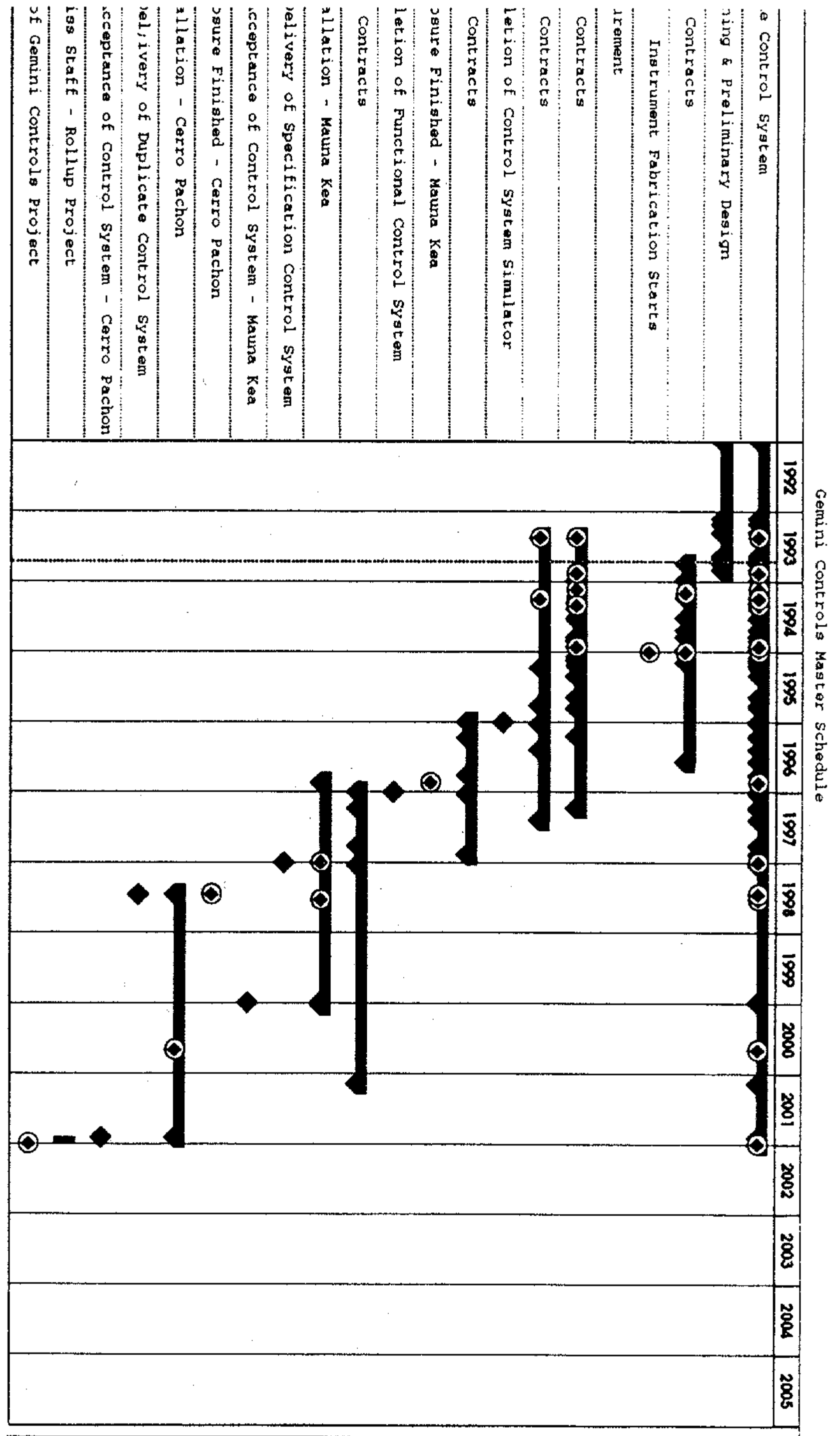
Abbreviations and Acronyms

The following abbreviations and acronyms are used in this document:

CDR	Critical Design Review
DFD	Data Flow Diagram
EPICS	Experimental Physics and Industrial Control System
EPROM	Erasable Programmable Read Only Memory
FS	Functional Specification
G8MT	Gemini 8 meter Telescope
GAG	Gemini Acronym Glossary
GCCB	Gemini Change Control Board
GSPR	Gemini Software Project Responsible
GWPR	Gemini Work Package Responsible
HOS	High-level Operation Software
ICS	Instrumentation Control Software
IEE	Institution of Electrical Engineers (UK)
IEEE	Institute of Electrical and Electronics Engineers (USA)
OCS	Observatory Control Software
PAM	Product Assurance Manager
PCS	Position Control Software
PDL	Program Design Language
PDR	Preliminary Design Review
PLC	Programmable Logic Controller
PM	Program Manager

QA	Quality Assurance
ROM	Read Only Memory
ROS	Remote Operation Software
RTE	Real Time Engineer
SCC	Software Configuration Control
SCCB	Software Configuration Control Board
SCCM	Software Configuration Control Manager
SCE	Servo Control Engineer
SCS	Software Concept Specification
SD	Software Design
SDD	Software Design Description
SE	System Engineer
SPR	Software Package Responsible
SQAM	Software Quality Assurance Manager
SRS	Software Requirements Specification
SSE	Software System Engineer
STP	Software Test Plan
TBD	To Be Defined
TBR	To Be Resolved
TCS	Telescope Control Software
WBS	Work Breakdown Structure
WPR	Work Package Responsible

Fig. 1-1 Gemini Controls Group Master Schedule



2. PROJECT ORGANIZATION

This section shall specify the process model for the project, describe the project organizational structure, identify organizational boundaries and interfaces, and define individual responsibilities for the various project elements.

2.1. Process Model

This subsection shall define the relationships among major project functions and activities by specifying the timing of major milestones, baselines, reviews, work products, project deliverables, and sign-offs that span the project. The process model must include project initiation and project termination activities.

The process model for the Gemini Software Project is based on the IEEE definition of the software life cycle (i.e., the period of time that begins when a software product is conceived and ends when the product is no longer available for use). The Gemini process model includes the following phases:

- Project Initiation
- Concept exploration
- Requirements
- Design
- Implementation
- Test
- Installation and checkout
- Operation and maintenance
- Project Termination

The Retirement phase, present in the IEEE definition, has been omitted as the management of retired versions of software is covered by the Software Configuration Control Plan. The Gemini software life cycle model is shown in figure 2.1a.

2.1.1. Milestones

Major project milestones are detailed below and the timing relationships are shown in figure 2.2.

- system design review
- allocation of individual work packages
- completion of the control system simulator
- completion of the functional control system
- delivery of specification control system
- acceptance of Mauna Kea control system

- delivery of duplicate control system to Cerro Pachon
- acceptance of Cerro Pachon control system

2.1.2. Baselines

The incremental delivery approach is the most suitable model for the Gemini Software project. In this approach, the software is delivered in multiple releases, each with increased functions and capabilities. The act of releasing software will be driven by the telescopes and common part installation planning, and, starting from the design phase, there will be multiple parallel streams of activity.

The proposed baseline systems will be:

- control system simulator - this system will be functional at the user level but is not required to actually control physical devices. The simulator will be delivered incrementally.
    - Simulator #1 - this will be the output from the Software Design Description Critical Design Review. It will consist of the top two levels of user screens and will provide animation and rapid prototyping capability
    - Simulator #2 - this will be the output from the Observatory Control System Preliminary Design Review and will be an expanded version of Simulator #1
    - Simulator #3 - this will be the output from the Observatory Control System Critical Design Review and will be an expanded version of Simulator #2
    - Simulator #4 - this will be the output from the Observatory Control System Progress Review #1 and will be an expanded version of Simulator #3. It will also incorporate the top level simulators for the Telescope and Data Handling Systems.
- functional control system - this system will control all devices but does not need to meet any specifications as to degree of control (for instance it might control the telescope with only a scale factor relating encoder units to telescope position). The functional system will be delivered incrementally.
    - Functional System #1 - this will be the output from the Observatory Control System Progress Review #2 and will consist of
        - expanded version of Simulator #4
        - functional Telescope Control and Data Handling Systems
        - simulators for Mount, Primary, Secondary, and Enclosure Control Systems
    - Functional System #2 - this will be consist of
        - Functional System #1
        - Telescope Control and Data Handling Systems after acceptance testing
        - functional Mount, Primary, Secondary and Enclosure Control Systems

- specification control system - this is the system which shall be subjected to commissioning and acceptance testing. It will consist of all the subsystems after they have gone through their own, individual, acceptance testing.
- handover control system - this is the system as delivered to the operations team after installation and commissioning.

The timing of these baselines is identical to the associated milestone of the same name and is shown in fig 2.3.

2.1.3. Reviews

Major reviews are detailed below and their timing relationships are shown in fig.2.4. Reviews are divided into two different types of reviews: validation and verification.

validation reviews provide scientific oversight of the work being performed

verification reviews provide technical oversight of the work being done

The model for providing scientific oversight of the Gemini Controls Project is shown in figure 2.1b.

2.1.3.1. Validation Reviews

Validation is the process of evaluating a system or component durng or at the end of the development process to determine whether it satisfies specified requirements - in this case the Science Requirements.

<u>Operational Concept Scientific Review</u>

This review sets the OCD as a document against which the controls system will be verified. As such it evaluates the OCD, and specifically the operational scenarios contained within, to ensure compliance with the Scientific Requirements.

The review also evaluates the SRS to ensure compliance with the Scientific Requirements.

A third document is also reviewed, which describes the traceability of the Scientific Requirements through to the OCD and SRS.

This review will also examine Simulator #1.

<u>Operational Concept Scientific Walkthrough</u>

In this review the scenarios in the OCD will be "walked through" with the current design - showing how the system will accomplish each scenario.

This review will also examine Simulator #2.

<u>Observatory Simulator Scientific review</u>

In this review the scenarios in the OCD will be run Simulator #4 - showing the system response to each scenario.

Observatory Control System Scientific Review

In this review the scenarios in the OCD will be run on Functional System #2 - showing the system response to each scenario.

Mauna Kea Acceptance Test Review

As part of this review the OCD scenarios will be run on the commissioned system.

Cerro Pachon Acceptance Test Review

As part of this review the OCD scenarios will be run on the commissioned system.

2.1.3.2. Verification Reviews

Verification is the process of evaluating a system or component to determine whether the products of a given development phase satisfy the conditions imposed at the start of that phase. - in this case the OCD and SRS. It is anticipated that new and/or modified operational scenarios will be added to the OCD over time.

The Controls Group propose a sequence of verification reviews.

System Design Review

This review establishes

- hardware / software choices
- hardware / software architecture
- Draft Software Requirements Specification (SRS)
- Draft Operational Concept Definition (OCD)
- management / development plans

but it does not relate these directly to Scientific Requirements.

The System Design Review is a technical review which provides the basis required to proceed with designs which can be validated against the Scientific Requirements.

Preliminary Design Review

This review is held to establish (sec.3.6.2.2 IEEE Std.730-1-1989) the technical adequacy of the software as depicted in the preliminary Software Design Description.

Critical Design Review

This review is held to determine (sec.3.6.2.3 IEEE Std.730-1-1989) the acceptability of the detailed software designs as depicted in the detailed Software Design Description in satisfying the requirements of the SRS.

Work Package Reviews (see section on individual work packages for timing)

- System Requirements Review

    - Preliminary Design Review
    - Critical Design Review
    - Acceptance Test Review
- Mauna Kea Acceptance Test Review
- Cerro Pachon Acceptance Test Review

2.1.4. Work Products

The major tangible items resulting from project functions, tasks, and activities are detailed below. Their timing relationships are shown in fig.2.5. except for individual work packages whose timing is contained in section 5.

- Software Requirements Specification document (part of System Design Review)
- Software Design Description
- Operational Concept Definition
- Work Package Descriptions
- Specific Work Package Documentation (see Sec.5 for timing)
    - System Requirements Review documents
    - Preliminary Design Review documents
    - Critical Design Review documents
    - Acceptance Testing documents
- Software and Controls Packages (delivered as part of respective baselines)
    - documentation
    - user manuals
    - supporting computer, network, and electronic hardware
    - sufficient spares to implement the maintainability and supportability requirements
- Mauna Kea Installation and Commissioning documents
- Cerro Pachon Installation and Commissioning documents

2.1.5. Project Deliverables

The work products which will be delivered to the customer are the same as the work products detailed in section 2.1.4.

2.1.6. Sign-Offs

The activities requiring formal sign offs are detailed below. Their timing relationships are shown in fig.2.2. except for individual work packages whose timing is contained in section 5.

- System Design Review
- Individual Work Package Reviews
    - System Requirements Review
    - Preliminary Design Review
    - Critical Design Review
    - Acceptance Test Review
- Mauna Kea System Handover Review
- Cerro Pachon System Handover Review

2.2. Organizational Model

This subsection shall describe the organizational structure of the project.

2.3. Organizational Boundaries And Interfaces

This subsection shall describe the managerial, administrative, scientific and technical boundaries between the project and each of the following entities:

- the parent organization
- the customer organization(s)
- subcontracted organizations
- other interacting organizations

In addition, the managerial and administrative interfaces of the project support functions, such as configuration management, quality assurance, and verification and validation shall be specified in this subsection.

The organizational boundary structure of the Gemini Project and external organizations is shown in figure 2.6.

2.3.1. Gemini Project

The structure of the Gemini Project staff is shown in figure 2.5.

- administrative representative will be the Gemini Contracting Officer.
- managerial representative will be the Gemini Project Manager
- technical representative will be the Gemini Controls Manager
- scientific representative will be the Gemini Project Scientist

2.3.2. Parent Organization

The parent organization of the Gemini Project is the Association of Universities for Research in Astronomy (AURA).

- administrative representative will be AURA's contracting officer
- managerial representative will be the Gemini Board of Directors
- technical representative will be TBD
- scientific representative will be the Gemini Science Advisory Committee

2.3.3. Customer Organization

The customer organization is composed of the scientific communities of the partner countries. These scientific communities are represented by the respective National Gemini Project Offices.

- administrative representative will be the national project manager
- managerial representative will be the national project manager
- technical representative will be the national project engineer or national project manager
- scientific representative will be the national project scientist

In specific instances the national project managers may delegate all or part of their authority to national work package managers. In an analogous manner the national project scientists may delegate all or part of their authority to national work package scientists.

The intent in this delegation is to delegate technical and/or scientific authority over broad groups of related work packages, not over individual work packages.

2.3.4. Subcontracted Organizations

Subcontracted organizations may consist of commercial companies, astronomical observatories, and groups within educational institutions in the partner countries. In each case the subcontracted organization must identify an administrative, managerial, technical, and scientific representative.

2.3.5. Project Support Functions

This subsection shall describe the managerial, administrative, scientific, and technical interfaces of the project support functions, such as configuration management, quality assurance, and verification and validation.

2.3.5.1. Configuration Management

Configuration management will be handled by the Controls Group. It will be the responsibility of each work package developer to handle configuration management for their particular work package up until handover to the Controls Group. All configuration management shall be in accordance with the Software & Controls Configuration Control Plan. The Controls Configuration Manager shall be the System Software Engineer.

The interfaces required can be divided between those within the project and those external to the project.

The managerial and administrative interfaces for configuration management within the Gemini Project shall be:

- Controls Configuration Manager
- Gemini Group Member responsible for work

The managerial and administrative interfaces for configuration management external to the Gemini Project shall be:

- Controls Configuration Manager
- Gemini Group Member responsible for work
- Work Package's project responsible

2.3.5.2. Quality Assurance And Quality Control

Quality is defined as the degree to which a system, component, or process meets specified requirements.

Quality assurance is a set of activities designed to evaluate the process by which products are developed or manufactured.

Quality control is a set of activities designed to evaluate the quality of developed or manufactured products.

It is not currently planned to have a formal QA plan as per IEEE 730-1989. However this project management plan currently contains 4 of the required 6 documents and 2 of the required 10 reviews of 730-1989.

QA and QC of the work done by the Controls Group will be handled by periodic reviews by an external review committee. The members of this committee, currently called the *Computer and Controls Working Group*, will be selected by joint agreement of the Controls Manager and the Project Scientist. The Quality Assurance Manager shall be the Gemini Controls Manager.

The managerial and administrative interface will be between the Quality Assurance Manager and the Working Group chairperson, who will be selected by the Gemini Project Scientist.

QA and QC of the work done by external contractors and developers will be handled by reviews of that work by the Gemini Project. The Quality Control Manager shall be the Real Time Software Engineer.

The managerial and administrative interface will be between the Quality Control Manager and the Work Package Responsible.

2.3.5.3. Verification and Validation

V&V for work done by external contractors and developers will be handled by the same reviews as for quality control. Formal acceptance tests will be done before the work package is accepted by Gemini. The managerial and administrative interface will be between the GWPR and the WPR.

Validation of work done by the Project will be handled by the set of validation reviews discussed in section 2.1.3.1.

Verification of the work done by the project will take place during acceptance testing of the integrated software and controls system from the Gemini Controls Group by the Gemini Operations Group. In this step the managerial interface is between the GCM and the Gemini Operations TBD.

2.4. Project Responsibilities

This subsection shall identify and state the nature of each major project function and activity, and identify the individuals who are responsible for these functions and activities.

In relation to the development of the Gemini Software and Controls, the following functions are foreseen within the Gemini Controls Group:

- overall management of the Gemini Software & Controls project
- development and allocation of the work packages
- management of the allocated work packages
- collaboration with Gemini Instrument Group
- software system engineering
- management of the software quality assurance.

These functions are described in detail in the following sections and summarized in table 2.1.

2.4.1. Overall Management of the Gemini Software and Controls Project

Responsibility for overall management of the Gemini Software and Controls project has been assigned to the Gemini Controls Group.

Within the Gemini Controls Group managerial responsibility for the Gemini Software and Controls is assigned to the Gemini Controls Manager (GCM), system software technical responsibility is assigned to the Gemini Systems Software Engineer (SSE), real time software technical responsibility is assigned to the Gemini Real Time Software Engineer (RTE), and controls technical responsibility is assigned to the Gemini Servo Control Engineer (SCE).

The GCM will be responsible for all managerial aspects of the development of the Gemini Software and Controls. Specifically, his responsibilities include:

- project planning and cost control of the Gemini Software and Controls project,
- production and maintenance of the Gemini Software and Controls Management Plan, (this document)
- production of the Gemini Software Concept Specification
- in cooperation with GWPR, WPRs and developers, the preparation and maintenance of the work breakdown structure (WBS). As the structure of each package and the content of each release are known in detail, the work breakdown structure (WBS) and the corresponding schedule are kept updated.
- The output of this activity is a periodically updated WBS of the software project. The updated WBS will be based on the information coming back from the design teams, both Gemini and external.

The SSE will be responsible for all technical aspects of the development of the Gemini system software. Specifically, his responsibilities include:

- technical management and coordination of the Gemini system software development, i.e., re-partition of work, both internally and externally, and coordination of the Gemini system software work packages
- production of the Gemini Software Requirements Specification
- production of the Gemini System Software Design Description
- control of external developers including interface control for the work packages for which he is GWPR
- integration of each Gemini Software release,
- delivery and on-site acceptance of each Gemini software work package for which he is GWPR

The SSE reports to the Controls Group Manager.

The RTE will be responsible for all technical aspects of the development of the Gemini real time software. Specifically, his responsibilities include:

- technical management and coordination of the Gemini real time software development, i.e., re-partition of work, both internally and externally, and coordination of the Gemini real time work packages
- control of external developers including interface control for the work packages for which he is GWPR
- delivery and on-site acceptance of each Gemini software work package for which he is GWPR

The RTE reports to the Controls Group Manager.

The SCE will be responsible for all technical aspects of the development of the Gemini Controls. Specifically, his responsibilities include:

- technical management and coordination of the Gemini Controls development, i.e., repartition of work, both internally and externally, and coordination of the Gemini controls packages,
- control of external developers including interface control for the work packages for which he is GWPR
- delivery and on-site acceptance of each Gemini controls system work package

The SCE reports to the Controls Group Manager.

2.4.2. Development And Allocation Of Work Packages

The development of individual work packages up to the point of being allocated to a specific developer will be handled by one of the SSE, RTE, or SCE. The current division of work package responsibility is:

- SSE
    - Observatory Control Infrastructure
    - Telescope Control Software
    - Data Handling
- RTE
    - Instrument Control Infrastructure
    - Mount Control System
    - Primary Support Control
    - Secondary Control
    - Individual Instrument Control Software
- SCE
    - Communications
    - Enclosure Control
    - Primary Thermal Control

2.4.3. Management of Allocated Work Packages

Managerial responsibility for each package will be assigned to a Gemini Work Package Responsible (GWPR) who will be one of SSE, RTE, or SCE. Responsibility for the development of each work package will be allocated to a WPR. It is anticipated that all WPRs will be external developers.

The responsibilities of the WPR will include:

- analysis and design of the assigned work package, producing the package FS and SDD,
- approval of the module analysis and software design, i.e., document review of module FSs and SDDs, both written in house or by an external developer, of modules that belong to the assigned package,
- coordination and control of in-house development,
- interface with external developers (for subcontracted work),
- contribution, in cooperation with other WPRs, of the Gemini System SDD,
- performance of acceptance tests of modules that belong to the assigned package,
- preparation of documentation for the software package,

The WPRs will report to the appropriate GWPR.

Gemini staff developing software packages belong to, or are attached to, the Gemini Controls Group.

2.4.4. Collaboration with Gemini Instrument Group

The following responsibilities are assigned to the SSE:

- attendance at all instrument reviews
- monitoring adherence of instrument work packages to Gemini Software & Controls Standards via the instrument reviews

The following responsibilities are assigned to the RTE:

- monitoring interface control of instruments through review of instrument work package documents
- participating in instrument acceptance testing

2.4.5. Software & Controls System Engineering

2.4.5.1. Software Engineering

The following responsibilities will be assigned to the Gemini Software System Engineer (SSE):

- the refinement of software engineering procedures and of the project approach. This will update the Gemini Software Management Plan (this document) and the related procedure documents .
- control of the interfaces of the Gemini Software, checking their consistency with the Gemini requirements
- definition of the standards and requirements for the operational handbooks, user's manuals and maintenance manuals
- maintenance of software project planning and reporting

- in conjunction with GWPR and with Gemini Project management, the definition of the content of each release in which the installation of the system will be split.
- verification of software versions and formal releases.

2.4.5.2. Software Configuration Management

The Software Configuration Control Manager (SCCM) will be responsible for the configuration control of documentation and code, namely:

- maintenance of the Gemini Software Configuration Control Plan,
- acting as chairman of the Software Configuration Control Board (SCCB),
- definition of software items, both documents and code, to be subject to configuration control,
- maintenance of the source code databases,
- maintenance of project records of SCC matters.

The SSE will, in addition to his other responsibilities, assume the role of SCCM. The SCCM reports to the GCM.

2.4.5.3. Management of Software Quality Assurance

Responsibility for software quality assurance within the Gemini Software project will be assigned to the Gemini Software Quality Assurance Manager (SQAM).

- production of the Integration Test Procedure and of the On-site Acceptance Test Procedure for each of the Gemini Software releases,
- organization and follow-up of formal review,
- acting as chairman of review meeting,
- performance of audits,
- representing Gemini for software QA matters in relation to external developers,
- final approval of test results (while the responsibility to define and perform the test activity is up to design and development people),
- maintenance of project records for software QA matters.

The role of SQAM is assigned to the RTE. The SQAM reports to the GCM.

2.4.5.4. Project Planning and Reporting

Project planning and reporting will consist of the following activities, all of which will be the responsibility of the GCM.

- work breakdown structure

A draft version of the WBS is contained within this document. It is intended that the first detailed version of the WBS will be produced on completion of the software requirements specification documents. More detailed versions will be produced by the developer as part of the review process of an allocated work package.

Gemini will expect a developer to produce a WBS based on his design as the basis for his schedule estimates. At the initial stages, Gemini will also expect each developer to include a schedule estimate in his proposal and will expect the successful developer to refine that estimate as development proceeds.

- schedule planning

A PERT chart showing the dates and durations of the various project activities will be produced and periodically updated.

- resource analysis

A first draft of the resource analysis, in terms of manpower and equipment, for the Gemini Software and Controls Project will be produced on completion of the software requirements specification documents and the production of the preliminary version of the WBS. A final version will be produced on completion of the design documentation and periodically updated.

- schedule control and reporting

Schedule control of the Gemini Software and Controls Project will be based on a system of monthly progress reports based on an agreed gannt chart. Where a package is produced in house, the monthly progress report will be produced by the GWPR. Where a package has been assigned to an external developer, the monthly progress report will be produced by the developer’s WPR.

To ensure that the Gemini Software and Controls Project meets its target delivery date, a system of monthly schedule reporting based on input from the GWPRs and from the developer’s WPRs will be used.

Their reports together with status reports generated will be presented to a monthly progress meeting chaired by the GCM. The monthly progress meeting for the Gemini Software and Controls Project will be timed so as to provide input for the Gemini Project schedule reporting.

To facilitate the performance of project planning and reporting activities, use will be made of a computer based project schedule control tool. The project schedule control tool is Microsoft Project.

Table 2-1 Project Responsibility Matrix

Area of Responsibility	GCM	SSE	RTE	SCE
project planning & cost control	X			
production and maintenance of SMP	X			
production of SCS	X			
production & maintenance of WBS	X			
production & maintenance of schedule	X			
technical management & coordination within area		X	X	X
production of SRS		X		
production of SDD		X		
Gemini Work Package Responsible within area		X	X	X
integration of each software release		X		
delivery and on site acceptance of work packages		X	X	X
software configuration manager		X		
software quality assurance			X	
collaboration with Gemini Instrument Group		X	X	
work breakdown structure	X			
schedule planning	X			
resource analysis	X			
schedule control & reporting	X			

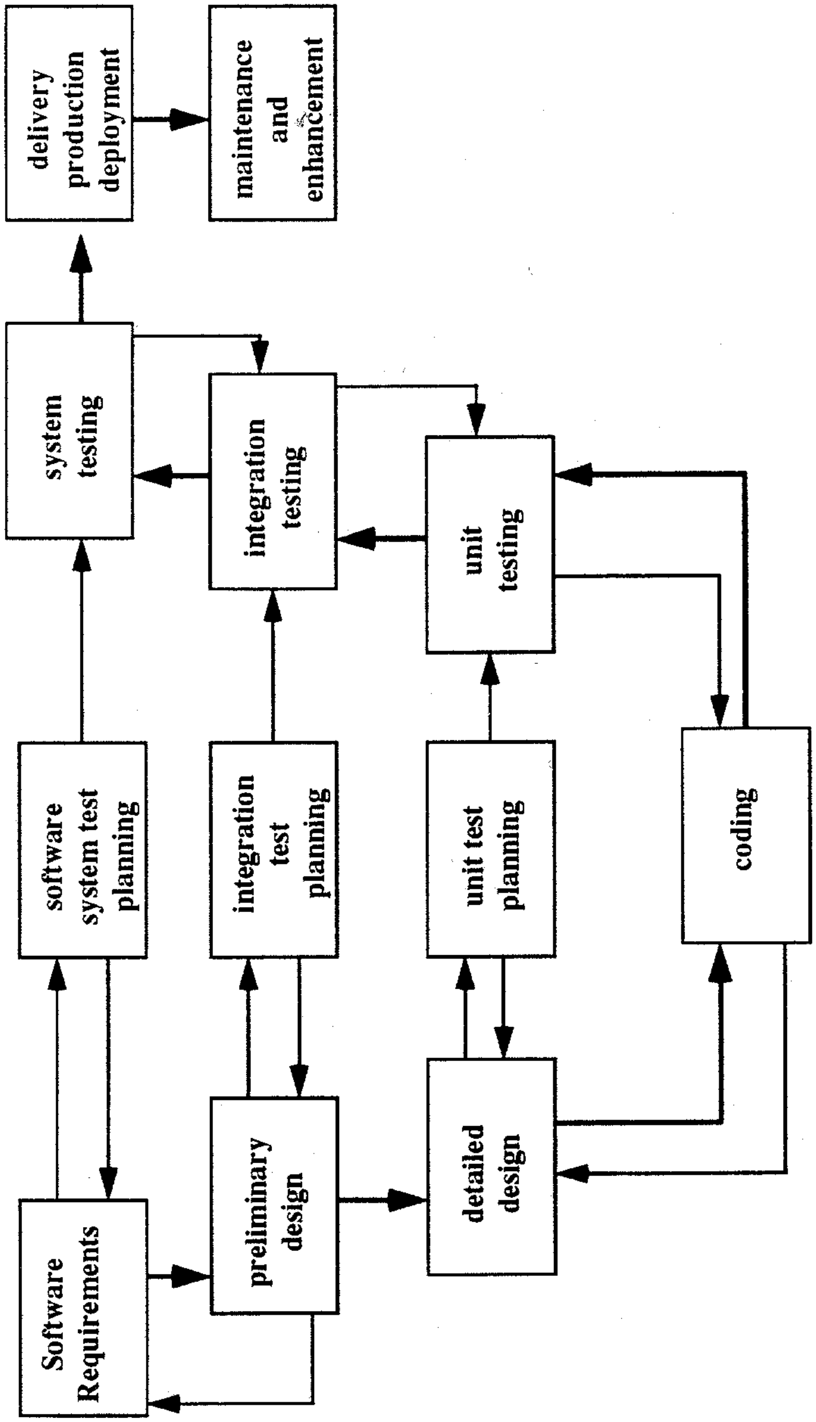


Fig.2-1 Software Engineering Life Cycle

Fig. 2.1b Scientific Oversight

Fig. 2.1c Delivery, Operations and Maintenance Lifecycle

Fig.2-2 Major Milestones, Reviews, etc.

Gemini Controls Major Milestones, Reviews, etc.

ID	Name	Start
14	Control System Design Review	9/28/93
21	Standard Instrument Controller - Contract Award	12/24/93
33	Observatory Control - Contract Award	12/24/93
44	Mount Control System - Contract Award	3/25/94
61	Telescope Control System - Contract Award	4/22/94
74	Enclosure Control System - Contract Award	5/20/94
89	Primary Control System - Contract Award	12/24/93
106	Secondary Control System - Contract Award	7/15/94
121	Primary Thermal Control - Contract Award	12/24/93
138	Enclosure Monitoring System - Contract Award	3/24/95
151	Remote Operations - Contract Award	3/24/95
160	Completion of Control System Simulator	1/1/96
167	Data Handling - Contract Award	3/22/96
177	Completion of Functional Control System	1/1/97
184	Instrument Integration - Contract Award	3/26/97
194	Delivery of Specification Control System	1/1/98
196	Mauna Kea Acceptance Test Review	9/1/99
197	Mauna Kea Installation & Commissioning Documents F	11/1/99
198	Mauna Kea Handover Review	12/15/99
200	Acceptance of Control System - Mauna Kea	12/28/99
207	Cerro Pachon Acceptance Test Review	8/1/01
208	Cerro Pachon Installation & Commissioning Document	10/1/01
209	Cerro Pachon Handover Review	11/15/01
210	Acceptance of Control System - Cerro Pachon	11/28/01

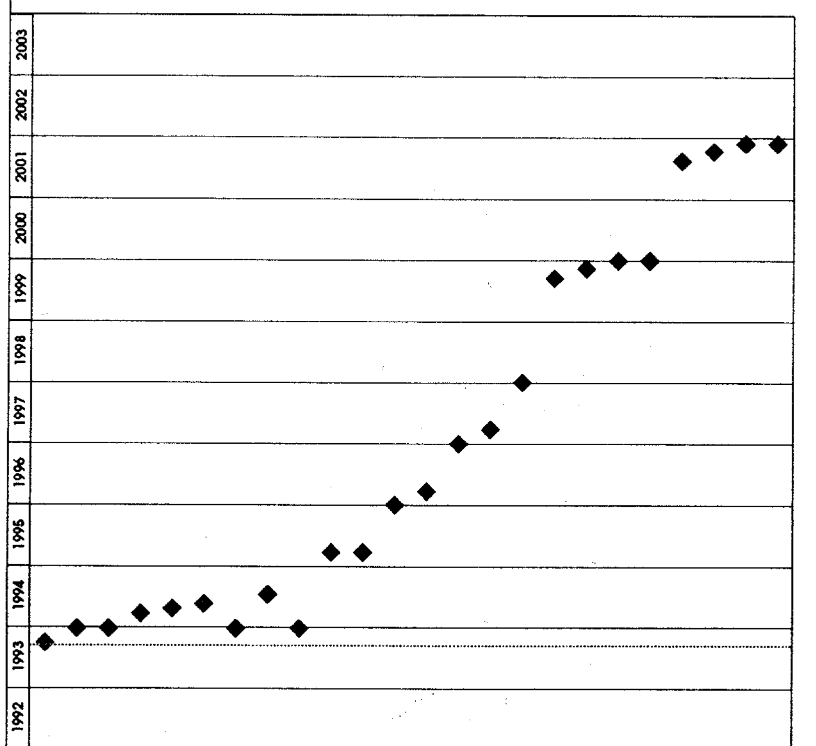


Fig.2-3 Project Organization

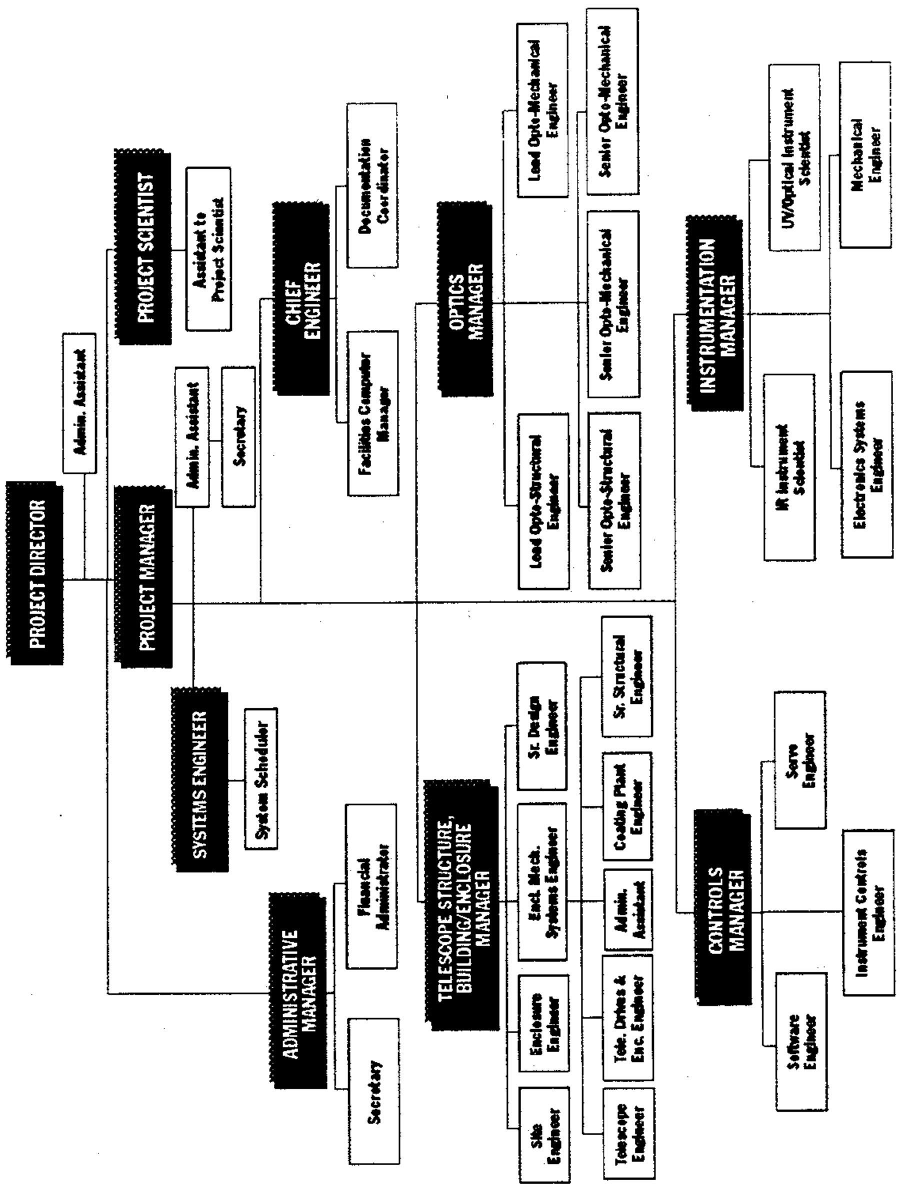
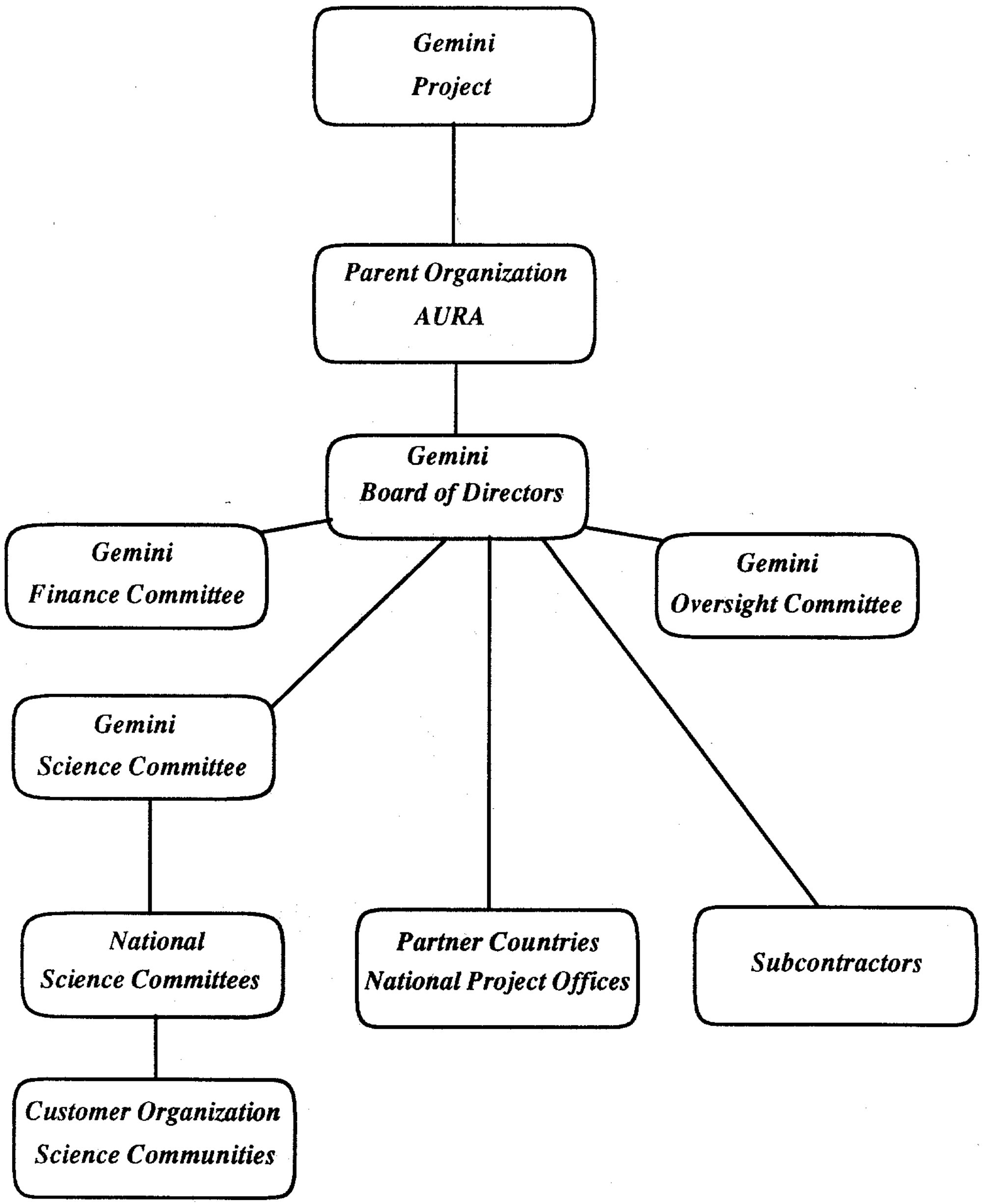


Fig.2-4 Organizational Boundaries



3. Managerial Process

This section shall specify management objectives and priorities; project assumptions, dependencies, and constraints; risk management techniques; monitoring and controlling mechanisms to be used; and the staffing plan.

3.1. Management Objectives And Priorities

This subsection shall describe the philosophy, goals, and priorities for management activities during the project. Topics to be specified may include, but are not limited to, the frequency and mechanisms of reporting to be used; the relative priorities among requirements, schedule, and budget for this project; risk management procedures to be followed; and a statement of intent to acquire, modify, or use existing software.

3.1.1. Philosophy

The philosophy of the management activities is based on the following mission statement:

> *We are the Gemini Controls Group, a team of software and controls professionals dedicated to and empowered by the strength of our staff.*
>
> *The software, computers, and controls which we provide to the Gemini astronomical telescope system will enable the project to meet its scientific requirements on budget and on schedule; and will make a statement about our dedication to excellent astronomical imaging quality.*
>
> *As we grow towards the culmination of this project, we shall continually focus on providing excellence at reasonable cost by following sound engineering practices.*

3.1.2. Goals

The prioritized goals of the management activities are as follows:

- to enable the handover to be on budget
- to guarantee the handover of deliverables which meet specification
- to enable the handover to be on schedule
- to effect a smooth transition between commissioning and handover.

As corollaries to the above goals:

- to use commercially available software and controls wherever possible
- to adopt community software and controls wherever possible
- to adapt to the functionality of available commercial and community software and controls wherever practical
- to recycle available community software and controls wherever possible by making selective modifications

- to collaborate in the creation of common software and controls with other projects
- to create new software and controls that are Gemini specific as a last resort

3.1.3. Priorities

As this is a fixed price telescope project the order of priorities must be:

- to deliver on budget
- to deliver to specification
- to deliver on schedule

Decisions as to changes in the specification in order to meet budget will be handled through a formal change control board.

3.1.4. Reporting

3.1.4.1. Biweekly

The WPRs should report to the appropriate GWPR on a biweekly basis via email or Fax as desired. This report should be a brief description of the WPRs activities on behalf of the project over the past two weeks. This biweekly written report should be the basis for a biweekly teleconference.

The frequency of these may be increased or decreased by mutual consent of the Gemini Controls Manager, GWPR, and WPR.

3.1.4.2. Monthly

The Gemini Controls Group reports to the Project Manager on a monthly basis. This report is to cover schedule and budget items.

The WPRs should report to the appropriate GWPR on a monthly basis via email or Fax as desired. This report is to cover budget and schedule related items only.

It is the purpose of the monthly reporting to enable Gemini to track budget and schedule for the allocated work packages.

3.1.5. Requirement Priorities

The priorities for requirements are as follows:

- image size requirements
- other quality requirements such as emissivity
- versatility requirements
- comfort requirements

3.1.6. Project Schedule

The software and controls project schedule is tied to the Gemini Project schedule which is:

- critical design review of telescope by first quarter 1994
- critical design review of enclosure by end of 1993
- critical design review of primary mirror assembly by end of 1994
- fabrication during 1994, 1995, 1996
- installation and commissioning on Mauna Kea during 1997, 1998, 1999
- installation and commissioning on Cerro Pachon during 1999, 2000, 2001

3.1.7. Project Budget

The Gemini Project budget is $176 M in US funds. This figure is fixed price and includes all inflation and contingency funds. Of this total ___[1] M is reserved for the Controls Group budget.

3.1.8. Risk Management Procedures

The risk management procedures to be followed are detailed in the Gemini Project Management Plan. Areas which are identified as a risk will require funds and manpower to be reserved for contingency plans and, in some cases, for funds and manpower to be expended in parallel development efforts.

3.1.9. Existing Software And Controls

As discussed above it is the goal and intent of the project to reuse software and controls wherever possible. The project is willing to modify requirements if by so doing existing software and controls may be used without compromising the scientific requirements of the project.

3.2. Assumptions, Dependencies, And Constraints

This subsection shall state the assumptions on which the project is based, the external events which the project depends upon, and the constraints under which the project is to be conducted.

3.2.1. Assumptions

This project is based on the assumption that imaging quality of the order of twice the diffraction limit, is possible with 8 meter telescopes utilizing state of the art engineering. This assumption has yet to be validated by appropriate design studies.

[1]the Controls budget figure is currently confidential

3.2.2. Dependencies

The project is dependent on an uneven and, to some extent, unpredictable cash flow from the funding agencies. This will require innovative techniques to allow the project to continue without violating the form or substance of the various rule sets governing the project. The main defense against this will be to structure contracts such that they can be subdivided and awarded as smaller work packages.

3.2.3. Constraints

The project is an international collaboration of scientific agencies of a number of countries. It is a goal of the collaborators that as much work as possible, especially design, should be contracted to entities in the collaborating countries. It may well occur that contracts are not awarded on the basis of price and ability due to this constraint.

3.3. Risk Management

This subsection shall identify and assess the risk factors associated with the project.

3.3.1. Tracking Risk

The tracking of areas identified as risks will be the duty of the Gemini Controls Manager. The method of tracking will be by creating a risk tracking document for the specific contract in question. This document will identify the risk, assess its possible impact, and track the risk through increased reporting and communication with the developer. In some situations the project may put a staff member on the developer's site for more frequent monitoring of progress.

The contents of this tracking document will be communicated to the Project Manager on a weekly basis.

The risk tracking document shall contain specific instances of risk. The areas where risk will be encountered are detailed below.

3.3.2. Contractual And Partnership Risks

3.3.2.1. Identification And Assessment

The main contractual and partnership risks are:

- termination of contract/partnership
- failure to deliver
- failure to deliver to specification
- cost overruns
- disqualification of developer for future work

Specific contractual risks will be identified by monitoring the developer's progress through regular reporting, regular reviews, and audits. Assessment of contractual and partnership risk will be based on the possible impact on specification, schedule, and budget.

The goal of all contractual and partnership statements of work will be to tie together the reporting and review procedure with specific milestones. Successful completion of these milestones will be required before percentages of the work package amount are paid.

Disqualification of the developer could occur if conceptual design, detailed design, and fabrication are done separately. In most cases it will be a goal to combine detailed design and fabrication within a single contract/work package.

3.3.2.2. Contingency Plans

By tying together reporting and review procedures with milestones the project does not expend large amounts of money without verifying that there is an interim product that meets specification. If the developer fails to meet an interim milestone, and by doing raises the risk to an unacceptable level, then the project always has the option of taking delivery of the product from the last milestone. In the worst case the project will lose the moneys associated with the last milestone.

The contingency plan will detail at what point and under what conditions Gemini will initiate termination of contract/partnership. It will also detail the process for recovering the work package deliverables which exists from the contract/partnership. The means of restarting the work package with a different developer will also be proposed.

3.3.3. Technological Risks

The main technological risks are:

- not possible to meet specification with future technology
- not possible to meet specification with current technology
- not possible to meet specification with current design
- not possible to meet specification with current budget
- not possible to meet specification with current schedule

3.3.3.1. Identification And Assessment

Risks associated with current and future technology will be identified by a continuous monitoring of the following activities:

- design study
- design simulation
- design prototype demonstration

- design implementation

If at any step it is decided that the risk is too great then the contingency plan for that area will be activated. The decision to do a design study will, in part, be based on an assessment of risk. The decision to do a design prototype will be based on the assessment of risk from the design study and/or the design simulation. The decision to proceed to design implementation will only be taken if the assessed risk is low.

Assessment of the risks will be, in general, part of the design study or simulation report associated with the work package. By monitoring the spend profile and timeline of the project versus that predicted an ongoing estimate of the risk associated with budget and schedule should be maintained.

3.3.3.2. Contingency Plans

The contingency plan included in the tracking document must detail the specification, budget, and schedule impact of terminating the activity at specific milestones in the contracts future timeline.

The plan must detail an alternate plan to provide a subset of the specifications within the allocated budget, including the amount of contingency reserve required to follow this plan.

3.3.4. Size And Complexity Risks

In a project of this scope there is always a chance that, due to the size and complexity of the project, subsystems which meet their subsystem specification fail to meet the system specification when they are integrated.

3.3.4.1. Identification And Assessment

All interfaces are a potential risk. Each such interface will have an associated interface control document which details exactly what is expected at the subsystem interface. The succession of baseline systems will allow the entire system to be integrated at an early date. It will be at this time that potential risks will be identified.

All risks which are identified during baseline system integration will be assessed as to impact and manpower and/or contingency funds will be requested in proportion to the assessed risk.

3.3.4.2. Contingency Plans

The contingency plan included in the tracking document must include the specification, budget, and schedule impact of having to rework the interface.

3.3.5. Personnel Risks

The main personnel risks are:

- inability to meet job requirements

- leaving project for another position

3.3.5.1. Identification And Assessment

Job requirement risks will be identified by semiannual reviews. These reviews will cover progress from last review and set goals for next review. Areas of employee development that can be improved through appropriate training will be so dealt with.

3.3.5.2. Tracking

The semiannual reviews will be reported on and tracked by the reporting document.

3.3.5.3. Contingency Plans

The main impact will be felt if an employee decides to leave the project. The plan to avoid as much of this impact as possible is to insist on employees leaving a paper trail that can be picked up quickly by an existing employee while a substitute is hired. This paper trail is spelled out in this document.

3.3.6. Customer Acceptance

The main customer acceptance risks are in the areas of:

- user interface
- functionality

3.3.6.1. Identification And Assessment

The means of identifying these risk areas is to insist on a short development cycle between conceptual design and actually having a preliminary product that can be *test driven*.

3.3.6.2. Tracking

These areas will be tracked by written feedback from various groups who will be involved in validating conceptual designs and prototypes.

3.3.6.3. Contingency Plans

As the feedback will be rapid and the prototype time scales short the contingency plan must plan on reworking areas which do not meet with user acceptance. A great deal of these risks can be avoided by involving key members of the communities in the specification process for the user interface.

3.4. Monitoring And Controlling Mechanisms

This subsection of the SMP shall define the reporting mechanisms, report formats, information flows, review and audit mechanisms, and other tools and techniques to be used in monitoring and controlling adherence to the SMP. Project monitoring shall occur at the level of work packages. The relationship of monitoring and controlling mechanisms to the project support functions shall be delineated in this subsection of the SMP.

3.4.1. Report Mechanisms, Format, And Information Flow

All documents, reviews, milestones, etc. must include a section detailing their conformance with the SMP. This should be a brief statement to the effect that "*this conforms to the Gemini Software and Controls Management Plan*" and should state the relationship of this document, review, milestone, etc. to the SMP. In addition there should be a following section which details the conformance of the underlying activity (which is covered by the document, review, milestone, etc.) to the SMP. All deviations from the SMP will become action items for the SSE and will be part of the SSE's monthly report until closed. Successful closure will either bring the activity into conformance or modify the SMP.

3.4.2. Review And Audit Mechanisms

It will be part of the approval process for the document, review, milestone, etc. to verify SMP compliance. This will, in general, be carried out by the GCM. The approval process will not be complete until successful closure is signed off by the SSE.

3.4.3. Relationship To Project Support Functions

The same monitoring and control mechanisms as detailed above will be used for configuration management, software quality assurance, and verification and validation.

3.5. Staffing Plan

This subsection of the SMP shall specify the numbers and types of personnel required to conduct the project. Required skill levels, start times, duration of need, retaining, and phasing out of personnel shall be specified.

3.5.1. Number And Type

The following personnel are required to staff the controls group, in addition to the controls manager:

- servo control engineer

Reporting to the Controls Group manager the Servo Control Engineer will be responsible for the software and control systems in the areas of telescope drives, telescope hardware compensation, servo modeling, primary mirror active optics and thermal control, secondary mirror chopping system, secondary mirror tip/tilt system, adaptive optics, and various image and instrument rotator systems.

- software systems engineer

Reporting to the Controls Group manager the Software Systems Engineer will be responsible for the software systems in the areas of observatory control, data acquisition, data archiving, data preprocessing and analysis, remote use of facilities, use of remote resources, computer and software infrastructure, and user interface design.

- real time engineer

Reporting to the Controls Group manager the Instrument Control Software Engineer will be responsible for the software and control systems in the areas of telescope control, positioning systems for telescope peripherals, enclosure positioning control, acquisition and guiding systems, instrument control and calibration systems, and CCD/IR array controllers.

3.5.2. Skill Levels

3.5.2.1. Servo Control Engineer

The minimum qualifications for this position are:

- undergraduate degree in Electrical or Control Engineering
- 7 years experience in servo systems
- demonstrated proficiency in 3 of the areas above
- 2 years experience with high precision (1 part in 10^5) tracking and position control systems

Desirable qualifications for this position are:

- an advanced Engineering degree
- 2 years at a managerial level with contract experience
- experience at a large astronomical observatory
- familiarity with the United States, Canadian, and United Kingdom astronomical community

3.5.2.2. Real Time Engineer

The minimum qualifications for this position are:

- undergraduate degree in Electrical or Software Engineering
- 7 years experience in instrument control systems
- demonstrated proficiency in 3 of the above areas
- 2 years experience with CCD and/or IR array controllers

Desirable qualifications for this position are:

- an advanced Engineering degree
- 2 years at a managerial level with contract experience

- experience at a large astronomical observatory
- familiarity with the United States, Canadian, and United Kingdom astronomical community

3.5.2.3. Software Systems Engineer

The minimum qualifications for this position are:

- undergraduate degree in Software Engineering or equivalent experience
- 7 years experience in large software systems with an emphasis on instrument control and data acquisition and processing
- demonstrated proficiency in three of the above areas
- 2 years experience with distributed software systems

Desirable qualifications for this position are:

- an advanced degree
- 2 of the 7 years must have been at a managerial level with contract experience
- experience at a large astronomical observatory
- previous work on astronomical observatory software systems
- familiarity with the United States, Canadian, and United Kingdom astronomical community

3.5.3. Start Times

It would be advantageous if all of the above engineers could start before the end of 1992.

3.5.4. Duration

The duration and main focus of work for the staff members is contained in the project staffing gannt chart in figure 3.1

3.5.5. Method Of Obtaining

Suitable candidates will be identified by a sequence of:

- advertising in observatory and trade journals
- preparation of a short list meeting qualifications
- telephone interviews
- on site interviews

3.5.6. Training

The Controls Budget contains a provision for one training course per year per employee. These course will be taken as a result of the semiannual reviews.

3.5.7. Retaining

The major means at Gemini's disposal to retain current employees is to provide them with interesting work to do. This, combined with a regular series of merit increases, should keep those staff that desire to stay.

3.5.8. Phasing out

At the end of the project it is planned to bring the project staff back to Tucson and to dismiss them. It is expected that a subset of the project staff seeks positions with the operations staff of the respective observatories.

3.6. Operations Staffing Plan

There is an existing plan for the transition from construction to commissioning to regular operation contained in the May 1993 Gemini BOD documents. The plan is to hire 1/3 of the complement a year before first light, 1/3 the year of first light, and 1/3 the year after first light.

This management plan assumes that a subset of this staff will be made available to work in parallel with the Controls Group. Specifically we recommend that the *Senior Electronics Engineer* be hired as part of the Controls Group and become Head of Electronics (including Software and Controls) after handover. The operations staff, as hired, would work for the Head of Electronics. We also recommend that 3 of the 6 astronomers hired be tasked specifically with commissioning the Controls.

The subset to be devoted to Controls is contained in the table below.

Table 3-1 Total Operations Staff (per site) Seconded to Controls Group

Position	Year 1		Year 2		Year 3	
	Hire	Total	Hire	Total	Hire	Total
Astronomers	2.00	2.00	1.00	3.00	0.00	3.00
Senior Electronics Engineer	1.00	1.00	0.00	1.00	0.00	1.00
Electronics Technician	1.00	1.00	2.00	3.00	0.00	3.00
Systems Manager/Programmer	1.00	1.00	0.00	1.00	0.00	1.00
Computer Hardware Specialist	1.00	1.00	0.00	1.00	0.00	1.00
Computer Support Specialists/Prog	0.00	0.00	2.00	2.00	0.00	2.00
Electronics Engineer	0.00	0.00	0.00	0.00	1.00	1.00
Computer Programmer	0.00	0.00	0.00	0.00	1.00	1.00

Fig.3-1 Controls Project Staffing Gantt

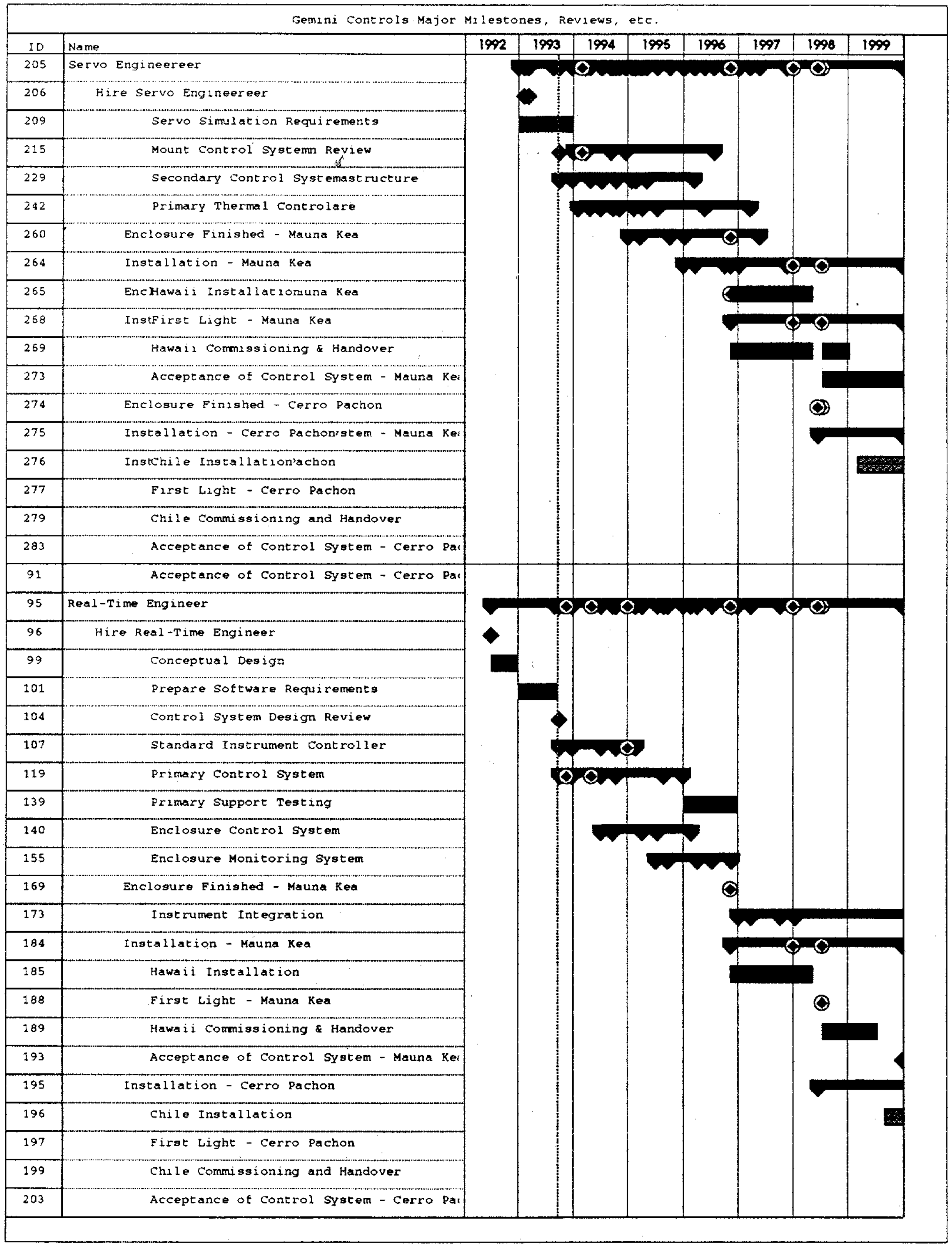
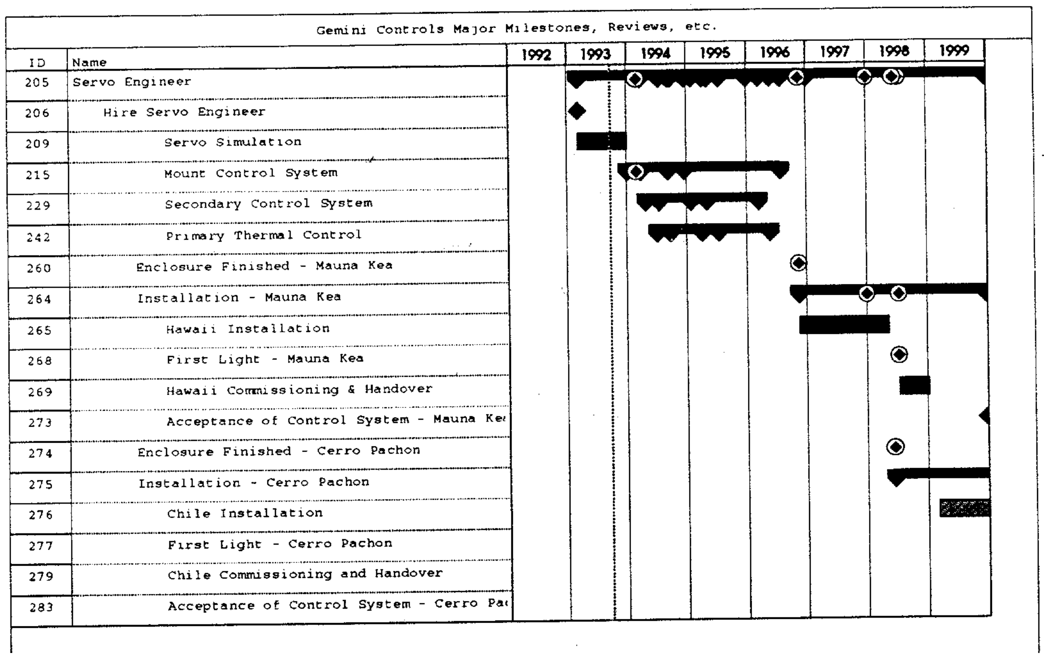


Fig.3-1 (cont'd)


Gemini Controls Major Milestones, Reviews, etc.
ID
Name
1992
1993
1994
1995
1996
1997
1998
1999
205 Servo Engineer
206 Hire Servo Engineer
209 Servo Simulation
215 Mount Control System
229 Secondary Control System
242 Primary Thermal Control
260 Enclosure Finished - Mauna Kea
264 Installation - Mauna Kea
265 Hawaii Installation
268 First Light - Mauna Kea
269 Hawaii Commissioning & Handover
273 Acceptance of Control System - Mauna Ke
274 Enclosure Finished - Cerro Pachon
275 Installation - Cerro Pachon
276 Chile Installation
277 First Light - Cerro Pachon
279 Chile Commissioning and Handover
283 Acceptance of Control System - Cerro Pa

4. Technical Process

This section of the SMP shall specify the technical methods, tools, and techniques to be used on the project. In addition, the plan for software documentation shall be specified, and plans for project support functions such as quality assurance, configuration management, and verification and validation may be specified.

4.1. Methods, Tools And Techniques

This subsection of the SMP shall specify the computing system(s), development methodology(s), team structure(s), programming language(s), and other notations, tools, techniques, and methods to be used to specify, design, build, test, integrate, document, deliver, modify or maintain or both (as appropriate) the project deliverables. In addition the technical standards, policies, and procedures governing development or modification or both of the work products and project deliverables shall be included, either directly or by reference to other documents.

4.1.1. Computing Systems

The different applications and target hardware/software standards adopted as baselines are detailed in the table below.

Vendor Software Standards

Area	**Baseline Standard**
operating system	Unix (move towards Posix compliance)
networking standard	TCP/IP
programming language	ANSI Standard C (C++ and OOPS encouraged)
window display	X-Windows
window style	Motif
host level realtime database	RTAP (TBD)
commercial database	Ingres
visualization software	PvWave
on-line data processing	PvWave + ICL
near-line data processing	PvWave + ICL (TBD)
real time control software	EPICS
real time operating system	Wind River VxWorks
detector array software	C language
software design methodology	Ward & Mellor
CASE software	TSEE from Westmount Technologies
Servo Simulation Software	Simulink from The Mathworks

Vendor Hardware Standards

Area	Baseline Standard
user interface / data reduction	Sun Sparcstation
computers	but software must be portable
real time platform	VME with 68040 processors
device control bus	Allen Bradley PLC
detector array control	Transputer or DSP56000 based

Community Standards Adopted by Gemini

Area	Baseline Standard
near-line data processing	IRAF & ADAM server (TBD)
off-line data processing	IRAF & ADAM standalone
host level client-server interface	ESO-VLT Central Computer Services (TBD)
graphical user interface conventions	ESO-VLT GUI Common Conventions
user interface functional specs	ESO-VLT UI Functional Specifications
user interface software	Tk
command language	TCL

4.1.2. Development Methodology

The chosen methodology that the Controls Group will work within is that of Yourdon/DeMarco, specifically the real-time oriented variant developed by Ward and Mellor[2].

Developers, however, will be free to use alternative methodologies/CASE tools internally. In particular, the use of an object oriented approach is encouraged and Gemini is open to discuss proposals in this respect on a case by case basis.

It is up to the developer how they implement a methodology internally. There are specific work products that must be provided to Gemini that are the outcome of the development methodology.

The Ward and Mellor methodology has distinct phases during which the different system models are developed and refined. It is Gemini's plan that the Controls Group will initiate this process, set constraints within which the models will develop, work with the developer through the analysis activity, and then handover entire responsibility for the remaining activities to the developer.

4.1.2.1. Analysis

During the analysis phase the essential model is to be developed in both environmental and behavioral parts.

[2]Paul T. Ward & Stephen J. Mellor, *Structured Development for Real-Time Systems*

The environmental model is a description of the environment within which the system operates and is contained in a context diagram and an event list. The context diagram is a description of the boundary that separates the system from its environment. The event list is a description of the external events in the environment to which the system must respond.

The behavioral model is a description of the system's behavior in response to events in the environment and is contained in a transformation schema and a data schema. The transformation schema is a description of the transformations the system makes in response to events. The data schema is a description of the information the system must have in order to respond.

4.1.2.2. Software Design

In the software design activities, during the design phase, the first two parts of the implementational model, i.e., the processor and the task allocation models, have to be developed.

The processor model is a description of the chosen allocation of the activities and data declared by the essential model and their interface. The description is contained in transformation and data schemas. These schemas describe the transformations and stored data allocated to processors and their interfaces.

The task model is a description of the chosen allocation to tasks (with a processor model) and their interfaces. The description is contained in transformation and data schemas. These schemas describe the transformations and stored data allocated to tasks and their interfaces.

4.1.2.3. Detailed Design

In the detailed design activities, part of the implementational phase, the module model must be developed.

The module model is a description of the chosen allocation to modules and their interfaces (within a task model) contained in structure charts. These structure charts describe the hierarchical organization of modules in a program.

4.1.3. Team Structure

It is the intent of the project that all software and controls be supplied by external developers. As such, the organization of the team is at the discretion of the developer. The developer must specifically identify a member of the team as Work Package Responsible (WPR). All technical and managerial communications related to the work package will pass between the GWPR and WPR.

4.1.4. Programming Language

All code specifically created for the Gemini project must be written in ANSI Standard C. Gemini encourages developers to propose using C++ and OOPS if they so desire.

Code which is reused on the Gemini project may be written in C and/or FORTRAN. Preference will be given to reusing C code.

4.1.5. Notations, Tools, Techniques, And Methods

The CASE tools selected to support the methodology are:

- TSEE / EMB
- Software Through Pictures
- Cradle

Gemini has chosen to use TSEE internally to the project. It is the developers choice which of these, if any, is used. There are, however, some design requirements better met with these tools.

4.1.6. Standards, Policies, and Procedures

4.1.6.1. Standards

It is the intent of the Controls Group to follow IEEE and MIL-STD standards and procedures where available and applicable. It will be the goal of adopting these procedures to streamline them and to ensure that their usage makes a contribution to the project.

4.1.6.2. Project Testing Policy

For an easier understanding of the following sections, it is worthwhile to introduce the testing approach. The philosophy governing testing of the Gemini Software depends on several factors:

- the Gemini Software will consist of a number of packages which, individually, will be complex real-time systems.
- the packages will be subdivided into 'modules' the majority of which will be developed by outside developers with Gemini retaining responsibility for integration and system testing.
- the possibility to test each part independently may be limited by mutual dependencies and by the need to use the real system, available only at the actual site (Hawaii/Chile).
- due to obvious logistic problems, there is the requirement to perform as much testing activity as possible at the developer's site or in Tucson.
- the Gemini system will gradually be put in service: at the beginning, each telescope; then new instruments will be added and, at the end, two or more instruments will work together. In other words, new parts will be integrated and added to an existing working system and this will last for a period of many years before the Gemini system is complete.

For these reasons, a bottoms-up approach to testing is most likely to lead to manageable testing activities in which the system-wide implications of error corrections are more easily seen and in which configuration control of the software is more easily managed. So, the test strategy is based on a bottoms-up approach in which:

- units/components are tested and integrated at the development site to form a module.

- each module as a whole is tested, accepted, and put under configuration control. (The acceptance of parts that are not testable at development site will be completed in Tucson or in Hawaii/Chile).
- different modules, belonging to a Gemini Software and Controls release, are integrated together, with the hardware components, and, except for the first release, with the existing system. The integration is performed stepwise and can use emulator and/or real systems.
- acceptance of the integrated release and delivery to Hawaii/Chile. (The acceptance of parts that are not integrable in Tucson will be completed in Hawaii/Chile.)
- installation at Mauna Kea/Cerro Pachon, completion of module and/or integration acceptance.
- release acceptance and commissioning.

In order to facilitate the integration of these parts by Gemini staff it is proposed that a software and controls package be delivered by the developer to Gemini in three distinct releases.

- control system simulator - this system will
    - be functional at the user level
    - simulate all interfaces to higher level systems
    - not control any physical devices
- functional control system - this system will
    - control all devices
    - not control devices to specification
- specification control system - this is the control system which will be subjected to acceptance testing.

The intent of these three releases is to close the loop at an early date with the developers and to prevent major problems during the acceptance testing and integration phases.

4.1.6.3. Project Phasing Procedure

Phases shall be regarded as bounded activities for each part to be developed but it will be normal that some parts will be in one phase while other parts are already in a later phase.

In the following sections the activities, inputs, and outputs of each phase are described.

The descriptions anticipate the use of terms that are fully explained in later sections. In particular, the detailed description of each documentation item follows and the definition and the profile of management responsibilities has been detailed in a previous chapter.

The Ward and Mellor methodology has been adapted to the requirement to allocate work packages to external developers as follows. The process of developing Gemini software is broken down into the following phases (following Ward and Mellor):

- concept exploration phase

- requirements phase
- work package allocation phase
- work package phase
    - design phase
    - implementation phase
    - test phase
- work package acceptance phase
- work package integration phase
- installation and checkout phase
- operation and maintenance phase

The details of the suggested work package phase are included in an appendix. It is not Gemini's intention to impose a specific methodology on the developers (although Gemini would like to encourage developers to <u>use</u> a methodology). What Gemini does insist on is certain work products from the work package phase which will be used as the basis for a number of reviews.

4.1.6.3.1. The Concept Exploration Phase

This phase consists of the first exploration of the user needs for the Gemini Program from a software and controls point of view. It produces the definition of software requirements in very broad, non-technical terms.

Outputs of this phase are:

- the Gemini Software Concept Specification, written by the GCM.
- the Gemini Project Goals and Requirements, written by the SSE.

4.1.6.3.2. The Requirements Phase

The purposes of the requirements phase are:

- to specify fully the functional and nonfunctional requirements of the proposed Gemini Software, i.e. to specify what services the software should provide and what functions it should perform, but without prescribing any implementation details
- to specify both the problems and the constraints upon the solution in a rigorous form.

This phase takes as input the Gemini Software Concept Specification and produces as output the requirements specification that will be articulated in more documents:

- the Gemini Software Requirements Specification, written by the SSE
- the Gemini Operational Concept Definition, written by the SSE.
- the Gemini Interface Requirements Specification, written by the SSE.
- the Gemini Design Requirements, written by the RTE.

- Work Package Descriptions, written by the GCM
- Gemini System Design Description, written by the SSE
- Gemini Software Configuration Control Plan, written by the RTE
- Gemini Control System Simulation Results, written by the SCE

The requirements phase will be validated by a System Design Review which will review and approve all of the above work products.

4.1.6.3.3. Work Package Allocation Phase

It is desirable to start the work package allocation phase prior to the end of the requirements phase in order to involve developers in the definition of requirements, the work package descriptions, and the work scopes.

During this phase the preliminary work package descriptions and scopes of work will be finalized prior to formal allocation to a developer.

As the preliminary work packages have already been approved during the System Design Review there will be no formal approval of individual work packages beyond circulation for comment amongst the Controls Working Group and involvement of Gemini contracting staff in the formal agreements.

4.1.6.3.4. Work Package Phase

The details of the work package phase, carried out by the developer, which are visible to the Gemini Controls Group are tied to specific milestones. Each of these milestones is accompanied by an external review during which specific work products must be reviewed and approved. The members of the external reviews will be jointly picked by the GCM and the current chairperson of the Controls Working Group.

The following milestones/reviews will each require specific work products.

- System Design Review
    - preliminary package functional specification including current environmental and behavioral models
    - plans for design process
    - plans for simulation
    - documentation plan
- Preliminary Design Review
    - package functional specification
    - package software design description
    - preliminary module functional specification
    - control system preliminary design

    - results of simulations showing design meets specification
    - preliminary user and maintenance documents' tables of contents
- Critical Design Review
    - module functional specifications
    - module software design descriptions
    - control system simulator design
    - module model
    - control system design
    - update of simulations
    - preliminary package test procedure
    - preliminary user and maintenance documents
- Implementation Progress Review #1
    - control system simulator
    - preliminary acceptance test plan
    - package test procedure
- Implementation Progress Review #2
    - acceptance test plan
    - functional control system
- Acceptance Testing Review
    - specification control system
    - user and maintenance documents

4.1.6.3.5. Work Package Integration Phase

In this phase the individual work package deliverables are integrated into a complete Gemini system, either in Tucson or on-site.

This phase will involve a TBD plan and review.

4.1.6.3.6. The Installation and Acceptance Phase

In this phase, the software is installed at the final site, and the on-site acceptance is performed.

On-site acceptance testing is, essentially, a repeat of the last step of integration testing, but is carried out on the actual site and interfacing to real hardware and communications subsystems. Its main purpose is to demonstrate the effective coverage of the system requirements.

The input requirements for each Gemini system release are:

- the integrated system release

- the On-site Acceptance Test Procedures.

The output requirements for each Gemini system release are:

- an installed and accepted Gemini Software release
- the On-site Acceptance Test Report.

4.1.6.3.7. The Operation and Maintenance Phase

TBD

4.2. Software & Controls Documentation Plan

This subsection of the SMP shall contain, either directly or by reference, the documentation plan for the software and controls project. The documentation plan shall specify the documentation requirements, and the milestones, baselines, reviews, and sign-offs for documentation. The documentation plan may also contain a style guide, naming conventions, and documentation formats. The documentation plan shall provide a summary of the schedule and resource requirements for the documentation effort. The documentation plan is contained in fig.4-1.

4.2.1. Documentation Requirements

4.2.1.1. Report Format

All reports generated from within the project shall be in AmiPro format and stored in electronic format. All reports delivered to the project must conform to one of the following formats (in priority order):

- AmiPro - uses current version of AmiPro
- AmiPro compatible - uses older version of AmiPro or originates from a Word Processor for which AmiPro has an import filter
- non-AmiPro compatible - originates from first generation word processors such as Tex/Latex

Only in exceptional cases will a report be accepted in paper format without an accompanying electronic copy. We realize that in a number of cases it may only be possible to obtain the text in electronic format.

4.2.1.2. Information Flow

All software related reports generated from within the project will originate from either the SSE or RTE as appropriate. All controls related reports will originate with the SCE. All reports delivered to the project will go through the GSE, RTE or SCE as appropriate.

4.2.1.3. *Review And Audit Mechanisms*

All reports generated within or delivered to the Controls Group will be approved by the GCM before being distributed as Gemini reports.

4.2.2. Documentation Baselines

The documents that, during the Gemini Software life cycle, will be produced, either by Gemini or by the developers to whom individual modules may be assigned, can be grouped into the following categories:

- Standards Documentation
    - Gemini Programming Standard
    - Gemini Electronic Design Specifications
- Management Documentation
    - Gemini Software & Controls Management Plan
    - Gemini Software Configuration Control Plan
    - Planning/Reporting
- Requirement Documentation
    - Gemini Project Goals and Requirements
    - Gemini Operational Concept Definition
    - Gemini Software Requirements Specification
    - Gemini Software Design Description
    - Work Package Descriptions
- Design Documentation
    - package Functional Specification
    - module Functional Specification
    - package Software Design Description
    - module Software Design Description
    - Control System Simulation Results
- Test Documentation
    - Gemini Software Test Plan
    - Package Test Procedures
    - release Integration Test Procedures
    - on-site Acceptance Test Procedures
    - Test Reports.
- User Documentation
    - Gemini Software & Controls User Manual

- Gemini Software & Controls Maintenance Manual.

For each document the following information is given in the following sections:

- description,
- applied standard, if any,
- when review is required, review specific data.

Except where explicitly excluded, each document, whether produced in house or by a developer, will be subject to configuration control as defined in the Gemini Software Configuration Control Plan and to formal review as defined in the appropriate section of the current document.

4.2.2.1. The Gemini Programming Standard

The Programming Standard will set:

- Programming Style
- Naming Conventions for subroutine, file, variable, etc.
- Directory Structure, i.e., the minimum standard directory structure that each development shall follow. Any additional structure shall be documented in the Software Maintenance Manual.
- MAKEFILE Standard.

These conventions will apply to both in-house and contracted software.

4.2.2.2. The Gemini Electronic Design Specification

The Gemini Electronic Design Specification defines the standards to which all electronic equipment, supplied as deliverables to the Gemini operations team, shall be constructed.

4.2.2.3. The Gemini Software & Controls Management Plan

The Gemini Software & Controls Management Plan, this document, defines the software engineering standards which will apply to the development of the Gemini Software and Controls.

The document shall be based on IEEE 1058.1-1987.

4.2.2.4. The Gemini Software Configuration Control Plan

The Gemini Software Configuration Control Plan defines the way in which both code and documents will be controlled. It also defines the minimum requirements for configuration control for software developers.

The Gemini Software Configuration Control Plan shall be based on the IEEE 828 and the IEEE 1042.

4.2.2.5. The Gemini Project Goals and Requirements

The Gemini PGR extracts the goals and requirements, relevant to Software and Controls, from the Gemini Science Requirements Document.

The only specific requirements for this document are:

- that it provide traceability of the goals and requirements contained therein back to the original Science Requirements
- that it provide the capability of traceability to future documents by uniquely identifying all goals and requirements contained therein

4.2.2.6. Software Requirements Specification

The purpose of a Software Requirements Specification is to provide a comprehensive description of the requirements for the Gemini Software from the user's point of view. It does not, however, propose any implementation details except where such details constitute a restraint or limitation on the subsequent design of the software.

A software requirements specification shall be written in the format defined by section 2 of the IEE Guidelines [6].

4.2.2.7. Gemini Operational Concept Definition

This document will define in detail how the facilities will be used during operations.

4.2.2.8. Work Package Descriptions

The initial document will detail the descriptions and work scopes of the individual work packages making up the Controls Group's effort. It will also contain the initial essential and implementation models for the system.

4.2.2.9. The Gemini Software Design Description

The Gemini Software Design Description will define the hardware and software components of the Gemini Software and Controls and their interfaces to establish a framework for its development.

The Gemini SDD shall be written in the format defined by IEEE 1016 and shall include the implementational model (of the whole Gemini Software), as defined by the Ward/Mellor analysis methodology, documented using the TBD CASE tool.

4.2.2.10. Package Functional Specification

A Package Functional Specification specifies the functional requirements of a package down to the module level. Its purpose is to provide a comprehensive description of the way in which the package shall operate functionally from the user's point of view and will not propose any design details except where such details constitute a restraint or limitation on the subsequent design phase of the project.

The Package FS shall include the essential model (of the package), as defined by the Ward/Mellor analysis methodology, documented as per Ward/Mellor.[3]

4.2.2.11. Module Functional Specification

The Module Functional Specification specifies the functional requirements of an individual module. Its purpose is to provide a comprehensive description of the way in which the module shall operate functionally from the users' point of view and will not propose any design details except where such details constitute a restraint or limitation on the subsequent design phase of the project.

Each Module FS shall include the essential model (of the module), as defined by the Ward/Mellor analysis methodology, documented as per Ward/Mellor.

4.2.2.12. Package Software Design Description

The Package Software Design Description will specify the logical structure of each package down to the module level.

The layout of a Package SDD shall conform to the IEEE 1016 recommended format and shall include the implementational model (of package), as defined by the Ward/Mellor design methodology, documented as per Ward/Mellor.

4.2.2.13. Module Software Design Description

A Module Software Design Description defines the logical and operational structure of the module. It will describe the breakdown of the module into 'units' and 'components'.

The layout of a Module SDD shall conform to the IEEE 1016 recommended format and shall include the implementational model (of the module), as defined by the Ward/Mellor design methodology, documented as per Ward/Mellor.

4.2.2.14. The Gemini Control System Simulation Results

This document will cover the results of simulating the tracking performance of the current telescope design including the effects of wind and a tip/tilt secondary.

4.2.2.15. The Gemini Software Test Plan

The Gemini Software Test Plan defines the overall approach to testing which will be adopted for the Gemini Software.

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[3] it is up to the developer whether to use a CASE tool or to do drawings by hand

The layout shall conform to IEEE 1012.

4.2.2.16. Package Test Procedure

It covers the integration, test and acceptance of a specific software package . A Package Test Procedure shall contain the following parts:

- the Test Plan
- the Test-Design Specification
- the Test-Case Specification,

in the format described in the IEEE 829. It is intended that this include a delivered regression test of the package.

4.2.2.17. Integration Test Procedure

This covers the integration, test and acceptance of a specific Gemini Software release. Each Integration Test Procedure shall be contain the following parts:

- the Test Plan
- the Test-Design Specification
- the Test-Case Specification,

in the format described in the IEEE 829.

4.2.2.18. On-site Acceptance Test Procedure

Each On-site Acceptance Test Procedure covers the installation and the acceptance of a specific Gemini Software release at the final site.

An On-site Acceptance Test Procedure shall contain the following parts:

- the Test Plan
- the Test-Design Specification
- the Test-Case Specification,

in the format described in the IEEE 829.

4.2.2.19. Test Report

Test Report will exist for:

- module acceptance test
- integrated release acceptance test
- on-site acceptance test.

A Test Report shall contain the following parts:

- the Test Log
- the Test-Incident Report
- the Test-Summary Report as described by the IEEE 829.

4.2.2.19.1. User Documentation

The Gemini Software User Documentation will include:

- the Gemini Software & Controls User Manual
- the Gemini Software & Controls Maintenance Manual.

The Gemini system will be a set of several documents, each covering a specific aspect of the system and/or some general concept. In general each specific work package will contribute a specific section to each manual. The structure of the documentation will be defined after the design phase. User Documentation shall be written in the format defined by the IEEE 1063.

4.2.3. Documentation Reviews

The Gemini Software Documentation Plan defines the baseline documents which are subject to formal review and which, once reviewed and formally approved, may be changed only via the formal change procedure and with the formal approval of the Software Configuration Control Board, as described in the Gemini Software Configuration Control Plan.

Where a document is produced in stages over a period of time, the reviews of the individual parts should be regarded as preliminary reviews, and a final critical review of the entire document should be performed when it is complete.

4.2.3.1. The Document Review Procedure

The purposes of a review are to ensure that the item under review:

- conforms to the appropriate standard(s)
- is technically correct
- meets the requirements of any previous phase
- provides an adequate basis for any subsequent phase.

The review procedure defined in this section is applicable to documents and not to code inspections and shall be used for all documentation reviews.

For the purposes of the Gemini Software and Controls a document review shall be made by:

- one or more technical reviews in which:
    - the technical adequacy of the document is assessed
    - the document is validated in relation to any previous requirements

    - the format of the document is verified against any applicable documentation standard,
- a formal review in which:
    - problems noted at the last preliminary review are verified as having been corrected in an acceptable manner
    - the document is formally accepted by both Gemini and, if relevant, the developer
    - the document is formally accepted as being, henceforth, under configuration control.

4.2.3.2. Review Document Maintenance

The following review-related documents shall be created during the project and shall be retained until the on-site acceptance of the system:

- memos convening all formal reviews detailing:
    - the document to be reviewed
    - the date of the review
    - the review chairman
    - the reviewers,
- review reports detailing:
    - the document to be reviewed
    - the date of the review
    - the outcome of the review, i.e:
        - accepted
        - accepted subject to minor corrections
        - rejected
    - the error list (if any)
    - the date of the re-review (if any).

4.2.4. Schedule And Resource Requirements

TBD

4.3. Project Support Functions

This subsection of the SMP shall contain, either directly or by reference, plans for the supporting functions of the project. These functions may include, but are not limited to, configuration management; software quality assurance; and verification and validation. Plans for project support functions shall be developed to a level of detail consistent with other sections of the SMP. In particular, the responsibilities, resource requirements, schedules, and budgets for each supporting function shall be specified. The nature and type of support functions required will vary from project to project; however, the absence of a software quality assurance, configuration management, or verification and validation plan shall be explicitly justified in project plans that do not include them.

4.3.1. Software Configuration Management

The requirements and procedures for software configuration management are described in the Gemini Software Configuration Control Plan.

The Gemini Software Configuration Control Plan also describes the system for reporting problems encountered with the Gemini Software and the procedures for dealing with those problems.

Documents will be placed under configuration control once reviewed and approved. Code shall be placed under configuration control at the end of the implementation phase, i.e., after module acceptance. Once a configuration item, both document and code, has been placed under configuration control, it shall not be changed without formal approval.

4.3.2. Software Quality Assurance

A specific Software Quality Assurance Plan (SQAP), as it is defined in the IEEE 730-1989 standard is not foreseen at the moment.

This management plan includes the core documents and reviews required by IEEE 730-1989. The combination of this management plan with the baseline system releases, the project phasing procedure, and the acceptance testing will accomplish the fundamental goals of a formal SQAP.

4.3.3. Software Verification and Validation

In IEEE 729 verification is the "act of reviewing, inspecting, testing, checking, auditing, or otherwise establishing and documenting whether or not items, processes, services or documents conform to specified requirements". The verification activities are essential for assuring the quality of a product and shall be clearly defined and controlled in their implementation.

IEEE also defines validation as "the evaluation of software at the end of the software development process to ensure compliance with the user requirements". Validation is, therefore, end-to-end verification .

The verification and validation strategy chosen for the Gemini Software is articulated in the following activities:

- formal reviews: The definition of review and the review procedure are described in a previous section. The documents which are subjected to review procedure are listed in a previous section.

- check of tracibility of software requirements to user requirements and of design components to software requirements: This activity is done during the review procedure and is the responsibility of WPR under the supervision of the GWPR.
- testing: The testing strategy is based on a bottoms-up approach and is articulated in unit testing, module testing, integration testing and in on-site acceptance.

Neither formal proof nor algorithms will be used.

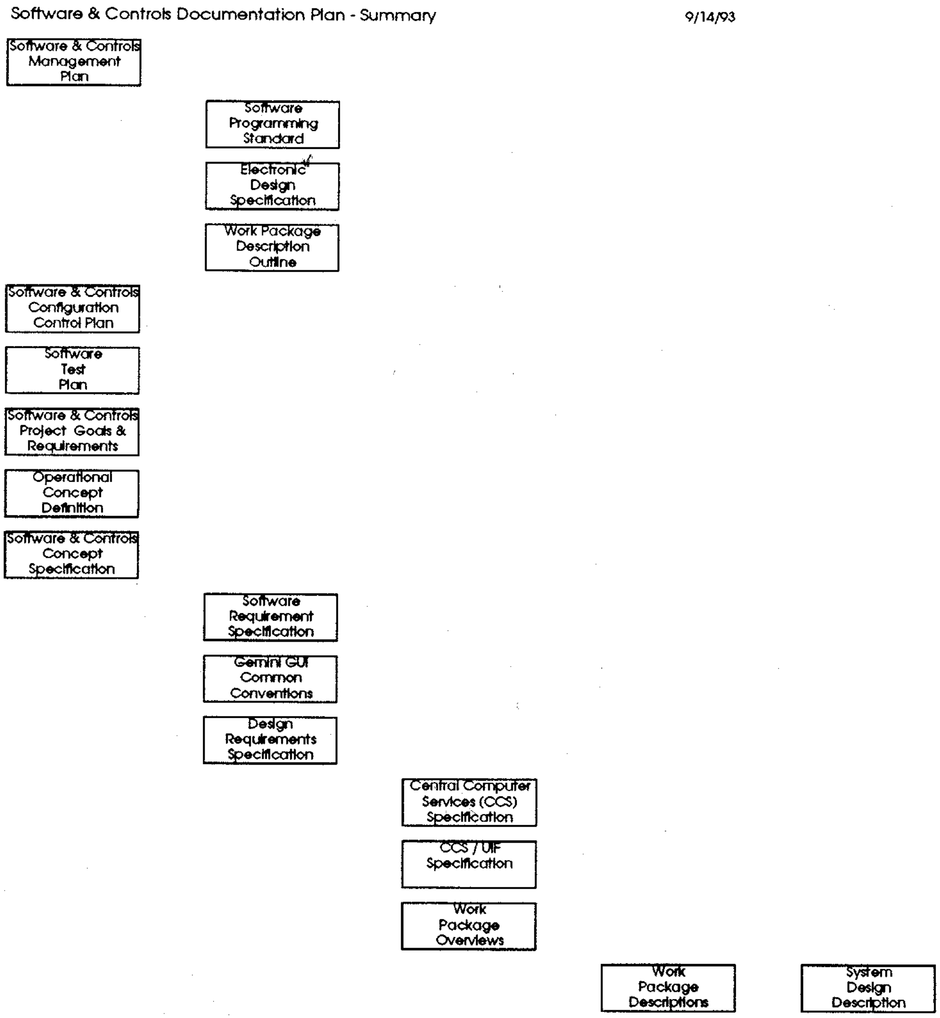
The Gemini Software Test Plan describes the verification and validation matters.

4.3.4. Quality Assurance Activities

The following QA activities are performed by SQAM during the design phase:

- preparing, for each identified release, the first issue of the Integration Test Procedure and of the On-site Acceptance Test Procedure. The first issue contains the final version of the Plan section and a draft of the Test-Design section.

Fig.4-1 Documentation Plan



5. Work Packages, Schedule, And Budget

This section of the SMP shall specify the work packages, identify the dependency relationships among them, state the resource requirements, provide the allocation of budget and resources to work packages, and establish a project schedule.

5.1. Work Packages

This subsection of the SMP shall specify the work packages for the activities and tasks that must be completed in order to satisfy the project agreement. Each work package shall be uniquely identified; identification may be based on a numbering scheme and descriptive titles. A diagram depicting the breakdown of activities into subactivities and tasks (a work breakdown structure) may be used to depict hierarchical relationships among work packages.

5.1.1. Work Package Specification

The work packages for the project are divided into four groups:

- staff work packages
- funded work packages
- contingency work packages
- unfunded work packages

5.1.1.1. Staff Work Packages

These work packages have been defined in order to track the staff costs of the different phases of the project.

- 8801 - Design
- 8802 - Procurement
- 8803 - Hawaii Installation and Commissioning
- 8804 - Chile Installation and Commissioning

5.1.1.2. Funded Work Packages

These work packages are

- 8805 - Communications
- 8806 - Data Handling and Archiving
- 8807 - Observatory Control Infrastructure
- 8808 - Telescope Control Software
- 8809 - Instrument Control Infrastructure

- 880A - Mount Control System
- 880B - Enclosure Control System
- 880C - Primary Control System
- 880D - Primary Thermal Control
- 880E - Secondary Control

5.1.1.3. Contingency Work Packages

None of the Controls Group work packages are currently part of contingency.

5.1.1.4. Unfunded Work Packages

These work packages do not have identified funding within the baseline budget.

- 880I - Hawaii Operations Ramp Up
- 880J - Chile Operations Ramp Up
- 880K - Inertial Encoders (Gyros)
- 880L - Mauna Kea Wide Field Control
- 880M - Cerro Pachon Wide Field Control

5.1.2. Work Package Allocation & Costing

Figure 5.1.2a is the current allocation and costing of the funded work packages amongst the partner countries.

5.2. Dependencies

This subsection of the SMP shall specify the ordering relationships among work packages to account for interdependencies among them and dependencies on external events. Techniques such as dependency lists, activity networks, and the critical path method may be used to depict dependencies among work packages.

The major dependencies are currently in a preliminary stage of development. The current status of work package dependencies is contained in the gannt chart in figure 5.1. In fig.5.1 the major work packages are outlined and external dependencies are indicated with the encircled arrow symbols. The dependencies between work packages are currently only embodied in their relative start times. The following general dependency principles may be noted.

5.2.1. Infrastructure

It is important to lay the proper infrastructure for software and controls first. The Standard Instrument Controller and Observatory Control Infrastructure lay the basis for the software and controls used throughout the project. They should precede all other work packages other than

Mount Control. The Mount Control work package may proceed in parallel with the infrastructure as a) it is mainly electronics and control and b) it must keep pace with the Telescope design.

5.2.2. Mechanism Work Packages

A large number of the work packages are intended to provide the software and controls needed for a mechanism which is being supplied to the Gemini Project. All of these mechanisms fall under the responsibility of one of the Telescope, Enclosure, Optics, or Instrument Groups. As such there are a number of times that the two developments should be synchronized. These are:

- controls system design review and mechanism preliminary design review
- controls preliminary design review and mechanism critical design review
- availability of controls system when required for testing mechanism
- acceptance testing of complete mechanism including controls

5.2.3. Software Only Work Packages

A small number of work packages are strictly software only and do not immediately impact the other tasks. However it is important that the interfaces to these packages are defined early on so that the development of the different packages can proceed in parallel if required.

5.3. Resource Requirements

This subsection of the SMP shall provide, as a function of time, estimates of the total resources necessary to complete the project. Numbers and types of personnel, computer time, support software, computer hardware, office and laboratory facilities, travel, and maintenance requirements for the project resources are typical resources that should be specified.

The resource requirements for funded and contingency work package are not detailed herein as all of this work is to be done by external developers. The only resources these work packages will require from the project will be budget, schedule, and management. For each of these work packages an estimate is given of the number of man hours required in figure 5.2.1a.

5.3.1. Personnel

The personnel required to staff the controls group have already been detailed in section 3.5. These personnel will be required throughout the duration of the project.

In order to perform the installation and testing it will be necessary to either hire additional staff or to have members of the work package development group come on site to perform installation and testing. In view of the large number of work packages and the costs of moving personnel on and off site it is recommended that the project explore the possibility of having JACH (in Hawaii) and CTIO (in Chile) second personnel under contract to Gemini during the installation and testing phase. This is detailed in section 3.6.

In order to ensure that the handover of the software and controls systems can be accomplished smoothly it is imperative not only that the operations staff have experience in the systems but that they have a professional stake in the systems as well. It is recommended that the operations group plan to start ramping up the software and controls operations staff two years ahead of acceptance testing with the goal of being at full strength 6 months ahead of acceptance testing.

5.3.2. Computer Time

There is currently no planned expenditures or requirement for computer time external to the project.

5.3.3. Support Software

In addition to the support software delivered with a) the computer systems used by Controls group members and b) the funded and contingency work packages the following support software will be required:

- 1992
    - VxWorks system
    - Matlab and MatrixX servo analysis software
- 1993
    - EPICS real-time system
    - Khoros user interface system
    - PV-Wave visualization system
    - RTAP applications software (TBD)
    - IDL data reduction system (TBD)
    - Extend servo analysis system (TBD)
    - TSEE computer aided software engineering tool
- 1996
    - VxWorks system for Mauna Kea office

5.3.4. Computer Hardware

The computer hardware required for the funded and contingency work packages will be detailed in their work package descriptions. The hardware required to support the project staff is detailed here.

- 1992
    - Sun Workstation for RTE
    - VME crate plus processor to support VxWorks/EPICS
    - Sun Workstation to interface to VME system

    - IBM PC to interface to encoder test setup
- 1993
    - Sun Workstation for SSE
    - IBM PC for SCE
    - IBM PC for group use (TBD)
    - Sun Workstation for SCE (TBD)
- 1994
    - Sun Workstation for configuration control
- 1996 (for Mauna Kea office)
    - 3 Sun Workstations
    - 2 IBM PCs
    - VME crate plus processor to support VxWorks/EPICS
- 1999 (for Cerro Pachon office)
    - 2 Sun Workstations
    - 1 IBM PC

5.3.5. Office and Laboratory Facilities

- 1992 - 1996
    - 4 workspaces in Tucson office
- 1997 - 1998
    - 6 workspaces in Hilo office
- 1999
    - 4 workspaces in Hilo office
    - 2 workspaces in Chile office
- 2000 - 2001
    - 6 workspaces in Chile office

5.3.6. Accommodations

The current staffing plan and the current time table for finishing the enclosure yield the following requirements for developers and staff accommodations at the base levels for Hawaii and Chile.

Time Period	Developers		Gemini Staff no family		Gemini Staff with family	
	Hawaii	Chile	Hawaii	Chile	Hawaii	Chile
1/97 - 12/98	0.00	0.00	0.00	0.00	4.00	0.00
1/99 - 6/99	2.00	0.00	0.00	0.00	2.00	2.00
7/99 - 12/99	1.00	1.00	0.00	0.00	1.00	3.00
1/00 - 12/01	0.00	2.00	0.00	0.00	0.00	4.00

5.3.7. Staff Relocation

The current plan calls for staff to relocate to each of the sites in order to manage and perform commissioning and installation. Including the Controls Manager there are the following relocation requirements:

- 1/1/97 - 4 families from Tucson to Hawaii
- 1/1/99 - 2 families from Hawaii to Chile
- 7/1/99 - 1 family from Hawaii to Chile
- 1/1/00 - 1 family from Hawaii to Chile
- 12/31/01 - 4 families from Chile to Tucson

It is not intended to relocate the developer associated with Instrument Integration nor the UK Work Package Scientist. It is expected to hire the Instrument Integration staff member from existing observatory personnel on site. It is expected that the UK Work Package Scientist will be relocated by SERC as part of his/her tour of duty at Mauna Kea and Cerro Pachon.

5.3.8. Travel

There are four requirements for travel during the project. These are:

- staff travel to manage work packages,
- staff travel to training courses and conferences,
- travel by developers to the different sites to support their respective work packages,
- travel paid for by Gemini for members of external review teams.

The current estimate of resources required to support the travel requirements are detailed by number of trips per year per requirement in figure 5.2.

5.3.9. Maintenance Requirements

Maintenance will be required in the following areas:

- computer hardware
- computer software

All of the hardware maintenance requirements will be handled by external contracts and so will not require project resources. Installation of software upgrades is currently handled by the Gemini computer coordinator and will not require any of the Controls groups resources.

Software that is particular to the work done within the Controls group; such as VxWorks, EPICS, and Khoros; will have software maintenance performed by members of the Controls group. It is estimated that this will consume one man week per year per package for a total of one man month per year throughout the duration of the project.

Hardware that is particular to the work done within the Controls group will not have maintenance contracts with outside agencies. Rather moneys will be budgeted each year for maintenance and it will be a yearly decision whether to use these moneys to maintain or retire existing equipment.

5.4. Budget And Resource Allocation

This subsection of the SMP shall specify the allocation of budget and resources to the various project functions, activities, and tasks. An earned value scheme may be used to allocate budget and resources, and to track expenditures and resource utilization.

The resource allocation has not been performed as of the distribution of this document.

The initial budget estimates for work packages are shown in 5.3. The unfunded and contingency work packages are shaded.

The current budget allocation amongst work packages is seen in figure 5.2.1a.

The allocation of travel moneys amongst the various travel requirements is detailed by year in fig.5.4.

5.5. Schedule

This subsection of the SMP shall provide the schedule for the various project functions, activities, and tasks, taking into account the precedence relations and the required milestone dates. Schedules may be expressed in absolute calendar time or in increments relative to a key project milestone.

The schedule is shown in the project gannt chart in figure 5.5. This is a top level schedule and only includes the major milestones and activities for each work package.

Fig.5-1 Project Dependencies

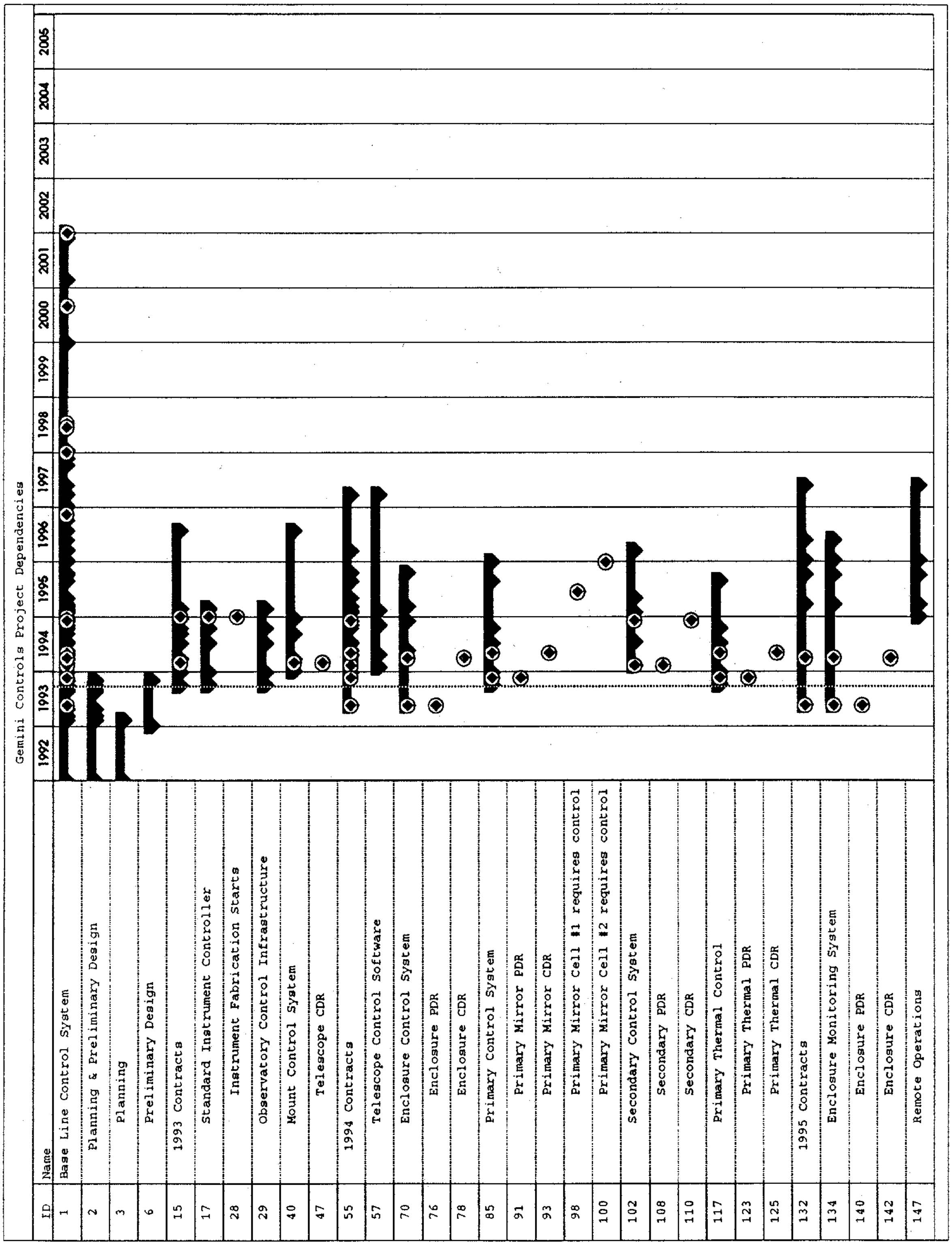


Fig.5-1 (cont'd)

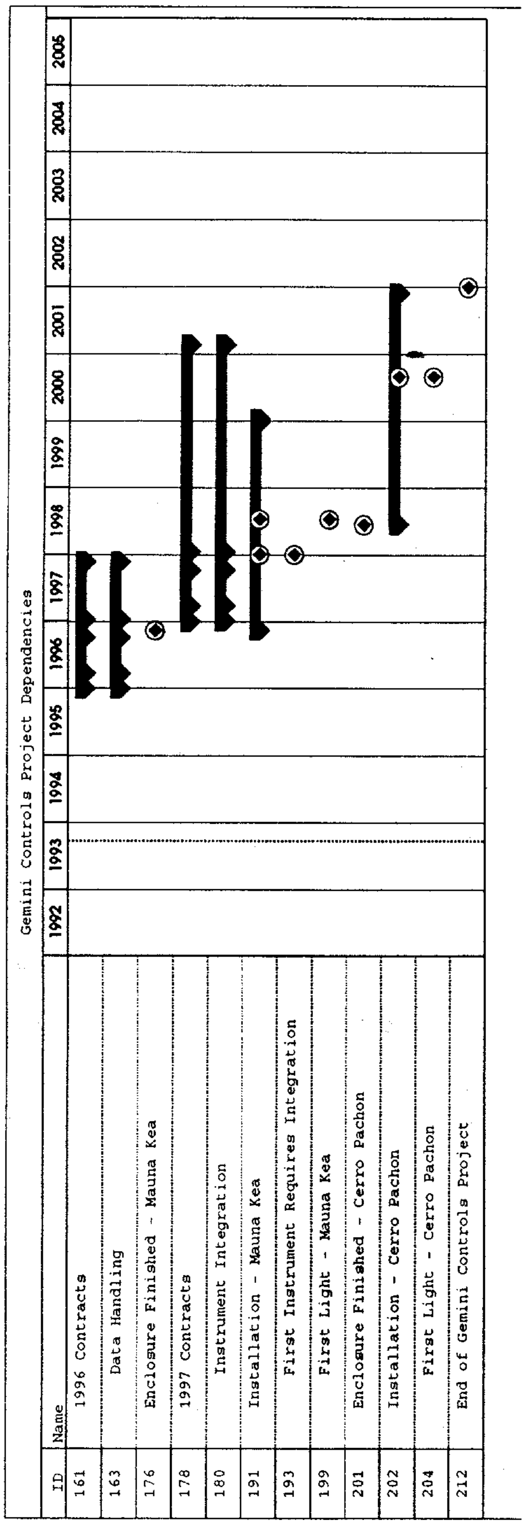

Gemini Controls Project Dependencies
ID
Name
161 1996 Contracts
163 Data Handling
176 Enclosure Finished - Mauna Kea
178 1997 Contracts
180 Instrument Integration
191 Installation - Mauna Kea
193 First Instrument Requires Integration
199 First Light - Mauna Kea
201 Enclosure Finished - Cerro Pachon
202 Installation - Cerro Pachon
204 First Light - Cerro Pachon
212 End of Gemini Controls Project
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005

Fig.5-2 Travel Requirements

GROUP: Controls	GEMINI 8M TELESCOPES PROJECT TRAVEL EXPENSES FOR DURATION OF PROJECT	9/14/93

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Totals
Staff Travel											
Work Package Travel	$11,000	$15,000	$20,000	$20,000	$20,000	$15,000	$10,000	$5,000			$116,000
Training/Conferences	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$120,000
Subtotal	$23,000	$27,000	$32,000	$32,000	$32,000	$27,000	$22,000	$17,000	$12,000	$12,000	$236,000
Non-Staff Travel											
Work Package Travel						$5,000	$10,000	$15,000	$20,000	$20,000	$70,000
Design Review Travel		$12,000	$12,000	$12,000							$36,000
Subtotal	$0	$12,000	$12,000	$12,000	$0	$5,000	$10,000	$15,000	$20,000	$20,000	$106,000
Total	$23,000	$39,000	$44,000	$44,000	$32,000	$32,000	$32,000	$32,000	$32,000	$32,000	$342,000

Project Total Travel Expenses $342,000

Group size	4
Staff manyears represented	37
Average staff travel expense / staff member / yec	$6,378
Average total travel expense / staff member / yec	$9,243

Notes:
1. Staff Work Package travel should ramp down starting in 1997.
2. Staff training/conferences assumes one training course and one conference per staff member annually
3. Non-staff Work Package travel is to bring system designers/manufacturers on site for acceptance and commissioning
4. Non-staff Design Review travel is to bring external review committees on site

Fig.5-4 Travel Costs

GEMINI 8M TELESCOPES PROJECT

TRAVEL REQUIREMENTS FOR DURATION OF PROJECT

GROUP: Controls

9/14/93

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Totals
Staff Travel											
Work Package Travel	5	7	10	10	10	7	5	2			56
Training/Conferences	6	6	6	6	6	6	6	6	6	6	60
Subtotal	11	13	16	16	16	13	11	8	6	6	116
Non-Staff Travel											
Work Package Travel						2	4	6	8	8	28
Design Review Travel		6	6	6							18
Subtotal	0	6	6	6	0	2	4	6	8	8	46
Total	11	19	22	22	16	15	15	14	14	14	162

Notes: 1. Entries are total number of trips per heading

Fig.5-5 Gemini Controls Top-Level Schedule (page 1)

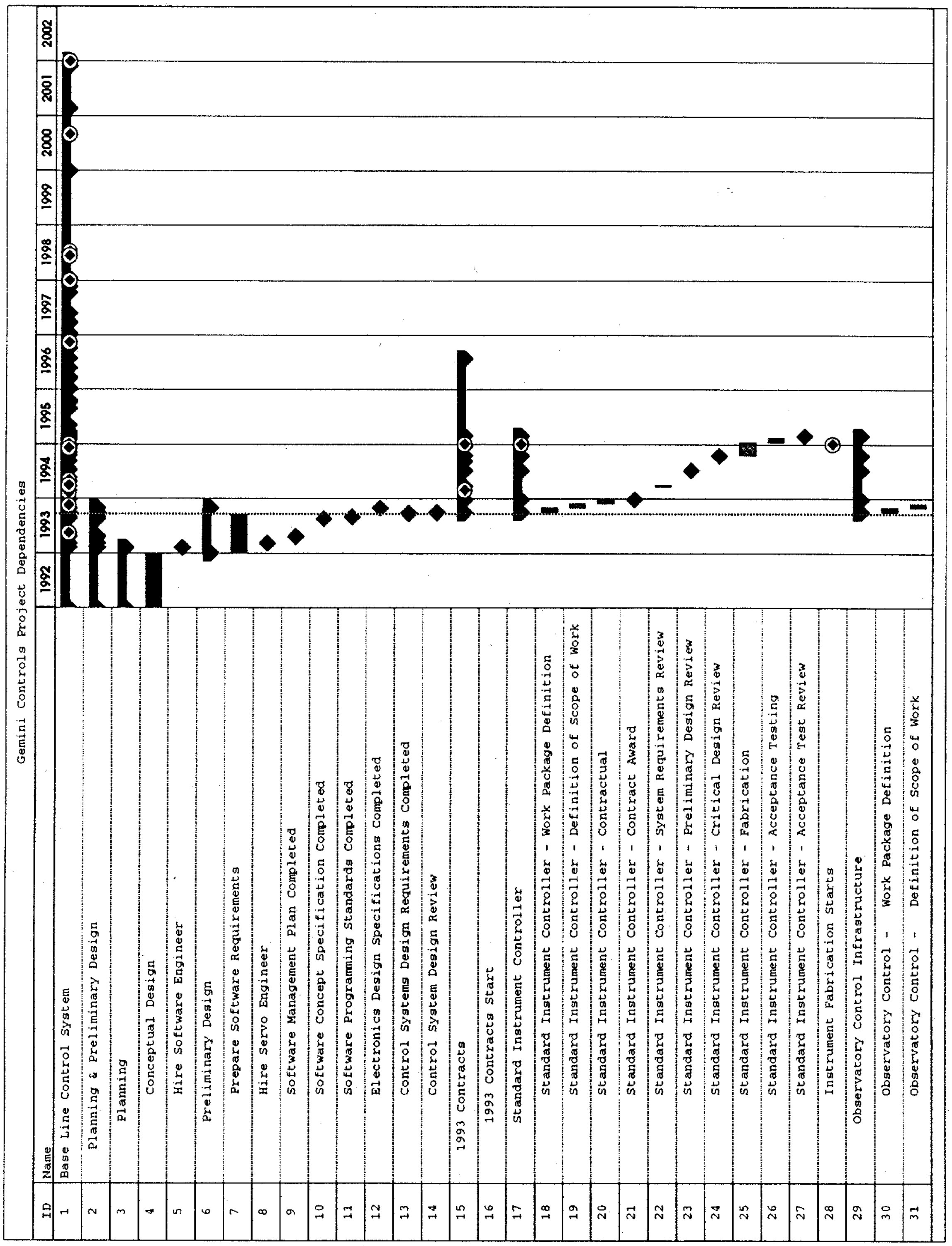


Fig.5-5 Gemini Controls Top-Level Schedule (page 2)

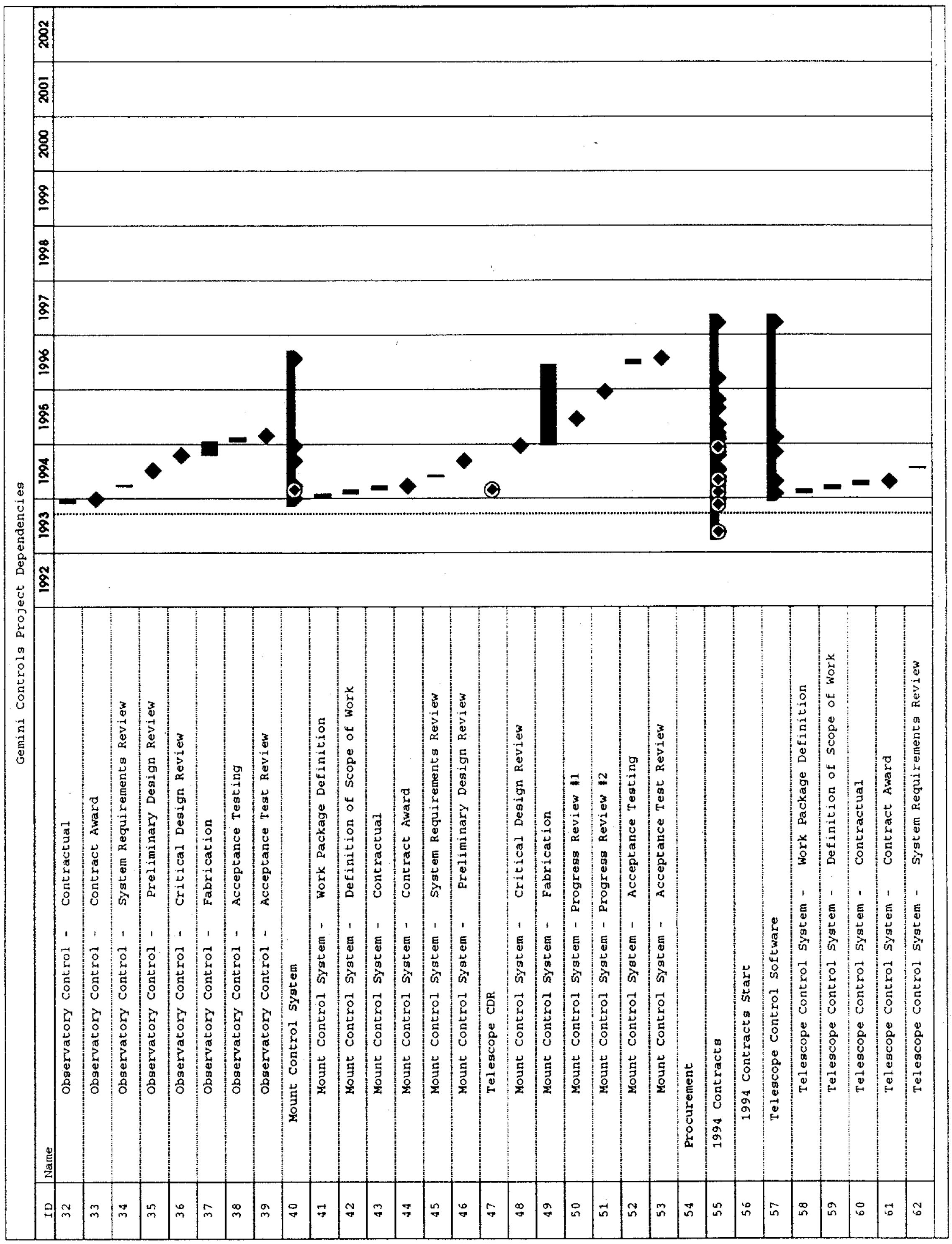


Fig.5-5 Gemini Controls Top-Level Schedule (page 3)

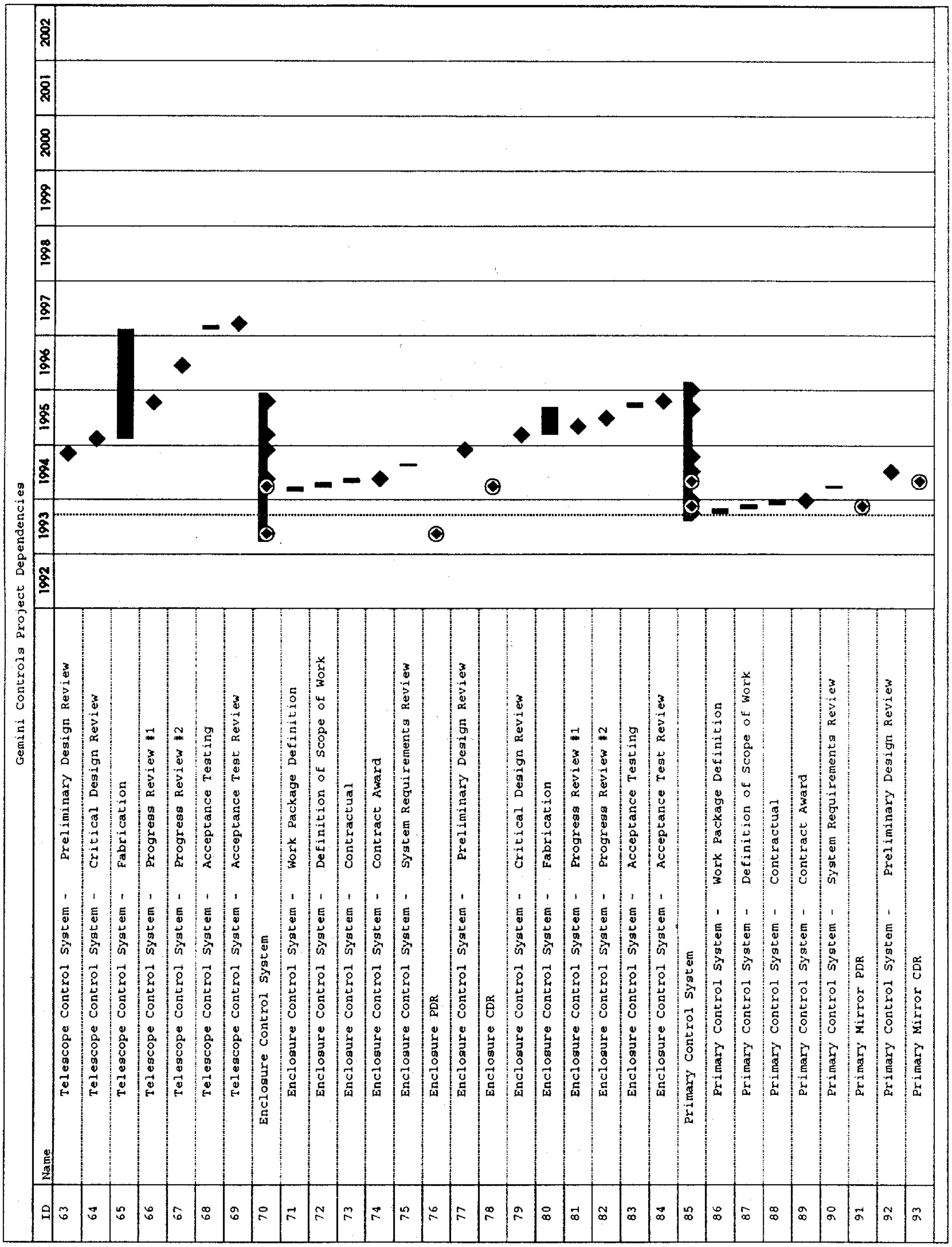


Fig.5-5 Gemini Controls Top-Level Schedule (page 4)

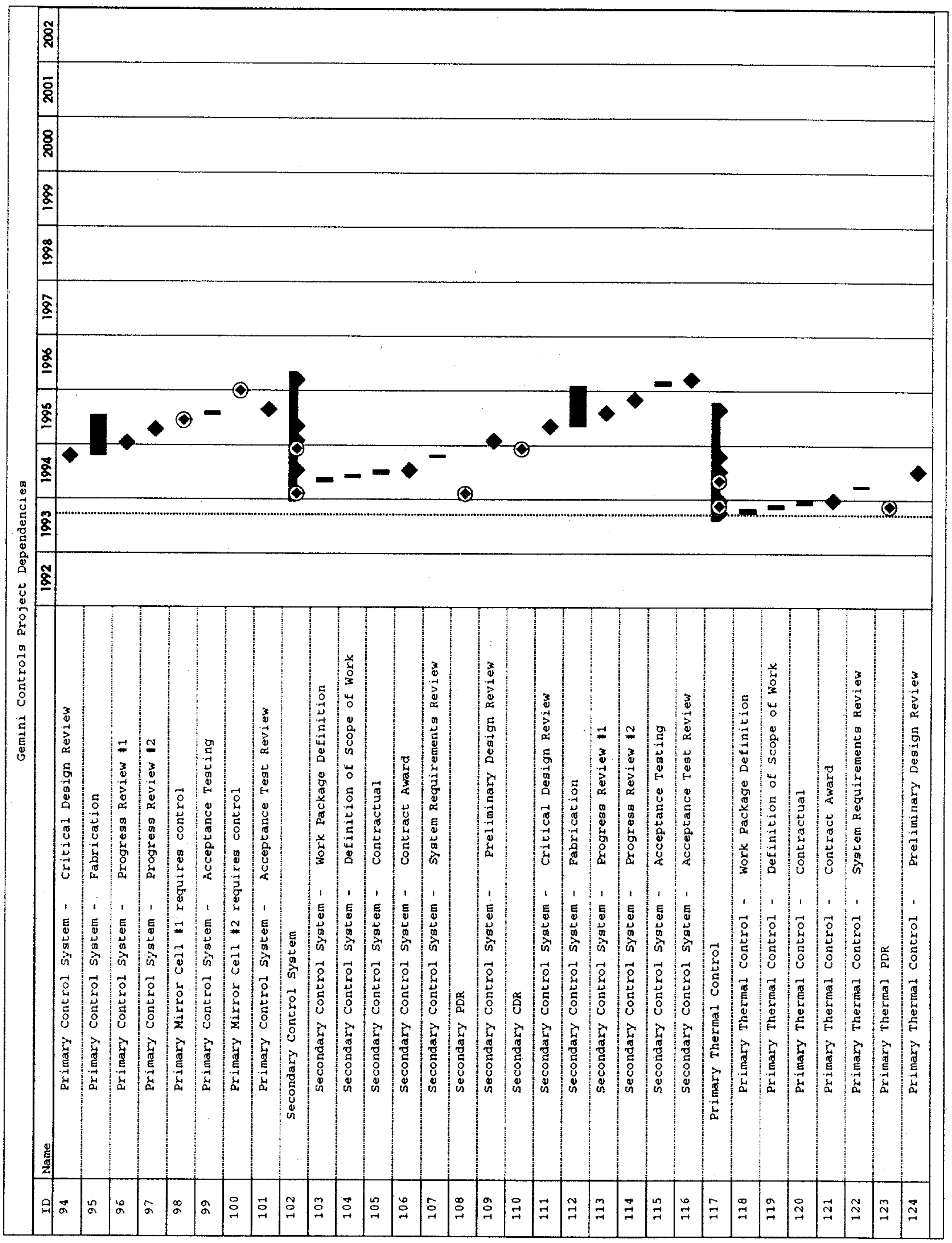


Fig.5-5 Gemini Controls Top-Level Schedule (page 5)

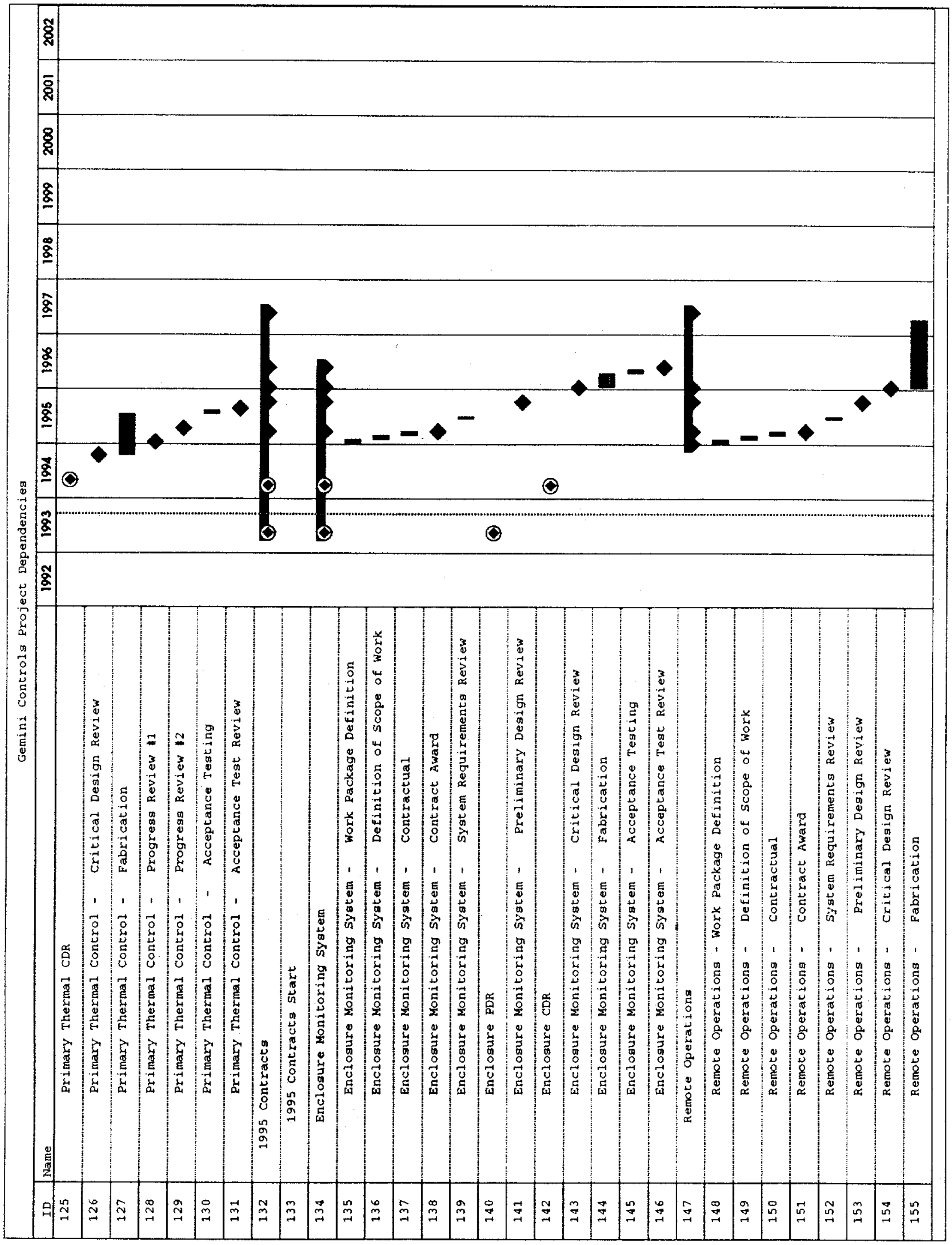
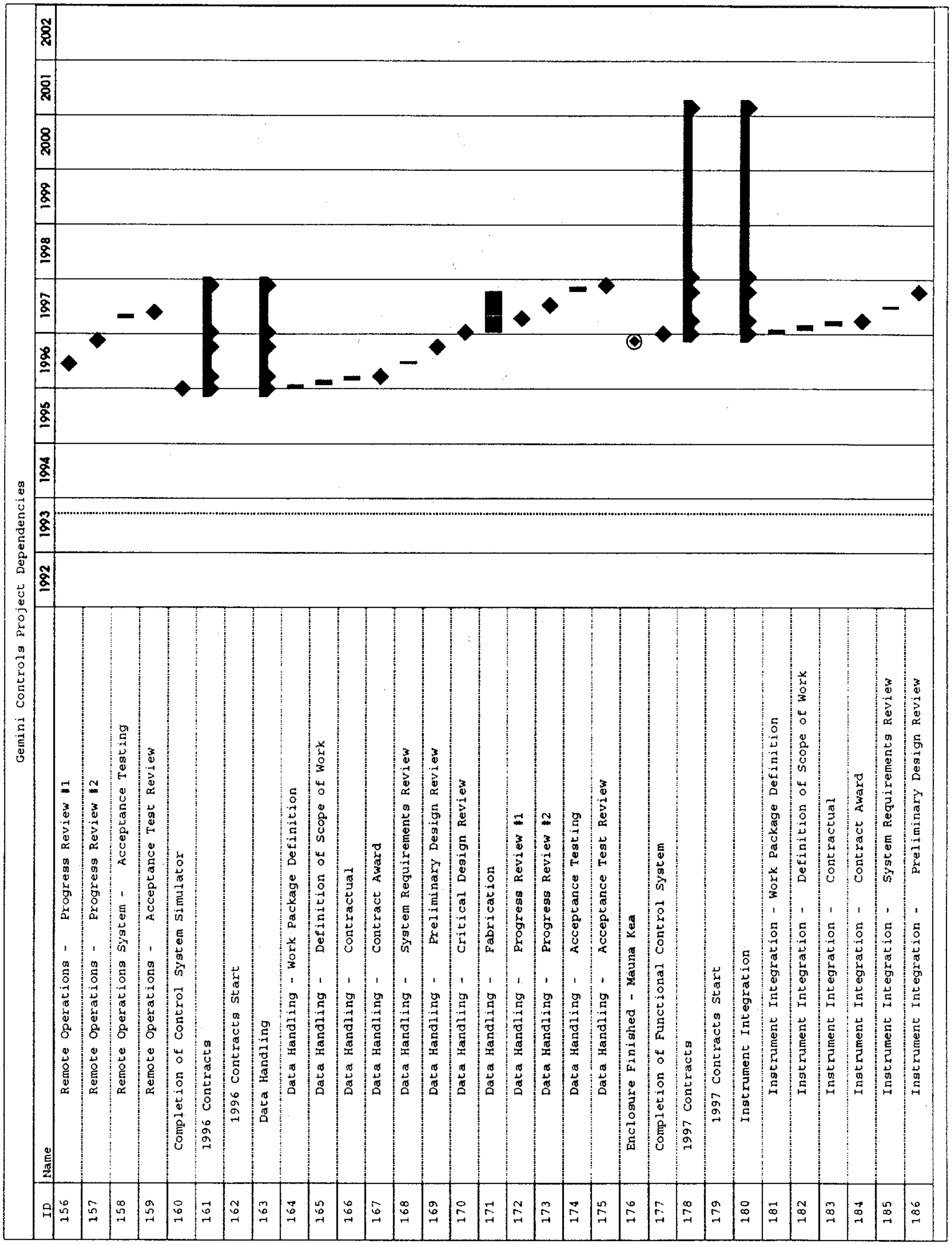


Fig.5-5 Gemini Controls Top-Level Schedule (page 6)



6. The Work Package Phase

In the work package phase the design of architecture, software components, interfaces, and data are created, documented, and verified to satisfy requirements.

> ***This section of the SMP describes one method of development based on the Ward and Mellor methodology. It is <u>not required that developers follow this section. It</u> is included as an example of how the methodology could be implemented.***

This phase is the technical key point of the project:

- each package will be divided into modules,
- the usage of vendor software or the development of specific solutions will be evaluated,
- implementation constraints will be defined.

Two types of technical activities are carried out:

- analysis (at package and module level)
- software design (at package and module level)

The analysis defines the system's scope and context by modeling its environment and the system's behavior by identifying the transformations, dynamics, and data requirements.

The software design is aimed at transforming the analysis outputs into implementation input, i.e., the physical organization of processing, the processes and data allocation, the tasks structure, etc.

The sequence of main activities is the following:

- Software Design of the packages
- Analysis of modules
- Software Design of modules

In addition, the following activities are also part of the design phase:

- Design Reviews:
- A Preliminary Design Review will be performed on each package after completion of the package SDs.
- A Critical Design Review will be performed on each package after completion of the module SDs.
- Management Activities
- Quality Assurance Activities

The following paragraphs provide a detailed explanation of the activities occurring during the design phase.

6.1. Package Analysis

For each of the identified packages the requirements defined in the software requirements specification documents are analyzed and a detailed description defining the functionality which is intended to be developed to cope with the requirements is provided in the form of the essential model of the package, i.e., environmental and behavioral models. Major points are:

- the analysis of the functionality
- the evaluation of possible market available solutions
- the definition of inter-package and inter-module interfaces
- the comparison of the package functionality with the package and system requirements

As a last step, the modules forming a package are identified and the module boundaries defined. This subdivision is the basis for configuration control.

The inputs are:

- the Gemini Software Requirements Specification

The outputs are:

- the Package Functional Specification

Each Package Functional Specification shall be submitted to formal review.

6.2. Package software design

The objective of the package software design is to define for each individual package the system logic, modules, interfaces and data; down to the module level where the specification of individual modules can begin. It includes the implementational model, processor and task architecture parts, of the package considered as a whole.

For each of the packages:

- the phase inputs are:
    - the Gemini System SDD. the package FS.
- the phase output is:
    - the package Software Design Description.

Each Package SDD is subject to formal review.

6.3. Analysis of modules

The analysis is continued to go deeply into module specific aspects. Starting from the module boundary and definition present in the essential model of the package, the essential model, i.e., environmental and behavioral models of the module, is built.

If the FS at package level is detailed enough to cover also the module specifics and under explicit approval by the GWPR, the module FS can be skipped.

The inputs are the FS and the SDD of the package to which the module belongs. The output is the module Functional Specification of the identified module. The module Functional Specifications will be written by the developer to whom the module is assigned.

Module FSs are subject to formal review.

6.4. Module software design

In module software design the module structure is specified down to the component level, defining the units and components to the point where implementation can begin. It contains the implementational model, processor and task architecture parts, of the module.

The module SDD can be omitted if the package SSD is detailed enough. The module SDD can be part of the module FS document. In both cases the explicit approval of the GWPR is required.

For each module, the inputs are:

- the module FS (or, in case that module FS has been skipped, the package FS of the package to which the module belongs)
- the Package SDD of the package to which the module belongs.

The output is a module Software Design Description for each module.

Each module Software Design Description will be written by the developer to whom the module is assigned.

It is during module software design that code prototyping typically takes place. It is essential that prototype code does not carry through to the implementation phase. All prototyped code must be specifically identified during reviews and the developer must be prepared to verify that it was not used for implementation.

Module SSD are subject to formal review.

The review of the module SDD or, in case that SDD is skipped, the review of the module FS establishes the end of the design phase for the specific module and authorizes the start of the implementational phase.

6.5. The Implementation Phase

In this phase, the software is created and tested on a module by module basis. The phase is characterized by the following sequential sub-phases:

- detailed design
- coding

- unit test and module integration
- module acceptance test

In parallel with the activities at module level, the preparation of the testing documentation shall continue.

6.5.1. Detailed Design

In the detailed design sub-phase, the outputs of the design phase are refined and expanded to contain more detailed descriptions of the processing logic, data structures and data definitions, to the extent that the design is sufficiently complete to be implemented. It corresponds with the code organization part of the implementational model. In the detailed design, the individual units and components are assigned by the implementer responsible (the developer's project manager).

The inputs are the module FS and/or the module SDD.

The outputs are:

- the unit/component detailed design, possibly in the format of a Structured Chart (PDL), written by the developer(s),
- the production of appropriate parts of the detailed design of the database and the data dictionary, written by the developer(s),
- the Module Test Procedure, written by the implementer responsible.

It will be the responsibility of the supplier to review and approve the detailed design. In view of the sheer volume of such documentation, Gemini would not expect to review the developer's detailed design, but Gemini retains the right to inspect the detailed design documentation.

The Module Test Procedure shall be subject to formal review as part of the Package test Procedure.

6.5.2. Coding

During coding, the component detailed designs are transformed into code which is then compiled and debugged. The user documentation is also developed.

It is the responsibility of the implementer responsible to review the source code to ensure that:

- it accurately implements the detailed design,
- it conforms to the coding standard.

The outputs are:

- the debugged code (in the form of source, library, procedure, makefiles, etc.).
- the user documentation.

6.5.3. Unit Test And Module Integration

The testing at unit level is intended to demonstrate the completeness and correctness of the developed module, covering both code and documentation.

The activity is terminated when the module deliverables, namely code and user documentation, are ready to be tested.

The inputs are:

- the debugged code of each unit,
- the software user documentation.

The outputs are:

- the module kit (code and user documentation)

6.5.4. Module Acceptance Test

The module Acceptance test is the official act where it is demonstrated that the developed software meets the module functional requirements. Module testing occurs at module level and is carried out by the development organization, prior to package integration. The testing environment is made by emulator(s) or, if feasible, using part of the real system.

The inputs are:

- the module kit,
- the Module Test Procedure.

The outputs are:

- an accepted module kit,
- the module Acceptance Test Report,

Depending on the required testing environment, the module testing may need more steps to be accepted. In this case, there will be a set of outputs for each step. The required steps and the scope and acceptance condition for each, shall be stated in the Module Test Procedure. In any case, the module is accepted only after the completion of all planned test(s).

The module acceptance test is carried on at the developer's premises. If, for technical reasons, it is not possible to perform a complete module acceptance test at developer's premises an additional requirement exists: a pre-delivery test has to be performed in order to give a reasonable level of confidence that the performance of the Acceptance tests, involving the real system, can be executed later without risks for the testing environments. The need of the pre-delivery test shall be stated in the Module Test Procedure.

After pre-delivery test, if any, and after acceptance test, the module code should be placed under configuration control.

6.6. The Package Test Phase

Within this phase, many modules, belonging to the same work package, are integrated in order to determine whether or not requirements have been satisfied. Tests are conducted to ensure that program or system components pass information or control correctly to one another.

The integration process is very complex and is made as a sequence of steps where one or more modules are inserted in an integration environment. The integration environment can be formed by real parts or by emulators, depending on availability of the real system and on the possibility to emulate its behaviour.

The general approach is to insert one module at a time and, using real parts or emulators, check the behaviour of the system with respect to the specified functionality. The integration of different modules continues up to complete involvement of the defined set of software modules that are part of the work package. The specified functionality will include the system interactions external to the work package.

The goal is to perform as much testing as possible at the Developer's site, at Gemini premises or at the pre-erection site. Usage of the actual site should be limited.

The Acceptance test of the work package is held at the end of the integration activity. The developer is responsible for integration.