



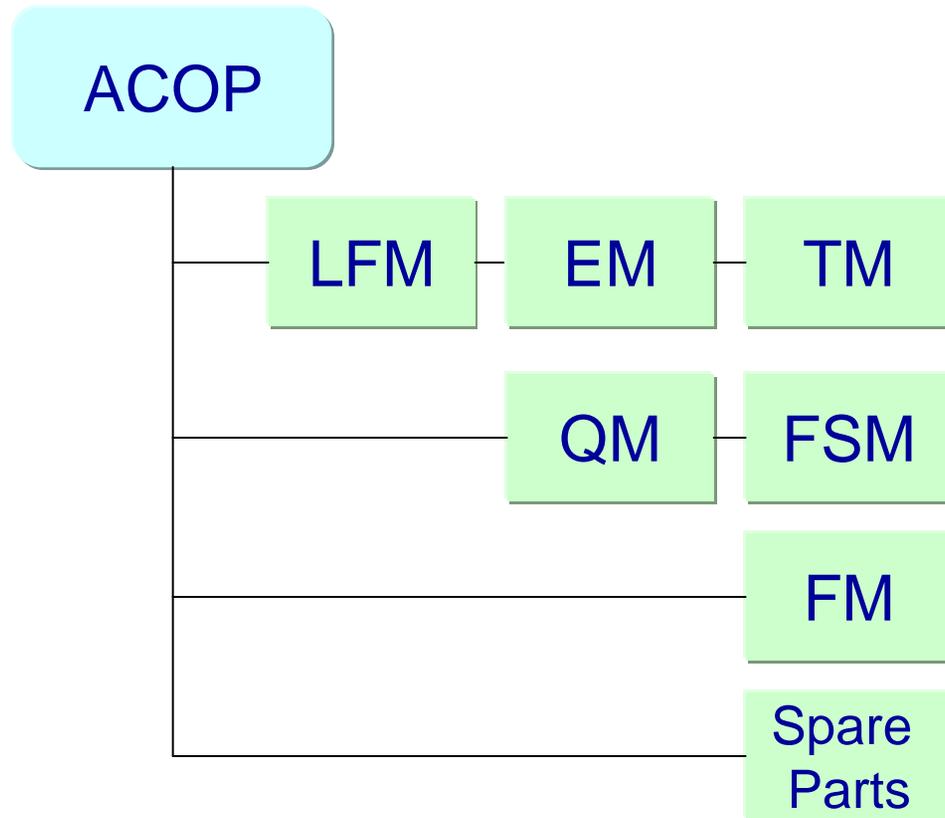
ACOP Models and Verification

Presenter: Peter Dennett

Input by MG, FG, RZ



ACOP Model Philosophy



- **LFM:** Low Fidelity Model
- **EM:** Engineering Model
- **TM:** Training Model
- **QM:** Qualification Model
- **FM:** Flight Model
- **FSM:** Flight Spare Model
- Spare Parts and ORU



Low Fidelity Model (LFM)

- The Low Fidelity Model is a platform for the early ACOP software development and engineering tests.
- It is based in part on commercial boards.
- Is not mechanically like ACOP (commercial case)
- Use AC power.
- It is not fully representative of the ACOP Flight Model



Engineering Model (EM)

- The Engineering Model is a platform for the early ACOP hardware engineering tests.
- It is based in part on commercial boards.
- Use AC power.
- It is not fully representative of the ACOP Flight Model



Training Model (TM)

- The Training Model will support the following main activities:
 - Crew training procedure and flight procedure development and validation
 - Training of crew trainers
 - Crew training
 - Off-nominal trouble-shooting and maintenance activities
- The Training Model will:
 - Be fully representative in functions and performances of the ACOP Flight Model
 - Provide a MMI identical to that of the ACOP Flight Model
 - Implement the same or equivalent safety controls as implemented on the ACOP Flight Model



Qualification Model (QM)

- The Qualification Model will be fully representative in functions, performances and form of the ACOP Flight Model
- It will support all the qualification tests, thus performed without stressing the ACOP Flight Model and without interfering with its integration:
 - Physical Characteristics Check
 - Functional & Performance
 - Acoustic noise
 - Electro-Magnetic Interference / Electro-Magnetic Compatibility
 - Random Vibration and Resonance Search
 - Environmental - Thermal



Flight Model (FM)

- The ACOP Flight Model is the principal product of the ACOP project.
- It will consist of all elements, hardware and software, which will be carried and/or utilized on-board the Space Shuttle and the ISS
- It will sustain a complete acceptance test campaign (acceptance levels and durations)



Flight Spare Model (FSM)

- The Flight Spare Model is an equivalent of the Flight Model, foreseen as spare unit.
- It will be obtained from the refurbishment of the Qualification Model after the qualification tests conclusion:
 - The QM parts overstressed during the qualification tests will be replaced in the FSM
 - The QM parts not overstressed by the qualification tests will be exploited for the FSM
- Functional & Performance Test will be performed on the unit after refurbishment



Verification Approach



Interfaces & Safety Requirements

- The main applicable document for the ACOP Interfaces design is the EXPRESS Rack Payloads Interface Definition Document SSP-52000-IDD-ERP
- The EXPRESS Rack Payload Verification Plan SSP-52000-PVP-ERP defines the complete set of verification requirements and activities necessary to ensure compliance with SSP-52000-IDD-ERP
- SSP-52000-PVP-ERP provides instructions and guidelines for creating the unique Payload Verification Plan (PVP) required by NASA to verify the compatibility, limited to the interfaces, and safety of as-built hardware and software for payloads to be placed on board the ISS inside an EXPRESS Rack.
- This payload specific PVP is substantially a collection of VRDS (Verification Requirements Definition Sheet) that clearly state the interface requirements, the verification methods and the data required, with the submittal date referred to the Launch Date.



Verification Requirements Definition Sheet

VERIFICATION REQUIREMENT DEFINITION SHEET

Verification Number	Requirement Title	Verification Method
TH-ER-008	Particulate(s) and Filters	A, or A and T, D and I
		Hazard Report Number
<p><i>Thermal Control Verification Requirement:</i></p> <ol style="list-style-type: none"> The payload cabin air cooling design will consider the possible ingestion of contamination from the cabin (e.g., 1.0 gram of lint-like material and/or 1.0 in² material blockage in 16 days in the middeck); otherwise, the PD must provide protection from this contamination. The PD cooling system shall not contribute to the contamination of the cabin air or the avionics air loop. (5.3.1.2.1) Payloads interfacing to the EXPRESS Rack Avionics Air System shall be filtered at the payload inlet with a filter of ≤280 μ size. This filter shall have provisions for cleaning. (5.3.1.3.5) 		
<p><i>Description of Verification Method:</i></p> <ol style="list-style-type: none"> Verify by analysis or analysis and test of the PD cooling system to show that particulates, airflow, and payload filters/screens do not contaminate the EXPRESS Rack. If filters/screens are employed, the PD shall assess the impact of filter cake buildup and degraded airflow. An inspection of the as-built flight hardware shall be performed to verify presence of filters. A demonstration/evaluation shall be performed to verify the cleaning provisions. 		
<p><i>Required Verification Data:</i> Certificate of Compliance (COC) with the requirement.</p>		<p><i>Data Submittal Dates:</i> L-4.5 mo</p>
<p><i>Description of Reverification Requirements:</i> Series Payload: Inspect as-built hardware to verify presence of filter. Refight Payload: None required.</p>		
<p><i>Required Reverification Data:</i> Series Payload: COC Refight Payload: None</p>		<p><i>Data Submittal Dates:</i> L-4.5 mo None</p>
<p><i>Applicable Documents and Notes:</i> SSP 5200-IDC-ERP: par 5.3.1.2.1, 5.3.1.3.5</p>		



HRDL Interface

ACOP is a “non-standard” Payload (according to the definition presented in SSP-52000-IDD-ERP Section 1.3), since it uses a data interface (HRDL) which is not listed in Table 1-I of SSP-52000-IDD-ERP.

Consequently, requirements concerning this data interface are not present in SSP-52000-IDD-ERP. SSP 50184 Section 3 and SSP 52050 Section 3.4 are applicable.



Functional & User Requirements

- The main applicable documents for the ACOP design are:
 - the ACOP System Specification ACP-SY-CGS-001
 - the ACOP Software Requirements Document ACP-SQ-CGS-001
- The ACOP Verification Plan ACP-PL-CGS-004 defines the complete set of verification requirements and activities (test, analysis, review of design, inspection) necessary to ensure compliance with the design requirements
- This Verification Plan will be followed by a Verification Control Document (VCD) that will list all the requirements related to the functions of the ACOP System, specifying for each requirement the type of verification and the document where the requirement is verified (Design Report, Test Report, Inspection Report, ...)



Verification Plan

- The ACOP Verification Plan ACP-PL-CGS-004 with its VCD and together with the NASA Required PVP completely defines the ACOP verification process.
- The verification process covers all activities (test, analysis, review of design, inspection) necessary to assure that the design fulfills, with adequate margins, all specified and derived requirements under all specified operational and environmental conditions
- The successful completion of the verification program leads to the qualification and acceptance of the design.
- A certificate of qualification and acceptance will formally document the completion of qualification and acceptance testing.

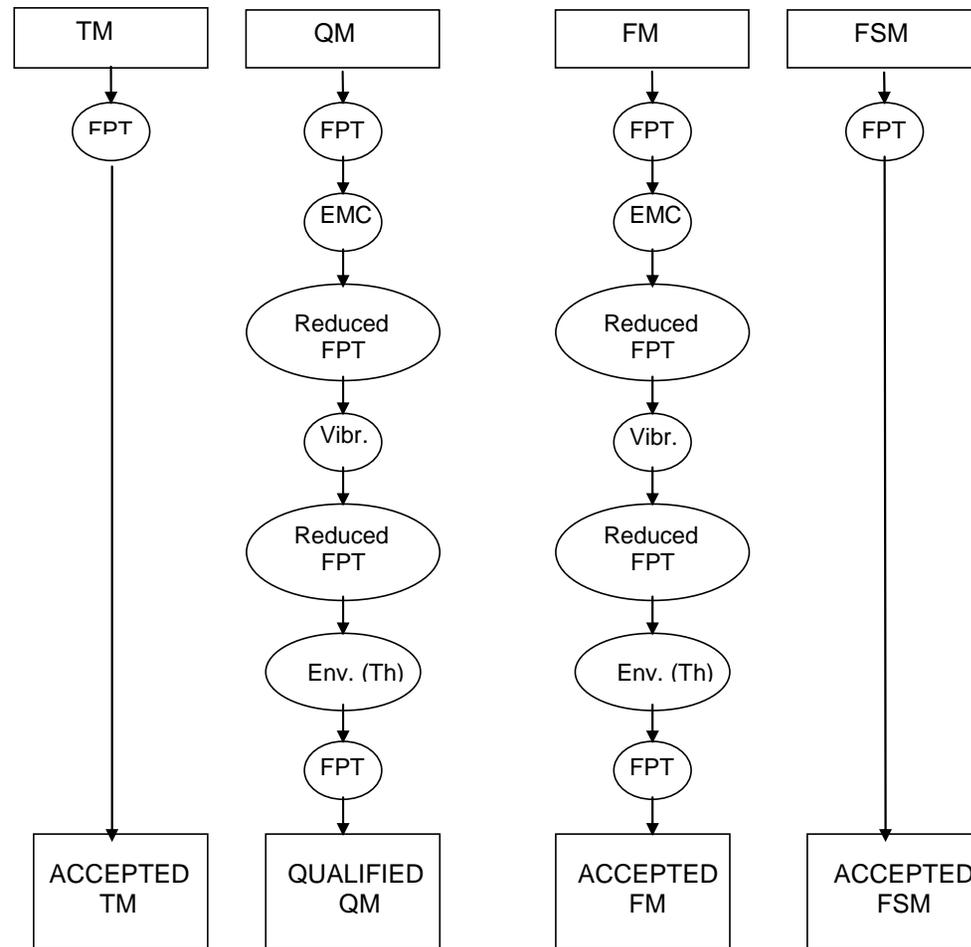


Verification Test Matrix

Model	TRM	QM	FM	FSM
Functional & Performance Test	X	X	X	X
EMC Test		X ¹	X ^{2,3}	
Vibration Test		X ¹	X ²	
Environmental Test (Thermal)		X ¹	X ²	
Acoustic Noise		X	X ⁴	
Note: ¹ at qualification level ² at acceptance level ³ only emissions (TBC) ⁴ Acoustic noise measurement will performed on the FM only if QM results are marginal				



Verification Process





Software Verification

- ACOP is developed as an embedded system in which the ACOP Software is an integral part, is not a stand-alone product and is only expected to operate within the ACOP System.
- Verification for all software:
 - Software reviews integrated with system reviews
 - Software acceptance test in the frame of the overall ACOP acceptance test
- Activities for ACOP Core Software only:
 - Specific test sessions
 - Integration test between ACOP Basic Software and ACOP Application Software
 - Integration test between ACOP Core Software and ACOP EXPRESS Rack Laptop Software

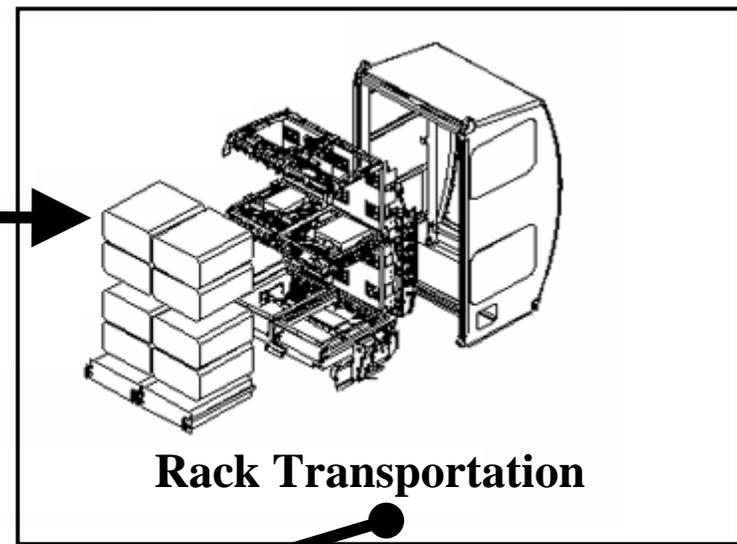
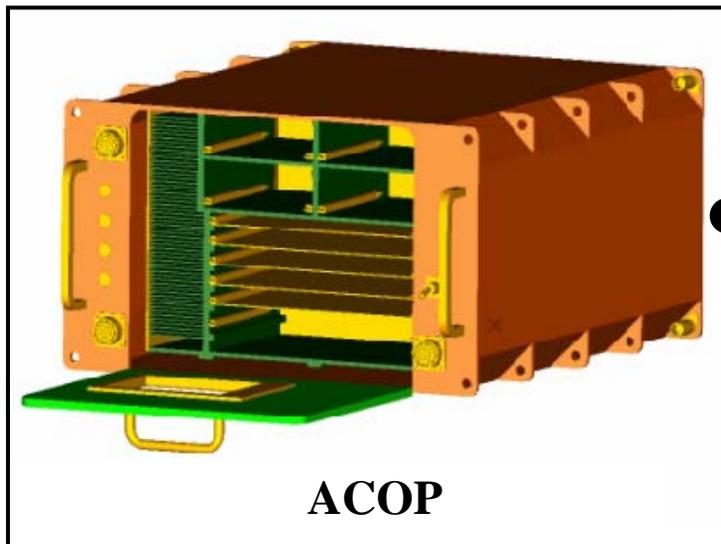


Thermal Verification Scope

1. Meet Temperature Requirements of ACOP components.
2. Meet Interface Requirements from the ISS.



Structural Verification



SSP-52000-IDD-ERP
SSP-52005



Requirements

From: SSP-52000-IDD-ERP

From: SSP-52005



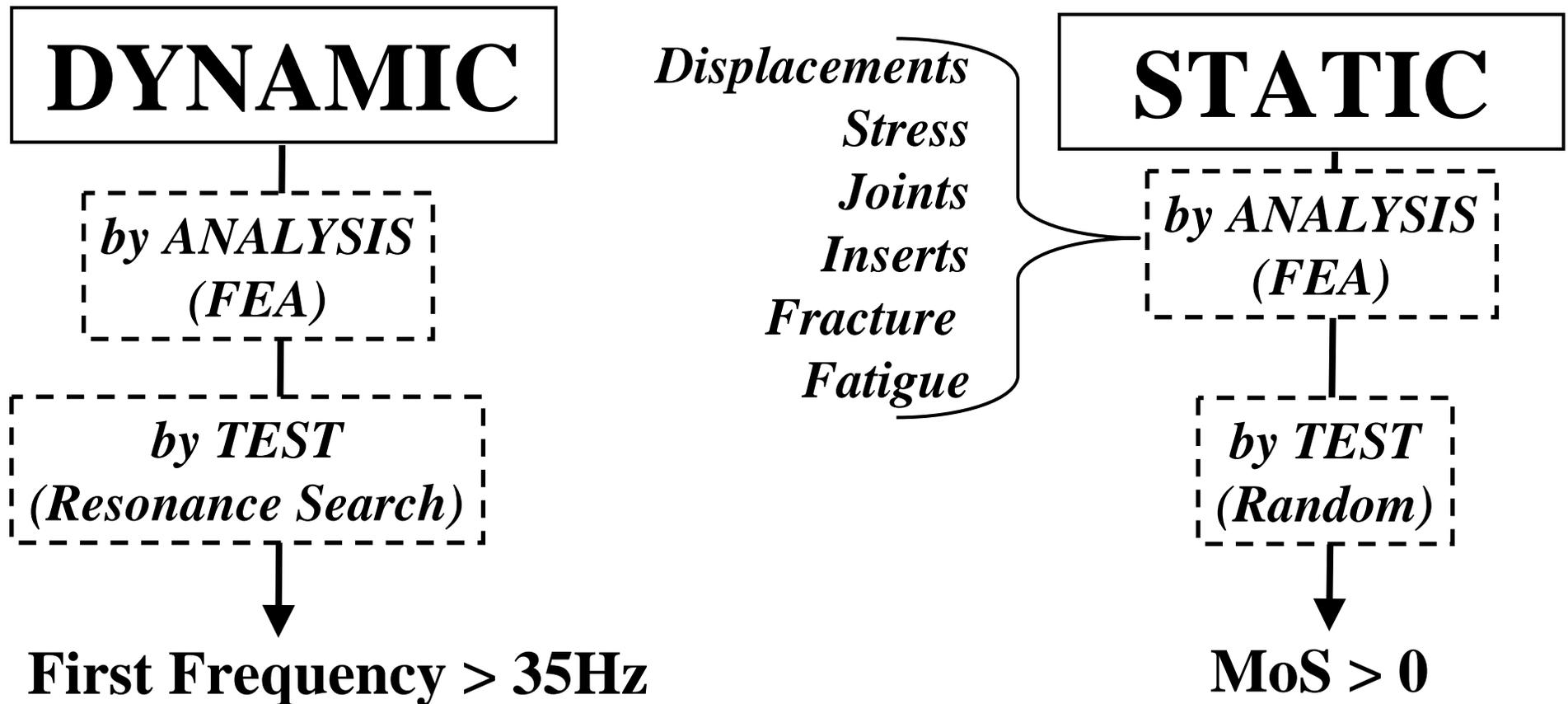
REQUIREMENTS

DYNAMIC

STATIC



VERIFICATION





Static Load Definitions

- | | |
|---|--------------------------|
| 1. Liftoff Low Frequency Loads | SSP-52000-IDD-ERP |
| 2. Landing Low Frequency Loads | SSP-52000-IDD-ERP |
| 3. Emergency Landing Loads | SSP-52000-IDD-ERP |
| 4. Random Vibration Loads | SSP-52000-IDD-ERP |
| 5. Crew-Induced Loads | SSP-52000-IDD-ERP |
| 6. Acoustic Loads | SSP-52000-IDD-ERP |
| 7. Depressurization/Repressurization | SSP-52000-IDD-ERP |
| 8. Ground Handling Loads | SSP-52000-IDD-ERP |