



Continuing Development and Enabling of Exploration Mission Systems Software

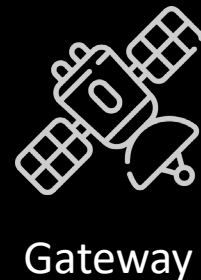
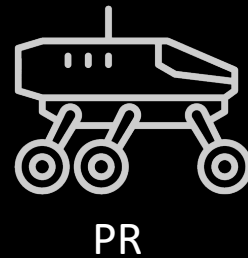
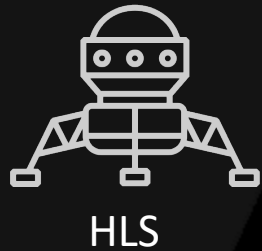
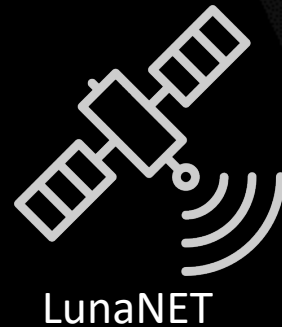
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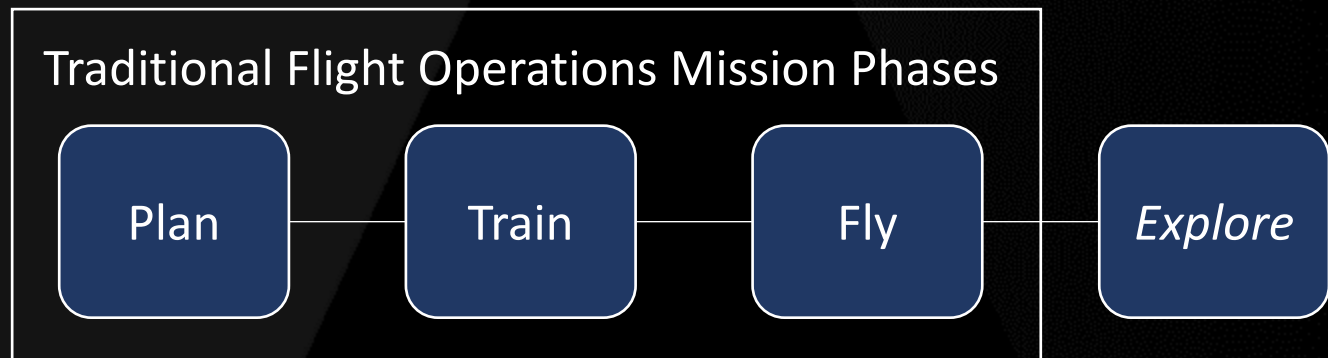
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Artemis missions face an unprecedented mission operations data management challenge



- Artemis missions will consist of many unique mission assets who will produce a myriad of data
- Mission operations personnel will need access to, synthesize, and create actionable information based on these mission assets
- Creating actionable information will require the the deliberate design and development of temporally and spatially integrated data management systems

Making decision support systems align with mission operations work needs



Explore examples include:

- Continued scientific learning from Apollo.
- Mishap reporting such as ISS EVA Suit Water Intrusion Mishap Report

This paper describes an update* on progress made for a specific set of tools, known collectively as the Extravehicular Activity (EVA) Mission System Software (EMSS), to enable Flight Operations EVA *plan, train, fly, explore* work processes.

*M. Miller, et. al, "Supporting Exploration Missions by Enabling Exploration Mission System Software," Jul. 2023. [Online]. Available: <https://ttu-ir.tdl.org/handle/2346/94669>

EVA Mission Software System (EMSS) progress since 2023



Collaborative Operations and Data Analysis (CODA)

- Temporally aligns disparate data sets
- Enhanced

Talky Bot

- Real-time voice loop transcription
- Created and Deployed



Maestro

- EVA Procedure authoring and execution
- Enhanced

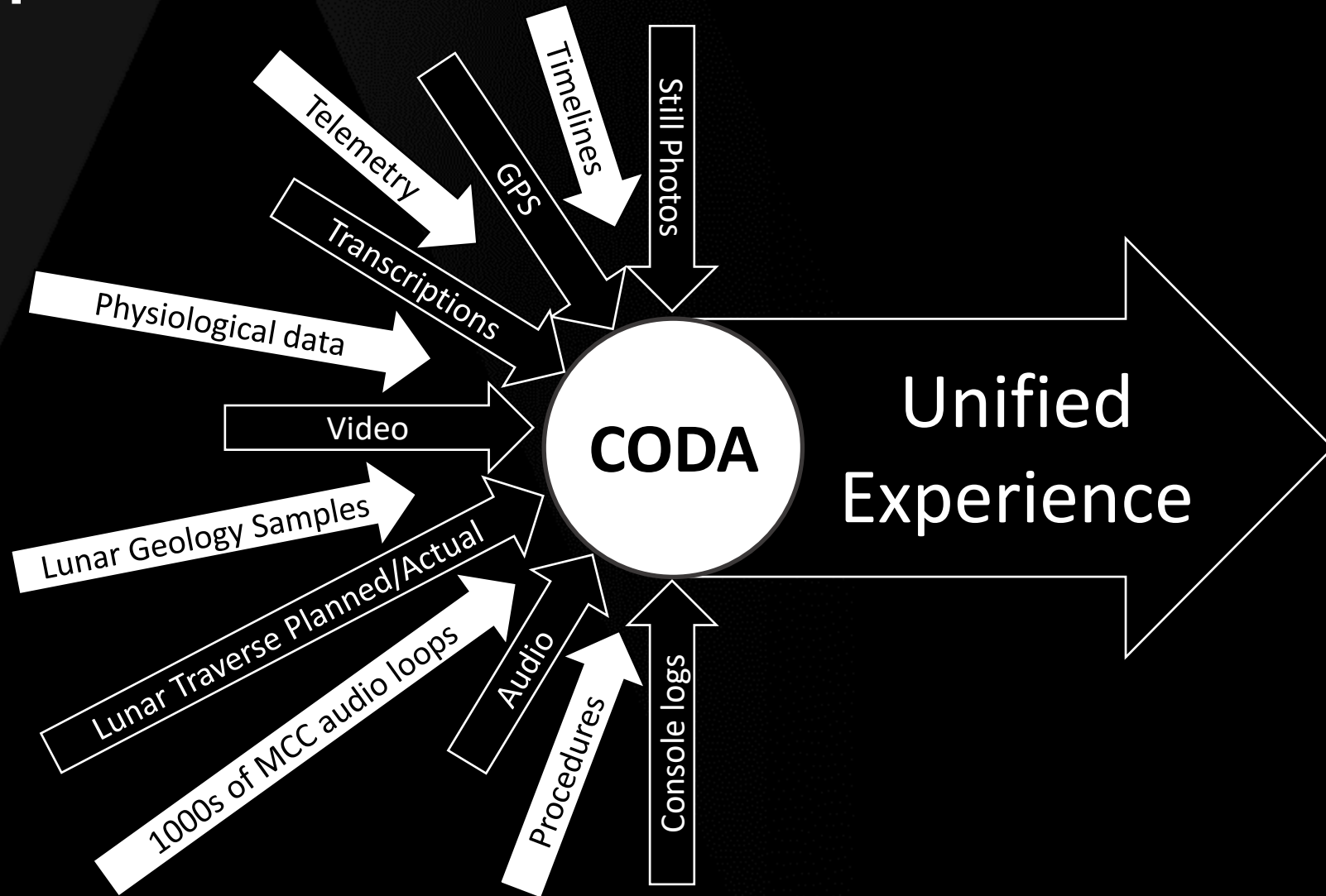
Artemis Extravehicular Activity Geographic Information System (AEGIS)

- EVA Procedure authoring and execution
- Enhanced

EMSS Dashboard

- Flight team wide execution awareness
- Created and Deployed

Collaborative Operations Data Activation (CODA) as a concept





Collaborative Operations Data Activation (CODA) as it exists today

Choose a data source | Choose a date and time or event | Load Preset | Choose a Display layout | Share current day and time | # of Viewers | Status of Data Sources

Choose a type for each frame

More Info & Access to Source Data

Play/Pause timeline

The screenshot displays the CODA interface with several key components:

- Top Bar:** Shows the current data source (ISS), date (2023-11-01), time (17:54:49 Z), and a specific event (US EVA 89 - S-Band RFG Retrie...). It also includes controls for load presets, display layout, and sharing the current day and time.
- Left Panel:** Features a map of the ISS position over the Pacific Ocean, a grid of photo thumbnails, and a communication transcript with timestamps and text.
- Right Panel:** Displays a large video frame showing astronauts working on the exterior of the ISS, with a smaller inset showing a close-up of a hand.
- Bottom Panel:** Contains a detailed timeline with play/pause controls and a red timestamp marker for 'PET: 05:40:49 17:54:49Z'.



Maestro as a concept

- **Primary Purpose**
 - A unified authoring and execution environment tailored specifically for the complex, interconnected constraints of Extravehicular Activity (EVA) procedures.
 - *Note:* Provides custom capabilities beyond legacy ISS tools (Optimis, PRIDE).
- **Operational Drivers (The "Why")**
 - **Multi-Agent Choreography:** Demands parallel sequencing for 2+ EVA crew members and support personnel at a highly granular level.
 - **Dynamic Tasking:** Crew seamlessly transitions between independent and tandem operations based on task requirements.
 - **Strict Proceduralizing:** ISS EVAs require minute-by-minute demarcation of details to ensure mission objectives are met safely.
- **Key Technical Capabilities**
 - Coordinates parallel activities with minute precision over multi-hour operations.
 - Enforces and tracks complex task dependencies across multiple agents.



Maestro as it exists today

Procedure Tabs

Procedure Participants

Completed Tasks

Input Fields

Actual Phased Elapsed Time (PET)

Overall Timeline

Current PET
Current Activity

Comparative Views

Enter Edit Mode

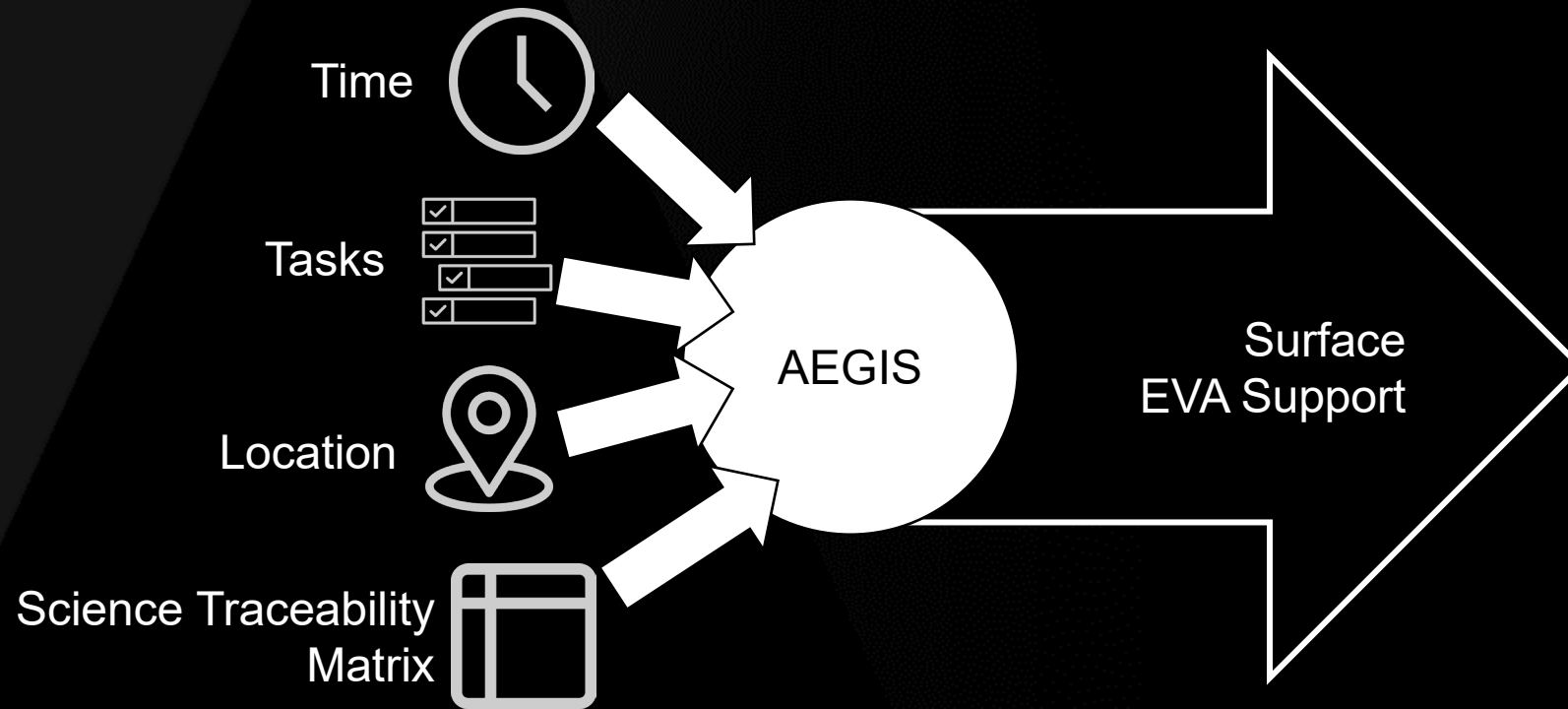
Adjust Layout

Follow Execution

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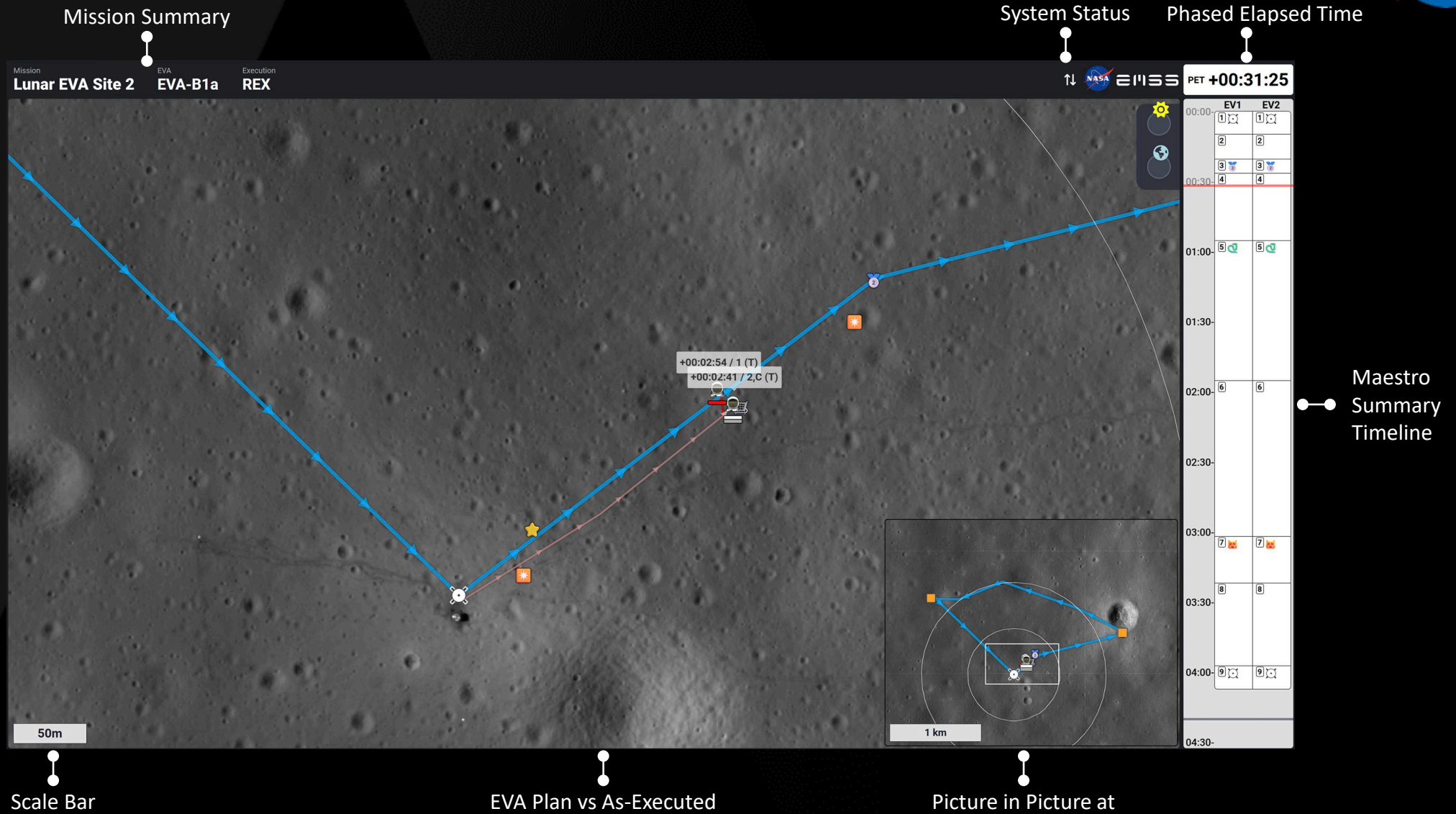
Deployment Version

Artemis EVA Geographic Information System (AEGIS) as a concept





The Emergence of an Integrated EMSS Display





Talky Bot: AI-Powered Voice Loop Transcription

- **System Architecture**
 - **Application Server:** Houses the API and Database for storing/retrieving source audio and transcription results.
 - **Web Frontend:** Client interface for real-time user viewing, playback, and interaction.
 - **Integration API:** Dedicated server providing transcribed audio directly to the CODA system.
- **Core Capabilities & UI**
 - **Live Processing:** Automatically segments, transcribes, and sequentially displays live voice loop audio.
 - **Verification & Sharing:** Users can playback specific audio segments to verify text accuracy, copy text, and generate shareable links.
 - **Advanced Tools:** Features selectable voice loops, keyword database search, snippet downloads, and active user tracking.
 - **Translation:** Automatically recognizes non-English languages and provides English translations.
- **Operational Drivers (The "Why")**
 - **Cognitive Offloading:** Mitigates flight controller cognitive overload when simultaneously monitoring and participating in multiple voice loops.
 - **Situational Awareness:** Converts fleeting audio into persistent text, providing a reliable, easily accessible method to double-check discrepancies and missed details.
- **Deployment Status**
 - Transitioned from a successful JETT5 prototype (Fall 2023) to daily ISS mission operations (Fall 2024), driven by high demand from flight directors.



Talky Bot User Interface

Select Voice Loop to Monitor

Search Download # of Viewers

1 S/G 1 1 S/G 2 1 S/G 3

2025-05-02 TALKY BOT v0.6.0

1 S/G 2 18:37:21 We did have good views from the camera, but after we had that view while it was still in Dragon, we derouted the video, and it sounds like you just confirmed you've moved the camera to Node 2, so I think we're in a good config. [Link/Copy]

1 S/G 2 18:37:37 I agree. Thanks. One more step. Could you confirm that the camera is turned off? [Link/Copy]

1 S/G 2 18:38:05 Just an airlock for the step 76, IRU P1, 1.6, IRU P2, 2.2, IRU total pounds, 6, and I think that puts me into the execution step that's written in there for 76.3. [Link/Copy]

1 S/G 2 18:38:24 Houston agrees. [Link/Copy]

1 S/G 2 18:38:30 All right, Johnny, on to all steps complete. The camcorder is powered off. [Link/Copy]

1 S/G 2 18:38:36 Copy. Thanks much. [Link/Copy]

1 S/G 2 18:39:40 Houston Airwatch is for status. We are looking good. The pressures are both over 7 and the total is 7.1 and increasing. [Link/Copy]

1 S/G 2 18:39:51 Houston concurs. Thanks. [Link/Copy]

1 S/G 2 18:40:21 Houston Station on 2 for your PDAs. [Link/Copy]

1 S/G 2 18:40:25 Go ahead Nicole for PBAs. [Link/Copy]

1 S/G 2 18:40:30 Mark, you're earning your money today. The Y19 for the stow note, I was told this morning just to grab any empty CTV, but I'm curious if you guys want me to label it in a specific way? [Link/Copy]

1 S/G 2 18:40:47 Yes, if you label that do not use, we would appreciate it. Okay, copy that. And then I had Teflon bags from one of the new PVA bottles, and I put those over the male and female QDs. I just wanted to make sure that was good with you guys. [Link/Copy]

1 S/G 2 18:41:06 We like that config. [Link/Copy]

1 S/G 2 18:41:11 Thank you. Thanks. [Link/Copy]

1 S/G 2 18:43:40 Station Houston on Space to Ground 2 for any crew member. Good news, no evening DPC. Thanks for the hard work. [Link/Copy]

1 S/G 2 18:44:02 Hey, Mark, that's great news, and it's great to hear my classmates' voice. Good to talk to you. Have a nice weekend. Hey, you too, Tuck, and thanks for giving me the opportunity to talk to you for a bit. It's really a pleasure to see you and hear you working. [Link/Copy]

1 S/G 2 18:44:18 Thanks for watching! [Link/Copy]

1 S/G 2 18:47:48 Airlock Houston on Space to Ground 2, 4 and. [Link/Copy]

1 S/G 2 18:47:58 Hey, I got a couple minutes before an LOS. Not trying to get you to change anything. This is completely up to you, and either option is neutral, but we want to, for us, we want to make sure that you have all the information we have. We just discussed that after you get into step 146 of your procedure, then we're committed to doing that later activity three hours later. So we think it will be about 2200 before you're able to wrap things up. And with the HECA? So we want to make sure you have that information before you decide to do that. [Link/Copy]

1 S/G 2 18:48:34 Houston, totally appreciate that. I'm happy to knock out that sliver activity at 10 p.m. It's Friday night after all. Big night on Space Station. Should be up. [Link/Copy]

1 S/G 2 18:48:45 All right, we got the whole team chuckling, and thanks for that. [Link/Copy]

1 S/G 2 18:48:51 Well, you know how it is. It takes a little bit to come off the adrenal of an EVA. So I'm totally happy to do it and get these suits back into normal config. All right. Much appreciated, Anne. [Link/Copy]

1 S/G 2 18:58:33 Houston airlock on two. We've got another low flow shutdown with our total at 20.5 and our pressures at 6.3 and 6.9. [Link/Copy]

1 S/G 2 18:58:44 CWCI still has water. [Link/Copy]

1 S/G 2 18:58:56 We're talking about it, Ann. [Link/Copy]

1 S/G 2 19:00:44 airlock Houston on space to ground two, and we think this is similar to what we ran into before, so we'd like you to execute the XTP steps that are in 76.3. [Link/Copy]

1 S/G 2 19:01:00 Okay, one thing to offer, I just looked in the CWCI again. It looks like there's a little more air, at least that I can see now. Wondering if it would be worth doing a quick degas. [Link/Copy]

1 S/G 2 19:01:10 checking. [Link/Copy]

1 S/G 2 19:05:02 Erlach Houston on Space to Ground 2 for Anne. [Link/Copy]

Return to latest

0:02 / 0:09

Link/Copy

Transcribed Segment Per Voice Loop

Timestamp

Transcribed Content

Audio Playback

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EMSS Mission Integration & Development Strategy



- **In-Situ Prototyping & Testing**

- **Operational Integration:** Tools are deployed and evaluated directly in operational environments, such as the MCC Front Control Rooms (FCR).
- **Observation-Driven Design:** Proactive assessment during major simulations (e.g., JETT5, Artemis 3 Mini-Sim 2) ensures the software effectively fits user needs and operational workflows.

- **Iterative Evolution**

- **Rapid Conceptualization:** Leverages readily available capabilities to explore concepts prior to launching dedicated software development campaigns.
- **Proven Pipeline:**
 - AEGIS evolved from early field test prototypes (JETT3, Fall 2022) into the prime surface mission planning tool for EVA operations in just three years.
 - Talky Bot originated from JETT5 testing and within months was being used in ISS mission operations

- **Future Pathway: Crew-Facing Capabilities**

- **Current State:** Empowering ground-based flight controllers through the "plan, train, fly" lifecycle.
- **Next Evolution:** Extending EMSS capabilities directly to in-space assets to support sustained Artemis lunar presence.
- **Goal:** Enable dynamic, synchronous collaboration and flight plan editing between the crew and ground teams.

EMSS Solutions Prototyping during Artemis Surface EVA Training Development in Mission Control



EMSS Dashboard

AEGIS Real-Time Execution Mode

CODA

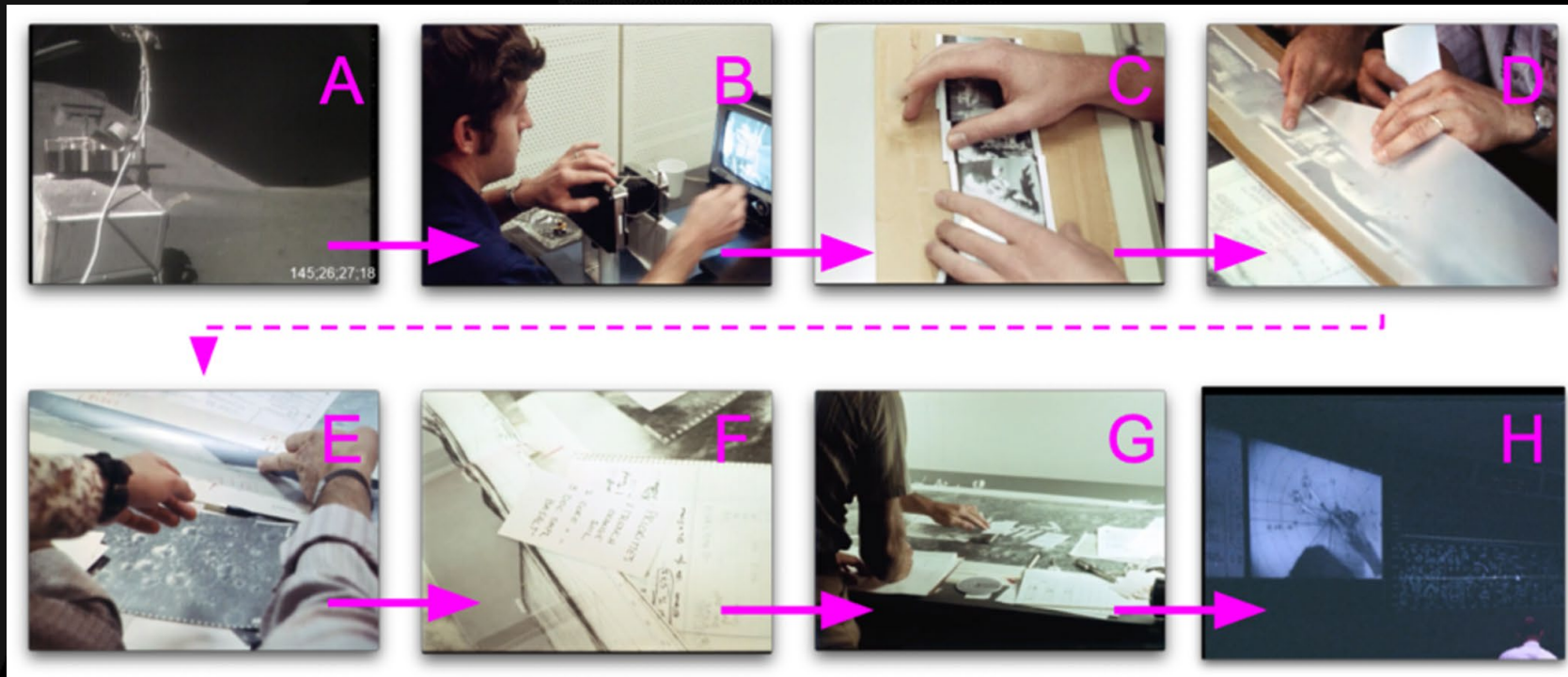
Maestro

AEGIS

Maestro

Talky Bot

Conclusion: Supporting human spaceflight operations requires the seamless integration of temporal and spatial data to enable mission operations personnel to make timely and accurate decisions



Snapshots taken from 16mm film shot during Apollo 17 EVA. Video feed from the lunar surface (A) was transferred to Polaroid still photography (B) and collated into panoramas (C) that were overlaid with precursor imagery to estimate crew location and facilitate scientific interpretation (D). These images were compared with other map products (E) to synthesize and articulate real-time science priorities that were passed along the chain of command to impact crew behavior (F). Additionally, estimates of crew location were indicated using icons moved manually on a map alongside operations relevant data such as clock time and event markers (G), which were all shared among the flight team via overhead projector (H).



Questions and Contact Information

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- We acknowledge here that Google Gemini was used in the refinement of content presented in this paper to ensure a brief, yet consistent level of detail and specificity was provided.