



**24th Aerospace Testing Seminar**

**On-Orbit Constraints Test - Performing  
Pre-Flight Tests with Flight Hardware,  
Astronauts and Ground Support  
Equipment to Assure On-Orbit Success**

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**National Aeronautics & Space Administration**

**Kennedy Space Center**



# Background

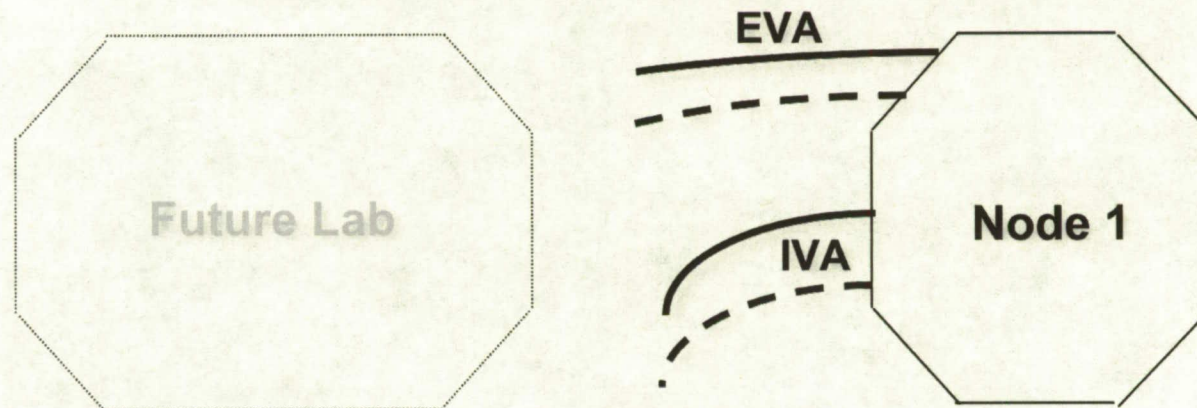


- **Astronauts were concerned about ISS Extra-Vehicular Activity (EVA) & Intra-Vehicular Activity (IVA) hardware integration on-orbit, “How do we verify hardware built and launched on different missions will connect together in orbit?”**
- **On-Orbit Constraints Test (OOCT) used during KSC ground processing on ISS Flight Hardware to assure EVA & IVA Hardware functions on-orbit. Performing “Dry-runs” of EVA & IVA hardware/operations before launch, OOCT’s included connecting cables, fluid umbilical & ducts that would test mating/demating, clocking, routing, etc. OOCT performed by Astronauts/rep with MOD support using Boeing Houston Procedure/Task leader with KSC NASA signature authority. OOCT is a physical check of interfaces, not a functional check.**

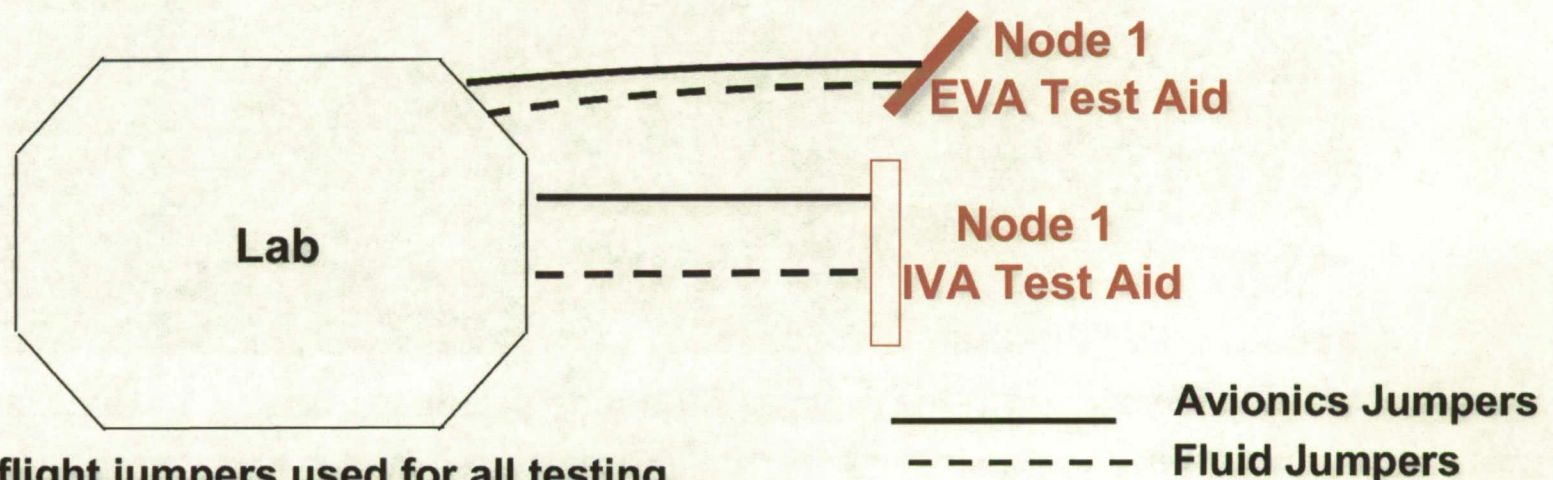


# ISS Fit Check and OOCT Concept

“Today” - Fit check future Lab flight jumpers to Node 1 flight Element



“X time in the future” - OOCT of Lab flight jumpers to Node 1 test aid  
(by default you get fit check to Lab, piggyback on testing so only connect to flight hardware one time)



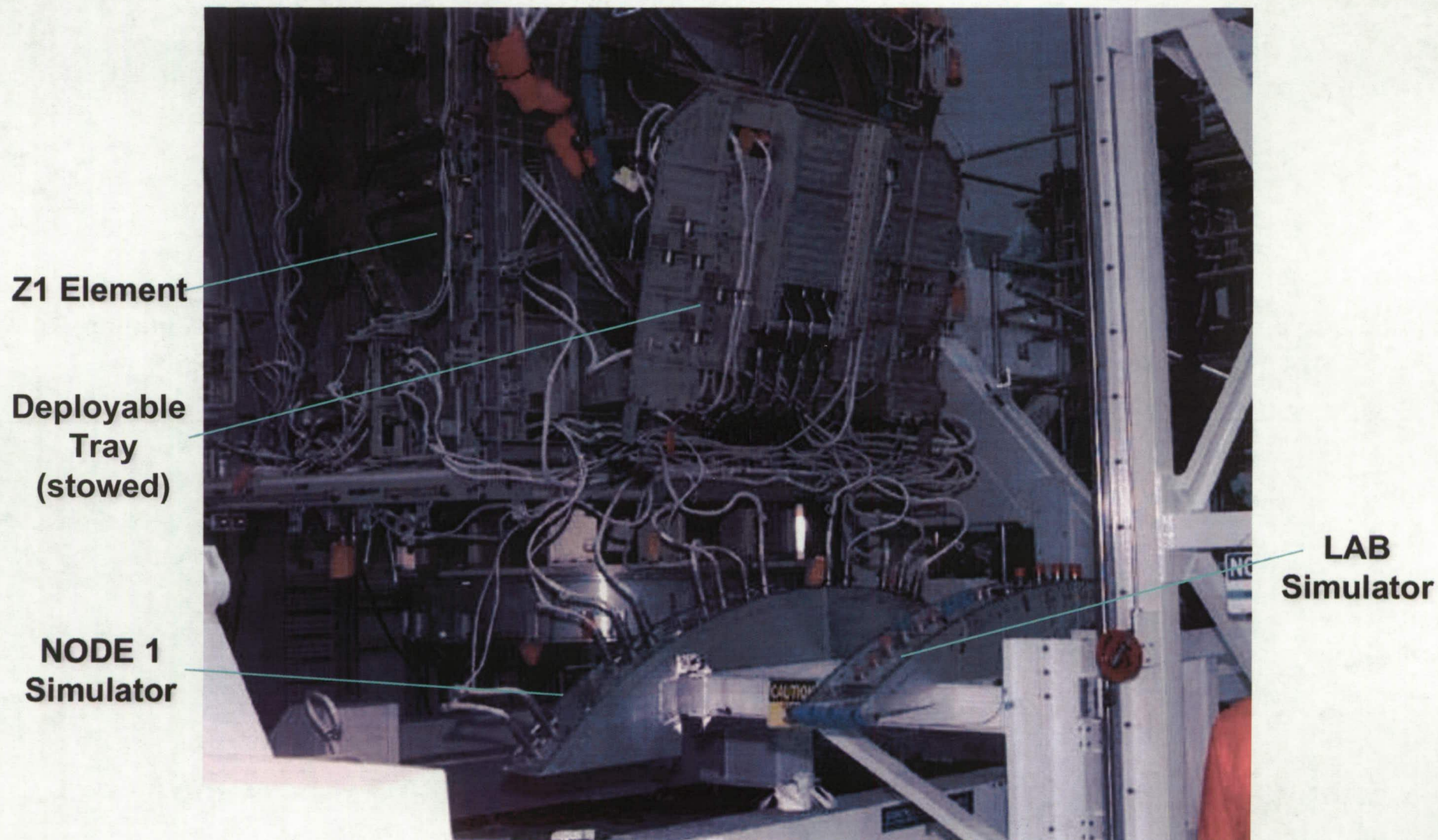
**Note: Same flight jumpers used for all testing**





# Z1/Node 1 & Z1/Lab EVA OOCT

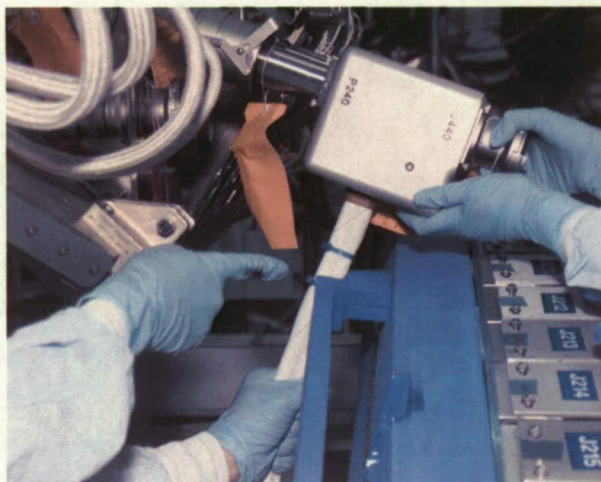
Actual Hardware - Space Station Processing Facility Highbay, Kennedy Space Center



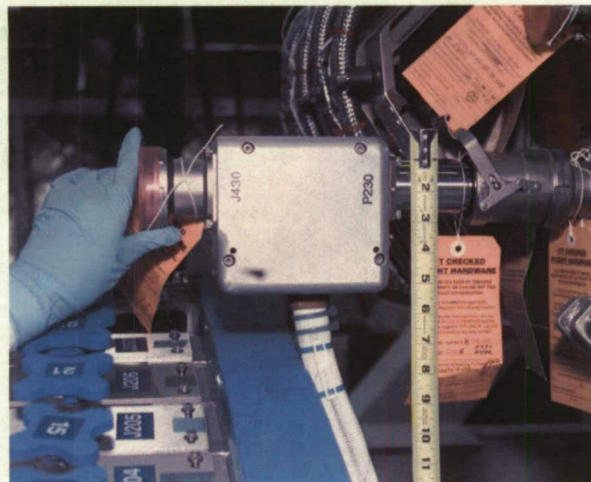
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# Many Problems Discovered during EVA Z1/Node 1 & Z1/Lab OOCT

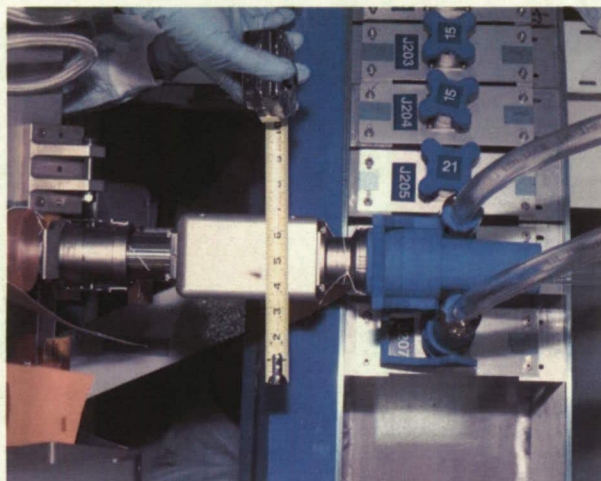


**Circuit Interrupt Device (CID) #5  
Interferes with handrail**

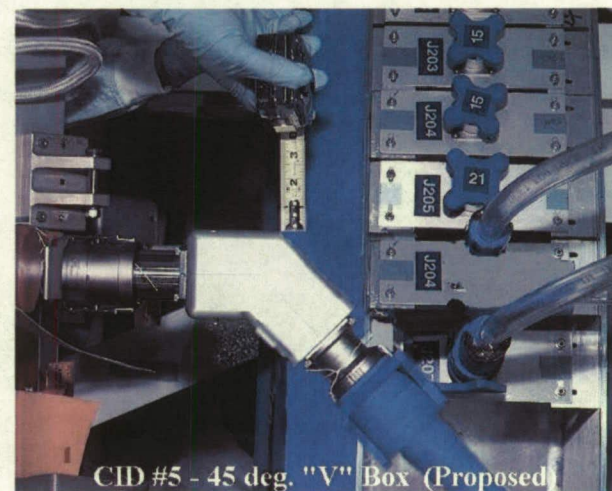


**Circuit Interrupt Device (CID) #6  
Interferes with hard structure**

*Note: Blue foam  
used to represent  
adjacent flight  
hardware*



**Circuit Interrupt Device (CID) #6  
Interferes with connectors**



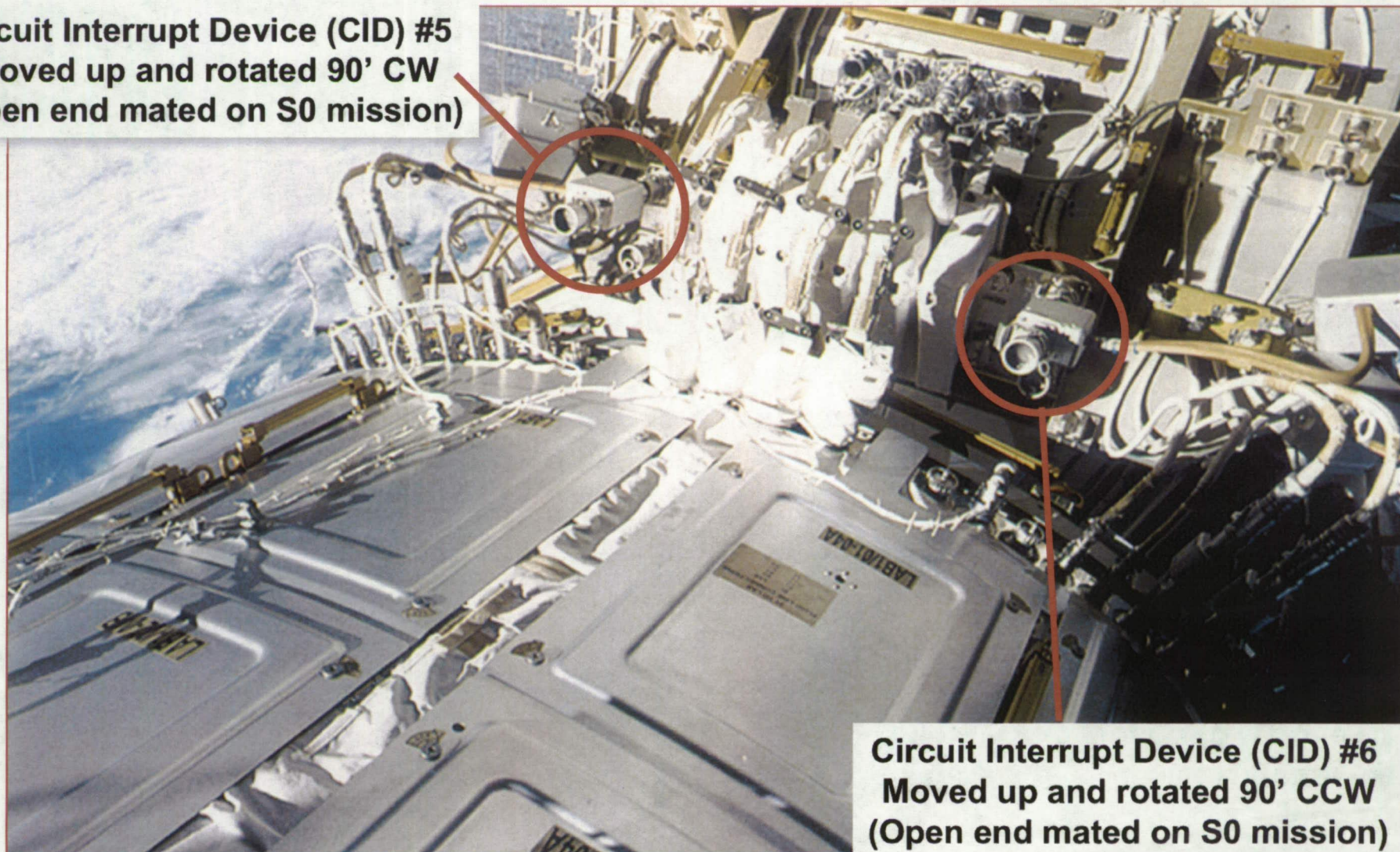
**Propose fix, modify Circuit Interrupt Device**





# Successful Z1/Node 1 & Z1/Lab On-Orbit

**Circuit Interrupt Device (CID) #5**  
Moved up and rotated 90° CW  
(Open end mated on S0 mission)



**Circuit Interrupt Device (CID) #6**  
Moved up and rotated 90° CCW  
(Open end mated on S0 mission)

***Note: This location was known as the “Rats Nest” do the fact that umbilical’s from Node 1, Z1, Lab and S0 Truss all came together in one congested area.***

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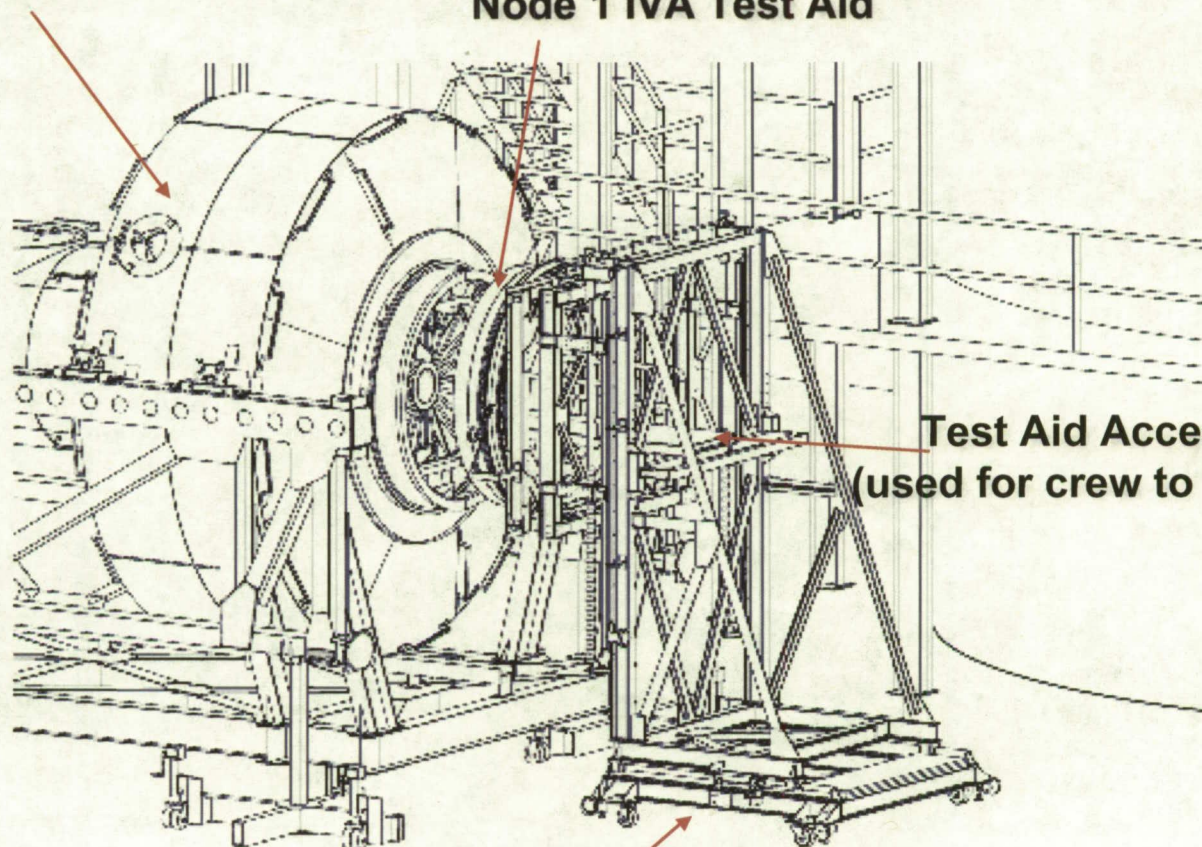




# Airlock to Node 1 Test Aid IVA OOCT

ISS Airlock Element in GSE stand

Node 1 IVA Test Aid



Test Aid Access Platform  
(used for crew to perform OOCT)

KSC SUPPORT EQUIPMENT - IPT

Test Aid Alignment Fixture





# Airlock to Node 1 Test Aid IVA OOCT

*Note: Blue foam used to represent CBM Hardware*

Electrical Connections

Fluid Fittings

Test Aid Access Platform  
(used for crew to perform OOCT)

## NODE 1 IVA Test Aid

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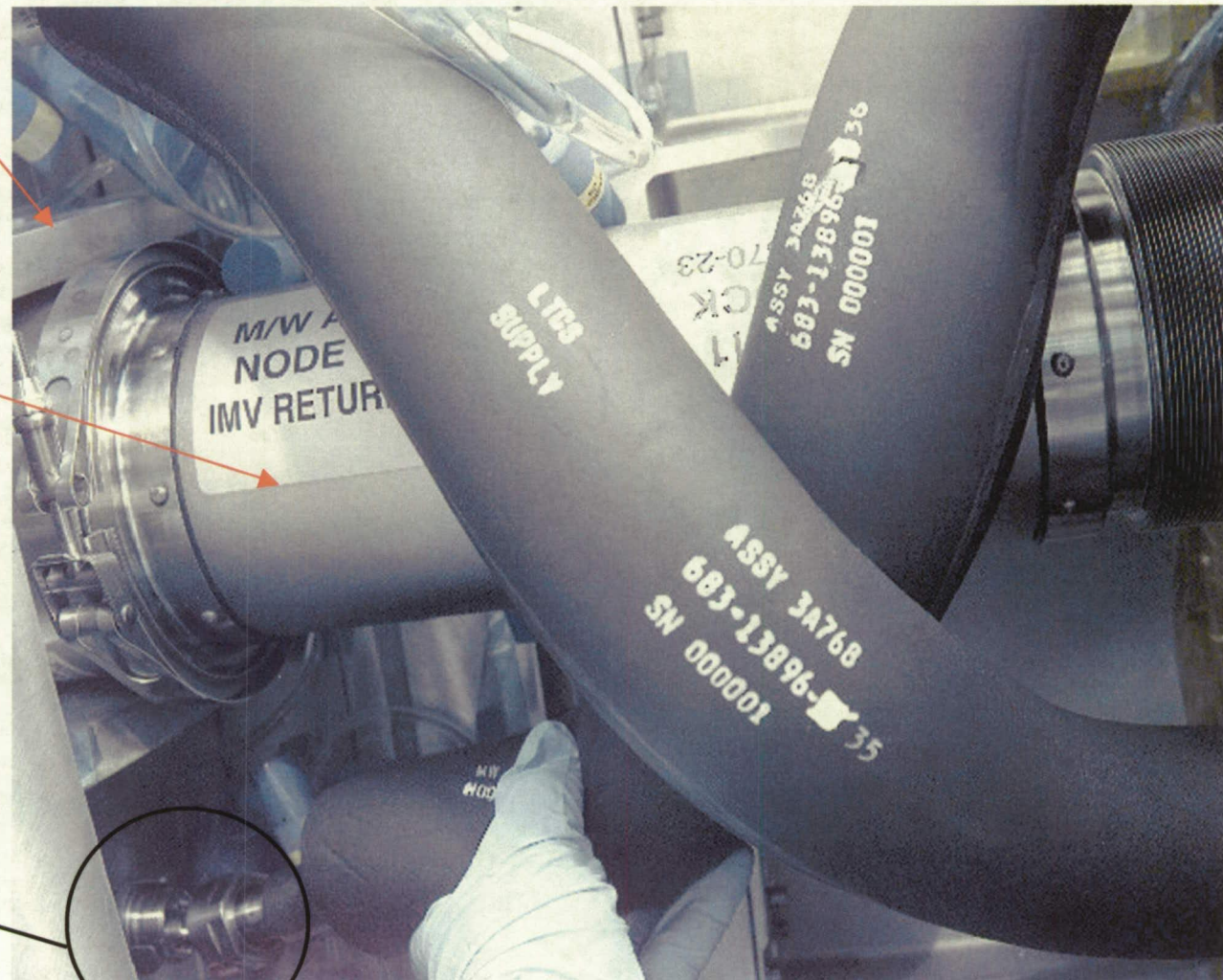
# Problem found during Airlock to NODE 1 Test Aid IVA OOCT



NODE 1  
Test Aid

IMV Duct

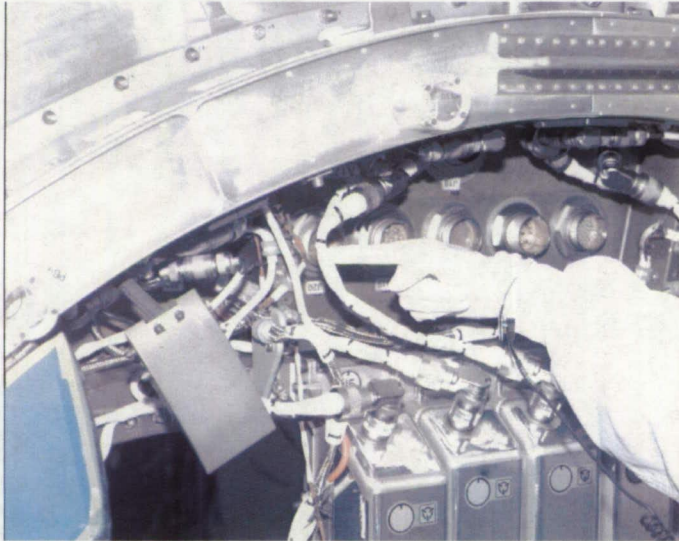
Fluid line  
is short



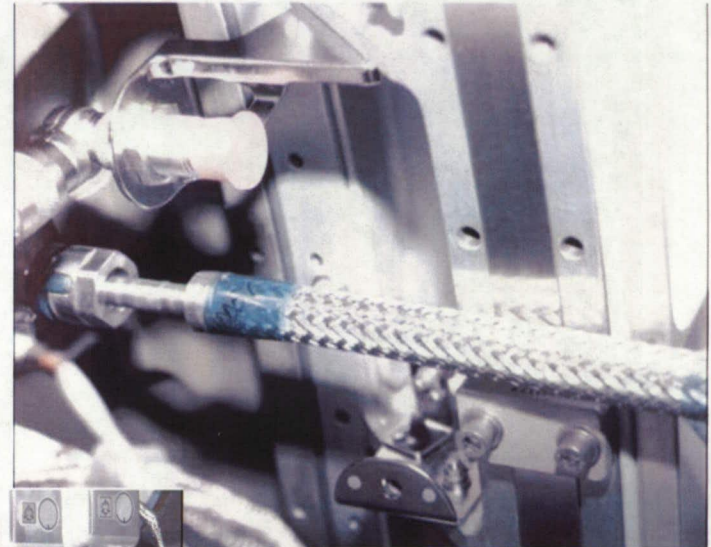
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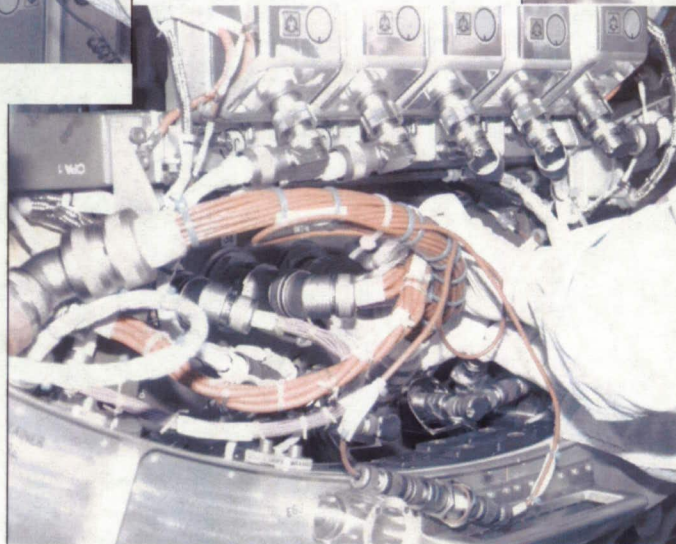
# Problems found during other IVA OOCT's



**Jumper interference  
with CBM cable**



**Jumper interference  
with CBM ring**



**Hand access problem**

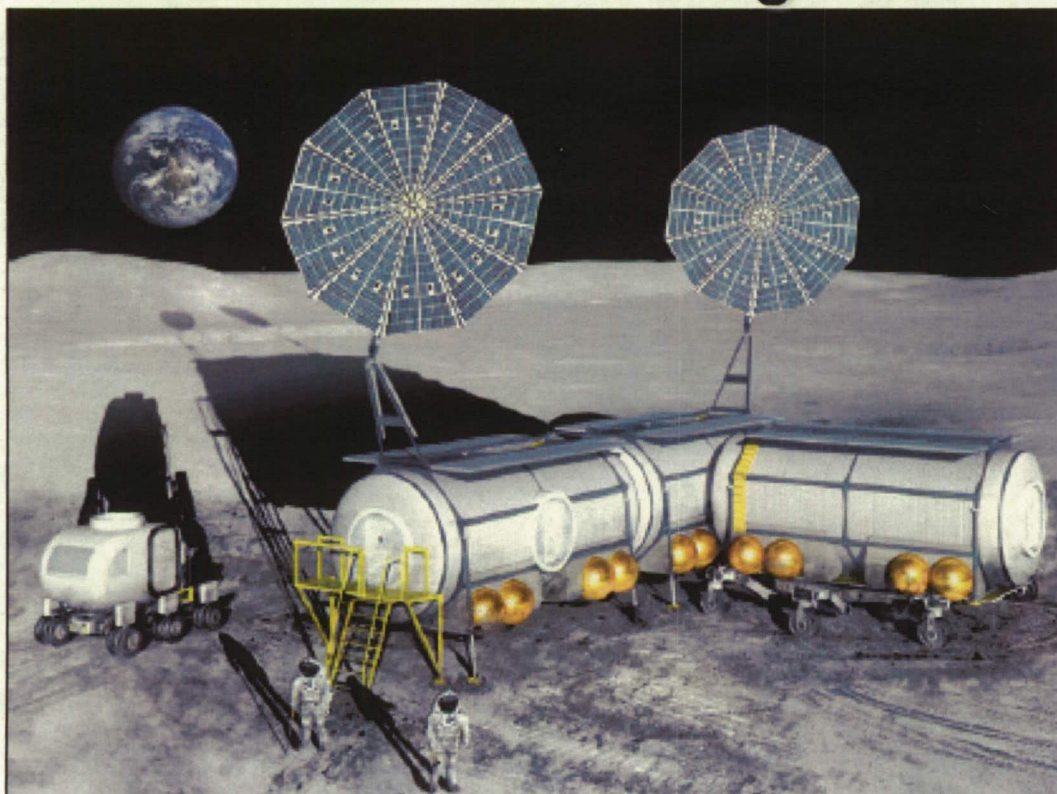
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# OOCT Applied to Constellation Program (Rename to Surface Systems Constraints Test SSCT)

## Possible Surface Configuration



## Lunar Orbit



## Surface Carrier



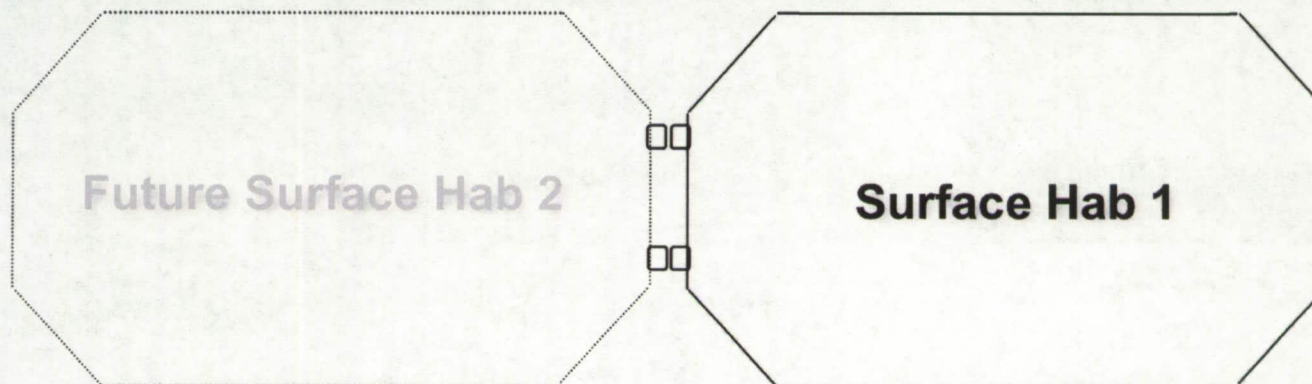
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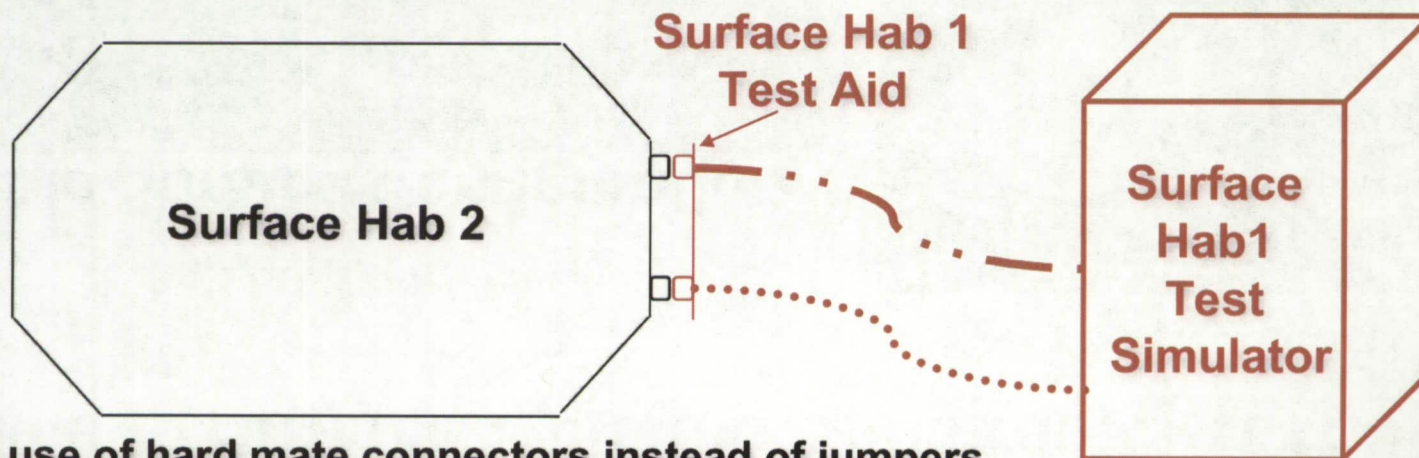
# CxP Fit Check & SSCT Concept



**“Today” - Fit check future Hab 2 connectors to Hab 1 flight Element**



**“X time in the future” - SSCT of Hab 2 Flight Element to Hab 1 test aid**  
(by default you get fit check to Hab 2, piggyback on testing so only connect to flight hardware one time)



**Note: Assume use of hard mate connectors instead of jumpers**

— . . . — GSE Avionics Jumpers  
..... GSE Fluid Jumpers





# Lessons Learned & How to Apply to CxP

- Design Flight Hardware and supporting GSE to allow physical mating of flight hardware elements together that are on the ground at the same point in time.
- Flight Hardware needs to be in final flight configuration
- Piggy back on MEIT or Integrated Testing. Flight jumpers used for test, test aid supports free end of flight jumpers and satisfies SSCT, free end of Test Aid Connectors use to connect test GSE
- ISS Test Aids designed with change out panels, Limits number of rings built, easy to reconfigure between OOCT's, panels can be maintained in "flight configuration" for specific missions
- Fabricate and assembly test aids in Florida to allow quick turn-around and repair of test aids.
- Early purchase of flight connectors, design and build of flight jumpers
- Flight Crew involved to get familiar with Flight Hardware and On-Orbit/Surface Operations. Flight Procedures verified or generated during OOCT
- Work Authorization Document (WAD) should have NASA KSC signature authority and task leader responsibility or designate Local Contractor as task leader.
- Plan early for CxP SSCT and incorporate into Milestone schedules to allow enough time to obtain hardware required
- Public Lessons Learned Entry: 1216  
<http://www.nasa.gov/offices/oc/llis/1216.html>