

# The Importance of Digital Transformation for future Deep Space Human Missions



**George Salazar , P.E., ESEP, LM-IEEE**  
**Human-Computer Interface Technical Discipline Lead**  
**Avionic Systems Division**  
**NASA/JSC**

# Topics

A space-themed background featuring a dark starry sky with various celestial bodies. In the foreground, the Moon is prominently displayed on the left. To its right is the reddish planet Mars. Further back, the gas giant Jupiter with its characteristic bands is visible, along with Saturn and its rings. The scene is illuminated by a bright blue light source, possibly a star or nebula, creating a sense of depth and wonder.

- **Planned Mission to Moon then Mars**
- **The Need for Digital Transformation**
- **Conclusion**

# Topics



- **Planned Mission to Moon then Mars**
- **The Need for Digital Transformation**
- **Conclusion**

# Artemis Phase 1: To The Lunar Surface by 2024

Artemis I: First human spacecraft to the Moon in the 21st century

Artemis II: First humans to orbit the Moon in the 21st century

Artemis Support Mission: First high-power Solar Electric Propulsion (SEP) system

Artemis Support Mission: First pressurized module delivered to Gateway

Artemis Support Mission: Human Landing System delivered to Gateway

Artemis III: Crewed mission to Gateway and lunar surface

**Commercial Lunar Payload Services**  
- CLPS-delivered science and technology payloads

**Early South Pole Mission(s)**  
- First robotic landing on eventual human lunar return and In-Situ Resource Utilization (ISRU) site  
- First ground truth of polar crater volatiles

**Large-Scale Cargo Lander**  
- Increased capabilities for science and technology payloads

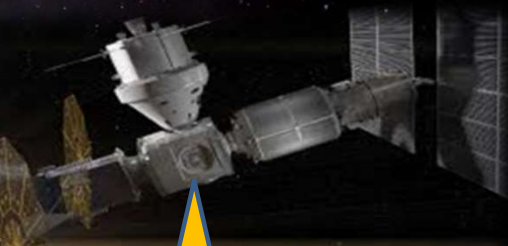
**Humans on the Moon - 21st Century**  
First crew leverages infrastructure left behind by previous missions

**LUNAR SOUTH POLE TARGET SITE**

2020

2024

# Deep Space Mission Operations



Crew/Mission Control-Dependent

Crew/Vehicle-Dependent

On-board Mission Control

Current

Future-Notional



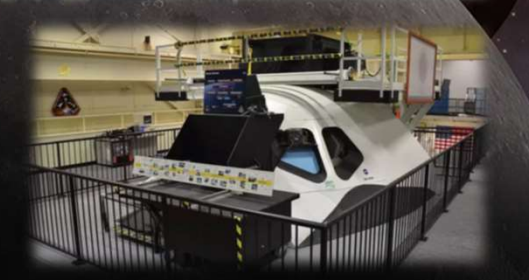
# Topics

A space-themed background featuring a dark starry sky with various celestial bodies. In the foreground, the large, cratered surface of the Moon is visible. Behind it, the reddish-orange planet Mars is shown. Further back, the gas giant Jupiter with its characteristic bands and the ringed planet Saturn are visible. A bright blue nebula or star cluster is also present in the background.

- **Planned Mission to Moon then Mars**
- **The Need for Digital Transformation**
- **Conclusion**

# NASA History of Digital Transformation

- **NASA has been involved in Digital Transformation since the 70s-digital twin.**
- **Apollo space program**
  - Apollo 11 lunar landing “1201” alarm
  - Apollo 13 manoeuvre to return to earth and power savings.
- **Shuttle & Station**
  - Shuttle Avionics Integration Lab
  - Station ground systems



# NASA Initiative to Embrace Digital Transformation



Missions are increasingly complex and integrated with industry, on shorter timelines



The aerospace industry, and the world, is digitally transforming around us



Technology Convergence-ML/AI, MBSE, High Performance Computing, Integrated Multidisciplinary Modeling and Simulation



Top talent is expecting to work in a digitally-enabled workplace



Enable integrated universal collaboration & partnerships

**Enhance NASA mission impact by reinventing its processes, products, and capabilities**



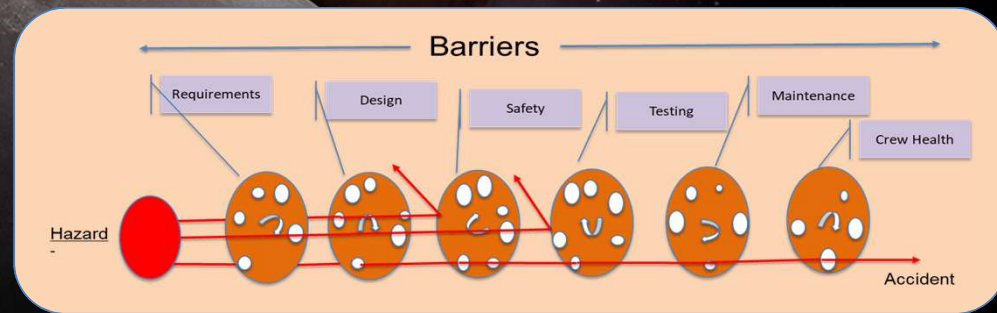
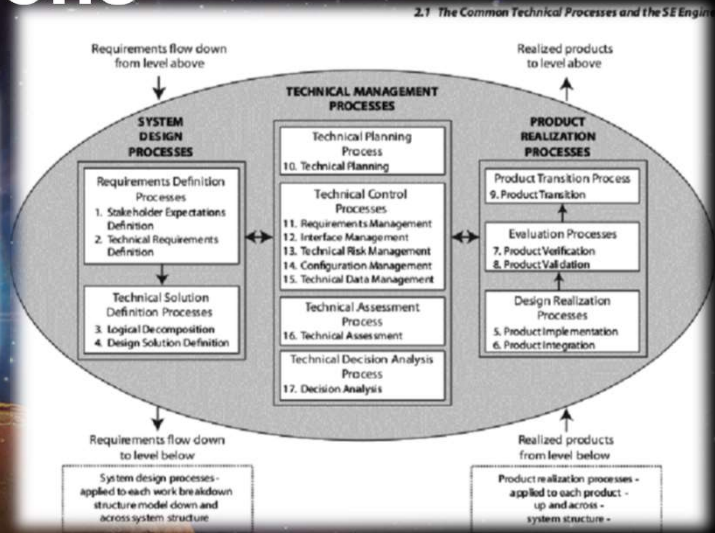
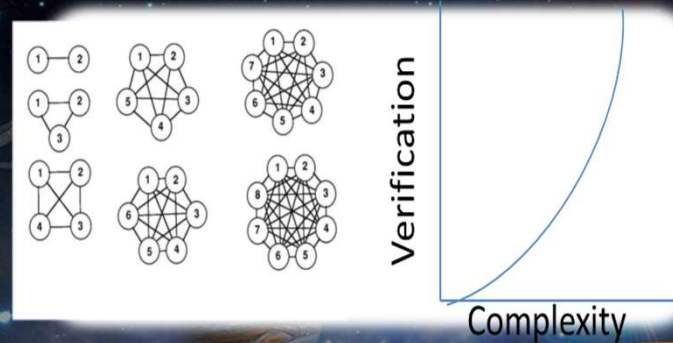
**New NASA opportunities**

# Human & Technology Challenges for Deep Space Missions-Notional

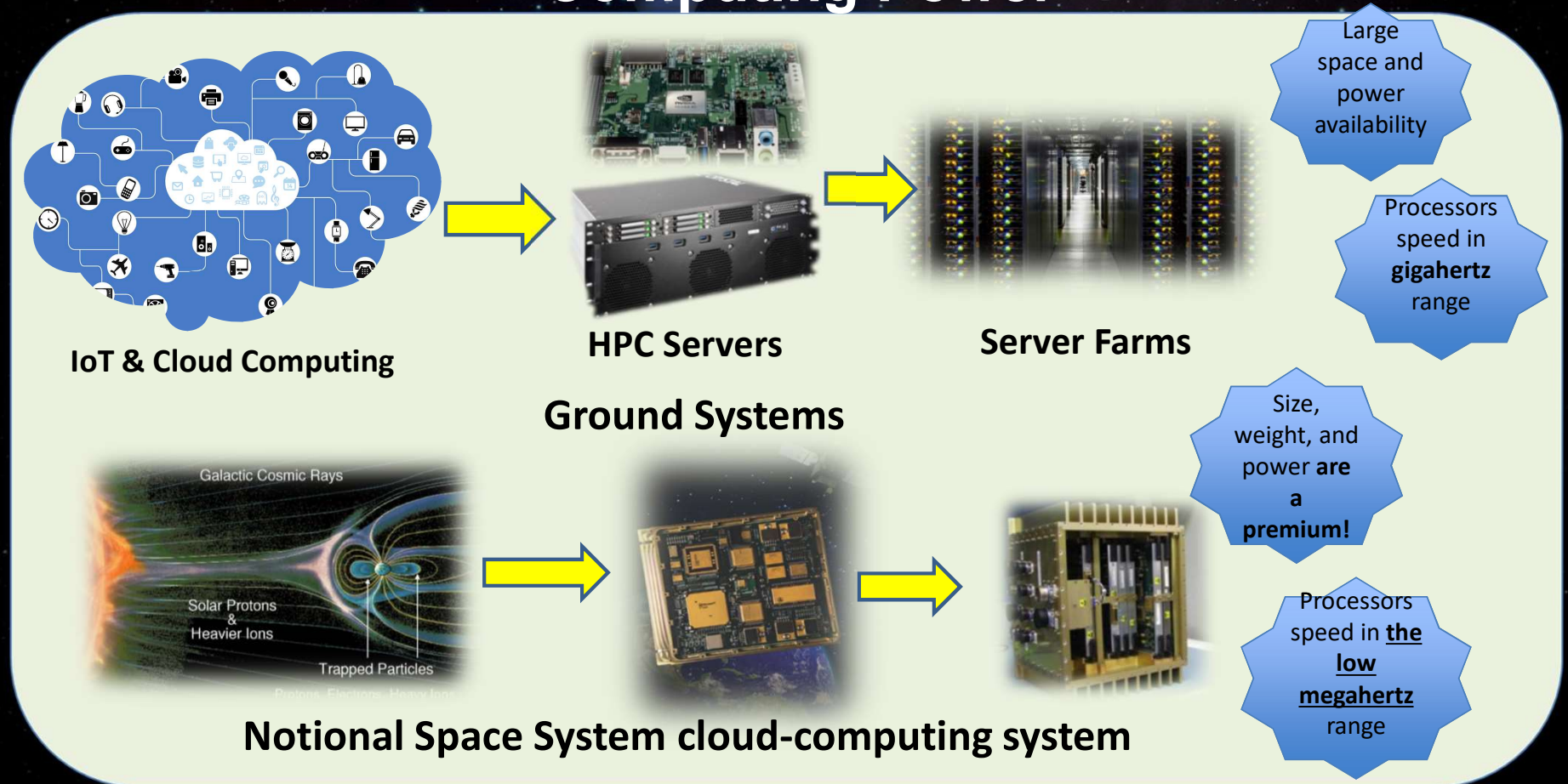


# The Need for Digital Transformation For Deep Space Missions

- ◆ Mars is a major paradigm change in mission complexity
- ◆ Improve mission success against risks
- ◆ Human Systems Integration critical to mission success



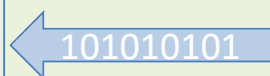
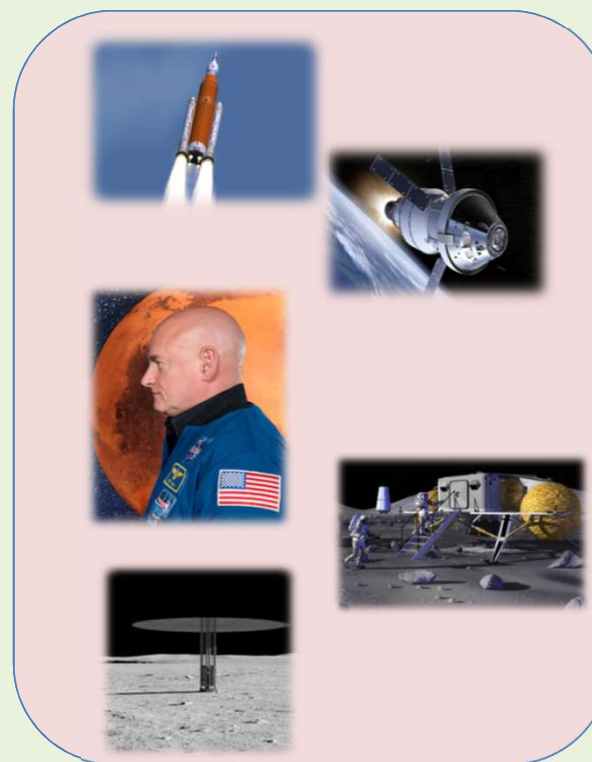
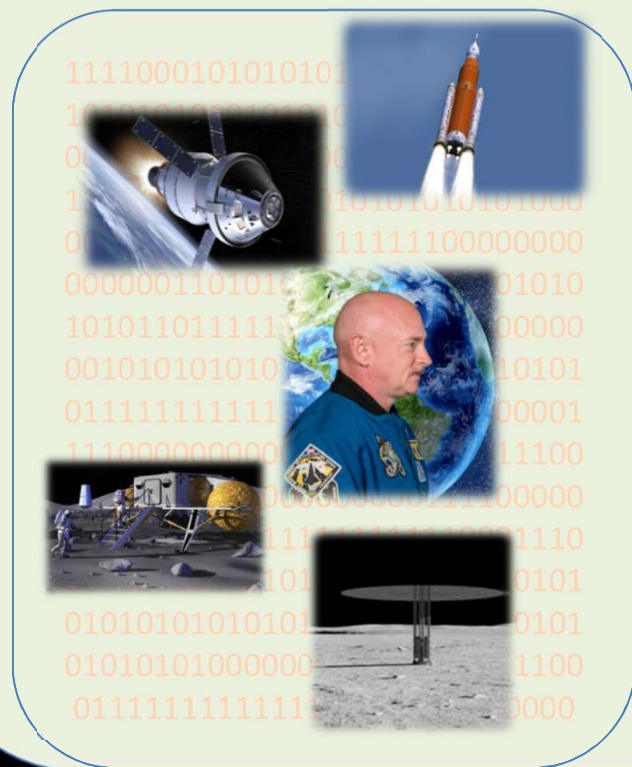
# Space Digital Twin Major Challenge 1 — Computing Power



# Space Digital Twin Major Challenge 2 — Distance & Data Rates

Earth

Mars



Virtual Space

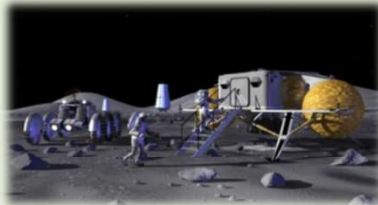
Physical Space

# Topics



- **Planned Mission to Moon then Mars**
- **The Need for Digital Transformation**
- **Conclusion**

# • Path to Future Space Missions through Digital Transformation(DT)



**Develop technology to learn to live and work on other worlds**

100000000110101010  
10100000001010  
11010000001111  
110000000101010101  
0101000000101  
0111000000111

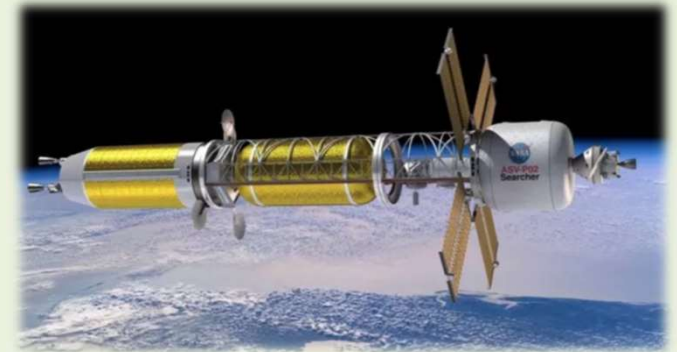
- Refine DT processes



**Settle Mars**

10000000010101010  
10100000001010  
11010000001111  
110000000101010101  
0101000000101  
0111000000111

- Continue to refine DT



**On to other worlds!**



Questions ?

\*Concept image