National Aeronautics and Space Administration

Continuing Development and Enabling of Exploration Mission Systems Software

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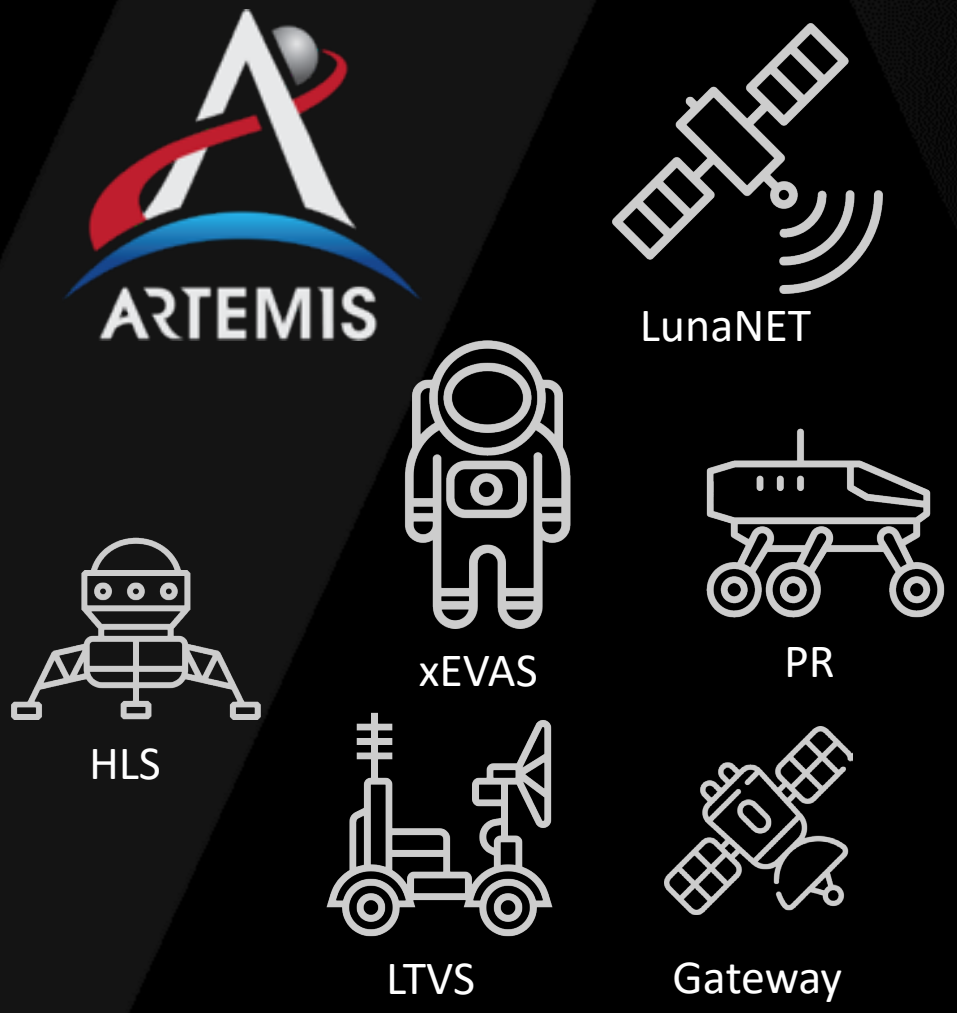
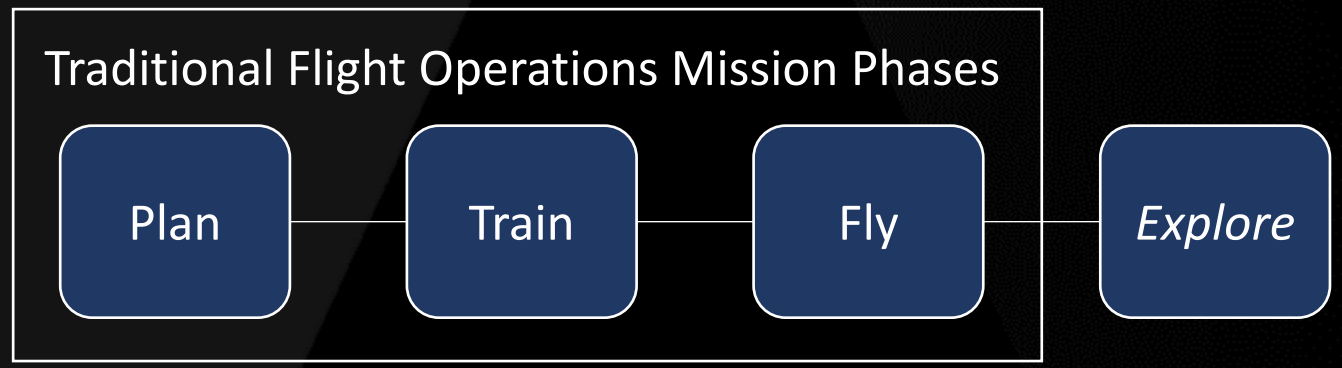
Artemis missions face an unprecedented mission operations data management challenge



- 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

Icons can be found at: https://www.flaticon.com/

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

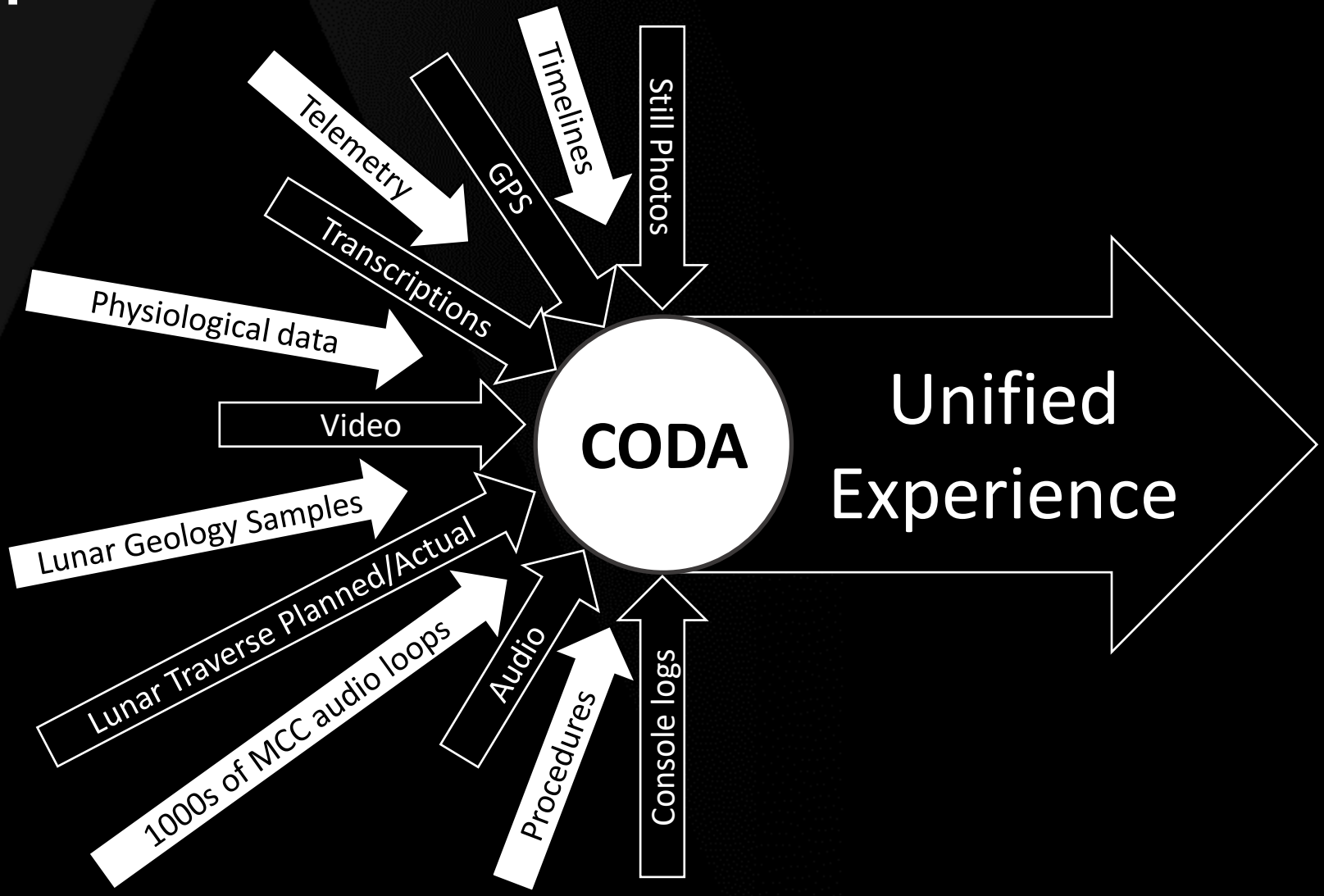
Artemis Extravehicular Activity Geographic Information System (AEGIS)

- EVA Procedure authoring and execution
- Enhanced

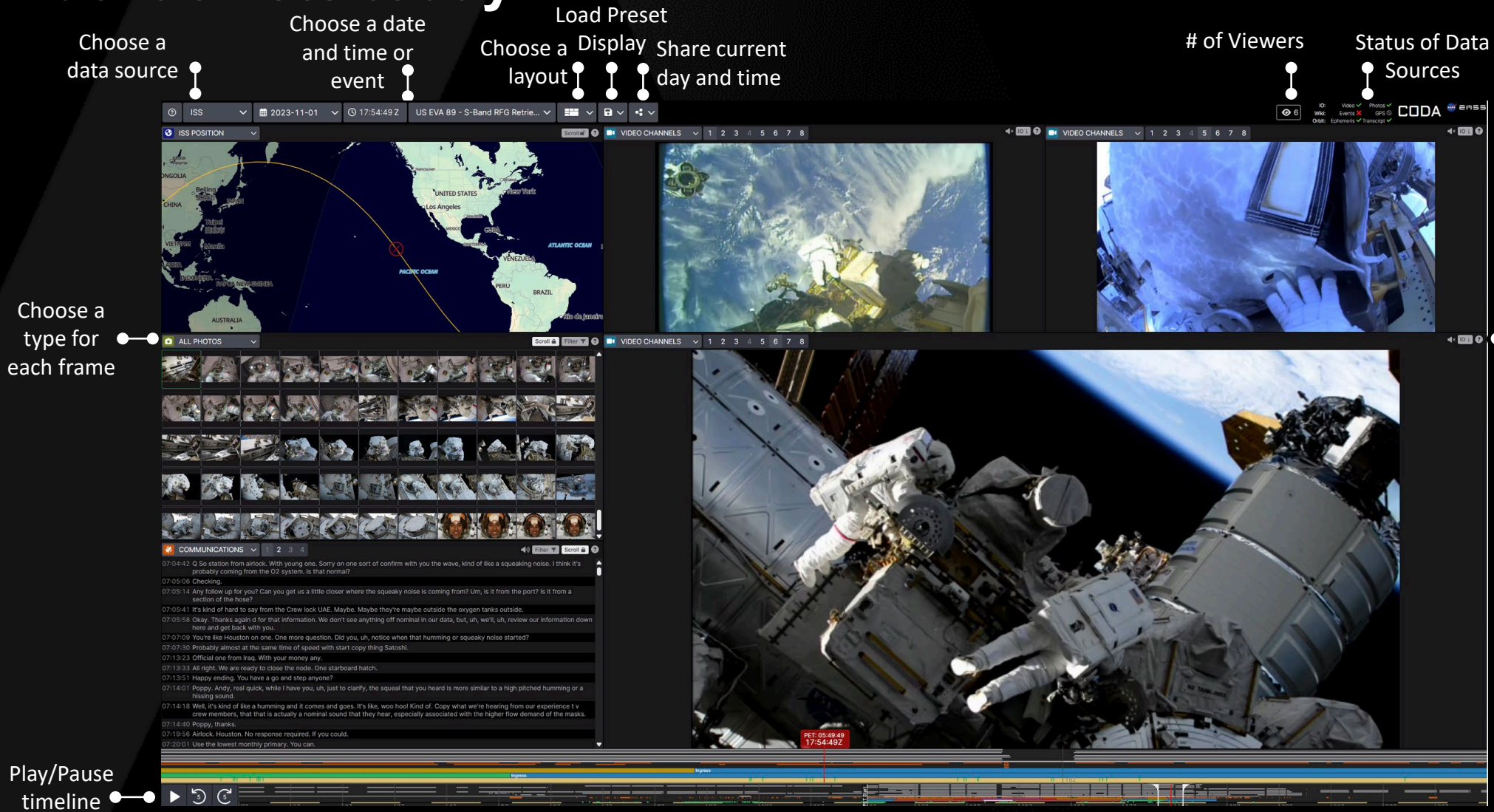
EMSS Dashboard

- Flight team wide execution awareness
- Created and Deployed

Collaborative Operations Data Activation (CODA) as a concept



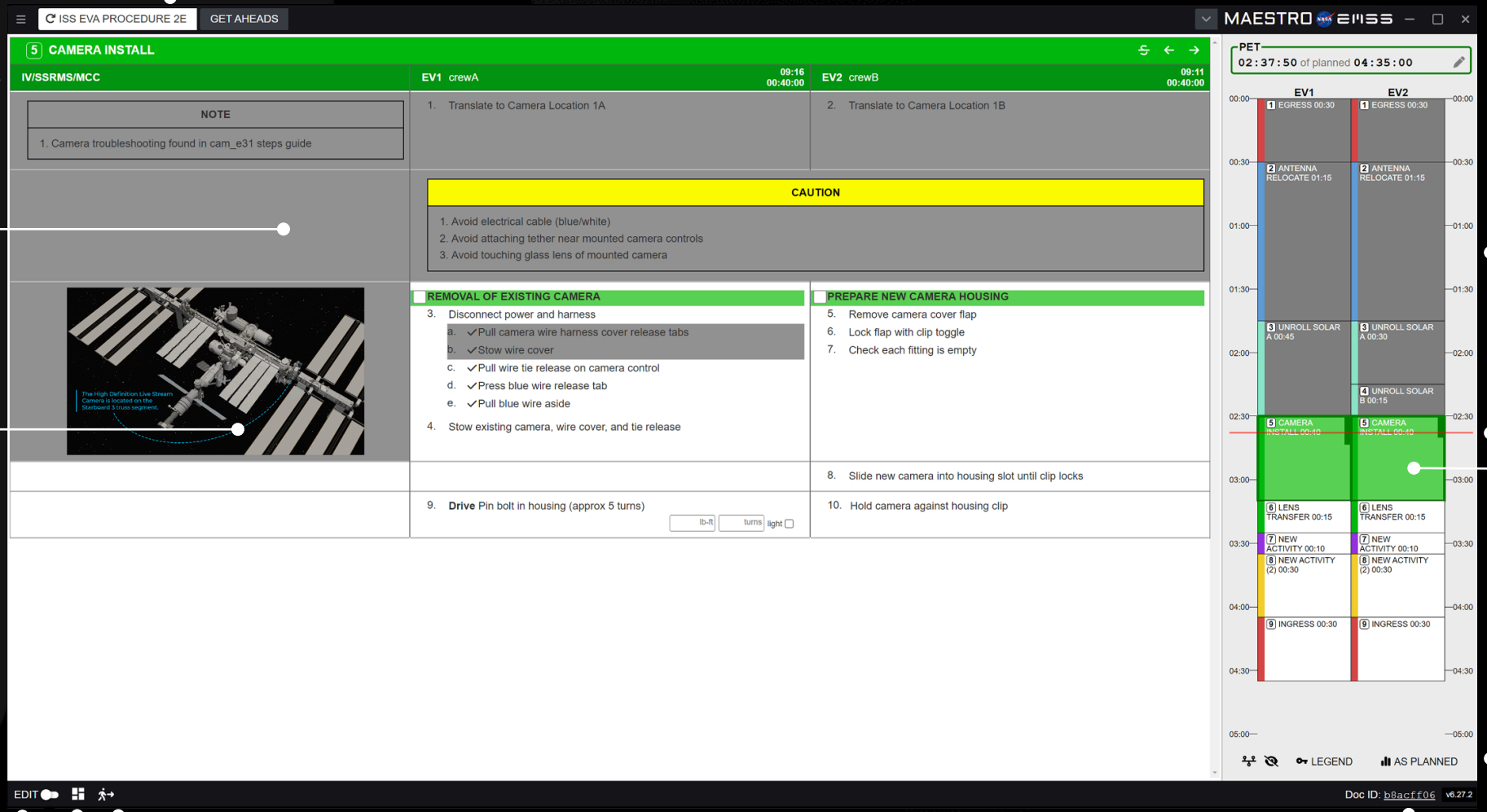
Collaborative Operations Data Activation (CODA) as it exists today



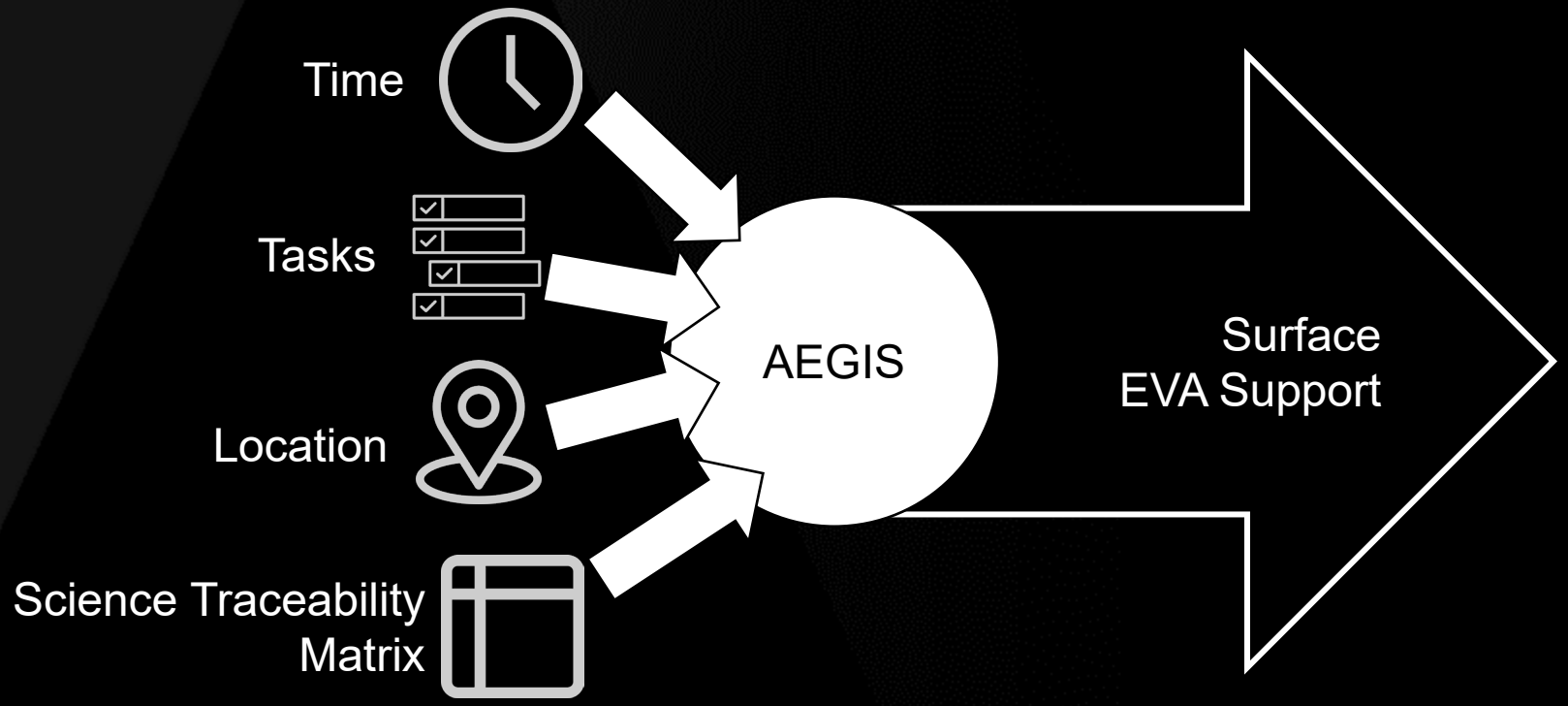
Maestro as a concept

- **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.

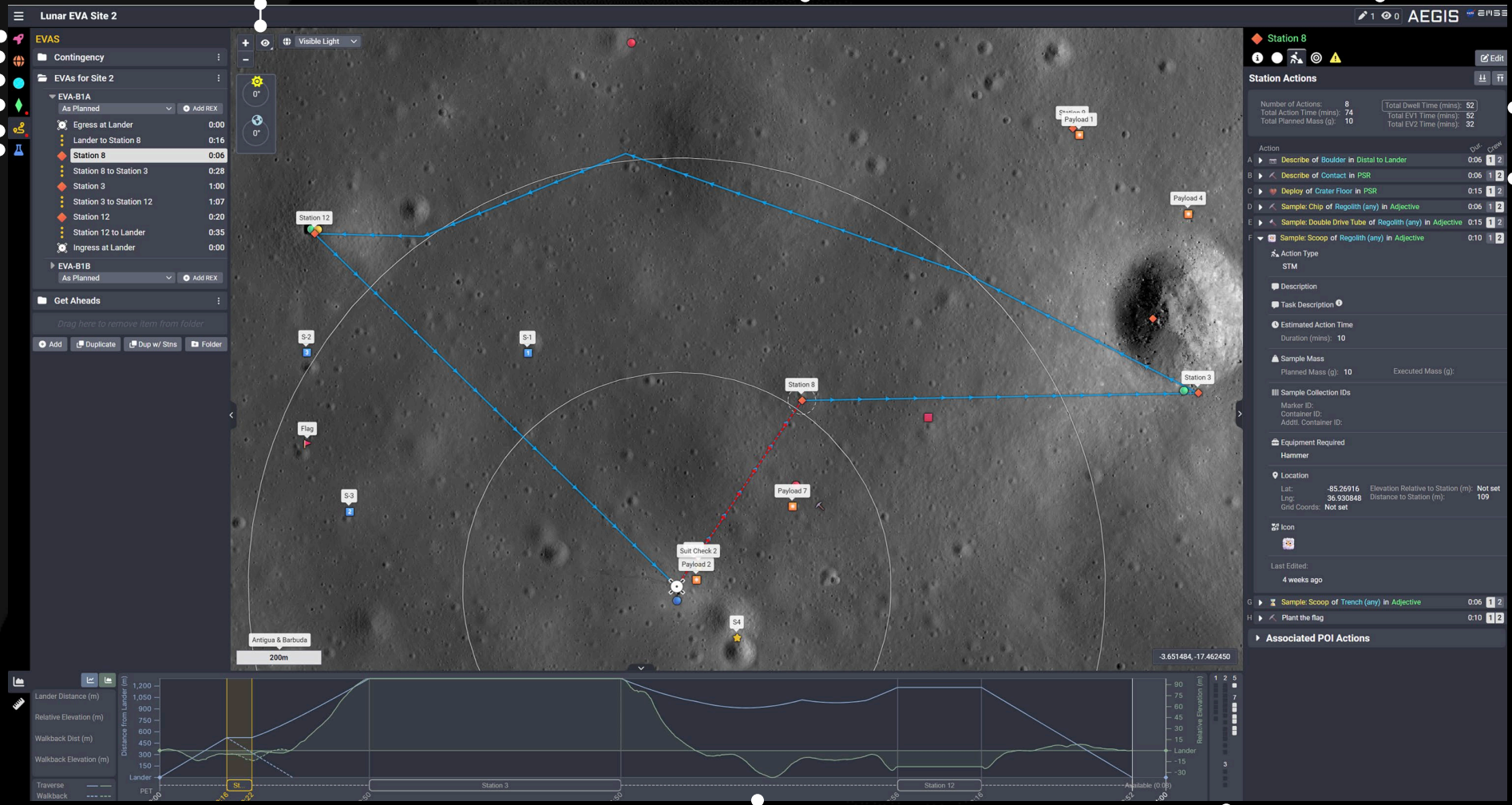
Maestro as it exists today



Artemis EVA Geographic Information System (AEGIS) as a concept



Artemis EVA Geographic Information System (AEGIS) as it exists today



Mission Presets
Map Presets
POI Composition
Station Composition
EVA Composition
Science Traceability Matrix

View Adjustment Options

Annotated Map

# of Editors/Viewers

Summaries

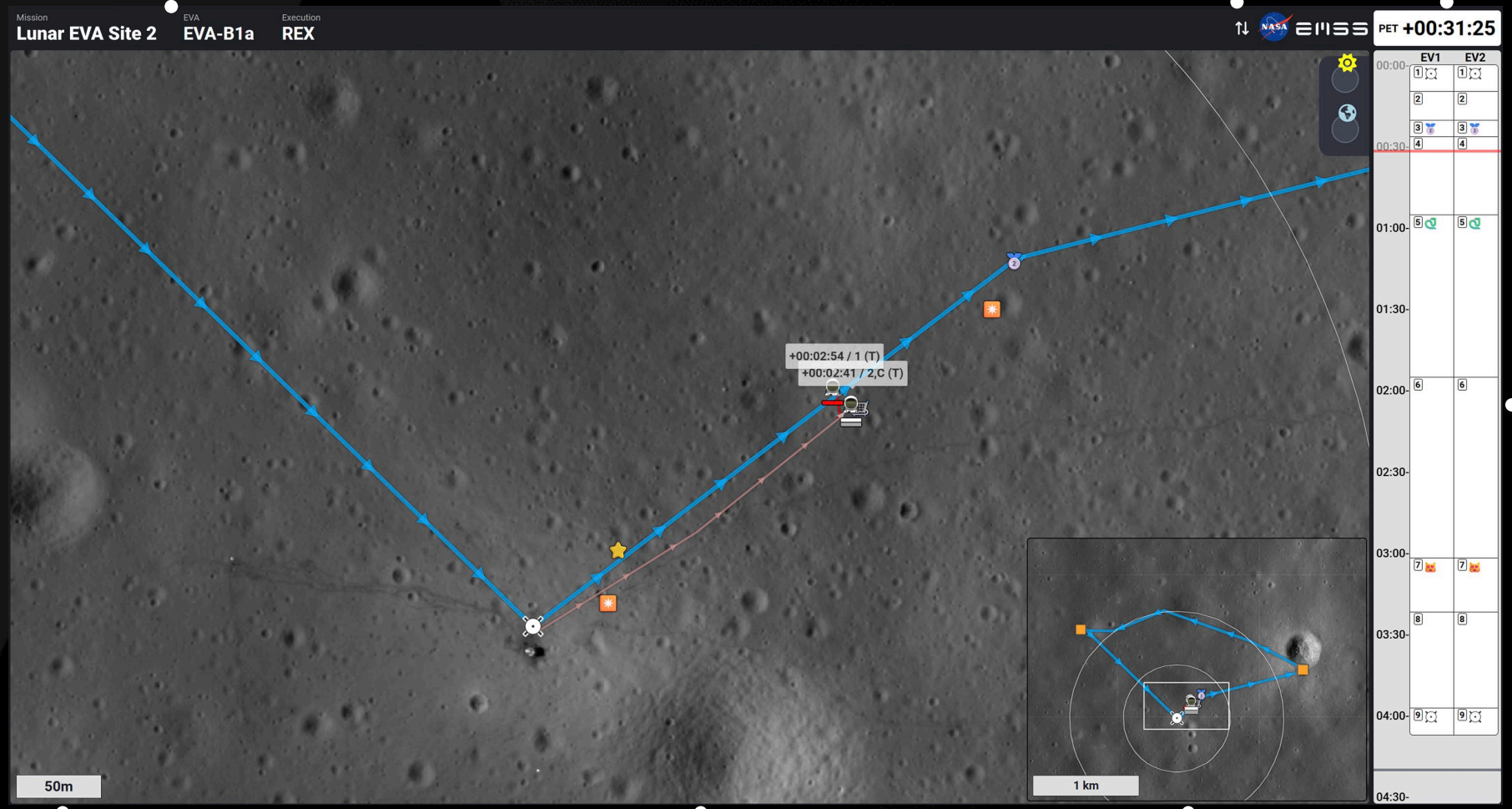
Rules based Actions

Data Profiles
Measure/Bearing Calculations

EVA Sequence Diagram

Science Traceability Matrix Coverage

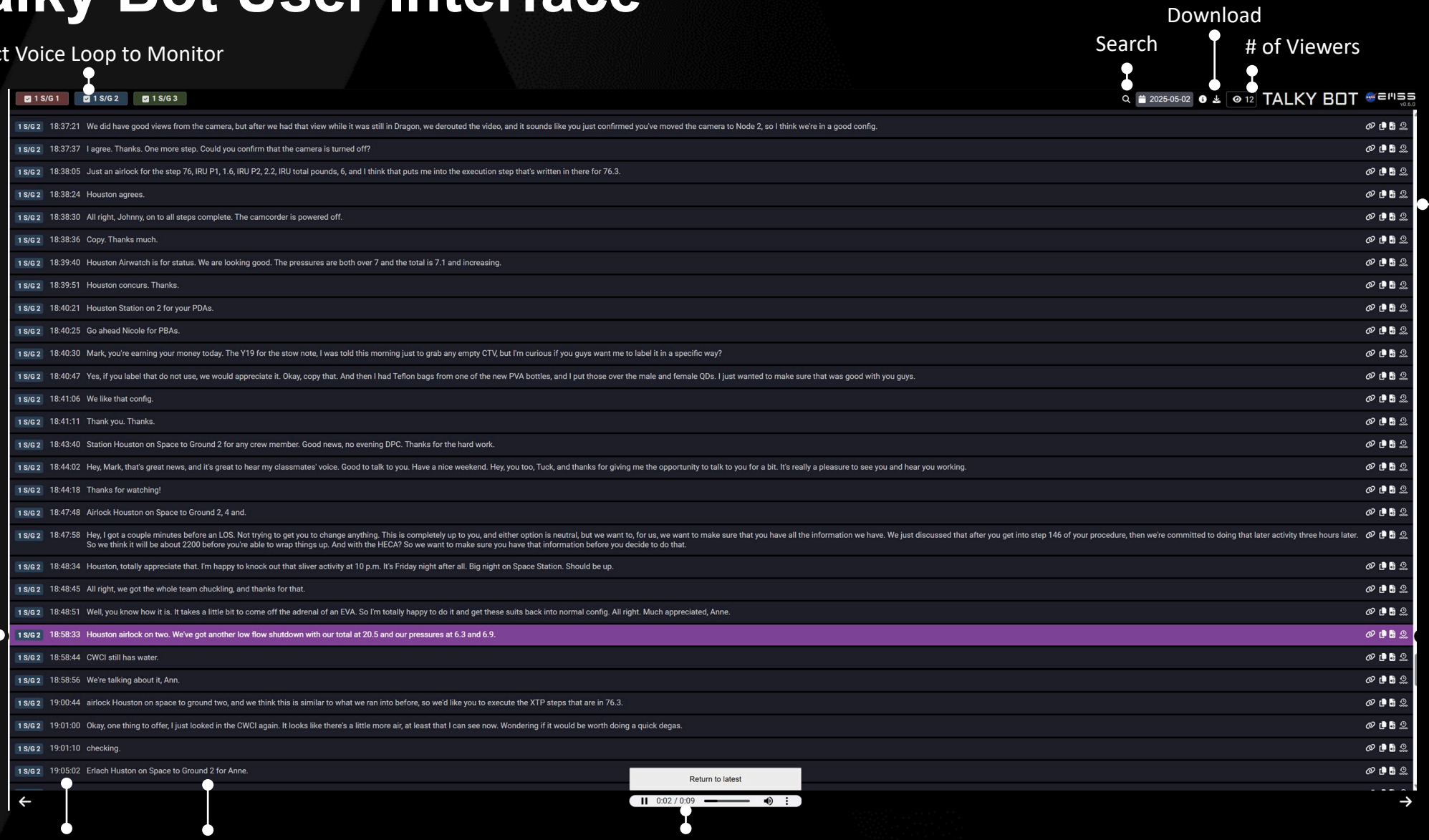
The Emergence of an Integrated EMSS Display



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

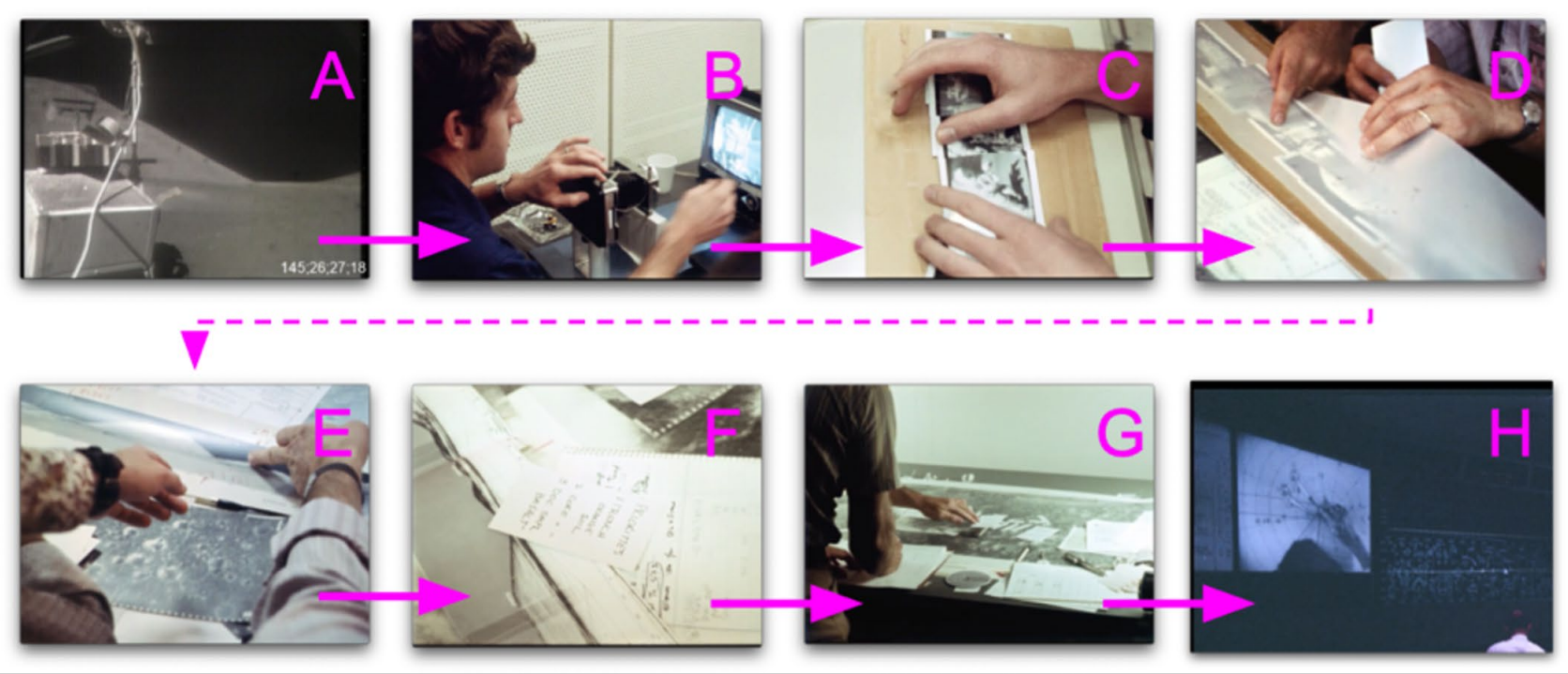


EMSS Mission Integration & Development Strategy

- **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

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 would also like to thank our Flight Operations Directorate (FOD) users for their use of, and feedback towards the continued development of the EMSS tools.
- 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.