# Constellation Program (CxP)
# Constellation Testing & Verification Control Panel (CxTVCP)
# May 20, 2009
# Co-Chair: David Petri
# Co-Chair: Rayelle Thomas
# Meeting Minutes

This special Constellation Program (CxP) Test and Verification Control Panel (TVCP) meeting was convened on Wednesday, May 20, 2009 at Johnson Space Center, Houston at 9:30 a.m. Central time by Mr. Dave Petri and Mrs. Rayelle Thomas, Co-Chairs. The following summarizes the topics and outcomes, and formal actions are noted below and on the CxTVCP portlet.

## Meeting Attendance

| | Representative |
|---|---|
| **Co-Chair** | David Petri |
| **Co-Chair** | Rayelle Thomas |
| **SE&I P&C** | Mike Jones |
| **SE&I DIO** | n/a |
| **SE&I ISP** | Tara Radke |
| **SE&I SAVIO** | Elizabeth Corderman |
| **CxSR&QA** | Stuart Monteleone |
| **CxO&TI/FAIO** | n/a |
| **Crew** | n/a |
| **CxPP&C/CM** | None |
| **OCE** | Don Prevett |
| **HMTA** | None |
| **OSMA** | None |
| **Ares** | Larry Huebner |
| **Orion** | Allen Rose |
| **Altair** | n/a |
| **Mission Systems** | Jason Kruska |
| **Ground Systems** | Tim Honeycutt |
| **EVA** | Adam Korona |
| **ISS** | None |



## Opening Remarks

Mr. David Petri stated that Margarita Sampson attended the Ares I Y meeting which discussed the Ares IY decision package, this served as the highest level and very difficult decision that will go to the CxCB. There are two main objectives or points noted which include:

- Orion Flight test objective orphaned with the IY material plan was not in the package which made it very difficult, the material is noted to go to an Orion board next week.

- Abort testing and the desire to do it with flight test software in the environment. An informative discussion on the needs was held and should find……

## Tool Approach to Support Acceptance Data Package (ADP) Certification Data Package (CDP) Verification Matrix Development/K. Williams

Mr. Kevin Williams presented this topic and started by commenting on an issue of the Acceptance Data Package (ADP)- Certification Data Package (CDP). Block I/II was mentioned as well as a question of what CxTV will ask projects for and making sure T&V needs are supported and met.

Ms. Thomas commented that although T&V plays a major role in implementing the verification requirements for packages such as the ADP and CDP; much of the dependencies is upon SR&QA for an outline. Configuration Management (CM) and SR&QA play an even larger role in giving overall status of this.

Mr. Don Monell stated there is an Information Systems (IS)/COFR product structure and make sure that is tightly coupled with ADP/CDP. 7146 is mentioned to map authoritative sources that support the aggregator.

| Action Name | Description | Actionee | Due Date |
|---|---|---|---|
| CxTVCP-20090520-1 | Create an integrated plan with IS that puts in place the requirements and implementation processes pertaining to ADP/CDP. | Colin Green<br>Robert Crain | 6/24/09 |

**Disposition: Statused**

## Design & Construction Standards Updates/K. Williams

Mr. Williams continued on the background of Design and Construction (D&C) and tailoring was noted by a participant as defined as the changing of requirements to something technically different and make it applicable or cohesive with the requirements.

Polled representatives commented that before a concurrence is made implementation and test cases are requested for closed loop tracking, more details are needed. Less reporting and tracking is thought to be more efficient for Level II and in turn Level III, and so on.

**Disposition: Statused**

## General Interface Callout Verification Updates

General verifications for CARD 3.7 Interface Requirements DCN deferral was briefly discussed. Mr. Petri included that the days of working exclusively with specs space are leaving with

developing technology; a top-level approach for verification activities in respect to depress CABIN and the analysis needed to close that requirement and find out who is doing what. There is hesitation and without knowing the actual material that needs to be changed.

**Disposition: Statused**

## T&V Quarterly Actions Review/Informational/B. Stevenson

Mr. Bob Stevenson requested that panel members review the T&V Quarterly 1 Actions an d suggest due dates for the actions. The actions will come to the T&V panel. Action #1 will go to panel mid June (6/3) and will. Action #6 is informal and due 6/17. Action #9 is similar to 3 and will need to be integrated or reworked.

## SAVIO TVR Review/E. Corderman

Mr. Elton Witt presented CA6210-PO RIC: Critical Comm Latency and the main responsibility is to obtain end-to end requirements. Safety and testing would benefit from knowing what margin is needed.

Mr. Mike Lewis presented CA3293-PO Software Updates without LRU removal. EVA would give the needed feedback and that info would be included on 3293V-TVR Permutations for (ISS DRM). Please note the verification objective and ISS On0orbit operations phase using each SIL. Uploading was also discussed.

# Tool Approach to Support Acceptance Data Package (ADP) – Certification Data Package (CDP) Verification Matrix Development

**Mapping of Hardware and Software Part#/Serial# to Requirements, Verifications, and Test & Verifications data**

# Acceptance Data Package (ADP) – Certification Data Package (CDP)

## Background

- ADP Requirements document CxP 70146 outlines the information elements required for the development of ADPs
  - Acceptance data, as defined in this document, shall be prepared and electronically delivered to the CxP and its projects for each applicable hardware or software delivery [CxP-SRQA-ADP-0004].
  - CxP deliverable for Hardware and Software:
    - Flight Hardware, Flight-Equivalent Hardware, or Ground Support Equipment (GSE)
    - Software, this document applies to CxP deliverable software designated as Class A, B, or C based upon the results of the Software Assurance Classification Assessment.
  - Hardware and Software are delivered to CxP using DD Form 250/DD Form 1149 or Equivalent
- There is a specific requirement in CxP 70146 to provide an Acceptance Verification Matrix
  - For this part #/serial #, what are the requirements and the objective evidence for verification closure
  - CDP Reqs still need to be developed but are very similar in nature to the ADP and thus would need to develop a Certification Verification Matrix
- ADP vs CDP
  - ADP =>serial # - build to print/workmanship
  - CDP =>part # - qualified/design cert

# Acceptance Data Package (ADP) – Certification Data Package (CDP)

- **Issue**
  - There is a gap on how the Cx Program will track, status, and support the Acceptance/Certification Verification Matrices for the ADPs and CDPs
  - Currently, requirements are not tracked to the part or serial # which is needed to develop the ADP & CDP requirements verification closure packages

# Acceptance Data Package (ADP) – Certification Data Package (CDP)

## Recommendation

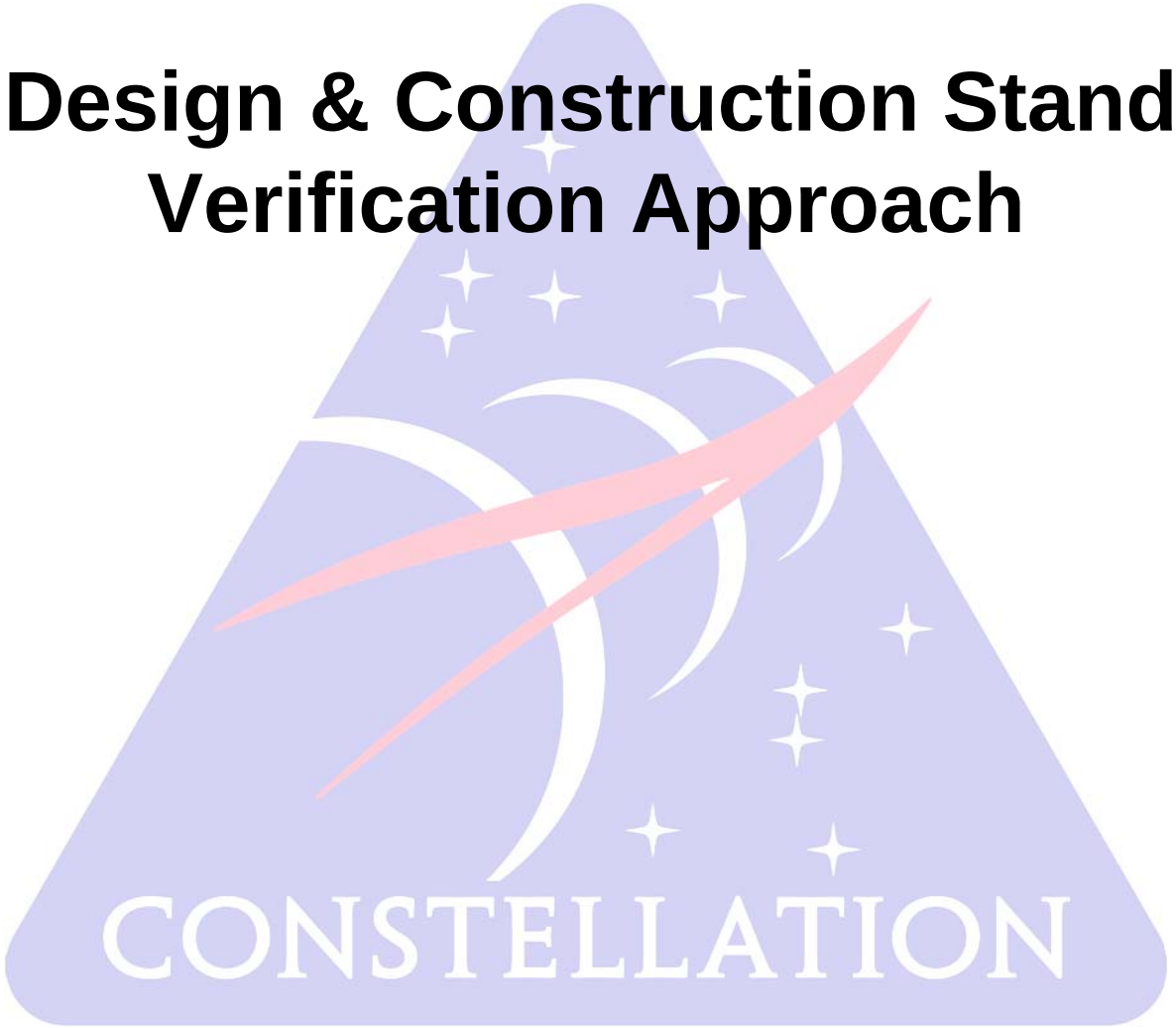
- CxP is utilizing Cradle/Windchill as the repository for Requirements, Verifications, Test & Verifications, and Program/Project documentation
- CxP 70146 outlines the information elements required for the development of ADPs
- These “informational elements” are a natural extension of the current information in Cradle/Windchill
- Develop plan implement the part # & serial # mapping to support the tracking, status, and reporting of ADPs and CDPs verification matrices for CxP.
  - Update the necessary database structures to allow:
    - Mapping of Hardware and Software Part#/Serial# to Requirements, Verifications, and Test & Verifications data
    - Build indentured parts list (Part#/Serial#) link between Cradle/Windchill
    - Populate the indentured parts list (working with projects & CM)
    - Add additional structure to allow tracking, status, and retrieval of ADPs and CDPs verification matrices
  - In order to support this initiative, CxP would require:
    - Request for projects to support setting up Cradle to implement this approach
    - Request support from vendors to provide “informational elements” as defined in CxP 70146 ADP Requirements and CxP “TBD” CDP Requirements

# Acceptance Data Package (ADP) – Certification Data Package (CDP)

## Expected outcomes

- Receive direction from the TVCP to develop plan implement the part # & serial # mapping to support the tracking, status, and reporting of ADPs and CDPs verification matrices for CxP.
  - Work with the Projects to implement the agreed to approach
- Receive direction form the TVCP update the Cradle Schema to facilitate the Acceptance/Certification verification matrix development
- Receive direction to coordinate with information systems & CM to drive the Windchill Linkage and Population
  - Coordinate intermediate data population efforts within Cradle needed as a stop gap until the operational capability is in place

# CxP Design & Construction Standards Verification Approach



# Background on Design & Construction (D&C) Standards

- **The D&C Standards are developed and maintained by several different organizations**
  - Constellation D&C
  - NASA (Center & Agency)
  - Military/Industry/International

- **Requirements in the D&C standards fall into the following categories**
  - Functional/Performance requirements,
  - Interoperability requirements,
  - Verification requirements,
  - Workmanship/Design guidance

- **Not all D&C Standards are created "equal"**
  - Significant level of varying technical detail exists between (and even within) Standards and, as such, differing levels of expected implementation have arisen
    - Standards require adherence via formal "Shall" statements
    - At least one Standard [CxP 70152: CxP Labeling Requirements and Process Document] implies governance via "Should" statements
    - Some are design data to be used (Navigation Standard)
  - The D&C standards have one or several categories of requirements within a single document
    - CxP 70024: CxP Human-Systems Interface Requirements (HSIR) is comprised of both workmanship and integrated performance requirements along with verifications
    - C3I is interoperability and functional/performance
    - Other Standards contain workmanship/Design guidance requirements (eg. Wiring and Composite Overwrapped Pressure Vessel (COPV) type of criterion)
  - Some are "tailorable"
    - SDVR requires the projects to submit their plans that are the tailoring of the SDVR requirements

# Issue: D&C Standards and Closed-Loop Tracking Criterion

- **Given the previously defined background on the varying levels of detail between (and within) the D&C Standards, and the shear number of requirements associated therein, several issues related to compliance and verification have arisen**
  - Is there an expectation that TVRs are to be generated for every requirement within the Standards, thereby necessitating the Close-Loop Tracking (CLT) of each and every requirement with each D&C standard?
    - For CLT, must develop TVRs and VCN for each piece part to demonstrate closure
    - Significant impact upon the Projects with respect to schedule/cost/resource allocation
  - Or do we instead flow the entire book down, allowing the Projects to incorporate the necessary requirement criterion at the appropriate level of implementation and provide verification close-out of the entire content of the Standard at the Document Level (upon roll-up inspection)?
    - Utilize an approach similar to that defined for GSE with a verification matrix to help demonstrate compliance
    - Not every Standard is adaptable to this, as previously alluded to in the case of the HSIR which requires a balance of CLT and roll-up inspection verification

# Recommendation / Expected Outcome

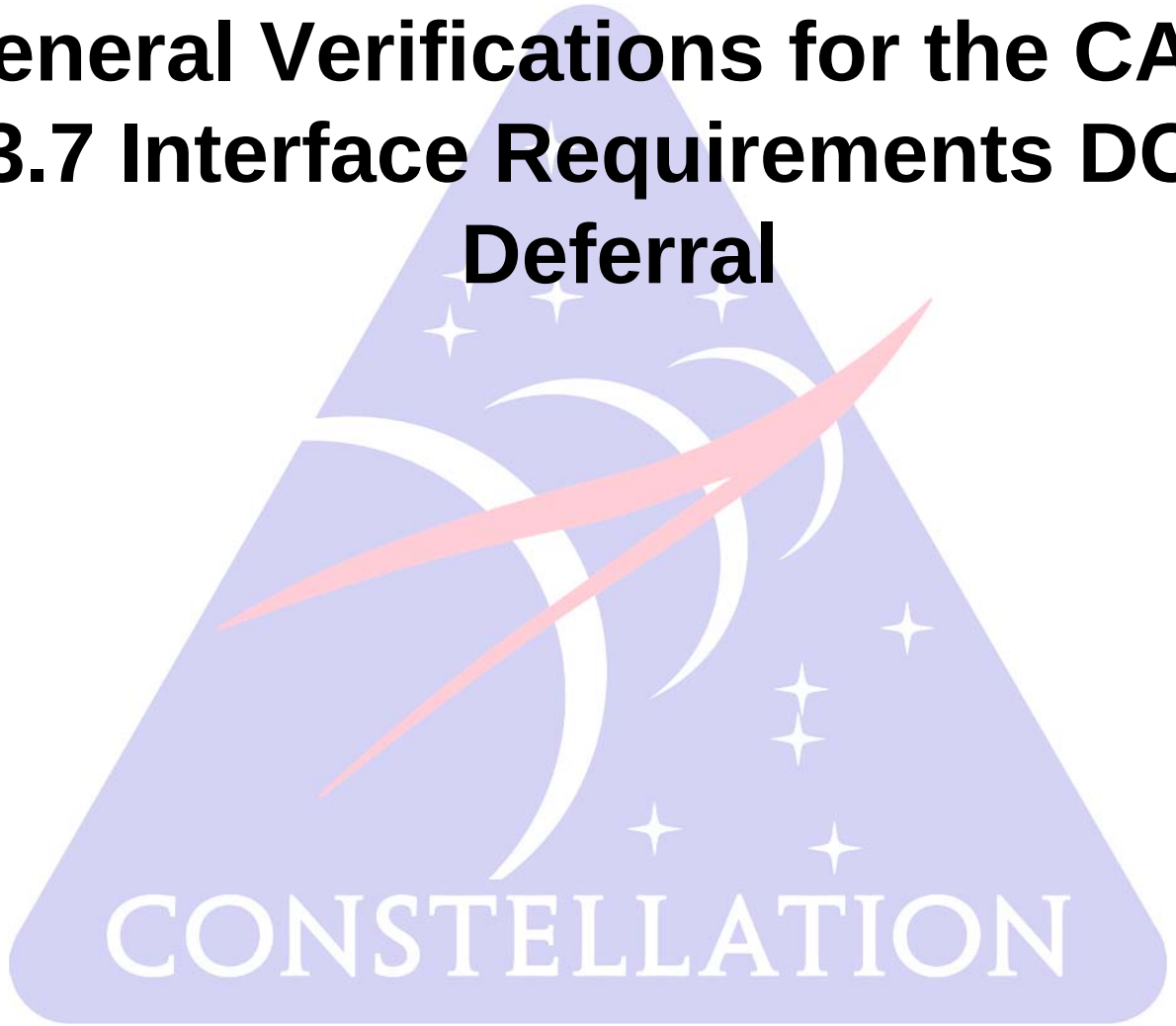
- **Recommendation:**
  - One size does not fit all - Do not require all D&C Requirements to CLT within the D&C Standards
    - Tag those requirements with in the Standard that *DO* require CLT vs. those that *DO NOT*
    - For those that *DO NOT* require CLT,
      - Document Level closure by the projects is performed using tools such as Verification Matrices for the individual identified requirements within a Standard
    - For those that *DO* require CLT,
      - the D&C Requirement is tagged and TVRs are developed and appropriately linked within Cradle with VCNs to close the requirements
  - Task ISP or SAVIO D&C Book Managers to tag the requirements that need to be CLT
    - General Criteria for CLT being:
      - Rqmt is a functional/performance/interoperability requirement no covered by a CARD or IRD call out (e.g. CARD 3.2 rqmt covered by a commanding in accordance with C3I)
      - Results in events that Level 2 needs to plan for specific tests, demonstrations, & analysis
      - Requirements owners to identify exceptions with rationale to the general criteria
    - Present CLT assessment results to the TVCP
    - Request schedule from the D&C Book Managers
  - Update Cradle schema to include method to tag the requirements that require CLT
  - Update the MIVP to reflect this approach
- **Expected Outcome:**
  - Approval of recommendations
  - Requested support from Level II Organizations and Level III Projects for implementation

# Backup

# Background on CxP Developed Design & Construction (D&C) Standards

- **CARD Section 3.3 Requirements, as direct allocations to the Projects, are what comprise the content of the CxP D&C Standards Documentation; whose listing (circa May '09) is detailed below:**
  - ISP Owned:
    - CxP 70023: CxP Prg Design Spec Natural Environments (DSNE)
    - CxP 70024: CxP Human-Systems Int. Requirements (HSIR)
    - CxP 70036: Constellation Program Enviromental Qualification and Acceptance Testing Requirements (CEQATR)
    - CxP 70044: CxP Natural Environment Definition for Design (NEDD)
    - CxP 70050 Vol 01: CxP Electrical Power System Spec Vol 1
    - CxP 70050 Vol 02: CxP Electrical Power System Spec Vol 2
    - CxP 70050 Vol 03: CxP Electrical Power System Spec Vol 3
    - CxP 70050 Vol 04: CxP Electrical Power System Spec Vol 4
    - CxP 70080: CxP Electromagnetic Environmental Effects (E3) Requirements
    - CxP 70130: CxP EVA Design and Construction Specification
    - CxP 70135: CxP Structural Design & Verification Requirements
    - CxP 70136: CxP Loads Data Book
    - CxP 70142: CxP Navigation Standard Guidance
    - CxP 70143: Induced Environments Design Specification
    - CxP 70152: CxP Labeling Requirements and Process Document
    - CxP 70156: CxP Fluid Procurement and Use Control Specification
    - CxP 70168: CxP Performance Assessment Document – (in development)
    - CxP 70199: CxP Pyrotechnics Specification
    - CxP TBD: CxP Integrated Aborts Verification Document – (in development)
  - SAVIO Owned:
    - CxP 70022-1: C3I Interoperability Spec
    - CxP 70022-2: C3I Spectrum & Channel Plan
    - CxP 70022-3: C3I Master Link Book
    - CxP 70022-4: C3I Information Representation Spec
    - CxP 70022-5: C3I Data Exchange Protocol
    - CxP 70022-6: Link Establishment Protocol
    - CxP 70022-7: C3I Framework Spec
    - CxP 70022-8: Common Command & Control
    - CxP 70065: Computing System Requirements
    - CxP 70166: Integrated Build Tools & Interface Requirements
    - CxP 70169: Cx-to-CTN Architecture and Services Requirements Document
    - CxP 70170: Constellation Program Information Technology (IT) Functional Security Requirements
    - CxP 70176: DSIL SRD Requirements
    - CxP 70177: DSILCA Specification
    - CxP 70178: DSIL IU Specification
    - CxP 70179: DSIL Interface Description

# General Verifications for the CARD 3.7 Interface Requirements DCN Deferral



# General Verifications for the CARD 3.7 Interface Requirements DCN Deferral

- **DCN 93 & 199 have been submitted to change the IRD interface requirements verifications from test and analysis to a roll-up inspection**
  - The IRD call outs are children requirements of the top level “do the mission” requirements
  - Original VRs requested tests that were Integrated Avionics & Software SILs based tests and other integrated tests that were to be defined in the CxP 70084 Integrated Test Plan
    - The CxP 70084 Integrated Test Plan is now being scoped to focus on MEIT/FEIT
    - The Analysis method was for a roll-up inspection of the lower level requirement verifications (now inspection with latest MIVP clarification)
- **DCN content was deferred until TVCP decision on general interface verification approach**
  - OTI originally non-concurred on the change because the top-level IRD Test VR was written as an entry point justifying/connecting to the MEIT/FEIT tests.
    - The agreement was made to remove Test as the verification method from the IRD-pointer requirements, but to ADD Test to the top-level mission requirements to maintain the connection with MEIT/FEIT
  - There is not agreement that a roll-up inspection is adequate for closure of the IRD call out requirements since the parent requirement is also a roll-up inspection
  - Will provide an example of the issue using a requirement from DCN 93
- **Premature to implement this change to the 3.4 & 3.7.n.4 interface callouts at this time.**
  - Interface integration & verification strategies have just started and will not be completed prior to the CARD Rev D cut off
  - Will process a change to the CARD interface VRs after we have those strategies developed
- **Recommend deferral of DCN 93 & 199 until the interface integration and verification strategy had been presented at the TVCP or at Quarterly 2**

# T & V Quarterly 1 Action Items

| Number | Description | Actionee | Report Milestone or due date | Comments | Where to track |
|---|---|---|---|---|---|
| 1 | Define the milestones and framework for the back end of the Program schedule, and provide a common understanding of SARs, SIRs, DCRs, pre-ship reviews, PCAs, etc. Submit a milestone change package to the Monthly Schedule Review, showing how the back end wires together for each of the flights and the DCRs. | Mobley | To June Schedules Forum with Deputy Program Manager | Put in SIP | TVCP |
| 2 | Develop proposed paragraphs for the Test Like You Fly philosophy and implementation at Level 2. | Dustin Shaw | 6/10/09 | Material has been sent out for OTI/FIT review. Will be discussed with Mike Ferguson in early June. Presentation to TVCP on 10 June is planned.<br><br>Project TLYF implementation will be left to their discretion. | TVCP |
| 3 | Provide test requirements baselining date for Scale Model Acoustic Test | Ares: Patterson | | | Presentation at Quarterly #2 |

| | | | | | |
|---|---|---|---|---|---|
| 4 | Confirm that resources are available and scheduled to produce interface compatibility (physical) based upon drawings/CAD models | Ares:<br>Cole/Robinson | | | Presentation at Quarterly #2 |
| 5 | Provide an integrated resolution plan for Umbilicals delivery for LETF testing<br>• Orion and Ares Projects to provide current funding status and planned delivery dates for Orion and Ares umbilicals. Determine if GO Need Dates can be satisfied. (Debruin, Cockrell)<br>• If Need Date cannot be supported, provide an estimate of when a cost ROM would be available in order to support impact evaluations. (Debruin, Cockrell)<br>• Provide an update to risk mitigation plan and LETF test schedule. (Sowards) | GMO SIG: Acosta | 6/3/09 | Present risk mitigation plan to TVCP on 6/3 | TVCP |
| 6 | Pursue the use of the Landing & Recovery Working Group as the focus for developing TVRs for landing and recovery. | Thomas, Petri | | | TVCP |
| 7 | Develop a metric to show CARD, IRD and D&C requirements coverage by T&V strategy/network diagrams. | Sampson | | | TVCP |

| | | | | | |
|---|---|---|---|---|---|
| 8 | Provide the agreed-to, comprehensive list of HITL tests, to be managed by the HITL WG. | Richardson | | HITL TIM held 5/14 | Presentation at Quarterly #2 |
| 9 | Develop plan for creating and managing the repository for Models and Simulations, used for verification and validation. | Boyce | 6/3/09 | | TVCP |
| 10 | Create a common abort run matrix (certification and assessment cases). | West | | | TVCP |
| 11 | Develop Orion IVGVT schedule, and support the development of an integrated plan for finalizing test requirements, test article fidelity, BEA update, etc. | Orion: Jeff Roberts | 6/3/09 | See item 13 | TVCP |
| 12 | Develop and present the IVGVT integrated schedule and plan | ILSM SIG, Ares: Meg Tuma, Bart Fowler | Summer 2009 | Ares plans and schedules anticipated to be available in July | TVCP |
| 13 | Update IRMA Risk 4246 on IVGVT content to incorporate scheduled Orion analysis completion date and March 2010 need date for start of Orion test design work. Consolidate Level II and III IVGVT risks in IRMA into fewer risks that clearly and accurately depict the situation. | Bartkowicz | | This is the IRMA part of the complete IVGVT action. See item 11 above. Initial update and consolidation effort is in work with Ares assistance for the June TRR. | Presentation at Quarterly #2 |

| | | | | | |
|---|---|---|---|---|---|
| 14 | Build a “swim lane” chart showing what is planned in addressing MMOD risk. | SR&QA: Tom Burton | 6/17/09 | Chart in work and to be presented to TVCP after John Turner approves. | TVCP |
| 15 | Splinter leads present to the TVCP their list of actions to become formal TVCP actions. | Will Ewing, Mike Ferguson, Art Vigil | 6/3/09 | Will to present at TVCP.<br><br>Mike’s and Art’s action is closed. | TVCP |
| | ~~Close the loop with Configuration Management on a common definition of GSE and STE, and the process to be used for establishing the appropriate classification of the equipment.~~ | ~~Ferguson~~ | ~~4/27/09~~ | ~~Action closed with participation in the MD-048 Technical Coordination Meeting (TCM). No Issues.~~ | |
| | ~~Develop T&V Quarterly outbrief for presentation to the 30 April SECB.~~ | ~~Williams~~ | ~~4/29/09~~ | ~~Closed. Presented to SECB~~ | |
| | ~~Provide additional background and rationale for additional ECLSS testing, plus alternatives as fallback options, in order to provide an integrated position for ECLSS DCN.~~ | ~~Carrasquillo~~ | | ~~Closed. Completed at 5/8/09 Special TVCP~~ | |
| | ~~Establish criteria for developing and approving test objectives and requirements for MEIT, FEIT, PSET tests, including nominal operations testing.~~ | ~~FMEITWG~~ | | ~~Close. Content input was provided to WG, where it will be worked.~~ | |

| | | | | | |
|---|---|---|---|---|---|
| | ~~Confirm that the integration/assembly reverse fishbone diagrams are being produced by Ares~~ | ~~Ares: Cole~~ | | ~~Close. Confirmation sent to Dave Petri.~~ | |
| | ~~Include items in MIVP update currently in work:~~<br>• ~~Requirements for incremental design changes and block updates~~<br>• ~~Definition of Certification Data Packages~~<br>• ~~Pre-Declared Development Testing criteria and process~~<br>• ~~Language for GSE Certification requirements~~<br>• ~~contents of GSE Cert Data Packages~~<br>• ~~Define Block Upgrade and call for identifying associated test needs~~ | ~~Mike Ferguson~~ | | ~~Closed. Already in work and will be brought to TVCP when ready~~ | |

# SAVIO CARD TVR Review

# CA3293-PO
# Software Updates without LRU Removal

**Mike Lewis**
**SAVIO V&V**

**TVCP**
**May 20, 2009**

# CA3293-PO

| CARD Cradle Key | CARD Reqt Name | CARD Rqt Text Frame | CARD Rationale Frame | Requirement Status | Requirement Type | OWNER Category | CARD Cradle ID |
|---|---|---|---|---|---|---|---|
| **CA3293-PO** | Software Updates Without LRU Removal | The Constellation Architecture shall accept software updates without requiring LRU removal. | The ability to reprogram devices and update software is needed for maintainability. CxP 70007, Constellation Design Reference Missions and Operational Concepts, Section 4.1.3, stipulates a general approach to maintenance that includes repair of failed items. Also, Constellation Design Reference Missions and Operational Concepts Document, Section 4.1.4, indicates a preference for direct access to LRUs. Access at the LRU level reduces cost and schedule impact and improves in-flight maintenance by avoiding disassembly to obtain access. An update capability also contributes to **mission success** and **crew safety** goals. Updates can be applied in **every feasible mission phase**. Changes to **configuration data** and **software** are included in the scope of software updates. **Firmware** updates may be included where deemed feasible by Constellation projects. | ACCEPTED | Functional | C3I Interoperability & Commonality | VR3375 |

# CA3293V-PO

| CARD VR Cradle Key | VR Text | VR Rationale | CARD Rationale Frame | Item Status | Verif Method |
|---|---|---|---|---|---|
| **CA3293V-PO** | The Constellation Architecture requirement to accept software updates **without requiring LRU removal** shall be verified by Demonstration. a. Demonstrations shall be performed using the **flight assets** (Ares I/Ares V/LSAM) along with **associated CxP elements** (i.e. Ground Systems and Mission Systems) and **Crew** under **simulated flight conditions.** b. Demonstrations of software updating using the flight/flight-like assets (Ares I/Ares V/LSAM) along with associated CxP elements (i.e. Ground Systems and Mission Systems) and Crew shall be **performed during simulation and training exercises**. The verification shall be considered **successful when** updates through the CxP architecture are: a. **Accepted** by the receiving LRU b. Is **accomplished** without LRU removal c. Is **confirmed** via C3I cross checking (i.e. ack, checksum) | Demonstrations using **flight quality assets, operational baseline, and C3I infrastructure** provides assurance that those participatory CxP elements can perform software updates. A demonstration **during simulations and training** reduces the risk of being unable to perform the necessary function. | The ability to **reprogram devices** and **update software** is needed for maintainability. CxP 70007, Constellation Design Reference Missions and Operational Concepts, Section 4.1.3, stipulates a general approach to maintenance that includes repair of failed items. Also, Constellation Design Reference Missions and Operational Concepts Document, Section 4.1.4, indicates a preference for direct access to LRUs. Access at the LRU level reduces cost and schedule impact and improves in-flight maintenance by avoiding disassembly to obtain access. An update capability also contributes to mission success and crew safety goals. Updates can be applied in every feasible mission phase. Changes to **configuration data** and **software** are included in the scope of software updates. **Firmware updates may be included** where deemed feasible by Constellation projects. | ACCEPTED | Demonstration |

# CA3293V-TVR Permutations (ISS DRM)

| Mission Phase | Software | Config | Firmware | Software | Config | Firmware | Software | Config | Firmware |
|---|---|---|---|---|---|---|---|---|---|
| | Umbilical | | | CTN | | | SN | | |
| **ARES 1** | | | | | | | | | |
| Pad Operations | TVR-1 | TVR-2 | TVR-3 | TVR-19 | TVR-20 | TVR-21 | | | |
| **ORION** | | | | | | | | | |
| Pad Operations | TVR-4 | TVR-5 | TVR-6 | TVR-24 | TVR-25 | TVR-26 | | | |
| LEO Loiter | | | | TVR-7 | TVR-8 | TVR-9 | | | |
| ISS Attached Ops | | | | | | | TVR-10 | TVR-11 | TVR-12 |
| **EVA** | | | | | | | | | |
| Pad Operations | TVR-13 | TVR-14 | | | | | | | |
| LEO Loiter | | | | TVR-22 | TVR-23 | | | | |
| ISS Attached Ops (Orion) | | | | | | | TVR-15 | TVR-16 | |
| ISS Attached Ops (ISS) | | | | | | | TVR-17 | TVR-18 | |

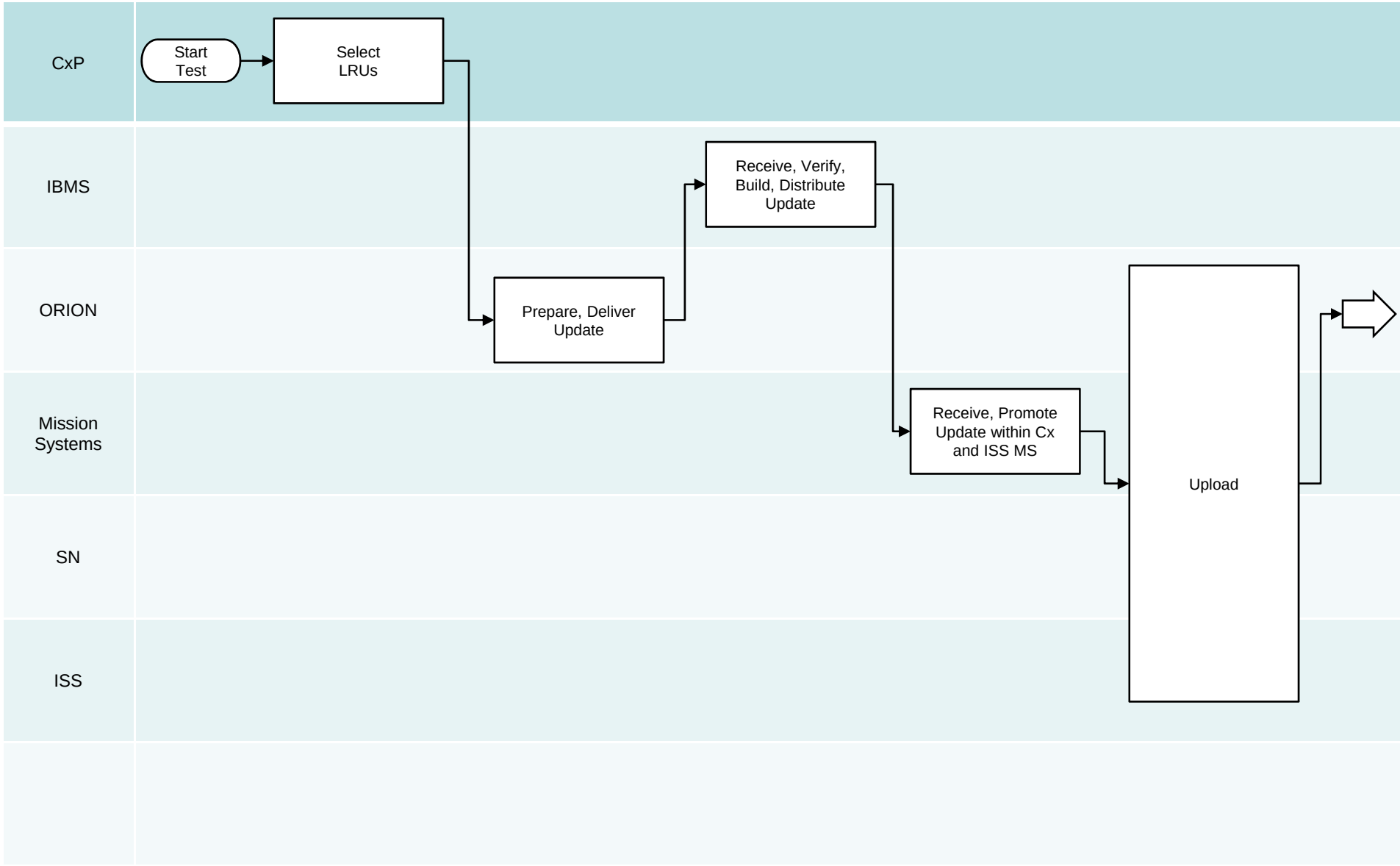
# CA3293V-TVR10

**Demonstrate acceptance of LRU software update originating from project to ORION through secured network to ISS in ISS Attached Operations (SN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | ISS Attached Ops | Verify that the Orion LRUs can accept software updates in nominal conditions from Orion project generated change to IBMS over secured network through ISS MCC LAN to ISS to Orion in flight during ISS On-orbit operations phase using each SIL | 1. Randomly select statistically valid Orion sample [TBD-2] of LRUs to use for test<br>2. Prepare update package for target Orion LRU and deliver Orion update package from Orion Software Production Facility to IBMS<br>3. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems<br>4. Mission Systems receives update package and promotes update to Mission Control Center System<br>5. Upload software (via SN) into LRU in the Orion (via ISS ICCA)<br>6. Demonstrate Orion LRU functions normally with updated software without removal<br>7. Retrieve original baseline, back-out update<br>8. Upload software (via SN) into LRU in the Orion (via ISS ICCA)<br>9. Demonstrate Orion LRU functions normally with original baseline software without removal |

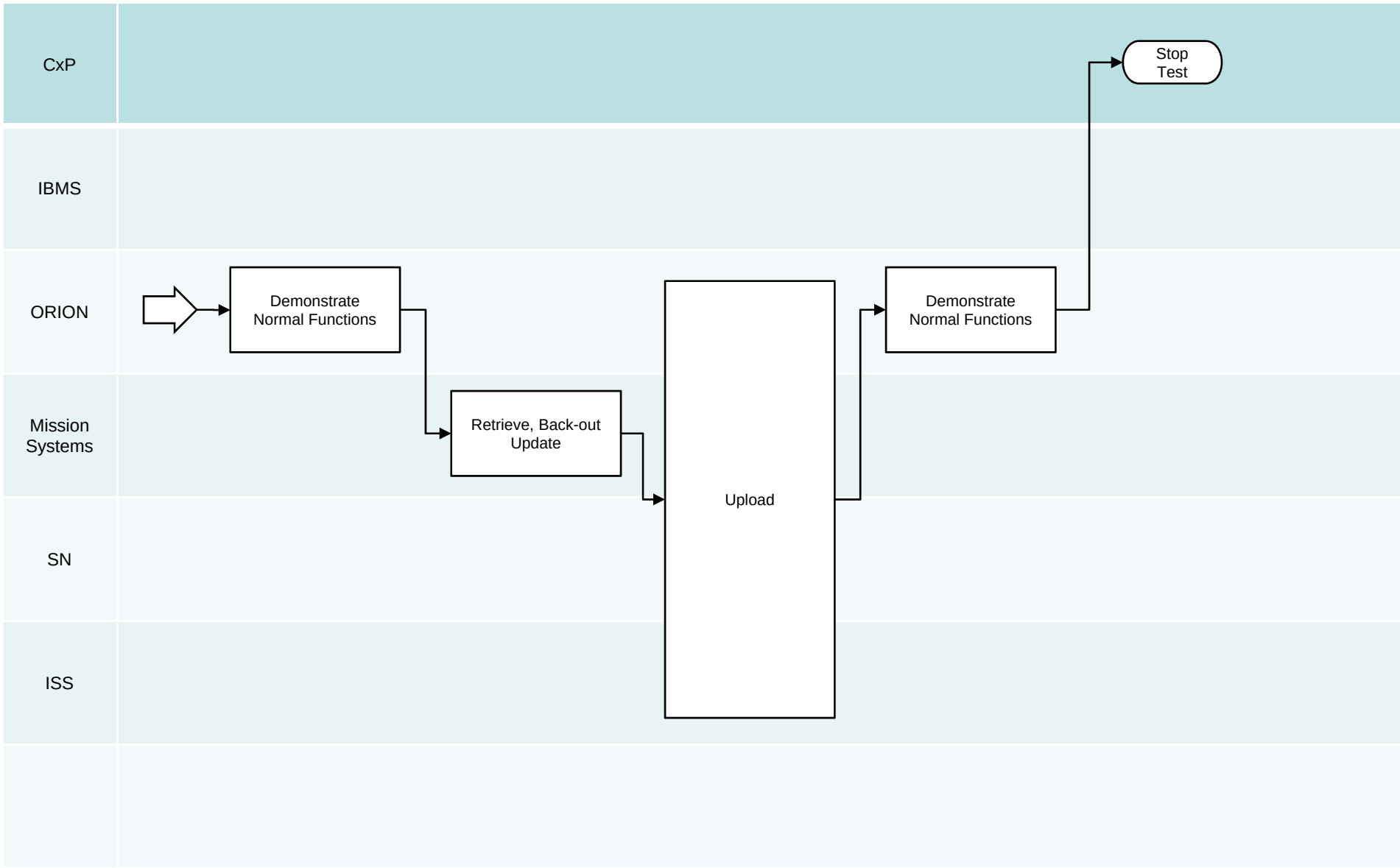
# CA3293V-TVR10

**Demonstrate acceptance of LRU software update originating from project to ORION through secured network to ISS in ISS Attached Operations (SN)**



# CA3293V-TVR10

**Demonstrate acceptance of LRU software update originating from project to ORION through secured network to ISS in ISS Attached Operations (SN)**



# BACKUP

# CA3293V-TVR1

**Demonstrate acceptance of LRU software update originating from project to ARES through secured network in pre-launch PAD Operations (Umbilical)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | Pad Operations | Verify that the Ares I LRUs can accept software updates in nominal conditions from Ares project generated change to IBMS over secured network through LSS LAN to Ares I on PAD during pre-launch ground processing phase using each SIL | 1. Randomly select statistically valid Ares I sample [TBD-1] of LRUs to use for test<br>2. Prepare update package for target ARES I LRU and deliver ARES I update package from Software Production Facility to IBMS<br>3. IBMS receives update package, verified update package, builds update and distributes to Ground Systems<br>4. Ground Systems receives update package an promotes update to Ground Systems Launch Control System<br>5. Upload software (via umbilical) into LRU in the ARES I<br>6. Demonstrate ARES I LRU functions normally with updated software without removal<br>7. Retrieve original baseline, back-out update<br>8. Upload software (via umbilical) into LRU in the ARES I<br>9. Demonstrate ARES I LRU functions normally with original baseline software without removal |

# CA3293V-TVR2

**Demonstrate acceptance of LRU configuration update originating from project to ARES through secured network in pre-launch PAD Operations (Umbilical)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | Pad Operations | Verify that the Ares I LRUs can accept configuration updates in nominal conditions from Ares project generated change to IBMS over secured network through LSS LAN to Ares I on PAD during pre-launch ground processing phase using each SIL | 1. Randomly select statistically valid ARES I sample [TBD-1] of LRUs to use for test<br>2. Prepare update package for target ARES I LRU and deliver ARES I update package from ARES I Software Production Facility to IBMS<br>3. IBMS receives update package, verifies update package, builds update and distributes to Ground Systems<br>4. Ground Systems receives update package and promotes update to Ground Systems Launch Control System<br>5. Upload configuration data (via umbilical) into LRU in the ARES I<br>6. Demonstrate ARES I LRU functions normally with updated configuration without removal<br>7. Retrieve original baseline, back-out update<br>8. Upload configuration data (via umbilical) into LRU in the ARES I<br>9. Demonstrate ARES I LRU functions normally with original baseline configuration without removal |

# CA3293V-TVR3

**Demonstrate acceptance of LRU firmware update originating from project to ARES through secured network in pre-launch PAD Operations (Umbilical)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | Pad Operations | Verify that the Ares I LRUs can accept firmware updates in nominal conditions from Ares project generated change to IBMS over secured network through LSS LAN to Ares I on PAD during pre-launch ground processing phase using each SIL | 1. Randomly select statistically valid ARES I sample [TBD-1] of LRUs to use for test<br>2. Prepare update package for target Ares I LRU and deliver ARES I update package from Ares I Software Production Facility to IBMS<br>3. IBMS receives update package, verifies update package, builds update and distributes to Ground Systems<br>4. Ground Systems receives update package and promotes update to Ground Systems Launch Control System<br>5. Upload firmware (via umbilical) into LRU in the ARES I<br>6. Demonstrate ARES I LRU functions normally with updated firmware without removal<br>7. Retrieve original baseline, back-out update<br>8. Upload firmware (via umbilical) into LRU in the ARES I<br>9. Demonstrate ARES I LRU functions normally with updated firmware without removal |

# CA3293V-TVR4

**Demonstrate acceptance of LRU software update originating from project to ORION through secured network in pre-launch PAD Operations (Umbilical)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | Pad Operations | Verify that the Orion LRUs can accept software updates in nominal conditions from Orion project generated change to IBMS over secured network through LSS LAN to Orion on PAD during pre-launch ground processing phase using each SIL | 1. Randomly select statistically valid Orion sample [TBD-2] of LRUs to use for test<br>2. Prepare update package for target Orion LRU and deliver Orion update package from Orion Software Production Facility to IBMS<br>3. IBMS receives update package, verifies update package, builds update and distributes to Ground Systems<br>4. Ground Systems receives update package and promotes update to Ground Systems Launch Control System<br>5. Upload software (via umbilical) into LRU in the Orion<br>6. Demonstrate Orion LRU functions normally with updated software without removal<br>7. Retrieve original baseline, back-out update<br>8. Upload software (via umbilical) into LRU in the Orion<br>9. Demonstrate Orion LRU functions normally with original baseline software without removal |

# CA3293V-TVR5

**Demonstrate acceptance of LRU configuration update originating from project to ORION through secured network in pre-launch PAD Operations (Umbilical)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | Pad Operations | Verify that the Orion LRUs can accept configuration updates in nominal conditions from Orion project generated change to IBMS over secured network through LSS LAN to Orion on PAD during pre-launch ground processing phase using each SIL | 1. Randomly select statistically valid Orion sample [TBD-2] of LRUs to use for test<br>2. Prepare update package for target Orion LRU and deliver Orion update package from Orion Software Production Facility to IBMS<br>3. IBMS receives update package, verifies update package, builds update and distributes to Ground Systems<br>4. Ground Systems receives update package and promotes update to Ground Systems Launch Control System<br>5. Upload configuration data (via umbilical) into LRU in the Orion<br>6. Demonstrate Orion LRU functions normally with updated configuration without removal<br>7. Retrieve original baseline, back-out update<br>8. Upload configuration data (via umbilical) into LRU in the Orion<br>9. Demonstrate Orion LRU functions normally with original baseline configuration without removal |

# CA3293V-TVR6

**Demonstrate acceptance of LRU firmware update originating from project to ORION through secured network in pre-launch PAD Operations (Umbilical)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | Pad Operations | Verify that the Orion LRUs can accept firmware updates in nominal conditions from Orion project generated change to IBMS over secured network through LSS LAN to Orion on PAD during pre-launch ground processing phase using each SIL | 1. Randomly select statistically valid sample [TBD-2] of firmware based LRUs for test<br>2. Prepare update package for target LRUs<br>3. Deliver Orion update package (descriptive information) from Orion Software Production Facility to IBMS.<br>4. Deliver IBMS update package from IBMS to Ground Systems Launch Control System<br>5. Promote firmware update to Ground Systems Launch Control System<br>6. Update Vehicle firmware while Stack is emulated to be on PAD<br>7. Upload firmware into randomly selected LRU non-volatile memory<br>8. Demonstrate LRU functions normally with updated firmware without removal<br>9. Back-out the change made<br>10. Show that the original firmware works normally |

# CA3293V-TVR7

**Demonstrate acceptance of LRU software update originating from project to ORION through secured network in LEO Loiter (CTN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | LEO Loiter | Verify that the Orion LRUs can accept software updates in nominal conditions from Orion project generated change to IBMS over secured network through MCC LAN to Orion in flght during LEO operations phase using each SIL | 1. Randomly select statistically valid Orion sample [TBD-2] of LRUs to use for test<br>2. Prepare update package for target Orion LRU and deliver Orion update package from Orion Software Production Facility to IBMS<br>3. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems<br>4. Mission Systems receives update package and promotes updates to Mission Control Center System<br>5. Upload software (via CTN) into LRU in the Orion<br>6. Demonstrate Orion LRU functions normally with updated software without removal<br>7. Retrieve original baseline and back-out update<br>8. Upload software (via CTN) into LRU in the Orion<br>9. Demonstrate Orion LRU functions normally with original baseline software without removal |

# CA3293V-TVR8

**Demonstrate acceptance of LRU configuration update originating from project to ORION through secured network in LEO Loiter (CTN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | LEO Loiter | Verify that the Orion LRUs can accept configuration updates in nominal conditions from Orion project generated change to IBMS over secured network through MCC LAN to Orion in flght during LEO operations phase using each SIL | 1. Randomly select statistically valid Orion sample [TBD-2] of LRUs to use for test<br>2. Prepare update package for target Orion LRU and deliver Orion update package from Orion Software Production Facility to IBMS<br>3. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems<br>4. Mission Systems receives update package and promotes update to Mission Control Center system<br>5. Upload configuration data (via CTN) into LRU in the Orion<br>6. Demonstrate Orion LRU functions normally with updated configuration without removal<br>7. Retrieve original baseline, back-out update<br>8. Upload configuration (via CTN) into LRU in the Orion<br>9. Demonstrate Orion LRU functions normally with original baseline software without removal |

# CA3293V-TVR9

**Demonstrate acceptance of LRU firmware update originating from project to ORION through secured network in LEO Loiter (CTN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | LEO Loiter | Verify that the Orion LRUs can accept firmware updates in nominal conditions from Orion project generated change to IBMS over secured network through MCC LAN to Orion in flght during LEO operations phase using each SIL | 1. Randomly select statistically valid Orion sample [TBD-2] of LRUs to use for test<br>2. Prepare update package for target Orion LRU and deliver Orion update package from Orion Software Production Facility to IBMS<br>3. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems<br>4. Mission Systems receives update package and promotes update to Mission Control Center Systems<br>5. Upload software (via CTN) into LRU in the Orion<br>6. Demonstrate Orion LRU functions normally with updated software without removal<br>7. Retrieve original baseline, back-out update<br>8. Upload software (via CTN) into LRU in the Orion<br>9. Demonstrate Orion LRU functions normally with original baseline software without removal |

# CA3293V-TVR11

**Demonstrate acceptance of LRU configuration update originating from project to ORION through secured network to ISS in ISS Attached Operations (SN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | ISS Attached Ops | Verify that the Orion LRUs can accept configuration updates in nominal conditions from Orion project generated change to IBMS over secured network through ISS MCC LAN to Orion in flght during ISS On-orbit operations phase using each SIL | 1. Randomly select statistically valid Orion sample [TBD-2] of LRUs to use for test<br>2. Prepare update package for target Orion LRU and deliver Orion update package from Orion Software Production Facility to IBMS<br>3. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems<br>4. Mission Systems receives update package and promotes update to Mission Control Center System<br>5. Upload configuration data (via SN) into LRU in the Orion (via ISS ICCA)<br>6. Demonstrate Orion LRU functions normally with updated configuration without removal<br>7. Retrieve original baseline, back-out update<br>8. Upload configuration (via SN) into LRU in the Orion (via ISS ICCA)<br>9. Demonstrate Orion LRU functions normally with original baseline software without removal |

# CA3293V-TVR12

**Demonstrate acceptance of LRU firmware update originating from project to ORION through secured network to ISS in ISS Attached Operations (SN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | ISS Attached Ops | Verify that the Orion LRUs can accept firmware updates in nominal conditions from Orion project generated change to IBMS over secured network through ISS MCC LAN to Orion in flght during ISS On-orbit operations phase using each SIL | 1. Randomly select statistically valid Orion sample [TBD-2] of LRUs to use for test<br>2. Prepare update package for target Orion LRU and deliver Orion update package from Orion Software Production Facility to IBMS<br>3. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems<br>4. Mission Systems receives update package and promotes update to Mission Control Center System<br>5. Upload software (via SN) into LRU in the Orion (via ISS ICCA)<br>6. Demonstrate Orion LRU functions normally with updated software without removal<br>7. Retrieve original baseline, back-out update<br>8. Upload software (via SN) into LRU in the Orion (via ISS ICCA)<br>9. Demonstrate Orion LRU functions normally with original baseline software without removal |

# CA3293V-TVR13

**Demonstrate acceptance of LRU software update originating from project to EVA through secured network in pre-launch PAD Operations (Umbilical)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | Pad Operations | Verify that the EVA LRUs can accept software updates in nominal conditions from EVA project generated change to IBMS over secured network through LSS LAN to Vehicle, from Vehcile to EVA on PAD during pre-launch ground processing phase using each SIL | 1. Randomly select statistically valid EVA sample [TBD-3] of LRUs to use for test<br>2. Prepare update package for target EVA LRU and deliver EVA update package from EVA Software Production Facility to IBMS<br>3. IBMS receives update package, verifies update package, builds update and distributes to Ground Systems<br>4. Ground Systems receives update package and promotes update to Ground Systems Launch Control System<br>5. Upload software (via umbilical) into LRU in the EVA 8. Demonstrate EVA LRU functions normally with updated software without removal<br>6. Retrieve original baseline, back-out update<br>7. Upload software (via umbilical) into LRU in the EVA<br>8. Demonstrate EVA LRU functions normally with original baseline software without removal |

# CA3293V-TVR14

**Demonstrate acceptance of LRU configuration update originating from project to EVA through secured network in pre-launch PAD Operations (Umbilical)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | Pad Operations | Verify that the EVA LRUs can accept configuration updates in nominal conditions from EVA project generated change to IBMS over secured network through LSS LAN to Vehicle, from Vehcile to EVA on PAD during pre-launch ground processing phase using each SIL | 1. Randomly select statistically valid EVA sample [TBD-3] of LRUs to use for test<br>2. Prepare update package for target EVA LRU and deliver EVA update package from EVA Software Production Facility to IBMS<br>3. IBMS receives update package, verifies update package, builds update and distributes to Ground Systems 5. Ground Systems receives update package and promotes update to Launch Control System<br>4. Upload configuration data (via umbilical) into LRU in the EVA 8. Demonstrate EVA LRU functions normally with updated configuration without removal<br>5. Retrieve original baseline, back-out update<br>6. Upload configuration data (via umbilical) into LRU in the EVA<br>7. Demonstrate EVA LRU functions normally with original baseline configuration without removal |

# CA3293V-TVR15

**Demonstrate acceptance of LRU software update originating from project to EVA through secured network to ISS/Orion in ISS Attached Ops (SN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | ISS Attached Ops (ISS) | Verify that the EVA Suit LRUs can accept software updates in nominal conditions from EVA project generated change to IBMS over secured network through ISS MCC LAN to ISS to EVA Suit in flght during ISS On-orbit operations phase using each SIL | 1. Randomly select statistically valid EVA sample [TBD-3] of LRUs to use for test 2. Prepare update package for target EVA LRU and deliver EVA update package from EVA Software Production Facility to IBMS 4. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems 5. Mission Systems receives update package and promotes update to Mission Control Center System 6. Upload software (via SN) into LRU in the EVA (via ISS) 8. Demonstrate EVA LRU functions normally with updated software without removal 9. Retrieve original baseline, backout update 10. Upload software (via SN) into LRU in the EVA (via ISS) 11. Demonstrate EVA LRU functions normally with original basline software without removal |

# CA3293V-TVR16

**Demonstrate acceptance of LRU configuration update originating from project to EVA through secured network to ISS/Orion in ISS Attached Ops (SN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | ISS Attached Ops (ISS) | Verify that the EVA Suit LRUs can accept configuration updates in nominal conditions from EVA project generated change to IBMS over secured network through ISS MCC LAN to ISS with EVA Suit connected in flght during ISS On-orbit operations phase using each SIL | 1. Randomly select statistically valid EVA sample [TBD-3] of LRUs to use for test 2. Prepare update package for target EVA LRU and deliver EVA update package from EVA Software Production Facility to IBMS 4. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems 5. Mission Systems receives update package and promotes update to Mission Control Center System 6. Upload configuration data (via SN) into LRU in the EVA (via ISS) 8. Demonstrate EVA LRU functions normally with updated configuration without removal 9. Retrieve original baseline, backout update 10. Upload configuration (via SN) into LRU in the EVA (via ISS) 11. Demonstrate EVA LRU functions normally with original basline configuraiton without removal |

# CA3293V-TVR17

**Demonstrate acceptance of LRU software update originating from project to EVA through secured network to ISS in ISS Attached Ops (SN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | ISS Attached Ops (ISS) | Verify that the EVA Suit LRUs can accept software updates in nominal conditions from EVA project generated change to IBMS over secured network through ISS MCC LAN to ISS to EVA Suit in flght during ISS On-orbit operations phase using each SIL | 1. Randomly select statistically valid EVA sample [TBD-3] of LRUs to use for test 2. Prepare update package for target EVA LRU and deliver EVA update package from EVA Software Production Facility to IBMS 4. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems 5. Mission Systems receives update package and promotes update to Mission Control Center System 6. Upload software (via SN) into LRU in the EVA (via ISS) 8. Demonstrate EVA LRU functions normally with updated software without removal 9. Retrieve original baseline, backout update 10. Upload software (via SN) into LRU in the EVA (via ISS) 11. Demonstrate EVA LRU functions normally with original basline software without removal |

# CA3293V-TVR18

**Demonstrate acceptance of LRU configuration update originating from project to EVA through secured network to ISS in ISS Attached Ops (SN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | ISS Attached Ops (ISS) | Verify that the EVA Suit LRUs can accept configuration updates in nominal conditions from EVA project generated change to IBMS over secured network through ISS MCC LAN to ISS with EVA Suit connected in flght during ISS On-orbit operations phase using each SIL | 1. Randomly select statistically valid EVA sample [TBD-3] of LRUs to use for test 2. Prepare update package for target EVA LRU and deliver EVA update package from EVA Software Production Facility to IBMS 4. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems 5. Mission Systems receives update package and promotes update to Mission Control Center System 6. Upload configuration data (via SN) into LRU in the EVA (via ISS) 8. Demonstrate EVA LRU functions normally with updated configuration without removal 9. Retrieve original baseline, backout update 10. Upload configuration (via SN) into LRU in the EVA (via ISS) 11. Demonstrate EVA LRU functions normally with original basline configuraiton without removal |

# CA3293V-TVR19

**Demonstrate acceptance of LRU software update originating from project to ARES I through secured network in On-PAD Operations (CTN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | On-PAD Ops | Verify that the ARES I LRUs can accept software updates in nominal conditions from ARES I project generated change to IBMS over secured network through MCC LAN to ARES I during on-PAD operations phase using each SIL | 1. Randomly select statistically valid ARES I sample [TBD-2] of LRUs to use for test 2. Prepare updat package for target ARES I LRU and deliver ARES I update package from ARES I Software Productio Facility to IBMS 4. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems 5. Mission Systems receives update package and promotes update to Mission Control Center System 6. Upload software (via CTN) into LRU in the ARES I 8. Demonstrate ARES I LRU functions normally with updated software without removal 9. Retrieve original baseline, backout update 10. Upload software (via CTN) into LRU in the ARES I 11. Demonstrate ARES I LRU functions normally with original basline software without removal |

# CA3293V-TVR20

**Demonstrate acceptance of LRU config update originating from project to ARES I through secured network in On-PAD Operations (CTN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | On-PAD Ops | Verify that the ARES I LRUs can accept config updates in nominal conditions from ARES I project generated change to IBMS over secured network through MCC LAN to Orion during on-PAD operations phase using each SIL | 1. Randomly select statistically valid ARES I sample [TBD-2] of LRUs to use for test<br>2. Prepare update package for target ARES I LRU and deliver ARES I update package from ARES I Software Production Facility to IBMS<br>3. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems<br>4. Mission Systems receives update package and promotes update to Mission Control Center system<br>5. Upload software (via CTN) into LRU in the ARES I<br>6. Demonstrate ARES I LRU functions normally with updated software without removal<br>7. Retrieve original baseline, back-out update<br>8. Upload software (via CTN) into LRU in the ARES I<br>9. Demonstrate ARES I LRU functions normally with original baseline software without removal |

# CA3293V-TVR21

**Demonstrate acceptance of LRU firmware update originating from project to ARES I through secured network in On-PAD Operations (CTN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | On-PAD Ops | Verify that the ARES I LRUs can accept Firmware updates in nominal conditions from ARES I project generated change to IBMS over secured network through MCC LAN to ARES I during on-PAD operations phase using each SIL | 1. Randomly select statistically valid ARES I sample [TBD-2] of LRUs to use for test 2. Prepare updat package for target ARES I LRU and deliver ARES I update package from ARES I Software Productio Facility to IBMS 4. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems 5. Mission Systems receives update package and promotes update to Mission Control Center System 6. Upload software (via CTN) into LRU in the ARES I 8. Demonstrate ARES I LRU functions normally with updated software without removal 9. Retrieve original baseline, backout update 10. Upload software (via CTN) into LRU in the ARES I 11. Demonstrate ARES I LRU functions normally with original basline software without removal |

# CA3293V-TVR22

**Demonstrate acceptance of LRU software update originating from project to EVA through secured network in LEO Loiter (CTN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | LEO Loiter | Verify that the EVA LRUs can accept software updates in nominal conditions from EVA project generated change to IBMS over secured network through MCC LAN to Orion to EVA in flght during LEO operations phase using each SIL | 1. Randomly select statistically valid EVA sample [TBD-3] of LRUs to use for test 2. Prepare update package for target EVA LRU and deliver EVA update package from EVA Software Production Facility to IBMS 4. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems 5. Mission Systems receives update package and promotes update to Mission Control Center System 6. Upload software (via CTN) into LRU in the Orion 7. Transfer Update from Orion to EVA 8. Demonstrate EVA LRU functions normally with updated software without removal 9. Retrieve original baseline, backout update 10. Upload software (via CTN) into LRU in the Orion 11, Transfer original from Orion To EVA 12. Demonstrate Orion LRU functions normally with original baseline software Without removal |

# CA3293V-TVR23

**Demonstrate acceptance of LRU configuration update originating from project to EVA through secured network in LEO Loiter (CTN)**

| Verification Phase | V&V METHOD | DRM | Mission Phase | Verification Objective | Verification Activity |
|---|---|---|---|---|---|
| Acceptance | Demonstrate | ISS | LEO Loiter | Verify that the EVA LRUs can accept Configuration updates in nominal conditions from EVA project generated change to IBMS over secured network through MCC LAN to Orion to EVA in flght during LEO operations phase using each SIL | 1. Randomly select statistically valid EVA sample [TBD-3] of LRUs to use for test 2. Prepare update package for target EVA LRU and deliver EVA update package from EVA Software Production Facility to IBMS 4. IBMS receives update package, verifies update package, builds update and distributes to Mission Systems 5. Mission Systems receives update package and promotes update to Mission Control Center System 6. Upload software (via CTN) into LRU in the Orion 7. Transfer Update from Orion to EVA 8. Demonstrate EVA LRU functions normally with updated software without removal 9. Retrieve original baseline, backout update 10. Upload software (via CTN) into LRU in the Orion 11, Transfer original from Orion To EVA 12. Demonstrate Orion LRU functions normally with original baseline software Without removal |

# SAVIO CARD TVR Review

## CA6210-PO
## RIC: Critical Communication Latency

**Elton Witt**
**SAVIO V&V**

**TVCP**
**May 20, 2009**

# CA6210-PO Requirement (updated by DCN 200)

**[CA6210-PO] The Constellation Architecture shall provide end-to-end latency for the Orion/Ares I integrated stack no greater than that specified in the Launch/Ascent Latency Sub-Allocation for Services Table.**

**Applicable Design Reference Missions: Lunar Sortie Crew, Lunar Outpost Cargo, Lunar Outpost Crew, ISS Crew, ISS Cargo**

***Rationale: Maximum end-to-end latencies are essential to ensure the performance of information paths across multiple systems. Information latencies are critical to certain operations and phases of flight, including, but not limited to ascent abort notifications and range safety decision making.***

***End-to-End Data Latency: End-to-end latency is the time from the instant that an event is detected until the instant that the resulting information is displayed, processed, or acted upon at its final destination. Serial data transfers are measured from the time the last bit is transmitted or received across the interface. The Total Allocation values for Range Safety, Forward and Return Voice, and Commanding includes free space propagation time of 300 ms.***

***Automatic Integrated Stack Abort: This is the ascent abort case that starts at Ares initial detection of a confirming signal of an abort condition and ends with Orion's LAS at 80% thrust. This case includes all detection, processing, and data transfers (across internal hard-lines) between vehicles and pertinent internal subsystems. Sensor latency is not included because it is application dependent and can vary widely. Allocations for Automated Integrated Stack Abort latency are on based general agreement from the aborts community that the End-to-End 500 ms estimate is acceptable for currently known ascent abort scenarios. The allocations to Projects are consistent with analysis of current hardware and software architectures with approximately 34% system level timing margin.***

# TABLE 3.2.10-1 Launch/Ascent Latency Sub-Allocation for Services (per DCN 200)

| System / Interface | Automatic Integrated Stack Abort (sec) | Range Safety (MOL Return) Max Delay (sec) | Launch/Ascent Voice Return (Orion to MS) Max Delay (sec) | Launch/Ascent Voice Forward (MS to Orion) Max Delay (sec) | Launch/Ascent CMD Max Delay (sec) |
|---|---|---|---|---|---|
| Ares I * | 0.2 | 0.2 | N/A | N/A | 0.04 |
| Orion * | 0.300 | 0.390 | 0.500 | 0.660 | 0.560 |
| SCAN * | N/A | 0.150 | 0.150 | 0.300 | 0.300 |
| MS * | N/A | 0.350 | 0.350 | 0.333 | 0.293 |
| GS * | N/A | 0.010 | N/A | N/A | N/A |
| USAF * | N/A | 0.563 | N/A | N/A | N/A |
| Total Allocation * | 0.500 | 1.963 | 1.300 | 1.593 | 1.453 |
| Program Margin * | 0.000 | 0.393 | 0.260 | 0.319 | 0.299 |
| Cx End-to-End Delay | 0.500 | 2.356 | 1.560 | 1.912 | 1.792 |

* For information only. Project requirements are in section 3.7 of this document. SCaN requirement in CxP 70169 and USAF requirement in CxP 70159.

300 ms free space propagation added

# TABLE 3.2.10-1 Launch/Ascent Latency Sub-Allocation for Services (per DCN 200)

| System / Interface | Automatic Integrated Stack Abort (sec) | Range Safety (MOL Return) Max Delay (sec) | Launch/Ascent Voice Return (Orion to MS) Max Delay (sec) | Launch/Ascent Voice Forward (MS to Orion) Max Delay (sec) | Launch/Ascent CMD Max Delay (sec) |
|---|---|---|---|---|---|
| Ares I * | CA6293-PO | CA6214-PO | N/A | N/A | CA6294-PO |
| Orion * | CA6291-PO | CA6212-PO | CA6298-PO | CA6213-PO | CA6292-PO |
| SCAN * | N/A | 0.150 | 0.150 | 0.300 | 0.300 |
| MS * | N/A | CA6215-PO | CA6216-PO | CA6297-PO | CA6295-PO |
| GS * | N/A | CA6296-PO | N/A | N/A | N/A |
| USAF * | N/A | 0.563 | N/A | N/A | N/A |
| Total Allocation * | 0.500 | 1.963 | 1.300 | 1.593 | 1.453 |
| Program Margin * | 0.000 | 0.393 | 0.260 | 0.319 | 0.299 |
| Cx End-to-End Delay | 0.500 | 2.356 | 1.560 | 1.912 | 1.792 |

3.2 Requirement is only this row (Unique 3.7s for project allocations)

Each column is verified independently

# CA6210-PO VR (DCN 200 version)

**[CA6210V-PO] Verification of end-to-end latency, no greater than that specified in the Launch/Ascent Latency Sub-Allocation for Services Table, shall be performed by test and analysis.**

**Verification of end-to-end latency shall be performed by testing the end-to-end system under simulated, flight/mission-like conditions for each column in the table. The test shall document the end-to-end latency, margin to requirement, and as-run conditions for each test configuration (each column in the table). Analysis shall be performed to ensure that the latency within each system for the services identified in the Launch/Ascent Latency Sub-Allocation for Services Table are within the specified allocation, or that the total overage in individual allocations does not exceed the program margin. Each column shall be analyzed independently supported by verification closures of lower level or externally levied requirements (tests).**

**The verification shall be considered successful when a) the test shows a positive margin for end-to-end latency for each column in the table (test configuration), and b) the analysis shows that the sum of the individual system latencies (lower level tests) is equal to or less than the total allocation plus program margin, for each column independently.**

***Rationale: Analysis of system performance (at this level) ensures that systems are individually meeting their allocations, or not exceeding established margins. Testing end-to-end performance is a reasonable way to confirm that program margins are positive.***

# TVR Summary and Metrics

| System / Interface | Automatic Integrated Stack Abort (sec) | Range Safety (MOL Return) Max Delay (sec) | Launch/Ascent Voice Return (Orion to MS) Max Delay (sec) | Launch/Ascent Voice Forward (MS to Orion) Max Delay (sec) | Launch/Ascent CMD Max Delay (sec) |
|---|---|---|---|---|---|
| Cx End-to-End Delay | 0.500 | 2.356 | 1.560 | 1.912 | 1.792 |
| Analysis | 1 | 1 | 1 | 1 | 1 |
| Inspection | | | | | |
| Test | 1 | 1 | 1 | 1 | 1 |
| Demo | | | | | |

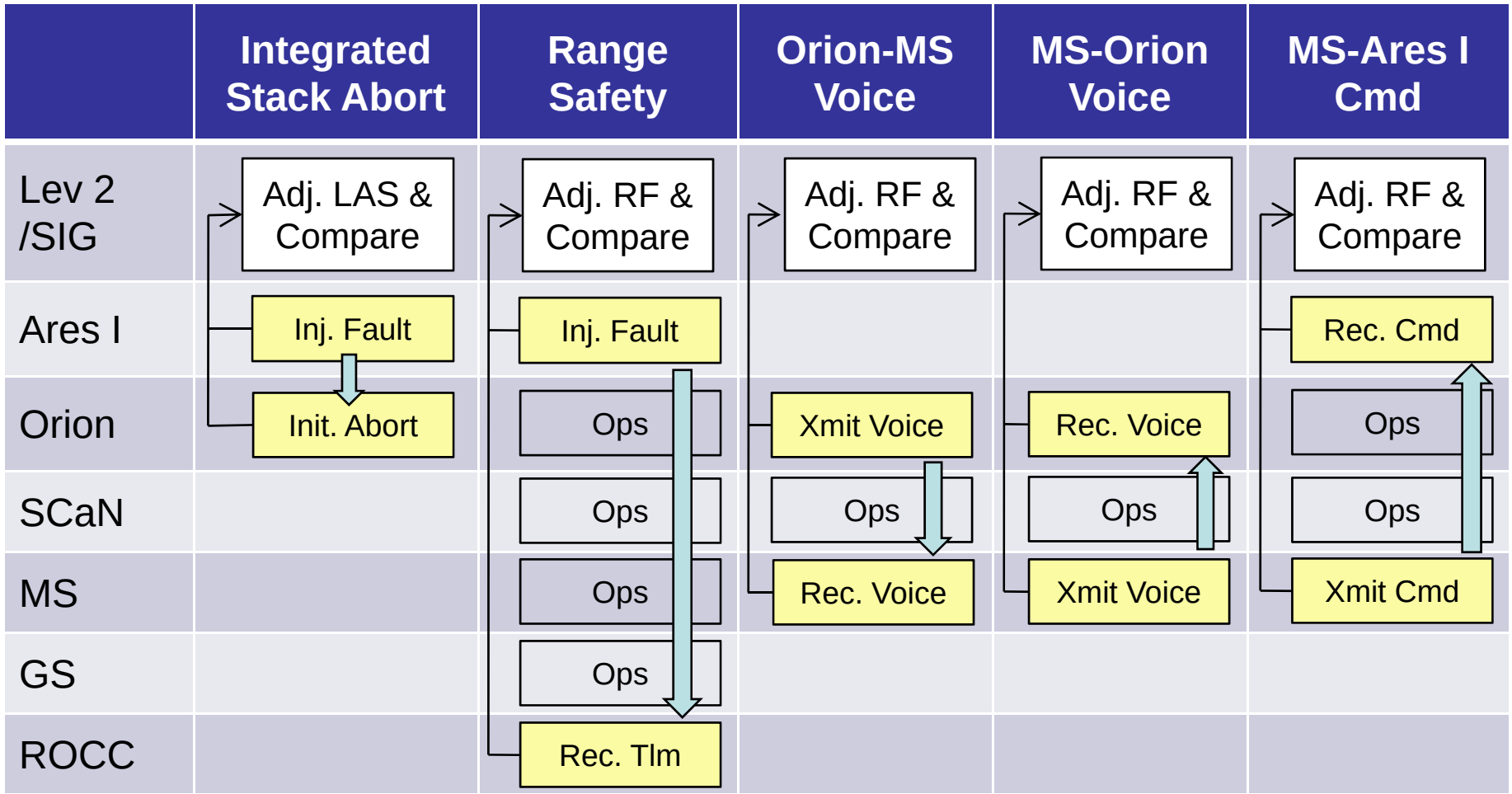
Analysis: VRs at 3.7 level call for test. Analysis at 3.2 level uses the 3.7 values to determine if 'sum' meets requirement.

Test: E2E test is performed to measure delay using integrated Cx systems. This also provides a quantified margin for each critical function.

# CA6210-PO VLN Diagram - Analysis

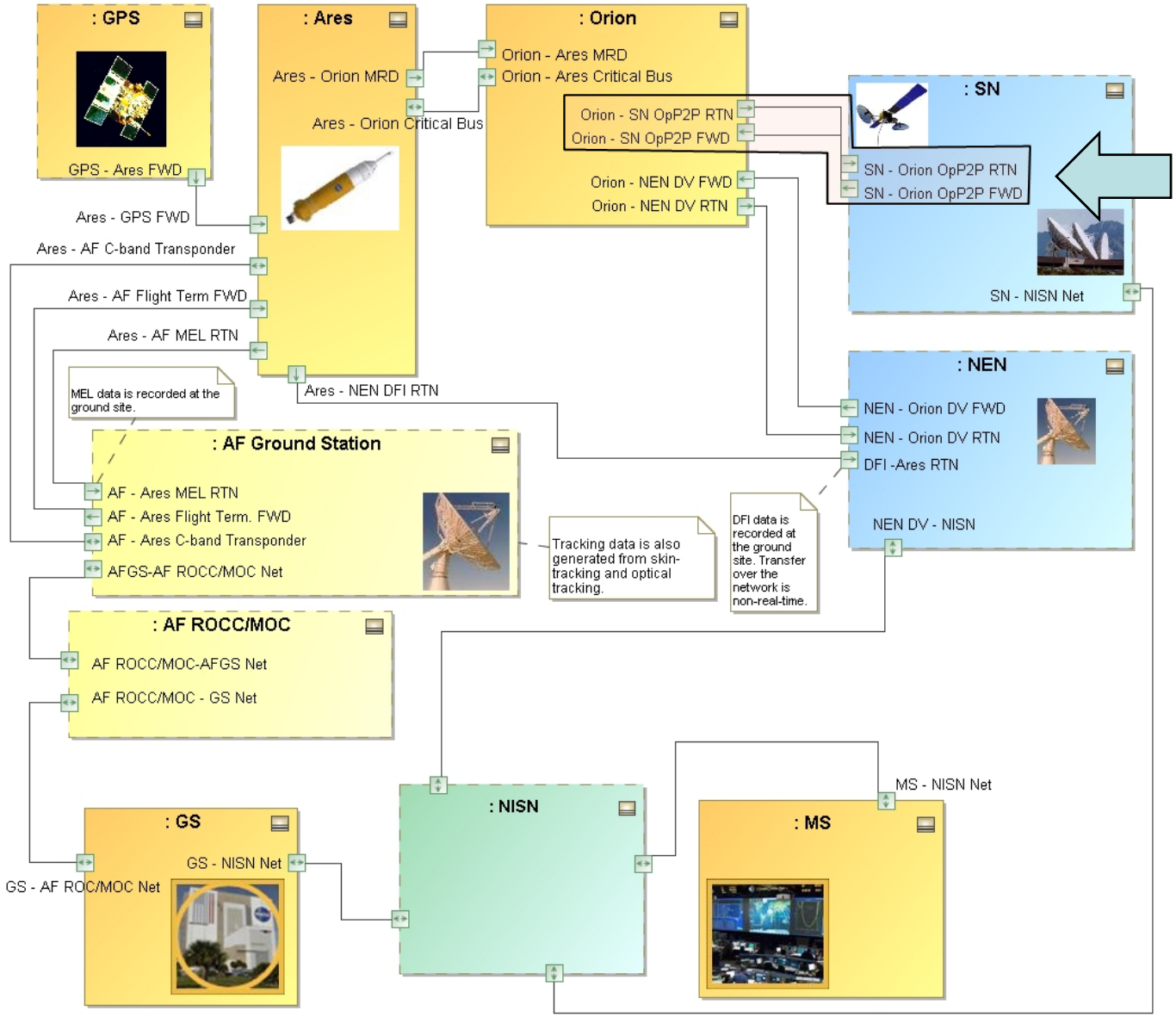
| | Integrated Stack Abort | Range Safety | Orion-MS Voice | MS-Orion Voice | MS-Ares I Cmd |
|---|---|---|---|---|---|
| Lev 2 / SIG | Sum & Compare | Sum & Compare | Sum & Compare | Sum & Compare | Sum & Compare |
| Ares I | CA6293-PO | CA6214-PO | | | CA6294-PO |
| Orion | CA6291-PO | CA6212-PO | CA6298-PO | CA6213-PO | CA6292-PO |
| SCaN | | 0.15 s | 0.15 s | 0.3 s | 0.3 s |
| MS | | CA6215-PO | CA6216-PO | CA6297-PO | CA6295-PO |
| GS | | CA6296-PO | | | |
| ROCC | | 0.563 s | | | |
| Program Margin | | 0.393 s | 0.260 s | 0.319 s | 0.299 s |

# CA6210-PO VLN Diagram - Test




- Test activity to measure delay in data start to end (yellow boxes)
- L2 activity to mathematically compensate (adjust) ground test data to reflect flight environment

# Adjustment in Tests for as-run vs. max RF delay




- The delay in the RF link between Orion and TDRS must be adjusted after the test
- The delay in the as-run configuration using stationary ground based “vehicles” is calculated using the distance between TDRS and the uplink site
- This value is replaced by the max RF link delay by simply subtracting the as-run value and adding the max RF link delay value.
- Simple Light-speed distance/time calculations are very accurate

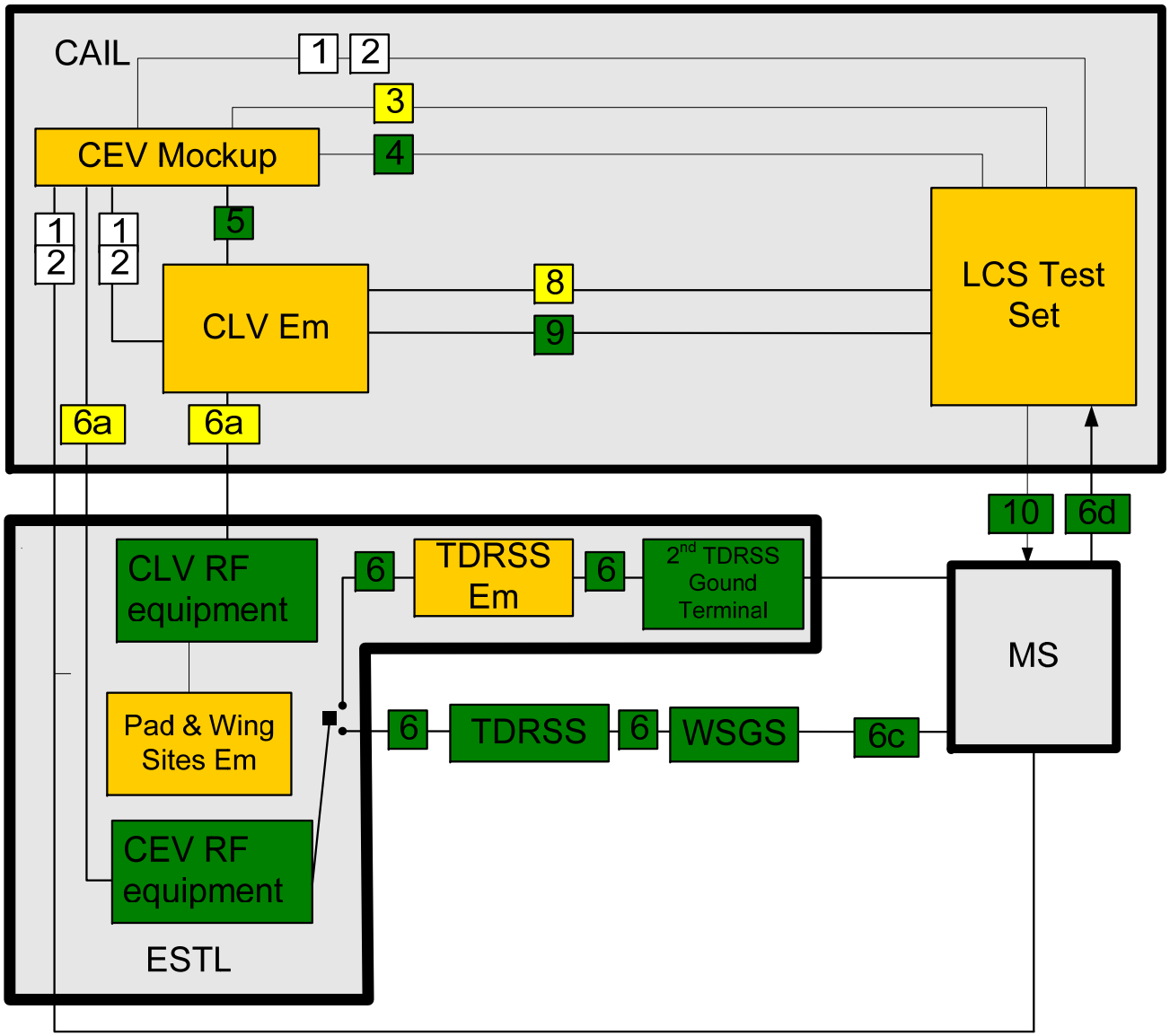
Ref: CSADD

# CA6210-PO TVRs (Embedded Excel File)

## Double-click to open TVR file

Microsoft
e Excel Works

# Notional CAIL-based Integrated Test Set-up




1 Synch & Truth Data
2 Test Control & Automation
3 CEV T0 Non-avionics
4 CEV T0 Avionics
5 CEV-CLV bus interface
6a Baseband & Control (Baseband over fiber)
6 C3I RF
6c C3I Ground Station
6d Downlink CEV & CLV Tlm
8 CLV T0 Non-avionics
9 CLV T0 Avionics
10 LCS / MS: TLM
Sim Support
Flight like
Not Flight like

Ref: Orion External Interface document from PTR #2