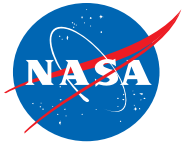
National Aeronautics and Space Administration



ACES Modifications to Support NextGen Studies at NASA Langley Research Center

Jeremy C. Smith

NASA Langley Research Center

Innovations in NAS-Wide Simulation

George Mason University, VA

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ACES Modifications to Support NextGen Studies at NASA Langley Research Center

- Airborne Merging and Spacing (M&S) for Terminal Arrivals (AMSTAR)
- Traffic Flow Management (TFM) and Tactical Conflict Detection and Resolution (CD&R) using *Integrating System for Independently-developed Software* (ISIS)
- Integration of Airborne Separation Assistance System (ASAS) Components and M&S

Acknowledgments

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Metron Aviation, Inc., 131 Elden Street, Suite 200, Herndon, VA 20170
Terry Thompson ,Jason Burke, John DiFelici, Robert Hoffman, Laurel Stell

POCs for algorithm development

- AMSTAR - Bryan Barmore, NASA Langley
  - Airborne Merging and Spacing for Terminal Arrivals (AMSTAR), a.k.a. Airborne Spacing for Terminal Arrival Routes (ASTAR) The Airborne Spacing for Terminal Arrival Routes (ASTAR) algorithm

- C2 – Terry Thompson, Metron
  - Command and Control Traffic Flow Management

- TSAFE – Heinz Erzberger, Karen Heere, U.C. Santa Cruz
  - Tactical Separation Assured Flight Environment

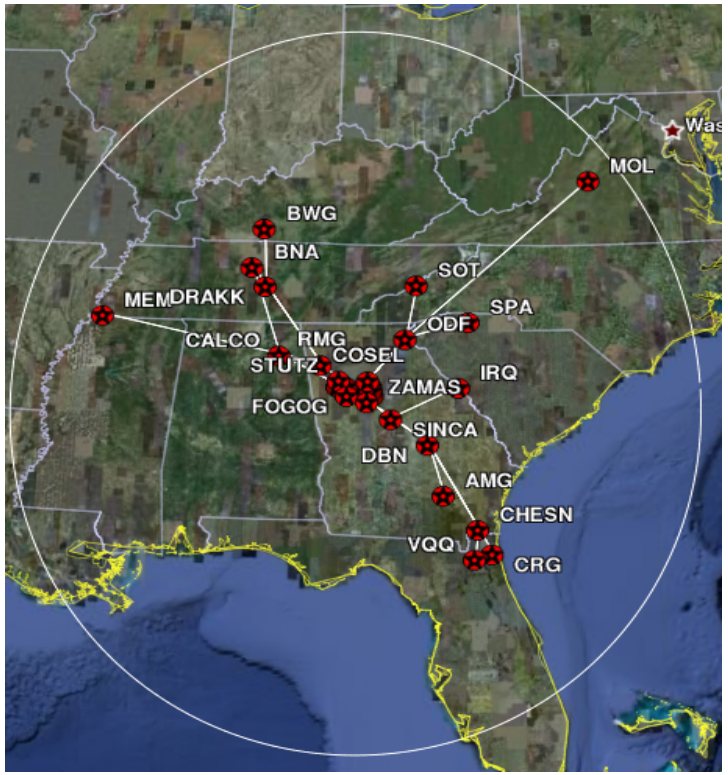
- ACCoRD , CPS, StratWay – Cesar Munoz, Ricky Butler, Jeff Maddalon, NASA Langley
  - Airborne Coordinated Conflict Resolution and Detection
  - Conflict Prevention System a.k.a. "Bands" algorithm
  - Strategic Waypoint adjustment program for conflict detection and resolution

Airborne Merging and Spacing

- ACES Modifications Developed by IAI (SBIR II, completed 11/2009)
- Based on NASA Langley Airborne Merging and Spacing for Terminal Arrivals (AMSTAR) algorithm.
- Development of a Simulation Test-bed for (M&S) within ACES
    1. Develop ground-based scheduler for sequencing and spacing
    2. Enhance the fidelity of the 4-D trajectory model implemented for flight dynamics in the terminal area (Kinetic Trajectory Generator, KTG)
    3. Implement the flight-deck component that executes merging and spacing (AMSTAR)

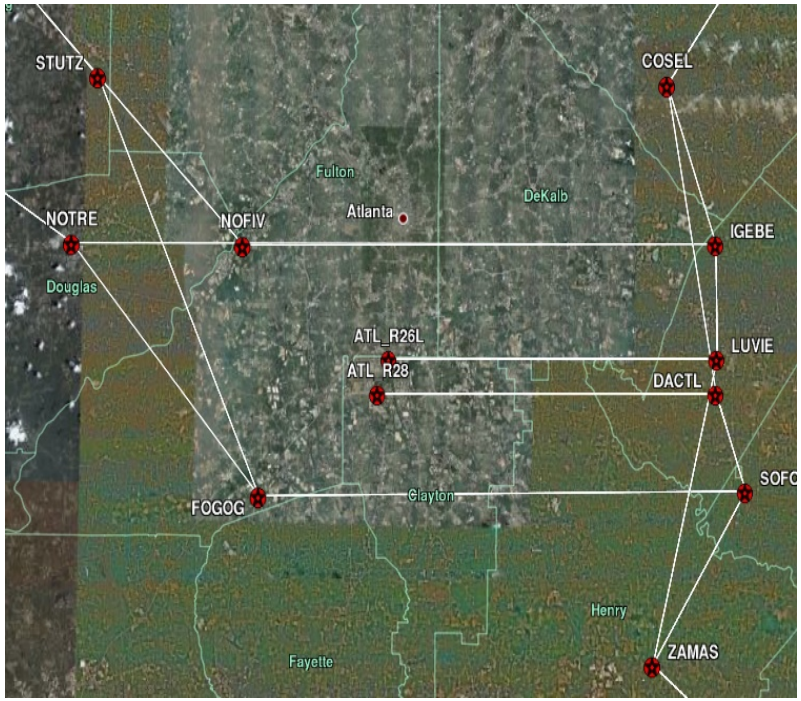
Airborne Merging and Spacing

- Region of Control for Arrivals – scheduler is contacted by aircraft at boundary
- Routes start some distance within boundary
- Configuration Options:
  - Circular region of control with a configurable radius
  - Any number of airports can be configured within region



Airborne Merging and Spacing

- Routes can be STARs, or any user defined route, series of waypoints with final waypoint at runway threshold
- Scheduler generates route that is conflict free at each waypoint by system of reservations
- M&S instructions are communicated to aircraft for the waypoints on the route:
  - Waypoint and required time-of-arrival (RTA)
  - Waypoint and spacing instruction (time spacing following another aircraft)



Airborne Merging and Spacing

- Aircraft Executes instructions using AMSTAR to control speed:
  - Lead aircraft has RTA at merge points and/or runway threshold
  - Follower maintains required time spacing
- Aircraft broadcast ETA to their next waypoint
- Aircraft monitor the ETA broadcasts of any leading aircraft

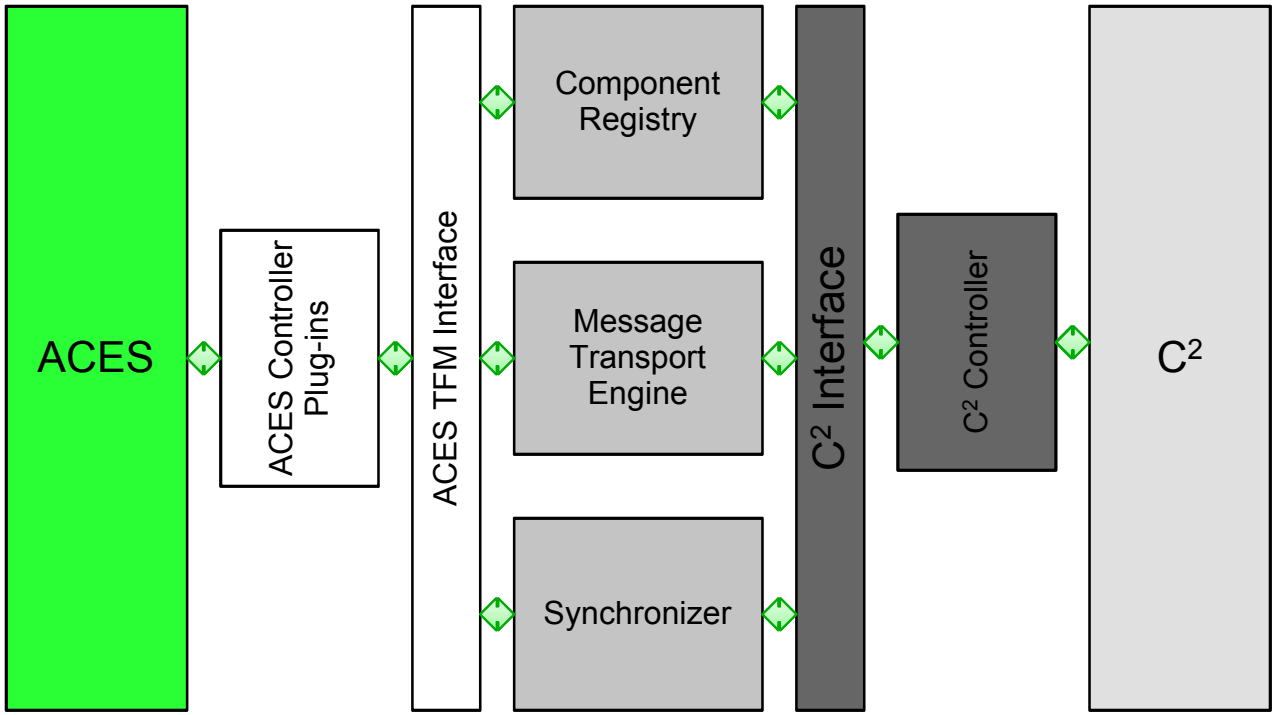
TFM and CD&R using ISIS

- ACES Modifications Developed by OSI (prime) and IAI (NRA, completed 08/2009)
- Develop a general software interface system that can be used to link a wide variety of software components
  1) TFM software, e.g. Command-and-Control (C2) developed by Metron (SBIR II, completed 12/2005)
  2) Tactical CD&R - State-based conflict detection and resolution algorithms
     - Airborne Coordinated Conflict Resolution and Detection (ACCoRD)

       (has formal specifications and proofs)

     - Tactical Separation Assured Flight Environment (TSAFE)

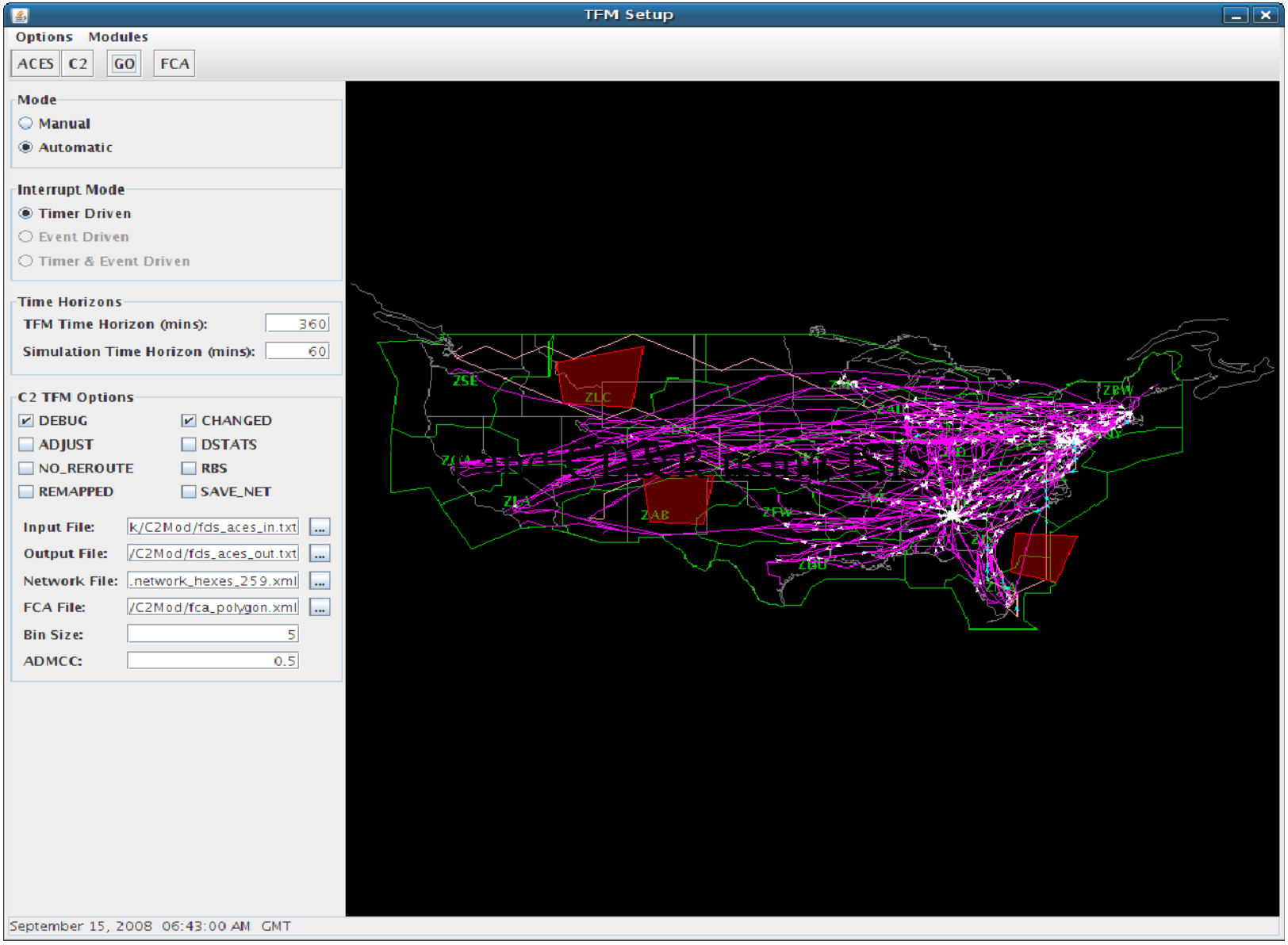
TFM and CD&R using ISIS



Message Transport

- Java RMI
- XML over HTTP (Tomcat web server)

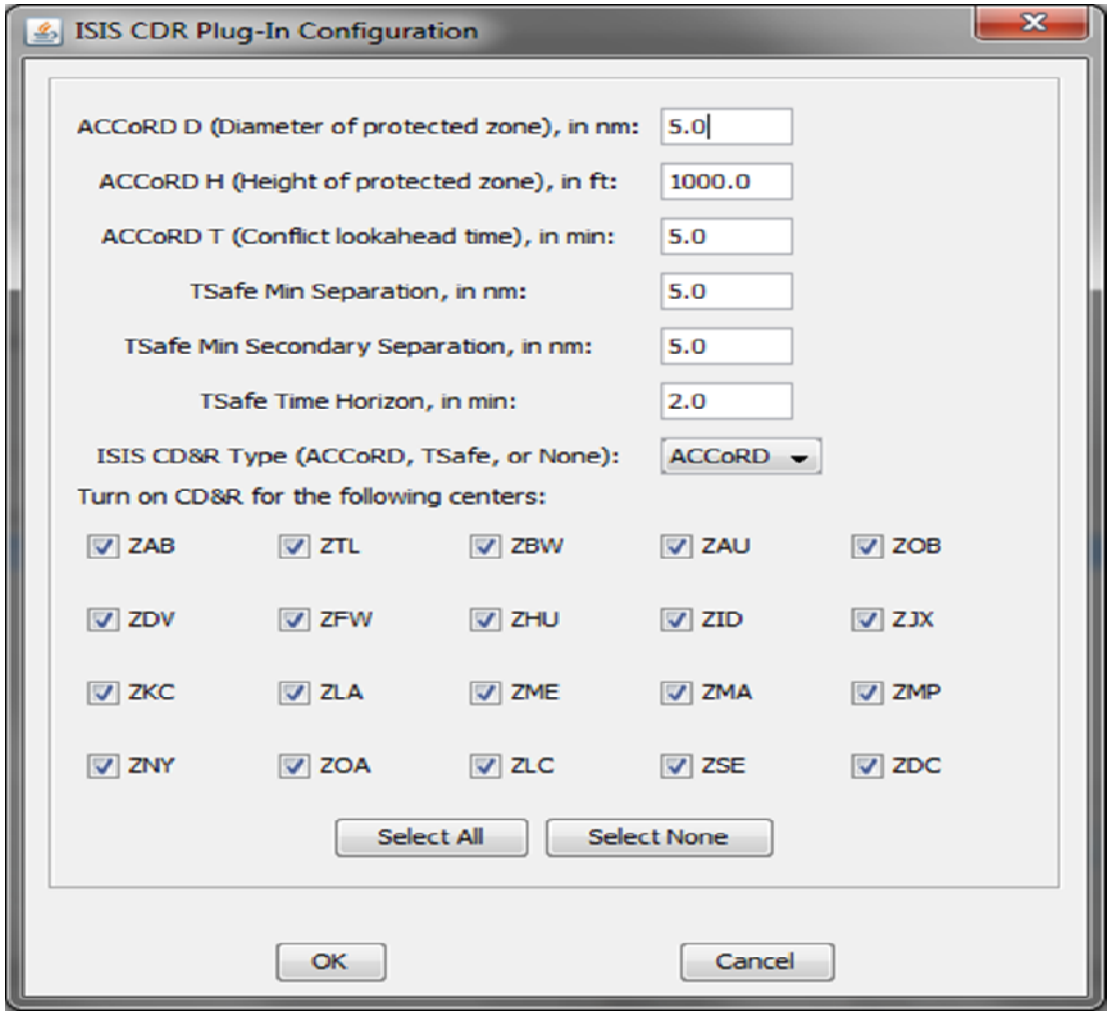
TFM and CD&R using ISIS



TFM and CD&R using ISIS

- A new pluggable and extensible modeling architecture for CD&R in ACES
  - Includes reusable interfaces for
    - Surveillance modeling
    - CD&R advisory generation and coordination
    - Pilot modeling
  - Provides flexibility for
    - Integrating new surveillance models with ACES
    - Integrating new CD&R algorithms for self-separation
- Used to integrate ACCoRD and TSAFE algorithms with ACES

TFM and CD&R using ISIS



The ISIS CD&R framework is fully integrated with ACES as an ACES plug-in.

Integration of ASAS Components and M&S

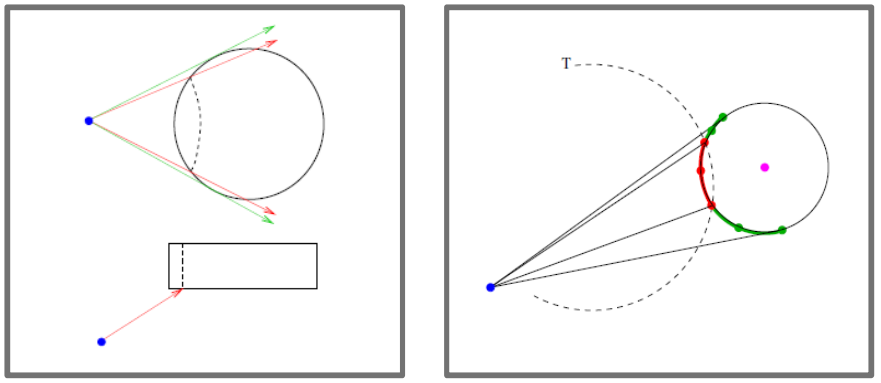
- ACES Modifications under development by IAI (SBIR III 11/2009 – 11/2010)
- Model Integration, Installation and Test of ASAS components into production version of ACES
    1) Airborne Merging and Spacing
    2) Tactical Conflict Detection and Resolution
    3) Strategic Conflict Detection and Resolution
    4) Pilot Decision Model
- Will provide significantly enhanced capability to study ASAS Concepts within ACES

Integration of ASAS Components and M&S

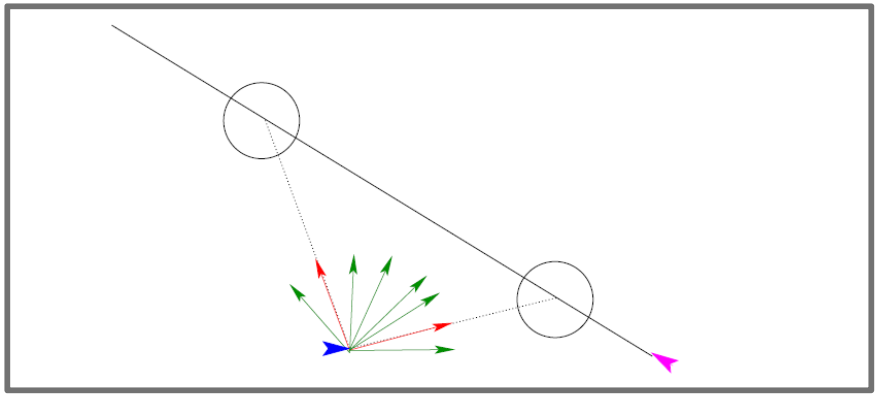
- Conflict Prevention System displays “bands” to pilot to indicate if trajectory changes will cause a conflict
  - Heading changes
  - Vertical speed changes
  - Horizontal speed changes
- Trajectory changes can be due to conflict resolution or normal operations
- Could also be used with automated system without pilot in-the-loop
- ACES modifications will include a pilot decision model to check maneuvers and select from resolution choices according to simple rules (no GUI or HITL capability)

Integration of ASAS Components and M&S

- Conflict Bands algorithm uses ACCoRD to determine conflict envelope
- Supports multiple conflict regions
- Deterministic, formal V&V



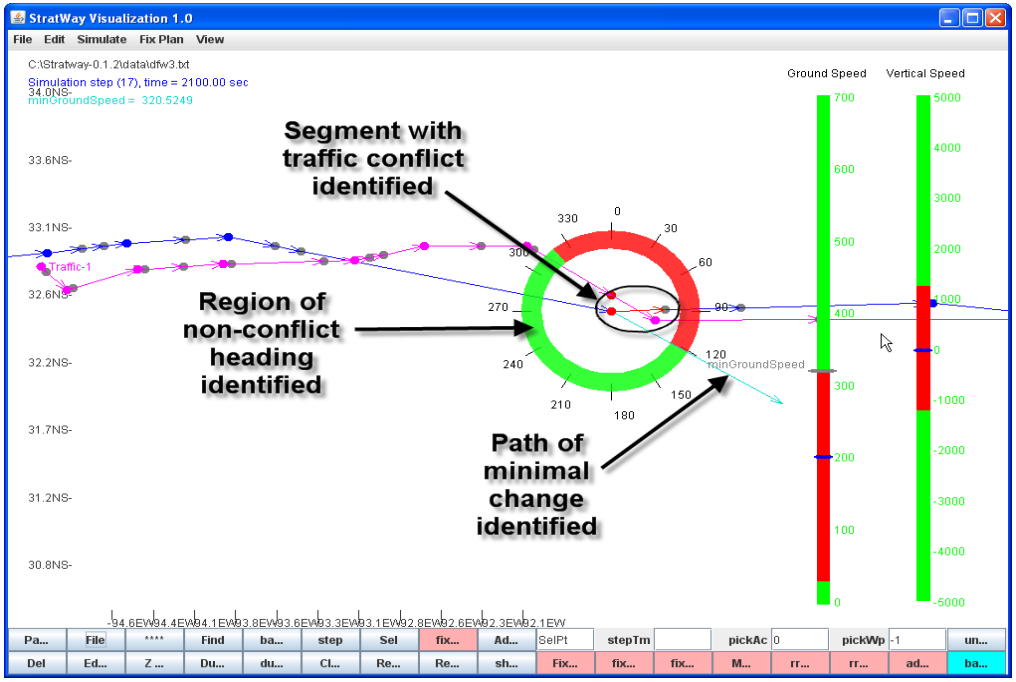
Heading conflict zone corrected with altitude and time



Resolution with multiple simultaneous conflicts

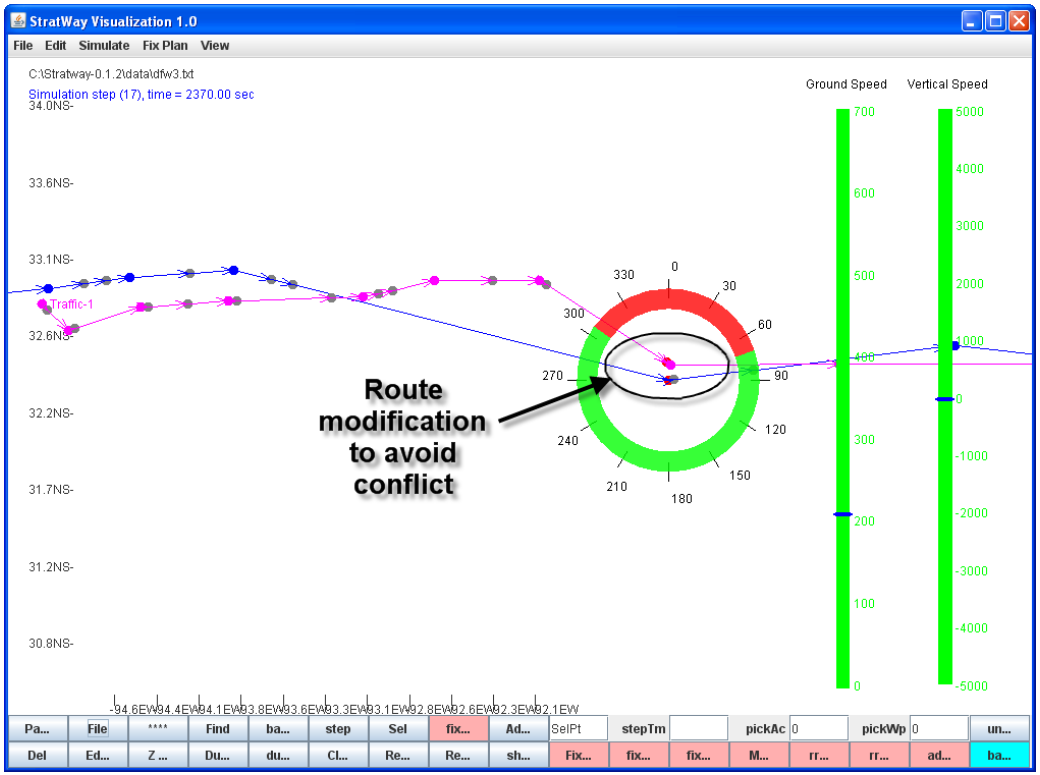
Integration of ASAS Components and M&S

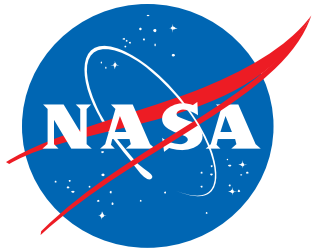
- Strategic CD&R algorithm under development is “StratWay” (Strategic Waypoint adjustment program)
- Performs piece-wise inspection of planned waypoints
- Uses Bands algorithms for conflict detection and resolution options



Integration of ASAS Components and M&S

- Moves minimum number of waypoints to de-conflict





End of Presentation