Precision Telescope Control System

PTCS/SN/11: Project Plan

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1 0	Original draft for internal review	03/15/03	RMP
2	General overhaul and public release	04/02/03	RMP

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Abstract

This document summarizes the project planning information for the Precision Telescope Control Systsem Project, including details on Resources, Schedule, Budget and risk mitigation.

1 Introduction

The Precision Telescope Control System (PTCS) Project as currently conceived received a major boost in priority and resources, following the GBT Review held in November 2002. Since that date, we have significantly increased the staffing numbers available to the project, and have started to make significant progress in a number of areas (for example, design of the overall system architecture) which were previously languishing. More importantly, the PTCS now has a unified project team under a single manager responsible for its success, rather than several loosely coordinate efforts each addressing only part of the problem. Despite the considerable amount of work which has been performed in some areas (e.g. the Active Surface, Laser Rangefinders) many areas of the project, and in particular the integration of the current sub-systems and enhancements to allow the telescope to achieve full 3mm operation, are still only at the conceptual design stage. For a number of years, the GBT has been advertising that full 3mm operation would be available approximately two years after the start of astronomical commissioning. However, that timescale was not based on any systematic work breakdown or other technique for estimating effort and timescales. The current project team will make every effort to achieve initial 3mm operation during the winter of 2004/05 (i.e. two years from the project reorganization), but that timescale must be considered very tentative, at least until an In-Progress Review, proposed for approximately six months from now.

2 Project Team

As currently constituted, the PTCS Project Team spans a number of Divisions, including Green Bank Electronics, Science, and Software Development Divisions, and the Charlottesville Scientific Services Division. We do not currently have any member of the Green Bank Mechanical or Operations Divisions associated with the project, but we keep the Division Heads of these divisions appraised of requirements via the Green Bank weekly and monthly project management meetings.

A brief summary of the roles and responsibilities of the Project Team members is given below and in Table 1. Note that only a single team member, Kim Constantikes, is devoted full-time to the project. This potential risk is addressed in more detail in Section 7.

Project Lead Roles

Project Manager: Richard Prestage (NRAO GB Scientific Services Division). Overall responsibility for the successful delivery of the project, and general project management. Participates in PTCS and High Frequency Observing System (HFOS) design, and astronomical characterization. Team Lead for Active Surface Improvements workpackage.

Project Engineer: Kim Constantikes (NRAO GB Electronics Division). Responsible for the overall architecture of the system. Leads the development of the PTCS system design, as well as Team Lead for a number of engineering work packages. Maintains project budget estimates and participates in long-term project planning.

Project Scientist: Jim Condon (NRAO Charlottesville). Ensures that the project is correctly addressing the scientific requirements; participates in PTCS and HFOS system design, leads the Antenna Characterization work-package.

NRAO Green Bank Electronics Division/Metrology Group

Dave Parker: (Group Leader), John Shelton, Bill Radcliff. Responsible for the Laser Rangefinder hardware Also responsible for general GBT metrology program, e.g. measurements in support of the AZ track improvements.

NRAO Green Bank Electronics Division/Digital Group

Jason Ray, J.D. Nelson, Randy McCullough. Responsible for PTCS antenna instrumentation development and support, including the Quadrant Detector, antenna temperature sensors and so on. Responsible for the Active Surface hardware.

NRAO Green Bank Software Development Division

Joe Brandt, Ray Creager, Paul Marganian, Melinda Mello, Amy Shelton. Responsible for all aspects of PTCS software development.

NRAO Green Bank Scientific Services Division

Dana Balser. Execution and analysis of PTCS astronomical commissioning and antenna characterization experiments. Participates in PTCS and HFOS system design discussions.

NRAO Charlottesville Scientific Services Division

Fred Schwab, Don Wells. General mathematical analysis, astronomical and engineering antenna characterization; focus-tracking and other antenna control algorithms.

As noted, only the Project Engineer (Kim Constantikes) is associated with this project full-time. Formal staff effort accounting for the identified Project Team members began on 1st February. Table 1 presents the percentage of effort which each staff member made available to the PTCS project for February and March of this year, and the percentage which we expect to have available for the six months April through September 2003 inclusive. These amount to ~6.5 ftes for the two months which have been tracked so far, and ~7.8 ftes for the coming six months.

In addition to the staff formally associated with the project, it must be noted that we benefit from input and/or support from a wide range of other GB staff who are less directly associated with the project.

Staff Member	% Effort Feb/March	% Effort April-September
Balser, Dana	5%	30%
Brandt, Joe	20%	30%
Condon, Jim	40%	40%
Constantikes, Kim	100%	100%
Creager, Ray	60%	60%
Marganian, Paul	70%	70%
McCullough, Randy	65%	60%
Mello, Melinda	25%	20%
Nelson, J.D.	50%	50%
Parker, Dave	10%	40%
Prestage, Richard	45%	40%
Radcliff, Bill	0%	40%
Ray, Jason	55%	50%
Schwab, Fred	25%	25%
Shelton, Amy	45%	45%
Shelton, John	0%	40%
Wells, Don	40%	40%
Totals:	6.55	7.80

Table 1: PTCS Project staff current and anticipated available effort

3 Development Approach

As discussed in PTCS/SN/1 we see PTCS development divided into a number of themes, including:

- System Design (HFOS, PCS, EMS, and so on)
- Engineering Development (e.g. installation of temperature sensors on antenna structure)
- Critical Experiments and characterization (e.g. "half-power tracking" pointing performance)
- Short-term astronomical improvements (e.g. adjusted antenna FEM coefficients)

This, combined with the realities of the seasonal antenna access and observing regimes has lead us to propose a series of six month development cycles, with specific development goals for each cycle, and project reviews at the end of each cycle.

In parallel to the six-month development cycle, we have divided the project into a number of work packages, each with a specific team lead. The initial task for each package is to produce a "Project Charter", which defines the specific goals the work group, summarizes the issues to be addressed, and defines a work breakdown structure which results in specific, monthly targets and deliverables. To date, this approach has only been applied to the Active Surface Improvements and Engineering Measurement System work packages, but we intend to expand this to the remainder.

As has been noted many times, the current PTCS project has inherited numerous sub-systems in various stages of development. Therefore the current work packages span the range from completely new activities to refurbishing existing capabilities that are already in use. As the project progresses, some of the existing work packages will be completed, and new ones identified.

4 Current Project Work Packages

The efforts of the project team have been divided into a number of different work packages. The current work packages are as follows:

> System Design; Antenna Characterization; Engineering Measurement System; Laser Rangefinders; Active Surface, Antenna Instrumentation, Structural Health Monitoring, Project Management and Documentation

Each work package has a single team lead, responsible for coordinating the work and reporting back to the wider group on a monthly basis. Each work package either has a Project Charter already associated with it, or one will be developed in the coming months. As the system design develops, new work packages will be required, and these will be developed. The next work package to be defined in detail will be antenna characterization.

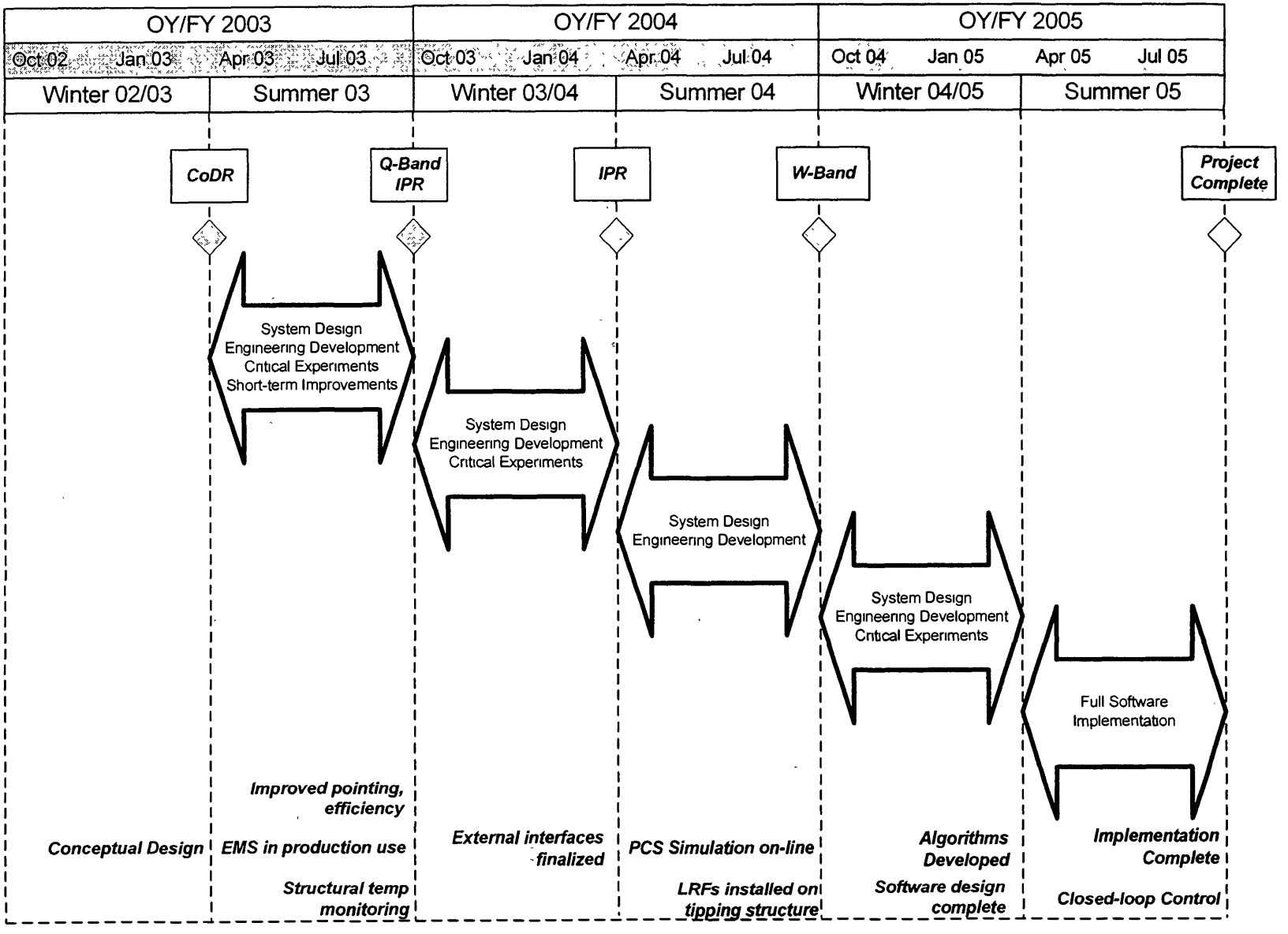
5 Project Schedule

The high-level project schedule is shown in Table 2, and in schematic outline in Figure 1. We have identified milestones for astronomical capability, and a series of Interim Progress Reviews as shown. A more detailed Gantt Chart for the project is given in Appendix A.

Date	Activity/Milestone
Q1, 2003	**Milestone:** Conceptual Design Review
Phase I: Q-band Capability **Q1, 2003 – Q3, 2003**	**Primary goals:** Implemented Temperature Compensation of Structure. Refined Gravitational compensation of structure. EMS providing data. EMS producing/exploring algorithms. **Secondary goals:** Structural Health Monitoring in production use. Elaborated (but not final) system design. **Q3, 2003: Milestone**: Ready for 50GHz Observing **Q3, 2003: Milestone:** In-Progress Review
Phase II: W-Band Feasibility **Q3, 2003 – Q1, 2004**	**Primary goals:** Production 50GHz science through winter 03/ 04. Demonstrate feasibility of W-band observing through critical experiments. **Secondary goal:** PTCS External Interfaces finalized. **Q1, 2004: Milestone:** In-Progress Review
Phase III : Initial W-Band Capability Development **Q1,2004 – Q3, 2004**	**Primary Goals**: 115GHz science capability available under benign conditions (no closed-loop control). Framework PCS/PMS interfaces in place. Laser Rangefinders installed on tipping sctructure. **Secondary Goal:** PCS simulation on-line. **Q3, 2004: Milestone:** Ready for limited 115GHz observing
Phase IV: W-band Capability Refinement **Q3, 2004 – Q1, 2005**	**Primary Goals:** Production 115GHz Science through winter 04/05. Iterative development of complete PCS/PMS. **Q1, 2005: Milestone:** Initial PTCS Development complete
Phase V: System Refinement **Q1, 2005 – Q3, 2005**	**Primary Goals:** algorithm enhancement to extend operating environment. Algorithm enhancement to extend capabilities (e.g tertiary chopper; frequency coverage). **Q3, 2005: Milestone:** Separate PTCS development complete.

Table 2: Major activities and milestones for the PTCS Project

PTCS Development Schedule



6 Project Budget

The nominal budget for 2002/2003, together with the proposed budget requests for 2003/2004 and 2004/2005 are show in Table 3.

PTCS 2002/2003 Budget		
Nominal Allocation		$60,000.00
EMS Development		
new instrumentation computer		$1,200 00
Wit development licence		$2,600.00
3rd wit seat (not devel)		$2,000.00
Matlab for sim, maint		$4,000.00
		$9,800.00
Antenna Instrumentation		
DT50 + software		$1,895.00
Control/status for QD (1x DT50)		$1,500.00
VS6		$435.00
Struct Temp. $450*25 nodes +6*1700 concentrators		$21,450.00
QD Hardware (access door)		$500.00
		$25,780.00
Rangefinder Covers Control System		**$20,000.00**
Travel Expenses (Review, Visitors)		**$5,000.00**
	Total:	**$60,580.00**

PTCS 2003/2004 Budget		
Additional Antenna Instrumentation		$15,000.00
Additional Software Licences/Modelling Tools		$10,000.00
Installation of LRFs on tipping structure		$50,000.00
Travel/Consultants/Contingency		$25,000.00
	Total:	**$100,000.00**

PTCS 2004/2005 Budget		
LRF laser diode retrofit 20 @ $1k per inst.		$20,000.00
Prototype beam split/PSD rangefinder upgrade		$15,000.00
Travel/Consultants/Contingency		$25,000.00
	Total:	**$60,000.00**

Table 3: PTCS Project Budget

7 Anticipated Risk and Risk Mitigation

The PTCS is an extremely challenging project for two separate reasons; it is both technically difficult and managerially difficult (highly cross-disciplinary). The whole project approach has been designed to mitigate these challenges:

- Perform critical experiments early to demonstrate feasibility.
- Build prototypes to demonstrate feasibility/develop functionality.
- Provide incremental improvements to capability as early as possible.
- Design system to be modular, flexible and extensible.

In addition, we benefit from the fact that the difficulty of providing 3mm operation depends critically on environmental conditions. Thus, although we might fail to deliver the full potential hoped for, it might still be possible for 3mm observations to take place under a more limited range of conditions. Although a detailed risk assessment has not been performed, we have made some attempt to identify the more likely causes of risk, and identify potential responses.

Technical Risks

- The Precision Telescope Control System is too complicated. Modularize and develop incrementally.
- The Precision Control System is unstable/inadequate. Simulate in advance.
- The Precision Measurement System doesn't provide the required performance. Prototype with Engineering Measurement System.
- The Laser Rangefinder accuracy is not adequate. Under intensive investigation; characterize with Engineering Measurement System.
- The Laser Rangefinder availability is inadequate. MTBF will be explored with EMS. Explore alternative geometries. Design system to degrade gracefully in absence of units.

Project Management Risks

- Most of the project staff are associated with the project at less than 50% of their time. Perform careful staff effort accounting, and keep track of trends. Attempt to ensure a few key individuals from each division are associated >50% of their time.
- The project is more complex and cross-functional than traditional for NRAO Green Bank. This has been one of the main reasons for lack of progress in the last two years. Apply formal project management procedures; both within PTCS and across GB development program.
- The project team has no members from the mechanical engineering or operations division. Ensure that the support requirements from these divisions are clearly detailed and agreed in advance.
- The project is subject to seasonal deadlines, requiring strict adherence to schedule. Descope rather than allow schedule to slip.
- The available staff skills mix is weak in two important areas: controls and structural engineering. Attempt to leverage staff at other sites (including lobbying for new hires); use external reviews and potentially consultants if affordable.

Organizational Risks

- Long-term development is always considered second in priority to operational emergencies. Attempt to ensure critical PTCS staff are not required for emergency response.

- Pressure may build for other GB projects to be raised in priority compared to the PTCS project. The most likely problem is for software group effort; either due to the ease-of-use project, or an exciting new instrumentation project. Mitigate by diligent planning of software group requirements; implementation of Software Development Division (SDD) Project Office which will ensure clear statement of priorities; ensure consequences of lack of SDD effort are always well known.

- GBT AZ track problems may swamp PTCS project. *In particular, this is a serious potential problem for both the metrology group and mechanical divisions; we have had almost no access to metrology group effort in the last two months.* Attempt to back-fill metrology group with other electronics division members. Contract out mechanical work, to other sites or commercially, at expense of project schedule and/or budget.

- GBT AZ track problems may limit antenna characterization/access to antenna. Mitigate with careful planning, and ensuring we are high priority.

External Risks

- Higher-level NRAO budget might drop, or resources are shifted to other priorities (track repair costs, ALMA, EVLA). Response to this will have to be formulated at a higher level.

8 List of acronyms

EMS Engineering Measurement System

HFOS High Frequency Observing System

LRF Laser Rangefinder

PCS Precision Control System

PMS Precision Measurement System

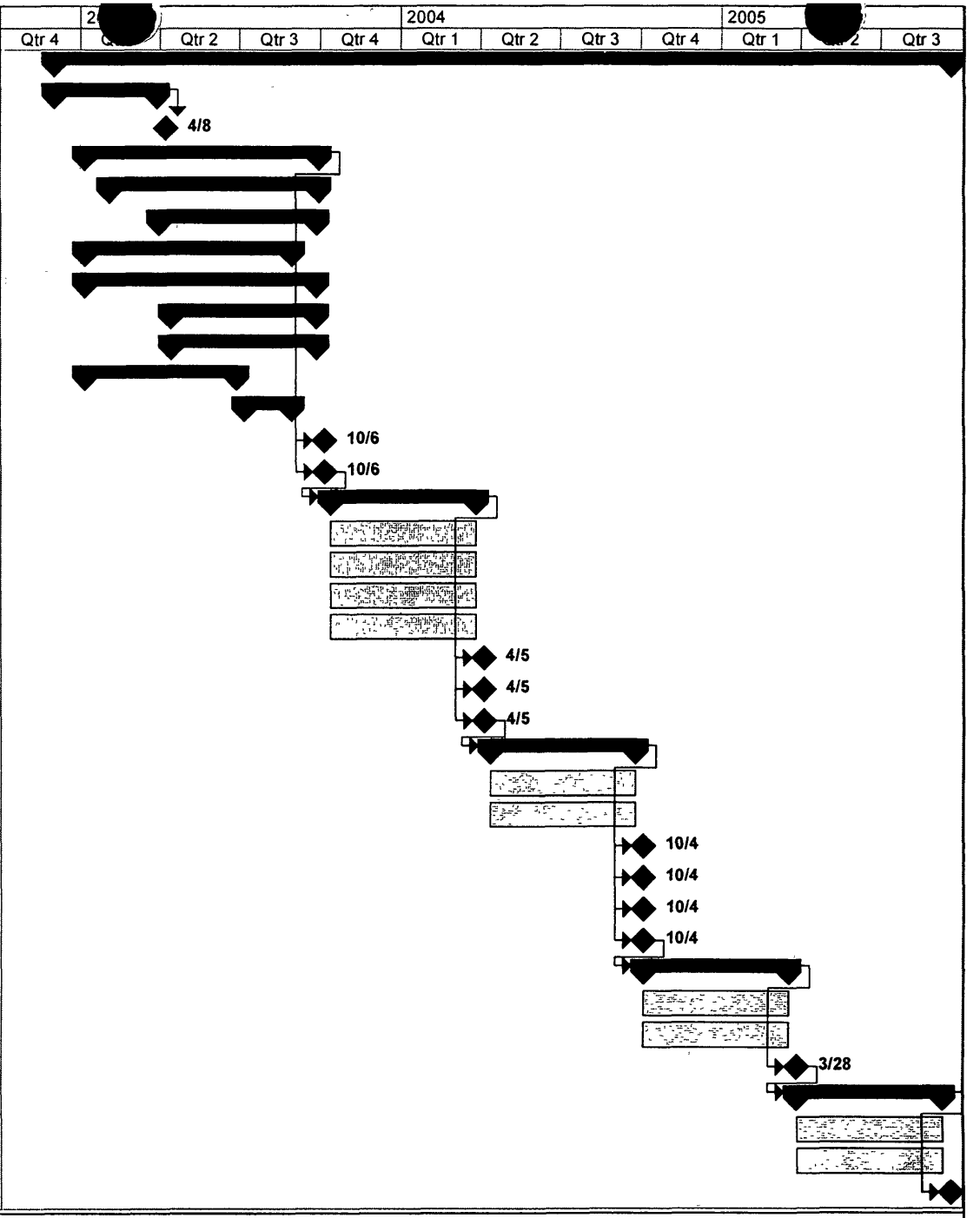
PTCS Precision Telescope Control System

A. Appendix – Detailed Gantt charts

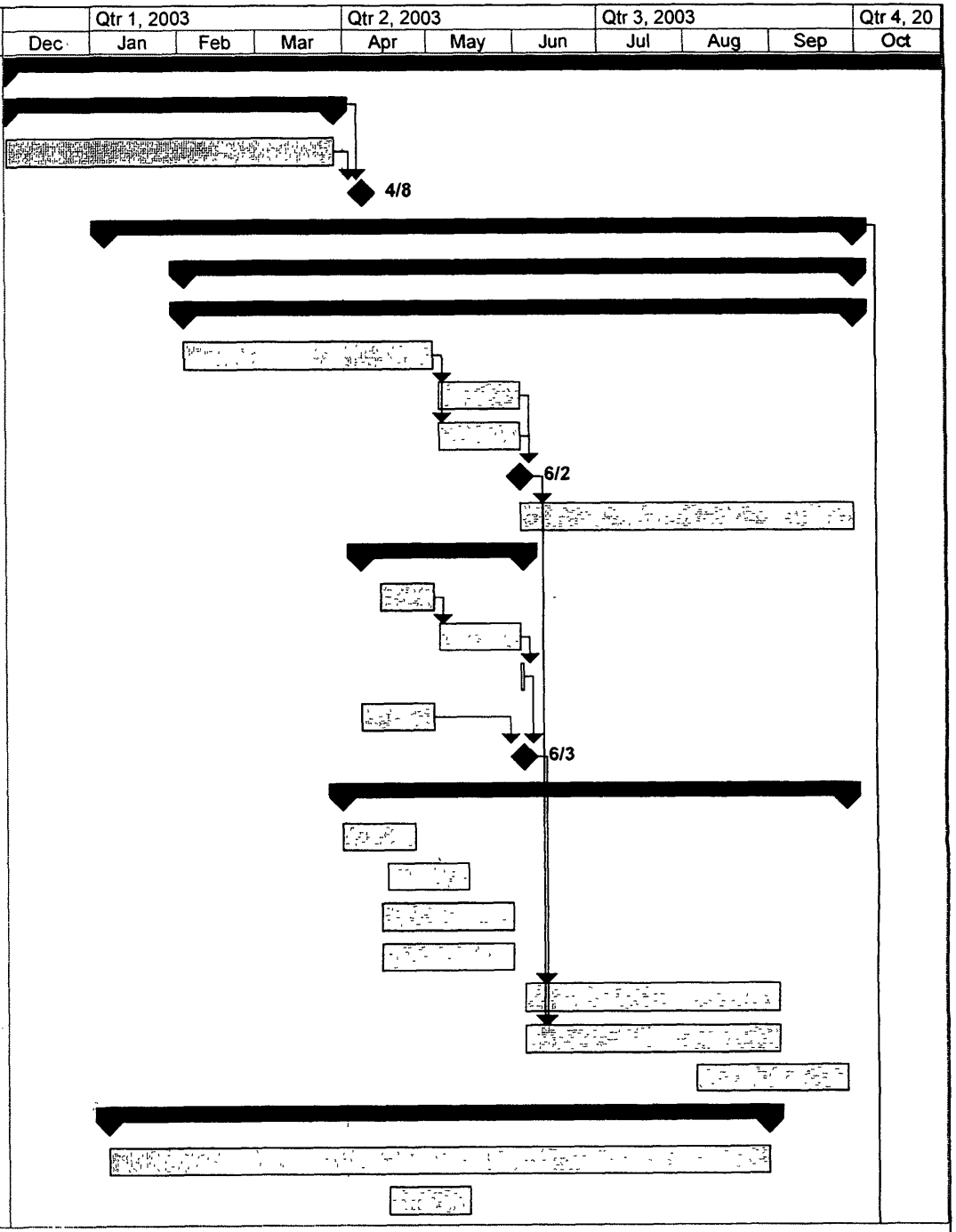
Figure 1. Rolled-up Gantt chart for entire project.

Figure 2. Detailed Gantt chart through October 2003.

ID	Task Name
1	**PTCS Project**
2	**PTCS Phase 0 - Project Initiation**
4	**Conceptual Design Review**
5	**PTCS Phase I - Q-band Capabilty**
6	**Antenna Instrumentation**
19	**Antenna Characterization**
27	**Active Surface Improvements**
31	**Engineering Measurement System**
45	**Algorithm Development**
48	**System Design**
50	**Structural Health Monitoring**
53	**Antenna Control Software Upgrades**
57	**In-Progress Review**
58	**Ready for Q-band Observing**
59	**PTCS Phase II - W-band Feasibility**
60	Q-band Science
61	Cntical Experiments
62	System Design
63	Engineenng Development
64	**W-band Feasibility Demonstrated**
65	**PTCS External Interfaces Finalized**
66	**In-Progress Review - feasibility of design**
67	**PTCS Phase III - Initial W-band Capability Development**
68	System Design
69	Engineering Development
70	**Rangefinders on Tipping Structure**
71	**Framework PCS/PMS interfaces in place**
72	**PCS Simulation on-line**
73	**Limited W-band observing capability**
74	**PTCS Phase IV - W-band Capability Refinement**
75	**W-band science in benign conditions**
76	Full PTCS Implementation
77	**Initial PTCS Development Complete**
78	**PTCS Phase V - System Refinement**
79	Algorithm Enhancement to extend operating conditions
80	Algorithm Enhancement to extend capability
81	Separate PTCS Development Complete



ID	Task Name
1	**PTCS Project**
2	**PTCS Phase 0 - Project Initiation**
3	Initial Project Work
4	**Conceptual Design Review**
5	**PTCS Phase I - Q-band Capabilty**
6	**Antenna Instrumentation**
7	**Temp Sensors**
8	Prototype
9	Feed-arm installation
10	M&C/CLEO Interface
11	Initial Capability
12	Complete Installation
13	**Quadrant Detector**
14	Performance Enhancements
15	Calibration
16	Installation
17	M&C/CLEO Interface
18	QD available for production use
19	**Antenna Characterization**
20	OOF Beam Map Technique Development
21	Traditional Holography Commissioning
22	Gravity only pointing model refinements
23	Gravity only focus tracking refinements
24	Temperature dependent focus-tracking upgrade
25	Temperature dependent pointing upgrade
26	Surface Figure Improvements
27	**Active Surface Improvements**
28	AS Charter improvements
29	Command Zernike offsets



ID	Task Name
30	"Tweak" FEM parameters
31	**Engineering Measurement System**
32	Basic Functionality
33	Trilateration Capability
34	Structural characterization algorithms
35	LRF characterization algorithms
36	LRF in-situ calibration/systematic effects
37	Measure linear structure parameters
38	Truss solution algorithms
39	**Laser Rangefinder Hardware/Software**
40	LRF Covers
41	LRF Maintenance/Refurbishment
42	RFI Mitigation
43	Autocollimation/Remote ZRG Software
44	Primary Rim Retros
45	**Algorithm Development**
46	Simple PCS Optical Model
47	Improved upstream pointing/ efficiency calculations
48	**System Design**
49	Elaborate System Design
50	**Structural Health Monitoring**
51	Complete Initial Development
52	Production System
53	**Antenna Control Software Upgrades**
54	Improved pointing model
55	Improved focus-tracking model
56	Improved position reporting
57	**In-Progress Review**
58	**Ready for Q-band Observing**