NextSTEP Habitat Ground Test

EVA Technology Workshop 2017

October 17, 2017
Bill Othon
NextSTEP Ground Test lead
Exploration Integration and Test Lead/EA53

NextSTEP Hab Overview

NextSTEP Phase 1: 2015-2016

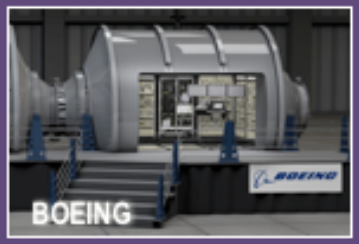
Cislunar habitation concepts that leverage commercialization plans for LEO

FOUR SIGNIFICANTLY DIFFERENT CONCEPTS RECEIVED

Partners develop required deliverables, including concept descriptions with concept of operations, NextSTEP Phase 2 proposals, and statements of work.

NextSTEP Phase 2: 2016-2018

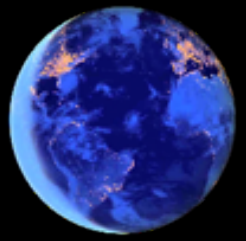
FIVE GROUND PROTOTYPES BY 2018



- Partners refine concepts and develop ground prototypes.
- NASA leads standards and common interfaces development.

ONE CONCEPT STUDY

Initial discussions with international partners



Define reference habitat architecture in preparation for Phase 3.

Phase 3: 2018+

- Partnership and Acquisition approach, leveraging domestic and international capabilities
- Development of deep space habitation capabilities
- Deliverables: flight unit(s)

NextSTEP Phase 2 Goal

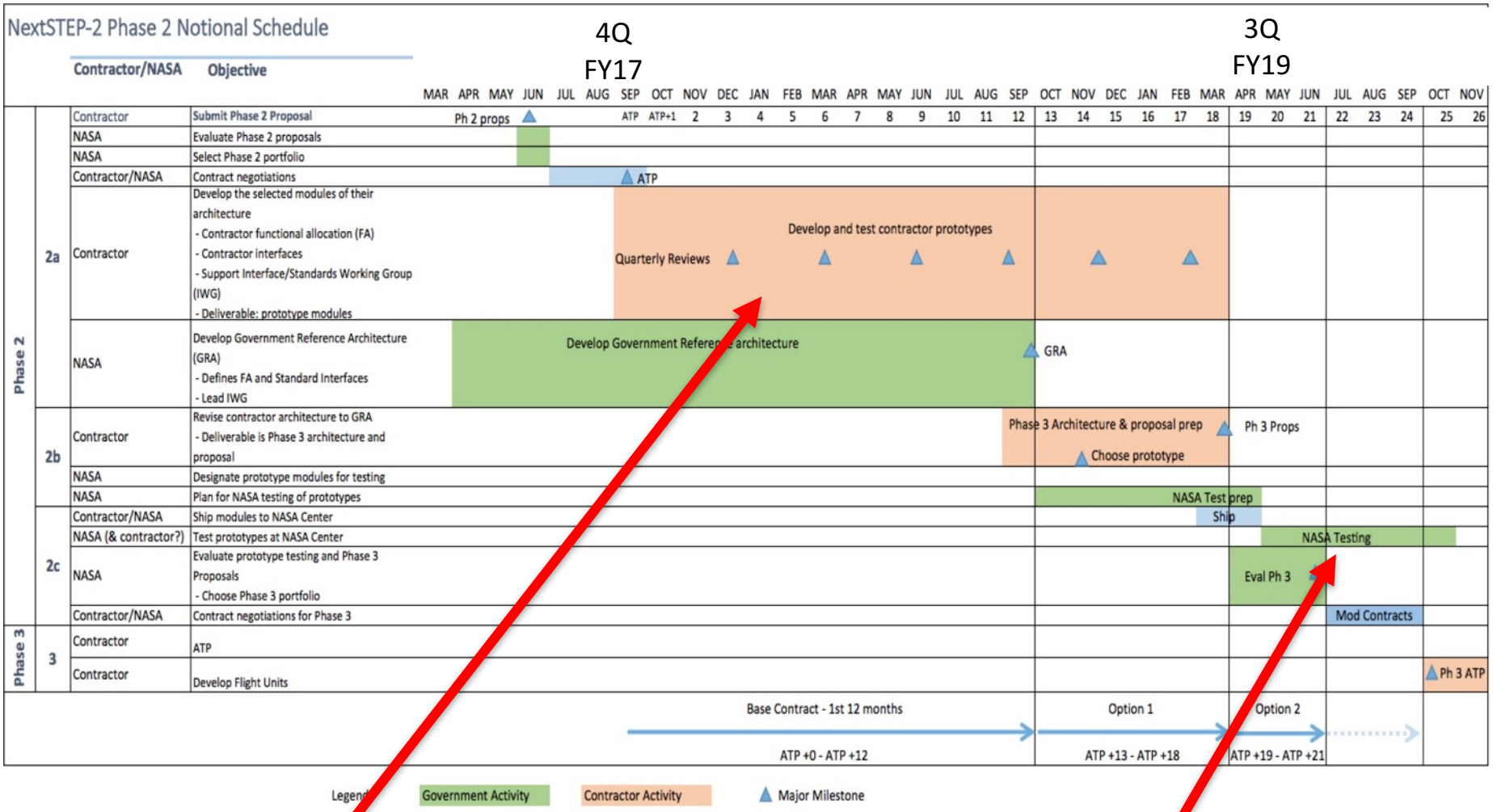
Develop a deep space habitat for ground-based testing by 2018, while simultaneously stimulating commercial habitat development in LEO

- Develop long-duration deep-space habitation capabilities that lead towards a deep-space transit habitat and can be flown on SLS flight(s) (or alternative launch vehicles) starting by the early to Mid 2020s.
- Advance the long duration deep space habitation capability concepts and mature the design and development of the integrated system(s) to achieve a high level of fidelity.
  - Developing prototype deep space habitation capability options to test a full size ground prototype unit(s) by the end of Phase 2 in 2018 to support first flight opportunities in Early to Mid 2020s
- Potential for different capabilities from domestic and international suppliers will require standards and common interfaces for aggregation. NASA led standards working group will be implemented during Phase 2.

Ground Prototype units delivered to NASA for testing and integration of NASA developed habitation systems

- Testing includes form, fit, volumetric, subsystem integration, and interface standards
- May use NASA-developed node/airlock and hab mockups for integration testing with contractor modules
- Ensures consistent test and interface verification approach, allows us to incorporate and test other AES subsystems, facilitates crew training and feedback on human factors, shows stakeholders progress

NextSTEP Phase 2 Schedule



18 Months of Prototype Development

6 Months of NASA Evaluation

Habitat Ground Testing

NextSTEP Ground Test

- Purpose of NextSTEP Ground Testing
  - Evaluate design concepts for habitation systems, through test
    - Use test to support RAC and DAC analysis
  - Mature requirements for NextSTEP Phase 3
- NextSTEP is a Public/Private Partnership
  - Collaborate with partners, to ensure design ideas are fully explored
  - Allow NASA to make the most of the limited time we have for test
- Identify elements of design that impact integrated performance
  - Packaging
  - Logistics
  - Consumables
  - Interfaces

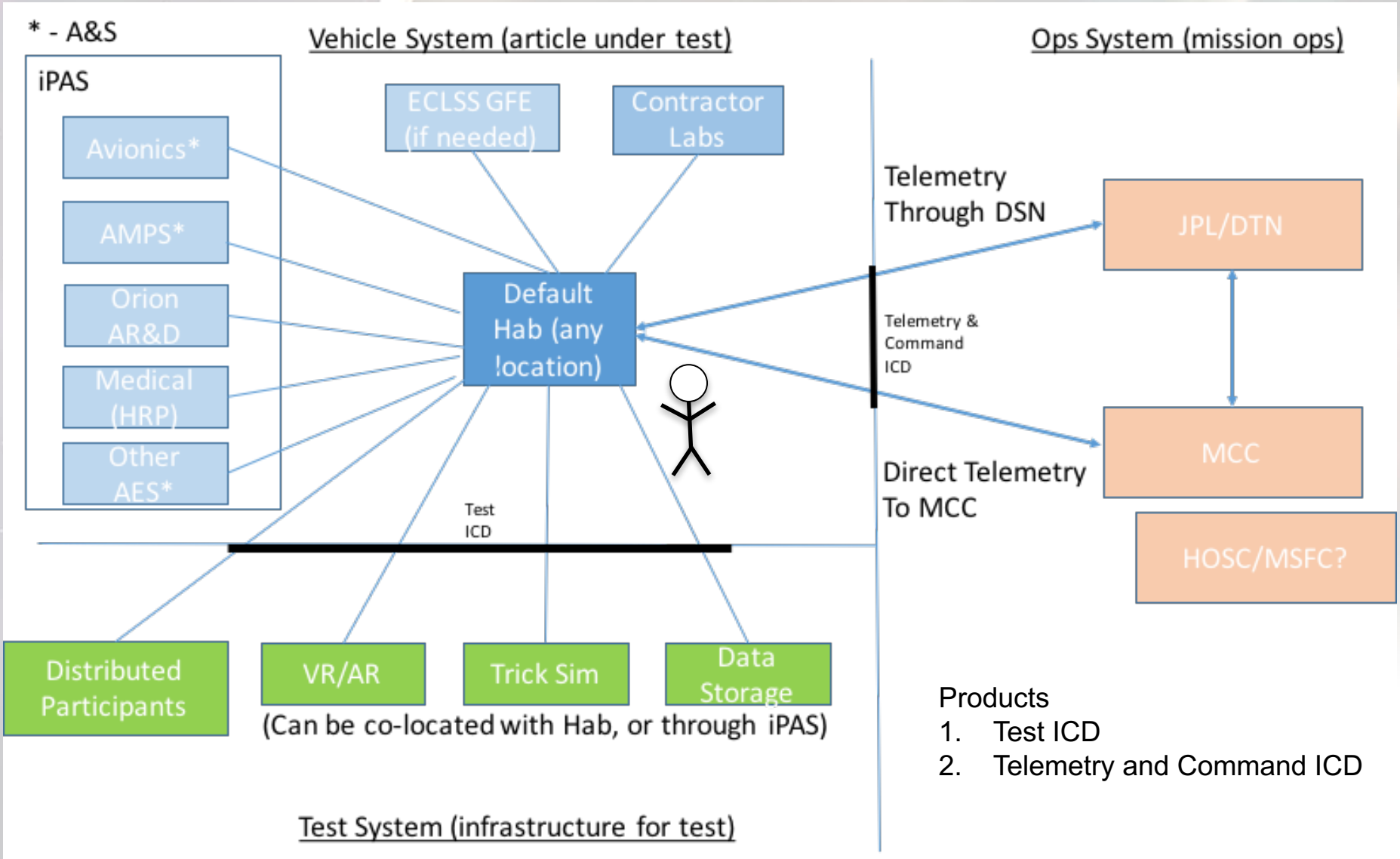
Goal: Prepare habitat systems for successful Ground Test execution

NextSTEP Ground Test

- Focus for FY17
  - Engage Stakeholders and Subject Matter Experts
    - "Break the Silos"
  - Develop and practice methodology for test
    - Includes managing Requirements, Test Objectives, Execution Plan
  - Develop and mature capability for integration and test
    - Ground Test Services: Architecture, Simulation, Visualization
    - Environments: iPAS "Flat Hab" and B9 Habitat Modules
  - If possible, derive value from tests (but not biggest thing this year)

Train the Testers and Prepare the Infrastructure

Test Architecture



Products

1. Test ICD
2. Telemetry and Command ICD

Ground Test Methodology – Top Down

HEOMD Exploration Objectives

- Objective 1.1: Expand human presence into the solar system and to the surface of Mars to advance exploration, science, innovation, benefits to humanity, and international collaboration

⋮

Hab Flight Objectives (BAA, FCT, HRP)

- ***Transportation:*** CTO TRN021 - Demonstrate Orion's ability to support missions with at least 4 crew of 21+ days in conjunction with additional elements

⋮

- ***Working in Space:*** CTO WIS006 - Demonstrate cis-lunar transit habitat EVA system servicing accommodation

- ***Staying Healthy:*** CTO STH012 -Obtain data and evaluate the ability to monitor recovery, purification, storage, and reuse of water for human consumption.

⋮

Stack-Level Functional Requirements

- The cis-lunar habitat shall accommodate one 30 – 60 day mission per year.
- The cis-lunar habitat shall provide accommodations for personal hygiene, including WCS operations, bathing, dental hygiene, personal grooming, etc. for 4 crewmembers.
- The cis-lunar habitat shall be designed to perform EVAs without depressurization of the Orion Crew Vehicle or the habitation element.
- The cis-lunar habitat shall provide robotic operations for berthing and repositioning.

⋮

Ground Test Objectives & Analysis Protocols

- Evaluate three different exercise devices in the various habitat options, accessing location, volumes, interferences etc.
  - Rationale
  - Hypothesis

⋮

Evaluation Methods

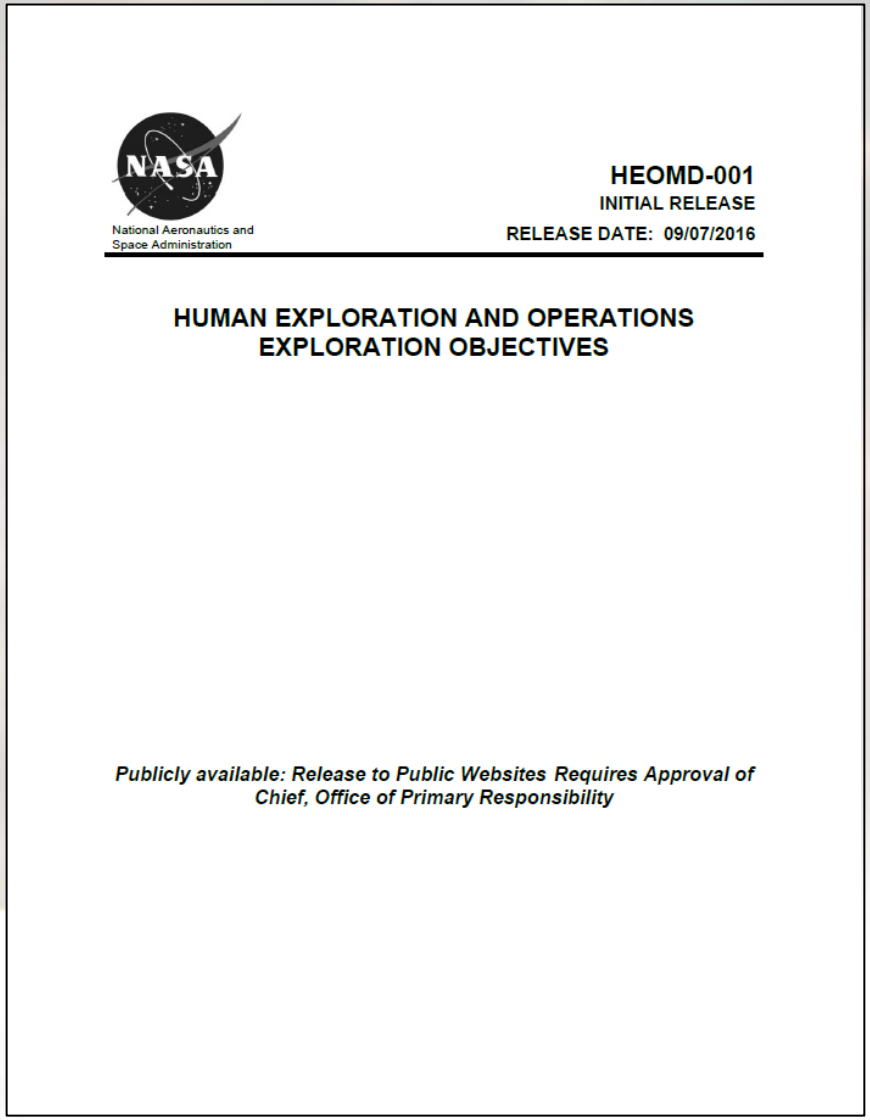
- Inspection
- Demonstration
- Analysis
- Subsystem stand-alone test
- Human-in-the-loop single day test
- Human-in-the-loop multi-day test

CTO = candidate test objective
TRN = transportation
WIS = working in space
STH = staying healthy

Source: Mike Gernhardt, Steve Chappel, Kara Beaton

HEOMD Objectives

- The National Space Policy of the United States of America directs that the Administrator of NASA shall:
  - Set far-reaching exploration milestones. By 2025, begin crewed missions beyond the Moon, including sending humans to an asteroid. By the mid-2030s, send humans to orbit Mars and return them safely to Earth.
- The NASA Authorization Act of 2010 establishes the following as a matter of national policy:
  - A long term objective for human exploration of space should be the eventual international exploration of Mars.
- The 2014 NASA Strategic Plan codifies this national policy as Agency policy under Strategic Goal 1:
  - Strategic Goal 1: Expand the frontiers of knowledge, capability, and opportunity in space.
- In support of this Agency Strategic Goal 1, HEOMD is responsible for three Objectives that are relevant to the establishment of the Exploration Objectives:
  - Objective 1.1: Expand human presence into the solar system and to the surface of Mars to advance exploration, science, innovation, benefits to humanity, and international collaboration.
  - Objective 1.2: Conduct research on the International Space Station (ISS) to enable future space exploration, facilitate a commercial space economy, and advance the fundamental biological and physical sciences for the benefit of humanity.
  - Objective 1.3: Facilitate and utilize U.S. commercial capabilities to deliver crew and cargo to space.



National Aeronautics and Space Administration

HEOMD-001
INITIAL RELEASE
RELEASE DATE: 09/07/2016

HUMAN EXPLORATION AND OPERATIONS EXPLORATION OBJECTIVES

Publicly available: Release to Public Websites Requires Approval of Chief, Office of Primary Responsibility

Ground Test Methodology – Bottoms Up

- SME List from NextSTEP
- Developed with Dan Sweeney
- Outreach to EA/FCT

- Common Introduction
- Introduce Test Objectives Request (TOR) form - Sharepoint
- Practice developing a few test objectives
- Trained to use Sharepoint list

- Teams met separately
- Developed 3-5 test objectives per area
- Teams enter objectives into Sharepoint

- Reviewed directly from Sharepoint
- Collected comments from broad team
- Learned how to write test objectives

- April

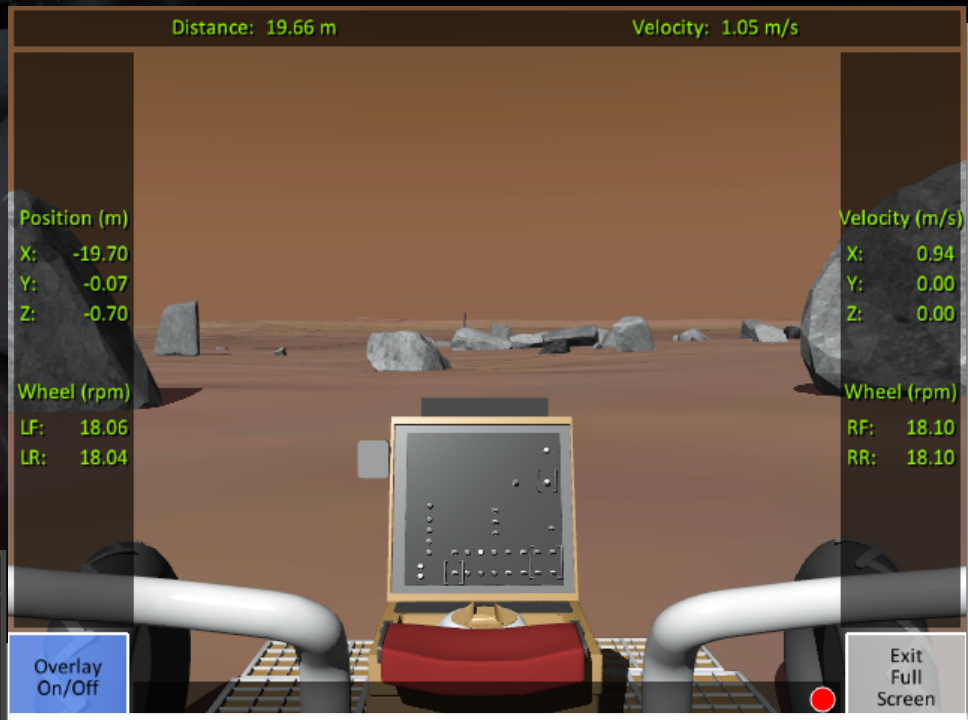
Identify meaningful and achievable objectives for Ground Test.

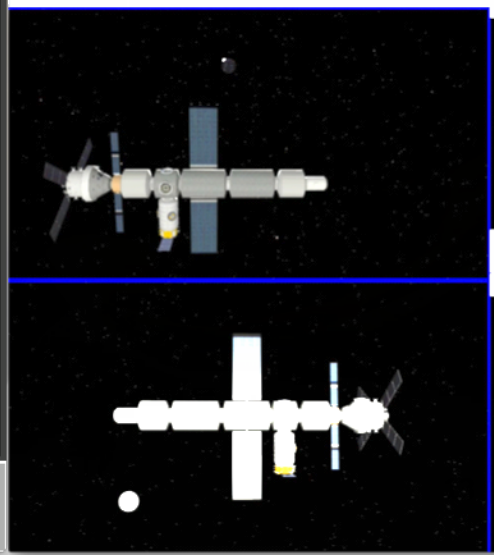
Test Objectives from SMEs

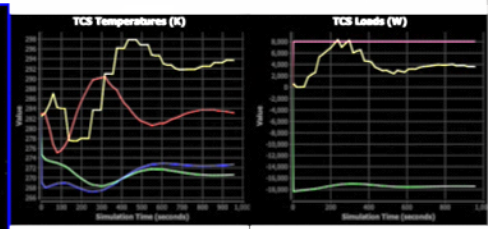
Group	Domain
GFE	ECLSS
GFE	Exercise
GFE	Radiation
GFE	SoftGoods
GFE	Windows
AES	Avionics & Software
AES	Power
AES	Autonomy
AES	Comm/ DTN
AES	Logistics
AES	Advanced EMU/ EVA
HRP	ExMC
HRP	Human Factors & Habitability
Domain	Propulsion
Domain	GNC
Domain	Structures
Domain	Active Thermal Control
Domain	EVA
Domain	MCC/Ops
Domain	Safety & MA
Domain	Robotics
Domain	Science

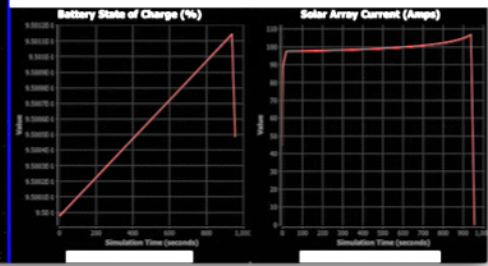
- Identified SMEs per category
- Consider test objectives
- Focus on what is achievable through Ground Test
  - VR
  - Simulation
  - Hardware Test

Simulation – Dr. Zack Crues



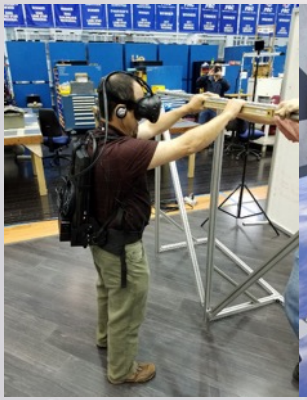


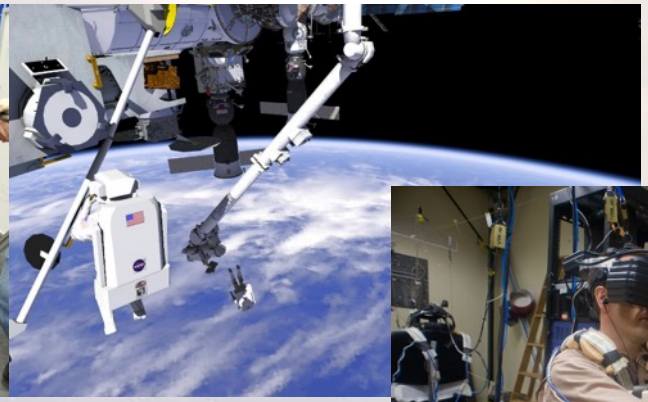




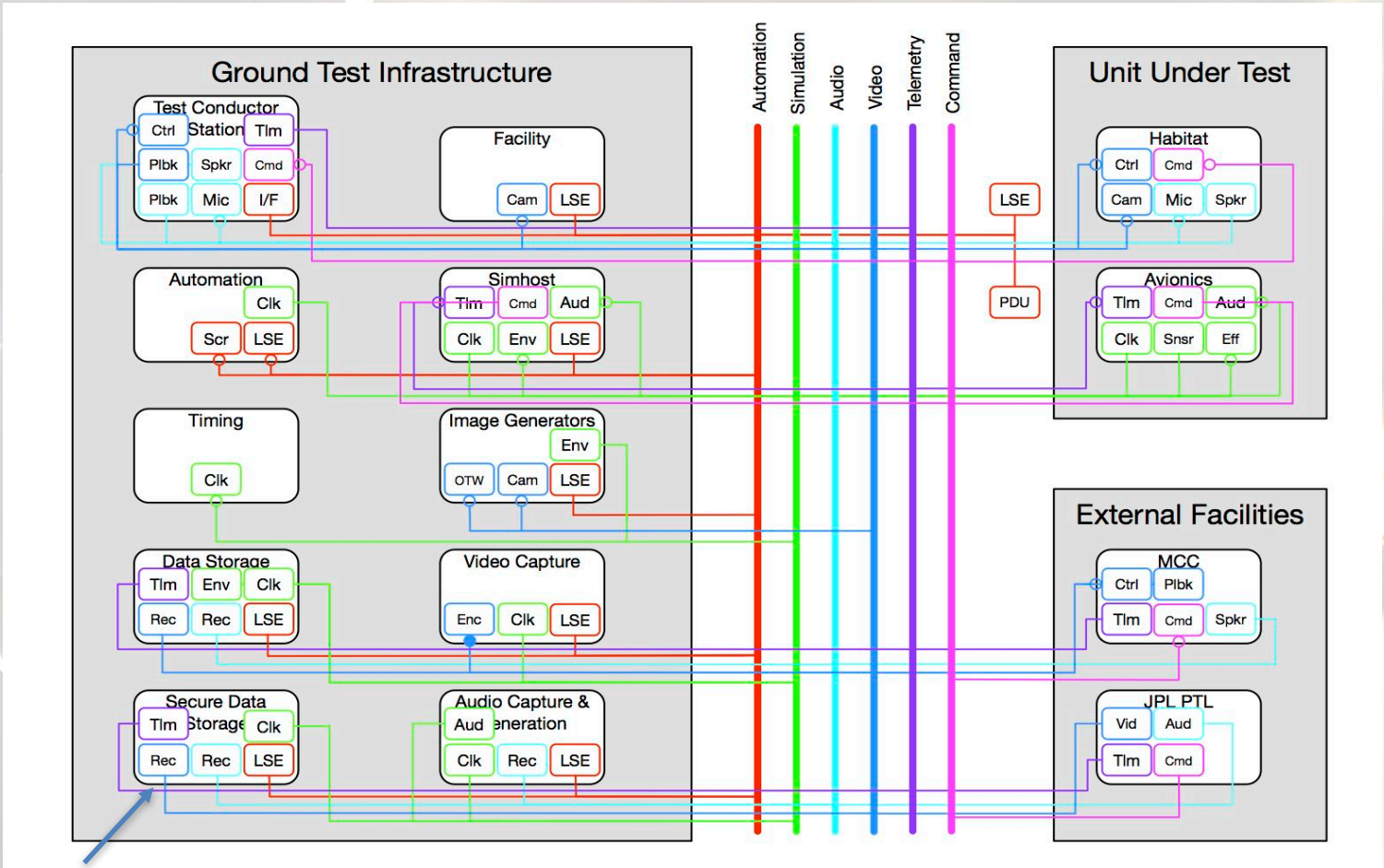
Visualization – Eddie Paddock

- Methodology
  - Establish Data Format requirements for contractor deliverables
  - Receive CAD and other data for habitats
  - Integrate data into NASA VR enviornments
  - Learn to evaluate designs using VR



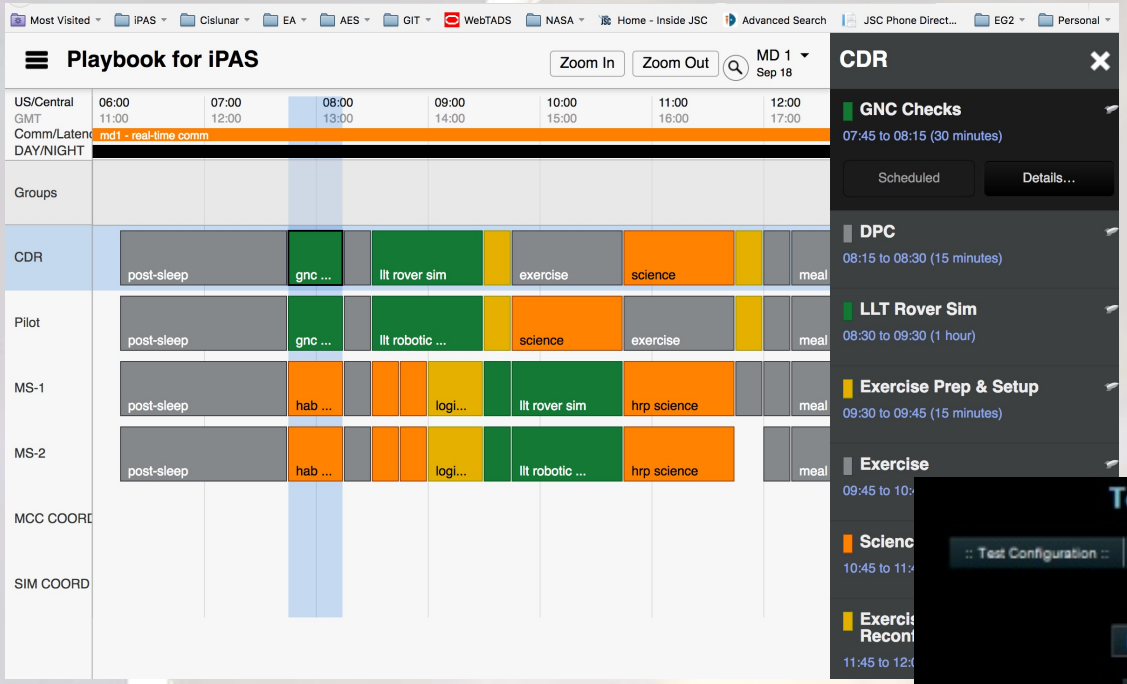


Test Architecture – Paul Bielski

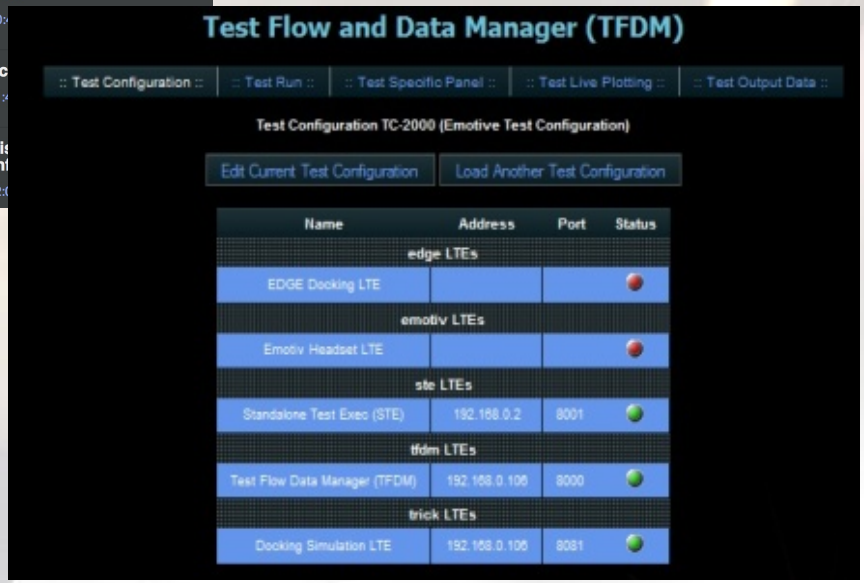


Medical Data
Proprietary Data

Test Execution



Crew Procedures : Playbook



Test Procedures : mREST

Mission Operations

MPCV Hardware / Software
iPAS Lab, JSC Bldg. 29

Command

Telemetry

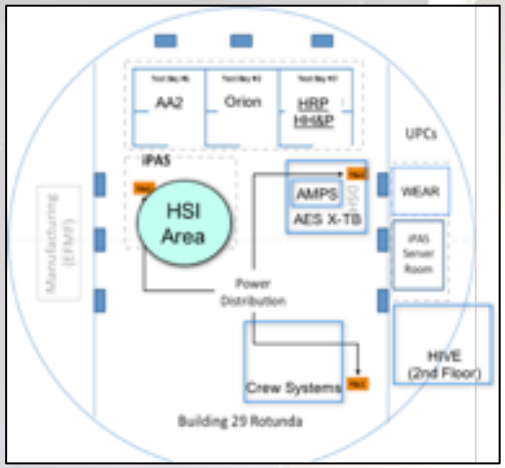
DSN Operations Center
JPL Protocol Test Lab

JPL

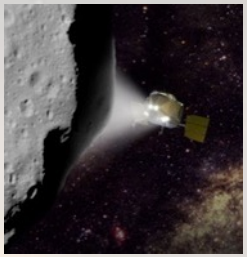
OTF, JSC Bldg. 30

Multi-Control-Center iPAS Overview

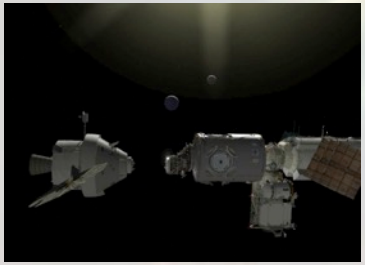
iPAS – Technology Integration and Test



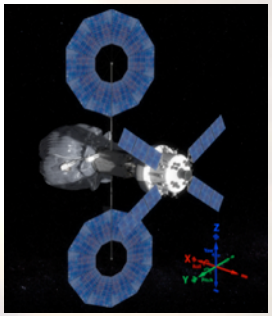
JSC, Building 29



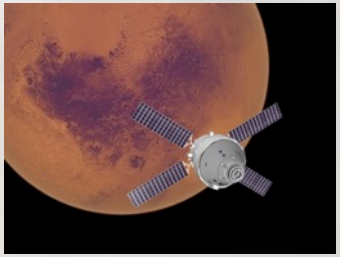
Asteroid Encounter
(2011)



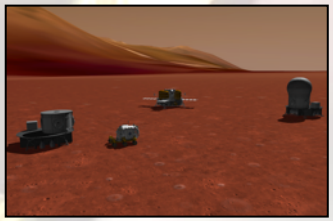
Waypoint Gateway
(2012)



Asteroid Redirect
(2013)



Phobos Orbit
(2014)

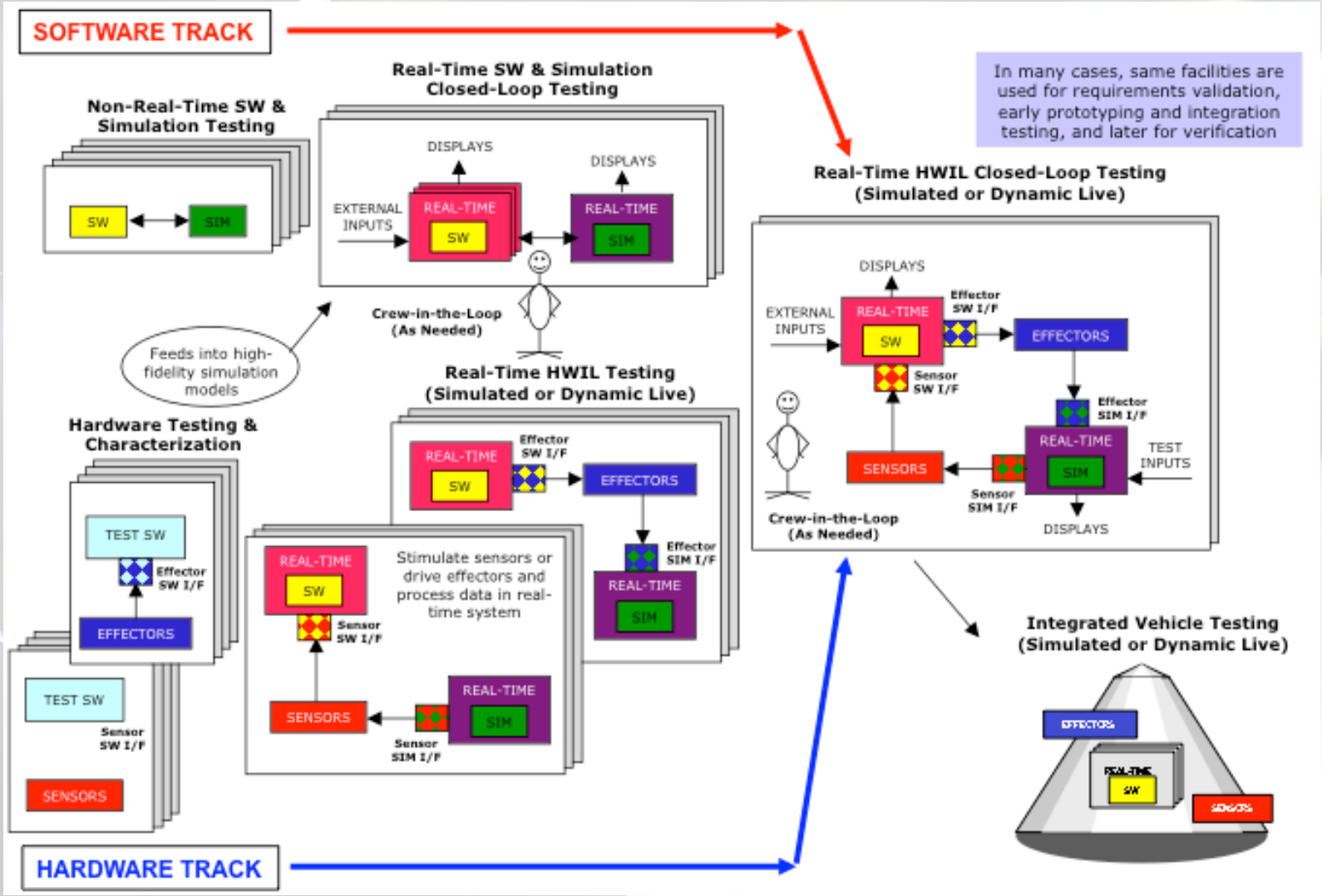


Mars Surface
(2015)

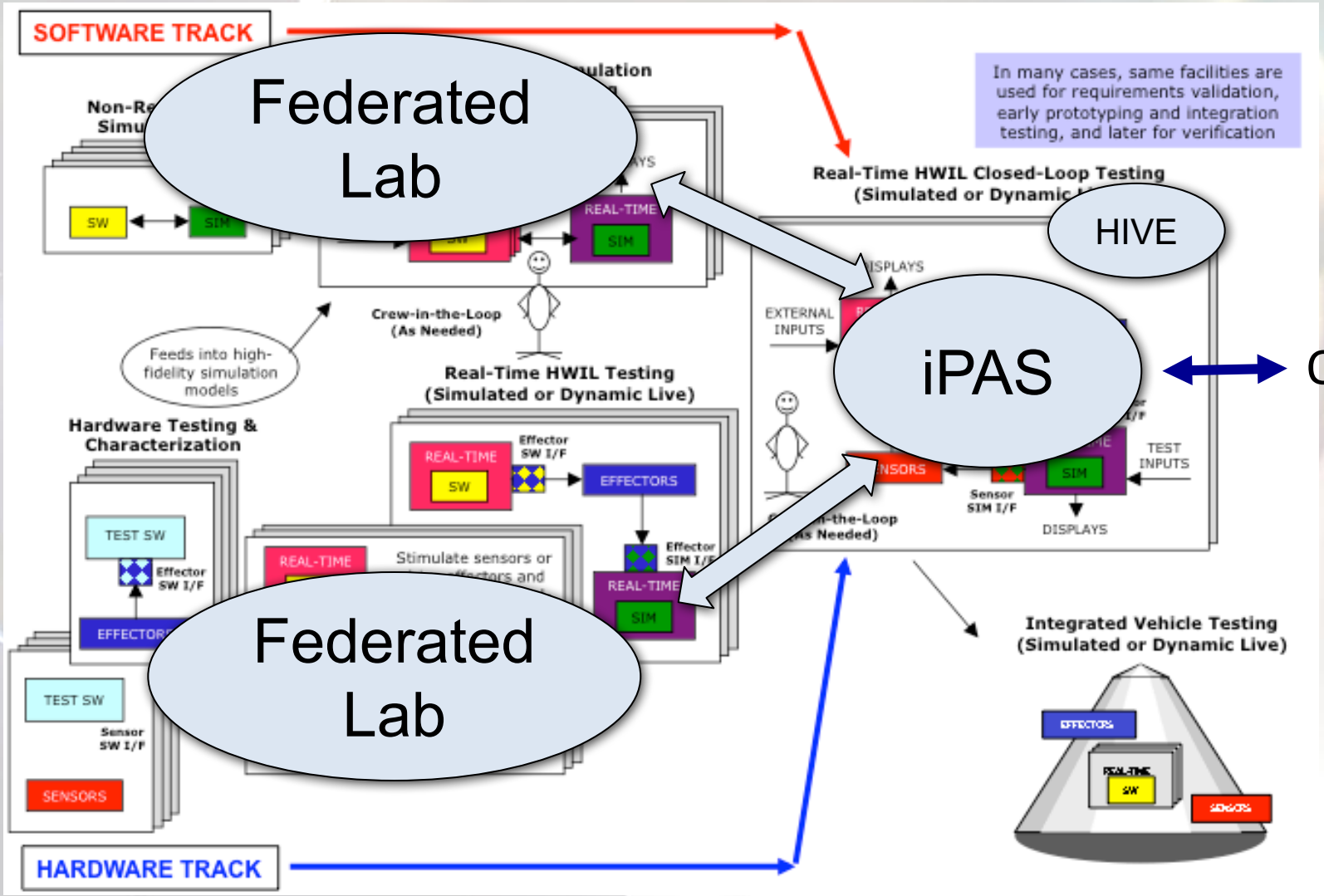
Distributed Data Network

AA2 HSI Testing
(2016)

Research & Technology Development



Research & Technology Development

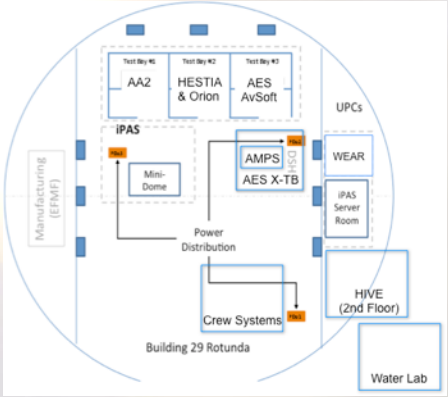


Co-location When Feasible

Avionics
- Processors
- Networks
- Wireless
- Comm

GN&C
- ALHAT
- Crew Piloting
- On-board Trajectory Planning

Core Flight SW
- Framework
- Apps Store
- GNC Apps
- Hardware Apps



Delay Tolerant Net
- Mission Evaluation
- DTN on Radio
- DTN on Computer

Advanced Modular Power
- Power Systems
- Integration with avionics in DSH

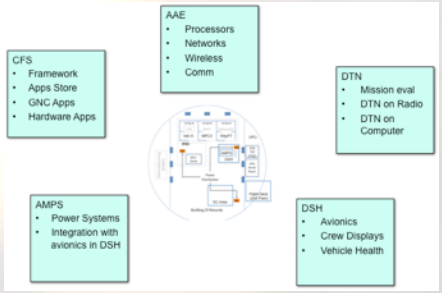
Habitat/HSI
- Exercise
- Medical
- Crew Displays
- Autonomy

JSC Lab Integration via Fiber

B30 – Mission Ops
- MCC emulator
- SNRF interface
- Telemetry and commanding

B16 – GNC/Dome
- Star Tracker
- Star Field
- Cockpits
- Dome

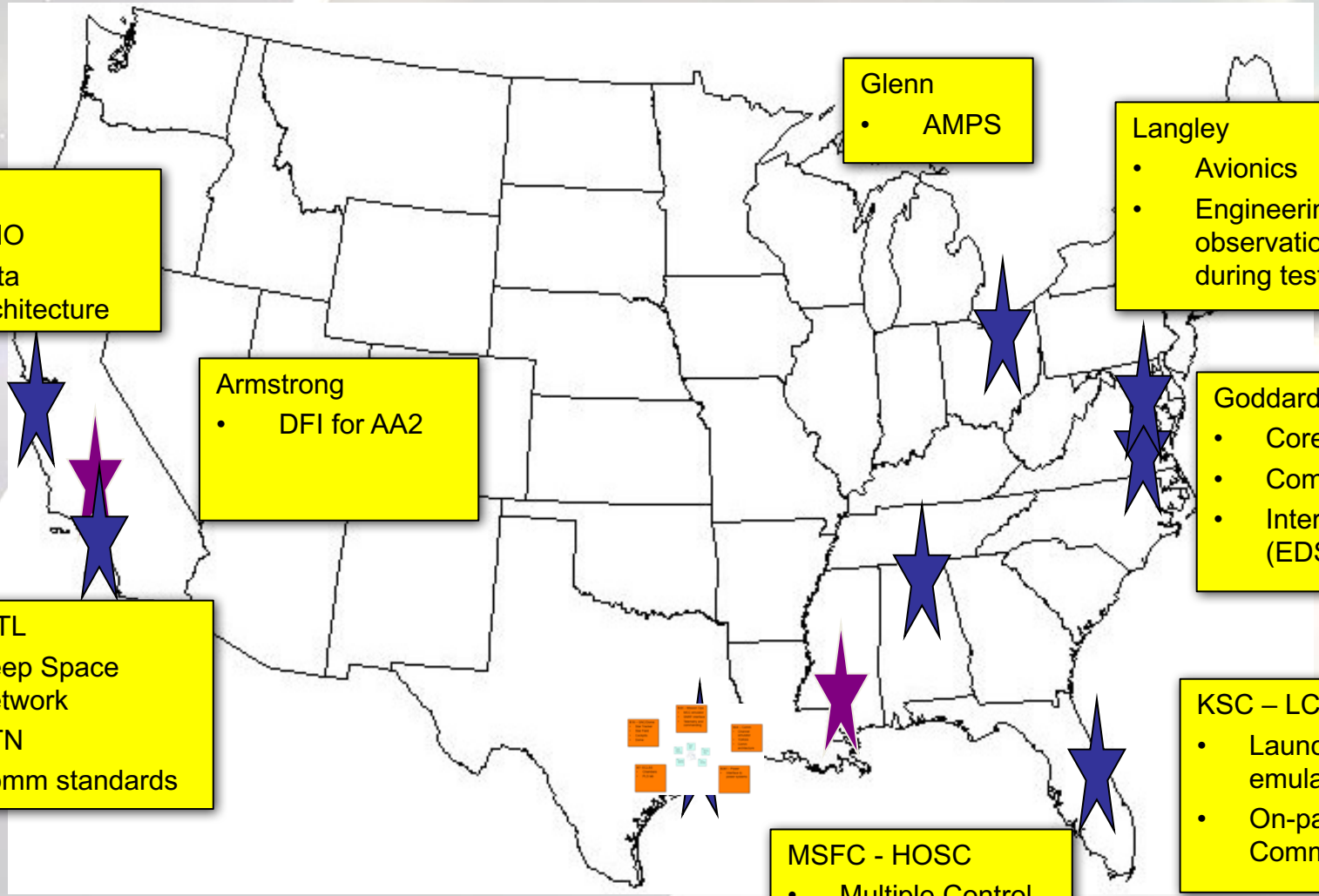
B44 – Comm
- Channel simulator
- TDRSS
- Comm architecture



B7- ECLSS/HESTIA
- Chambers
- PLS lab

B361 – ISRU/Power
- Interface to power systems

Multi-center Integration



Glenn
- AMPS

Langley
- Avionics
- Engineering observation during test

Ames
- AMO
- Data Architecture

Armstrong
- DFI for AA2

Goddard
- Core Flight SW
- Comm
- Interface Specs (EDS)

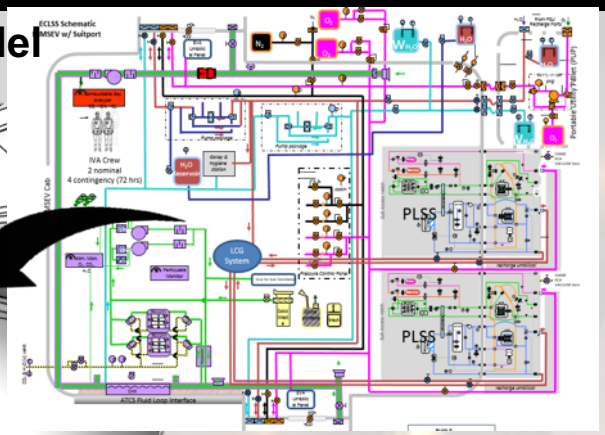
JPL - PTL
- Deep Space Network
- DTN
- Comm standards

KSC – LCC
- Launch Control emulator
- On-pad Vehicle Communication

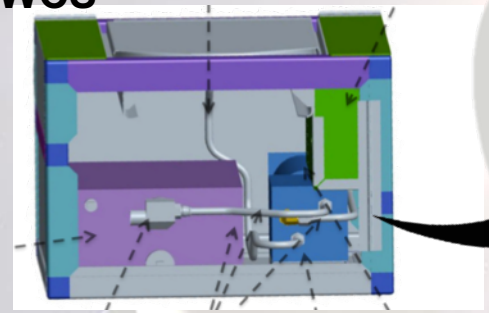
MSFC - HOSC
- Multiple Control Center activities
- ECLSS Lab

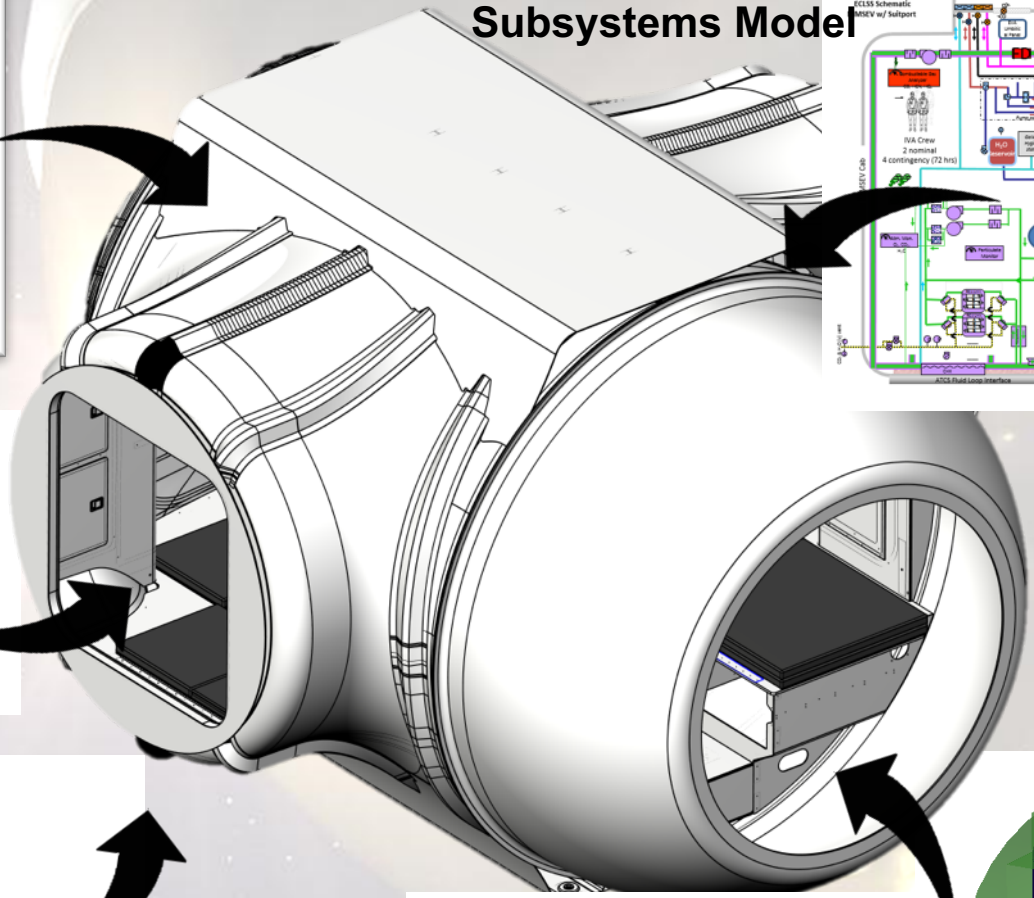
Summary of Node / Airlock Test Unit – Building 9

Subsystems Model

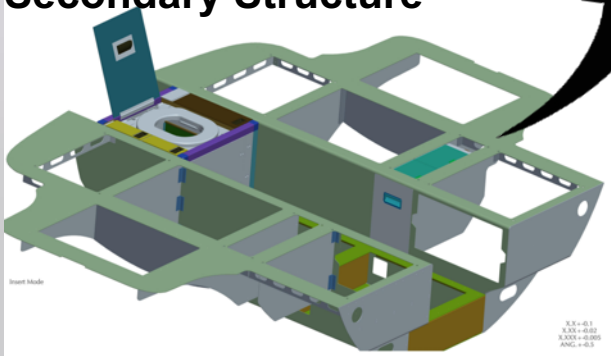


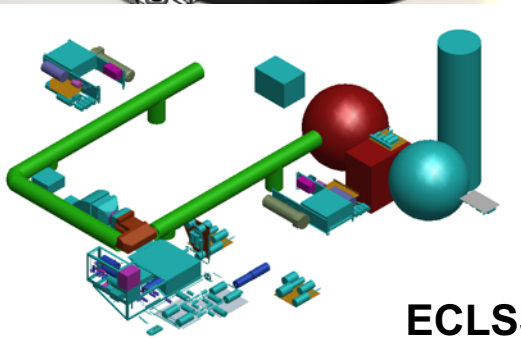
WCS



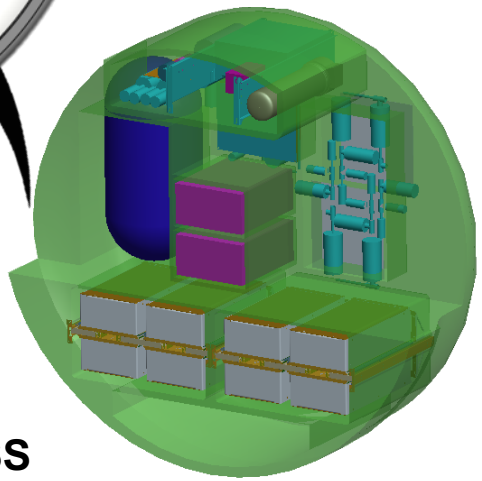


Secondary Structure

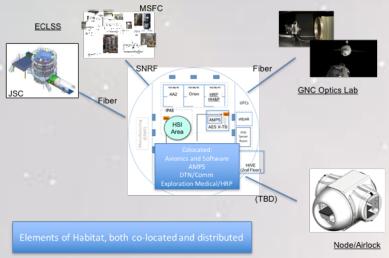




ECLSS

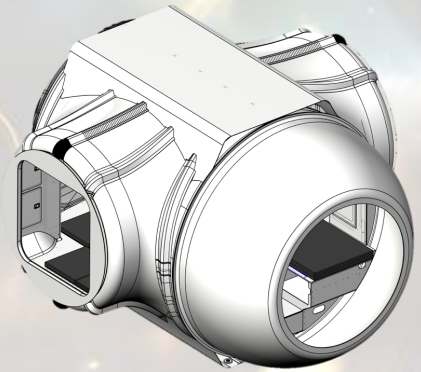


Integration and Test Environment



PET (hr:min)	CDR	Pilot	MS 1	MS 2
0:30	Rendezvous and Docking		Systems Monitoring	
1:00	GNC Activation and Checkout		Systems Activation and Checkout	
1:30	Logistics Transfer		Inventory	
2:00	Exercise Device Deployment		WCS and Galley Activation	
2:30	Experiment 1 Activation		Experiment 2 Activation	
3:00	Configuration Specific Tests and Evaluations 1			
3:30	LLT Mobility Simulation		LLT Mobility Simulation	Subsystems Monitoring and Operation
4:00	Exercise	Daily Housekeeping		
4:30	WCS			
5:00	PAO		PAO	
5:30	Subsystems Monitoring and Operation	Exercise		
6:00		WCS	Exercise	
6:30		Sample return logistics		
7:00			WCS	
7:30			IFM	IFM
8:00	Systems Malfunction Recovery		Systems Malfunction Recovery	PAO
8:30				Exercise
9:00				WCS
9:30	Meal Prep/Eating			
10:00	Configuration Specific Tests and Evaluations 2			
10:30	Configuration Specific Tests and Evaluations 3		Configuration Specific Tests and Evaluations 4	
11:00			Systems Malfunction Recovery	
11:30	Configuration Specific Tests and Evaluations 4			
12:00			Configuration Specific Tests and Evaluations 3	
12:30	Configuration Specific Tests and Evaluations 5			
13:00				
13:30				
14:00	Configuration Specific Tests and Evaluations 5			
14:30	Pre Sleep Ops			
15:00	Sleep			
15:30				
16:00				
23:30				
0:30	Post-Sleep			

Notional



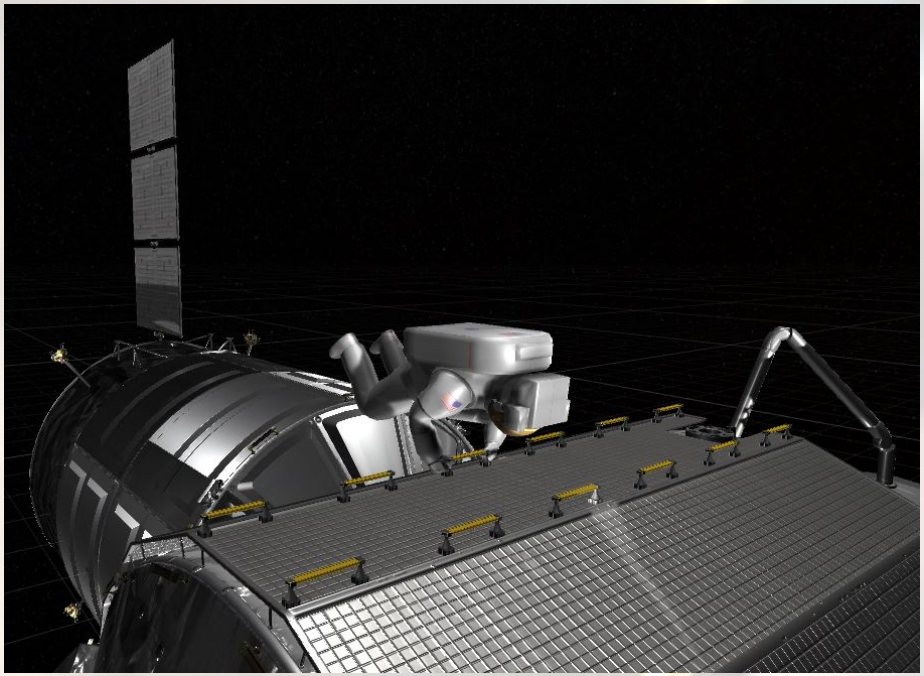
Ultimately, functions supplied by Next Step Contractor Mockups

Test Schedule

- Initial iPAS Test: September 2017
  - Completed
- Crew in the loop Test: December 2017
- Follow on habitat tests: Spring/Summer 2018
- Initial Contractor Hab tests: 1Q FY19
- In Addition: Contractors will be providing status and data during FY18, providing data such as VR models, etc.

EVA Considerations

Virtual Reality

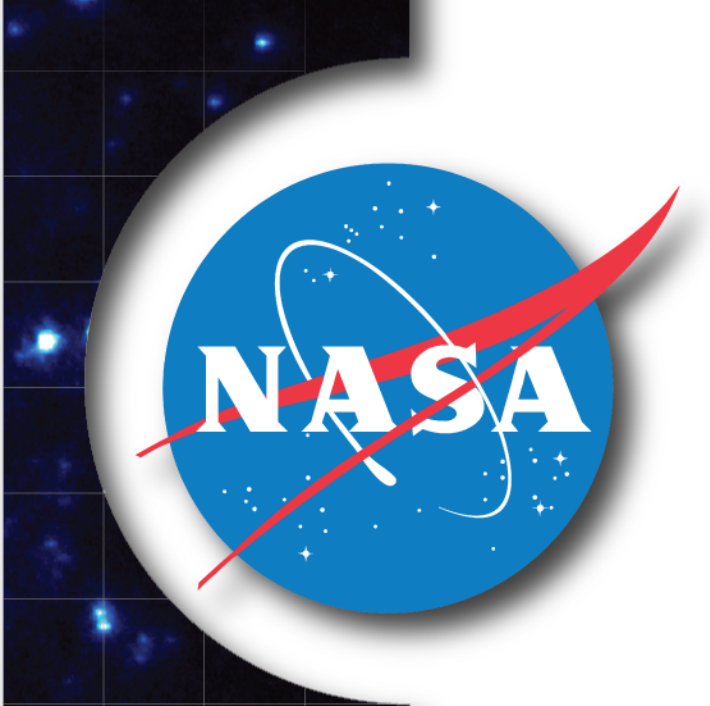


- Design Evaluation
- Mission Planning
- Crew Training
- Just in Time Training On-board

System Design and Interfaces

- Some NextSTEP Contractors may include airlock
- Design considerations
  - Stowage
  - EVA Operations
  - Integration with ECLSS
- Eventual Ground Test Plan
  - ECLSS Chambers
  - NBL

Consider what tests can be conducted on the ground, and when



BACK UP