



NextSTEP Cislunar Habitat Ground Test Planning

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NextSTEP Habitat Ground Test



- **Purpose of NextSTEP Ground Testing**
 - Evaluate design concepts for habitation systems, through test
 - Mature requirements for NextSTEP Phase 3
 - Not a down-select, looking for ideas and innovations
- **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
- **Ground Test can offer value**
 - Value to NASA stakeholders, to run tests that inform decisions
 - Value to NextSTEP partners, providing test services and ensuring NASA stakeholders and subject matter experts are engaged in test prep

Goal: Prepare habitat systems for successful
Ground Test execution

NextSTEP BAA Phases



NextSTEP Phase 1: 2015-2016

Cislunar habitation concepts that leverage commercialization plans for LEO



LOCKHEED MARTIN



BIGELOW AEROSPACE



ORBITAL ATK



BOEING

**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



BIGELOW
AEROSPACE

**FIVE GROUND
PROTOTYPES
BY 2018**



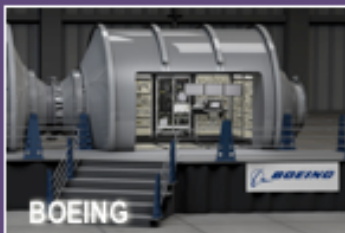
SIERRA NEVADA
CORPORATION



ORBITAL ATK



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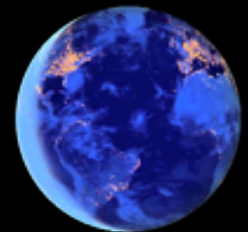
- Partners refine concepts and develop ground prototypes.
- NASA leads standards and common interfaces development.

ONE CONCEPT STUDY



NANORACKS IXION

Initial discussions with international partners



Define reference habitat architecture in preparation for Phase 3.

Phase 3: 2018+

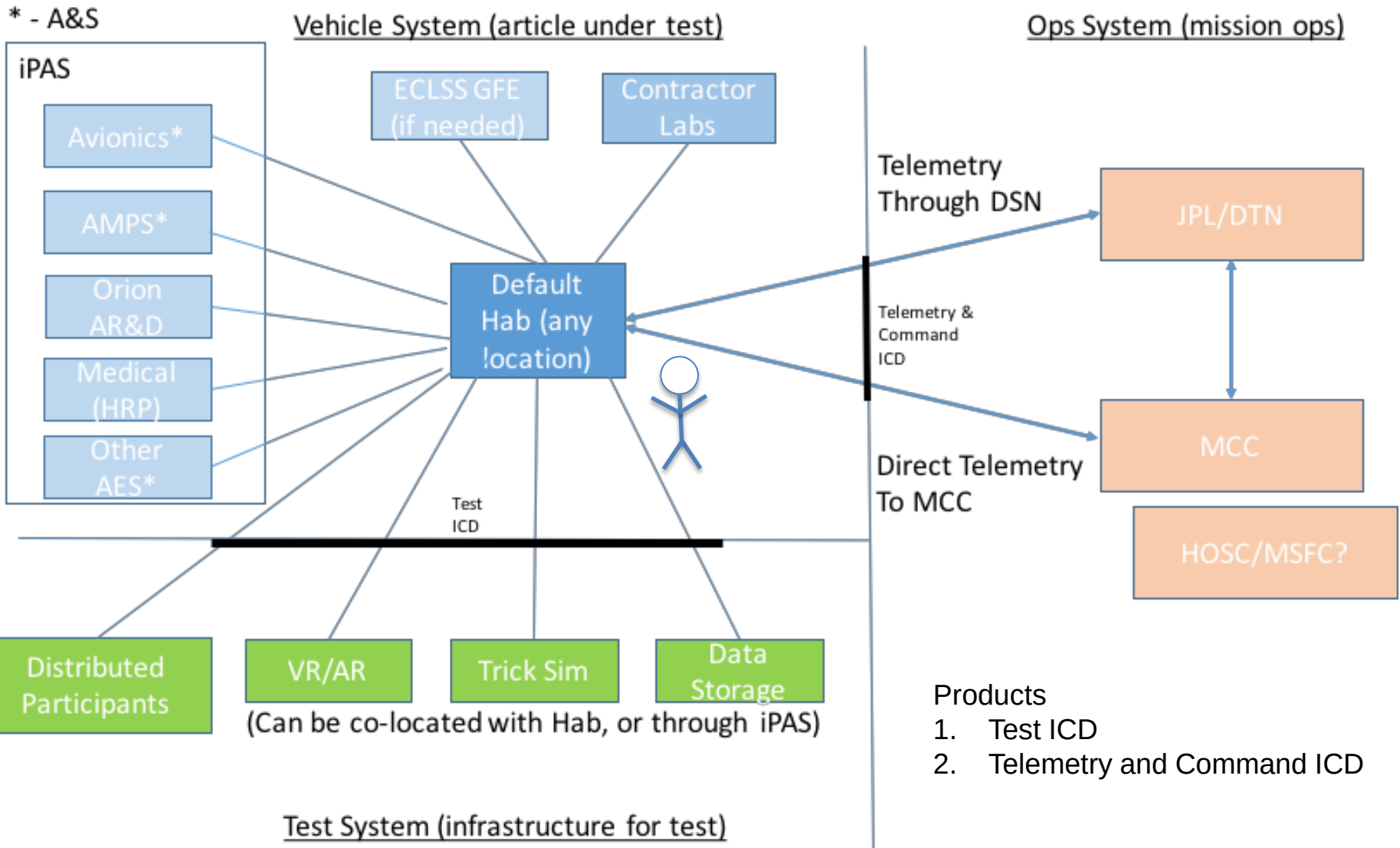
- Partnership and Acquisition approach, leveraging domestic and international capabilities
- Development of deep space habitation capabilities
- Deliverables: flight unit(s)

- **Focus for FY18**

- 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 other modules
- If possible, derive value from tests (but not biggest thing this year)

Train the Testers and
Prepare the Infrastructure

Test Architecture

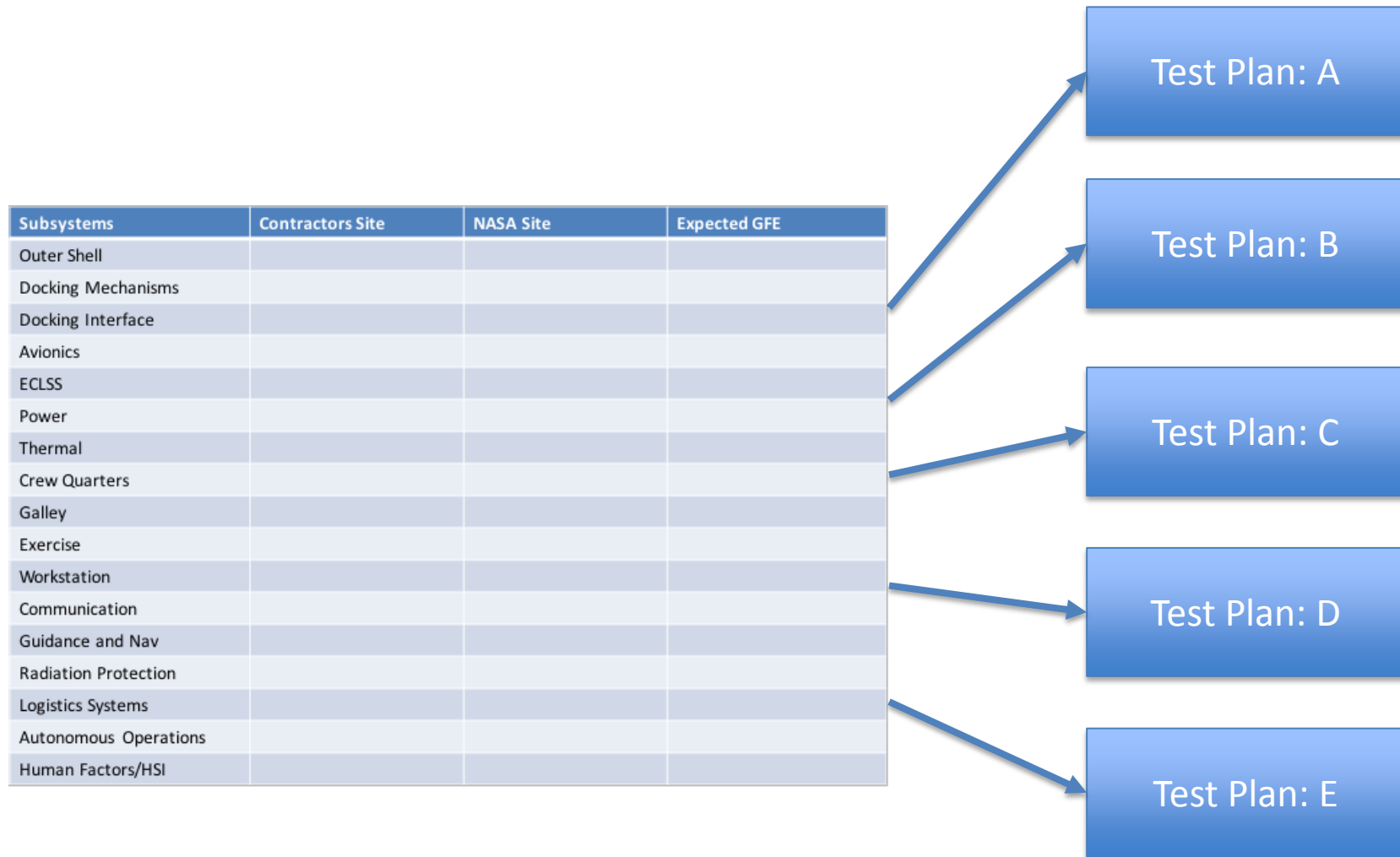


Subsystem Fidelity Chart, per contractor



Subsystems	Contractors Site	NASA Site	Expected GFE
Outer Shell			
Docking Mechanisms			
Docking Interface			
Avionics			
ECLSS			
Power			
Thermal			
Crew Quarters			
Galley			
Exercise			
Workstation			
Communication			
Guidance and Nav			
Radiation Protection			
Logistics Systems			
Autonomous Operations			
Human Factors/HSI			

Challenge: Agile Test Approach



Test Objectives from SMEs



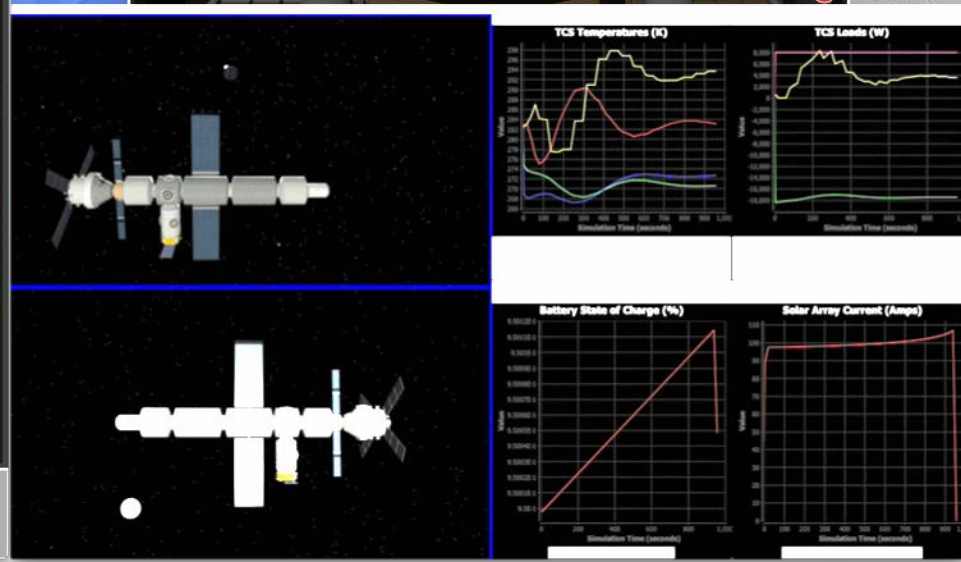
Group	Domain
GFE	ECLSS
GFE	Exercise
GFE	Radiation
GFE	SoftGoods
GFE	Windows
AES	Avionics & Software
AES	Power
AES	Autonomy
AES	Comm/ DTN
AES	Logistics
AES	Advanced EMU/ EVA
HRP	ExMC
HRP	Human Factors & Habitability
Domain	Propulsion
Domain	GNC
Domain	Structures
Domain	Active Thermal Control
Domain	EVA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

- **Virtual Reality**
 - Portable, virtual evaluation
 - Integrate elements of procedures checking
 - Can be augmented with tools (for clearance, etc)
 - CONTRACT: Data Formats and Deliverables
- **Mockup**
 - Physical representation but no vehicle subsystems
- **System Level**
 - Single system test (ECLSS, Power)
- **Human in the Loop Tests**
 - NASA Crew representatives executing Timeline within habitat

Align Test Objective with Habitat Fidelity,
determine what conclusions can be drawn

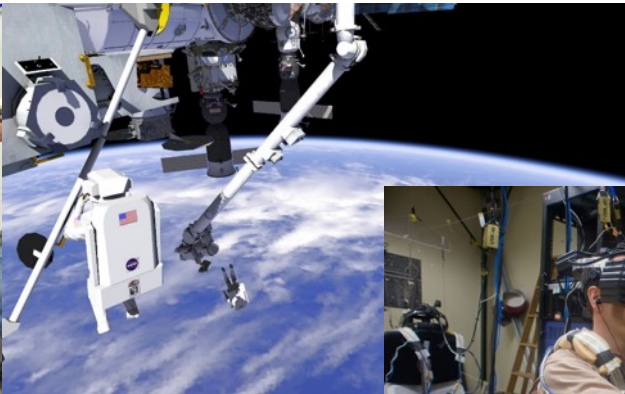
Habitat Simulation Capability – Dr. Zack Crues



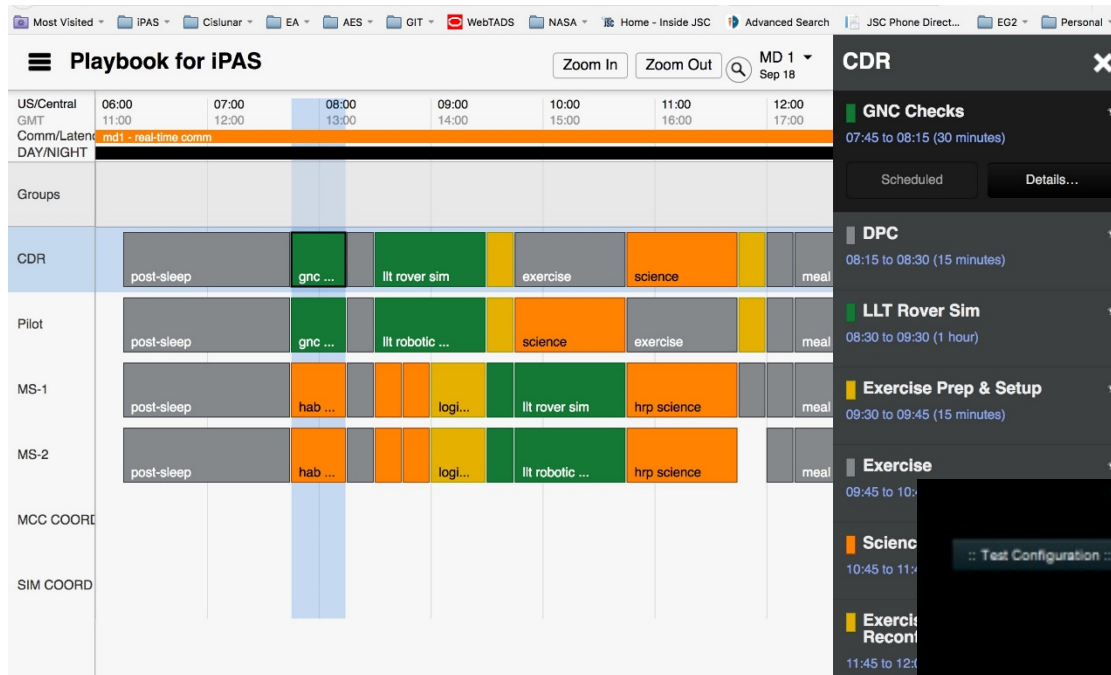
Visualization/VR – Eddie Paddock



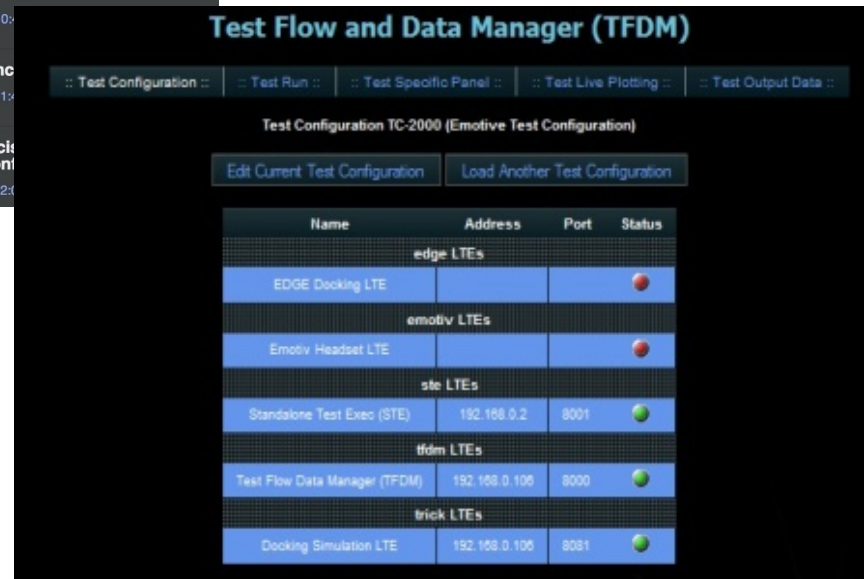
- **Establish Data Format requirements for contractor deliverables**
 - Receive CAD and other data for habitats
- **Integrate data into NASA VR environments**
 - Give Crew and SMEs early familiarization
- **Learn to evaluate designs using Visualization**
 - 3D graphics
 - VR goggles



Test Execution



Crew Procedures : Playbook



Test Procedures : mREST

Integration with Flight Operations



Gateway Hardware / Software
iPAS Lab, JSC Bldg. 29

Command



Telemetry

DSN Operations Center
JPL Protocol Test Lab

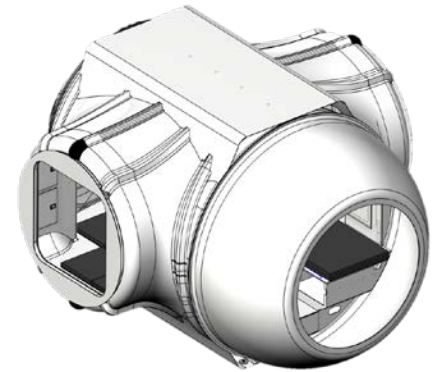


JPL



OTF, JSC Bldg. 30

Populate functions to support hab evaluation tests



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		Subsystems Monitoring and Operation			
4:00	Exercise	Daily Housekeeping			LLT Mobility Simulation	
4:30	WCS				PAO	
5:00	PAO					
5:30	Subsystems Monitoring and Operation	Exercise				
6:00		WCS			Exercise	
6:30					WCS	
7:00					IFM	
7:30	Systems Malfunction Recovery	Sample room activities				IFM
8:00						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					



Ultimately, functions supplied by
Next Step Contractor Mockups

Key Elements of NASA Test Execution Plans

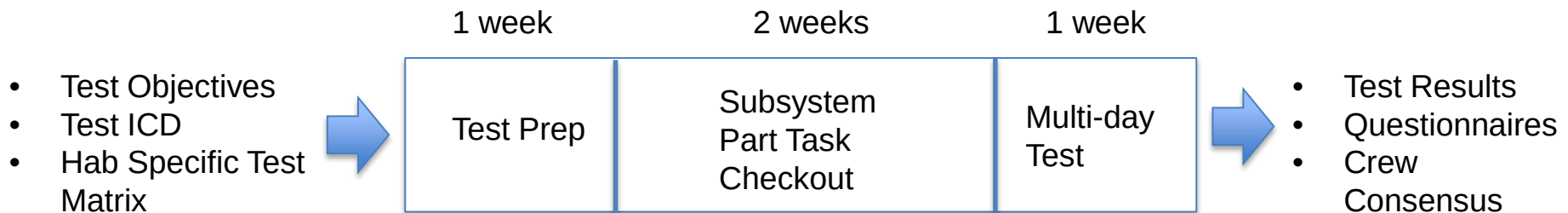


- **Identification of Habitat Fidelity and Test Locations**
 - Fidelity defined in the Fidelity Matrix
 - Identify system labs and habitat areas
- **Habitat Test Objectives**
 - Based on fidelity
 - Defined with Subject Matter Experts
 - Type of tests (system, human-in-the-loop)
- **Identify Test Procedures to be performed**
 - Based on examples in the Test Protocol
- **Develop a Crew Timeline per habitat test**
 - Based on standard procedures
 - Includes additional habitat-specific procedures
 - Highlight habitat design ideas and discriminators

Logistics of Habitat Test Execution (Notional)

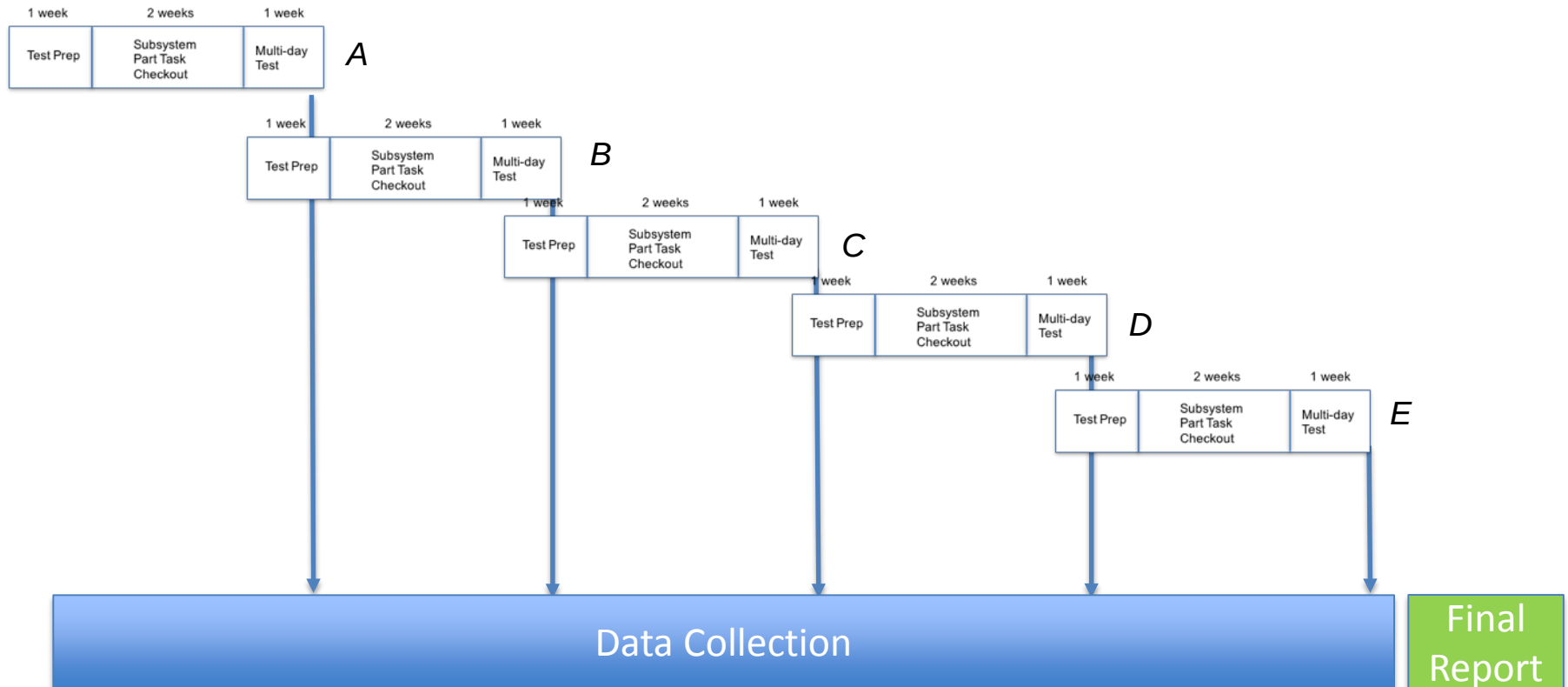


- **Consider one consistent template for each habitat**
 - Ensure same, impartial tests are executed at each hab
 - Tailored as needed based on capability in hab (see matrix)
- **5 habitats and 4 locations**
- **Example: 1 month template (Time is negotiable...)**



- Negotiate with Contractors to make entry conditions clear
- Ensure efficient operation of tests by practicing first in iPAS and HAB/HAL

Possible Test Campaign



NextSTEP Habitation Testing Milestones



- **FY18**

- November: B9 Module and Habitable Airlock
- First Contractor Deliverables : VR and Early Analysis
- May/June: NASA-Sponsored Ground Test
- Sept/Oct: NASA-Sponsored Ground Test
 - Dress rehearsal for habitat delivery
- Several site visits to prepare NASA team for test

- **FY19**

- Contractor Habitat Tests
 - One test team, staggered in time
 - Starting in January
- Open to discussion about early testing

- **Products**

- NASA Test Execution Plan
 - Integration of NASA Assets
- NASA Test Protocol, tailored for delivered habitat
- List of Test Locations and Labs
- List of Test Objectives
 - Linked to SMEs
- List of Test Procedures

- **Bi-weekly Meeting with Partners**

- Discuss mockup development status
- Answer partner questions
- Engage SMEs as needed

- **Schedule for Partner tests**

- NASA observers
- Integration of NASA assets

Ensure NASA is ready to evaluate Partner Habitat Mockup

