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Course of Action Modeling and Visualization in Augmented Space (CAMVAS)

GSAW 2019 – Modeling Complexity

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Problem Statement

Situational awareness (SA) relies on persistent intelligence, surveillance, and reconnaissance (ISR), and connectivity

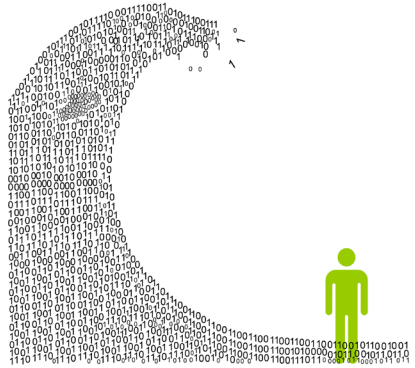


Image: Mark Smiciklas CC

Image: Angela Waye

Operators are inundated with a **deluge of information**

- Environmental (weather, terrain), positioning of other spacecraft/debris, etc.
- Limited time and ability to characterize, organize, correlate, and understand

How can information be **visualized for effective decision making**?

- Courses of action (COA) development depends on accurate, correlated information
- Current approaches to COA analysis and visualization are not sufficient

CAMVAS Objective

Explore how mixed reality (MR) technologies can aid operational decision makers

- Utilize available Space SA (SSA) effectively
- Visualize space COAs
- Achieve successful Battle Management Command and Control (BMC2)

Image: Australian Royal Air Force

Image: Microsoft

Image: DARPA

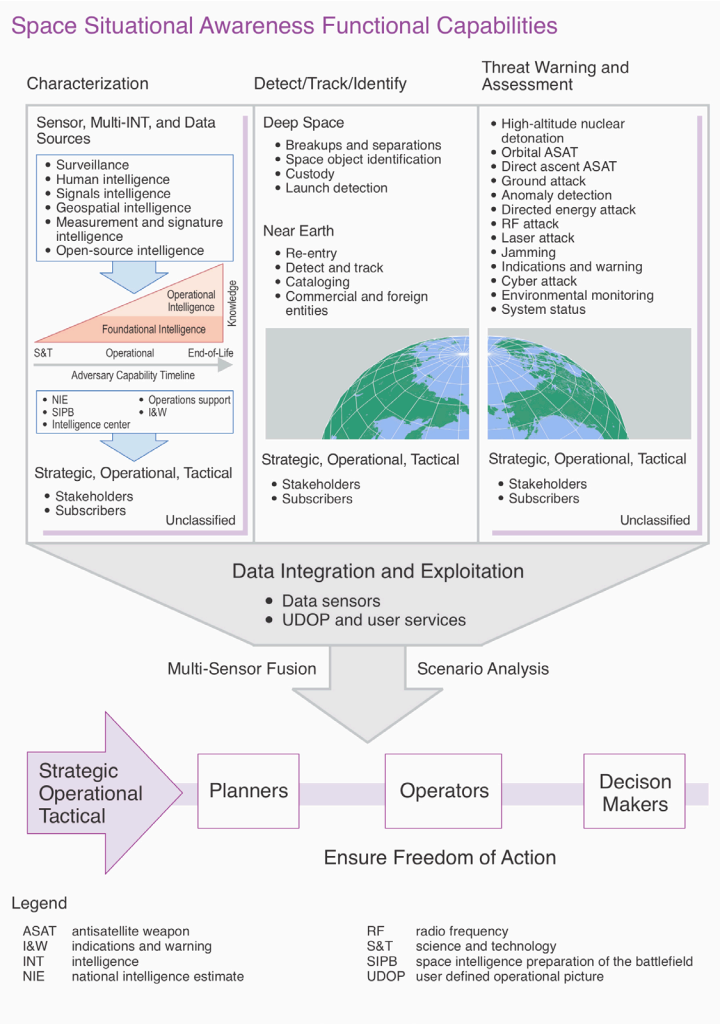
Facilitate a common operating picture for space COA visualization and interaction

Background

SSA [1]

Space Situational Awareness (SSA)

- Characterizing the space capabilities operating within the terrestrial environment and the space domain
- Dependent on:
  - Integrating space surveillance, collection, and processing
  - **Environmental monitoring**, processing and analysis
  - **Status of US and cooperative satellite systems**
  - Collection of US and multinational space readiness
- Data integration and exploitation (DI&E)
  - "The ability to fuse, correlate and integrate multi-source data into **a tailorable common operating picture (COP)** and enable decision making for the entire set of space operations missions"
  - Facilitates **decision making and more responsive COAs** for space and non-space forces



[1] U.S. Joint Chiefs of Staff. (2013, 29 May). *Space Operations*. Joint Publication 3-14.

Background

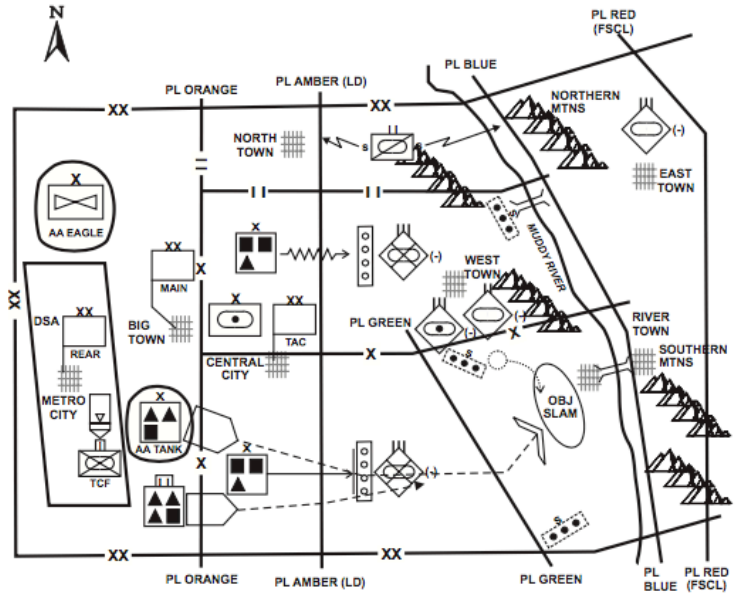
Space COA Visualization

Courses of action (COA)

- Represent **potential plans to accomplish the assigned mission** and meet the commander's intent

Space COA visualization

- For planning and operational decision making, users need to visualize:
  - **Pre-planned decision tree** branches and sequels
  - **Space objects of interest** and associated information
  - **Timelines of simultaneous events** and actions
  - A summary of **the SSA picture**
  - Updated **current and anticipated future temporal constraints**



Example COA sketch (division offense) [2]

[2] Department of the Army. (1997). *Staff Organization and Operations*. FM 101-5.

Background

Reality-Virtuality Continuum

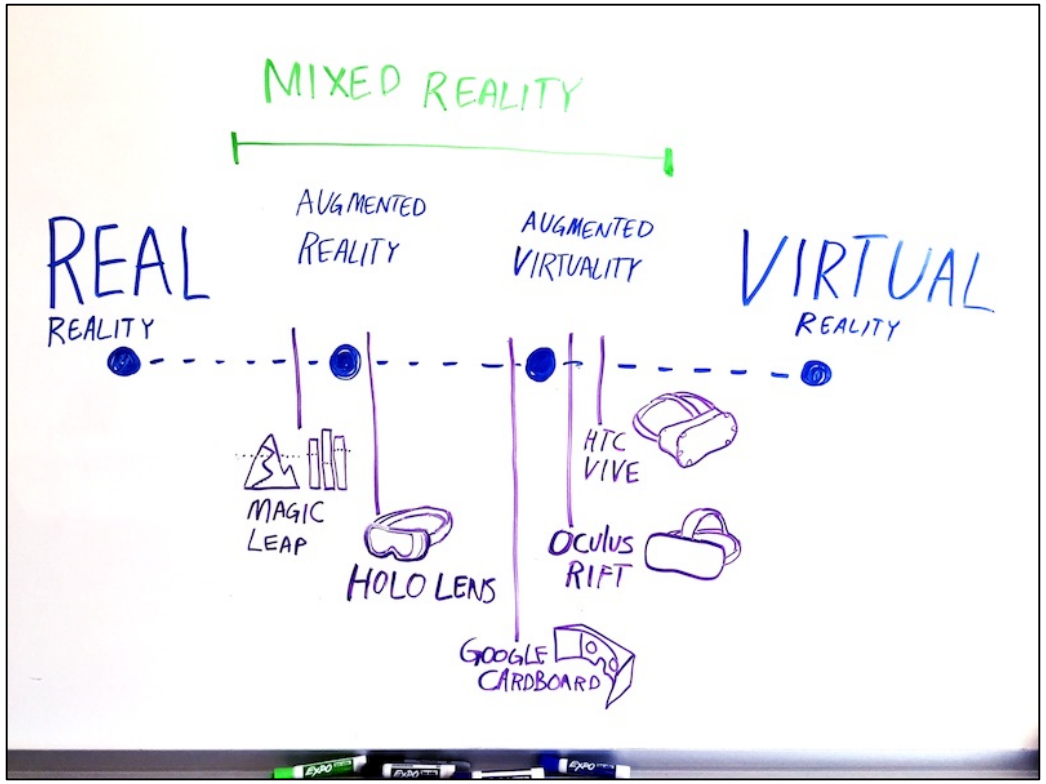


Image: Andrea Everman

- **Virtual Reality (VR)** "provides a computer-generated 3D environment that surrounds a user and responds to an individual's actions in a natural way, usually through immersive head-mounted displays (HMDs)" [3]
- **Augmented Reality (AR)** is "the real-time use of information in the form of text, graphics, audio, and other virtual enhancements integrated with real-world objects and presented using a head-mounted-type display (HMD) or projected graphics overlays" [3]
- **Mixed Reality (MR)** is a single technology, but one that includes an underlying group of technologies, including the spectrum of immersive displays and interactive systems that spans from the digitization of real environments, to AR and VR [3]

[3] Nguyen, T., Resnick, M., & Blau, B. (2017). Hype Cycle for Human-Machine Interface, 2017. *Gartner*. Retrieved from www.gartner.com.

Background

Advantages of AR Technologies

- Rather than separating them from it, users' interaction with the environment is enhanced in AR [3]
- AR provides a medium that can fundamentally change the way complex spatial concepts and content are understood [4]
- Integration of AR technologies in applications has been shown to improve productivity in the performance of tasks [5]

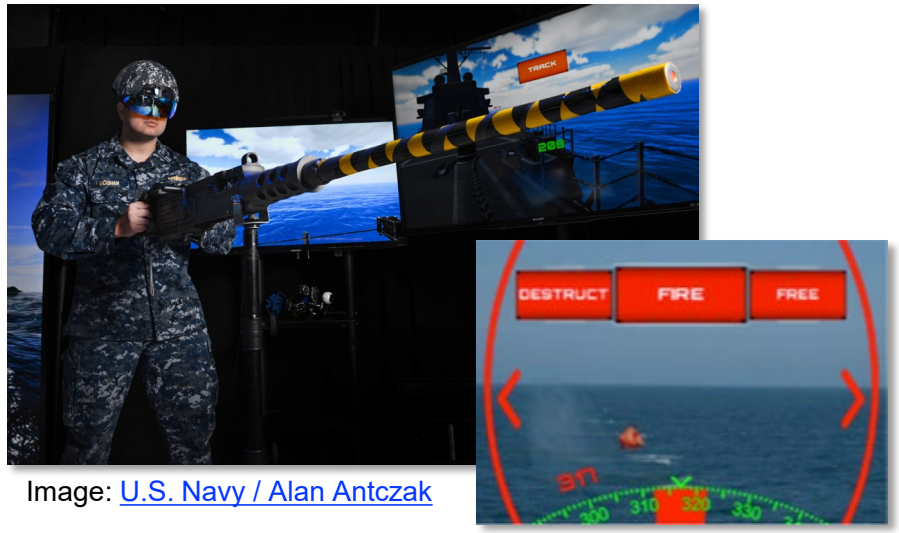


Image: U.S. Navy / Alan Antczak

Image: Microsoft

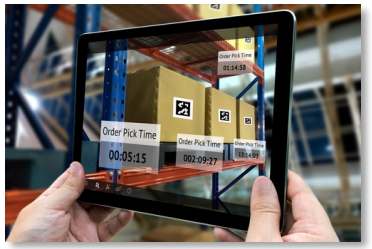


Image: Sam Radocchia

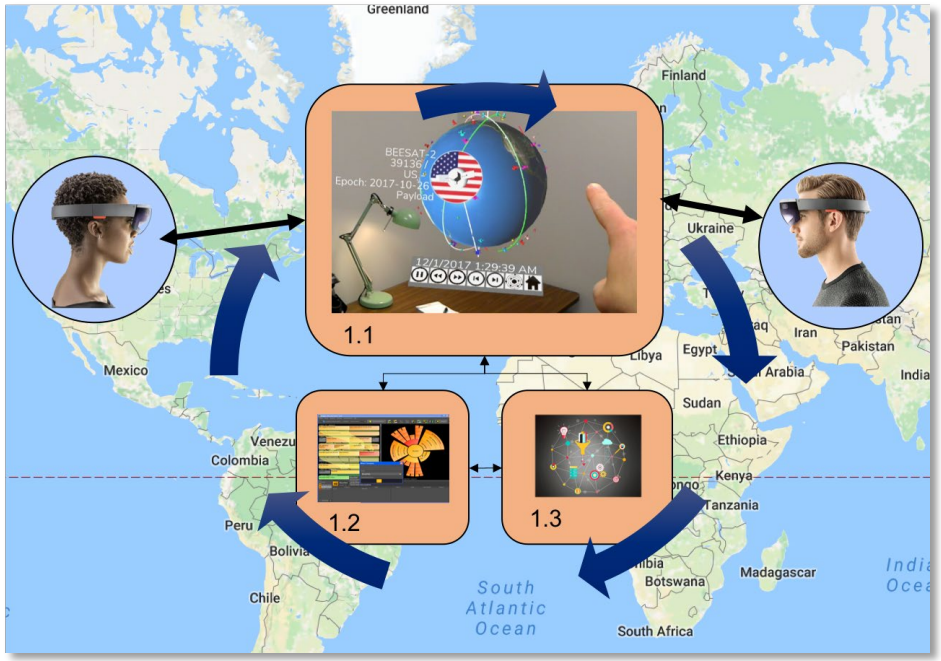
[4] Shelton, B. E., & Hedley, N. R. (2002). *Using augmented reality for teaching earth-sun relationships to undergraduate geography students*. Paper presented at Augmented Reality Toolkit, The First IEEE International Workshop. Retrieved from http://ieeexplore.ieee.org.

[5] Abraham, M., & Annunziata, M. (2017, 13 March). Augmented Reality Is Already Improving Worker Performance. *Harvard Business Review*. Retrieved from http://hbr.org.

CAMVAS Concept

System Overview

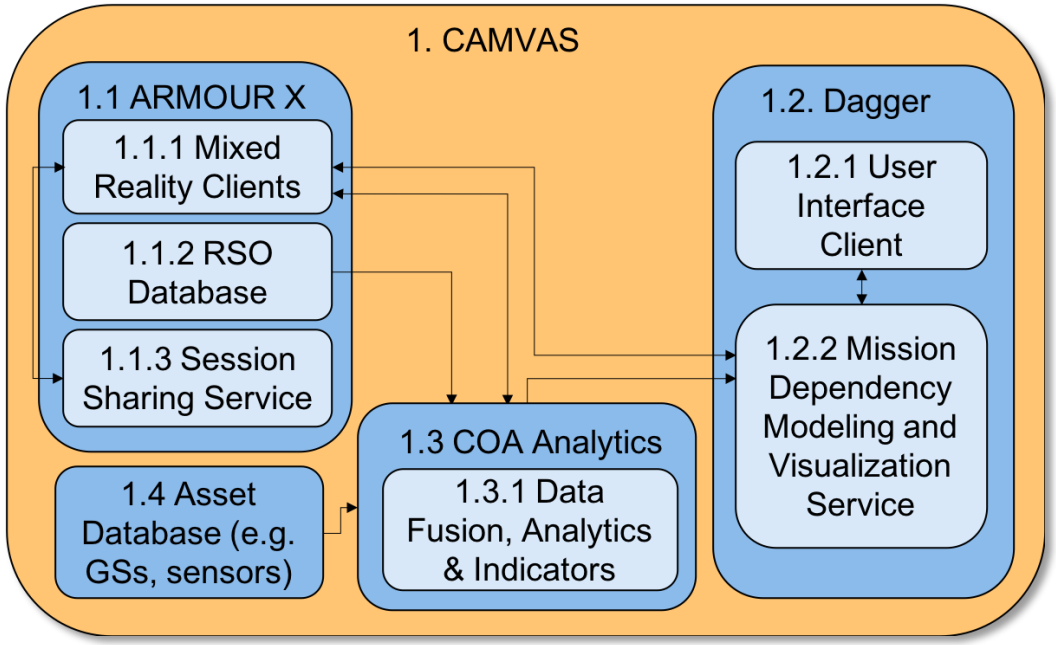
- Visualize space- and ground-based assets and characteristics
  - Sensor Field of View (FOV)
  - Satellite earth coverage
  - Satellite-to-satellite visibility
  - Communication paths to ground stations
  - Orbital flight propagation
  - System status
- Determine effects on mission COAs
  - Develop mission model including all assets and mission tasks
  - Correlate and compare data from operational environment (e.g., weather and terrain)
- Design, construct and visualize COAs
  - Building temporal and spatial sequence of events
  - Rank and score COAs based on pre-defined parameters



CAMVAS Concept

System Architecture

- Composed of systems developed at JHU/APL
  - Augmented Reality Mission Operations UseR eXperience (ARMOUR X)
  - Mission modeling and visualization (Dagger)
  - Data analytics applications
- Distributed, service-oriented computing architecture to support AR application
  - Asset database
  - Mission dependency models
  - Data fusion and analytics
  - Real-time sharing of state information between multiple clients



CAMVAS Concept

Dagger

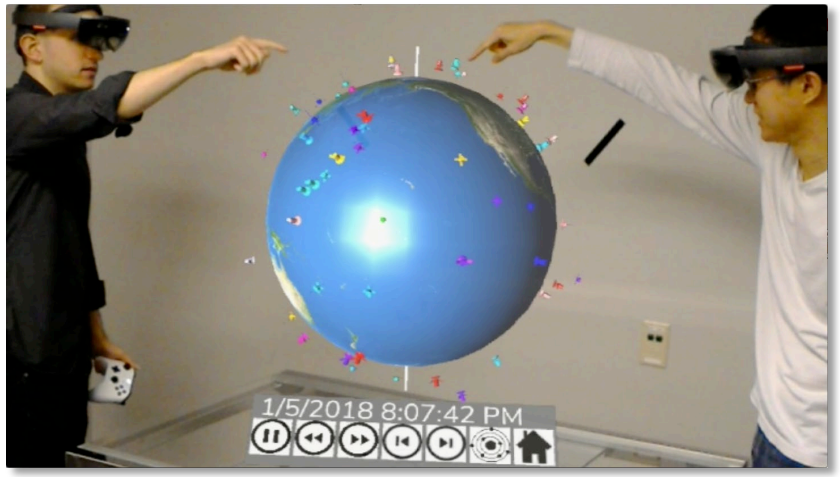
- Mission modeling and visualization
  - Mission planning
    - Represent models of missions, supporting components, and dependencies
  - Situational awareness during mission execution
    - Real-time data feeds compute status of mission, capabilities, and components
  - COA analysis before, during and after the mission
    - Timeline allows playback of status history
    - Simulate actions and events over time, enabling predictive analysis over changing temporal variables

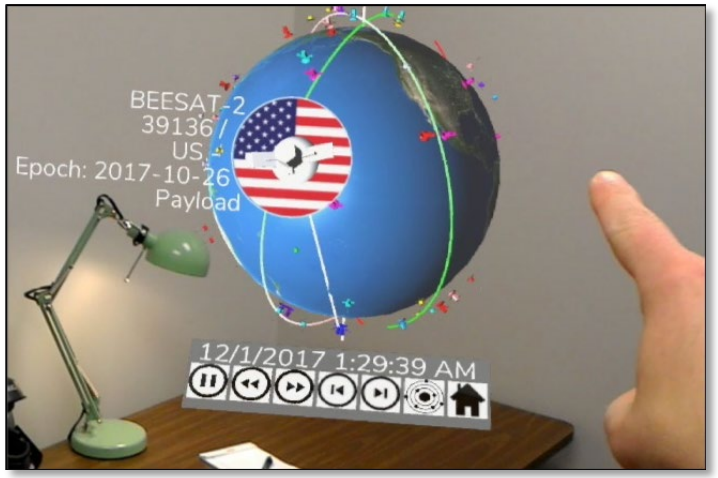
CAMVAS Concept

ARMOUR X

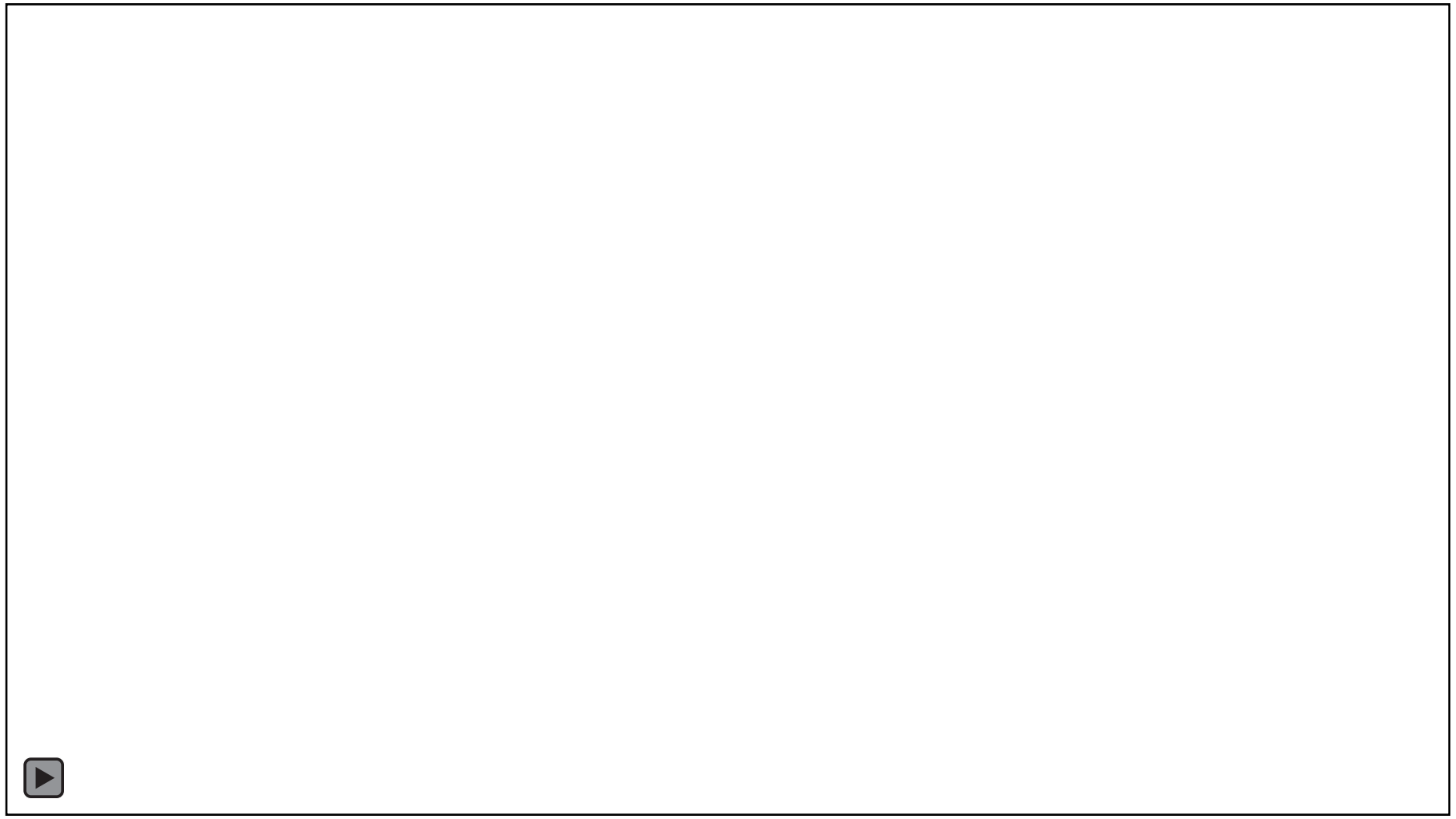
Geocentric visualization in AR

- Multiple users interact in a shared experience
- Resident space objects (RSO) in low earth orbit (LEO) to geosynchronous orbit (GEO)
- Data visualization and interaction
  - Historical and predicted orbital trajectories
  - Playback time and speed controls
  - RSO characteristics and coverage





ARMOUR X



Conclusions & Next Steps

- AR technologies provide functionality that **enables users to effectively analyze complex relationships in a collaborative environment**

- To **facilitate COA development and analysis**, operational decision makers and SSA analysts can benefit from having a capability that allows them to **collaboratively build, visualize and interact with space mission models and simulations in AR**

- CAMVAS provides a capability to collaborate beyond just sharing data – context, analysis, and experience are shared – resulting in a **common operating picture that strengthens command and control of space missions**

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