DCC

# CALIFORNIA INSTITUTE OF TECHNOLOGY

Laser Interferometer Gravitational Wave Observatory (LIGO) Project


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Refer to: LIGO-[redacted] T960036-00-E
Date: 6 March 96

Subject: **Comments on PSI's Proposed Electrical Conduit Stub-Up Plan for the LVEA and VEAs**

Reference: PSI Drawing V049-3-124, Rev. P2, 3/5/96 (2 sheets)
PSI Drawing V049-3-305, Rev. P1, 2/29/96 (1 sheet)
PSI Drawing V049-3-505, Rev. P1, 2/29/96 (1 sheet)
and clarifications in Telecon notes V049-TN-29, 3/4/96

In response to an action item from the contractor review meeting[1], PSI has proposed an alternative electrical conduit distribution plan from what was documented and proposed in the VE-CC ICD (E950088-03-E, 1/10/96). PSI's proposed electrical conduit stub-up plan for the corner station LVEA is documented in PSI drawing V049-3-124 (2/2/9/96). PSI has also proposed an electrical conduit distribution plan for the VEAs of the mid- and end-stations (drawings V049-3-305 and V049-3-505 respectively).

Introduction

The AC electrical power distribution plan in the ICD was developed before PSI had developed all of their requirements. The basic approach was to allocate approximately the correct number of circuits and KVA and distribute them to a relatively few locations. The number of locations was minimized since we did not know precisely where the VE would ultimately be located and we believed that the VE locations might be subject to frequent change until late in the CC design effort. Consequently, we envisioned a few locations from which the electrical power would then be routed in above floor conduit or cable trays to the appropriate termination locations.

PSI has basically finalized the locations of their equipment and proposes to stub-up the electrical power essentially at the VE and (for the most part) eliminate the need for above floor electrical power routing. The stub-up locations in the LVEA and VEA floors would be capped flush by the CC with a pull tape/cord installed, but no wire. The benefit to LIGO is less clutter and obstruction around the chambers and under the beam tubes.

A comparison of the ICD and the PSI proposed conduit stub-up locations is provided in the comments below. The comments are separated into general comments and then specific comments for

1. F. Asiri, Contractor Meeting Minutes - Feb 13, 1996, LIGO-C96, 2/14/96.

the Corner Station LVEA, Mid-Station VEA and End-Station VEA. While PSI's proposal has significantly more stub-up locations called out, the number of additional circuits is not very large. In addition, (as discussed at the last PSI monthly review) PSI will provide the electrical wire, receptacles and termination boxes and install the wires from the electrical panels (to be provided on the walls of the LVEA and VEA) to the termination receptacles at the stub-up locations. This reduction in material and labor costs (compared to the ICD proposed electrical distribution plan) tend to offset the additional embedded conduit costs. The total cost increase of the PSI plan compared to the ICD plan accounting only for the additional conduit (i.e., not compensating for the reduction in wiring/termination costs on the CC side, and the modest increase in branch circuits) is $32,700. I recommend that we proceed with the PSI proposed electrical distribution plan, ammended by the comments below.

General

1) VE Interface Conduit has been added. This was discussed (in concept) at the contractors meeting for the mid- and end-stations. This conduit interconnects the isolated vacuum volumes across the separation between the ends of the manifold arms of the two interferometers. The alternative is to run cabling along the vacuum manifolds to the vertex region and back out again. The VE interface conduit makes sense and should be added.

2) At the time that the ICD was prepared, the voltage requirements of the VE were preliminary. PSI's electrical distribution plan has the correct required voltages. The ICD (Table 3-1) needs to be corrected to reflect the appropriate voltages for vacuum equipment.

3) No cryopump re-generation power has been called out in the PSI plan. The ICD has allocated circuits which stub-up near the vacuum manifold near the cryopumps. The intent is for PSI to route this power above the floor, through the wall (along the cryo piping path) and out to the LN2 tank area. This should be added to PSI's plan.

4) PSI has used the designation VEAC_n to refer to circuit breaker panel locations along the wall of the LVEA and VEAs. This designation is used in the ICD to denote the stub-up locations. Since the CB panel number and locations are not critical, they were not specifically called out in the ICD. I suggest that PSI revise it's notation to be consistent with the ICD.

Corner Station LVEA

1) PSI had added conduit for routing a data highway (PSI drawing V049-3-124, rev. P1); this was subsequently removed (V049-TN-29 and PSI drawing V049-3-124, rev. P2). This amounts to daisy-chaining conduit runs from one stub-up location to another along the beam tube arms. This was never envisioned in the ICD, nor was it discussed at the contractor meeting. Burying signal cable can of course be done, but if there is ample space above the floor (and there is), it would allow for better access and the ability to more readily add cabling if future VE control requirements dictated the need for additional signal routing for control or monitoring.

2) The number of stub-up locations has increased from 15 to 40. This is largely driven by the clean room requirement to allow for two cleanrooms at each chamber without undue interference and running electrical power either across the perimeter "aisle" (as was the intent in the ICD) or through an adjacent cleanroom. In retrospect, the allocation of combined Bake-out/Clean Room

electrical outlet locations is inadequate in the ICD and PSI's proposed distribution is reasonable. Consequently, the number of circuits allocated to the Bake-out heater carts or Clean Rooms (dual purpose) increases from the 13 called out in the ICD to 30.

3) The number of circuits has increased from 61 to 73 (20%, including the addition of 2 circuits for cryopump regeneration to PSI's plan). This is also largely driven by the clean room requirement to allow for two cleanrooms at each chamber (as in #3).

4) The number of circuit breaker panels remains unchanged; the indicated circuit breaker panel locations (and number) on the walls of the LVEA and VEA are suggestions only. The CC can provide circuit breakers along the walls of the LVEA to feed the embedded conduit runs in the quantity and locations desired. I suggest that PSI eliminate the panel locations from their drawing until they are defined by the CC.

5) If a single conduit is run per circuit, then the estimated increase in embedded conduit number is 20% (61 vs 73) and the increase in length is 762 ft. or 43% (2529 ft. for PSI's proposed plan versus 1767 ft. per the ICD layout. If all circuits to a stub-up location can be run in the same (larger) conduit, then the increase in length would be 1098 ft. According to the "Means Electrical Cost Data 1994", the installed cost of 1-1/2" dia. conduit is $6.65/ft.. Consequently the additional cost of the conduit is approx. $7500 for the Hanford corner station. For the Livingston corner station, the estimated additional cost is $5400.

Mid-Station VEA

1) The number of stub-up locations has increased from 3 to 9. This is largely driven by routing power to each equipment item, rather than running above the floor from wall CB panels.

2) The number of circuits has decreased from 19 to 17 (including the addition of two cryopump regeneration circuits to PSI's plan)..

3) The number of circuit breaker panels remains unchanged; the indicated circuit breaker panel locations (and number) on the walls of the LVEA and VEA are suggestions only. The CC can provide circuit breakers along the walls of the LVEA to feed the embedded conduit runs in the quantity and locations desired. I suggest that PSI eliminate the panel locations from their drawing until they are defined by the CC.

5) The estimated increase in embedded conduit length is 500 ft. Using the "Means Electrical Cost Data 1994" the installed cost of $6.65/ft for 1-1/2" dia. conduit, the increased cost is $3300 per mid-station.

End-Station VEA

1) Generally the same comments for the mid-station apply to the end-station. The ICD has the mid-and end-stations electrical requirements the same (with the exception of one less gate valve). The reason is to readily allow for future expansion, associated with the allocated floor space for another BSC chamber in the end-stations. I suggest we install the same electrical capacity and embedded conduit in the end-station as the mid-station, as proposed in the ICD.

DCC:dcc

Attached:
(1) Spreadsheet print-outs from file ~coyne/icd/E950088_ICD_VE_CC/VE_conduit_req.exl (3 sheets)
The stub-up location designations in the spreadsheets are <interferometer number><X or Y to designate the arm><sequential number from most negative coordinate to most positive), e.g. 1X3
(2) PSI Drawing V049-3-124, Rev. P2, 3/5/96 (2 sheets)
(3) PSI Drawing V049-3-305, Rev. P1, 2/29/96 (1 sheet)
(4) PSI Drawing V049-3-505, Rev. P1, 2/29/96 (1 sheet)

cc:
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Chronological File
Document Control Center

## PSI PROPOSED ELECTRICAL STUB-UP LOCATIONS/NUMBER (per PSI Dwg V049-3-124, 2/29/96)

LVEA Corner Station

| Conduit Stub-up Designation | No. Circuits | No. Stub-Ups | BO/CR | 480/277 VAC Gate Valve | 480/277 VAC Roughing | 480/277 VAC General/Ion | 120 VAC Turbo | 120 VAC BO Controls | VE Interface | Data Hwy | Assoc. ICD E950088-03 AC Location(s) | Stub-Up Locations X (ft) | Stub-Up Locations Y (ft) | Panel Locations X (ft) | Panel Locations Y (ft) | Approx. Conduit Distance (ft) | ~ Total Conduit Distance (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1X1 | 1 | 1 | 1 | | | | | | | | VEAC_01,_07,_14 | -70.5 | 3.5 | -25.5 | -15 | 48.65 | 48.65 |
| 1X2 | 3 | 4 | 1 | | | 1 | | 1 | | 1 | VEAC_01,_07,_14 | -59.67 | 3.5 | -25.5 | -15 | 38.86 | 116.57 |
| 1X3 | 3 | 5 | 1 | | | 1 | | 1 | | 2 | VEAC_01,_07,_14 | -25.5 | 3.5 | -25.5 | -15 | 18.50 | 55.50 |
| 1X4 | 1 | 1 | 1 | | | | | | | | VEAC_01,_07,_14 | -16.5 | 3.5 | -25.5 | -15 | 20.57 | 20.57 |
| 1X5 | 2 | 4 | 1 | | | | | 1 | | 2 | VEAC_02,_08,_09 | 7 | -3.5 | 25 | -50.67 | 50.49 | 100.98 |
| 1X6 | 3 | 5 | 1 | 1 | | | | 1 | | 2 | VEAC_02,_08,_09 | 22.5 | -3.5 | 25 | -50.67 | 47.24 | 141.71 |
| 1X7 | 2 | 3 | 1 | | | | | 1 | | 1 | VEAC_05, _10,_15 | 39.25 | 3.5 | 92.75 | -15 | 56.61 | 113.22 |
| 1X8 | 2 | 2 | | | 1 | 1 | | | | | VEAC_05, _10,_15 | 58.25 | 3.5 | 92.75 | -15 | 39.15 | 78.29 |
| 1X9 | 1 | 1 | | | | | 1 | | | | VEAC_05, _10,_15 | 65.75 | 3.5 | 92.75 | -15 | 32.73 | 32.73 |
| 1X10 | 2 | 4 | 1 | | | | | 1 | | 2 | VEAC_05, _10,_15 | 92.75 | 3.5 | 92.75 | -15 | 18.50 | 37.00 |
| 1X11 | 0 | 3 | | | | | | | 3 | | VEAC_05, _10,_15 | 121.25 | 4.75 | 92.75 | -15 | 34.67 | 0.00 |
| 1X12 | 3 | 4 | 1 | | | | 1 | 1 | | 1 | VEAC_05, _10,_15 | 129.58 | 3.5 | 92.75 | -15 | 41.22 | 123.65 |
| 1X13 | 2 | 4 | 1 | | | 1 | | | 2 | | VEAC_05, _10,_15 | 147.17 | 3.5 | 92.75 | -15 | 57.48 | 114.96 |
| 1Y1 | 1 | 1 | 1 | | | | | | | | VEAC_02,_08,_09 | 3.5 | -70.5 | 25 | -50.67 | 29.25 | 29.25 |
| 1Y2 | 3 | 4 | 1 | | | 1 | | 1 | | 1 | VEAC_02,_08,_09 | 3.5 | -59.67 | 25 | -50.67 | 23.31 | 69.92 |
| 1Y3 | 1 | 1 | | | | | 1 | | | | VEAC_02,_08,_09 | 3.5 | -50.67 | 25 | -50.67 | 21.50 | 21.50 |
| 1Y4 | 1 | 1 | | | | | 1 | | | | VEAC_02,_08,_09 | 3.5 | -29.83 | 25 | -50.67 | 29.94 | 29.94 |
| 1Y5 | 3 | 5 | 1 | | | 1 | | 1 | | 2 | VEAC_02,_08,_09 | 3.5 | -25.5 | 25 | -50.67 | 33.10 | 99.31 |
| 1Y6 | 1 | 1 | 1 | | | | | | | | VEAC_02,_08,_09 | 3.5 | -16.5 | 25 | -50.67 | 40.37 | 40.37 |
| 1Y7 | 2 | 4 | 1 | | | | | 1 | | 2 | VEAC_01,_07,_14 | -3.5 | 8.17 | -25.5 | -15 | 31.95 | 63.90 |
| 1Y8 | 3 | 5 | 1 | 1 | | | | 1 | | 2 | VEAC_01,_07,_14 | -3.5 | 24.17 | -25.5 | -15 | 44.93 | 134.78 |
| 1Y9 | 2 | 3 | 1 | | | | | 1 | | 1 | VEAC_06, _13,_16 | 3.5 | 54.25 | -15 | 80.75 | 32.32 | 64.64 |
| 1Y10 | 2 | 2 | | | 1 | 1 | | | | | VEAC_06, _13,_16 | 3.5 | 73.25 | -15 | 80.75 | 19.96 | 39.92 |
| 1Y11 | 1 | 1 | | | | | 1 | | | | VEAC_06, _13,_16 | 3.5 | 80.75 | -15 | 80.75 | 18.50 | 18.50 |
| 1Y12 | 2 | 4 | 1 | | | | | 1 | | 2 | VEAC_06, _13,_16 | 3.5 | 107.75 | -15 | 80.75 | 32.73 | 65.46 |
| 1Y13 | 0 | 3 | | | | | | | 3 | | VEAC_06, _13,_16 | 4.75 | 136.25 | -15 | 80.75 | 58.91 | 0.00 |
| 1Y14 | 3 | 4 | 1 | | | | 1 | 1 | | 1 | VEAC_06, _13,_16 | 3.5 | 144.58 | -15 | 80.75 | 66.46 | 199.37 |
| 1Y15 | 2 | 4 | 1 | | | 1 | | | 2 | | VEAC_06, _13,_16 | 3.5 | 162.17 | -15 | 80.75 | 83.50 | 166.99 |
| 2X1 | 2 | 2 | | 1 | 1 | | | | | | VEAC_03,_11 | 25 | 33.75 | 45 | 57 | 30.67 | 61.34 |
| 2X2 | 2 | 4 | 1 | | | | | 1 | | 2 | VEAC_03,_11 | 38.08 | 26.75 | 57 | 25 | 19.00 | 38.00 |
| 2X3 | 1 | 1 | 1 | | | | | | | | VEAC_03,_11 | 47.25 | 26.75 | 57 | 25 | 9.91 | 9.91 |
| 2X4 | 2 | 4 | 1 | | | | | 1 | | 2 | VEAC_03,_11 | 57 | 26.75 | 57 | 25 | 1.75 | 3.50 |
| 2X5 | 2 | 3 | 1 | | | | | 1 | | 1 | VEAC_03,_11 | 89.5 | 26.75 | 57 | 25 | 32.55 | 65.09 |
| 2X6 | 1 | 2 | 1 | | | | | | 1 | | VEAC_03,_11 | 101.5 | 26.75 | 57 | 25 | 44.53 | 44.53 |
| 2Y1 | 2 | 2 | | 1 | | | 1 | | | | VEAC_04,_12 | 33.75 | 25 | 57 | 25 | 23.25 | 46.50 |
| 2Y2 | 2 | 4 | 1 | | | | | 1 | | 2 | VEAC_04,_12 | 26.75 | 38.08 | 45 | 57 | 26.29 | 52.57 |
| 2Y3 | 1 | 1 | 1 | | | | | | | | VEAC_04,_12 | 26.75 | 47.25 | 45 | 57 | 20.69 | 20.69 |
| 2Y4 | 2 | 4 | 1 | | | | | 1 | | 2 | VEAC_04,_12 | 26.75 | 57 | 45 | 57 | 18.25 | 36.50 |
| 2Y5 | 2 | 3 | 1 | | | | | 1 | | 1 | VEAC_04,_12 | 26.75 | 89.5 | 45 | 57 | 37.27 | 74.55 |
| 2Y6 | 1 | 2 | 1 | | | | | | 1 | | VEAC_04,_12 | 26.75 | 101.5 | 45 | 57 | 48.10 | 48.10 |
| | | | | | | | | | | | | | | Totals | | 1384 | 2529 |

(electrical power only)

3/5/96

1071 2028

# CORNER STATION

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PSI | | | | | | | | | | ③ | |
| ICD E950088-03 | V049-3-124 | No. | No. | | 480/277 VAC | | | | 120 VAC | | | |
| AC Locations | Stub-up Locations | Locations | Circuits | BO/CR | Gate Valve | Roughing | Cryo Regen | General/Ion | Turbo | BO Controls | VE Interface | Data Hwy |
| VEAC_01,_07,_14 | | 3 | 11 | 3 | 2 | 1 | | 4 | 1 | | | |
| | 1X1-1X4, 1Y7, 1Y8 | 6 | 13 | 6 | 1 | | | 2 | | 4 | | 7 |
| VEAC_02,_08,_09 | | 3 | 11 | 3 | 2 | 1 | | 4 | 1 | | | |
| | 1X5,1X6,1Y1-1Y6 | 8 | 15 | 6 | 1 | | | 2 | 2 | 4 | | 7 |
| VEAC_05,_15 | | 2 | 11 | 1 | 2 | | 1 | 6 | 1 | | | |
| | 1X7-1X13 | 7 | 11 | 4 | | 1 | | 2 | 2 | 2 | 5 | 4 |
| VEAC_06,13,16 | | 3 | 12 | 2 | 2 | | 1 | 6 | 1 | | | |
| | 1Y9-1Y15 | 7 | 12 | 4 | | 1 | | 2 | 2 | 3 | 5 | 4 |
| VEAC_03,_11 | | 2 | 8 | 2 | | 1 | | 4 | 1 | | | |
| | 2X1-2X6 | 6 | 10 | 5 | 1 | 1 | | | | 3 | 1 | 5 |
| VEAC_04,_12 | | 2 | 8 | 2 | | 1 | | 4 | 1 | | | |
| | 2Y1-2Y6 | 6 | 10 | 5 | 1 | | | | 1 | 3 | 1 | 5 |
| ICD E950088-03 Totals | | 15 | 61 | 13 | ① 8 | 4 | 2 | 28 | 6 | 0 | 0 | 0 |
| | PSI V049-3-124 Totals | 40 | 71 | 30 | 4 | 3 | ② 0 | 8 | 7 | 19 | 12 | 32 |
| | | | | | | | | | | | | |
| | | 2.6667 | 1.1639 | | | | | | | | | |

① Over-allocated gate value power due to uncertainty in desired power routing and possibility (at the time) of replacing the pneumatic valves with electric.

② Should be added to the PSI conduit stub-up plan.

③ Specific power allocation for Bake-Out Control (i.e. beyond "general use 120 VAC) was not carried in the ICD; should be revised.

| VE ELECTRICAL POWER LOCATIONS IN THE LVEA/Corner Station | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (per ICD E950088-03, 1/10/96) | | | | | | |
| | | | | | | Approx. | ~ Total |
| ICD | | Stub-Up Locations | | Panel Locations | | Conduit | Conduit |
| E950088-03 | No. | X | Y | X | Y | Distance | Distance |
| AC Locations | Circuits | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) |
| VEAC_01 | 9 | -30.5 | 3.5 | -25.5 | -15 | 19.16 | 172.47 |
| VEAC_02 | 9 | 3.5 | -30.5 | 25 | -50.67 | 29.48 | 265.32 |
| VEAC_03 | 7 | 57 | 26.75 | 57 | 25 | 1.75 | 12.25 |
| VEAC_04 | 7 | 26.75 | 57 | 45 | 57 | 18.25 | 127.75 |
| VEAC_05 | 9 | 129.58 | 3.5 | 92.75 | -15 | 41.22 | 370.94 |
| VEAC_06 | 9 | 3.5 | 144.58 | -15 | 80.75 | 66.46 | 598.11 |
| VEAC_07 | 1 | wall | | | | | |
| VEAC_08 | 1 | wall | | | | | |
| VEAC_09 | 1 | wall | | | | | |
| VEAC_10 | 1 | wall | | | | | |
| VEAC_11 | 1 | wall | | | | | |
| VEAC_12 | 1 | wall | | | | | |
| VEAC_13 | 1 | wall | | | | | |
| VEAC_14 | 1 | wall | | | | | |
| VEAC_15 | 2 | 138 | 4.75 | 92.75 | -15 | 49.37 | 98.74 |
| VEAC_16 | 2 | 4.75 | 138 | -15 | 80.75 | 60.56 | 121.12 |
| VEAC_17 | 16 | mech rm wall | | | | | |
| | | | | | | | |
| | | | | | Totals | 286 | 1767 |

## ELECTRICAL STUB-UP LOCATIONS/NUMBER IN THE MID-STATION

(per PSI Dwg V049-3-305, 2/29/96)

| | PSI | | | | 480/277 VAC | | | | 120 VAC | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ICD E950088-03 | V049-3-124 | No. | No. | | | | | | | | | |
| AC Locations | Stub-up Locati | Locations | Circuits | BO/CR | Gate Valve | Roughing | Cryo Regen | General/Ion | Turbo | BO Controls | VE Interface | Data Hwy |
| VEAC_01,_03 | | 2 | 10 | 1 | 2 | | 1 | 5 | 1 | | | |
| | X1-X5 | 5 | 9 | 2 | 2 | | | 1 | 2 | 2 | | |
| VEAC_02 | | 1 | 9 | 1 | 2 | | 1 | 4 | 1 | | | |
| | X6-X9 | 4 | 6 | 1 | 2 | | | 1 | 1 | 1 | 4 | |
| ICD E950088-03 | | 3 | 19 | 2 | 4 | 0 | 2 | 9 | 2 | 0 | 0 | 0 |
| | PSI V049-3-12 | 9 | 15 | 3 | 4 | 0 | 0 | 2 | 3 | 3 | 4 | 0 |
| | | | | | | | | | | | | |
| | | 3 | 0.789 | | | | | | | | | |

# PSI PROPOSED ELECTRICAL STUB-UP LOCATIONS/NUMBER IN THE MID-STATION

(per PSI Dwg V049-3-305, 2/29/96)

| Conduit | | | | | | | | | | | Assoc. ICD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stub-up | No. | No. | | 480/277 VAC | | | 120 VAC | | VE | Data | E950088-03 |
| Designation | Circuits | Stub-Ups | BO/CR | Gate Valve | Roughing | General/Ion | Turbo | BO Controls | Interface | Hwy | AC Location(s) |
| X1 | 1 | 1 | | 1 | | | | | | | VEAC_01,_03 |
| X2 | 1 | 1 | | 1 | | | | | | | VEAC_01,_03 |
| X3 | 4 | 4 | 1 | | | 1 | 1 | 1 | | | VEAC_01,_03 |
| X4 | 1 | 1 | | | | | 1 | | | | VEAC_01,_03 |
| X5 | 2 | 2 | 1 | | | | | 1 | | | VEAC_01,_03 |
| X6 | 1 | 1 | | 1 | | | | | | | VEAC_02 |
| X7 | 4 | 4 | 1 | | | 1 | 1 | 1 | | | VEAC_02 |
| X8 | 1 | 3 | | 1 | | | | | 2 | | VEAC_02 |
| X9 | 0 | 2 | | | | | | | 2 | | VEAC_02 |
| | | | | | | | | | | | |
| TOTALS | 15 | 19 | 3 | 4 | 0 | 2 | 3 | 3 | 4 | 0 | |