



# CHARA TECHNICAL REPORT

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## OPLE Cart: Schedule for Delivery from JPL

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### 1. INTRODUCTION AND GENERAL INFORMATION

The CHARA Array will employ five 1-m size, alt-azimuth style telescopes at a site on Mount Wilson in southern California. The telescopes will be housed separately and operated remotely from a central laboratory. Light from each telescope will be directed by subsequent flat mirrors through vacuum pipes to additional optics and instrumentation at the central laboratory.

This document describes the remaining tasks that need to be completed in order to take delivery of the OPLE cart control system, software and hardware from JPL. Tasks have been broken down into the following areas:

1. Overall Schedule.
2. Cart Hardware.
3. Optics.
4. Metrology.
5. Software.
6. Rails.
7. Documentation.
8. Future Expansion.

Each will be briefly discussed and the remaining tasks listed, along with the person responsible for completion and a deadline date. Both GSU and JPL personnel will be included.

### 2. OVERALL SCHEDULE

Our aim is to take delivery of the control electronics racks, user interface computer and at least one, but preferably two, functioning carts by the 15th of May 1998. Currently one completed cart is being used at JPL in the RICST test-bed and the components for a second cart are on Mount Wilson. The remaining three carts will be assembled and integrated by

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GSU personnel. The operation of the system with five carts needs to be demonstrated in simulation before completion of the contract, and with the real hardware when all five carts have been installed. This final test will need to involve both JPL and GSU staff and is due to be completed before 31 July 1998.

In all places below where a test is mentioned a successful test means that a cart will have full functionality including all commands listed in the GSU Delay Line Programmer's Guide section 3.2. Simultaneous testing means the same functionality with multiple carts running. We will have to agree upon a specific testing method(s), which will include tests such as having some carts track while others slew, all five carts tracking and so on. Also included in the acceptance tests will be a maximum rms tracking error of  $\leq 10\text{nm}$ . Brad(?) and Theo should discuss this in the near future. If a cart fails to pass these tests JPL and GSU personnel will diagnose the problem together to determine where the problem lies. Responsibility for fixing any such problem will lie with the party with the initial responsibility of constructing the subsystem in question. For example, if the problem lies with the software it will be debugged by JPL staff, while if the problem lies in the assembly or wiring work of GSU staff, GSU will fix the problem.

On the weekend of the 25th and 26th of April 1998 CHARA is holding a workshop on Mt. Wilson involving all CHARA Personnel. Charles Hopper and Laszlo Sturmann will stay for the first four days of the following week in order to work on the OPLE systems, Charles at JPL and Laszlo on the mountain. By the end of that 'work-fest' week, the 1st of May, we will have two completed carts and enough rail here on the mountain to test them.

During a meeting with Mike Shao on the 10th of April it was agreed that we would go about the final phase of the OPLE cart delivery as follows:

1. GSU will deliver the parts for the second cart, including electronics, to JPL.
2. This cart will be assembled and wired by JPL and GSU personnel.
3. Cart #2 will be tested in the RICST test-bed by JPL and any wiring errors fixed with both JPL and GSU personnel in attendance.
4. Cart #1 will be delivered to the CHARA site on Mt. Wilson by JPL and installed on the rails.
5. The electronics rack, metrology system, and Sparc-Station interface computer, complete with all software, will be delivered to the CHARA site by JPL.
6. Cart #1 and the control system will be tested on the mountain by JPL and GSU personnel.
7. Cart #2 will be delivered, installed and tested for simultaneous operation with cart #1 by JPL.
8. GSU will take responsibility for assembly, wiring and installation of the final three carts.
9. All five carts will be tested together on Mount Wilson with both JPL and GSU staff in attendance.
10. We celebrate.

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### 3. HARDWARE

During the period of 27th to 30th of April, GSU head machinist, Charles Hopper, will spend time at JPL wiring up cart #2 with the assistance of JPL personnel (Dean Palmer?). Note that the racks are to be wired up by JPL, GSU involvement will only be in the wiring of the cables on the carts themselves.

During our last visit, when this cart was assembled, little or no time was allocated for Dean, forcing him to find time between other responsibilities, and Charles was left to work mostly on his own (and using his own Leatherman tool). It is essential that adequate time be set aside for Dean and that he have no other commitments during this week so that he will be available to work with Charles. Similar concerns exist with other JPL staff.

Parts for the remaining three carts will be completed by the end of May and Charles and Bob Cadman will take responsibility for their assembly and wiring. For this task they will need to borrow the alignment jig from JPL, probably during the month of June.

Nils Turner will be responsible for completing the secondary assemblies for the carts within the same time frame.

Once cart #2 has been assembled and tested, cart #1 can be delivered and installed on Mount Wilson. It remains unclear to me if the RICST team still require one of the GSU carts for their test-bed. If so, it should be possible for cart #2 to remain at JPL until we install and test the remaining carts on the mountain. If not, cart #2 can be delivered and installed at the same time as cart #1.

The target date for having the electronics and two carts delivered and ready for installation on Mount Wilson is the 15th of May. These carts should be operational by the end of May.

### 4. OPTICS

The contractor for the primary optics is now over a year behind schedule, although he promises delivery of the first mirror in June. The test mirror now in cart #1 will have to be moved over to cart #2 for the time being. This will allow GSU personnel (Laszlo Sturmman and/or Theo) to work through the alignment procedure with JPL staff. Again, it will be important for someone at JPL to be available for this (Kent?). Hopefully, this alignment can occur on Thursday the 30th of April, allowing time to test the system on Friday, although it may be necessary for this to slip into the following week.

As for the remaining carts, it may be possible for the mirrors being purchased for the acquisition system to be used as test mirrors. Laszlo will look into this (see TR32 for the mirror specification), and a decision should be made by the 1st of May. If the first primary is indeed delivered in June it can be used in cart #1 for tests.

If both of these options fail, at least a second test mirror (and perhaps more) will have to be purchased in order to test multiple cart functionality of the system.

### 5. METROLOGY

At least one metrology system needs to be ready for tests at JPL by the beginning of the week of the 27th of April, so that it can be used in conjunction with carts #1 and #2 in

the test-bed. The laser head table, control electronics and remaining optical systems will be delivered with carts one and two on the 15th of May.

During the work-fest week of 27th April – 1st May, Gerard and Theo will spend some time together to transfer the necessary knowledge for metrology installation and alignment. This will include agreeing on fiber lengths, and a baseline design for the mounting plate of jigs required for placement of these optical systems on the appropriate optical tables on the mountain. Theo, in cooperation with Charles, will work on having at least one of these jigs ready for tests by the end of May. A temporary jig will be required for any earlier tests and enough materials exist on the mountain for it's construction.

## 6. SOFTWARE

From GSU's point of view, five important tasks remain before we can take delivery of the control software. These are: (1) having our VxWorks license and complete software suite installed on the GSU Sparc Station; (2) final specification and implementation of the interface between the OPLE system and the GSU fringe-tracker; (3) testing of the system on the mountain with multiple carts; (4) future expansion issues; and (5) training of GSU staff members.

GSU has purchased a VxWorks license which will be delivered to JPL, who will then install it on the Sparc-Station. Theo will take responsibility for getting the appropriate materials to JPL, which hopefully should only consist of a 'magic number', and can therefore be done by phone. With VxWorks on the machine, the remaining source code and software can be installed on the computer. It is important that it is possible to recompile the entire software suite and run the control system on this machine alone. During the work-fest week Theo will spend time with the appropriate JPL staff (Brad or Phil?) to ensure that this is possible, and that he knows how it's done. This may also have to be a part of the training schedule discussed below. A backup copy of the entire software set on CDROM should also be made available. When GSU takes delivery of this machine it will include all the original Solaris installation disks and manuals.

While we have had some discussions concerning communication between the GSU fringe-tracker and the OPLE control systems these issues need to be resolved. Theo will spend time with Brad (Beth?) nailing this down during the work-fest week at the end of April. This system should be implemented and tested in the test-bed before we take delivery. The interface definition will also include resolving the issue of timing signals between the OPLE controller and the rest of the Array control system.

The entire system should be installed on the mountain by late May, including two carts. The simultaneous operation of these two carts needs to be demonstrated by the end of May or early June. This will be done by both JPL and GSU staff (Brad? & Theo), including the fringe-tracker interface. The operation of all five, and perhaps more, carts will not be possible until the remaining carts have been assembled, aligned and wired, and so will not be possible until July. It is my understanding that operation of five carts will have been tested in simulation by JPL before the delivery date of the 15th May. Barring a miracle, some JPL staff time will be required in July to debug multi-cart operation. It may also be necessary for Mark to spend some time on servo tuning. This should be done in conjunction with Theo so any future tweaking of the servo parameters can be done by GSU. Theo and Mark should spend some time discussing these issues during the work-fest week.

Brad and Theo need to discuss the issue of possible future debugs/upgrades of the software

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system. It is highly unlikely that the system will be entirely bug free, even after initial testing on the mountain. Some JPL staff time will be required to aid in the necessary debugs. It is absolutely certain that work on the OPLE cart software system will continue after GSU takes delivery. Terms for possible upgrades should be discussed in advance so that we will have no surprises or disagreements in the future.

Finally, Brad and Theo also need to discuss how much time will be required for training of two GSU personnel (Theo and Nils) on the software system, and when this will be done. Once again, this can be done during the work-fest week.

## 7. RAILS

All five rails and a subset of the drive rails have been installed in the OPLE/BCL building. GSU will align enough rails for testing two carts during the work-fest week (Laszlo and Steve). Only the first 20 feet or so of rails will be required for initial tests, although it is to be hoped that more can be accomplished in this time. Enough of the three remaining rails system will be aligned and ready for cart installation by the end of June. GSU will take responsibility for the final alignment of the entire length of the rail systems.

Since the metrology system has not, to my knowledge, been tested over the full length of the CHARA delay-lines final tests and acceptance will have to be delayed until one full section of rail has been completed. The priorities will therefore be:

- Alignment of a small section of two rail systems by the 15th of May for initial tests.
- Complete alignment of one rail system for tests by the end of June.
- Final alignment of the remaining rail systems.

There are two outstanding issues on rail systems. The first of these are the cable trays and Laszlo and/or Steve will work on these. Small sections of trays will be required for the first two carts, while the rest can be delayed until final testing in July. Secondly, we will need some mechanical stops at the end of the rails to ensure that there is no possibility of the carts ever running off the rails. Charles is to design and construct these to be completed for the final tests in July.

## 8. DOCUMENTATION

Obviously, complete documentation is part of the deliverable. This will include the documents already available on the online document system, all circuit diagrams, all documentation related to electronics purchased and install in the rack and on the carts, metrology documentation, documentation regarding the fringe-tracker/delay-line interface and timing issues, servo tuning parameters and methods, and all documentation related to the Sparc-Station. I noticed that the circuit diagrams I received in hard copy making up Appendix A of the Optical Delay Line Electronics Document are not included in the online version. Preferably these diagrams can be added to the MS-Word file (Phil?).

Besides the user documentation supplied as part of the package, it will be invaluable to have access to the more detailed technical documentation of the control system. This will be essential when it comes time to add more carts to the system. Brad (Phil?) and Theo will discuss these issues during the work-fest week.

Any future debugs or upgrades will need to be reflected in the documentation. This will include a list of all commercial components required in order to expand the system for more than five carts.

During my last visit to JPL, Kent promised to produce a small write up concerning optical alignment of the carts, this should be ready for delivery during the work-fest week.

## 9. FUTURE ADDITIONAL CARTS

Eventually more than five (and up to eight) delay-lines will be required at the CHARA Array. It will be essential that enough internal knowledge of the software and hardware exist within GSU for this to be possible.

It is my understanding that the rack, as currently configured, is capable of driving more than five carts as follows:

- There are up to 12 counters available for metrology but it is configured for only six. We need to know how to configure the software for more than six. Theo is to talk to Gerard concerning this during the work-fest week.
- The metrology laser head table is capable of driving all eight systems.
- There are six channels available on the PZT A/D converter, motor controller and voice coil boards. Again we need to ensure we know how to reconfigure the system to use these extra channels and how to increase the number of channels should we get funding for the seventh and eighth telescopes.
- We will need to purchase more high voltage amplifiers for any future PZT drivers.

We need to nail down a list of exactly what is required in order to add carts to the system, which can again be done during the work-fest week. My current understanding is:

- There are two specialized cards made by JPL: the laser card and the timing card. These can be rebuilt at any time in the future.
- There are many commercial boards in the system. GSU will need to at least purchase spares of these components before they are discontinued by the manufacturers.

At our last meeting JPL agreed to keep in mind provision for up to keep eight carts during final assembly of the electronics rack. The possibility of GSU buying into the required purchases of future racks for other RICST customers should be investigated in the hope that this can result in cost savings for all parties.

## 10. SUMMARY OF TASKS FOR WORK-FEST WEEK

We need to get a lot done during the week of 27 April – 1 May. I have listed these below with people's names and suggested times.

- Startup meeting (Theo, Charles, Mike(?) and Brad(?)). [Mon AM]
- Brad(?) and Theo to agree on acceptance test procedures. [Mon AM]

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- Charles and Dean to complete assembly and wire up cart #2. [Mon-Wed]
- Nils is to have a secondary assembly ready for cart #2 [By Mon]
- Laszlo to determine if the acquisition mirrors will be suitable of cart testing. [By Mon]
- Gerard and Theo to discuss status, documentation, mounting jig, installation and alignment of the metrology system. [Mon PM]
- GSU VxWorks license installed on GSU Sparc-Station. [Mon PM]
- Source code and control software installed on GSU Sparc-Station. [Mon PM]
- Fringe-tracker/delay-line interface needs and timing issues to be nailed down (Brad? and Theo). [Tue AM]
- Terms of possible upgrades discussed (Brad? and Theo). [Tue AM]
- Training requirements and schedule agreed upon (Brad? and Theo). [Tue PM]
- Mark and Theo to discuss servo tuning and parameters. [Tue PM]
- Discussion of access to more technical documentation (Brad? and Theo). [Wed AM]
- Documentation for optical alignment to be finished (Kent?). [Wed AM]
- Hardware and software required for additional carts to be written up (Phil?). [Wed]
- Discussions concerning possible pooling of purchases for future systems and GSU spares. [Wed AM]
- Laszlo and Steve to align at least part of two optical rails, including the cable trays. [Mon-Thur]
- The test mirror in cart #1 to be moved to cart #2 and aligned (Kent? and Laszlo/Theo). [Thur AM]
- Initial testing of cart #2 in the test-bed to be done and any wiring errors corrected. [Thur-Fri]
- Wrap-up meeting (Theo, Mike(?) and Brad(?)) [Fri]
- Dinner and drinks?