JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

# Utilizing enterprise services for spacecraft telemetry visualization

## GSAW 2021

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# Problem Statement & Objective

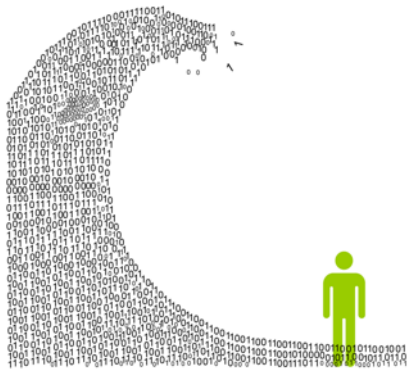


Image: Mark Smiciklas CC

Spacecraft operators are inundated with a **deluge of information**

Significant changes to ground system architectures are affecting how they are acquired, deployed, and operated

- Enterprise services (IaaS, PaaS, SaaS) in the government and commercial sectors are being planned or have already come online to enable modular open system architectures (MOSA) (e.g., EGS)

In digital engineering (DE) environments, **digital twins** provide a construct for integrating authoritative models and disparate data from spacecraft systems and simulating potential scenarios

**Facilitate operator communication and decision making through the development of a digital twin visualization in an enterprise environment**

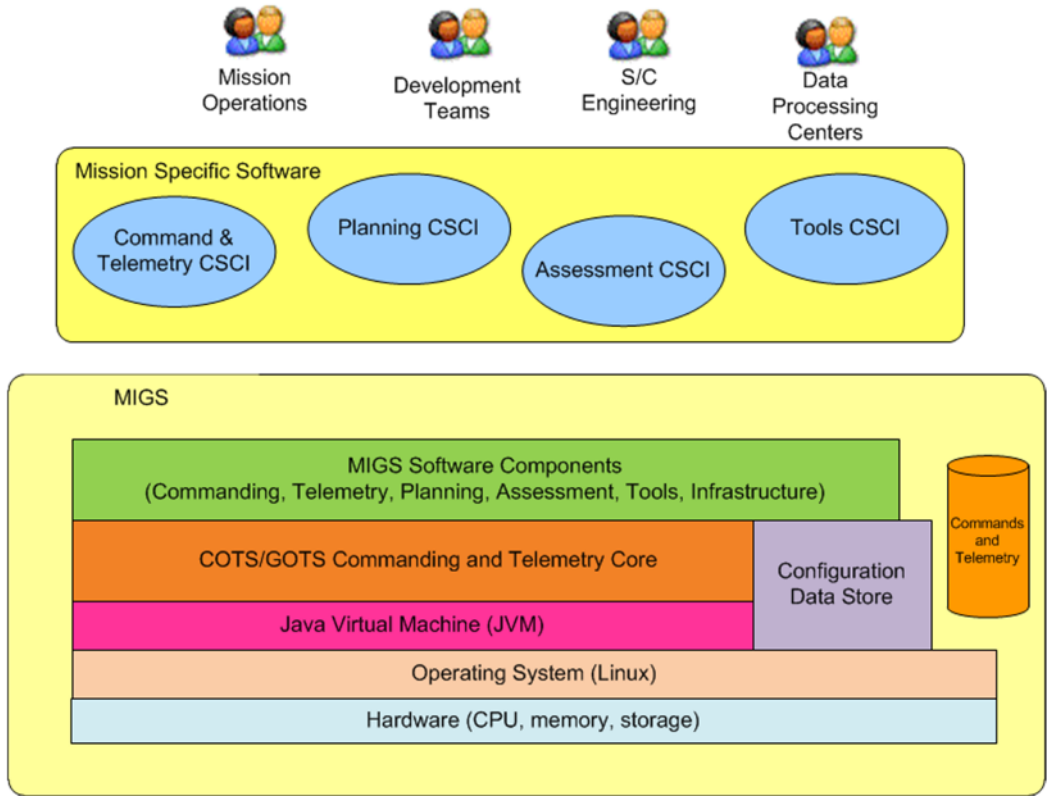
# Background

## JHU/APL ground system software

JHU/APL builds and operates multiple spacecraft missions for U.S. Government sponsors

Mission independent ground system (MIGS)

- Used across a variety of missions and consists of common components to enable modular reuse
- Incorporates COTS & GOTS to support integration and test (I&T) and mission operations
  - Kratos EPOCH-2000, L3Harris InControl, Peraton OS/COMET, NASA AMPCS

# Background

## Digital engineering [1]

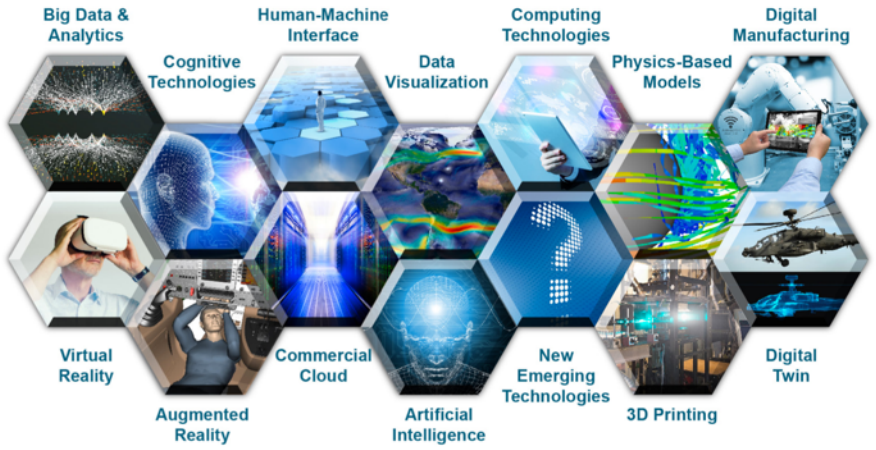
### Digital engineering

- An integrated digital approach that uses authoritative sources of systems' data and models as a continuum across disciplines to support lifecycle activities from concept through disposal
- Make use of data to improve awareness, insights and decision making
- Advance human-machine interactions

### Digital twin

- An integrated multiphysics, multiscale, probabilistic simulation of an as-built system
- Uses the models, sensor information, and input data to mirror and predict activities/performance over the life of its corresponding physical twin

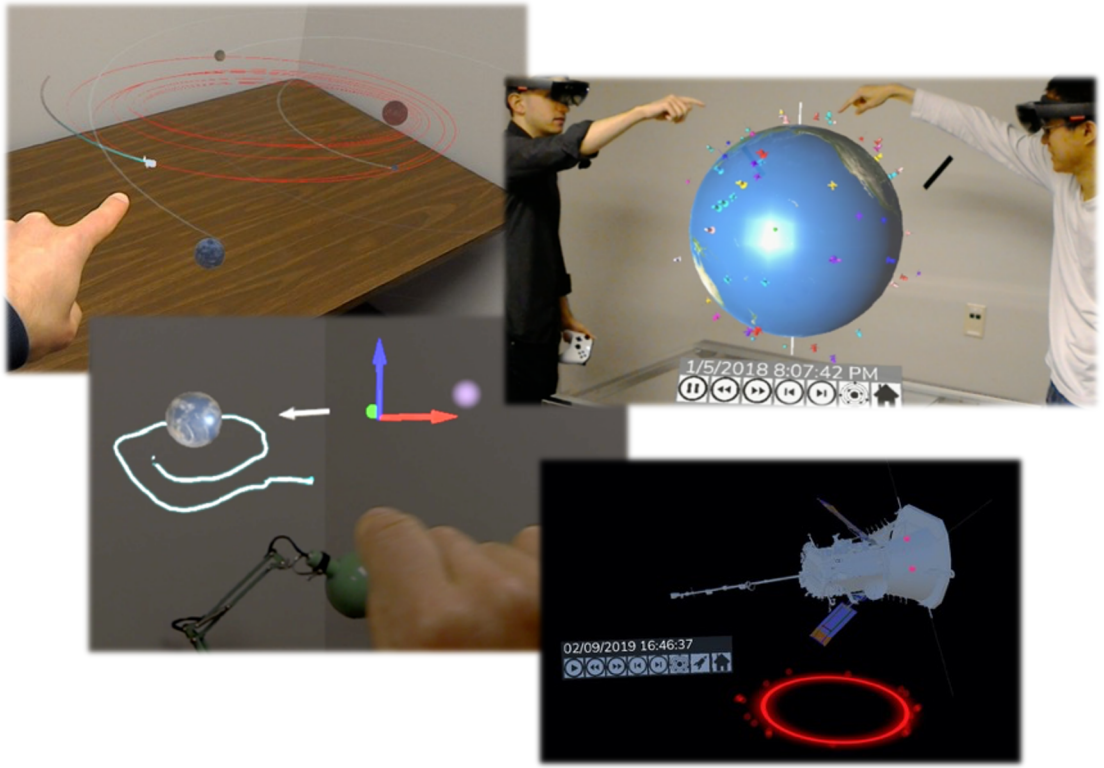





[1] https://ac.cto.mil/digital_engineering

# Background

## xR technologies




Display technology used in operations centers is dated and insufficient for advanced data visualization

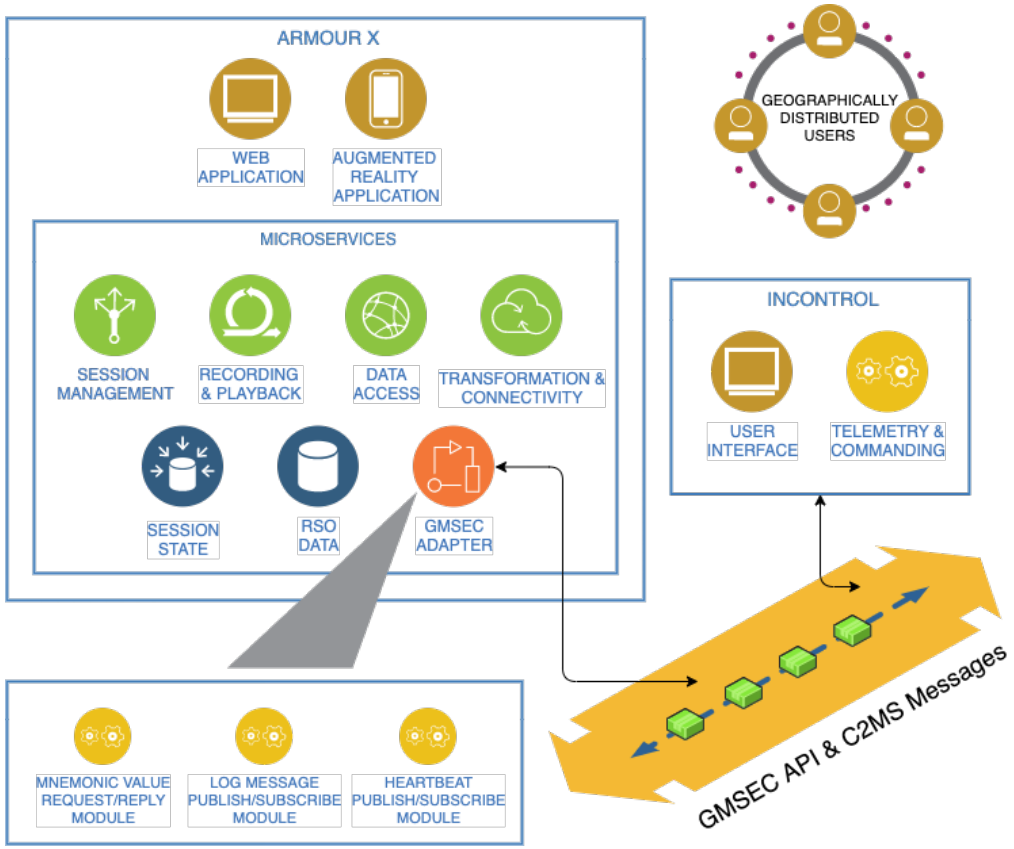
- Mission operators and planners need to move beyond passively observing data and begin experiencing data in mission context
- xR technologies enable users to interact with and experience information from digital twins

JHU/APL is investigating the use of xR technologies to help decision making throughout the space mission lifecycle

- Augmented Reality Mission Operations UseR eXperience (ARMOUR X) prototype

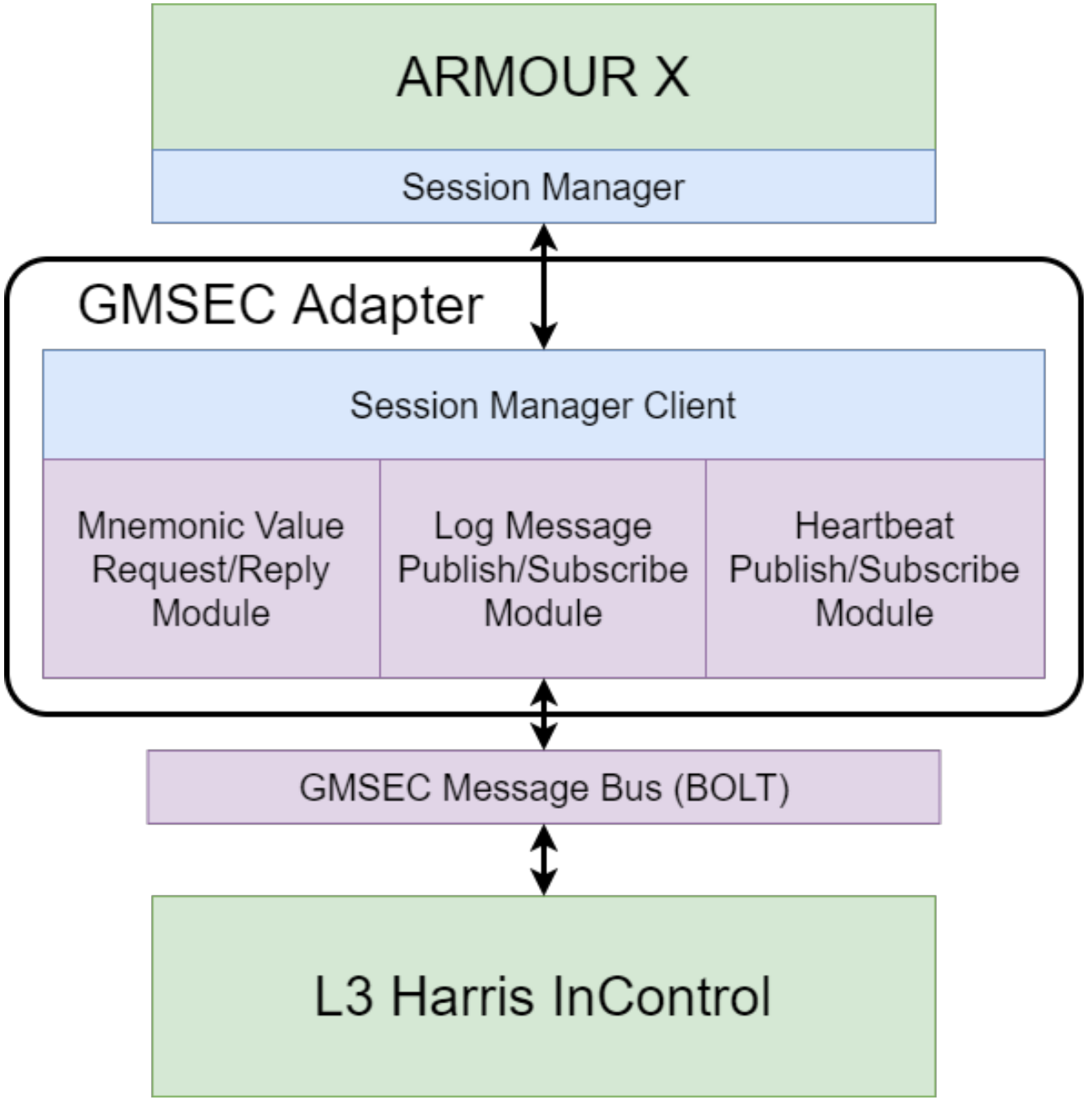
# Approach

- Utilize NASA GMSEC API and software bus as the common messaging platform
- Create an ARMOUR X service to send and receive C2MS messages
- Collaborate with Parker Solar Probe and L3Harris to send and receive C2MS telemetry and commanding messages from MIGS and InControl
- View telemetry information in the context of a spacecraft orbit visualization in xR

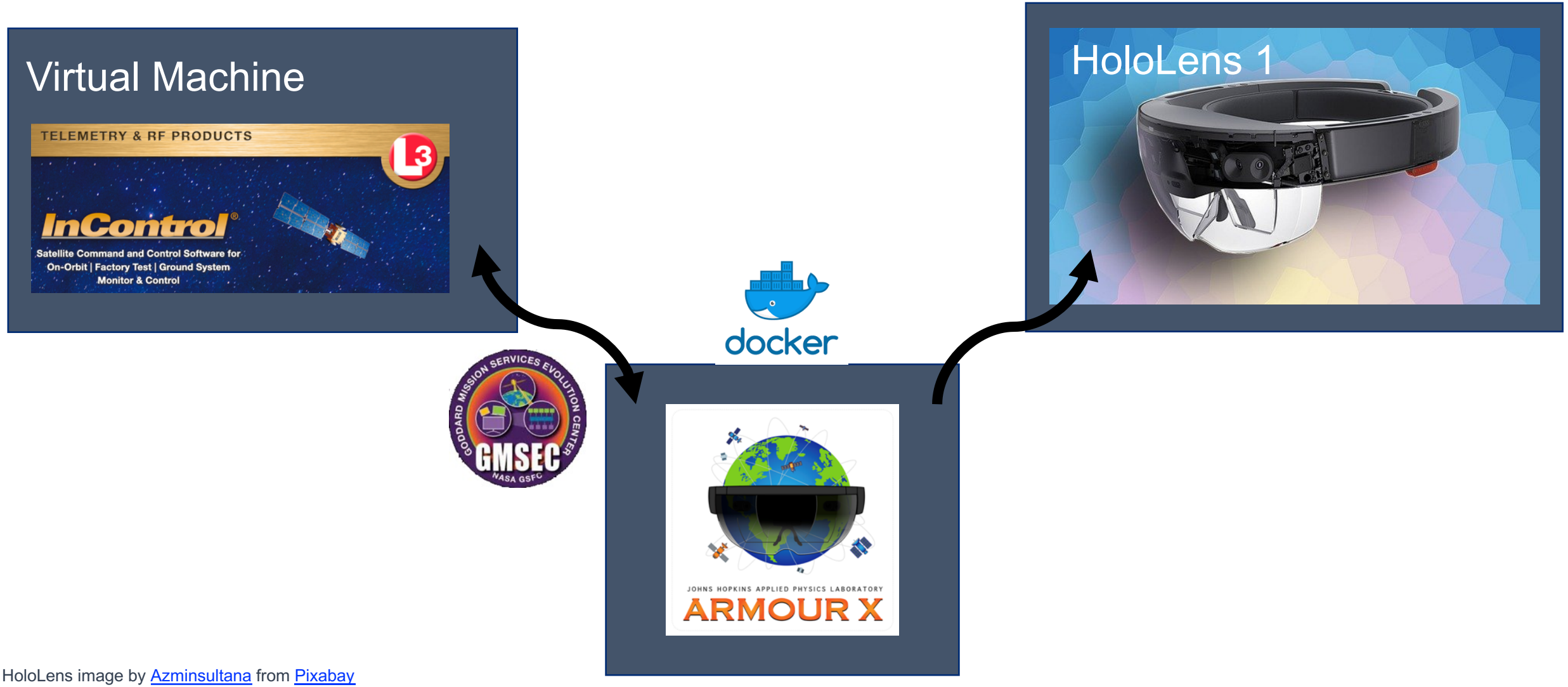


# Architecture

- "GMSEC Adapter" microservice
  - Translates C2MS messages from the GMSEC software bus into ARMOUR X-compatible JSON messages
- Modular approach increases flexibility
  - GMSEC Adapter library allows extension to customize modules per message type
  - Can easily add modules to support new message types in the future



# Architecture: Demo Design




HoloLens image by Azminsultana from Pixabay

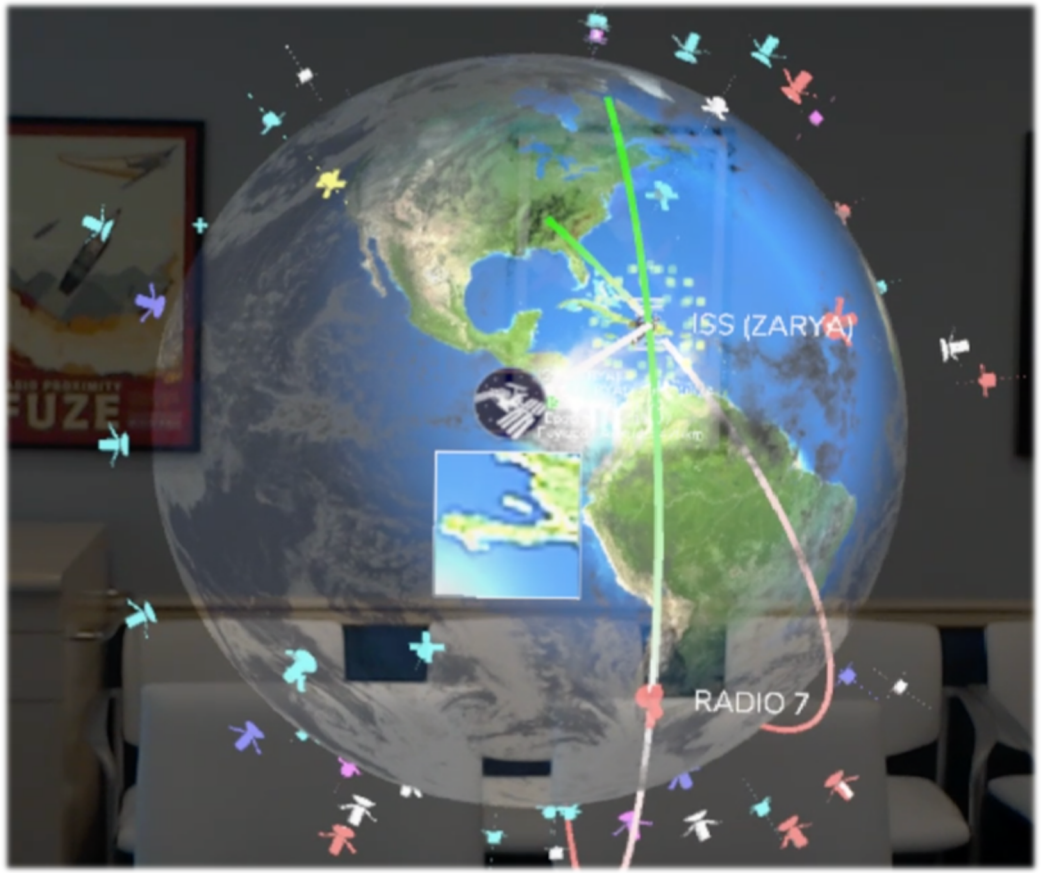
# Preliminary results

## Enterprise services

Demonstrated the integration of a space mission xR visualization and T&C software with enterprise services

- Common ground services
  - Deployed GMSEC software message bus
- Telemetry & Commanding
  - Successfully demonstrated sending PSP spacecraft telemetry using C2MS messaging over the GMSEC bus
- xR Visualization
  - Implemented UI enhancements in ARMOUR X to visualize telemetry data
  - Developed adapter software to interface messaging between GMSEC bus and ARMOUR X SocketIO bus


# Next Steps




- Implement additional telemetry and commanding message types
- Upgrade current AR visualization
  - Display changes in telemetry points over time
  - Add UI functionality to select specific telemetry points
- Incorporate data from multiple stages of the space mission lifecycle
  - Utilize a zoomed-in view of spacecraft CAD model with overlaid data for design, I&T, and operations
- Integrate data feeds from multiple spacecraft
  - Visualize telemetry that is relevant for each spacecraft
  - Expand visualization to include inter-planetary spacecraft missions and trajectories
  - Use Kafka for publishing and subscribing to event streams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