Advanced Tactical Command & Control (ATacC2)

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Overview

- Goal / Objectives
- M&S Motivation
- Sensor, C2, & Communications modeling enhancements
  - CEC Concept
  - CEC Sensor Netting
  - CEC Warfighting Benefits
  - Real-time Time Division Pairwise Access (TDPA) Comms (details not presented)
  - Distributed measurement-level Sensor Fusion – Model Switching Filter (MSF) over TDPA comms
  - Set Cover Problem C2
  - Communication Models Features
  - Near-real-time Time Division Multiple Access (TDMA)
  - Single-Sensor Track-to-Track Correlation
  - Track Quality and Reporting Responsibility (R2…"R Squared") over TDMA comms
  - Message Scheduling
  - Extended Range Comms
  - Enhanced C2 functionality
- Conclusion
- Q&A

ATacC2 Goal

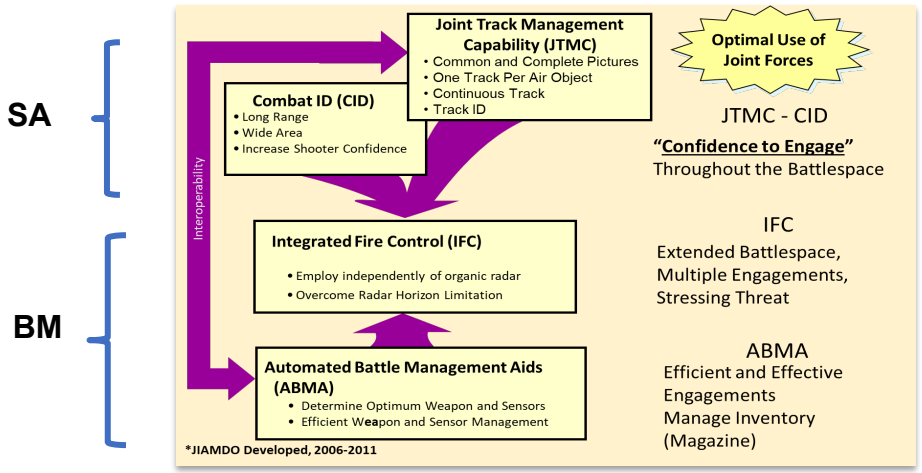
Provide real-time Tactical C2-level capabilities for ABMS in support of JADC2/JIAMD:

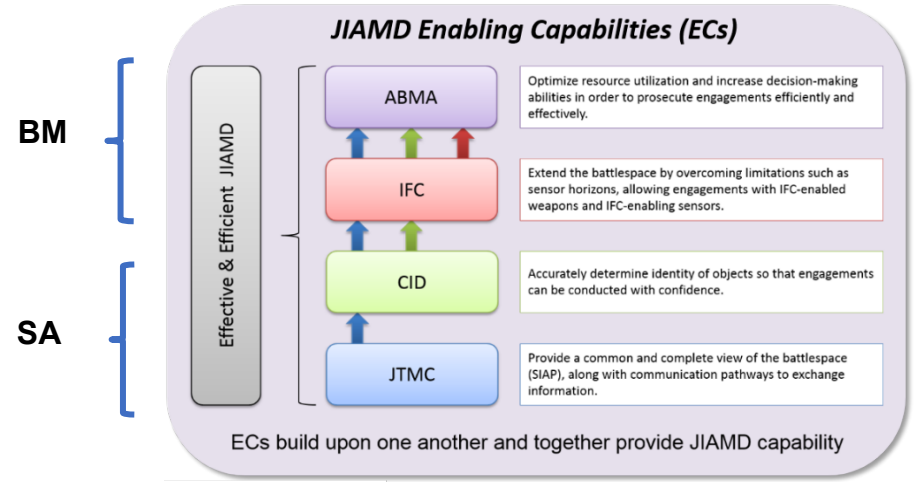
- Battlespace/Situational Awareness (SA)
  - Joint Track Management Capability (JTMC): real-time Sensor Network / near-real-time TDL integration
  - Combat Identification (CID): rules-based and feature-based
- Battle Management (BM)
  - Integrated Fire Control (IFC): any sensor/any shooter
  - Automated Battle Management Aids (ABMAs): right sensor/right shooter

Assess JADC2/JIAMD capabilities over real-time TDPA and near-real-time TDMA comms

Focus areas:

- Air Base Air Defense (ABAD)
- Cruise Missile Defense of the Homeland (CMD-H)
- Long-Range Strike / Dynamic Targeting





ATacC2 Objectives

- Provide real-time Tactical C2-level capabilities for ABMS in support of JADC2/JIAMD
  - Fielded and Planned capabilities (i.e., CEC and related C2/sensor/weapon capabilities)
  - Ongoing S&T efforts across AFRL, Services/MDA
  - Benefits to USAF and DoD

- Field advanced/interoperable JIAMD/JADC2 capability sooner
  - Perform risk reduction/mitigation activities prior to fielding
  - Minimizes costs and duplication of efforts
  - Maximizes investments on capability gaps

M&S Motivation

- Current large mission-level scenario are built upon perfect or near-perfect sensors, C2, and comms constructs.
  - Insufficient as a baseline for studying ABMS/JADC2 concepts and JIAMD
  - Existing comms/C2 M&S is high-fidelity and does not scale to theater-level scenarios

- Model real world effects such as:
  - Information sharing and processing
    - Real-time, measurement-based, directional comms for sensor networks (i.e., CEC)
    - Near-real-time, track-based, broadcast comms for tactical data links (i.e., Link-16)
  - Information deconfliction
  - Tracking uncertainties
  - Asset resource management

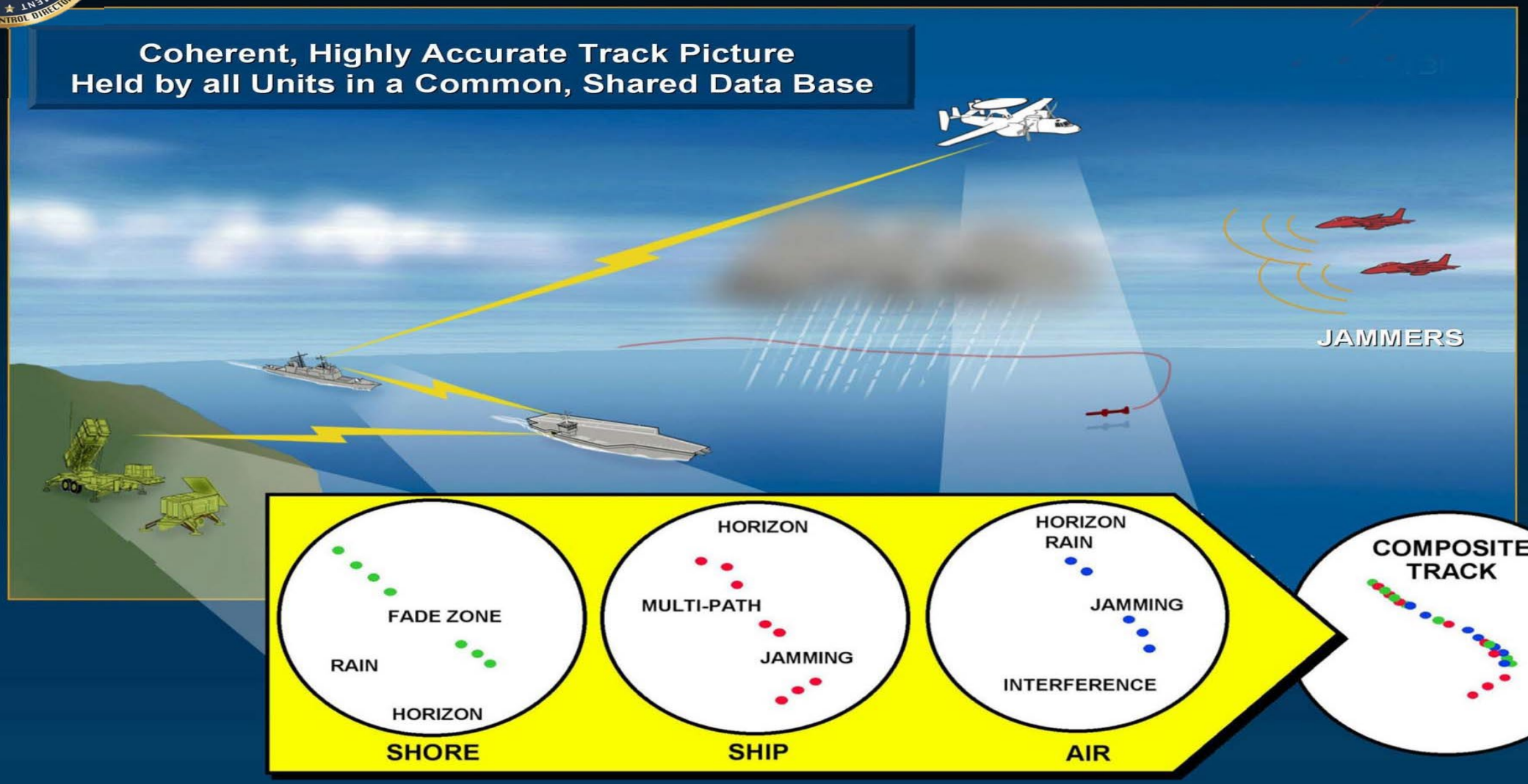
- Assess JADC2/JIAMD capabilities with and without real-time Sensor Networks

CEC Concept

- Take advantage of sensor diversity across the force
- Make better use of sensor (Radar and IFF) data
- Provide a composite track picture to the combat system that is more continuous, complete, consistent, and accurate
- When desired, distribute fire control quality data from available providers to the weapon systems engaging the threat

Source: Cooperative Engagement Capability: A Sensor Netting Enabler Date: 9 January 2018

Sensor Netting
Composite Tracking Concept



Source: Cooperative Engagement Capability: A Sensor Netting Enabler Date: 9 January 2018

CEC Warfighting Benefits

- Detection and tracking
  - Quantum improvement in track continuity & accuracy superior to any single sensor
  - Sensor cueing extends force detection ranges
  - Expands capability of existing sensors and weapons

- Engagement
  - Significant increases in depth of fire; higher Pk
  - Engagement of targets not held by own sensors
  - Enables self defense systems to maximize performance against stressing targets
  - Earlier track formation resulting in increased time for combat system to react
  - Improved ability in jamming environments

Source: Cooperative Engagement Capability: A Sensor Netting Enabler Date: 9 January 2018

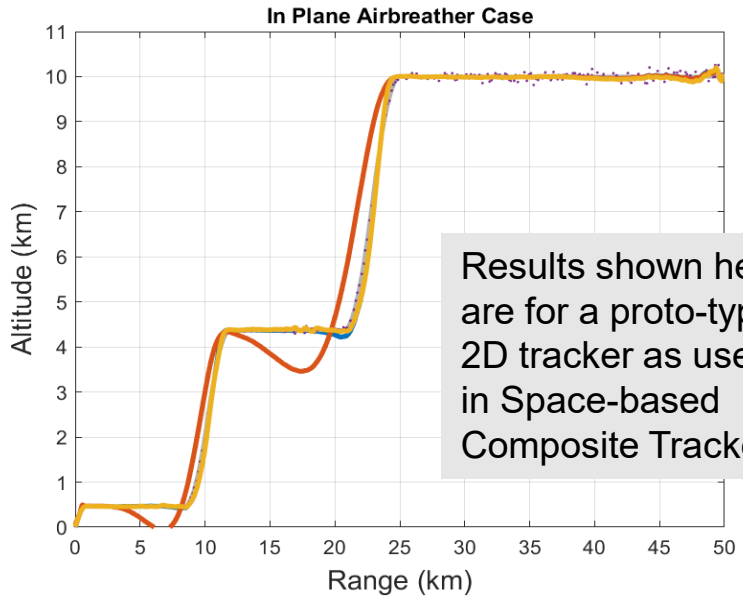
Time Division Pairwise Access (TDPA) Comms

- Real-time directional comms in support of sensor netting/fusion (composite tracking); platforms simultaneously send and receive messages in pairs to efficiently distribute measurements (and other C2 information) to all entities in a network
- The smallest time unit is a frame, in which a platform can only send or receive (or idle)
- Model estimates latencies based on frame duration portrayed in the final schedule
- *Additional detail available upon request*

Model Switching Filter (MSF) Tracking

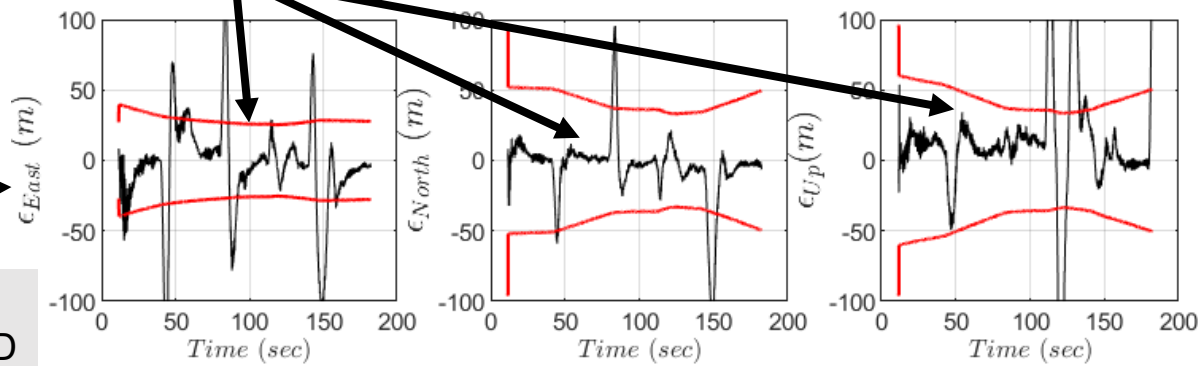
Composite Tracking improves Blue Force performance across ALL aspects of SIAP

- The MSF tracker is a composite tracker composed of several target motion models (e.g., cruising, climbing, diving)
  - Uses a quantitative metric to determine which motion model best aligns with the current track state
  - For ATacC2, the motion models used are **Port**, **Cruise**, **Starboard**, **Dive**, and **Climb**
- The purpose of these trackers is to provide blue forces in time compressed, high-density raids track estimates that are accurate enough to:
  - Maintains track continuity and Combat ID
  - Support Integrated Fire Control and other JIAMD capabilities



Results shown here are for a proto-type 2D tracker as used in Space-based Composite Tracker

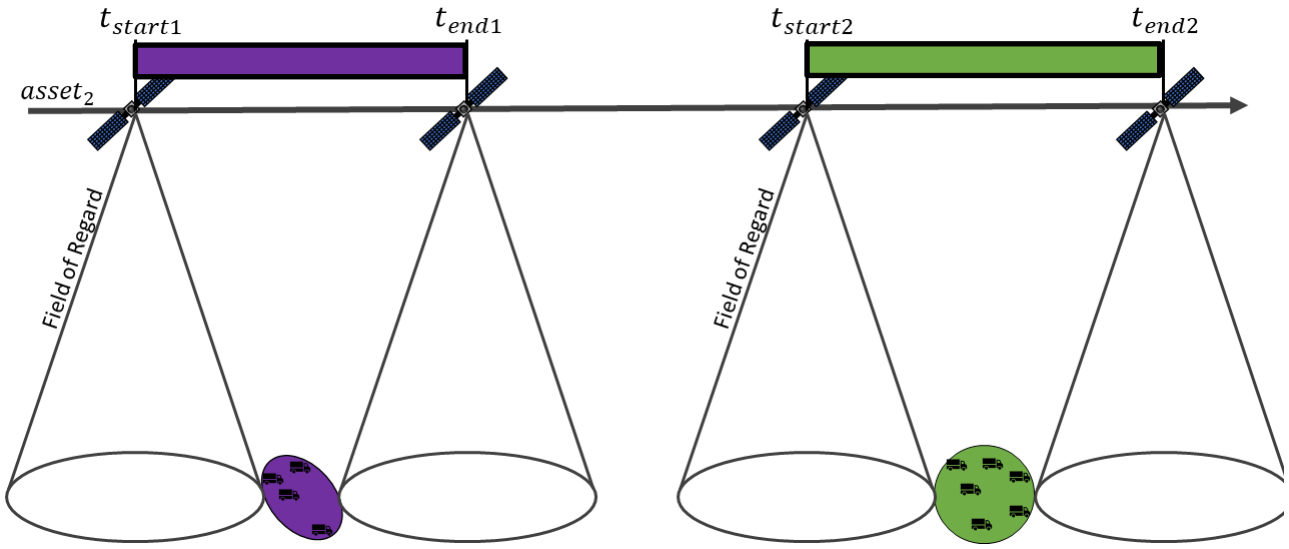
Average error demonstrates that remote engagements are feasible

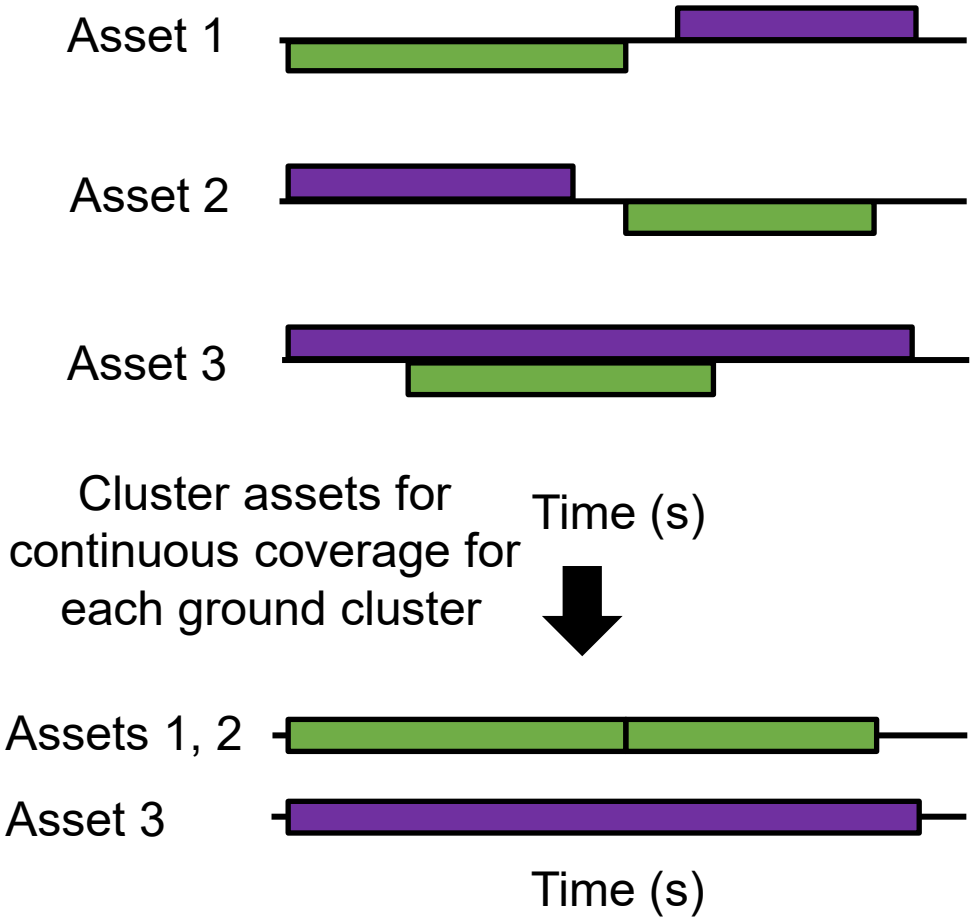


Results shown here are for a proto-type 3D tracker for ATacC2

Set Cover Problem C2 Tasking

- Spatially isolated ground target clusters hold different time windows for being in an ISR satellite's field of regard
- Clustering of assets for continuous coverage of ground threats requires additional consideration for multiple ground clusters

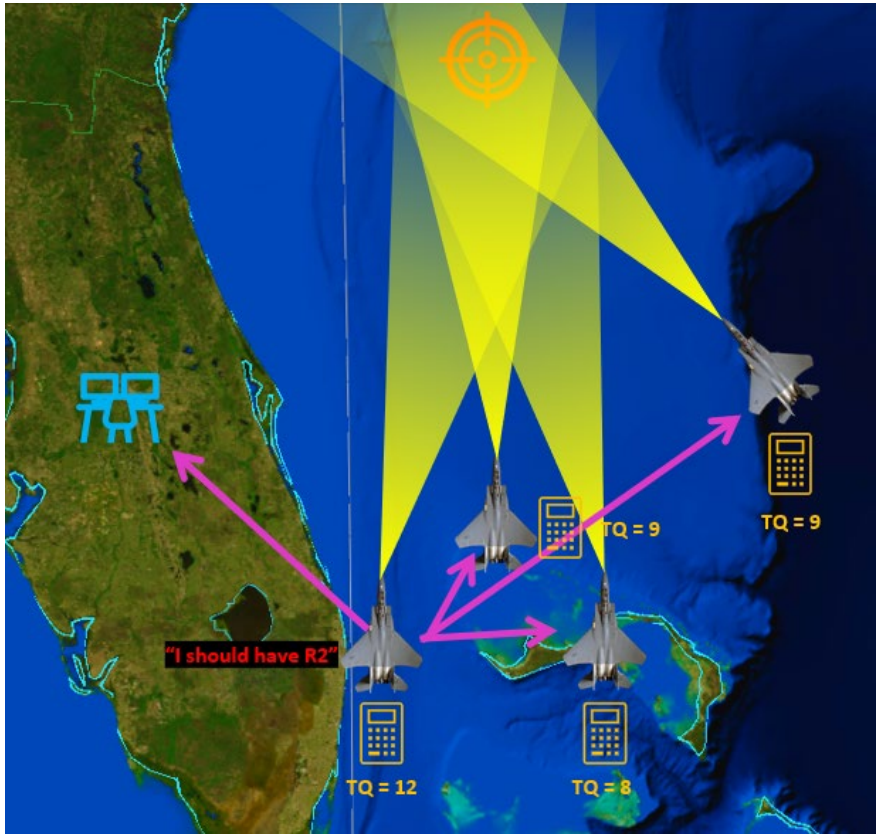




Communication Model Features

Features are developed as modular parts for drop-in integration with analysis scenarios

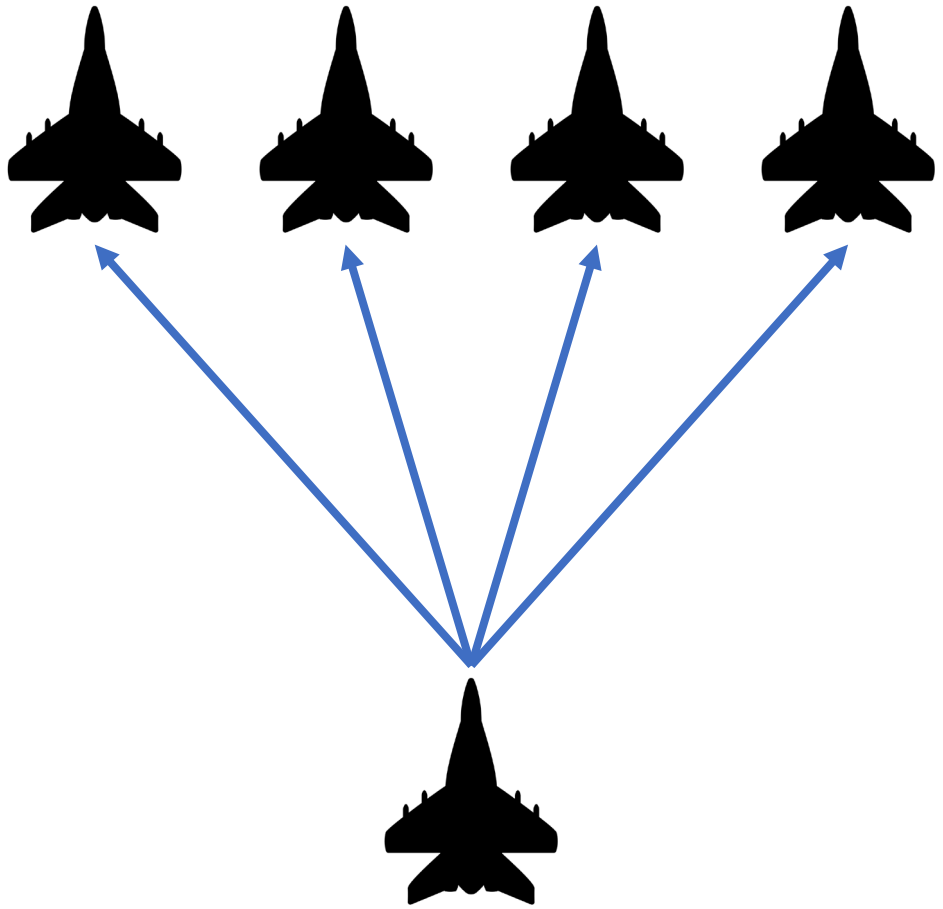
- Data Link Integration
  - Effects-based model of Time Division Multiple Access (TDMA)
- Cueing and Integrated Fire Control
  - Normal Acquisition using Single-Sensor Tracks
  - Limited Forward Pass and Remote Launch capabilities
- Track Quality (TQ) Processor
  - Calculated based on the Circular Area of Probability
- Reporting Responsibility (R2)
  - Including logic for track drops, platform timeouts, and multiple platforms sensing a single target



Example: Track Quality and R2

Time-Division Multiple Access (TDMA)

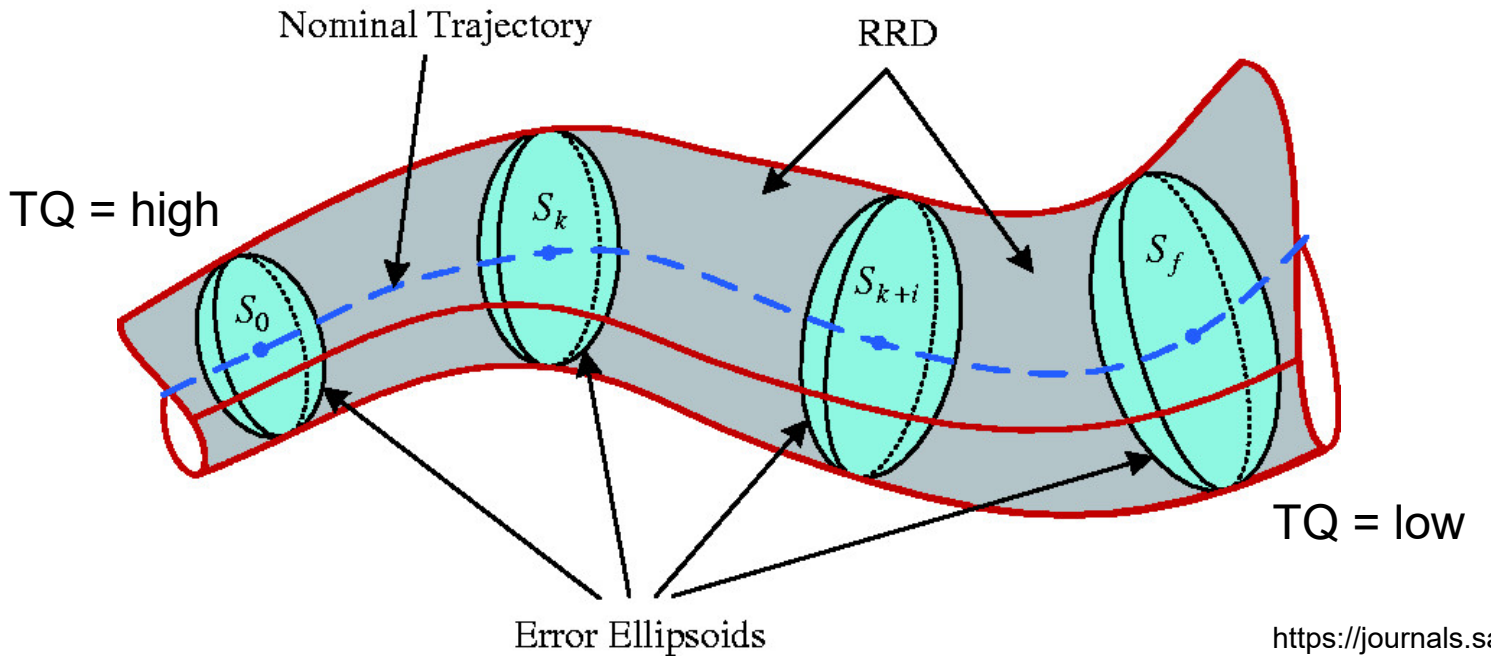
- TDMA allows for one platform to broadcast while other platforms listen
  - This creates a dynamic star network where the hub can shift based on the rules of Reporting Responsibility
  - There can be multiple hubs reporting different target tracks, but there can only be one hub per target
    - This is based on Track Quality and the rules of R2
- Multiple platforms can simultaneously have R2 for the same track until they share track information and adjudicate the conflict



Single-Sensor Track state error defined by Track Quality (TQ)

Track Quality is dynamically set based on the Circular Area of Probability

- Track Quality (TQ) is generated based on the Circular Area of Probability(CAP) function.

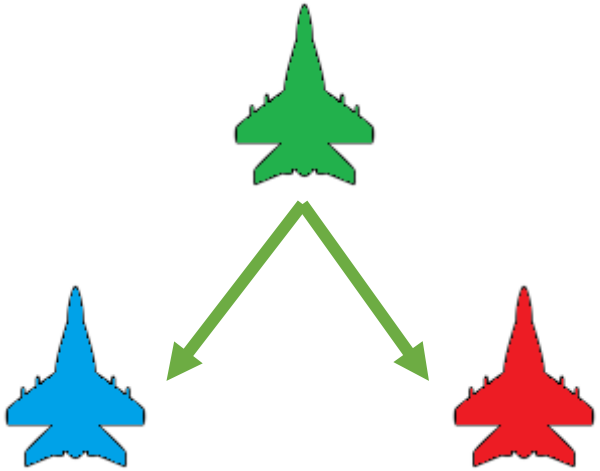


https://journals.sagepub.com/doi/10.1177/0954410018755259

Message Scheduling

Track Update Rates and R2 logic are modelled to allow for a more realistic network track picture

- Track Update Rates limit how often surveillance tracks can be sent to other units on the network
  - These vary based on Track Categories which are based on the mover type in this model
  - Reduces bandwidth requirements at the penalty of slower data sharing

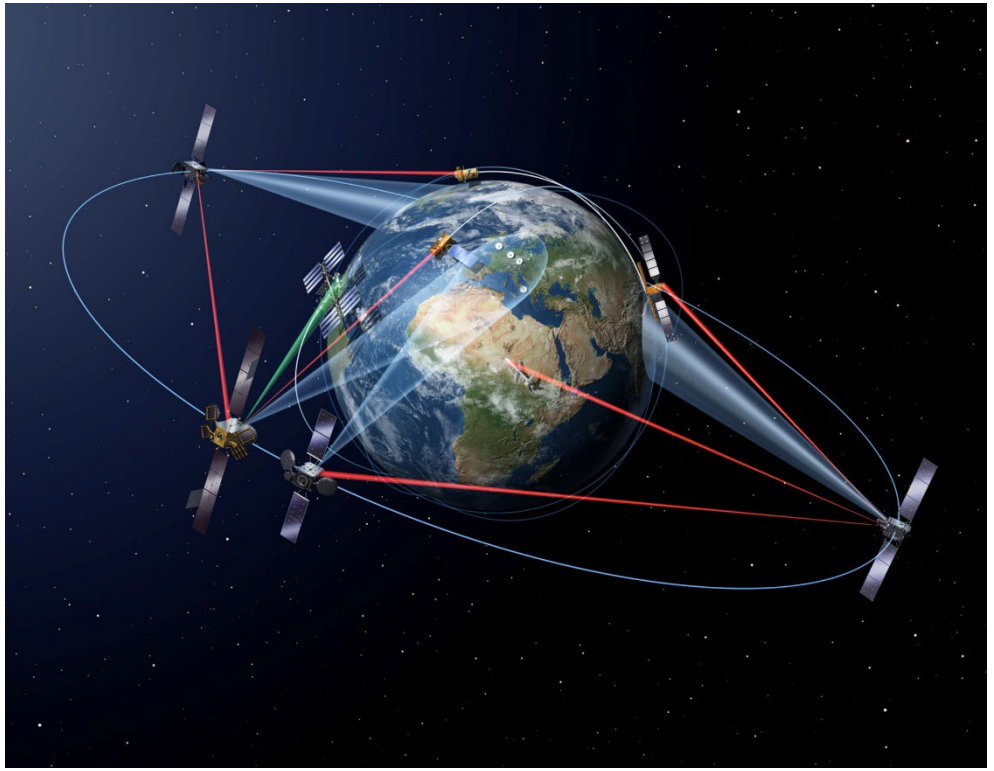


- Messages can be queued and transmitted to model time division multiplexed signal types.

Extended Range Comms

Message timing becomes a challenge at long ranges and for satellite up/downlinks. ATacC2 is developing additional models to support these use cases to include the following features:

- **Point to Point** – Each update cycle set closest commander as the reporting target
- **Broadcast** – Sends to all platforms that share a command chain
- **Space-based Sensor Networking/Composite Tracking over TDPA comms**
  - Every satellite checks if they are the closest to a ground station, and if so than they report
  - A satellite can report to more than one ground station, if they are the closest asset to both



Conclusion

- Breaking away from perfect sensor, C2 and communication networks adds important fidelity to kill chains and system-of-systems behaviors.
- Provide more realistic baseline Joint IAMD capabilities
- Provide more realistic advanced Joint IAMD capabilities
- Analyst gain the ability to understand how new or existing platforms and react to more dynamic/complex C2 and communication networks.

Questions?

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