# Storage in Space Enables and Accelerates Edge of the Edge Computing on the International Space Station (ISS)


Mark R. Fernandez, Ph.D.

Principal Investigator, Spaceborne Computer-2

Chief Scientist, Space Technologies and Solutions

mark.r.fernandez@hpe.com


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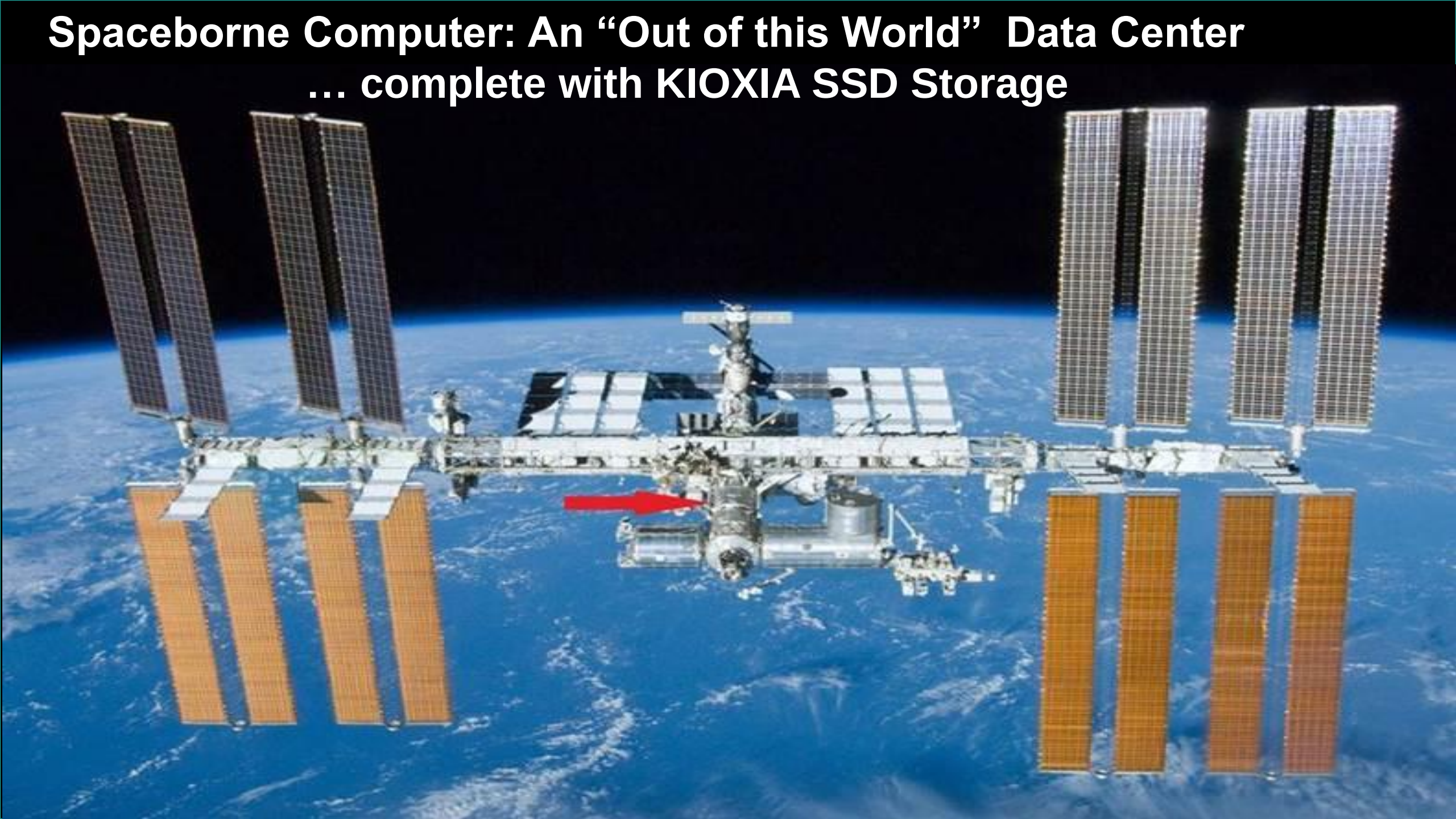
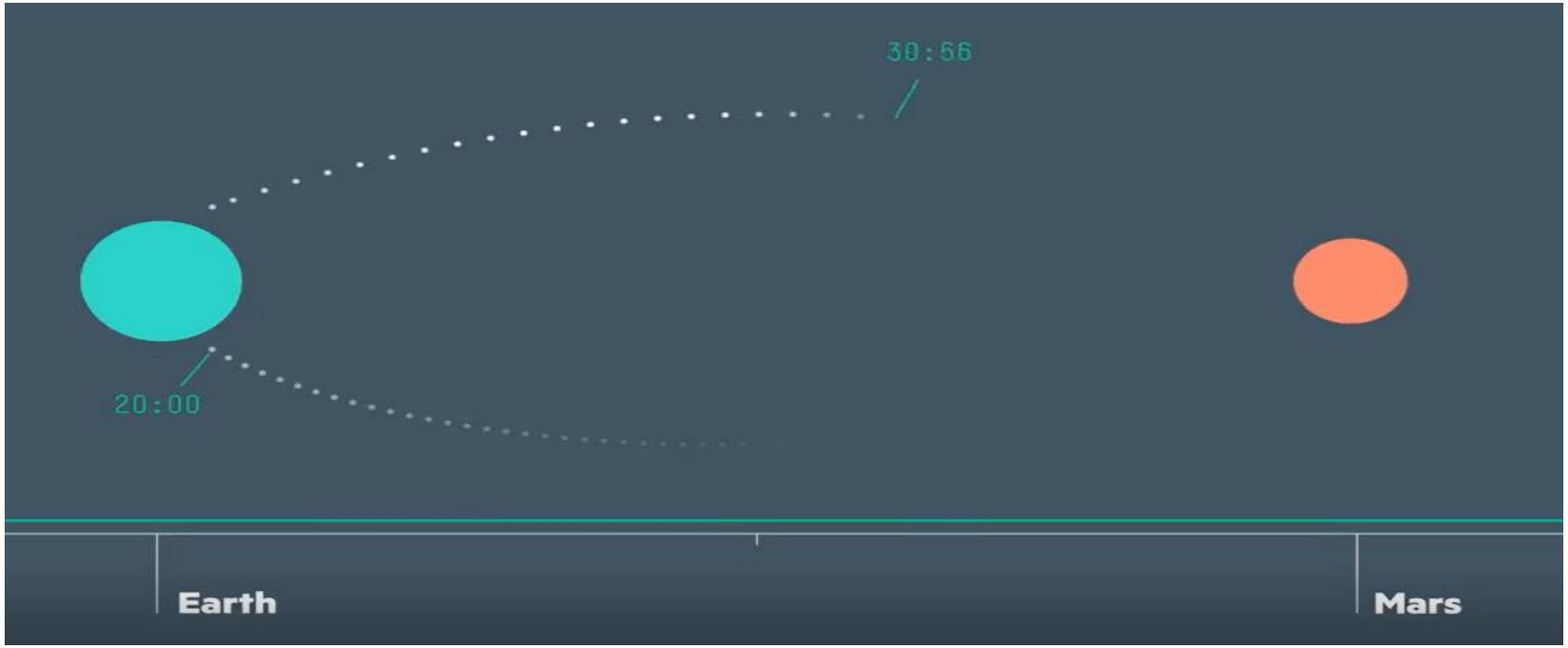
# Spaceborne Computer: An “Out of this World” Data Center … complete with KIOXIA SSD Storage



# Spaceborne Computer: Objective / Mission: Why?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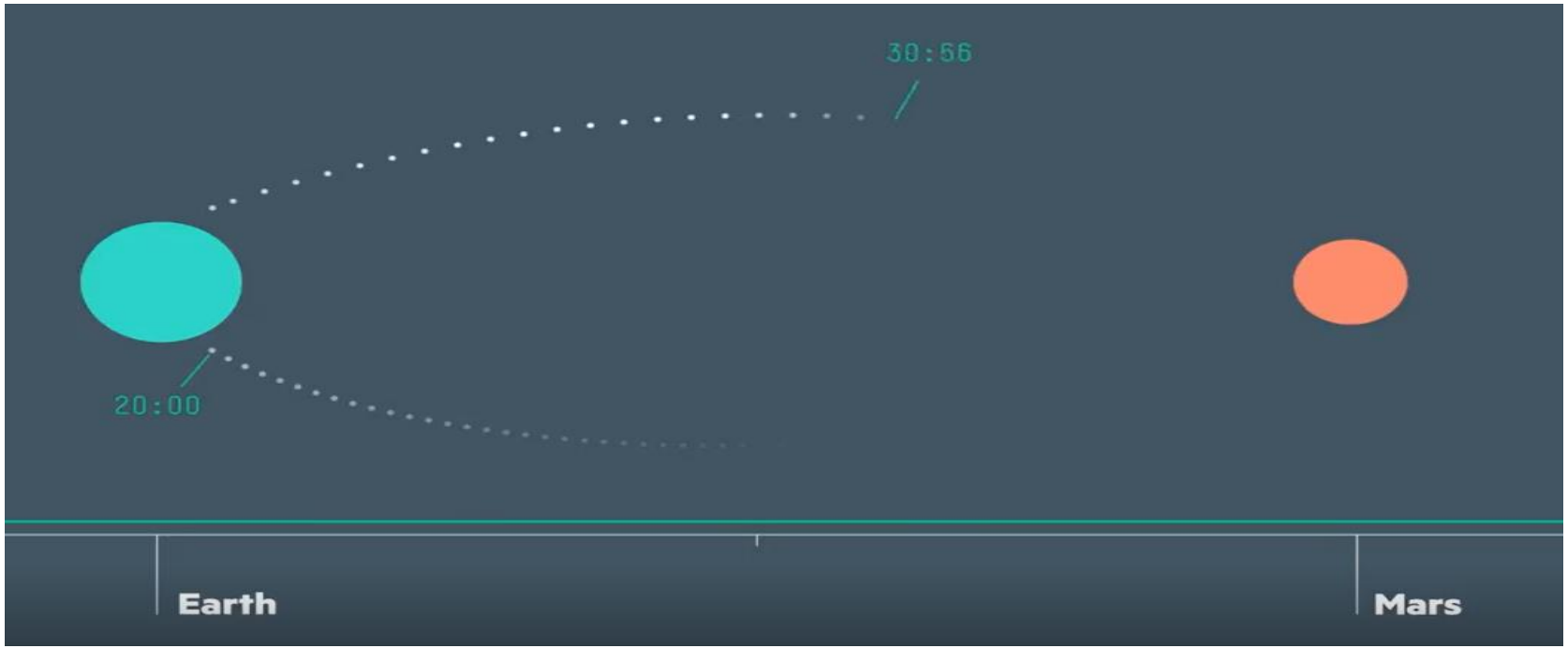
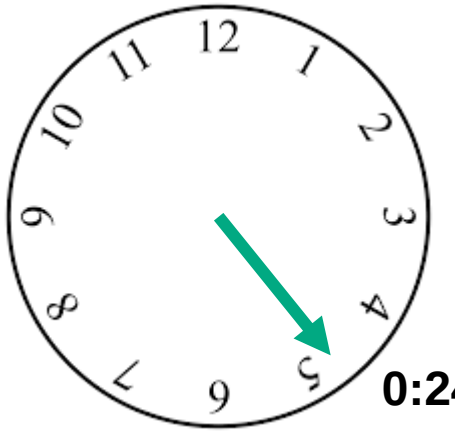



**0:00:**




**0:24:**

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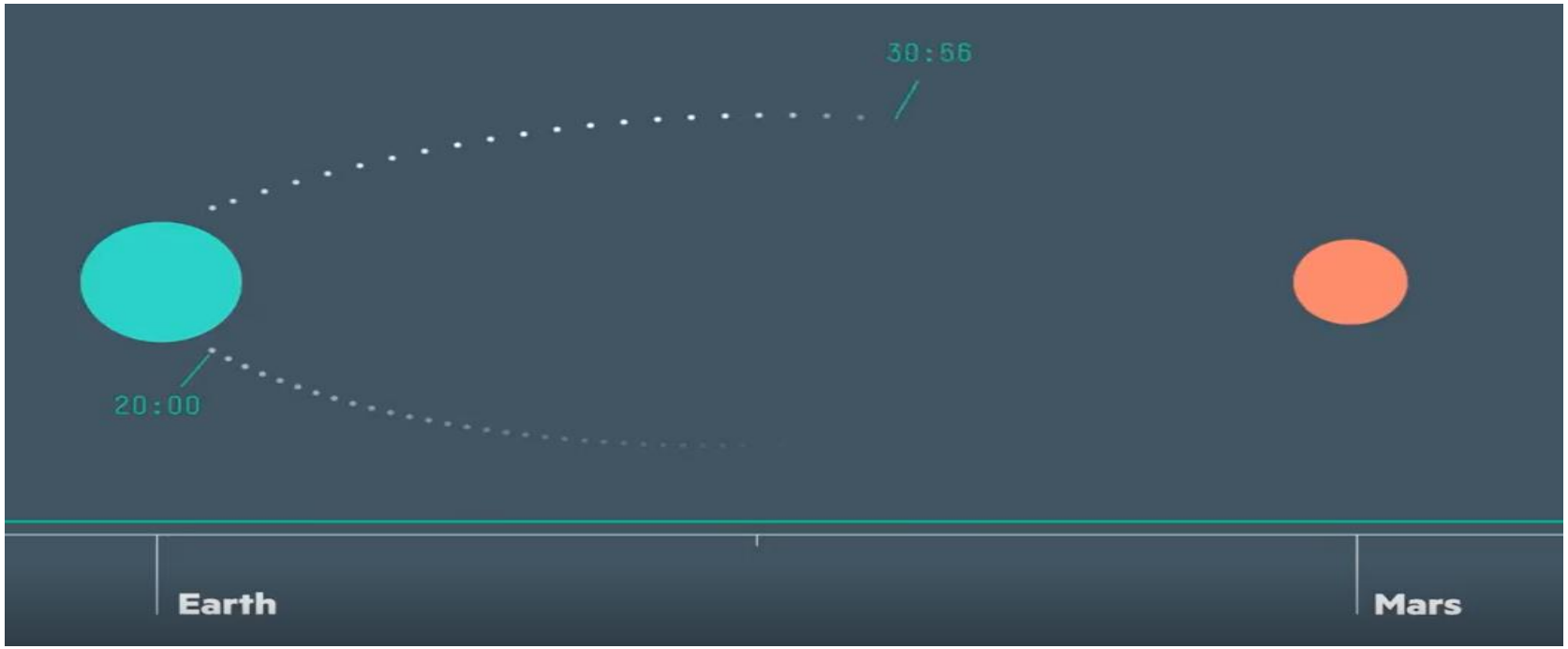
# Spaceborne Computer: Objective / Mission: Why?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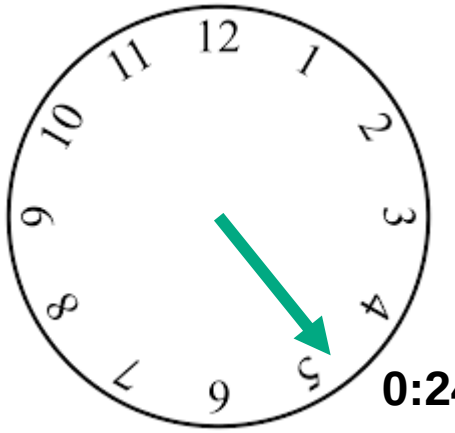


**0:24: "Okay, Houston, we've had a problem here."**

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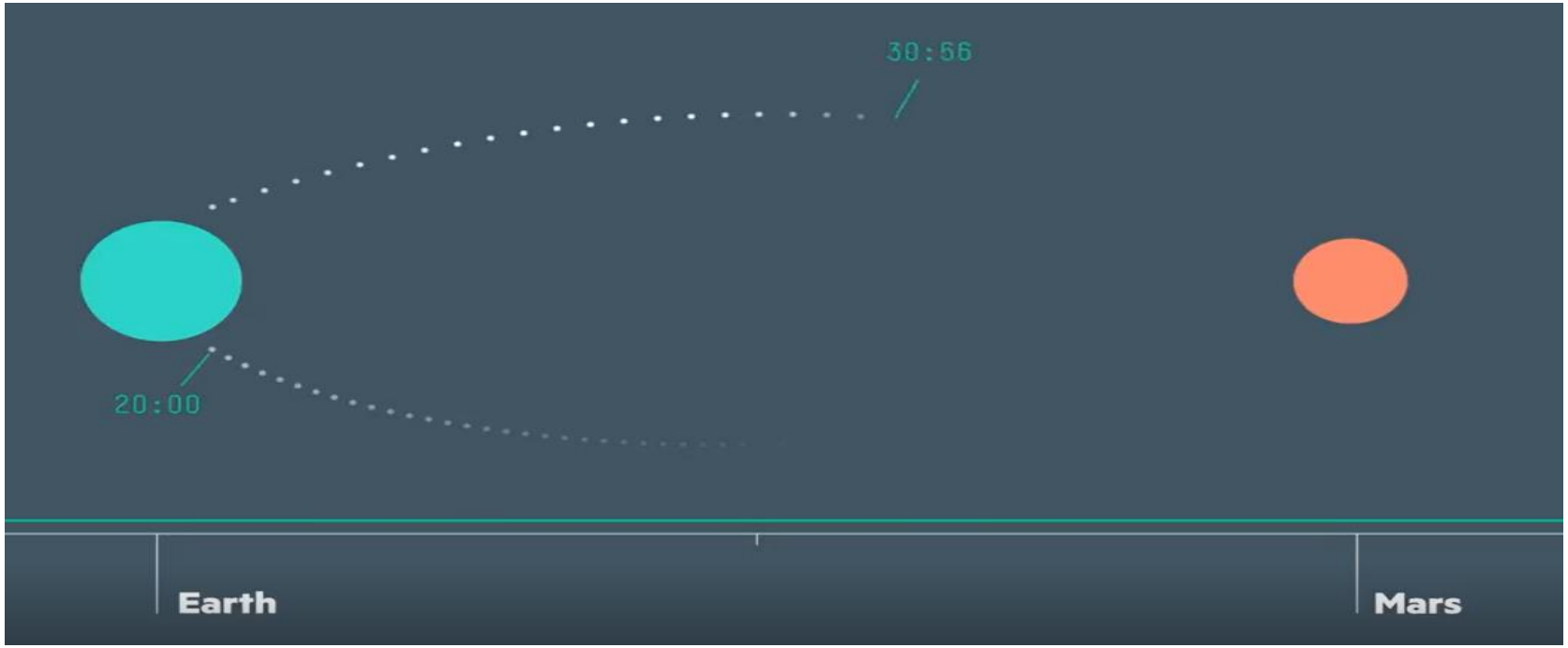
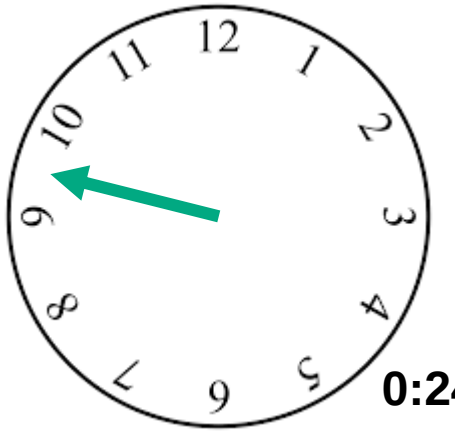
# Spaceborne Computer: Objective / Mission: Why?


**0:48:**



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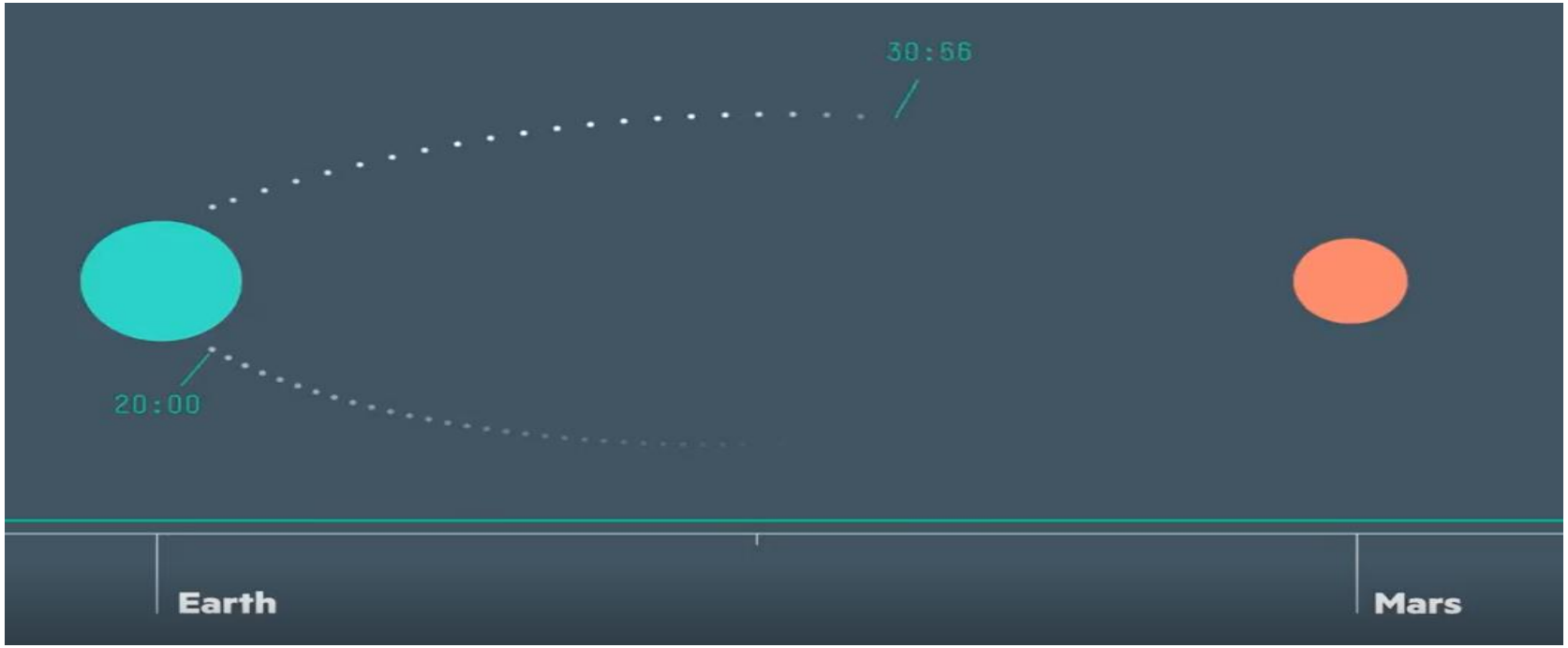
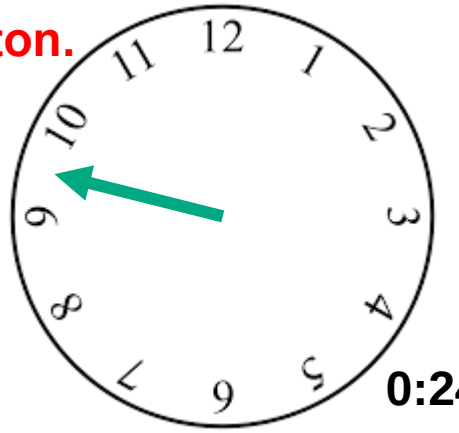
# Spaceborne Computer: Objective / Mission: Why?


**0:48: "This is Houston. Say again, please."**



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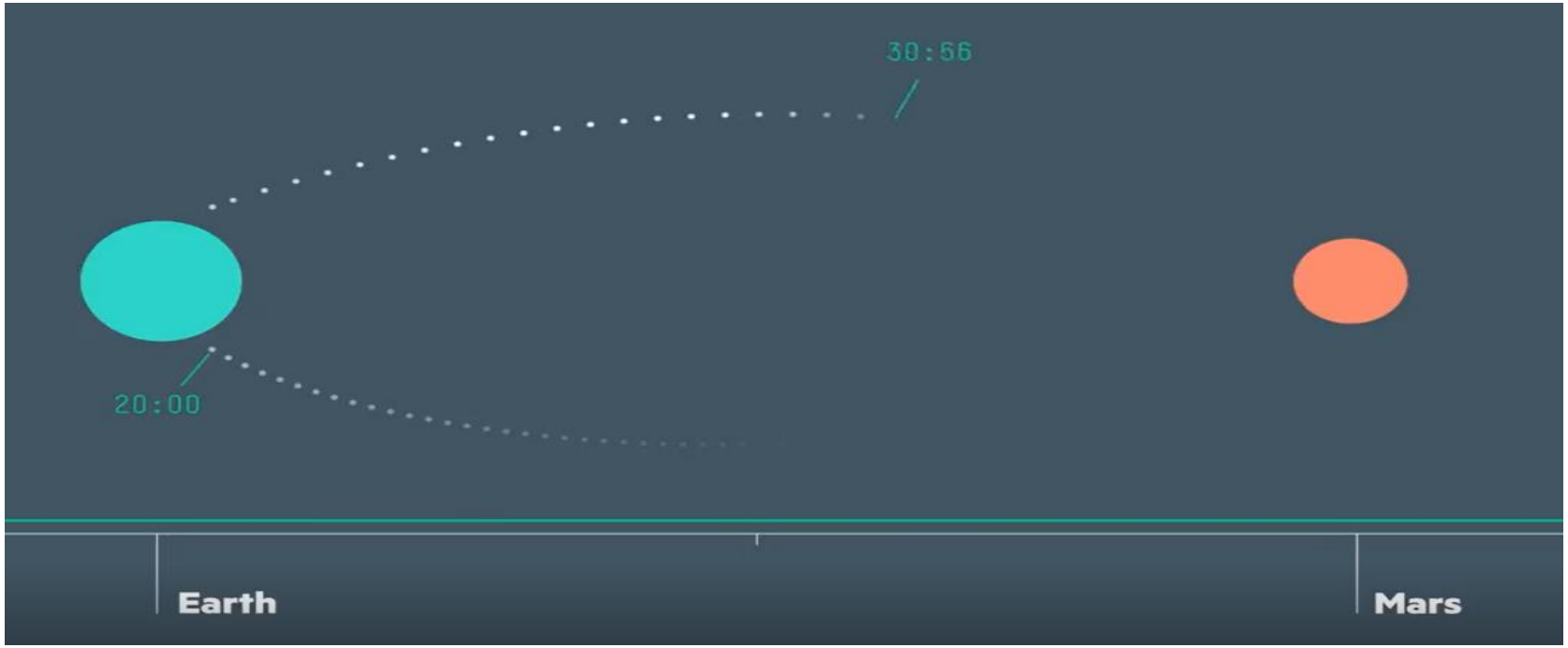


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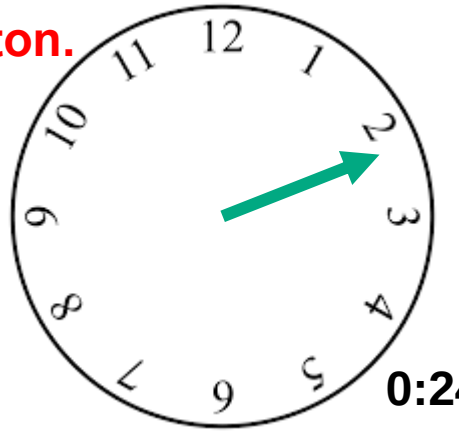

**1:12: "Houston, we've had a problem."**

**0:24: "Okay, Houston, we've had a problem here."**

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# Spaceborne Computer: Objective / Mission

Run **a year long experiment** on the ISS to verify

if a high performance commercial off-the-shelf computer system **– COTS HPC –**

can still **operate correctly.**

… and to capture the parameters under which this occurs.

**ISS : "… investigate human exploration *beyond Low Earth Orbit (LEO)*."**

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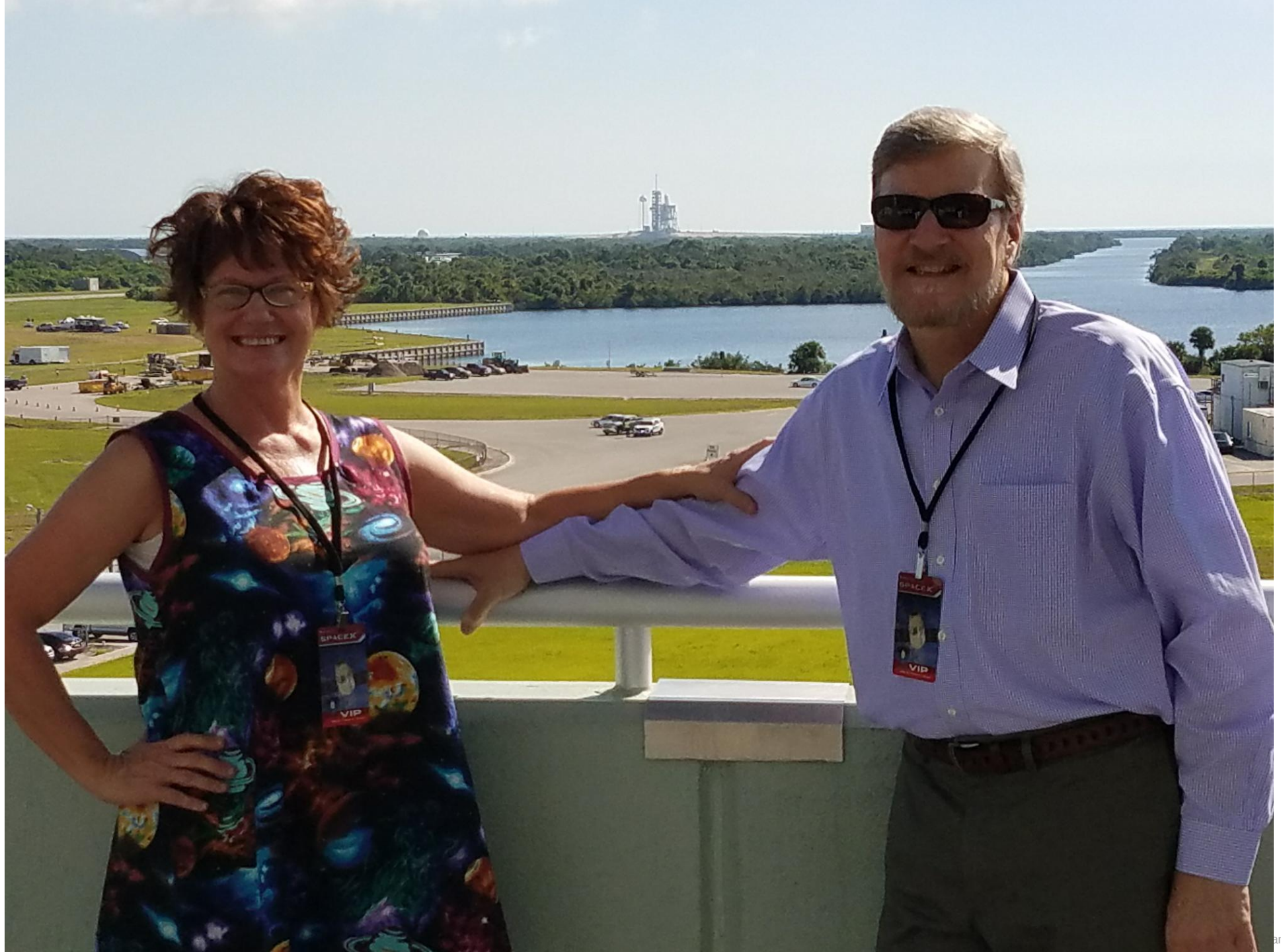


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# Spaceborne Computer (SBC): Buzz Aldrin Talk Before Launch

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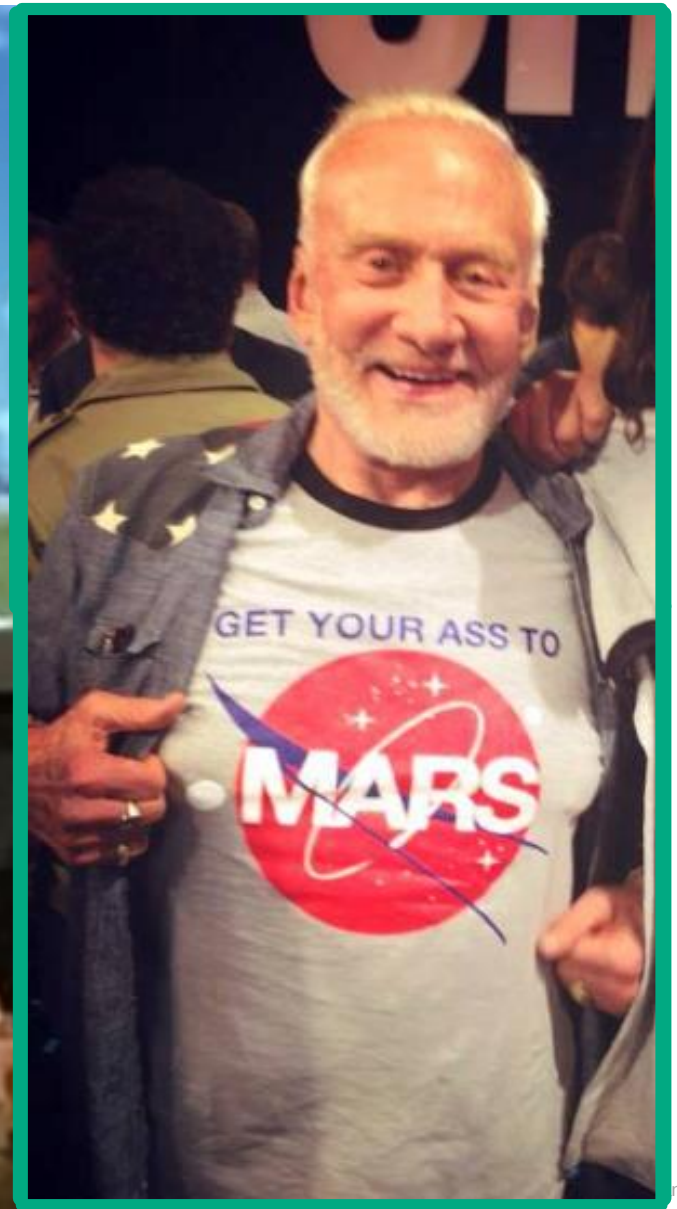

# SBC: SpaceX-12 Launch! Monday, 14-Aug-2017 @ 12:31 p.m. EDT

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# SBC: SpaceX-12 Launch! Monday, 14-Aug-2017 @ 12:31 p.m. EDT
# ——— …….. And Landing!!! Monday, 14-Aug-2017 @ 12:39 p.m. EDT

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# Spaceborne Computer: The Dawn of HPC And AI Above the Clouds

SBC-1: Launched on SpaceX CRS-12 on 08/14/2017 -- Flown for 1.8 years

9,562 orbits -- 6,879 SAA Passes -- 53,936 Experiments Completed -- All Successful

## First COTS HPC System in Space (1.1TF HPL)

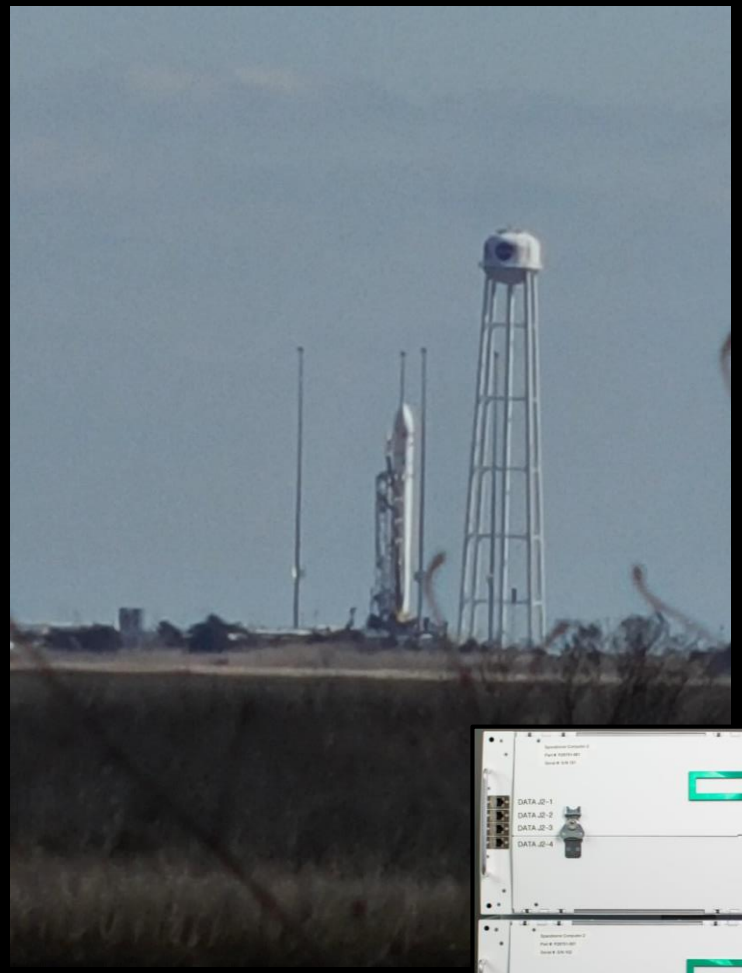



# Next Mission: Spaceborne Computer-2

## Launched: 20-Feb-2021, Northrop Grumman Resupply Mission to the ISS (NG-15)

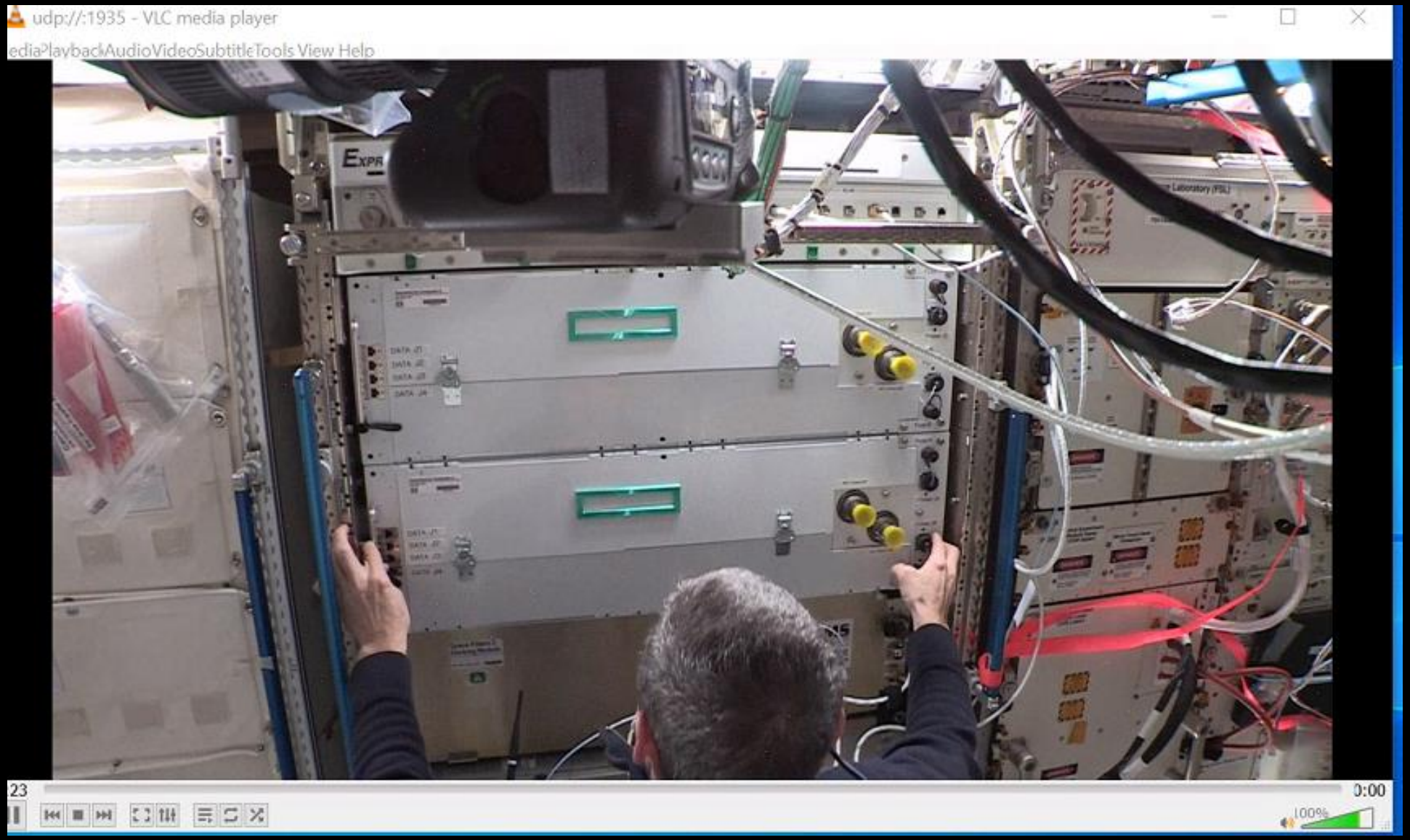

# Spaceborne Computer-2

## Launched: 20-Feb-2021 (aboard the NG-15 SS Katherine Johnson)



# Spaceborne Computer-2

## Installed: 29-Apr-2021 (in the “overhead” of the Columbus Module)



# Spaceborne Computer-2

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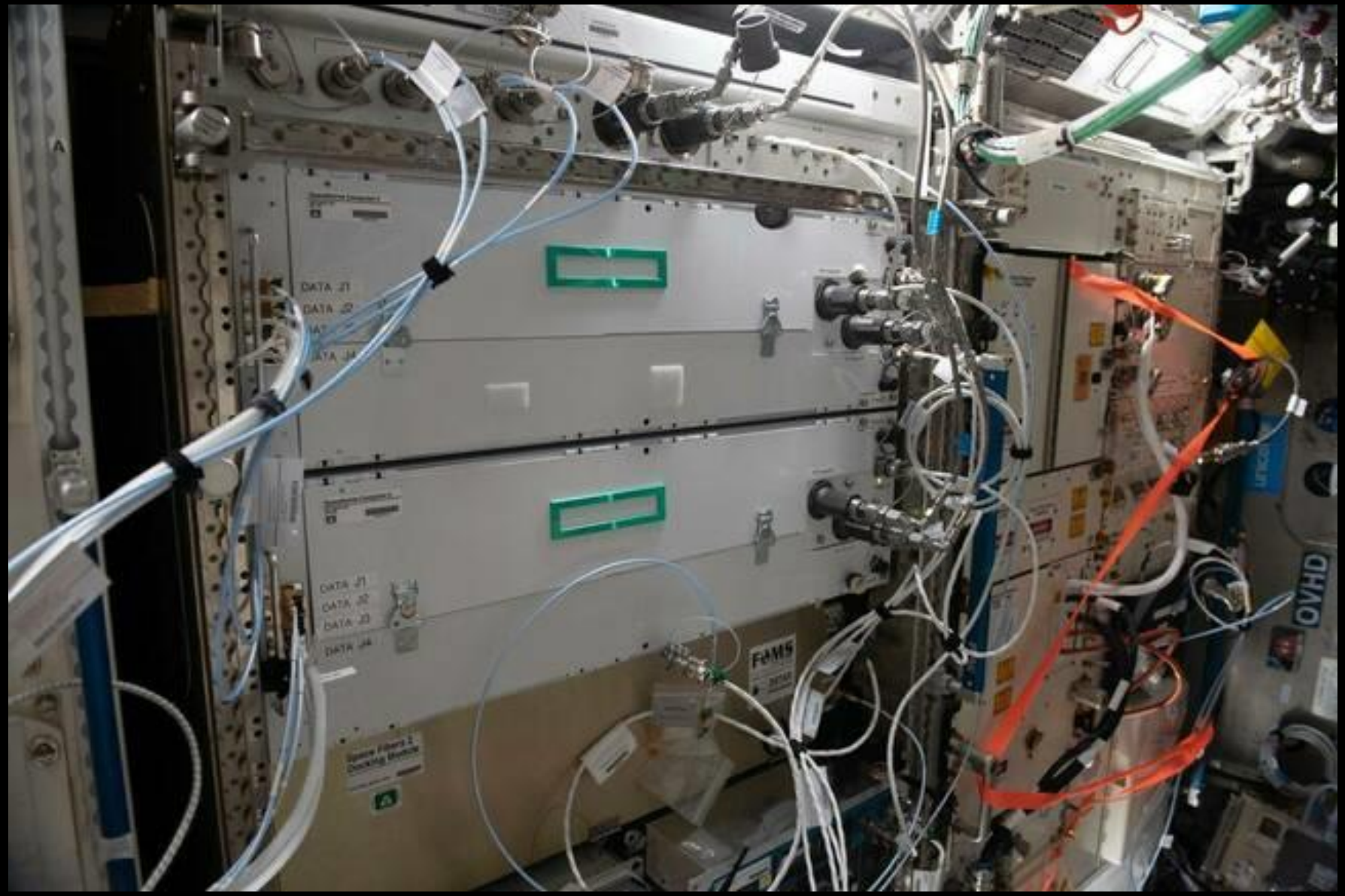

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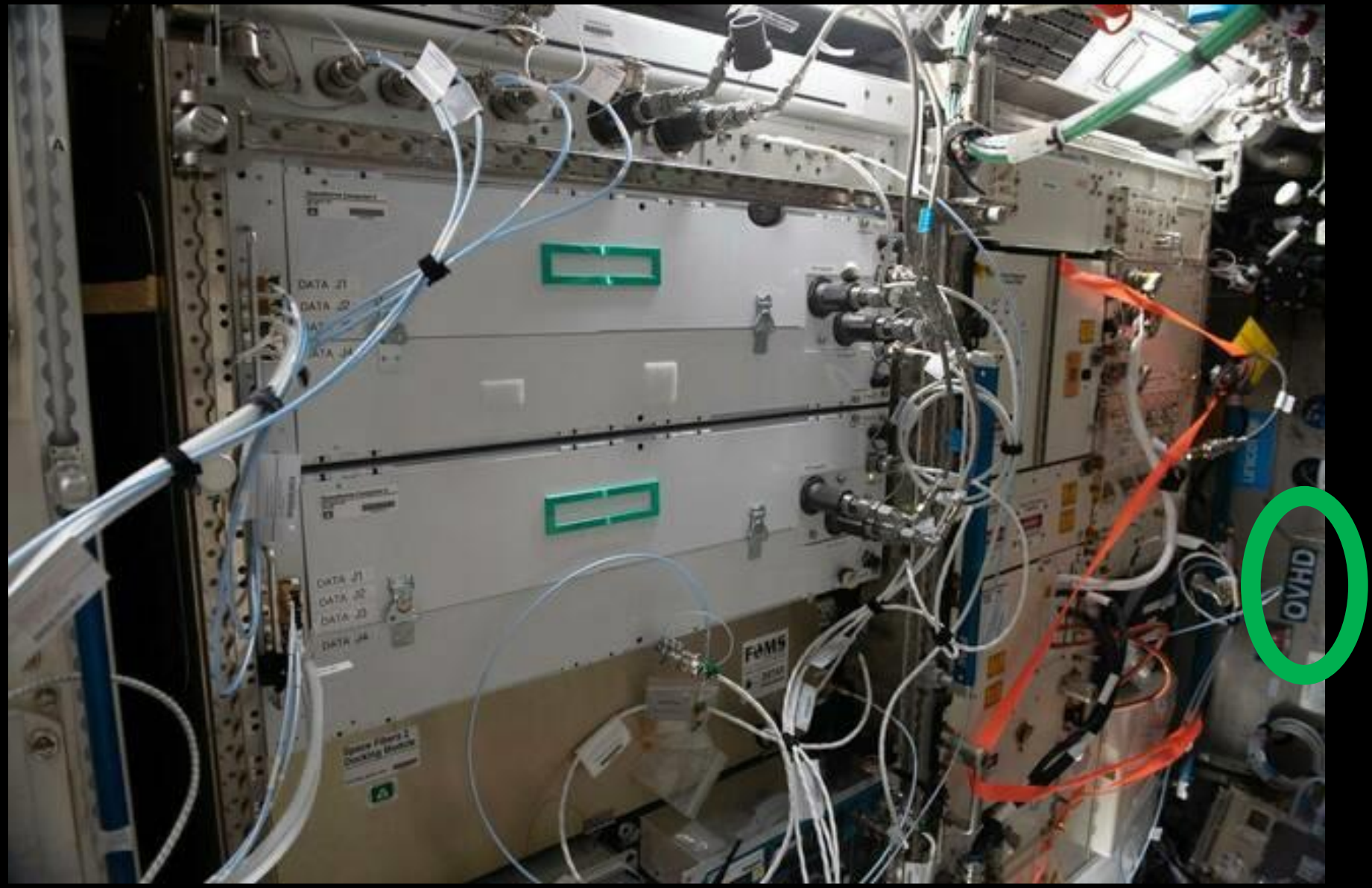

# Spaceborne Cor

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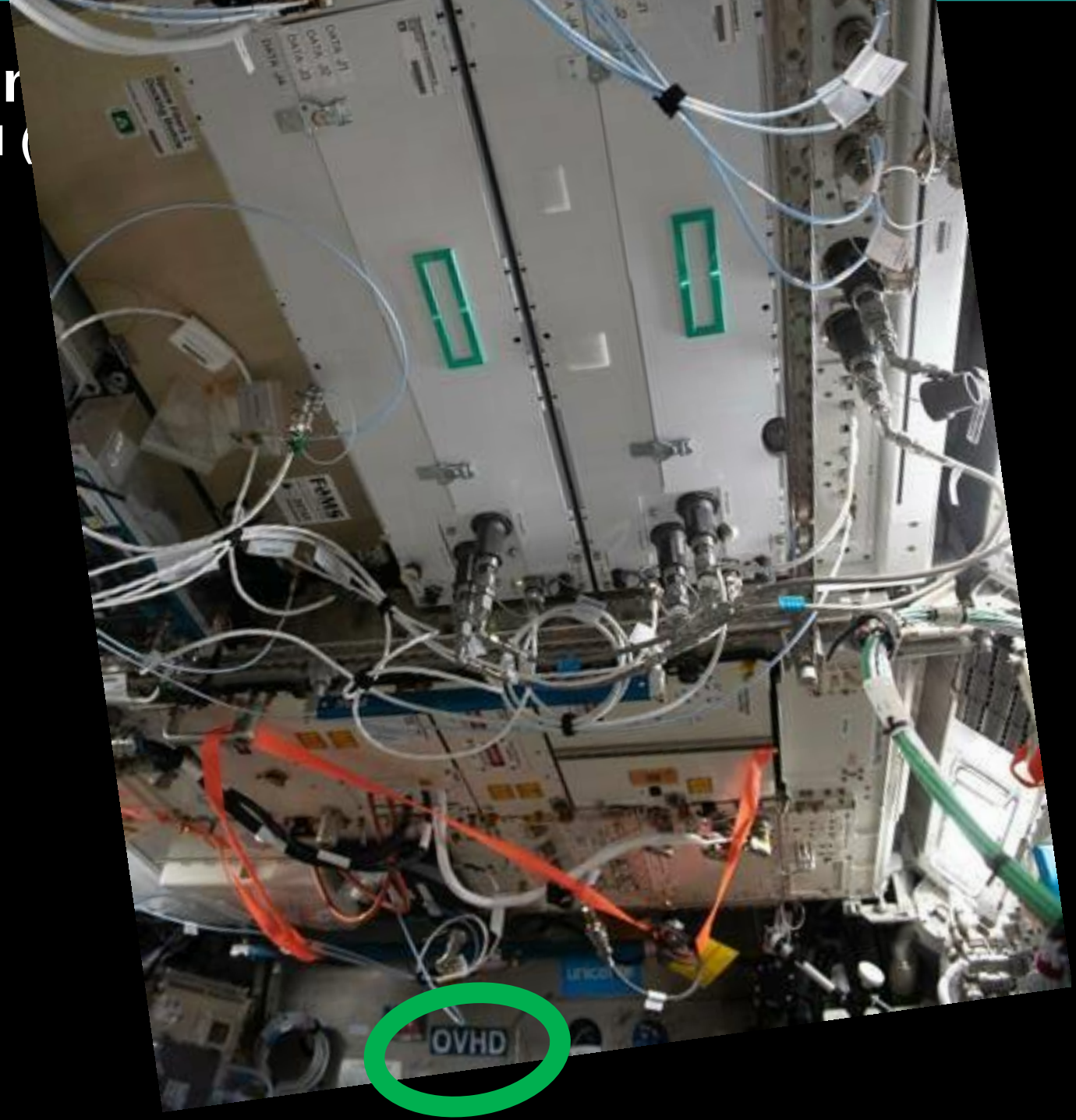
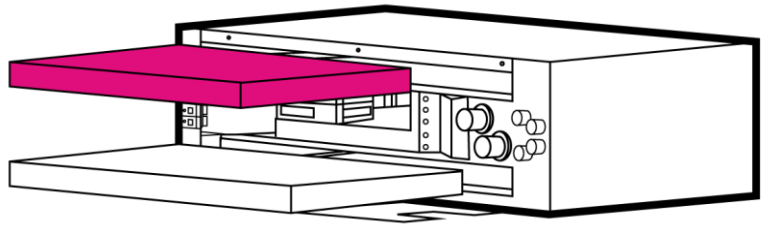



EXPRESS Rack 9
COL1F2

# Spaceborne Computer-2: Hardware & Software

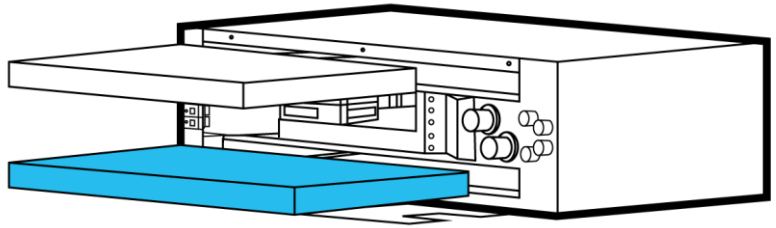
**Hardware:** HPE Edgeline EL4000
(edge-focused single socket with a single GPU)

- 1 x low wattage x86
- 1 x low wattage GPU
- 64 GB of memory total
- **4 x 240GB solid state drives**
- 1 x 10GbE Ethernet adapter



**Hardware:** HPE DL360 Gen10 server
(traditional 2-socket HPC compute node)

- 2 x low wattage x86 processors
- 192 GB of memory total
- **8 x 240GB solid state drives**
- 1 x 10Gb Ethernet Adapter



Software: Red Hat 7.8 Operating System
NASA TReK 5.3.1

* Powered from 28Vdc
* Cooled by AAA & MTL

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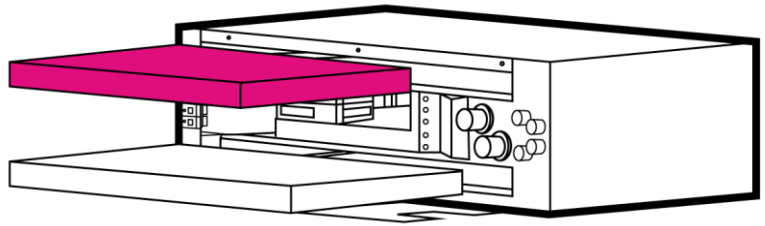
# Spaceborne Computer-2: Hardware & Software Refresh

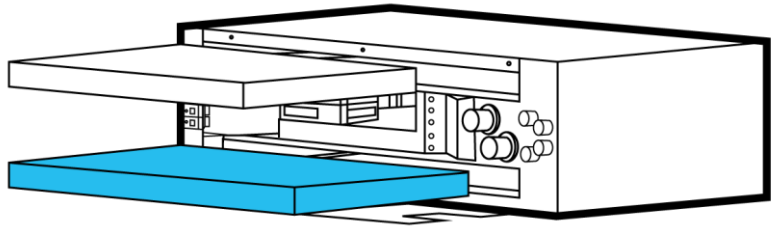
**Hardware:** HPE Edgeline EL4000
(edge-focused single socket with a single GPU)

- 1 x low wattage x86
- 1 x low wattage GPU
- 64 GB of memory total
- **4 x 1024 GB KIOXIA XG6 M.2 SSDs**
- 1 x 10GbE Ethernet adapter



**Hardware:** HPE DL360 Gen10 server
(traditional 2-socket HPC compute node)

- 2 x low wattage x86 processors
- 192 GB of memory total
- **8 x 960 GB KIOXIA RM6 2.5” SSDs**
- 1 x 10Gb Ethernet Adapter



Software: Red Hat 7.8 Operating System
NASA TReK 5.3.1

* Powered from 28Vdc
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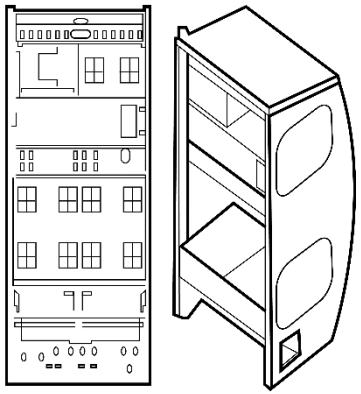
# Spaceborne: Demonstrating the Value of Edge Storage & Computing



**1,873,704 KB**

**(1.8 GB)**

**12.2 hours**

Proven in Space – Available on Earth™

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**Self-Sufficient Computers Enable Self-Sufficient Explorers**

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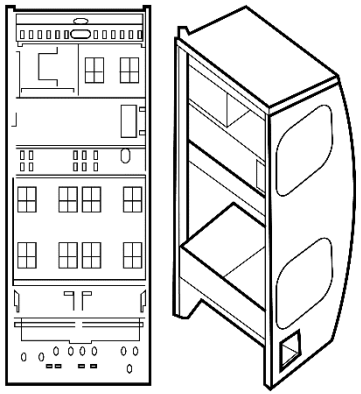
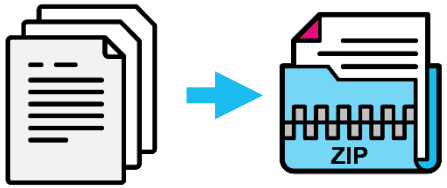
# Spaceborne: Demonstrating the Value of Edge Storage & Computing



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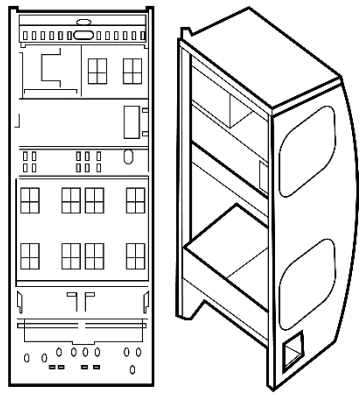

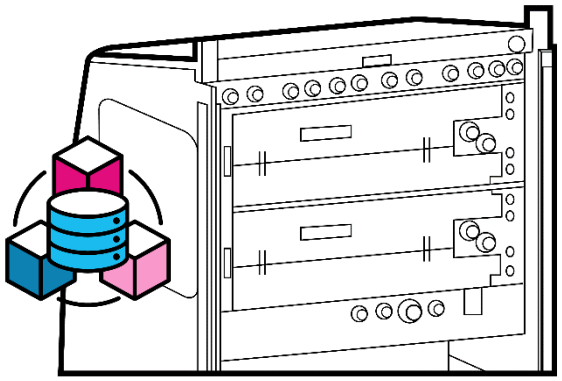

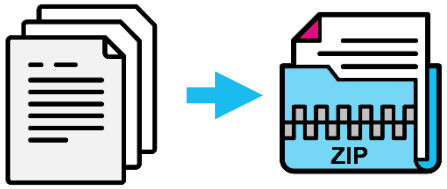


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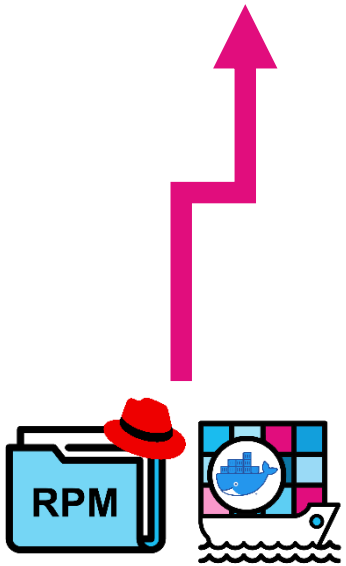


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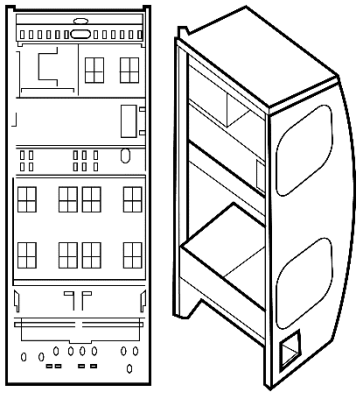
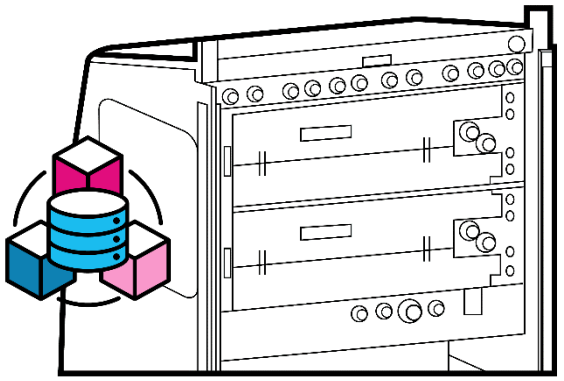
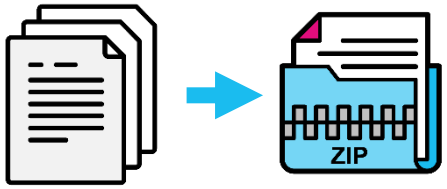




~6 minutes of Hybrid CPU/GPU processing

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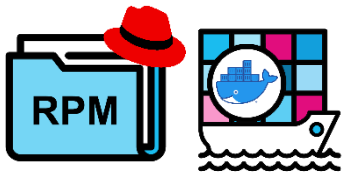


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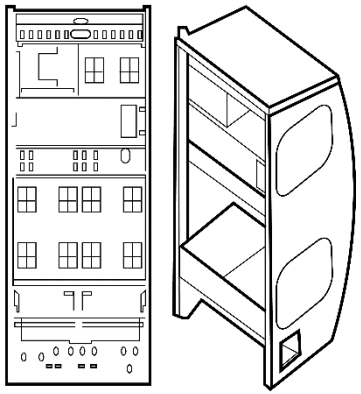

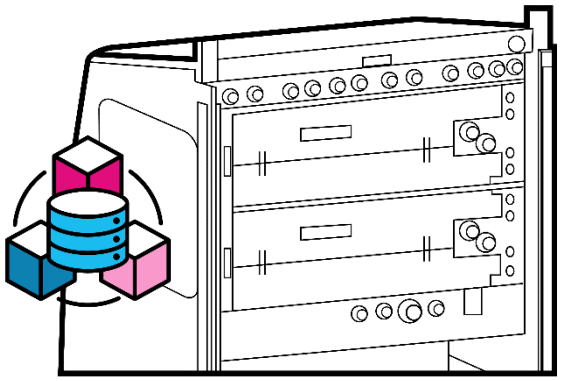

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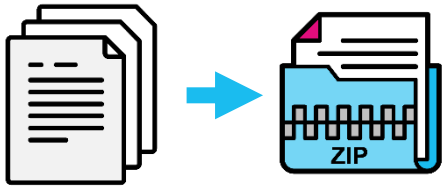


10x

1,873,704 KB
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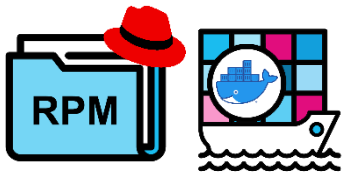
12.2 hours

92 KB
20,000x reduction
2 seconds!

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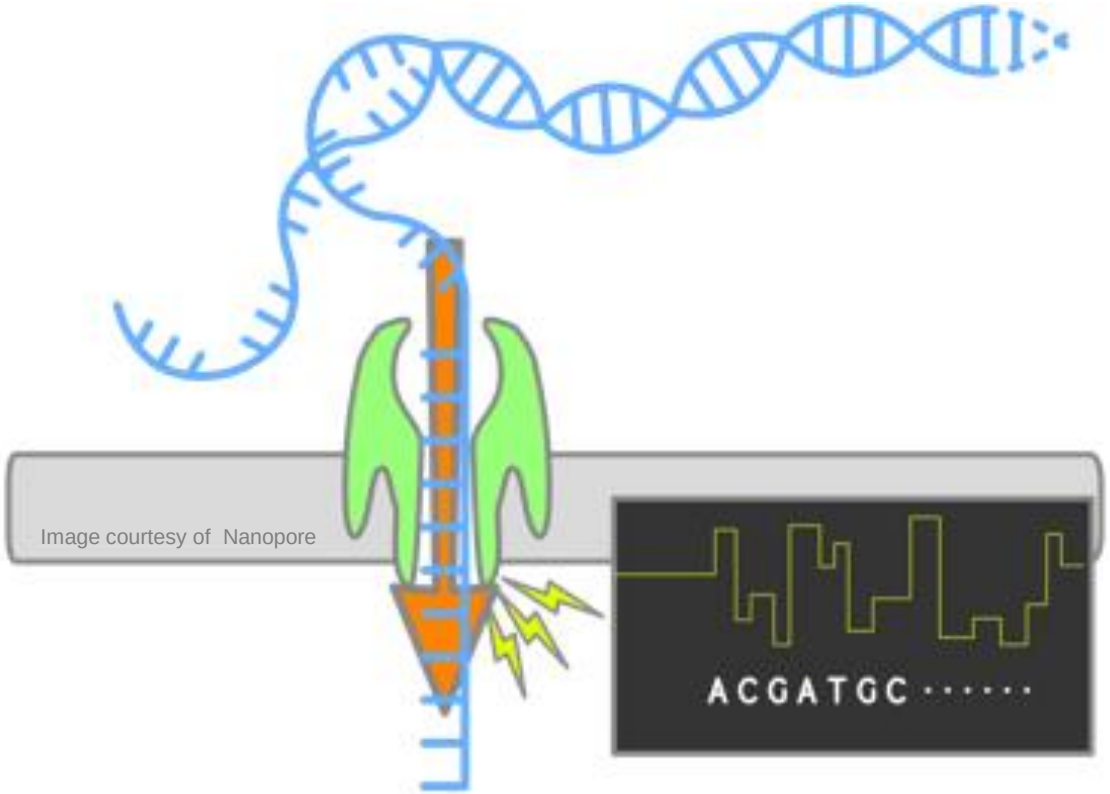
# Spaceborne Computer: Mission Success – Life Sciences / Healthcare


DNA Sequencer onboard the ISS

DNA Sequences are ***LARGE***

Today: “about a month to get the data”

***Mutations*** are hopefully non-existent or tiny

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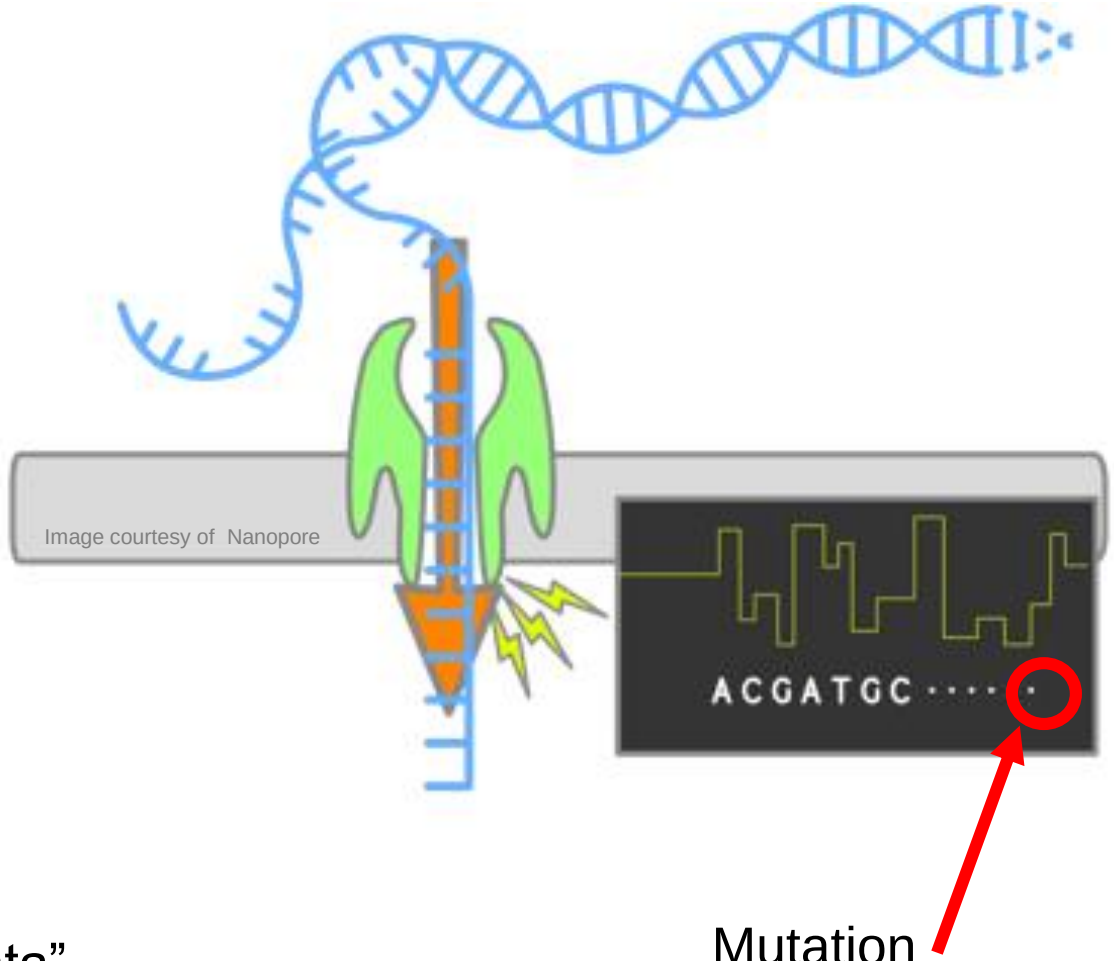
# Spaceborne Computer: Mission Success – Life Sciences / Healthcare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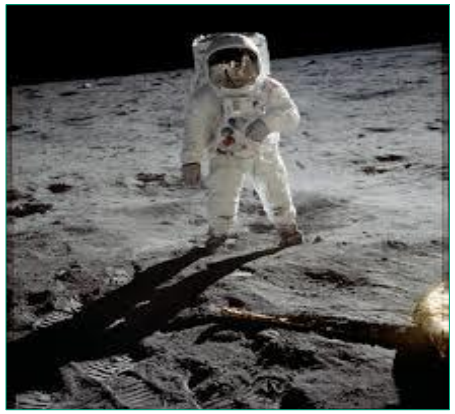
# Spaceborne: Demonstrating the Value of Edge Storage & Computing

## … Proven 99+% reduction



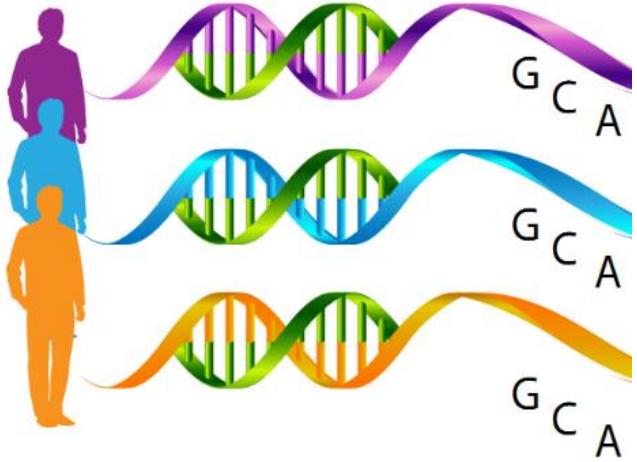
Today:

- 1 Sample.  1 Month


With Spaceborne:

- Multiple Samples
- … ***in minutes***

- ***Months to minutes***

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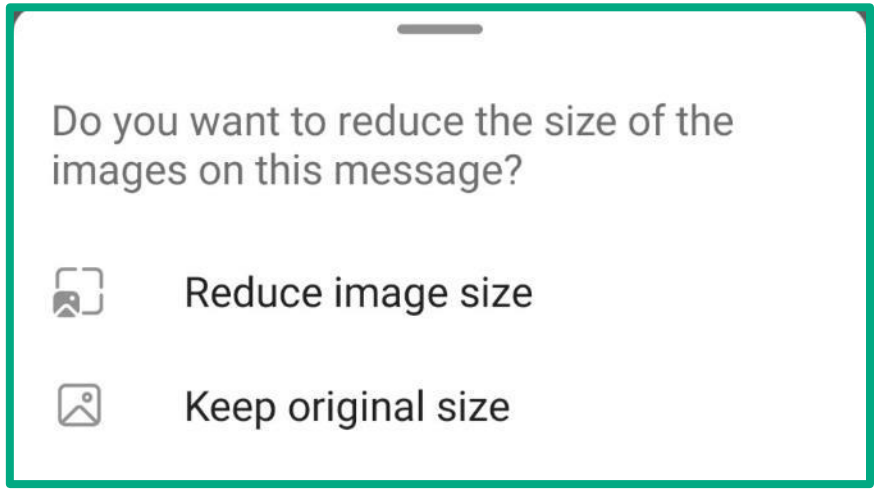


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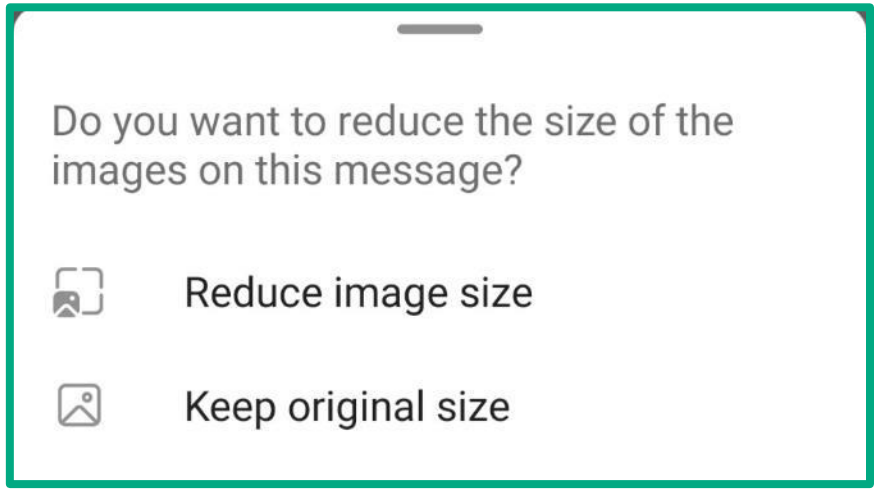
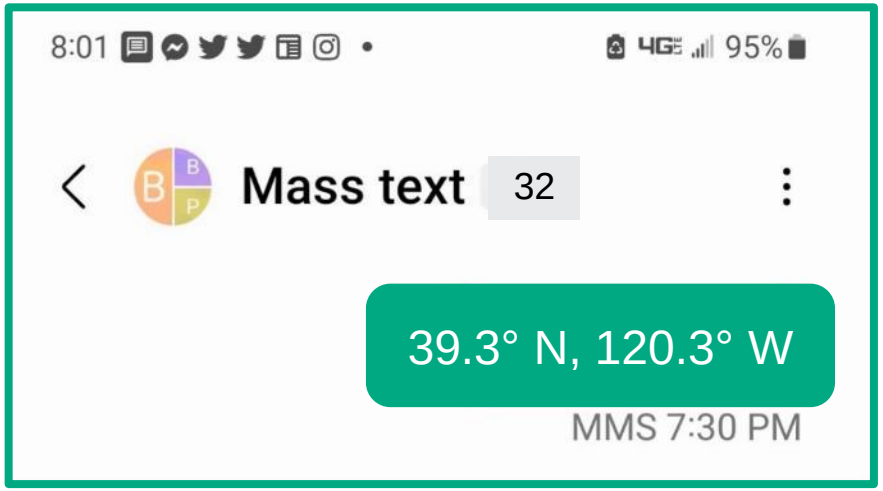



## Edge Storage & Computing

Image Processing
Feature Extraction
AI / ML

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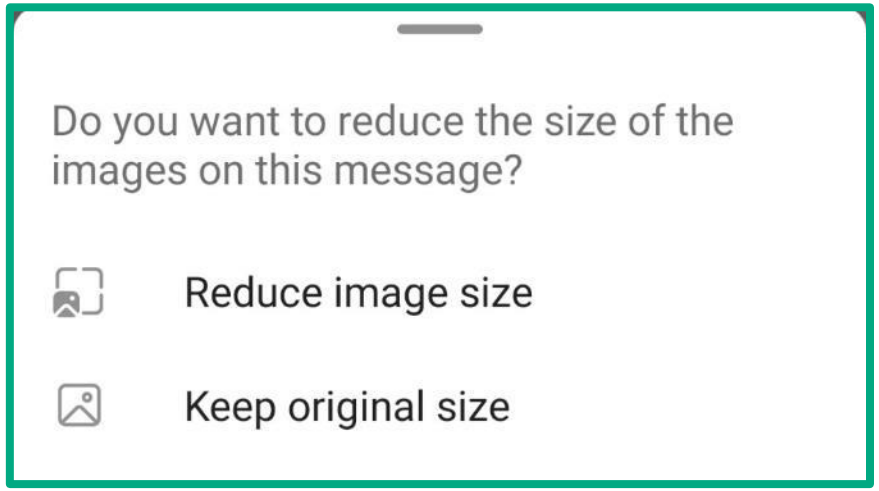
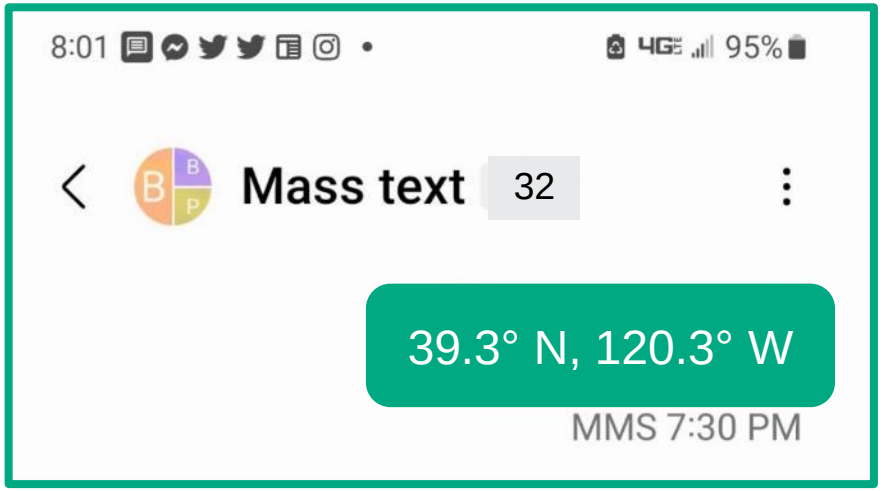



## Edge Storage & Computing

Image Processing
Feature Extraction
AI / ML

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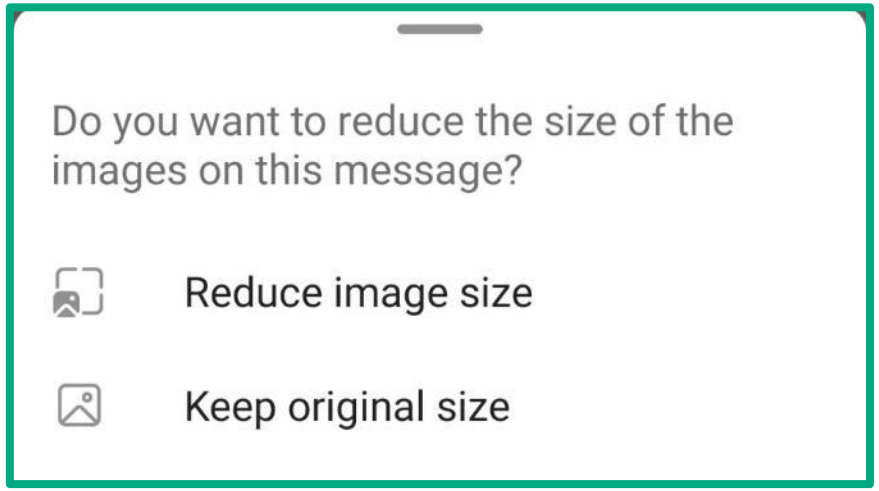
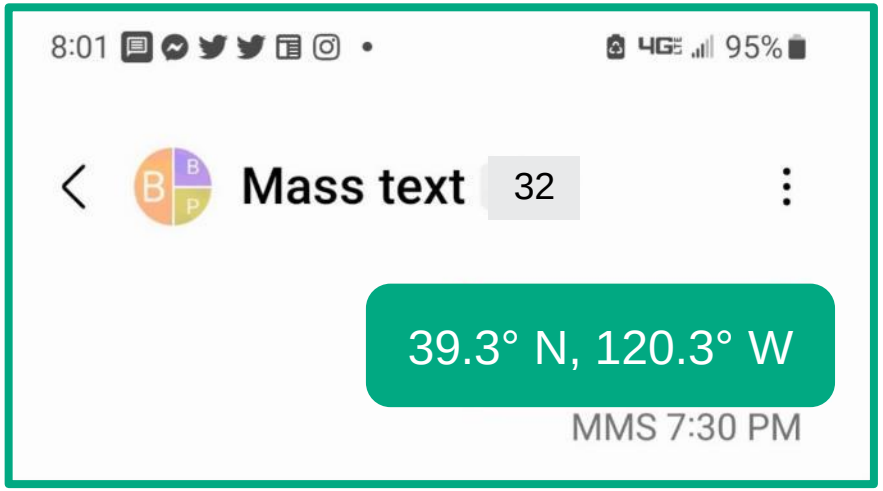



# Edge Storage & Computing

Image Processing
Feature Extraction
AI / ML

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# Spaceborne: Demonstrating the Value of Edge Storage & Computing

## Proven Examples Since the Initial 20,000X Improvement…


Proven in Space – Available on Earth™

**Self-Sufficient Computers Enable Self-Sufficient Explorers**

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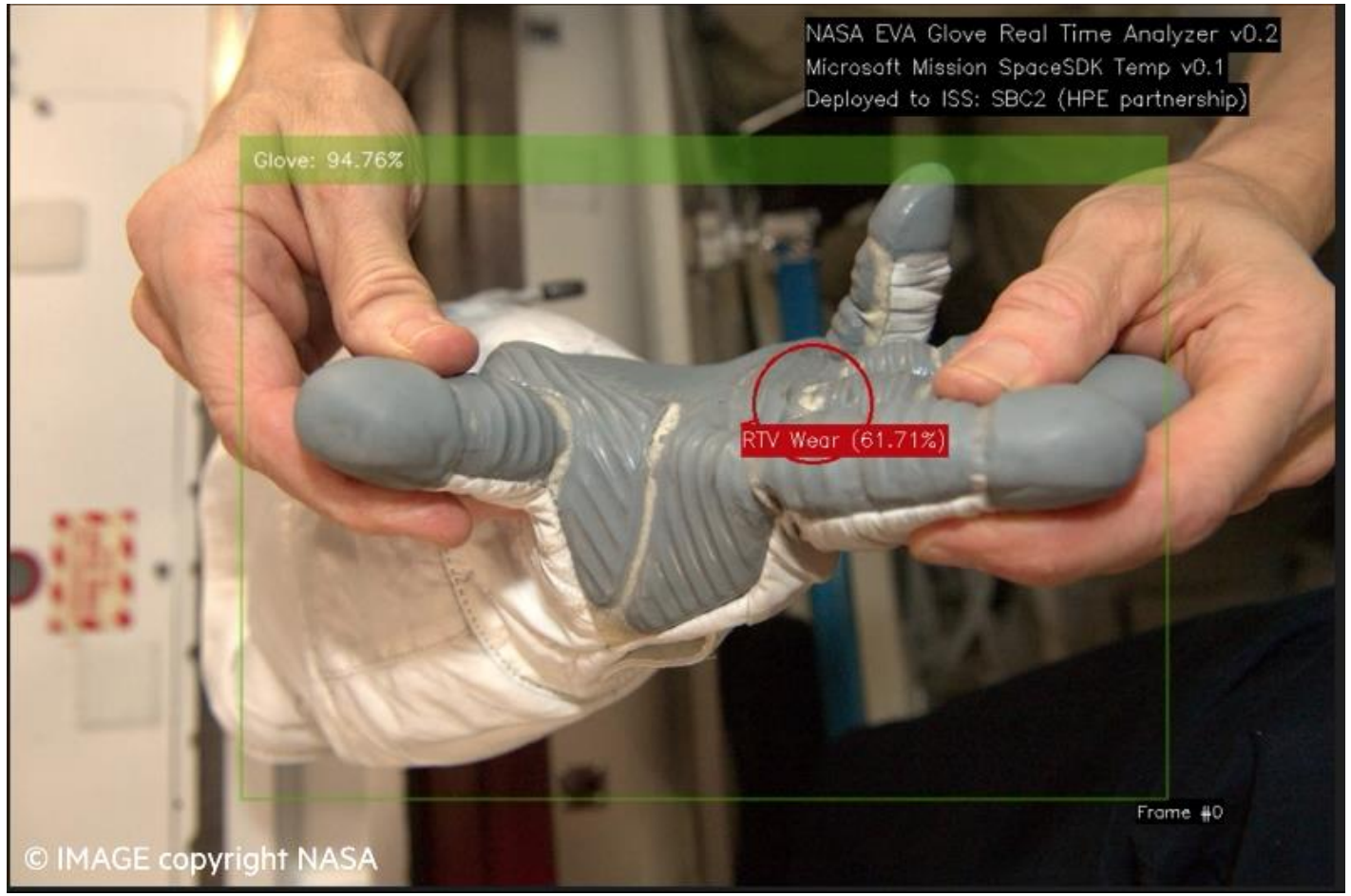
# Spaceborne: Demonstrating the Value of Edge Storage & Computing

## Proven Examples Since the Initial 20,000X Improvement…

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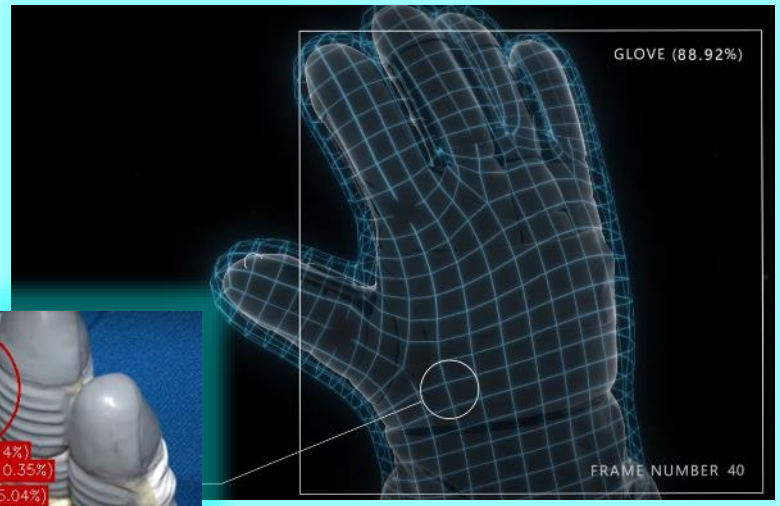
# Spaceborne Computer: Mission Success – QA / QC & Safety

24+ Experiments conducted on station thus far in partnership with the international scientific community

An example: AI & ML ‘Glove’ experiment conducted with HPE, Microsoft, NASA – winner NASA 2022 Team Flight Award



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# Spaceborne: Demonstrating the Value of Edge Storage & Computing

The EVA Glove Inspection process is traditionally performed by a group of individuals and **requires *multiple days*** to analyze data and develop a recommendation. While on the ISS, the AI/ML model was able to perform and generate a recommendation ***in less than 45 seconds***, validating how AI/ML technology can benefit human space flight.


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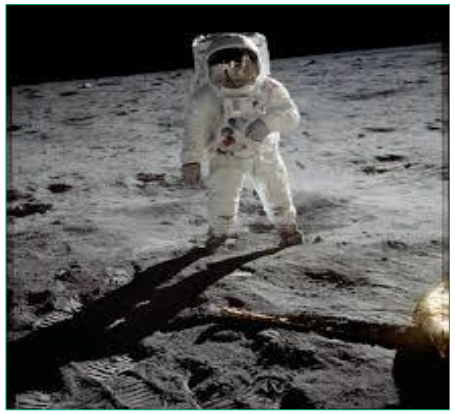
# Spaceborne: Demonstrating the Value of Edge Storage & Computing

## … Proven 99+% reduction



Today:

- 1 Astronaut.  1 EVA
- … ***multiple days of downtime***

With Spaceborne:

- Multiple Astronauts
- … ***0 days of downtime***
- … 5 day work week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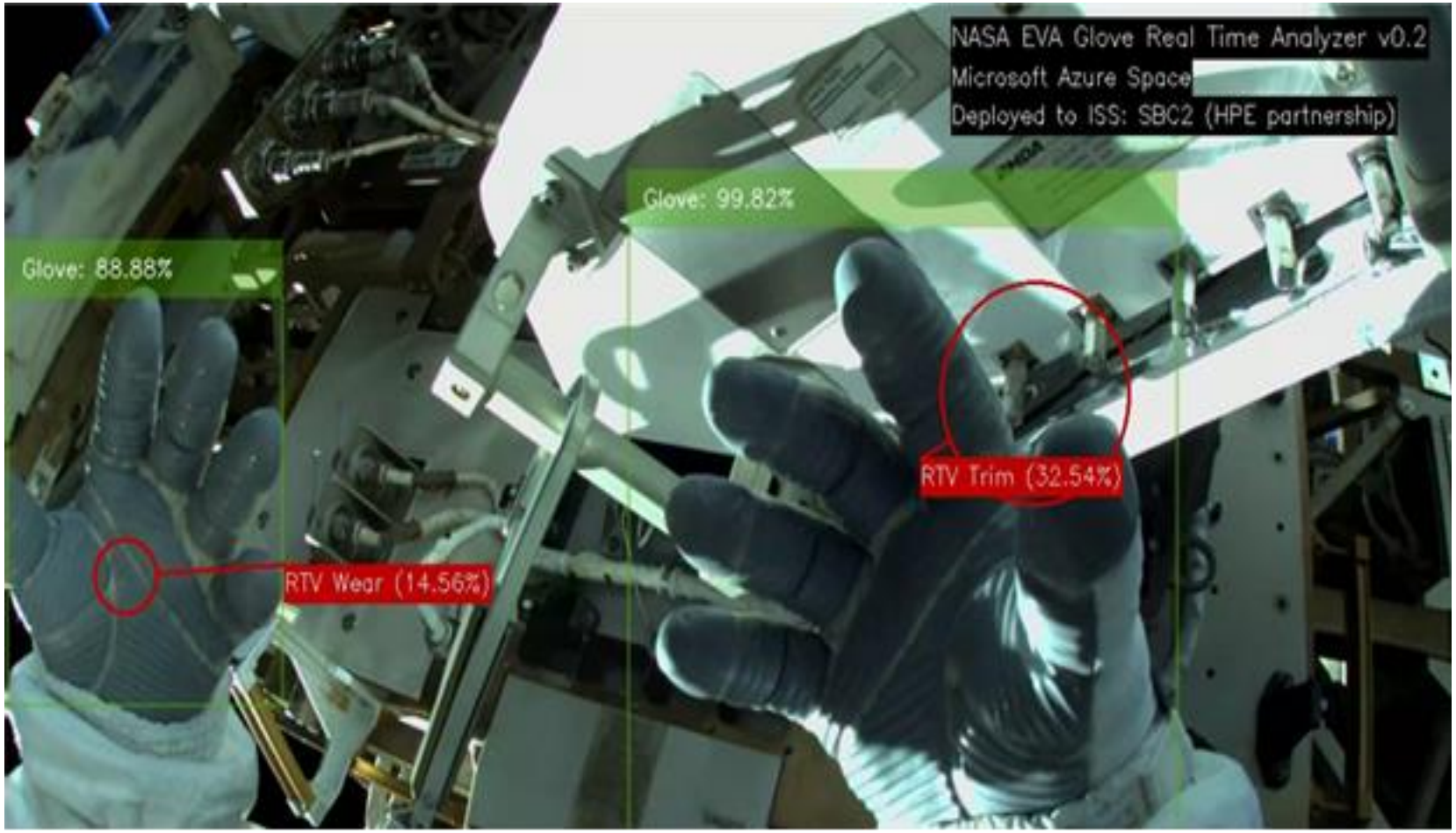


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# Spaceborne: Demonstrating the Value of Edge Storage & Computing

| SBC-2 ISS Projects | | Traditional Collect & Forward | | SBC-2 Edge Storage & Computing | | |
|---|---|---|---|---|---|---|
| Vertical | Edge Technologies | Raw Data Size | Original Download Time | SBC-2 Download Time | Output / "Insight" Size | Download Size Improvement |
| Life Sciences | GPU-enabled | 2.8 GB 2,816,431 KB | "about 18 hours" | ~2 secs | 92 KB | 30,000X |
| Life Sciences | Hybrid CPU-GPU multistep workflow | 22 GB 22,702,059 KB | "days to weeks" | ~11 secs | 235 KB | 93,000X |
| Image Processing QA/QC | GPU-enabled AI/ML model | 899 MB 898,896 KB | "about a day" | <1 sec | 5 KB | 179,000X |
| Image Processing Feature Extraction | AI/ML model | 299 Photos 5.5GB of .NEF | "about 6 hours" | ~7 minutes | 100 MB | 98% Reduction |
| Feature Extraction | Docker Containers (updates) | 5GB image (tar.gz) | 383 min. (over 6 hours) | ~2 secs (upload) | 50 KB "patch" (upload) | 99% Reduction (upload) |

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# Spaceborne: Demonstrating the Value of Edge Storage & Computing

## … *requires* Data Generated at the Edge to be Stored at the Edge

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**Storage Solutions from the Edge to the Cloud**

- ✓ **Completed FA on SBC-1 SSDs**
- ✓ **Design Assistance for Future Missions**
- ✓ **New SSDs in SBC-2 Locker-1!!!**

Proven in Space – Available on Earth™

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**Self-Sufficient Computers Enable Self-Sufficient Explorers**

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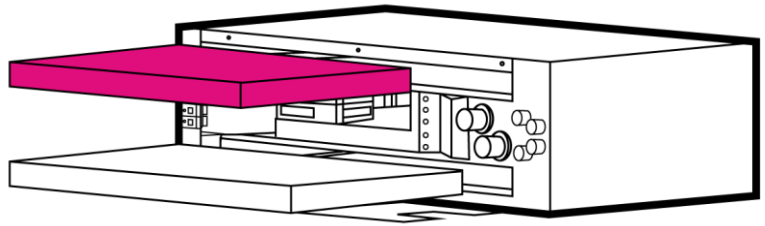
# Spaceborne Computer-2: Hardware & Software Refresh

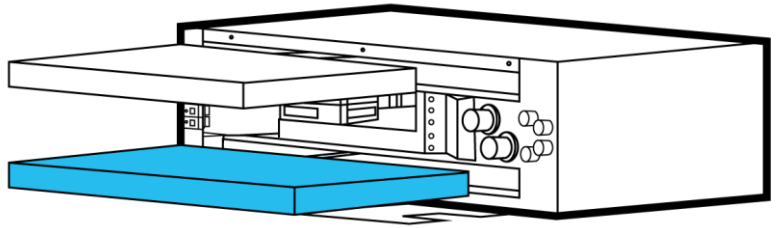
**Hardware:** HPE Edgeline EL4000
(edge-focused single socket with a single GPU)

- 1 x low wattage x86
- 1 x low wattage GPU
- 64 GB of memory total
- **4 x 1024 GB KIOXIA XG6 M.2 SSDs**
- 1 x 10GbE Ethernet adapter



**Hardware:** HPE DL360 Gen10 server
(traditional 2-socket HPC compute node)

- 2 x low wattage x86 processors
- 192 GB of memory total
- **8 x 960 GB KIOXIA RM6 2.5" SSDs**
- 1 x 10Gb Ethernet Adapter



Software: Red Hat 7.8 Operating System
NASA TReK 5.3.1

* Powered from 28Vdc
* Cooled by AAA & MTL

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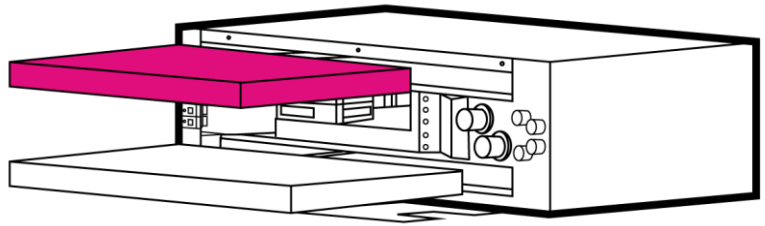
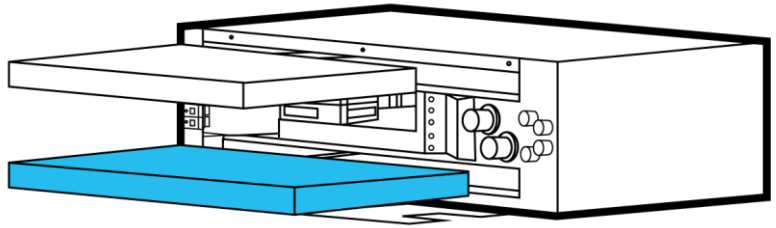
# Spaceborne Computer-2: Hardware & Software Refresh !

**Hardware:** HPE Edgeline EL4000
(edge-focused single socket with a single GPU)

- 1 x low wattage x86
- 1 x low wattage GPU
- 64 GB of memory total
- **4 x 1024 GB KIOXIA XG6 M.2 SSDs**
- 1 x 10GbE Ethernet adapter



**Upgraded with:**
- **4 x KIOXIA PM6 30.72 TB SSDs**
- **> 120TB storage**



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# Spaceborne: Demonstrating the Value of Edge Storage & Computing

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# Spaceborne: Demonstrating the Value of Edge Storage & Computing

## … *requires* Data Generated at the Edge to be Stored at the Edge

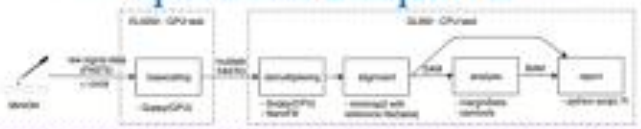
### BioMole: Onboard Data Analysis

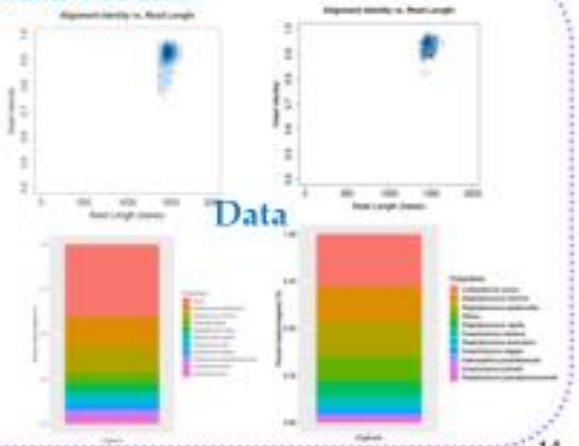
- Collaboration with HPE, IBM, and ISSNL
- Utilize the IBM Open Data and AI Edge software platform on Spaceborne Computer-2 (SBC-2)
- Results perfectly paralleled the downlinked data analyzed on the ground
- 24 hours from swabbing to final data (as the data is not processed in real-time by the SSC)
- Sample-to-answer is possible, reducing the time from sample collection to result from weeks/months to 24 hours

First Sample-to-Answer Microbial Identification onboard the ISS

Space Station Computer

Spaceborne Computer-2





Data

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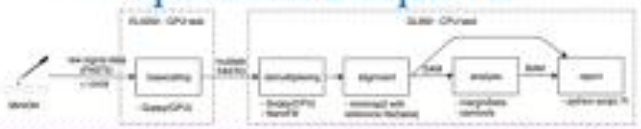

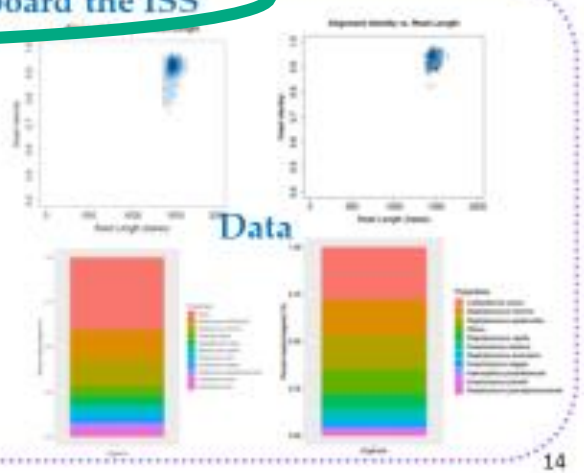

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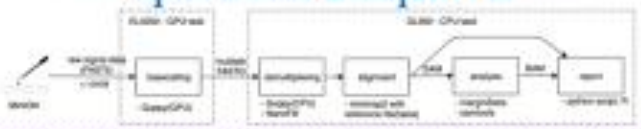

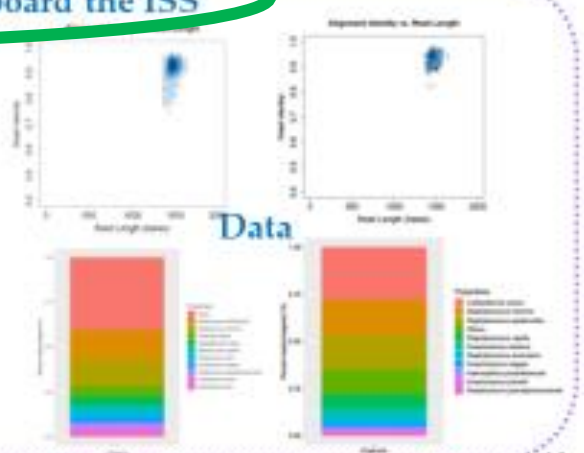

Data

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# Spaceborne: Demonstrating the Value of Edge Storage & Computing

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The Abstract/Bio:

… at the forefront of developing and implementing molecular methods to allow for **in situ** microbiome **analysis**. These ISS-based methods have ***changed the*** sample return ***paradigm*** associated with spaceflight.

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# Thank you!

**Inquiries to:**


mark.r.fernandez@hpe.com

spaceborne@hpe.com



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1. Dave Petersen, PD for Hardware
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5. Calandra Szulgit, Technical Writer
6. Carrie Knox, Systems Administrator
7. Mark Fernandez, PI & Software PD

8. Ben Bennett, Business Development
9. Norm Follett, Marketing
10. Nahren Khizeran, Communications
11. Eng Lim Goh, PI SBC


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