

National Aeronautics and Space Administration



ENABLING MODERN FLIGHT CONTROL AND GROUND SCIENCE SUPPORT TEAMS USING SOFTWARE SUPPORT SYSTEMS

Matthew Miller, Ph.D.
Exploration Research Engineer
Jacobs/NASA JSC – Astromaterials Research & Exploration Science



This document does not contain information subject to U.S. Export Control Laws.



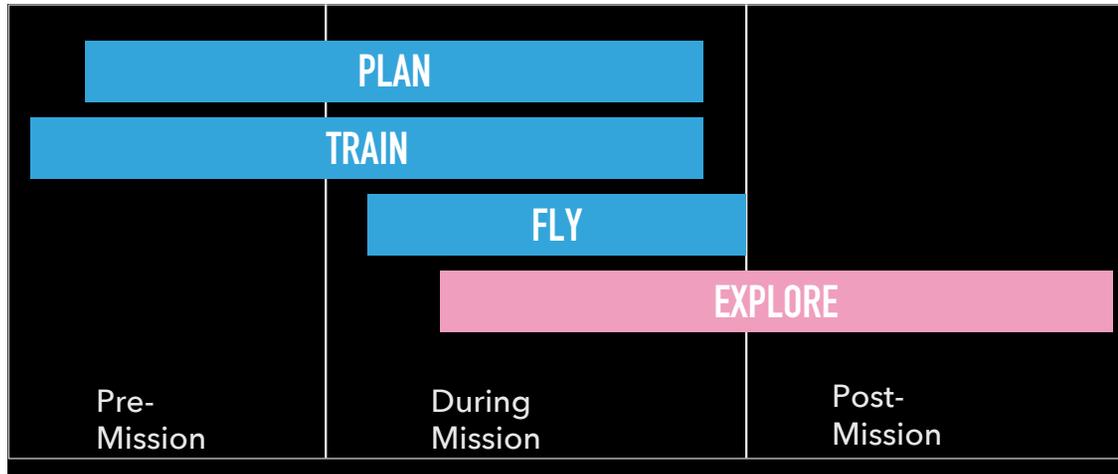
Purpose of this presentation



- Informational briefing to highlight the following
 - EVA Mission System Software (**EMSS**) Initiative
 - EMSS is a cross-organization team focused on integrating cross-organization software in the planning, training, execution, and exploration phases of ISS and Artemis EVA operations
 - **Integration** across NASA Orgs and Centers
 - EMSS personnel span JSC, Ames, Goddard, and the broader scientific community
 - **Incorporating** the Exploration Science mindset (and associated data handling needs) to EVA execution
 - Plan/Train/Fly Flight Control Mantra now includes Explore



EVA Flight control structure



- **Plan:** A way to generate consensus across the team/community
- **Train:** A way to teach the crew what they're going to do days/weeks/months before the activity
- **Fly:** A series of steps to follow on the day of the activity
- **Explore:** Explore-phase depending on what content is recorded along with the procedure

WHAT QUESTIONS PERSIST THROUGHOUT EVA?

WHERE ARE WE?

WHAT ARE WE DOING?

WHAT ARE WE LEARNING?

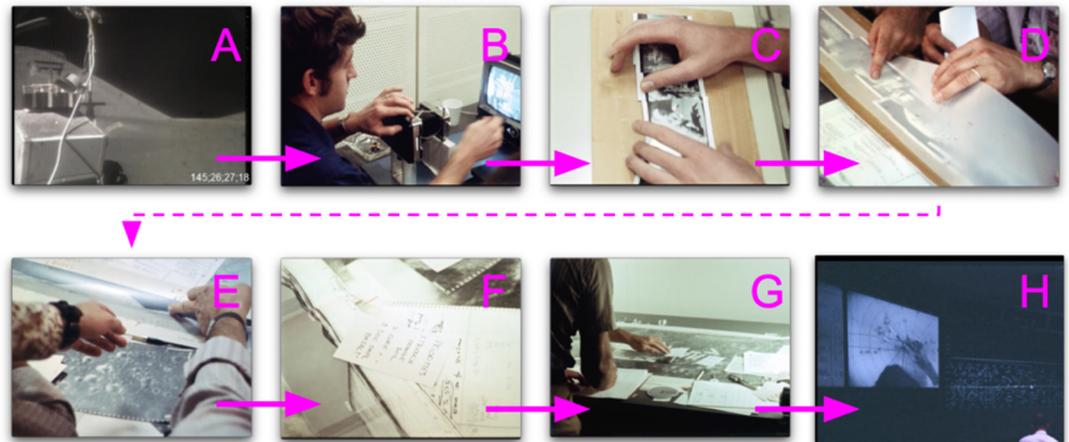
EMSS initiative is making software that helps address the where, when, why questions that is ultimately beneficial to both Ops and Science endeavors throughout the Plan/Train/Fly/Explore Structure



Considering Mission Ops - Apollo context



- (A) Video footage from the lunar surface
- (B) Transferred to Polaroid still photography
- (C) Collated into panoramas
- (D) Overlaid with precursor imagery to estimate crew location and facilitate scientific interpretation
- (E) Images were compared with other map products
- (F) Synthesize and articulate real-time science priorities that were passed along the chain of command to impact crew behavior
- (G) Estimates of crew location were indicated using icons moved manually on a map alongside operations relevant data such as clock time and event markers
- (H) Information shared among the flight team via Main display 2 in the Mission Operations Control Room (MOCR)

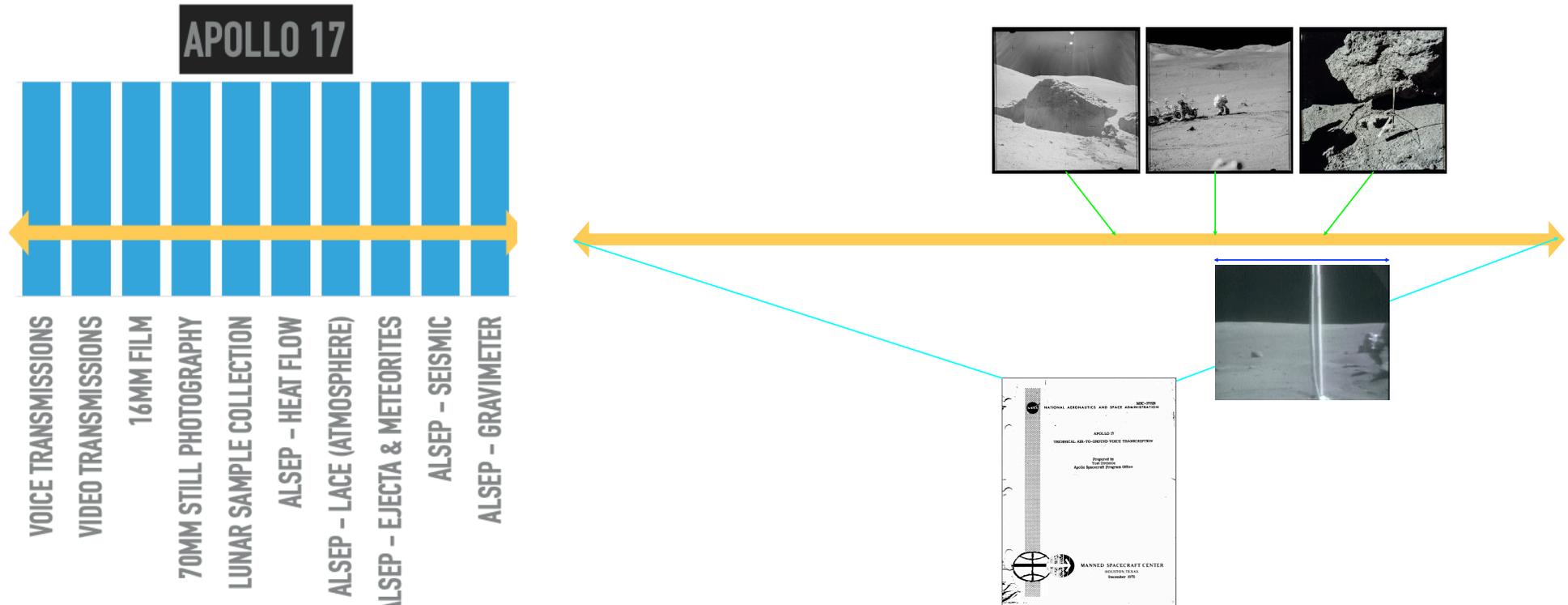




Apollo 50+ Years Later



Horizontally Integrate Disparate Data sets via time





Apollo in Real Time



The Last Mission to the Moon
Apollo 17
Real-Time Mission Experience
Wed Dec 13 1972 1:12:56 AM
Mission elapsed time: 140:05:56

Establish the key to the Moon
Surface Day 1
Surface Day 2
Surface Day 3
Surface Day 4
Surface Day 5
Surface Day 6
Surface Day 7
Surface Day 8
Surface Day 9
Surface Day 10
Surface Day 11
Surface Day 12
Surface Day 13
Surface Day 14
Surface Day 15
Surface Day 16
Surface Day 17
Surface Day 18
Surface Day 19
Surface Day 20
Surface Day 21
Surface Day 22
Surface Day 23
Surface Day 24
Surface Day 25
Surface Day 26
Surface Day 27
Surface Day 28
Surface Day 29
Surface Day 30
Surface Day 31
Surface Day 32
Surface Day 33
Surface Day 34
Surface Day 35
Surface Day 36
Surface Day 37
Surface Day 38
Surface Day 39
Surface Day 40
Surface Day 41
Surface Day 42
Surface Day 43
Surface Day 44
Surface Day 45
Surface Day 46
Surface Day 47
Surface Day 48
Surface Day 49
Surface Day 50
Surface Day 51
Surface Day 52
Surface Day 53
Surface Day 54
Surface Day 55
Surface Day 56
Surface Day 57
Surface Day 58
Surface Day 59
Surface Day 60
Surface Day 61
Surface Day 62
Surface Day 63
Surface Day 64
Surface Day 65
Surface Day 66
Surface Day 67
Surface Day 68
Surface Day 69
Surface Day 70
Surface Day 71
Surface Day 72
Surface Day 73
Surface Day 74
Surface Day 75
Surface Day 76
Surface Day 77
Surface Day 78
Surface Day 79
Surface Day 80
Surface Day 81
Surface Day 82
Surface Day 83
Surface Day 84
Surface Day 85
Surface Day 86
Surface Day 87
Surface Day 88
Surface Day 89
Surface Day 90
Surface Day 91
Surface Day 92
Surface Day 93
Surface Day 94
Surface Day 95
Surface Day 96
Surface Day 97
Surface Day 98
Surface Day 99
Surface Day 100

Surface Day 9: 31:75
Arrived at the Lunar Module
Begin Lunar orbit 31:75

147:19:52:04

Apollo 17 - 146:40 - 154:40 V2

TRANSCRIPT GUIDED TOUR COMMENTARY

147:19:52 Schmitt I just sampled the glass in the bottom of a crater. I documented it by shooting the LM across the crater at infinity and then shooting the crater with stereo at 11 feet and in that cross-Sun pair at 7; and then I sampled it.

147:20:13 Mission Okay.
Control

147:20:14 Schmitt Then I took a cross-Sun pair at 7 after.

147:20:17 Mission I guess - I guess now gimmon is a LM.
Control

147:20:20 Schmitt It's very fragile. That's right. It's very fragile, and I double bagged it. I don't know whether we can keep it or not.

147:20:20 Mission Okay. We'll hope.
Control

147:20:20 Cernan You may think about how to preserve it.

147:20:22 Mission Okay.
Control

147:20:42 Schmitt While you're thinking, I'll put it on my floor pan, I guess. Okay.

This document does not contain information subject to U.S. Export Control Laws.



Linking scientific data to mission ops



Geology Sample Information - Bag: 469

Sample 70019

External links: Lunar_Sample_Curation_Info - Lunar Sample Compendium (PDF)

Specimen Name: 70019 Lunar Station: Apollo 17 Station 5

Specimen Type: ROCK/Breccia/Regolith Breccia Return Container: SRC2/469

Sampling Technique: Weight: 159.988 g

Landmark: CAMELOT CRATER Pristinity: 78.576% (9/19/2014)

Description: breccia soil breccia-agglutinate

Child Specimens: 70019, 29 70019, 94, 7 70019, 23 70019, 9GLASS CONCENTRATE 70019, 18

Sample Photography

Transcript: 147:19:52:22
Schmitt: I just sampled the glass in the bottom of a crater. I documented it by shooting the 16 across the crater at infinity and then shooting the crater with stereo at 11 feet and in that cross-sun pair at 7; and then I sampled it.
Mission Okay. Control.
Schmitt: Then I took a cross-sun pair at 7 after.
Mission: I guess - I guess now ground is a LM.
Control.
Schmitt: It's very fragile. That's right. It's very fragile, and I double bagged it. I don't know whether we can keep it or not.
Mission Okay. We'll hope.
Control.
German: You may think about how to preserve it.

Publications

Revisiting the field geology of Taurus-Littrow

Journal: JOURNAL OF METAMORPHIC GEOLOGY, Volume 30, December 2012, Pages 3-31

Edited by: John W. Valley, Lisa Cahill, Neil Price, David Rostrom

Highlights:

- The Looe Looch fault, Mt Tycho, may have triggered two light-magnitude earthquakes.
- Apollo 17 sample 1616 includes Clinopyroxene in basal Serenite and Irizite.
- The Sculptured Hills consist of portions of a Big Scuba plateau eroded from Irizite.
- Large pyroclastic flows cut through the Sculptured Hills and the North Massif.
- A young impact glass has been previously located and oriented in these orientations.

APOLLO SAMPLE 70019

Sample Information

| | |
|--------------------|------------------------------|
| Collection Date | 1969 |
| Mission | Apollo 17 |
| Station | 17-14-01-01 |
| Landmark | CAMELOT CRATER |
| Bag Number | 469 |
| Original Weight | 160.00 g |
| Sample Description | Basalt |
| Rock Type | Basalt |
| Rock Texture | Fragmental |
| Description | Basaltic breccia-agglutinate |

Sample Analysis

Report of Petrology Sample Analysis: 78-276

Date of Petrology Collection: May 18, 1974

This Section Available: See list of available data sections.

Public Release: See list of available data sections.

Other Information

Other Links: Lunar Sample Compendium

Guidance and Publications

Guidance of AMT Fragments in Lunar Bags and Boxes: Guide to Published Thin Sections

Lunar Sample Compendium

Catalog of Apollo 17 Rocks, Volume 2, Central Valley, Part 1

Curation

70019
Regolith Breccia
1969

Introduction

Sample 70019 was collected from within a fresh, 3-meter-diameter crater located near the Lunar Module (Figures 2 and 3).

70019 could be considered as an example of a large "agglutinate" made up of pieces of regolith breccia cemented together with black glass (Figures 1 a,b and 1b).

Note: Numerous photographs are documented and stored in the Lunar Sample Compendium (LSCM) database. An internet access to the LSCM database is available at: <http://www.nasa.gov/centers/goddard/pdf/55201mainmain.pdf>

| Material | Mass (g) | Volume (cm ³) | Density (g/cm ³) |
|----------------|----------|---------------------------|------------------------------|
| Basalt | 159.988 | 60.00 | 2.666 |
| Basaltic Glass | 1.000 | 0.100 | 10.000 |
| Basaltic Glass | 0.2 | 0.2 | 1.000 |
| Basaltic Glass | 0.2 | 0.2 | 1.000 |
| Basaltic Glass | 0.2 | 0.2 | 1.000 |
| Basaltic Glass | 0.2 | 0.2 | 1.000 |
| Basaltic Glass | 0.2 | 0.2 | 1.000 |
| Basaltic Glass | 0.2 | 0.2 | 1.000 |
| Basaltic Glass | 0.2 | 0.2 | 1.000 |
| Basaltic Glass | 0.2 | 0.2 | 1.000 |

Integrated Mission Context links the moment data is generated in the mission to all subsequent advancements with that data during and after the mission



Geographic Information System Infusion

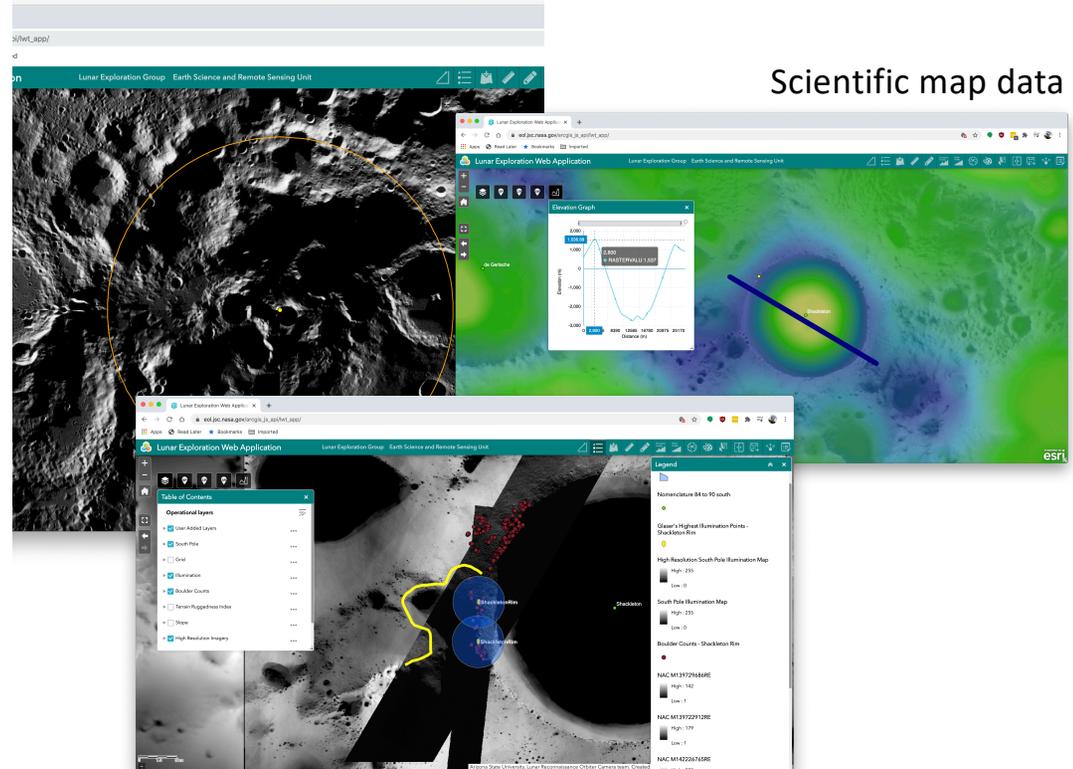


WHERE ARE WE?

- Leverage existing Geographic Information Systems software capabilities
- Produce relevant EVA Traverse visualization and coordination capabilities
- Future integration with mission planning to integrate where we hope to be on EVA with where we actually are during execution
- Answering this question is a core way to inject scientific interest/objectives into the mission

EMSS Status: In early concept development

Map planning products



Scientific map data

Operations and Scientific data on maps



Procedure Drafting and Execution



WHAT ARE WE DOING?

- EVA timeline creation via modern timeline tasking approach
- Improved change management
- Establishing structured data for EVA procedures
- Currently focused on ISS EVA with an eye to Artemis (e.g. Mimic the output of MS Word process)
- Creating procedures that are both human and machine readable (this could perhaps replace "establish structured data for EVA procedures")
- Write once, export to digital collaboration systems, mission procedure systems, head-up displays, print, etc.
- Working with these details gets us data formatted in a way that gives context to the mission

EMSS Status: In Active development

Summary Timeline view

The image shows two overlapping windows from the Maestro software. The top window displays a 'Summary Timeline' for 'Maint 2 - Summary Timeline' starting at PET 06:00. It shows a Gantt-style chart with tasks for EV1 and EV2, including 'EGRESS / SETUP (00:20)', 'WORKSITE SETUP (00:25)', 'MMOD SHIELD REMOVAL (00:45)', and 'REMOVE FAILED (FHX) (00:45)'. The bottom window shows a 'Detailed Procedures view' for 'Maint 5 - ESP-2 Spare FHRC Removal (00:50)'. It is organized into columns for 'IV/SSRMS/MCC', 'EV1 (Kayla) (crewA)', and 'EV2 (Drew) (crewB)'. The EV1 column contains a list of steps for releasing FHRC struts, with a comment box providing context: '1. For FHRC R&R, the SSRMS would have been configured during EVA 1, however this is a good skill for crew to practice. Previous EVAs also vented the spare FHRC QDs, removed stinger caps and released the stinger bolts. 2. Note that there are also 2 NZGL caps not included in this run due to NBL FSE inferences.' Below the text is a diagram of a stinger bolt assembly with two red arrows pointing to 'Stinger Bolts (2S, 1S)'. The EV2 column contains steps for preparing the stinger, including opening MLI flaps, removing FGD caps, and translating to the ESP2 forward edge.

Detailed Procedures view



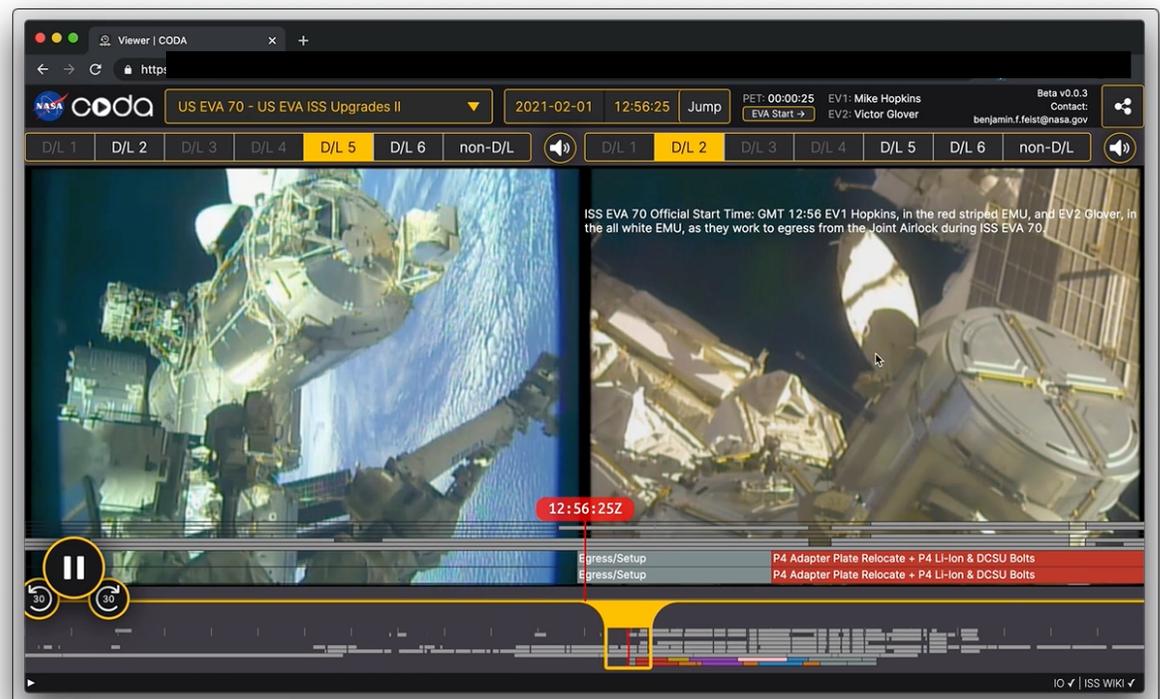
Horizontally Integrated Data



WHAT ARE WE LEARNING?

- Operations and science data integrated view
- Decoupled from source systems (RISE2, NBL, ISS, Artemis)
- Treat all data as time-series data
 - Record capture-time of non-time-series data to put it in context during analysis
 - For Example:
 - Engineering/Suit data
 - Human health and performance data
 - Audio/Video/Imagery

ISS EVA Operations Interface



EMSS Status: In Active development



Conclusions and Next Steps



WHERE ARE WE?

WHAT ARE WE DOING?

WHAT ARE WE LEARNING?

EMSS Initiatives
(Current)

EVA GIS
Software

Data exchange



Maestro



Collaborative Operations
Data Activation

EMSS Team is establishing core capabilities to address these three questions as well as understanding what it might mean to share data between these systems

EMSS Initiatives
(Future)

- As the EVA flight control team is built, target more specifically the workers in those consoles and pull data from the **relevant data sources** to ensure those who need it, have it to successfully plan, train, fly, explore
- Incrementally add other systems to the EMSS ecosystem to meet the needs of Artemis Flight Operations



Concluding Thought



Imagine if the Artemis crew, science team, MCC team, and members of the general public all used the same system to experience humanity's return to the Moon.

