

National Aeronautics and Space Administration



Human Exploration and Operations Committee Status

Ken Bowersox
Committee Chair
July 30th, 2015



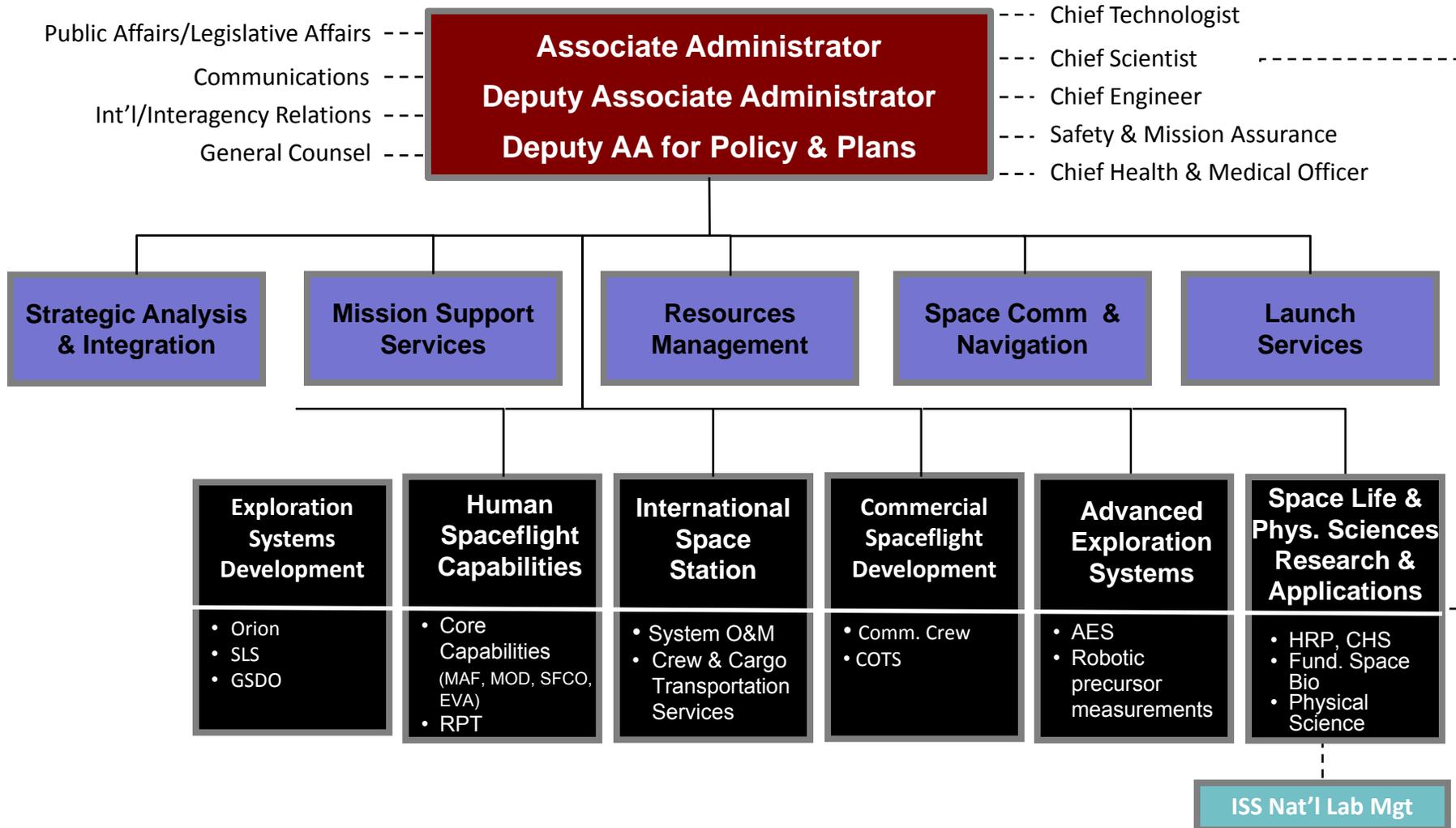
NAC HEO Committee Members



- Ms. Bartell, Shannon
- Mr. Bowersox, Ken, **Chair**
- Ms. Budden, Nancy Ann
- Dr. Chiao, Leroy
- Dr Condon, Stephen "Pat"
- Mr. Cuzzupoli, Joseph W.
- Mr. Holloway, Tom
- Mr. Lon Levin
- Dr. Longenecker, David E.
- Mr. Lopez-Alegria, Michael
- Mr. Malow, Richard N.
- Mr. Odom, Jim (James)
- Mr. Sieck, Robert
- Mr. Voss, James

Human Exploration & Operations Mission Directorate

Organizational Structure



Major Events Since Last NAC Meeting



- One Year Crew – past 30% complete
- Successful Recovery of SpaceX 6 Dragon
- Loss of Progress 59P Cargo Mission
- Loss of SpaceX 7 – delayed arrival of new docking adapter
- Successful launch and docking of Progress 60P Cargo Mission
- Launch of Soyuz 43 crew to ISS
- Daily science activity on ISS
- Dragon pad abort test
- Designation of NASA crews for Commercial Crew Vehicles
- Continued RS-25 Engine Testing
- Humans To Mars Summit

NAC HEO Meeting Summary April, 2015



NAC HEO Committee Meeting

Monday , July 27th, 2015

Human Exploration and Operations Budget and Status Update

Humans to Mars

Joint Meeting with NAC Technology Committee

Hydrocarbon Engine Development

Nasa Launch Support Program Overview

Technology development for Human Exploration

Tuesday, July 28th, 2015

HEOMD Communication Strategy

Exploration Systems Status

Commercial Crew Status

Asteroid Redirect Mission Status

ISS Program Status

Tour of JPL

Research Subcommittee Status

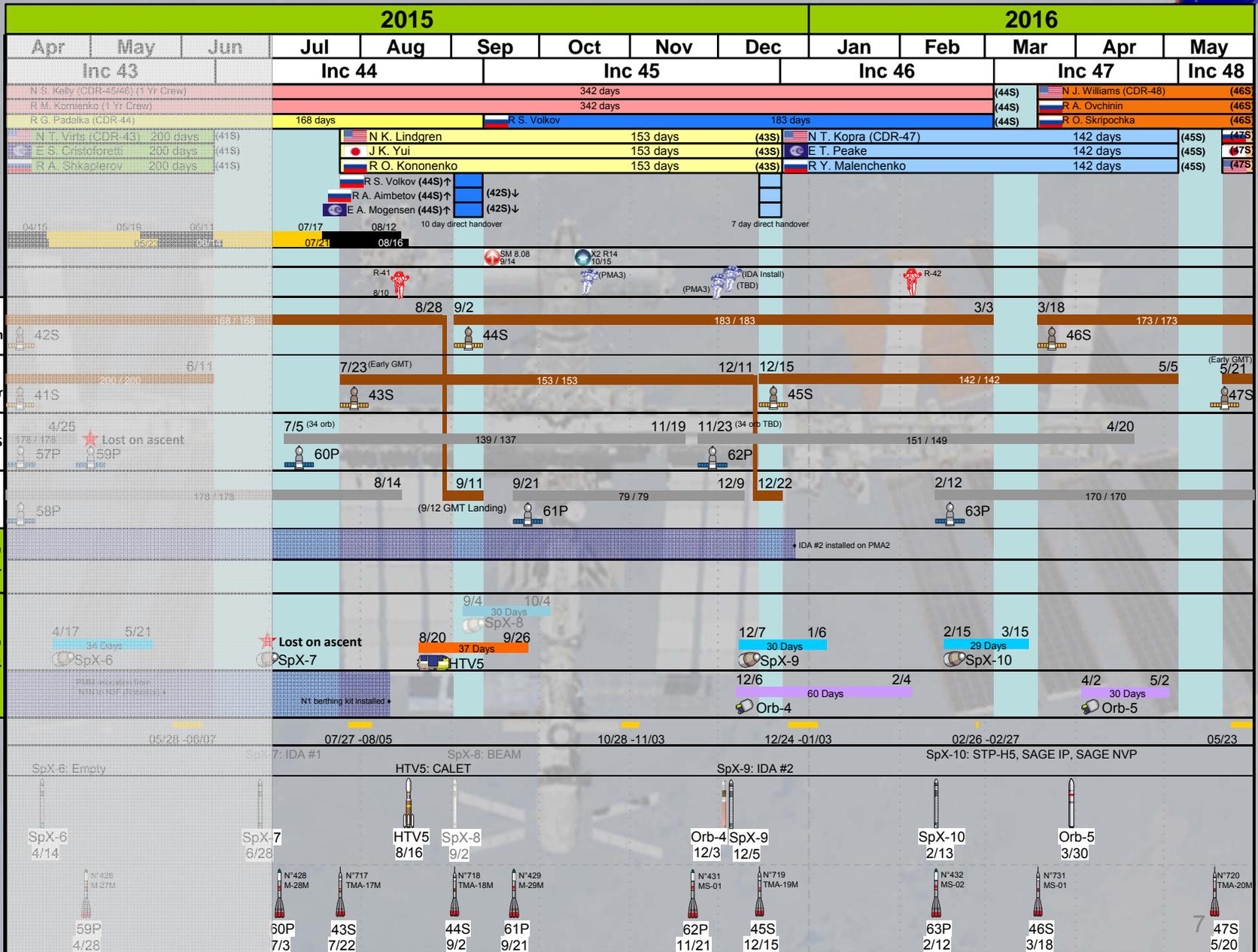
Committee Discussion and Deliberation

International Space Station Status



Sam Scimemi
Director, International Space Station

HEO NAC
July 2015



Crew Rotation

Soyuz Lit Landing
Stage S/W
Stage EVAs

Port Utilization

Solar Beta >60
External Cargo

Launch Schedule



43 Soyuz Launch/Increment 44 July - December 2015



Vehicle: 43 Soyuz

Launch: July 22, 2015 (planned 4 orbit rendezvous)

Docking: July 23, 2015

Undock/Landing: December 22, 2015



42 Soyuz crew

**Genady Padalka, Soyuz and Increment 44
Commander**

Scott Kelly, Increment 45/46 Commander

Mikhail Kornienko, Flight Engineer



43 Soyuz Crew

Oleg Kononenko , Soyuz Commander

Kjell Lindgren, Flight Engineer

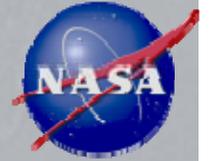
Kimiya Yui, (JAXA) Flight Engineer



Total ISS Consumables Status



Consumable – based on current, ISS system status	T1: Current Capability		T2: Current Capability + HTV5	
	Date to Reserve Level	Date to zero supplies	Date to Reserve Level	Date to zero supplies
Food – 100%	October 22, 2015	December 06, 2015	November 20, 2015	December 31, 2015
KTO	October 13, 2015	November 27, 2015	December 04, 2015	January 15, 2016
Filter Inserts	June 05, 2016	July 20, 2016	November 10, 2016	> December 31, 2016
Toilet (ACY) Inserts	February 10, 2016	April 03, 2016	February 10, 2016	April 03, 2016
EDV + TUBSS (UPA Operable)	March 08, 2016	June 21, 2016	March 08, 2016	June 21, 2016
Pre-Treat Tank	December 11, 2015	January 22, 2016	December 11, 2015	January 22, 2016
Water (Nominal Usage)	December 06, 2015	March 17, 2016	January 30, 2016	May 21, 2016
Consumable - based on system failure				
EDV + TUBSS (UPA Failed)	November 26, 2015	January 09, 2016	November 26, 2015	January 09, 2016
Water, if no WPA (Ag & Iodinated)	October 15, 2015	December 17, 2015	November 22, 2015	January 22, 2016
O₂ if Elektron supporting 3 crew & no OGA	September 02, 2015	December 15, 2015	September 02, 2015	December 15, 2015
O₂ if neither Elektron or OGA	July 31, 2015	September 22, 2015	July 31, 2015	September 22, 2015
LiOH (CDRAs and Vozdukh off)	~0 Days	~14 Days	~0 Days	~14 Days

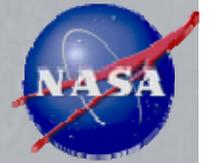


Progress 59P Anomaly

- Launch of 59P occurred on April 28th but failed to reach proper orbit
 - Most telemetry lost and attempts to activate and gain control of Progress unsuccessful
 - Reentered on May 8, 2015
- Russian commission formed to investigate failure, determine cause, provide recommendations – Alexander Ivanov, First Deputy Head Roscosmos as chair
 - 10 versions analyzed, reduced to 1 most probable cause
- NASA formed independent team to review the anomaly, partners participated – similar to 44P investigation, detailed fault tree analyses aligned with Russian findings
- Most probable cause findings
 - Commission Report : “Design feature of the Soyuz-2 .1a LV Stage 3-to-Progress M cargo vehicle stack, related to its structural response, which resulted in the LV oxidizer and fuel tank pressure integrity breach and damage to the Progress vehicle”
 - NASA Assessment : “Engine shutdown oscillations coincided with integrated vehicle longitudinal structural eigenmode as a dynamic interaction to cause structural failure
- One possible failure scenario
 - structural failure resulted in oxidizer integrity breach after engine shutdown (shutdown is rapid, significant propellant remaining in tanks, large accelerometer spike reflected in data due to “hammer” effect)
 - Resulting pressure loads on fuel tank calculated at 167MT of force, enough to result in mechanical separation of Progress with 3rd stage pyro bolt system



Progress 59P Anomaly



- After each flight, Rocket & Space Center Progress analyzes the actual loads, including a comparison and verification of the structural response during ascent with the pre-flight analysis and previous flights
 - dynamic interaction upon engine shutdown not seen on FG/U 3rd stage configurations
- No changes have been introduced into the Soyuz FG 43S launch vehicle systems configuration
- Successful 60P launch with Soyuz U 3rd stage on July 2nd (nominal performance)
- Russian teams recently completed modal testing of the 2.1a / Progress configuration, analyses in work
- Plan to utilize the 2.1A 3rd stage for 62P in November (modal survey results and subsequent mods dependent)
 - No restrictions in place for other missions utilizing the 2.1A 3rd stage
- No planned crew missions on the 2.1a configuration thru 2020



SpaceX-7 Mission Anomaly

- SpX-7 successfully launched on time at 9:21am CT on 6/28/15
- At 139 seconds, the Falcon launch vehicle experienced an anomaly that ended in loss of vehicle
- SpaceX is leading the investigation with FAA oversight
- NASA supporting with LSP, CCP, and ISS Program personnel
 - Team collocated in Hawthorne, daily status meetings, independent assessments being performed by LSP
 - Excellent sharing of information
- Detailed fault tree developed with emphasis on second stage operation and performance
- Detailed timeline (to the msec's) developed, taking into account video lag, sensor to computer latency, etc. to correlate timing of events
- Complete audit underway of as flown configuration, reviewing preflight approved issue tickets, component level acceptance packages, integrated stage testing results, etc.



SpX-7 Lost Cargo Summary

- **Crew Supplies** **690 kg**
 - 92 Food BOBs, 2 Bonus Food Kits, 2 Fresh Food Kits
 - Crew Provisions, Crew Care, ODF
- **Utilization** **573 kg**
 - CSA: Vascular Echo Exercise Band
 - ESA: Circadian Rhythms, KUBIK EBOXes, Interface Plate, EPO Peake, BioLab, Spheroids, EMCS RBLSS, Airway Mon. LiOH Cartridge
 - JAXA: Atomization, Biological Rhythms, Multi-omics, Cell Mechanosensing³, Plant Gravity Sensing³, SAIBO L&M, Space Pup, Stem Cells, MSPR LM, Group Combustion Camera
 - US: 2 Polars, 6 DCBs & Ice Bricks, 1 MERLIN, FCF/HRF Resupply, HRP Resupply [Kits, MCT, Microbiome, Twin Studies], IMAX Camera, Meteor, Micro-9, MSG resupply, Nanoracks Modules & 0.5 NRCSD #7, Universal Battery Charger, Veg-03, Microbial Observatory-1, Microchannel Diffusion Experiment, Wetlab RNA Smartcycler, SCK, Story Time, MELFI TDR Batteries
- **Computer Resources** **36 kg**
 - Proj. Screen, Sidekick, OCT Laptop & Pwr. Supply, 32GB MicroSD Cards, Generic USB Cables & Pwr Modules & Card Readers, Preloaded T61p Hard Drives, CD Stowage Container, Network Attached Storage Devices, XF305 Camcorders, RS-422 Adapter Cable
- **Vehicle Hardware** **462 kg**
- CHECS CMS: HRM Watches, Bench Lock Studs, Glenn Harness for Kelly, Kopra, and Peake
- CHECS EHS: CO2 Monitoring Assys, Filter Assys, CSA-CP/CDM Battery Assys, SIEVE Cartridge Assys, Water Kit, Petri Dish Packets
- CHECS HMS: IMAKs, Oral Med Packs
- C&T: C2V2 Comm unit (and HTV5 Unit Data Converter)
- ECLSS: 3 Pretreat Tanks, Filter Inserts, 9 KTOs, UPA FCPA, CDRA ASV, IMV Valve, Wring Collector, Water Sampling Kits, OGS ACTEX Filter, ARFTA Brine Filter Assys, O2/N2 Pressure Sensor, NORS O2, 3 PBA Assys, 2 MF Beds, 2 Urine Receptacles, Toilet Paper Packages, H2 Sensor, Ammonia Cartridge Bag, PTU XFER Hose
- EPS: 2 Avionics restart cables
- Makita Drill, PWD Filter, N3 Bulkhead Connectors, Yellow/Red Adapters, IWIS Plates, 6.0 & 4.0 Waste Xfer Bags, BEAM Ground Straps, JEM Stowage Wire Kit
- **EVA** **167 kg**
 - SEMU, REBA, EMU Ion Filters (4), Equipment Tethers, Gas Grap, EMU Mirrors, Crewlock Bags, SEMU arms / legs
 - Lindgren / Yui ECOKs & CCAs, Lindgren LCVG
 - Kelly LCVG, Padalka EMU Gloves
- **RS Cargo – RS Torque Wrench**
- **Unpressurized Cargo: IDA #1 (OB)** **526 kg**



Orbital-4 Mission Status

- **Mission Planning**
 - Orbital has contracted with United Launch Alliance (ULA) for an Atlas V launch of Cygnus
 - First use of Atlas V401 with the Cygnus spacecraft
 - Integrated Mission Review (IMR) #1 was conducted on 4/9/15 with IMR #2 planned for 7/14/15
 - Integrated Ground Processing Technical Interchange Meeting (TIM) was completed on 5/20/15
 - Trilateral Joint Operations Panel (JOP) was conducted on 5/27/15; planning for a 60 day berthed capability
 - Cargo Integration Review (CIR) is planned for 7/29/15; upmass cargo capability is 3,513 kg
 - On track for late November/early December launch
- **Pressurized Cargo complement**
 - Final ISS cargo manifest will be due in Jul at Launch minus 5 (L-5) months
- **Unpressurized Cargo**
 - Cubesats manifested on this mission; scheduled post ISS departure for deployment operations
- **Cygnus Status**
 - First enhanced Cygnus with a longer Pressurized Cargo Module (PCM) and ultraflex solar arrays
 - Final Integrated Systems Test (FIST) began on 6/27/15
 - PCM was shipped to the Cape on 6/23/15 with arrival to the Cape on 8/7/15
 - Service Module planned to be completed in Aug with shipment to the Cape in Oct
- **Atlas V 401**
 - Serial Interface Test was completed on 4/22/15
- **Orb-3 Mishap Investigation Report provided by Orbital ATK to the FAA last week**



NAC HEO Research Subcommittee July 20, 2015 – Meeting Highlights



Review: Research Plan for Space Biology and Physical Sciences

- Draft Research Plan sent to the RS for review and comment prior to the July 20 meeting – edits provided by RS members individually
- Presentations at the meeting described the goals and plans for the research areas at five- and ten-year horizons. Committee provided feedback in extended dialog with the SLPSRAD staff
- Two major issues noted by the RS during the review:
 - 1) Stature of the scientific community drawn to ISS research, and quality of the selected research, is impressive
 - 2) Crew time to implement labor-intensive fundamental research is greatly curtailed in NASA's plans. SLPSRAD estimates that only ~2% of projected crew research time will be devoted to space biology or physical science investigations w/o additional collaboration/alignment with CASIS and HRP; these are being explored currently

ISSUE: ISS Crew Time for NASA Research

Increment 45/46 (September 2015 – March 2016)

Crew Time Research Plan 15 April 2015

NASA/CASIS Research Plan:	Prime Requested	Prime Adjusted
National Lab (NLO) / CASIS	389.26	291.75
NASA Research - HRP	414.32	289.40
NASA Research - Non HRP ¹	314.34	0.00
Tech Demo	83.41	6.00
Cold Stowage	40.75	40.75
Other IP Agreements ³	25.41	25.41
Totals	1267.49	653.31
Total NASA Allocation:	--	652.50

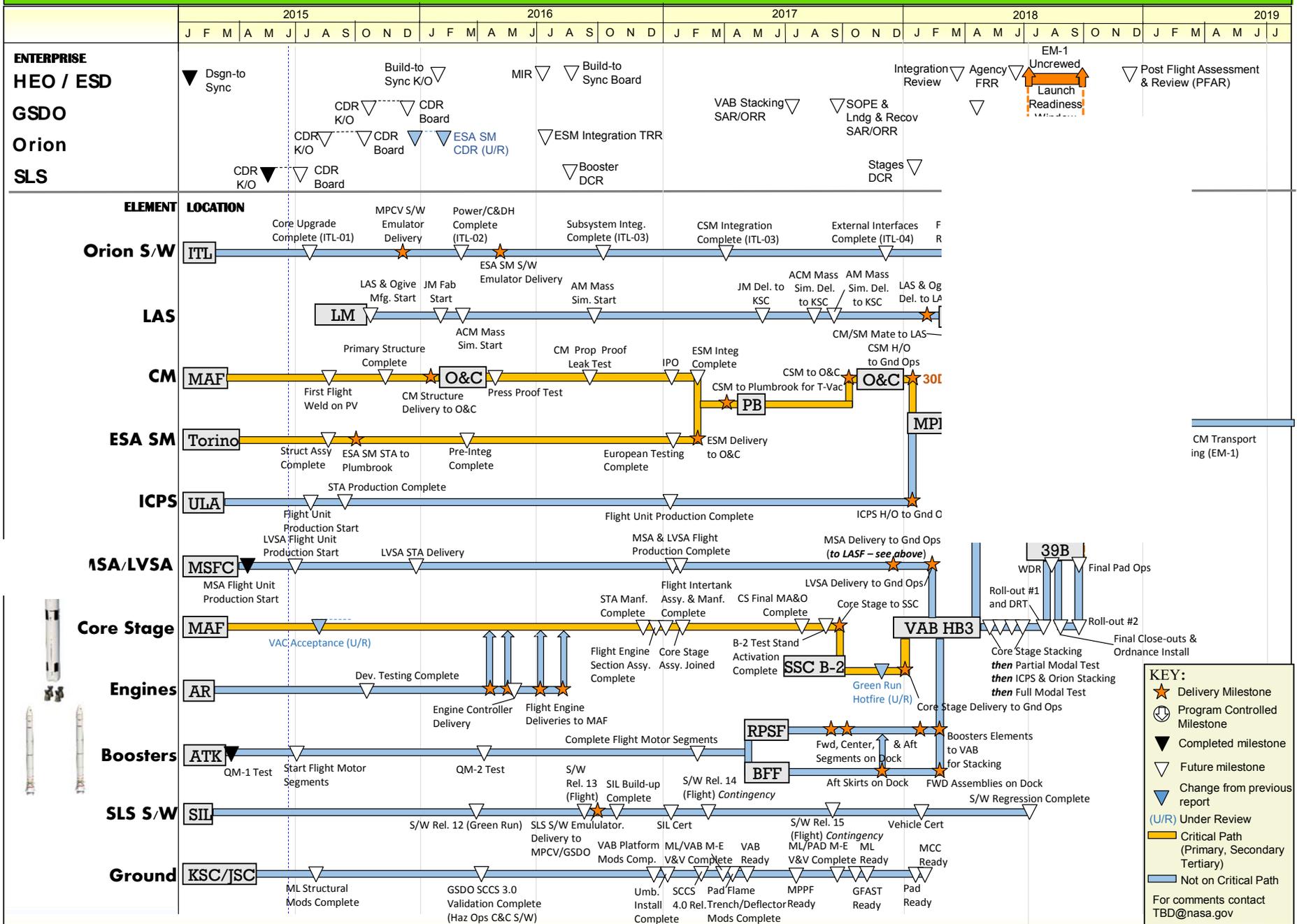
Conclusion: Crew time allocations are severely limiting Space Biology and Physical Science's ability to implement the guidance of the National Research Council and to support NASA's strategic objective for the ISS: *“Conduct research on the International Space Station (ISS) to enable future space exploration, facilitate a commercial space economy, and advance the fundamental biological and physical sciences for the benefit of humanity”* – NASA 2014 Strategic Plan, Objective 1.2

Exploration Systems Development Status
NASA Advisory Committee
July 27, 2015



ESD EM-1 INTEGRATED MISSION MILESTONE SUMMARY

NASA ESD
Chart Updated: 06/18/2015



Orion Accomplishments



Integrated Test Lab Mockup,
Denver, Colorado



EM-1 Pathfinder First Weld at
Michoud Assembly Center



Crew Module Structural Test Article
arrives at GRC



EM-1 Flight Aft Bulkhead



EM-1 Flight Barrel machining



EM-1 Flight Tunnel

Space Launch System Accomplishments



The RS-25 engine fires up at the beginning of a 500-second test June 11



At the Promontory, Utah test facility of Orbital ATK, the booster for NASA's Space Launch System rocket was fired for a two minute test on March 11



On May 13, a major milestone in its preparation for testing the core stage



Crews complete a 250-foot-long metal canopy for NASA's Pegasus barge.



Hydrogen burn-off igniter test is conducted May 5 at the Redstone

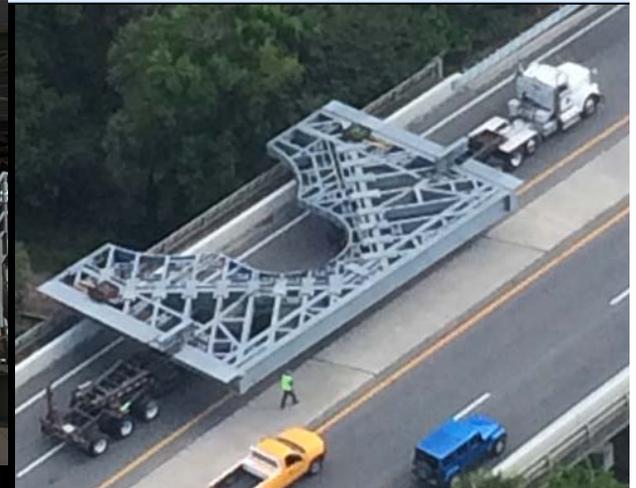
Ground Systems Accomplishments



Mobile Launcher structural modifications are complete. Ground subsystem installation contract award planned for August



The Orion Service Module Umbilical (OSMU) is being installed at the Launch Equipment Test Facility. Testing begins in August



The first work platforms have been delivered to the VAB



Testing of the Aft Skirt Electrical Umbilical (ASEU) was successfully completed at the Launch Equipment Test Facility in June



Upgrades and modifications to the 175-ton crane are complete; the crane has been placed back to its original position

National Aeronautics and Space Administration



Commercial Crew Program Status

NAC HEO Committee
July 2015

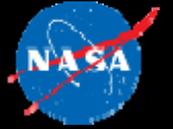


Overview



- **The Commercial Crew Program (CCP) is an essential element of the the broader strategy to achieve our nation's goals in space.**
- **CCP will re-establish the capability to launch astronauts from US soil.**
- **CCP will increase the ISS crew time available for research by an amount equivalent to one additional astronaut dedicated to research.**
 - This is critical to accomplishing the human research required for deep space exploration during the lifetime of ISS
- **Commercial transportation is vital to expanding the commercial market for low Earth orbit services, enabling NASA and its international and commercial partners to extend human presence into the solar system and to the surface of Mars.**

Summary



- **CCP remains committed to supporting our Space Act Agreement partners as they advance their concepts**
- **Both Boeing and SpaceX are advancing their CCtCap designs**
- **Hardware is actively being built and tested to inform design**
- **CCP is engaged in meaningful insight with the providers**
- **Important design challenges remain for both providers**
- **CCP is preparing for the flight phases of the program**



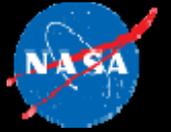
SpaceX: Pad Abort Test Static Test Firing



Boeing: Test 1 Water Landing and Rotation to Stable 2

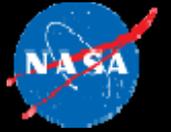
CCP is now at the point where all the preliminary work through the previous phases of the program is all paying off, and our two partners are off and running with effective NASA insight/oversight. We need to keep up the momentum with adequate funding to achieve safe, reliable, and cost effective commercial crew transportation services.

Budget Status



- **NASA FY2016 President's Budget Request for CCP is \$1.243B.**
 - Fixed price, FAR-based contracts are in place
 - Both companies have demonstrated good progress and performance
 - Ending U.S. reliance on Russia for crew transportation is a priority
- **While some CCtCap milestones may move from FY 2016 to FY 2017, this does not correspond to a reduction in NASA's FY 2016 funding requirements from the President's Budget Request.**
- **Milestones must be funded (obligated) prior to the contractor beginning work on the milestone.**
- **At this point, and given all the current milestone changes, NASA still requires the full CCP President's Budget Request for FY 2016.**

Budget Implications



- **Near-Term**

- If the Agency is funded with a Continuing Resolution for the first quarter of FY 2016, NASA will need to address how it will fund our partners' development activities at the current contractual schedule.

- **Longer-Term**

- If NASA does not receive sufficient funds in FY 2016 to maintain the current schedules, the contractors will have to stop work or work at risk until additional funding can be obligated.
- In that case, the existing CCtCap contracts will need to be renegotiated, most likely resulting in schedule delays and increased contract costs.
- NASA will need to continue to rely on Russian Soyuz capability to meet America's requirements for crew transportation services.

- **NASA has no plans to downselect the number of partners in response to lower-than-requested funding levels. As experience has shown with cargo, NASA's plan to establish a redundant crew transportation capability is critically important for robust, safe ISS operations.**



HEOMD Response to NAC HEO Committee Finding Regarding “Domestic Hydrocarbon Rocket Main Engine”

Bill Hill, Dep AA Exploration Systems Division
Jim Norman, Director Launch Services
27 July 2015

Notes from Hydrocarbon Engine and LSP Overview



- **NASA is participating and offering support for the Nation's effort to develop a new hydrocarbon engine.**
- **NASA is not limited in use of Russian engines for NASA missions.**
- **Limitations on use of Russian engines for other user's payloads could affect costs of future NASA missions.**
- **Current missions under contract using RD 180 are fixed price, and should not be affected.**
- **Launch Support Program has formal launch readiness input for NLS launches**
- **Advisory role for CRS**
- **NASA Role for launch decisions on future Commercial Crew Flights still being defined but expected to be greater than for CRS and NLS, but reduced from SLS/Orion type program**
- **HEO committee requesting more information from the CRS program on the launch readiness process to be presented at a future committee meeting.**

National Aeronautics and Space Administration



REACH
—NEW—
HEIGHTS

BENEFIT
—ALL—
HUMANKIND

REVEAL
—THE—
UNKNOWN



Dr. Alotta Taylor

Director, Strategic Integration and Management Division,
Human Exploration and Operations Mission Directorate (HEOMD)



HEOMD Communications Goals



HEOMD Communications Goal 1:

Enhance public and Congressional recognition of the value of human space exploration and understanding of the capabilities-driven approach in our pursuit of sending humans to Mars.

Strategies

1. Mobilize the NASA workforce to serve as knowledgeable and excited ambassadors.
2. Articulate the challenges, risks, and benefits of human space exploration; communicating in terms meaningful to our stakeholders and always delivering a call to action.
3. Leverage milestones and activities as proof points, citing the capabilities-driven approach, in our advancement towards reaching Mars with humans.
4. Cultivate and maintain relationships with opinion leaders and influencers.
5. Partner with industry and academia to expand capabilities and broaden message dissemination.
6. Proactively collaborate with Public Affairs and the Office of Legislative and Intergovernmental Affairs to ensure they are fully equipped to achieve HEOMD communications goals.

HEOMD Communications Goal 2:

Enhance public awareness of the marvels associated with the International Space Station and its role in advancing human space exploration.

Strategies

1. Incorporate the International Space Station (ISS) into the public's everyday consciousness.
2. Articulate the benefits to humanity, world-class research opportunities, and the role the ISS plays as a proving ground in sending humans to Mars; communicate in terms meaningful to our stakeholders and always delivering a call to action.
3. Leverage milestones and activities as proof points, citing ISS as a proving ground, in our advancement towards sending humans to Mars.
4. Cultivate and maintain relationships with opinion leaders and influencers.
5. Partner with industry and academia to expand capabilities and broaden message dissemination.

JOIN US ON THE JOURNEY TO MARS DAY ON THE HILL

We invite you to join us and enjoy interactive exhibits and engaging conversation with NASA experts who are developing solutions to solvable challenges for robotic and human missions to Mars, including transportation, technology, and scientific developments that will allow us to get there, land, live, work, and return safely to Earth.

THURSDAY, JUNE 25, 2015 • 3-7 P.M.
Rayburn House Office Building Foyer
Reception with light hors d'oeuvres begins at 5 p.m.
Register to attend by e-mailing CongressionalEvents@nasa.gov

#JOURNEYTOMARS

Meet special guest NASA astronaut Barry "Butch" Wilmore, who just returned to Earth from the International Space Station after 167 days in space.

ISS Benefits for Humanity Videos: In Their Own Words

- Changing Lives
- Eyes on the Tide
- Farming from Space
- Found At Sea
- In Plain Sight
- Station Inspiration
- The Sound of Life
- Water for the World



Facebook



Twitter



Instagram

Facebook Account	Followers
NASA	11M
The White House	4M
U.S. Navy	2.1M
Air Force	2M
ISS Facebook	1.8M
Kennedy	1M
Curiosity	1M
SpaceX	878K
Goddard	785K
JSC	601K
Orion	369K
Marshall	81K

Twitter Account	Followers
@NASA	10.8M
@TheWhiteHouse	6.47M
@MarsCuriosity	1.93M
@SpaceX	875K
@NASAKennedy	850K
@USNavy	491K
@NASA_Astronauts	393K
@NASA_Johnson	343K
@NASAGoddard	250K
@ISS_Research	238K
@NASA_Orion	202K
@Space_Station	174K
@NASA_Marshall	104K

Instagram Account	Followers
natgeo	23.8M
nasa	3.4M
Nasagoddard	843K
iss	595K
Usnavy	126K
nasajohnson	41.4K
Nasakennedy	21.8K
Nasa_marshall	17.9K

Conference, Large-Scale Events and Exhibits



FY2015 CLEE Events

Event	Location	Event Date
SXSW	Austin, TX	03/13-17/15
Earth Day Nat'l Mall – Union Station	Washington, DC	04/18 - 22/15
World Science Festival/Fleet Week	New York, NY	05/22-30/15
San Mateo Maker Faire	San Mateo, CA	05/16-17/15
Comic-Con	San Diego, CA	07/9-12/15
Essence Festival	New Orleans, LA	06/29 -07/06/15
World Maker Faire, NYC	New York, NY	09/26-27/15
Balloon Fiesta	Albuquerque, NM	10/2-10/15
Bay Area Science Festival	San Francisco, CA	10/24
CA Science Center Endeavour Fest	Los Angeles, CA	11/15 (TBC)

FY2016 CLEE Event Recommendations

Total number of events submitted: 79

Total number of unique events submitted: 67

Events identified by multiple submitters:

- NFL SuperBowl 2016 (2)
- AARP Life@50+ (2)
- SXSW (2)
- Comic-Con San Diego (2)
- Albuquerque Balloon Fiesta (2)
- Earth Day at the National Mall & Union Station (3)
- Oshkosh or Spirit of St. Louis Air Show (6)

Events by Target Audience:

- Non science technology attentive (29)
- Science and technology interested public (11)
- Space and aviation enthusiasts (9)
- Technology savvy; early tech adopters/influencers (5)
- STEM attentive students (4)
- Other – Non CLEE audiences (9)

HEO Communications Strategy



- Communicate as widely as possible
- Build communities of fans & followers
- Transform them into advocates, ambassadors, creators, & collaborators

HEO Committee Finding



Proposed NASA Human Exploration and Operations Committee Finding

Name of Committee: Human Exploration and Operations Committee
Chair of Committee: Mr. Ken Bowersox
Date of Public Deliberation: July 27, 2015 (HEO Advisory Committee)

Short Title of Finding: Communication Strategy for Exploration Plans

Finding: The Committee noted a positive improvement in NASA's effort to communicate plans for Pioneering Space, including the Journey to Mars. Because of the critical importance of public engagement in the human exploration program, the committee plans to request future briefings on this topic to monitor progress. During briefings on this topic, the committee members thought that the following aspects of the communication approach were especially important:

1. The existence of a formal strategy to guide communication efforts
2. Engagement of the public using the latest communication methods including social networking.
3. Engagement of the public in new forums
4. Collection of data to evaluate the effectiveness of communication efforts

H u m a n J o u r n e y t o M a r s

Thoughts on an Executable Program

Firouz N a d e r i
Hoppy P r i c e
John B a k e r

Jet Propulsion Laboratory



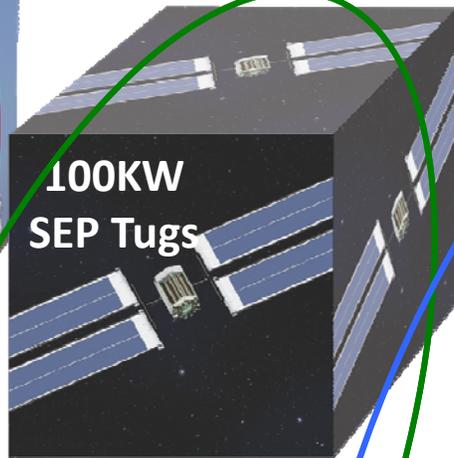
Building Blocks of a Minimal Architecture

Mars Surface Elements

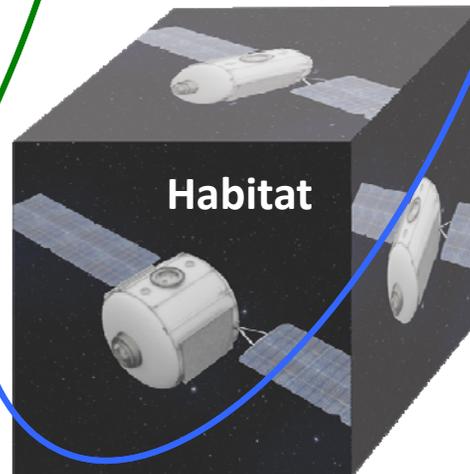
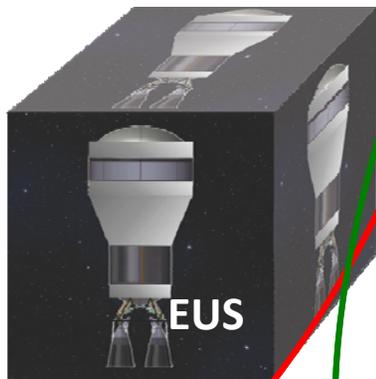
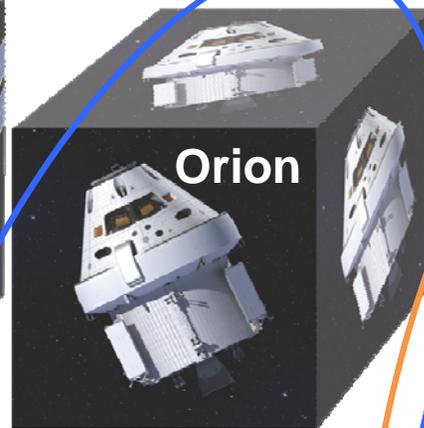
Launch



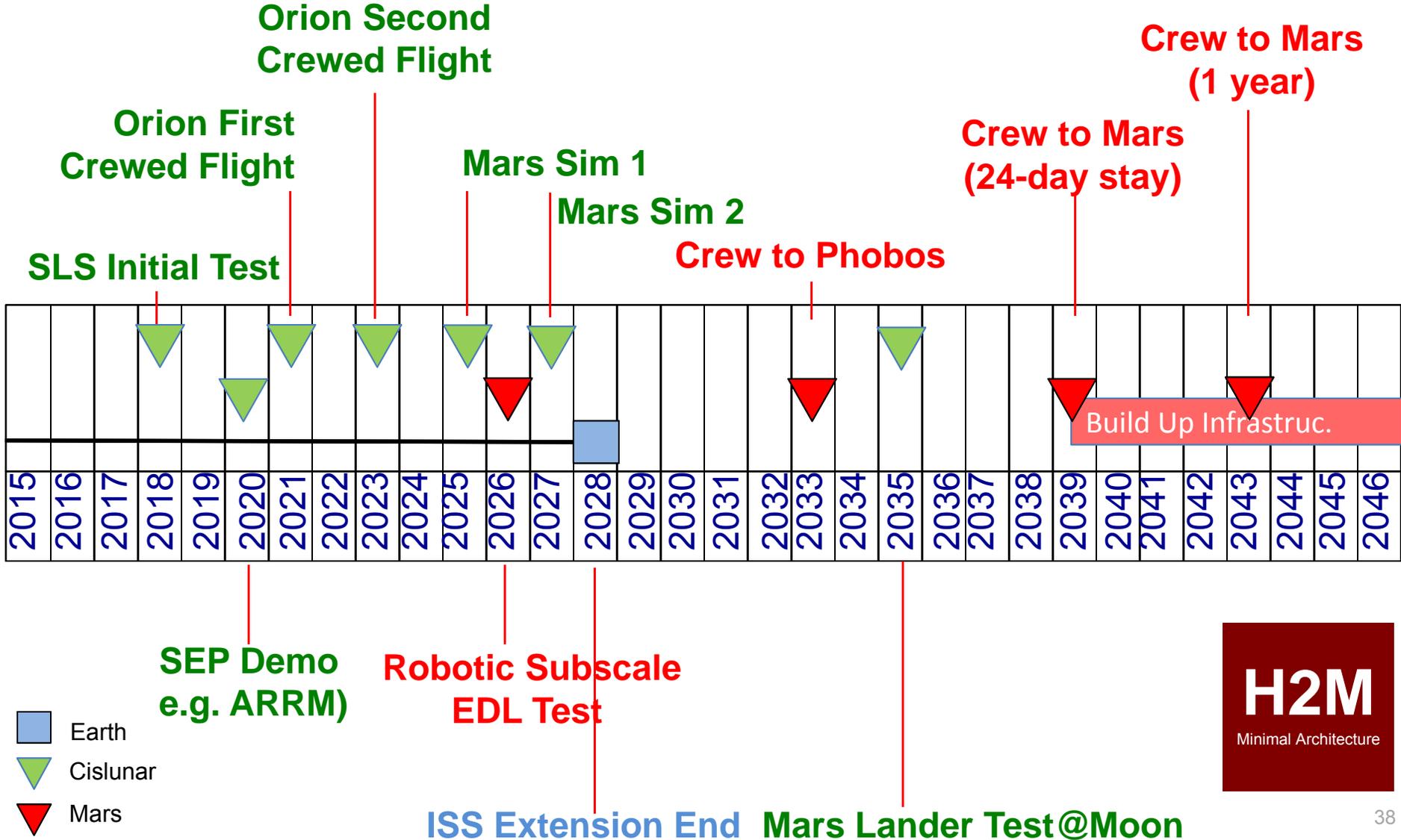
In-Space Propulsion



Crew Quarters

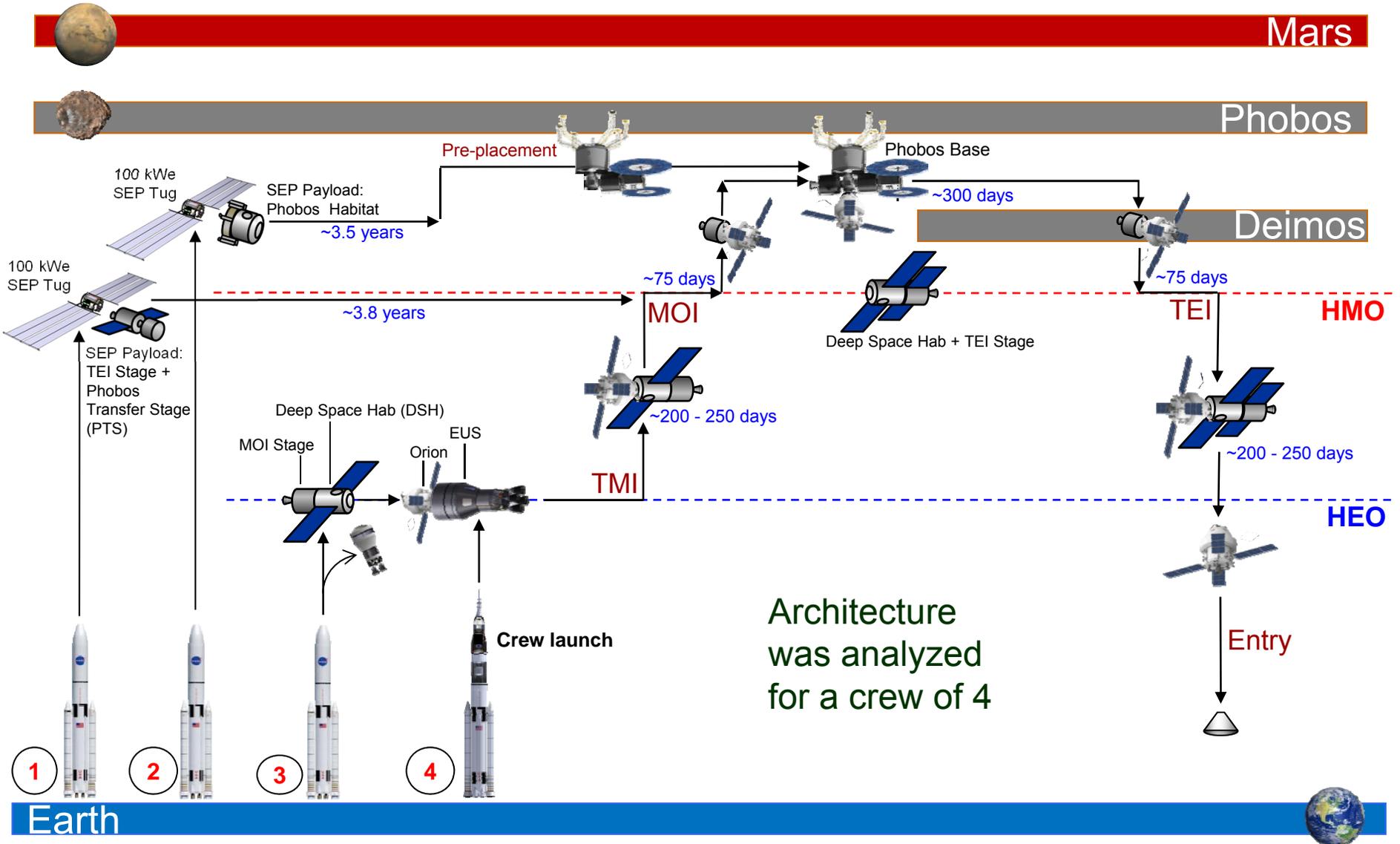


Notional Timeline



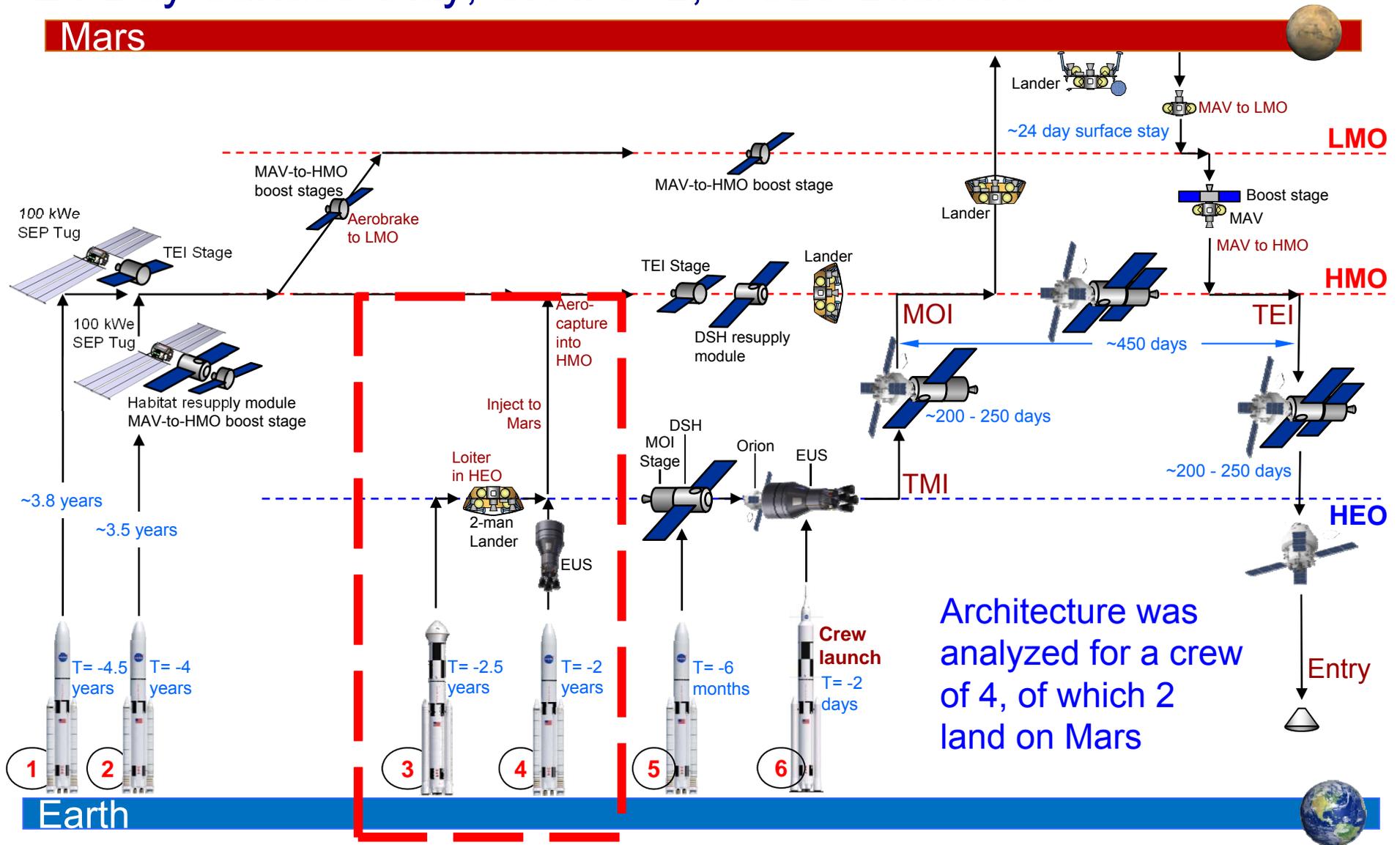
Overall Architecture Concept

4 SLS Launches



Short-stay Surface Concept

24-Day Surface Stay; Crew of 2; 6 SLS Launches

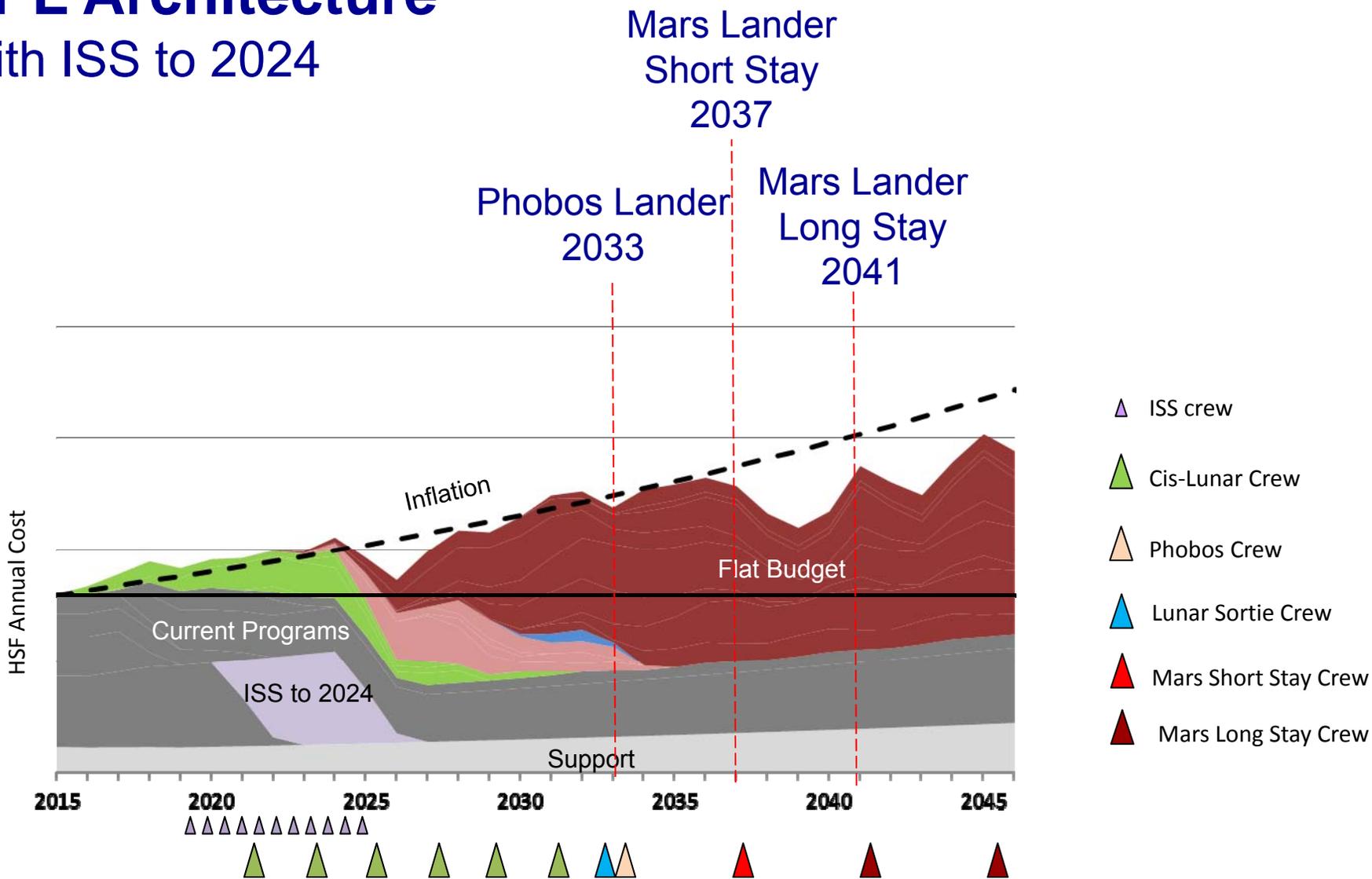


Cost “Sanity Check”

- Aerospace Corporation did the first-look cost assessment
- The cost estimating is based on models and analogy
 - Used model developed for NRC Pathways to Exploration study
 - As technical concepts mature, grassroots rather than model-based cost assessments should be performed for budget commitment
- Aerospace’s assessment suggests that meeting the Study Team’s self-imposed cost constraint is plausible



JPL Architecture with ISS to 2024



This work was aimed at showing an example (an existence proof) that journeys to Mars using technologies that NASA is currently pursuing is plausible on a time horizon of interest to stakeholders and without large spikes in NASA budget.

Takeaway



HEO Committee Finding



Proposed NASA Human Exploration and Operations Committee Finding

Name of Committee: Human Exploration and Operations Committee
Chair of Committee: Mr. Ken Bowersox
Date of Public Deliberation: July 28, 2015 (HEO Advisory Committee)

Short Title of Finding: Outside Participation in Exploration Mission Planning

The HEOMD is leading an effort to build the technical rationale for a sustainable human exploration effort which will allow humans to pioneer space called the Evolvable Mars Campaign. Inclusion of groups outside the core NASA team in the Evolvable Mars Campaign study process helps to build support for the study results, and also allows for a wider set of creative approaches from which to build the final plans for human exploration. The HEO Committee endorses the HEOMD's current effort to include outside participation in NASA's planning efforts for the Journey to Mars.

Transition from ISS to Cis-Lunar Space



A proposed two pronged approach to ensuring that HSF transitions without a gap between ISS and cis-lunar space

and

research and technology development in LEO continues seamlessly between ISS end-of-life and commercially available capabilities



Transitioning HSF from LEO to Cis-Lunar Space (Earth Dependent to the Proving Ground)

Earth Dependent



Long Duration Human Health & Habitation
Research and Demonstrations

First half of the 2020's

Knowledge & Capabilities

Second half of the 2020's

Goal:
One year crewed
mission(s) in cis-
lunar space

Proving Ground



Short Duration Habitation
& Transportation system validation

Long duration human health & habitation
Validation for Mars transit

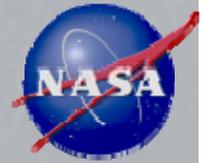
Knowledge & Capabilities



ARM

- SLS/Orion performance
- Deep space multi-body navigation
- Integrated crewed/robotic vehicle operations in deep space staging orbits
- System and crew performance in deep space radiation environments
- Advanced autonomous proximity operations and rendezvous in deep space and with non-cooperative objects
- Astronaut EVA for sample selection, handling, and containment
- Validating Earth return trajectories and emergency return strategies

- Validate crew health and performance countermeasures developed on ISS
- Validate habitation system and crew performance in deep space radiation environment developed on ISS
- Simulate Mars transit crew operations –
 - Limited interaction with MCC based on path finders on ISS
 - Limited/No re-supply
 - No crew exchanges
- Develop and validate the operational habitation, life support and environmental monitoring systems that were validated on ISS integrated with other systems (e.g. thermal, power, etc.)



Implications for the next several years

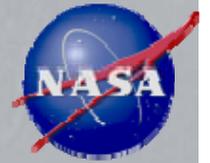
- Having this goal of a “shake down cruise” (*or multiple cruises*) near the end of the 2020’s provides an anchor for other HSF activities and possibly broader scientific objectives

Human Spaceflight

- Drive SLS/Orion performance and EM mission objectives
- Provide the basis for ISS-to-PG transition discussions with IP’s
- Provides the pull for shorter duration missions – particularly ARM
- Provides focus for near-term policy and budgets
- Help drive requirements for other areas such as logistics, propulsion, etc.

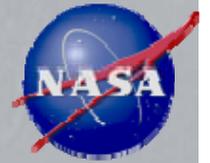
Robotic/Science

- Lunar robotic exploration
- Lunar surface in-situ demonstration
- Cis-lunar space science objectives



Commercial and International Partnership

- There are many opportunities for public-private and international partnerships in achieving the goal of one year duration crewed missions in cis-lunar space
 - Habitation and habitation systems
 - Dissimilar redundancy
 - Logistical support
 - Communications
 - Navigation
 - Propulsion and re-fueling systems
 - Transportation
 - Other mission or scientific objectives



So What does this mean for ISS

- All the critical research and system demonstrations needed to validate long duration HSF must be completed on ISS...before they are applied in the Proving Ground...
 - Human research and performance
 - Habitation systems such as ECLSS, environmental monitoring, crew systems, etc.
 - All the other technologies and systems that need maturation
 - Docking, communication protocols, autonomous crew operations, etc.
- We are now in the process is determining specifically what transitional objectives we want to accomplish on ISS and what we expect to transfer to cis-lunar space
 - Human research, system performance, operational considerations, etc.

We are beginning to plan for the transition of HSF out of LEO
and into the Proving Ground



Second Prong:

Expand the full breadth of the US economy into LEO



Vision: Sustained economic activity in LEO enabled by human spaceflight, driven by private and public investments creating value and benefitting Earth through commercial supply and public and private demand

Goals

1.0 LEO commercialization enabled by leveraging ISS

- User-friendly ISS process improvements
- Maximize throughput
- Demonstrate & communicate value proposition of ISS
- Foster “success stories”
- Utilize more commercial acquisition strategies

2.0 The policy and regulatory environment promotes commercialization of LEO

- Establish interagency working group to address policy and regulatory issues
- Investigate economic cluster potential
- Address barriers such as IP retention, liability, ITAR

3.0 A robust, self-sustaining, and cost effective supply of US commercial services to/in/from LEO accommodates public and private demands

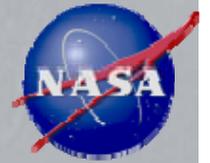
- Leverage NASA NEXTSteps BAA studies and follow-on to enable commercial LEO capabilities
- Enable Earth-similar laboratory capabilities for ISS that can transition to commercial platforms
- Transition from NASA-supplied to commercially-supplied services and capabilities once available

4.0 Broad sectors of the economy using LEO for commercial purposes

- Establish consortia for potential high-payoff, market-enabling microgravity applications with public and private funds to support development (e.g. protein crystallization, exotic fibers, lightweight alloys, 3D tissues)
- Establish commercial LEO utilization university curriculum and programs



Next HEO NAC



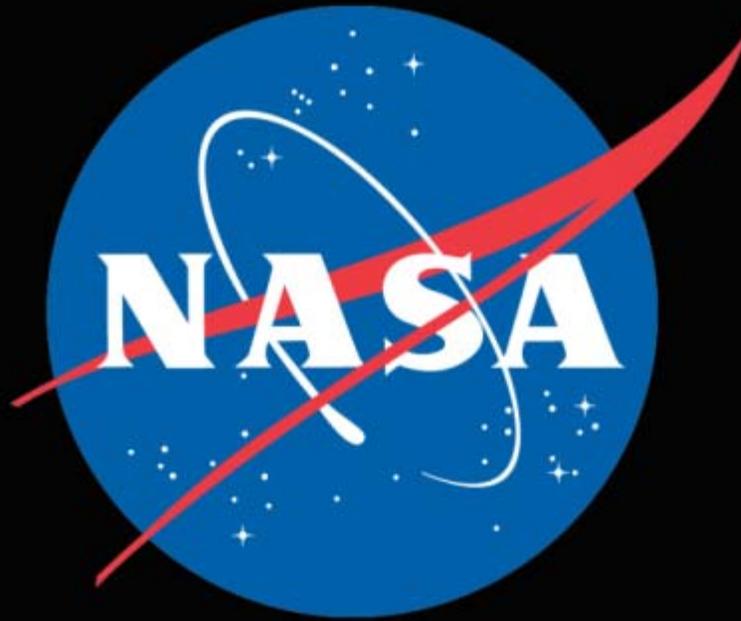
We hope to present a top level draft of the HSF ISS to Proving Ground transition plan and progress towards building the commercial and OGA demand for LEO



Special Topics at Future HEO Committee Meetings



- Future Special Topics:
 - International Participation in Future Human Exploration
 - ISS uses for Exploration development
 - ISS transition after 2024
 - Exploration plans after ARM
 - Launch readiness process for commercial crew
 - Commercial crew vehicles – contractor briefings



www.nasa.gov