



NASA / Ames Research Center

Virtual Airspace Modeling and Simulation

Airspace Concepts Evaluation System

Build 3.2.1

Contract Number: NNA05BE01C

Raytheon ACES Team

9 March 2005

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Agenda

- **Model Enhancements for Build 3.2.1**
- **Infrastructure Enhancements for Build 3.2.1**

VAMS – Technical Interchange Meeting #5, March 8-9, 2005

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ACES Build 3 Enhancements

- **Model Improvements**

- Improved Error and Uncertainty Support
- Addition of Missing Flights
- Tail Connectivity
- Rerouting
- Separation at the Arrival Meter Fix
- Enhanced Terminal Area and Airport Runway System

- **Infrastructure Enhancements**

- Event-based Scenario Generation
- Multiple Run Capability
- Centralized Random Number Generator

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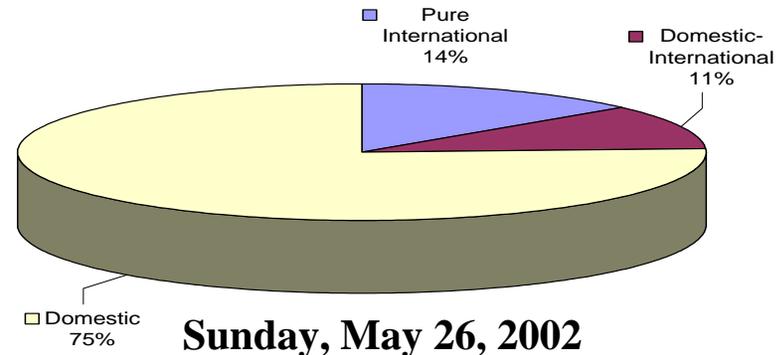
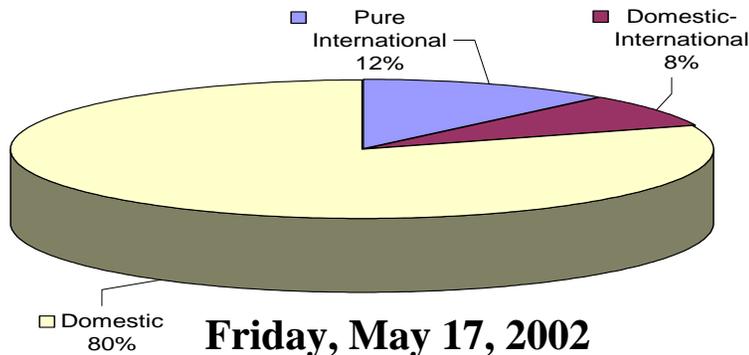
Improved Error and Uncertainty Support

- **ACES Build 3 tracks “truth” (i.e., true state of a flight) independent from any specific agent’s knowledge of future events**
 - Decouples trajectory truth tracking from strategic agent trajectory tracking and prediction of flights, enroute airspace only
- **Any agent can contain Flight Plans and Trajectory calculations for inclusion of uncertainties into the data**
- **The MPAS Flight modeling for the prediction of aircraft position is done in individual ARTCCs instead of the ATCSCC**
 - Results in a 30% - 40% improvement in processing time.

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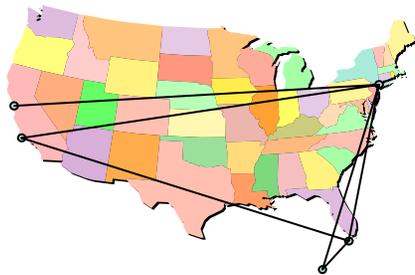
- **Addition of International Flights**
 - Flights are instantiated/removed at the CONUS Boundary
 - Single International Center handles all International Flights
- **Inclusion of flights with null sector boundaries**



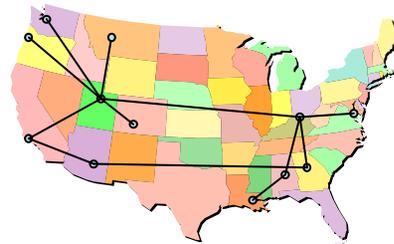
- **Additional flights brings the ACES baseline 5/17/02 day to roughly 40,000 flights out of 62,601 contained in the original ETMS data file.**

Tail Connectivity

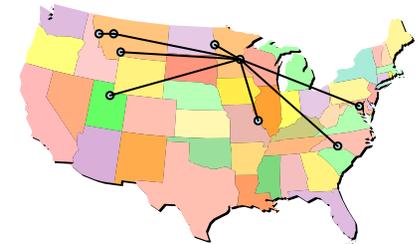
- Tail Tracking of individual aircraft throughout the NAS
- Departing flights need to await the physical aircraft assigned to that flight
 - Flight must arrive and have a reasonable (e.g. 30 minute) turn-around
- Based on existing Tail Number to Flight Number Datasets supplied by NASA (BTS Data)
 - BTS supports 10 commercial airlines currently



An American Airlines MD-10



A Delta Airlines Boeing 727



A Northwest Airlines DC-9

- Updated AOC model with 4 modes
 - No AOC model or new Tail Tracking
 - Original AOC model only, no new Tail Tracking
 - New Tail Tracking AOC model only
 - Mix of new Tail Tracking for BTS flights and Original AOC tail connectivity for non BTS flights

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Rerouting

- **Capability supports rerouting before flight initiation or during flight**
 - Rerouting only during the en route phase of flight
- **Build 3 contains a model for generating new flight plans based on avoiding certain sectors (emulating a convective weather event or significant congestion)**
 - Reroutes are triggered via scenario messages
 - A scenario message modifies the sector capacities
 - A scenario message is sent to the aircraft to cause a reroute
- **There is currently no decision support logic for planning reroutes in any agent. This will be enhanced in Build 4**
- **This does not include rerouting to alternate MF or airports – This will be included in Build 4**

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Separation at the Arrival Meter Fix

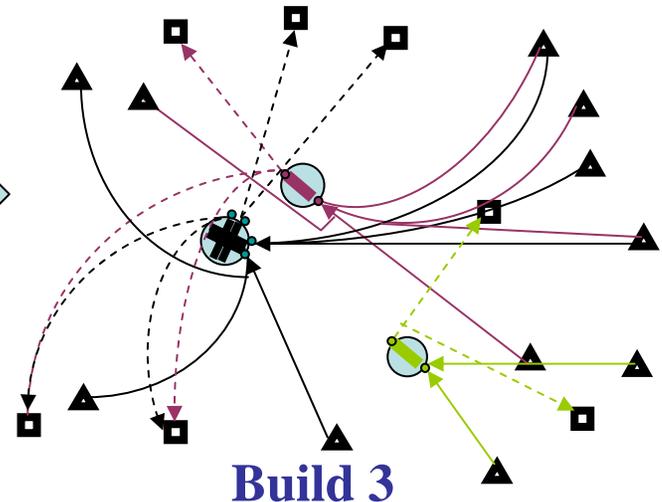
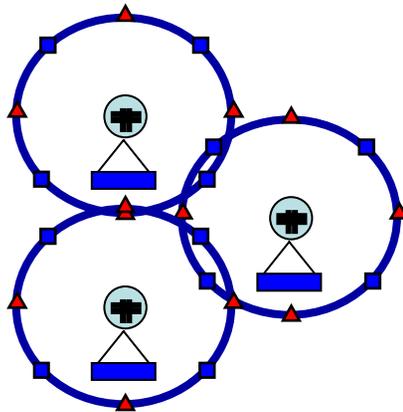
- Assure meter fix spacing for realistic terminal area routing and spacing
- Detect spacing of arrival aircraft at the meter fix
- Ensure minimum spacing by delaying in en route and descent phase
- Attempt to use speed control
- Use dog-leg turn if speed control insufficient.
- Holding pattern is final resort

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Enhanced Terminal Area and Airport Runway System

- **Simplified Terminal Airspace Network Modeling**
 - Multiple Terminal Area Boundary Fixes/Flexible Terminal Airspace Boundary
 - Simplified (Node) Linkage Network Operation
 - Multiple Airports in a TRACON Airspace
 - Runway-to-Fix Assignment
- **Runway Modeling**
 - Individual Runway Operations
 - Aircraft Spacing Matrices



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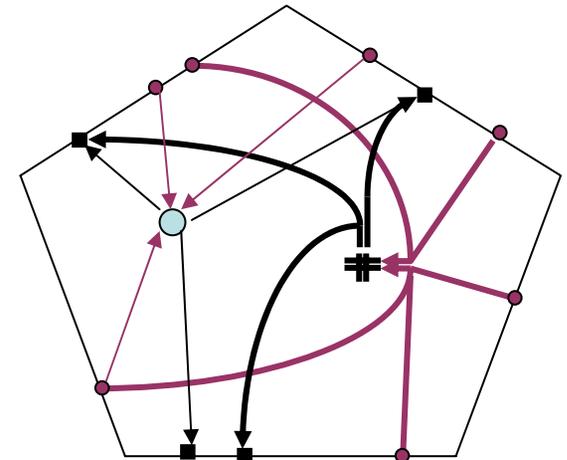
Network Centric Systems **Build 1 and 2**

Build 3

Simplified Terminal Airspace Network Modeling

- Multiple arrival & departure boundary fixes
- Flexible Boundary
- Aircraft type-dependent terminal airspace transit times
- Multiple airports in TRACON Coordinated terminal area airports & boundary traffic sequencing
- Delay at boundary nodes
- Actual Departure Fix Crossing Times
- Requested Landing times
- Boundary fix-runway assignment

ACES enables Mixed Nodal & Airport Linkage



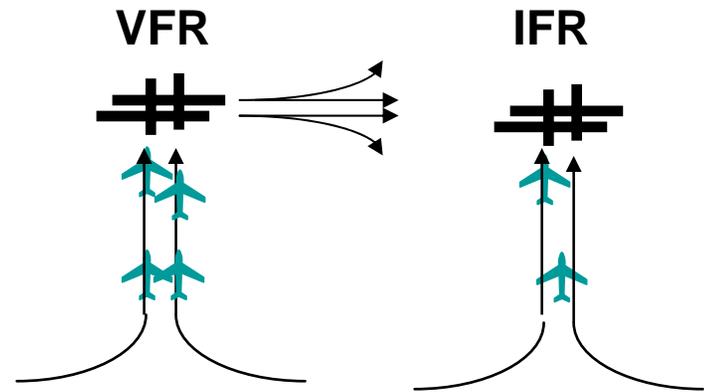
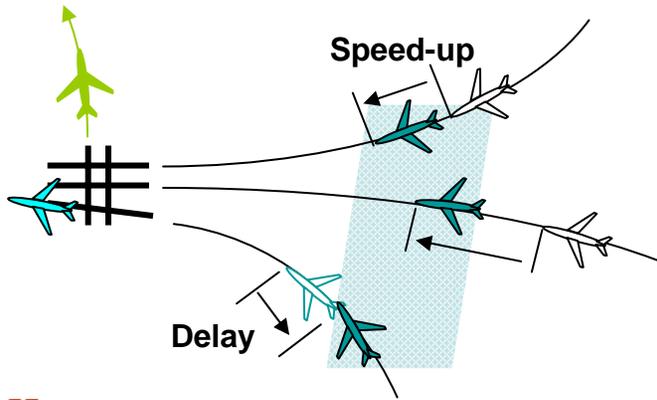
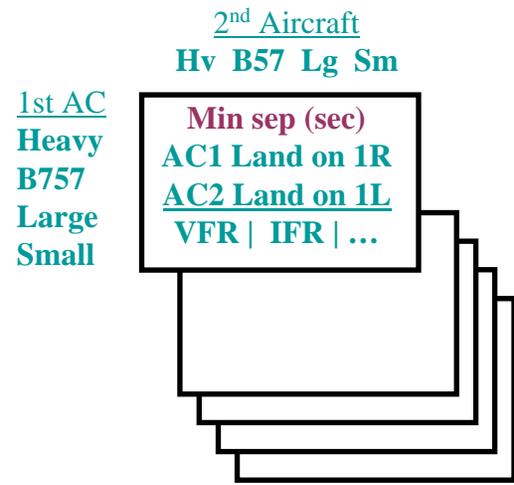
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Runway Modeling

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- Individual runways at airports
- Runway configurations by operating condition
- Runway assignment for each flight
- Runway geometric/procedural dependencies encoded in spacing matrices
- Synchronized formations



Raytheon Landing Formation
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Event-based Scenario Generation

- **Event-based Scenario generation provides users with the following capabilities:**
 - Using the triggering events to set up scenarios.
 - Triggering events include:
 - Time trigger (relative or absolute), Sector boundary crossing, Center boundary crossing, Departure meter fix crossing, Arrival meter fix crossing, flight Take-off and landing, Gate departure and arrivals
 - Boolean logic (AND/OR) capability for multiple triggers (e.g. multiple flights)
 - Changes in the following parameters when a trigger event occurs.
 - Sector capacity
 - Airport capacity
 - Flight cancellation
 - Gate departure time
 - InterTfm Restriction
 - IntraTfm Restriction
 - Airport state
 - Flight plan amendment

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Event-based Scenario Generation

- **Rules for combining multiple scenario events:**
 - Priority field/matrix
 - Last value in
 - Most conservative
 - First-in
 - First-out A
 - Additive/Subtractive/Multiplicative
- **Saving default values to revert to at a later time**
- **Time offset from trigger**
- **Scenario error message logging**

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- **The Multiple Run System provides the user with the ability to configure and execute multiple ACES jobs from a centralized simulation manager.**
- **Some of the capabilities include:**
 - Submission of an ACES run via a user interface or ACP files
 - Use of persistent database to store job information
 - Manually configure a run or assign nodes to GMs' based on a default scheme
 - Preliminary validation of the input data and report errors to the operator/user
 - Capability to pause/stop between jobs
 - Capability to allow the user to specify LDC related data
 - Execute and terminate queued up jobs in a FIFO format without human intervention
 - Execute multiple jobs in parallel only if they are adjacent in the job queue and sufficient machines are available to run both jobs
 - Copy and edit the configuration parameters of jobs

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Multiple Run Capabilities

- **Capabilities** (continued)
 - Provide the operator capability to delete active jobs, and reorder or delete queued up jobs
 - Provide run time job status to the operator
 - Termination of current run upon detection of critical execution errors
 - Detect if the simulation appears to be “hung” (no time advance) and terminate the run
 - Load all LDC data into a database
 - Move all simulation output data (LDC database, Centralized Logging, Error, File Summary, console output) to a common data repository and clean up (delete data from) the ACES output directories
 - Notify operator about job status via e-mail

Multiple Run System

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The screenshot displays three overlapping windows of the 'Aces Multiple Run - Editor/Scheduler' application. The top-left window shows the 'Owner Editor' tab with a table of users:

Name	Email Address	Category
Chris	cye@i-a-i.com	Administrator
David	dditzenberger	Researcher

The top-right window shows the 'Job Editor' tab with a 'Jobs' list and a 'Details' panel. The 'Jobs' list includes:

- STD1
- 517 No TFM VWind
- 100 Airport

The 'Details' panel shows configuration for a job named '4800 fds 3 machine' with fields for Job Description, Auto Config File, LDC Config File, and Random Seed File. It also includes a '# of GMs' dropdown set to 3 and a table for RTI (Real Time Interval) settings:

GM	Host
GM_1	cto7/wk1
GM_2	cto7/wk2
GM_3	cto7/wk3

The bottom window shows the 'Job Scheduler' tab with a 'Scheduled Jobs' table and a status log. The 'Scheduled Jobs' table is as follows:

Job Name	Status
STD1	Completed_Success
STD1	Running
517 No TFM VWind	Pending
100 Airport	Pending

The status log shows the following text:

```

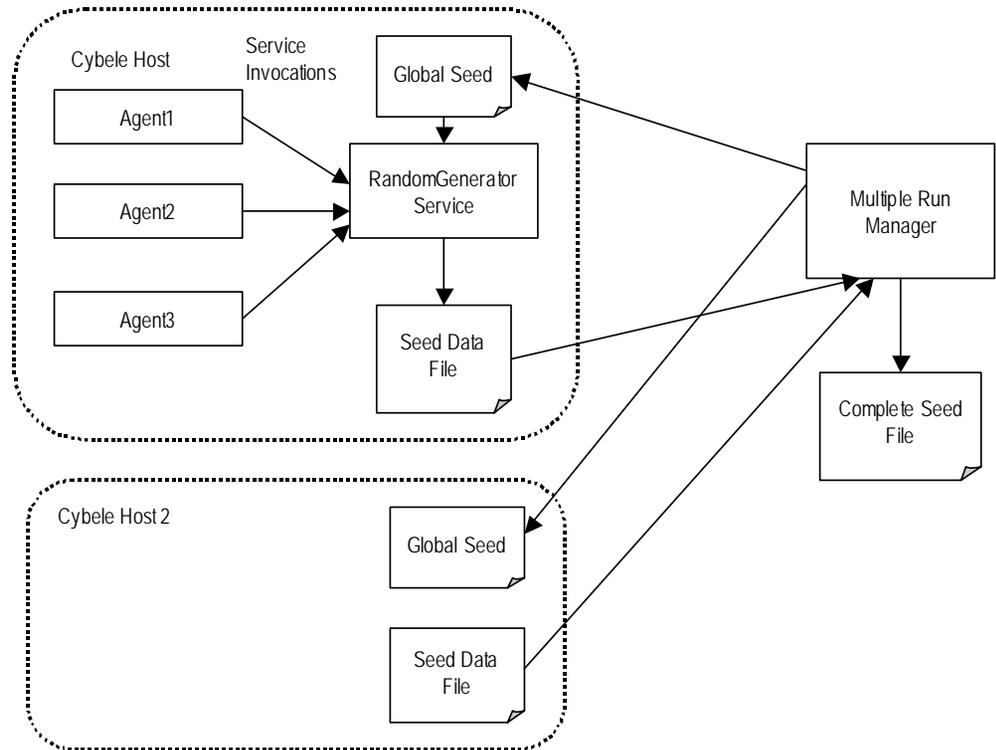
<No activities>
Start batch processing ...
*****
Select batch job [id=20, description="STD1"] to ru
Job [id=20] start at 2004-09-08 16:29:06.972 ...
Run pre-processing for job [id=20] ...
Start RTI of job [20] on host cto7/wk3 ...
Start SYNC of job [20] on host cto7/wk3 ...
    
```

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Random Number Generator

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- **Build 3 provide the capability for generation of the exact same random sequence under multiple runs and under any configuration of agents running on different hosts following capabilities**
- **A graphical user interface integrated into the multiple run user interface to allow the user to set the RNG system options.**



Build 3.2.1 Additions

- **Memory Improvements**
 - Increased capability for greater number of flights
- **AAC Improvements**
 - New data interfaces
 - Corrections in flight models for rerouting
- **Bug Fixes**
 - 3.2 and 3.2.1 corrected an additional 56 bugs
 - Several issues affecting Rerouting
 - Includes memory improvements
 - Improved data collection

Future Enhancements

- **CybelePro™**
 - Increase number of flights
 - Increased Performance
 - Portability
- **Multiple Run Enhancements**
 - Installation
 - Enhanced Configuration Interface
 - Enhanced Job Scheduling
 - Performance Improvement of data import to database
- **Enhanced Rerouting**
 - Alternate MF and Airports – Weather, Safety and Security
- **Documented Input Datasets**

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