# LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
# - LIGO -

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***LIGO Detector Subsystem Review Report***

## PRELIMINARY DESIGN REVIEW
## Control & Data System (CDS):
## Control and Monitoring (CM)

*Title*

Review Board: K. Blackburn, M. Coles, D. Coyne (Chair),
A. Lazzarini, Dale Ouimette, M. Zucker

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*This is an internal working note*
*of the LIGO Project*

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# REPORT ON THE PRELIMINARY DESIGN REVIEW OF THE CONTROL & DATA SYSTEM: CONTROL & MONITORING SUBSYSTEM (CDS-CM)

## Signature Page

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Interferometer Sensing and Control
Task Leader

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Interferometer Sensing and Control
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# REPORT ON THE DESIGN REQUIREMENTS REVIEW OF THE CONTROL & DATA SYSTEM: CONTROL & MONITORING SUBSYSTEM (CDS-CM)

## PARTICIPANTS

### Presenters

R. Bork and J. Heefner

### Review Board

K. Blackburn, M. Coles, D. Coyne (chair), A. Lazzarini, D. Ouimette, M. Zucker

### Other attendees

R. Abbott, J. Klohoker, S. Liu, A. Lazzarini, B. Lucas, D. Shoemaker, B. Ware, S. Whitcomb, W. Young,

## DOCUMENTS PRESENTED AND DISCUSSED

### Reviewed Preliminary Design Documents:

1. R. Bork, CDS Control and Monitoring Preliminary Design, T960142-00-C (PD), 8/20/96.
2. R. Abbott and J. Heefner, Vacuum Feedthrough and Cabling Design Requirements Document, T950095-01-C, 9/9/96.
3. R. Abbott and J. Heefner, Vacuum Feedthrough and Cabling Preliminary Design, T960155-00-C, 9/13/96.

Note: The CDS Control and Monitoring Design Requirements Document (DRD) did not require revision for the PDR; the latest version of the DRD is:

R. Bork, CDS Control and Monitoring Design Requirements Document, T950054-02-C, 8/5/96.

### Viewgraph Handouts

4. CDS Control and Monitoring Preliminary Design Review, LIGO-G960204-00-C, 9/19/96.
5. Vacuum Cabling and Feedthroughs (Preliminary Design Review), LIGO-G960xxx-00-C, 9/19/96.

## REVIEW BOARD REPORT

The review was conducted on 19 Sep 1996, in the Caltech LIGO Engineering Conference Room and (via conference phone) in the MIT LIGO Conference Room. The presenters summarized the design requirements and conceptual design, illustrated by the viewgraph handouts, and the Board discussed the documents, the presentation, and the Requests for Action.

The review scope covered the Control and Monitoring subsystem of the Control and Data System (sometimes referred to as "Global CDS") and the Vacuum Feedthrough and Cabling design. The Review Board charge (as specified in documents LIGO-L960657 and LIGO-L960683) and its response are as follows:

## Control and Monitoring:

1. **Charge:** Determine if the requirements identified in the (DRR level) Design Requirements Document (DRD) are still applicable and complete based upon the current (evolved) state of the LIGO system
   **Response:** The requirements as presented (and incorporated into the revised DRD) are applicable and complete, except for questions to be resolved through some of the Action Items below. It is possible that the response to some of the Action Items will change or add to the Requirements, but the Review Board believes that they are substantially correct.
2. **Charge:** Evaluate the preliminary design to determine if:
   a) the design is consistent with the requirements
      - key performance & functional requirements are substantiated with supporting design calculations, e.g. does the system have the capacity (flops, throughput, storage) to meet requirements
      - all requirements are addressed

   b) the design is sufficiently developed to proceed with a Final Design
      - layout/assembly drawings are adequate
      - basic components have been identified/selected
      - a software architecture has been defined and the required functional/object modules have been defined (though not coded); in particular is the graphical user interface design complete and acceptable
      - are paths for system expansion and adaptability apparent
      - fabrication/assembly procedures, processes and fixtures are identified and defined (to preliminary level)
      - self-test and diagnostics been incorporated to an adequate degree

   c) have interfaces been defined and are they consistent with the mating subsystems
   d) final design plans/tasks and schedule (including prototype test activities) are appropriate, and technical risks are identified and addressed in planning

   **Response:** The design is responsive to the requirements and complete to a PDR level, except for questions to be resolved through some of the Action Items below. Final design plans are acceptable.

3. **Charge:** Determine if actions from the DRR have been adequately addressed.
   **Response:** Key action items from the DRR have been addressed adequately; signoffs for the DRR action items are pending and will be handled in separate memorandum

## Vacuum Feedthrough and Cabling:

1. **Charge:** Determine if the requirements identified in the Design Requirements Document (DRD) are applicable and complete.

**Response:** The requirements are applicable and complete, except for questions to be resolved through some of the Action Items below. It is possible that the response to some of the Action Items will change or add to the Requirements, but the Review Board believes that they are substantially correct.

2. **Charge:** Evaluate the preliminary design to determine if:
   a) the design is consistent with the requirements
   b) the design is sufficiently developed to proceed with a Final Design
   c) interfaces have been identified or defined (and are they consistent with the mating subsystems)
   d) final design plans/tasks and schedule (including prototype test activities) are appropriate, and technical risks are identified and addressed in planning

   **Response:** The preliminary design, as modified per the enclosed review board's recommendations and action items, is consistent with the requirements (except for questions to be resolved through some of the Action Items below) and ready to proceed to final design.

3. **Charge:** Determine if actions from the DRR have been adequately addressed.
   **Response:** The DRR action items have been addressed satisfactorily with the exception of one which is re-addressed in action item 13 below; signoffs for the DRR action items are pending and will be handled in separate memorandum.

# RECOMMENDED ACTION ITEMS

## Control and Monitoring:

1. **Concern**: The sparcstation 20" monitors may produce electromagnetic radiation that exceeds the electromagnetic limits imposed on CDS equipment in the EMC plan.
   **Action**: Determine the electromagnetic emission from the monitors and, if required, consider LCD displays as an alternative.

2. **Concern**: Hardware reset of a processor using network monitoring watchdog should be explicitly required.
   **Action**: Add to the design requirements.

3. **Concern**: The proposed control room layout does not appear to use the available floor space judiciously.
   **Action**: Revise the layout to conserve available floor space for operators, while allowing reasonable access for cabling and maintenance and repair activities (in the rear of the operator consoles/stations).

4. **Concern**: No mention of spares and support equipment.
   **Action**: Present a recommended spares list and a support equipment list (OTDR, buss analyzers, etc.) at the FDR.

5. **Concern**: Lack of C-code design/writing standards or style guidance.
   **Action**: Develop a C-code specification which (among other requirements) calls for ANSII standard code.

6. **Concern**: There is a need to define an exception handler to trap, log and recover from error conditions.
   **Action**: Define the exception handler.

7. **Concern**: The requirements for instrument & diagnostics data analysis and display capabilities are incomplete and as a consequence the proposed approach of using DaDisp or similar analysis/display package cannot be evaluated.
   **Action**: The science and operations groups should define analysis and display needs for the CDS-CM system. Based on these requirements, the science and operations groups should recommend/evaluate one or more packages (DaDisp, PVWave, Matlab, etc.) to be accessible within the CDS-CM framework. The need for any glue software (e.g. for import/export of data) should be identified.

8. **Concern**: The latency of an ATM network may not support high rate servo loops.
   **Action**: Evaluate (through test if necessary) the expected latency on the ATM network and

determine if this will support LSC and ASC requirements.

9. **Concern**: The network bandwidth requirement table (as summarized on slide 14 of the view-graph presentation) does not include the suspension (SUS) subsystem.
   **Action**: Verify that the requirements include all interferometer subsystems.

10. **Concern**: The open interface nature of the proposed CDS networks appear to allow "unauthorized" code to read/write to real-time control systems; this risk should be precluded.
    **Action**: Define a means of controlling access to the CDS network by uncontrolled/unreviewed software (e.g. developed by scientists involved in interferometer debug).

11. **Concern**: Only 50% spare capacity (18 fibers total) are proposed for the fiber-optic cabling along the interferometer arms.
    **Action**: Consider increasing the initial spare capacity to 24 or 36 fibers.

## Vacuum Feedthroughs and Cabling:

12. **Concern**: The vacuum cabling design is predicated upon acceptable vacuum contamination testing for the kapton material; we are proceeding into final design without assurance of an acceptable material.
    **Action**: Accelerate vacuum compatibility testing.

13. **Concern**: The response to DRR action #22 on serviceability missed the point; the issue is serviceability of the vacuum envelope (feedthrough leak, conflat leak, etc.) and not serviceability of the wiring.
    **Action**: Incorporate an internal connector(s) so that the electrical feedthrough port can be removed without requiring either in situ desoldering or disassembly of the cabling from the seismic stack.

14. **Concern**: Proposed "female" connector design is unconventional.
    **Action**: In addition to proceeding with planned prototype tests, consult with connector socket manufacturer on the proposed design and their experience in similar applications, if necessary perform mechanical dimensioning/tolerancing and stress analysis to assess manufacturability and reliability. If reliability or manufacturability appear questionable, consider alternatives such as the Hughes gold-dot connectors.

15. **Concern**: Applicability of the vacuum feedthrough and cabling design was not shown to be explicitly suitable for any interferometer subsystem.
    **Action**: Demonstrate through design calculations that current, resistance, shielding, capacitance, pin count, etc. meet the suspension (SUS) system requirements (at the PDR level) and indicate the number of units required by SUS.

16. **Concern**: Proposed testing of cable "crackling" in the 40m interferometer may be difficult

and perhaps not the best testbed for such a test.
**Action**: Develop test criteria and a test plan.

17. **Concern**: The vibration isolation requirements on the vacuum cabling (stiffness and density), derived from the seismic isolation DRD, were stated, but not shown to be met.
**Action**: Show by analysis or test that these requirements will be met by the design.

18. **Concern**: Installation method(s), procedures, limitations, design and interface implications were only briefly addressed.
**Action**: Address the installation of the vacuum feedthrough and cabling for each application.