Open-ended Questions:

• What are the necessary support systems future crew will need and what will functions will they support?
• How can we answer the envisioned world problem facing the human spaceflight community?

Study Objectives:

1. Compare present-day and envisioned EVA concept of operations
2. Discuss key work functions inherent to the EVA work domain
3. Illustrate prototype support system designs and development efforts
Records provide details as to **What** was performed with limited insight into **How** EVA was performed.

As of 7/27/2016, NASA performed 391 EVAs, **110 (28%) experienced significant incidents**
- Crew injury (12)
- Early Termination (14)
- System Issue (52)
- Operational Issue (36)

Thinking about the future...
- Central to the success of EVA execution is the **relationship between in-flight crew and ground support personnel**
- However, existing data is saturated with in-flight crew perspectives
- Additionally, deep-space operations imposes a multitude of new operational constraints to consider
  - Delayed communication
  - E.g. 4-20 min one way between Earth and Mars
Understanding what is necessary to conduct EVA today

Motivating Questions
- What structure and functions exist in the current EVA work domain?
- What shifts are likely to occur for future operations?

Information Flow Model

How is the current EVA work domain structured?

What functions are required to ensure successful EVA execution?

Assumptions for the future
- IV operator will take on more functions that MCC currently provides
- Timeline and life support system management are highest priority to transition

**Processes of EVA preparation and post-processing not included**

AIAA SciTech - 1/12/2017
Miller, McGuire, & Feigh (2016, 2015a)
Envisioning future EVA operations

Assumptions for the future
- Analog environments provide a representative means to explore what exploration teams will contend with at various destinations (e.g. NEOs, Moons or Mars, Mars surface)
- Provide a means to situate operators under envisioned physical and cognitive problem spaces

In 2016, 3 simulation campaigns we leveraged to explored the design considerations of the IV operator and workstation
- NEEMO 21 (10+ EVAs)
- BASALT-1 (10+ EVAs)
- GT Laboratory (18+ EVAs)

**Graph only includes recent field deployments with published reports**
Supporting Envisioned Work

**Assumption:** Time-delayed communication will necessitate the IV operator to support the moment by moment *(tactical)* operations of EVA execution that include the following functions:

**Timeline Management**
- Timeline articulates the intended pathway of actions (minute by minute) that lead to the completion of the *a priori* specified objectives
- Constituent IV workstation elements include:
  - Summary Timeline
  - Detailed Procedures
  - Flight Notepad
  - Map/Geospatial Tracking Display

**Life Support System Management**
- Life support system is composed of soft goods and the portable life support system (PLSS). The PLSS generates various data streams that are monitored during execution
- Constituent IV workstation elements include:
  - Numerical Telemetry Displays
  - Graphical Telemetry Displays
Supporting Envisioned Work

**Communication Management**
- EVA operations depends on the ability to exchange information among the various members of the team
- Modes of communication include: Video, Audio, Text, Imagery

**Science Operations Management**
- Future EVA objectives will contain science-driven objectives, which introduces a spectrum of new data products to the EVA work domain
- Constituent IV workstation elements include: Science Data Display, Science Notepad

**Physiological Data Management**
- Medical professionals (e.g. Flight Surgeon) currently manages crew physiological data. Future operations will likely require IV operator to manage this data in addition to traditional EVA variables.
- Constituent IV workstation elements include: Physiological Data Display
### IV Workstation Configurations – Analog Environments

<table>
<thead>
<tr>
<th>Work Function</th>
<th>Support System Element</th>
<th>Analog</th>
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<tbody>
<tr>
<td>Timeline management</td>
<td>Summary Timeline</td>
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<td></td>
<td>Detailed Procedures</td>
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<td></td>
<td>Flight Notepad</td>
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<td></td>
<td>Map/Geospatial Tracking Display</td>
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<td>Life support system management</td>
<td>Numerical Telemetry Display</td>
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<td></td>
<td>Graphical Telemetry Display</td>
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<td>Communication Management</td>
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<td>Text Client</td>
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<td>Physiological data management</td>
<td>Physiological Data Display</td>
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<tr>
<td>Science operations management</td>
<td>Science Data Display</td>
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<tr>
<td></td>
<td>Science Notepad</td>
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</tbody>
</table>
Conceptualizing the Operational Layout

ISS EVA Operations

Laboratory EVA Operations

BASALT-1 EVA Operations

NEEMO 21 EVA Operations
IV Workstation Configurations - Laboratory
IV Workstation Configuration: NEEMO 21

NEEMO 21 EVA Operations
IV Workstation Configurations: BASALT-1
**Objective #1:** Compare present-day and envisioned EVA ConOps

Framed EVA operations in terms of inherent work domain features to facilitate the extension of present-day ops into the future

**Objective #2:** Discuss key work functions inherent to the EVA work domain

Articulated five aspects of EVA work we expect future IV crew to perform

**Objective #3:** Illustrate prototype system designs and development efforts

Linked envisioned work capacities with various prototyped workstation software components to guide future development efforts

Each Prototype acts as a hypothesis about how to best enable IV operator work
Study Implications and Future Work

Open Research Questions

• What does it mean to have situation awareness from the perspective of the IV operator?
• What is the appropriate distribution of responsibility and authority among the entire flight team?

This research is the first attempt to understanding the representations and responsibilities necessary for the IV operator enable future EVA

Future Work

• Examine how we can better design both the surface (interface) and internal (software structure) representations to facilitate desired IV work responsibilities
• Extend similar rationale to examining other members of the EVA flight team to understand system-wide implications from support system design
Questions?

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References

- See manuscript for full reference list

Upcoming BASALT and NEEMO publications: