CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)

Communications, Navigation, Surveillance and Avionics within a 2020 Future Vision

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CAASD

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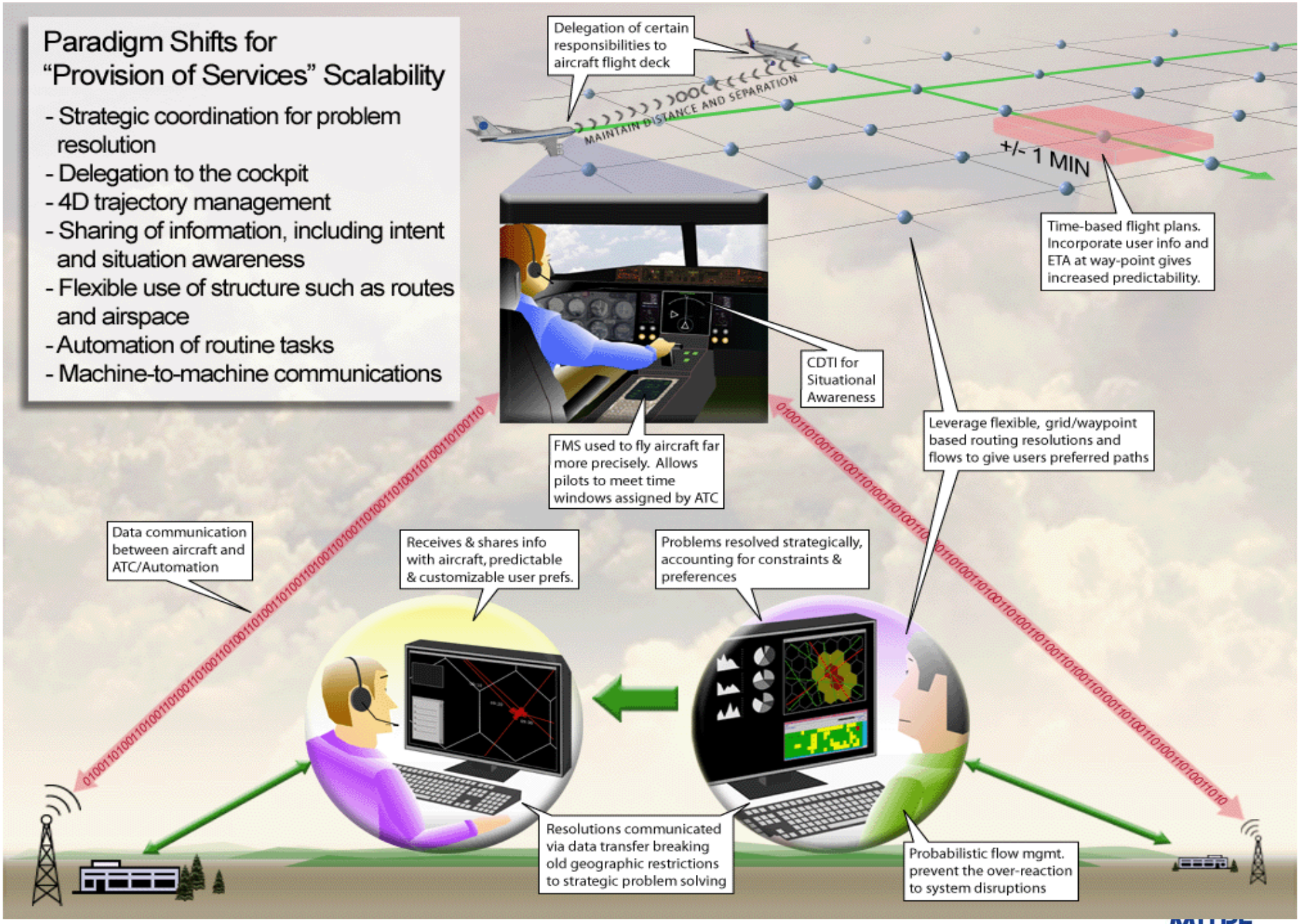

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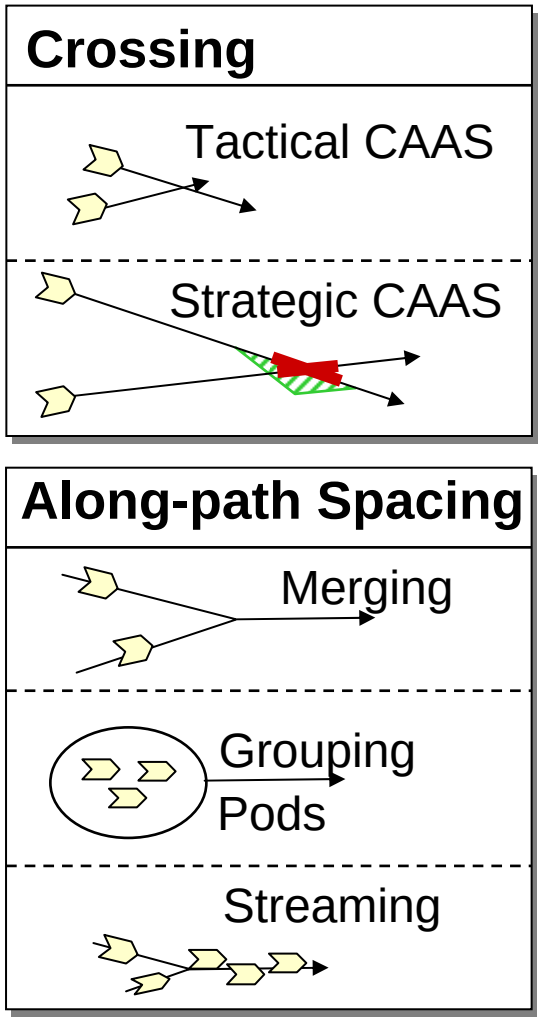
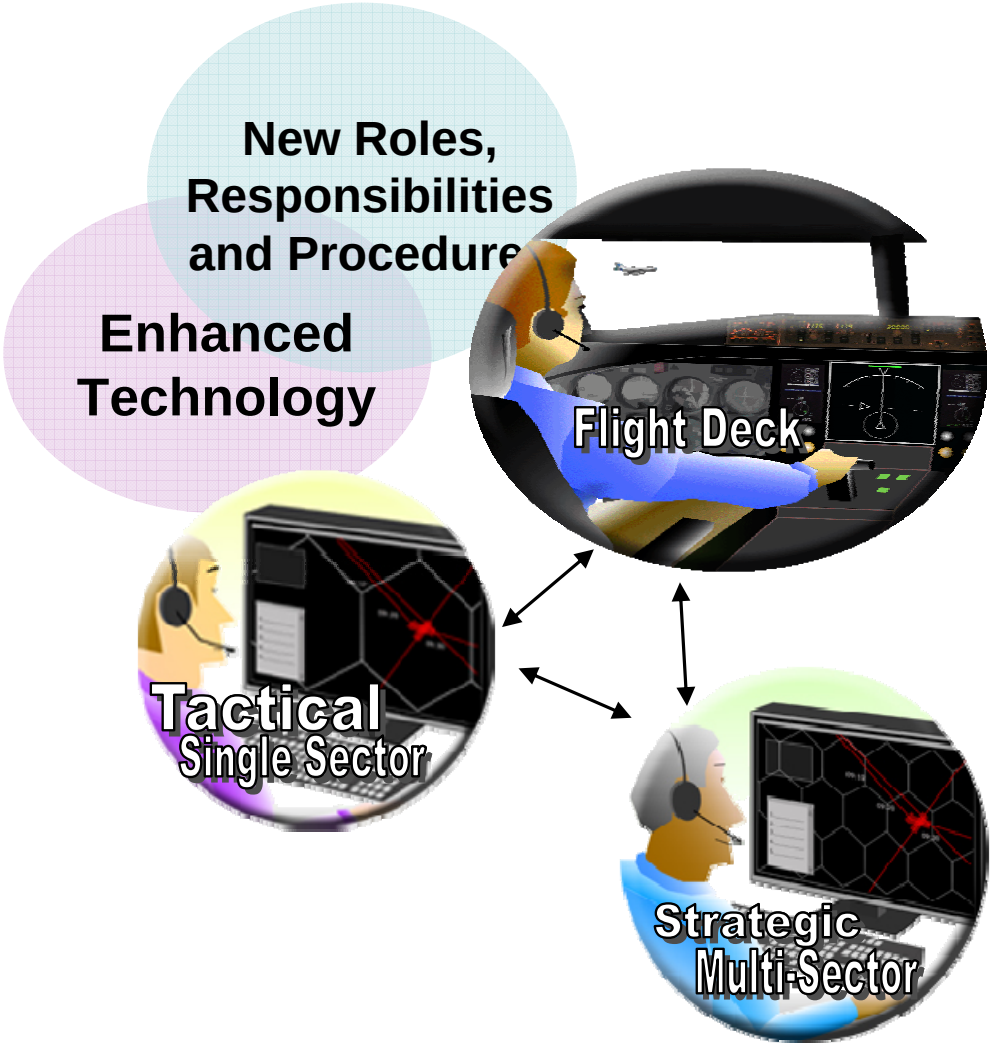
Shared Separation Authority

How do the ground and air interact in the future NAS?





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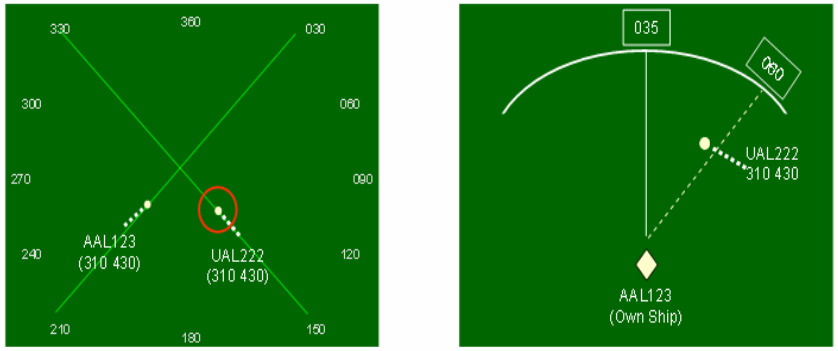
Shared Separation and Delegation

Provide alternative methods for spacing and separation

Delegate to the cockpit when and where appropriate!



Controller Display Cockpit Display

- **Responsibility for separation, and spacing can be delegated to the cockpit by ATC on a situational basis, for limited durations, to mitigate controller workload and improve efficiency of operations.**
  1. Pair-wise crossing separation
  2. Merging and spacing operations
  3. Limited streaming and grouping
- **Minimum separation standards for delegated maneuvers are smaller due to the closed loop control and response time capability of the pilot**
- **Maneuvers types are procedurally predefined**
  - **Stakeholders know what to expect**
  - **Flexibility remains for the pilot to achieve maneuver goals**
  - **Uncertainty is NOT added to the system**

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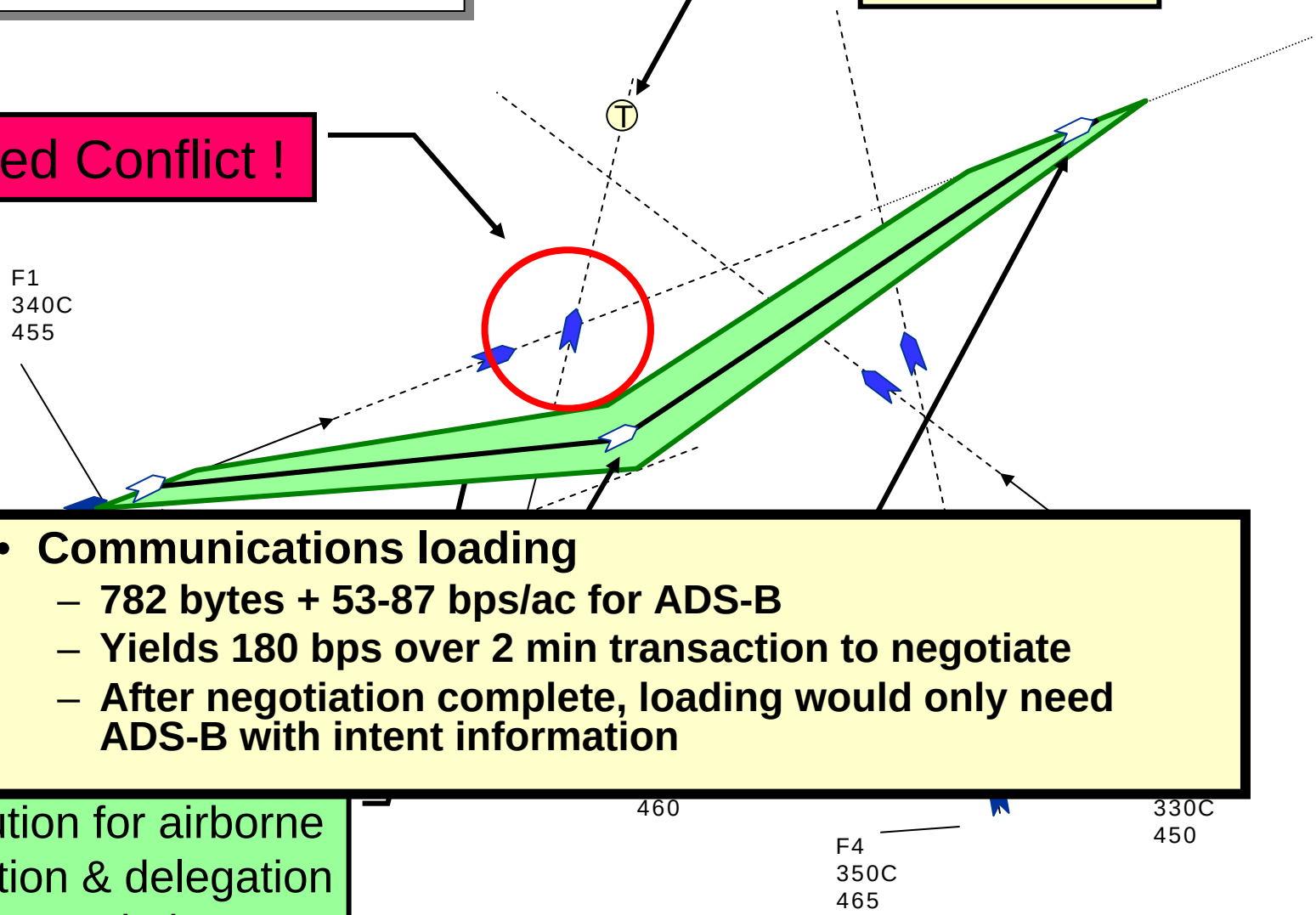
Pair-wise Crossing

4D time constraint

Projected Conflict !



Aircraft appro proce

- **Communications loading**
  - **782 bytes + 53-87 bps/ac for ADS-B**
  - **Yields 180 bps over 2 min transaction to negotiate**
  - **After negotiation complete, loading would only need ADS-B with intent information**

Resolution for airborne separation & delegation to cockpit

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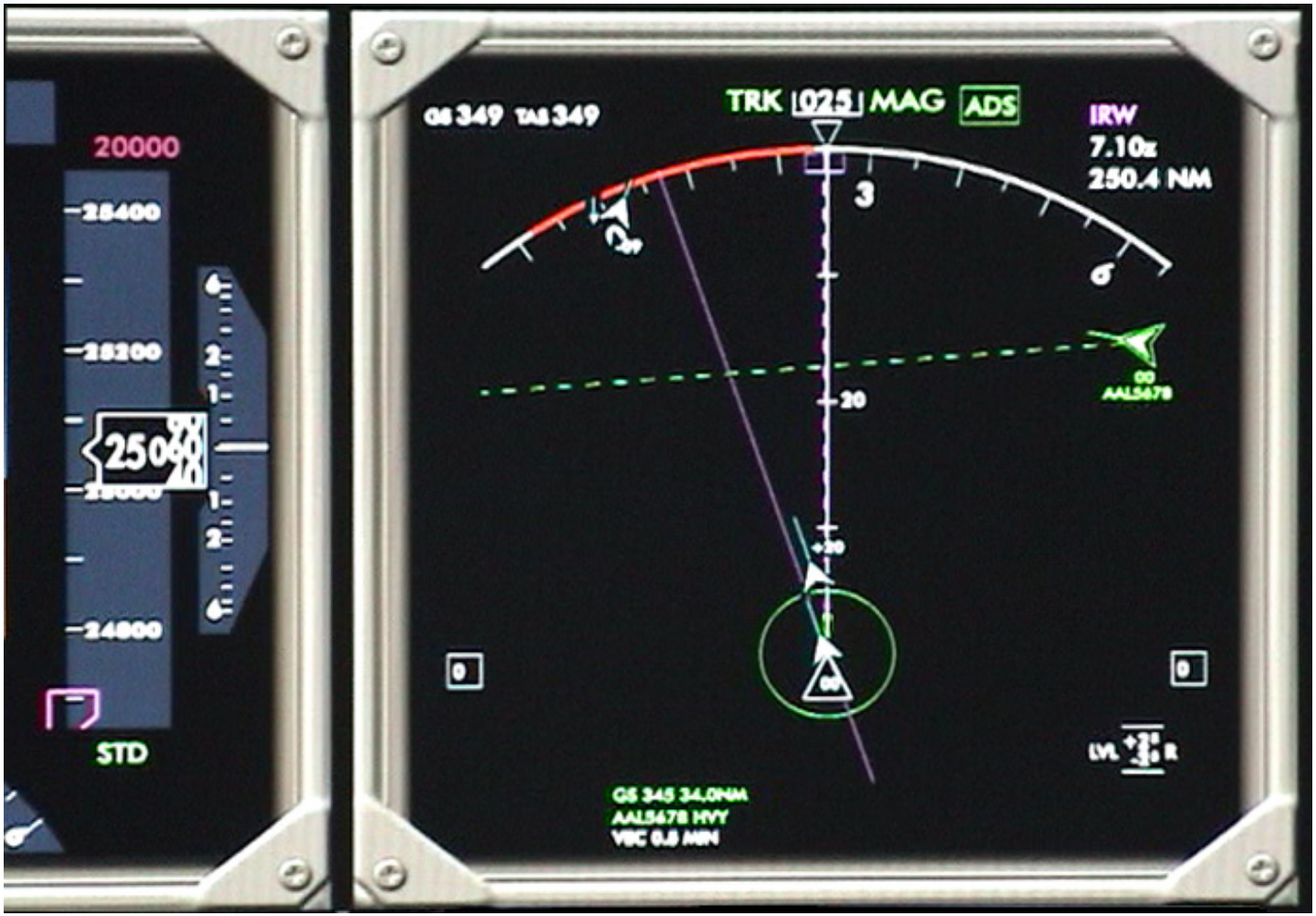
Pair-wise Crossing – Cockpit View



As soon as the target aircraft is in range, the 'turn bug' and the MSP (maneuver start point) appears. At that point the pilot confirms the clearance via data link, and the beige line connecting the two aircraft on the controller display turns from beige to green.

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Pair-wise Crossing – CNS Impacts

- Data communications & RNAV capability required
  - New message needed
- Graphical Display integrated with aircraft automation
- Aircraft automation system needs to interface with FMS and CMU
  - Compute recommended maneuver
  - Conformance monitoring
- ADS-B system capable of transmitting intent information
  - Class A3 equipment
- Existing TCAS equipment provides safety net

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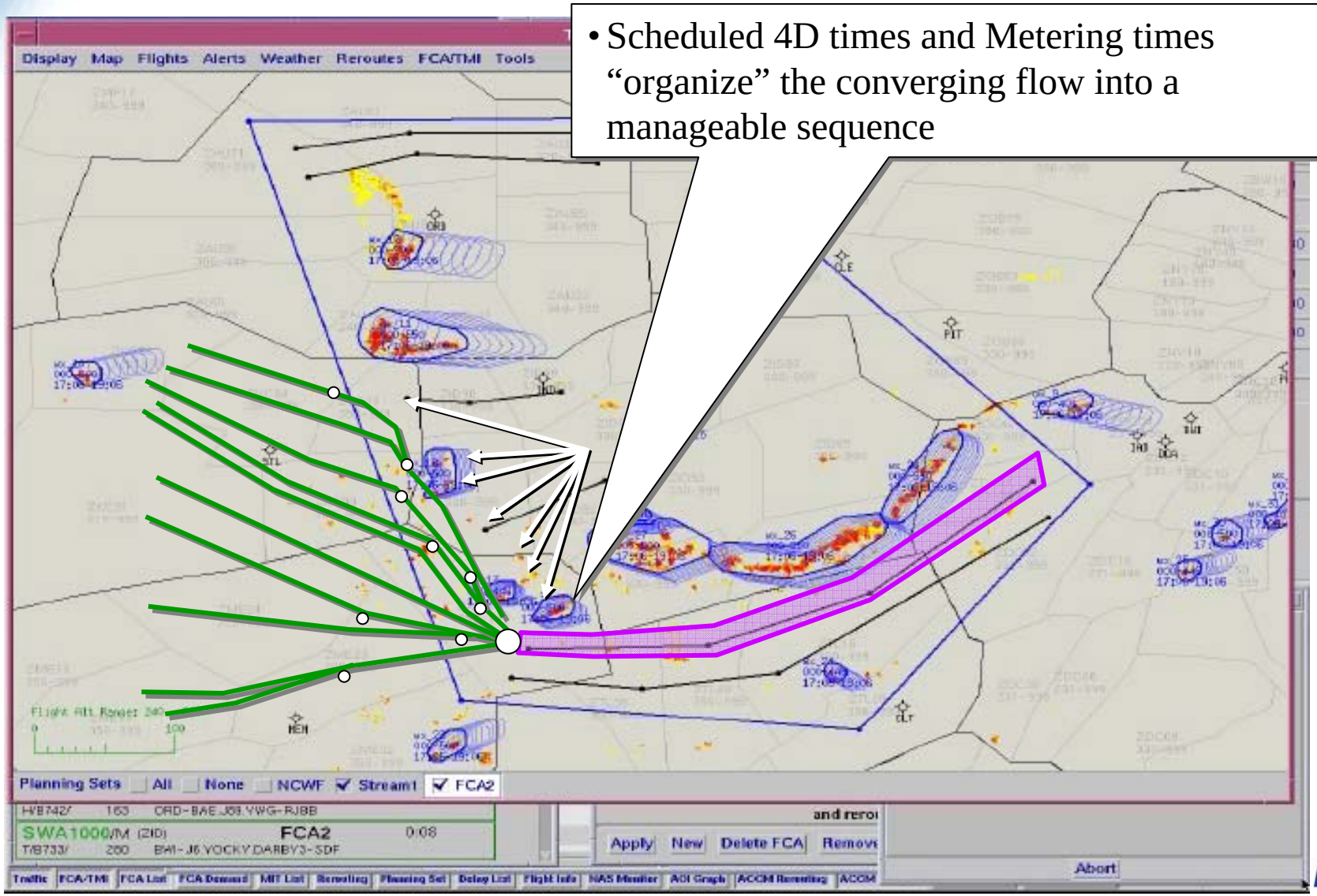
Sequencing & Merging

- Scheduled 4D times and Metering times "organize" the converging flow into a manageable sequence



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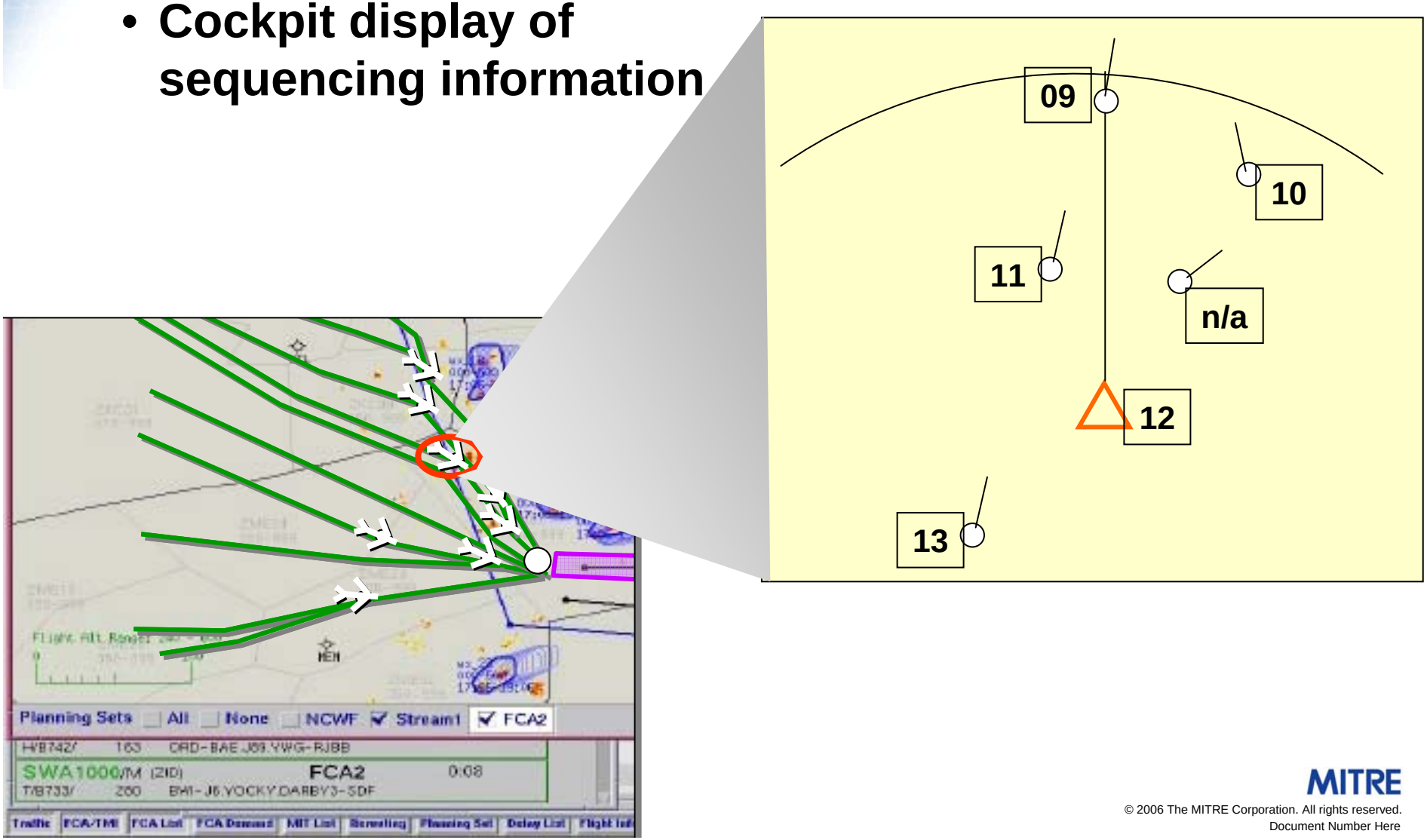
Sequencing & Merging – Cockpit View concept

- **Cockpit display of sequencing information**



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Sequencing & Merging – Broadcast vs. Addressed

- **Communications loading**
  - **10 aircraft merge assuming 5 waypoints on merge path**
  - **Addressed**
    - **3500 bytes + 53-87 bps/ac for ADS-B**
    - **Over 2 min negotiation, averages 1101 bps (233 bps non-ADS-B)**
  - **Broadcast**
    - **2172 bytes + 53-87 bps/ac for ADS-B**
    - **Over 2 min negotiation, averages 1013 bps (145 bps non-ADS-B)**
- **Broadcast preferable due to lower bandwidth utilization & less channel occupancy**
  - **Service Volume engineering should ensure reliability of broadcast messaging**

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Sequencing & Merging – CNS Impacts

- Data communications & RNAV capability required
  - New message required
- Graphical display integrated with aircraft automation
- Aircraft automation system needs to interface with FMS and CMU
  - Compute desired route to meet RTA at merge point
  - Conformance monitoring
- ADS-B system capable of transmitting intent information
  - Class A3 equipment
- Existing TCAS equipment provides safety net

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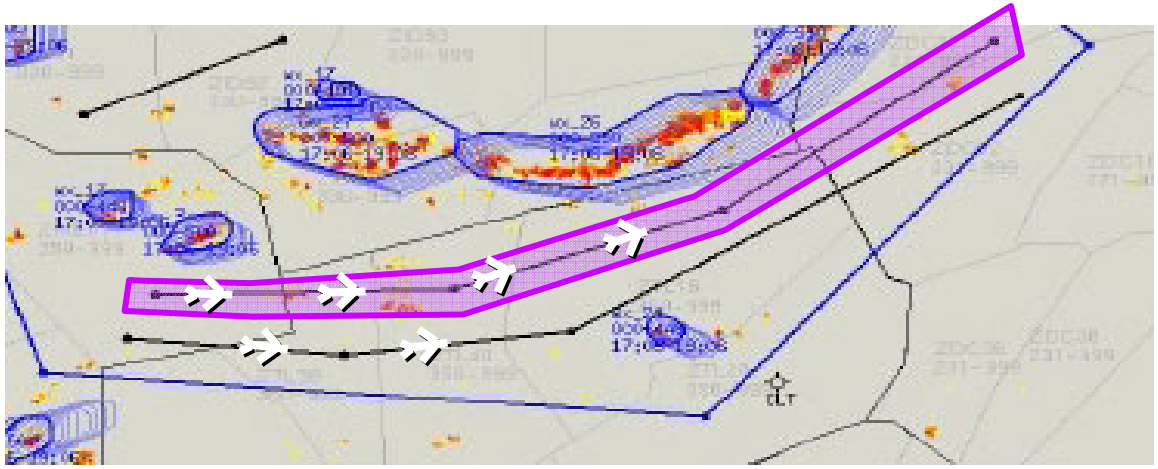
Grouping / Streaming

- **Initiates with a Sequence & Merge operation**
- **Aircraft are tightly packed into a traffic flow and provide station-keeping**
  - **Frees controller to handle non-participating aircraft**
- **Will likely require a coordination channel and possibly a bail-out area/altitude in case of equipment outage**



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Grouping/Streaming – CNS Impacts

- RNAV capability required
- Graphical display integrated with aircraft automation
- Aircraft automation system needs to interface with FMS and CMU
  - Conformance monitoring
- ADS-B system capable of transmitting intent information
  - Class A3 equipment
  - Separation standard may affect update rate
- Existing TCAS equipment provides safety net
- Ground surveillance sensors need to be networked and surveillance data must be 'fused' to support dynamic airspace

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Summary

- **Identified existing technologies and system options that need to be fielded to support concepts**
  - **New data communications messages will be required**
  - **Additional bandwidth demand is low**
  - **Intent information needed for ADS-B**
  - **Graphical cockpit display needed for situational awareness**
  - **Broadcast distribution of Sequencing information is more efficient than addressed**
  - **Coordination channel needed for Grouping/Streaming**
  - **Need RNP 0.3 navigation capability capable of operating during GPS outage**

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Backup Slides

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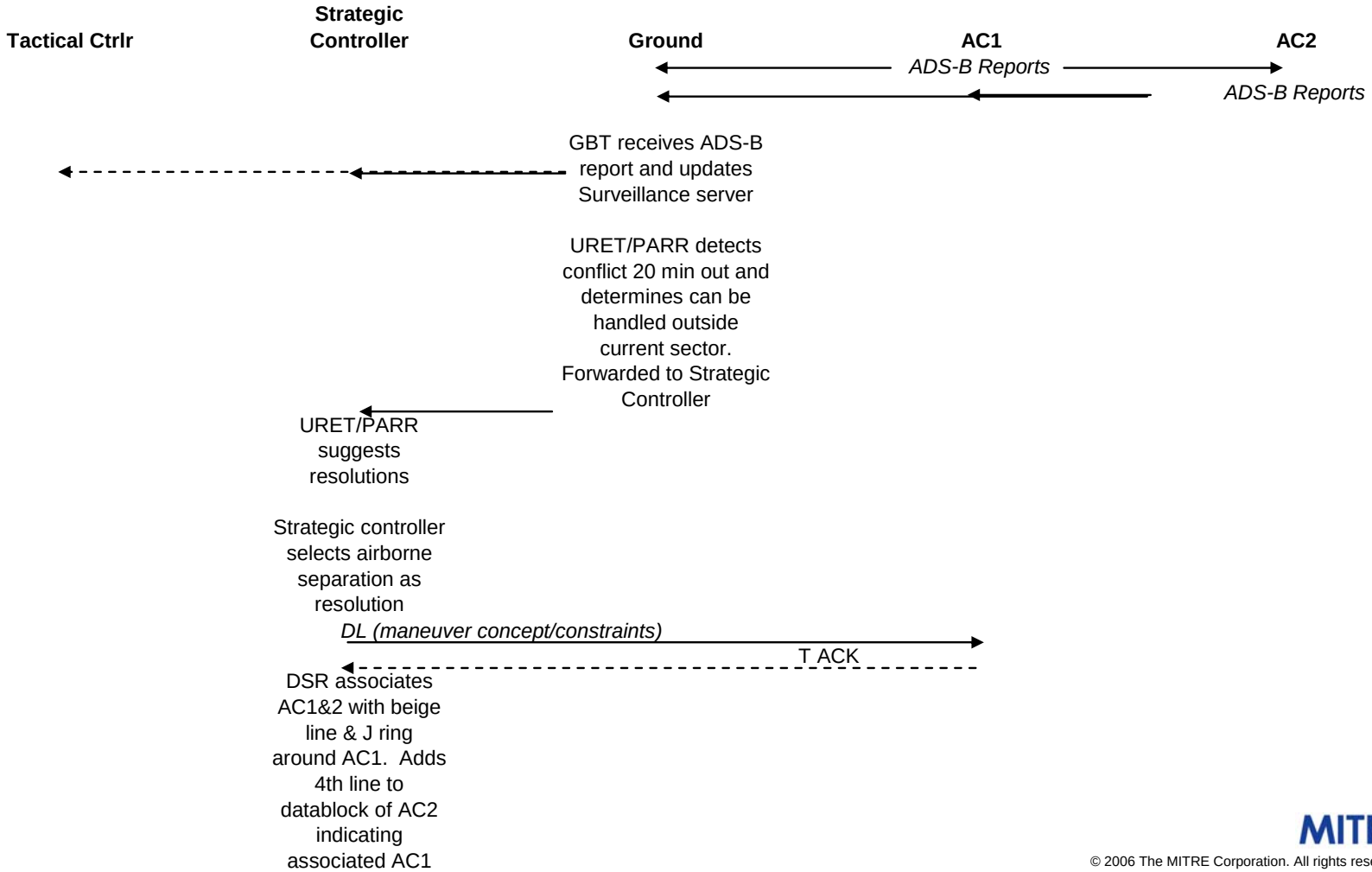
Pair-wise Crossing – Message Sequence

- **Relatively light comm load**
  - **~782 bytes + 53-87 bps/ac for ADS-B**



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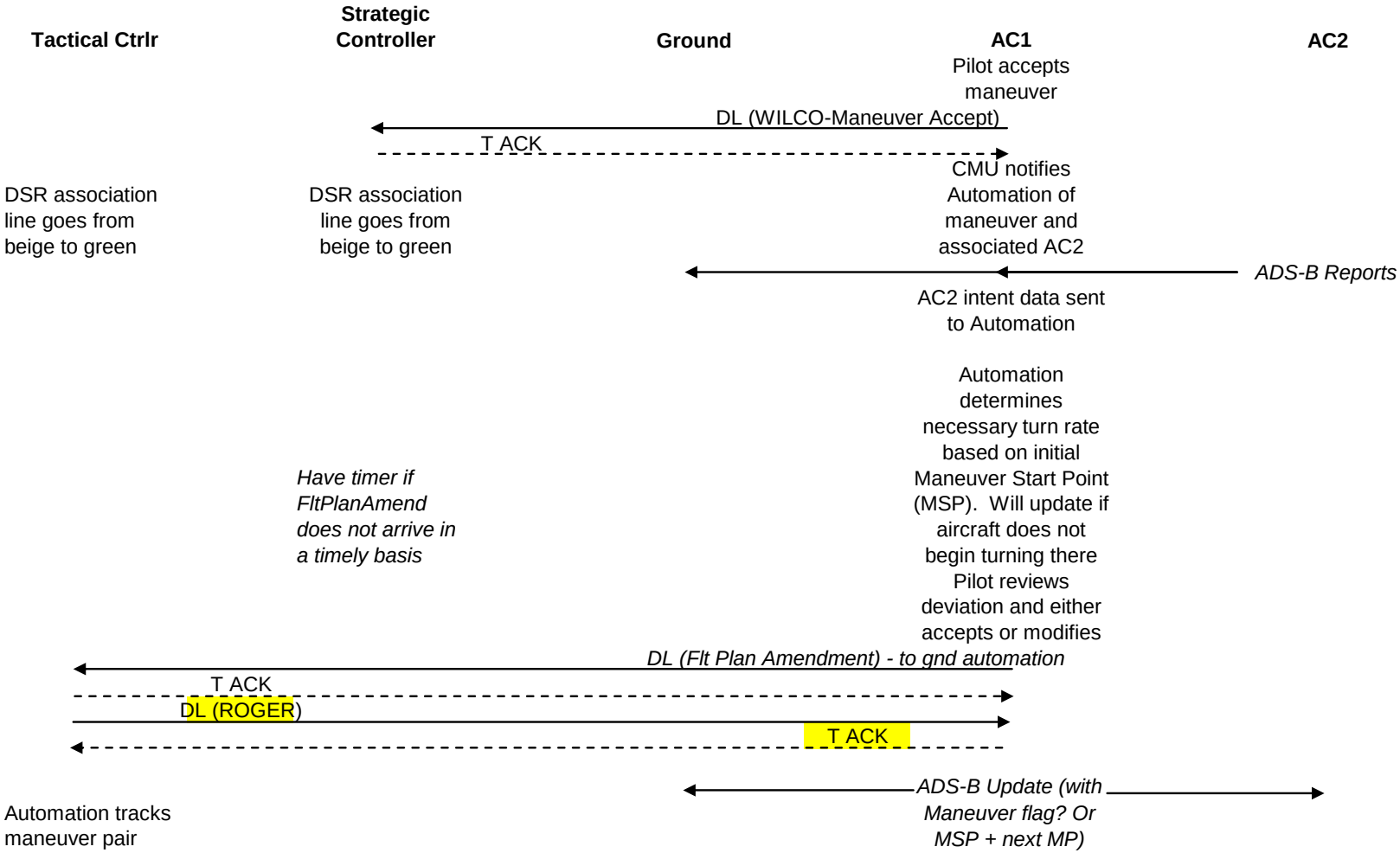
Pair-wise Crossing – Message Sequence (cont'd)



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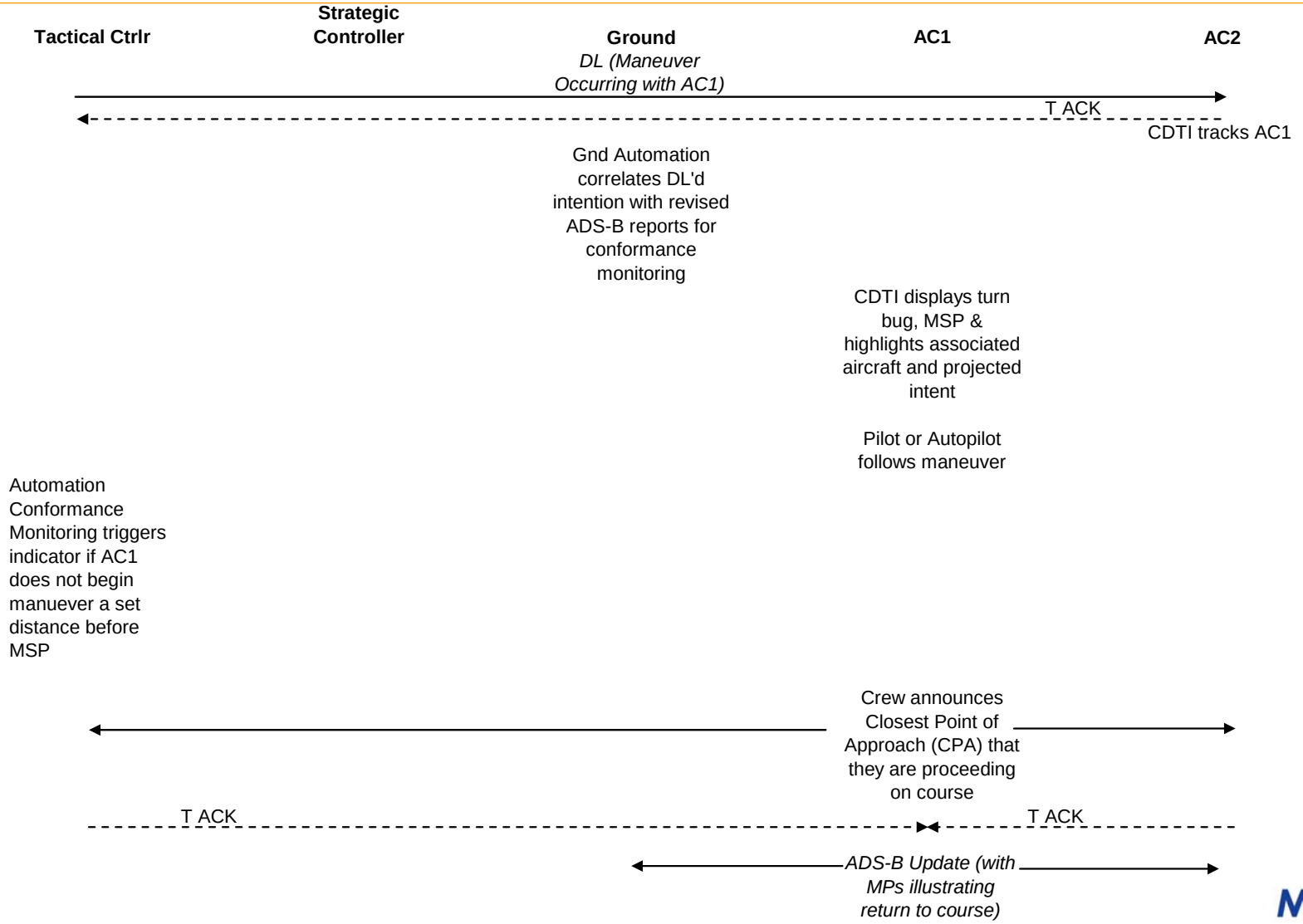

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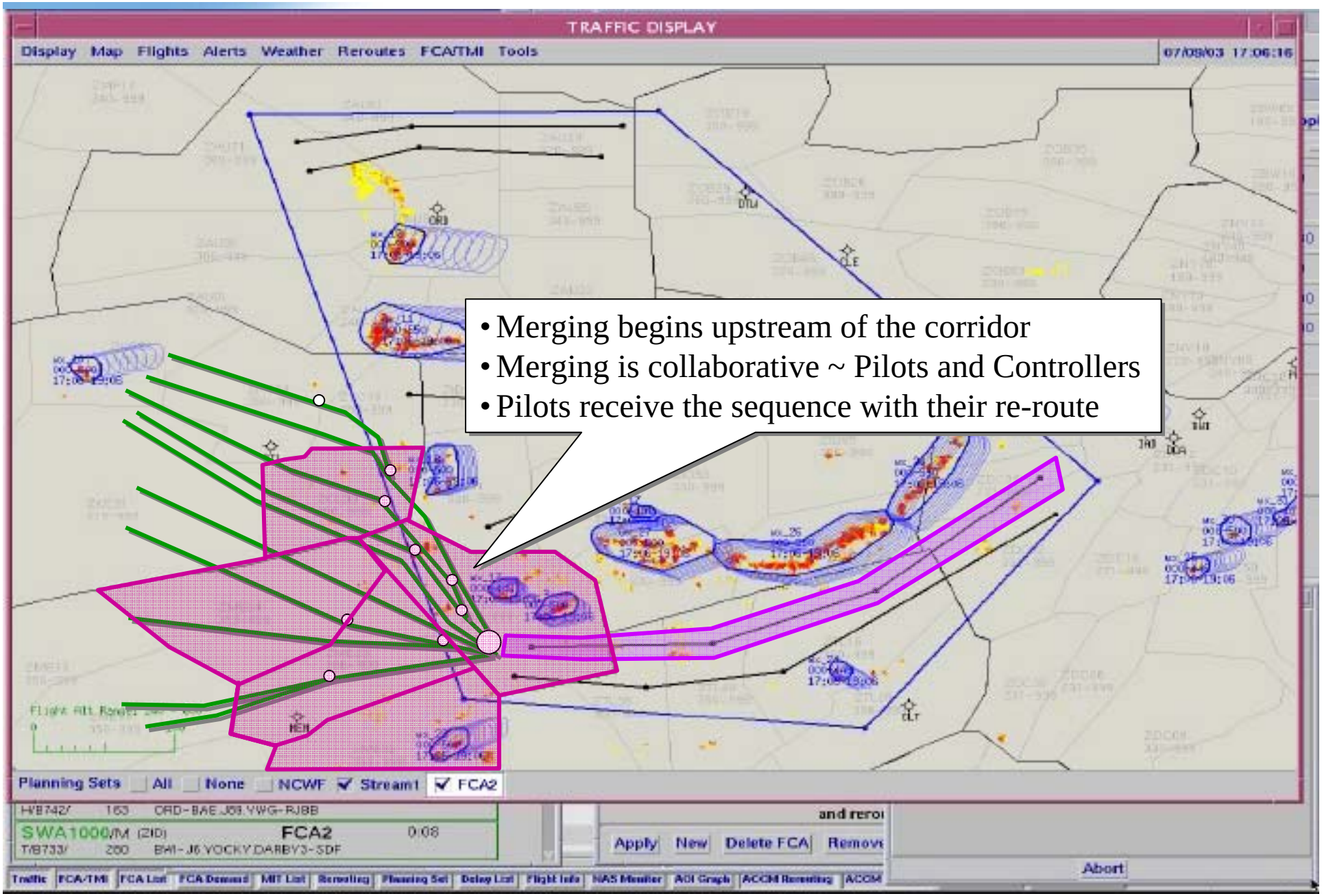

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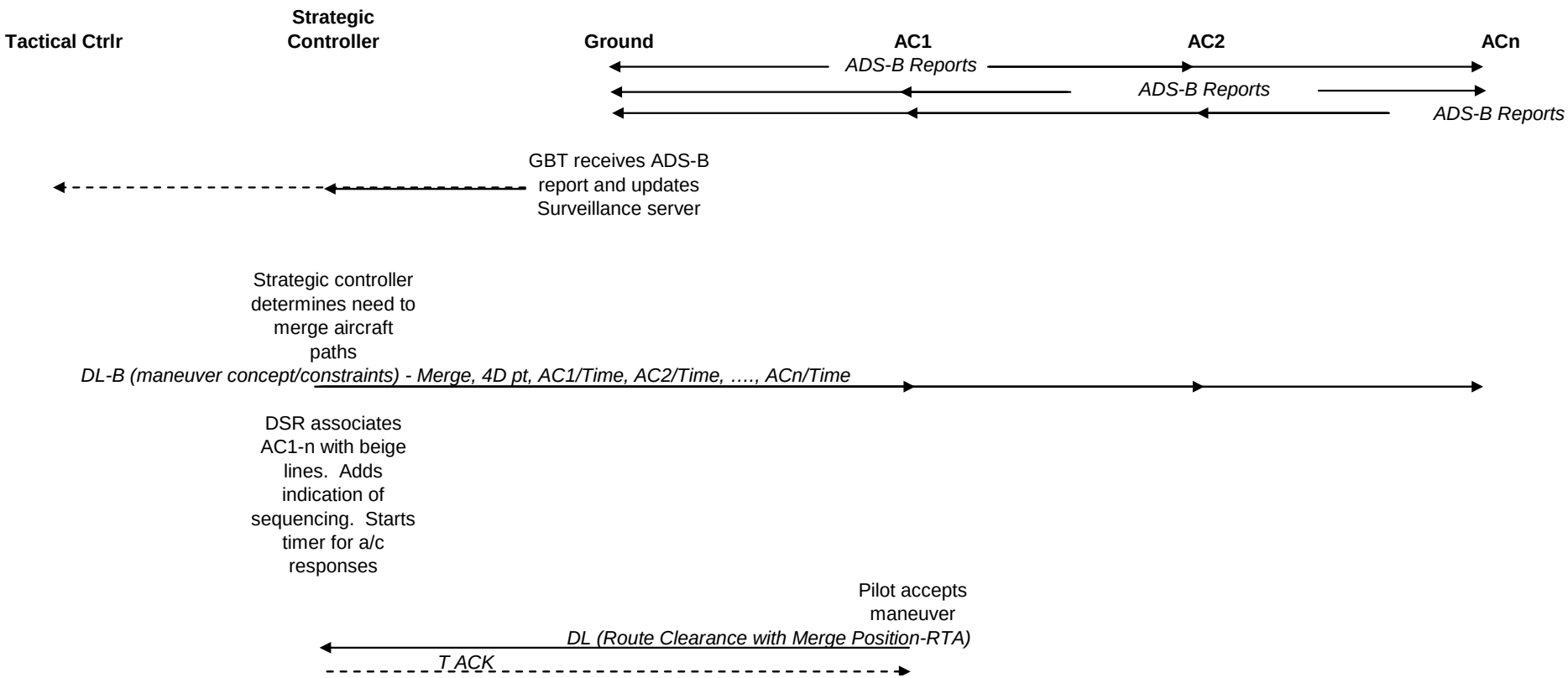
Sequencing & Merging – Message Sequence

- **Light to moderate comm load**
  - **10 ac merge assuming 5 pts on merge path**
  - **2172 bytes + 53-87 bps/ac for ADS-B**



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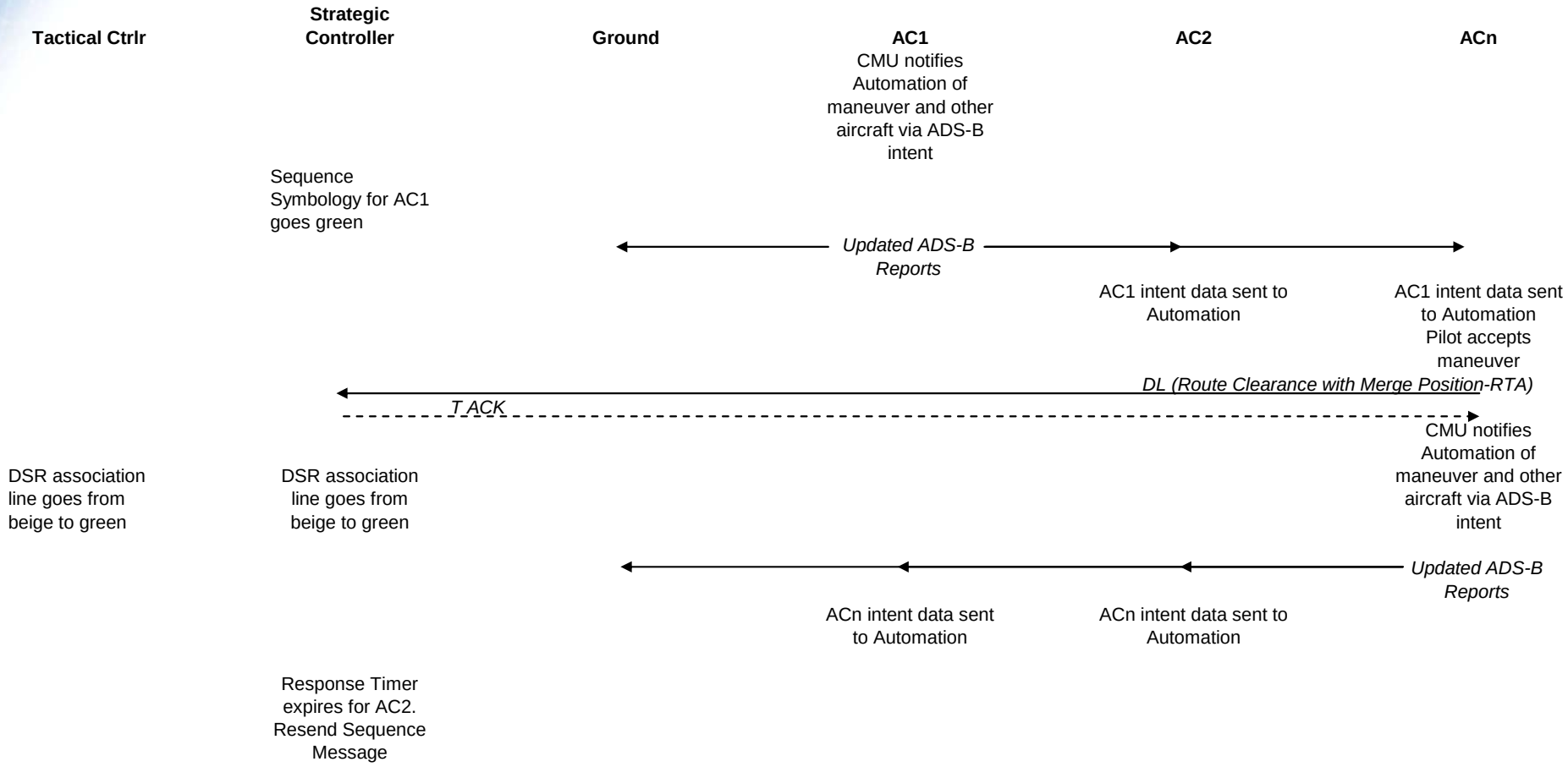
Sequencing & Merging – Message Sequence (cont'd)



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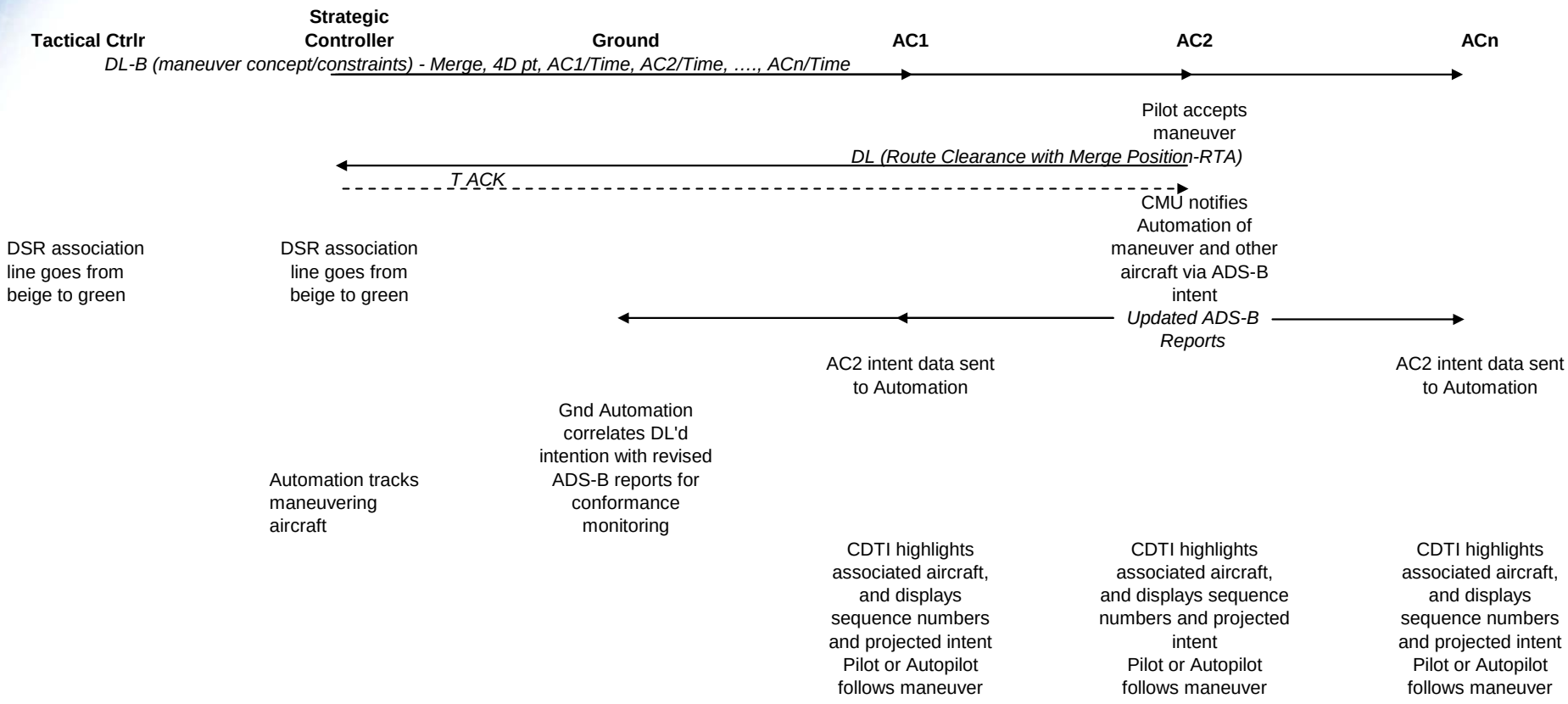

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