NASA Simulation Capabilities

Aug 7, 2017
ver. 072517b
Simulation Tool Overview

- The Future ATM (Air Traffic Management) Concepts Evaluation Tool (FACET) has provided a core capability to conduct air traffic management research for NASA’s Aeronautics Research Mission Directorate (ARMD) since 2000.

- Under the NASA-CAE agreement, FACET will be adapted to support simulations and analyses of Shanghai Pudong International Airport (IATA: PVG, ICAO: ZSPD) arrival and departure operations.
FACET Overview

- National Airspace System (NAS) - wide simulations and planning on a laptop computer
- Ability to model airspace operations at U.S. national level (~50,000 aircraft per day)
- Alternative navigation modes available
  - Flight Plan Routing
  - Great Circle Routing
  - Wind Optimal Routing
- Software written in ‘C’ and ‘Java’ programming languages
- Can be used for both off-line analyses and real-time applications
Sample of FACET Supported Studies

- “What-if” capabilities for evaluating traffic flow options to avoid bad weather and airspace congestion while minimizing air traffic delays
- Airspace performance metrics using operations data
  - Relationships between traffic, weather and delay
  - Techniques for clustering and data mining to identify similar types of days/operations
- U.S. domestic and Pacific wind optimal routing studies
- Aggregate air traffic flow models
  - Transform collections of similar trajectories into flow streams
  - Linear models with 100-fold order reduction

Sample “what-if” evaluation display
High-level FACET Architecture

National Weather Service
- Winds
- Severe Weather

Real-time and Historical Air Traffic Data
- Tracks
- Flight Plans

Aircraft Performance Data
- Climb
- Descent
- Cruise

Adaptation Data
- Airspace
- Airways
- Airports

FACET Core Features
- Route Parser & Trajectory Predictor
- User Interface
- Traffic & Route Analyzer

Sample Applications
- Airborne Self-Separation
- Data Visualization
- Direct Routing Analysis
- Controller Workload
- System-Level Optimization
- Traffic Flow Management
FACET Inputs

- FACET Interface Control Document (ICD) provides a comprehensive description of the system’s airspace adaptation and air traffic data requirements

- Airspace adaptation requirements included for navigational aids, waypoints, airways, airport locations, Flight Information Regions (FIRs), sectors, Special Use Airspace (SUA), standard arrival and departure routes and airspace capacities

- FACET formatted ASCII air traffic data format derived from the FAA’s System Wide Information Management (SWIM) data provided

Note: FACET ICD is currently being reviewed and will be released shortly
FACET Inputs :: Airways Example

<table>
<thead>
<tr>
<th>Airway Identifier</th>
<th>YYC</th>
<th>ALOMO</th>
<th>YEA</th>
<th>YQV</th>
<th>BRW</th>
<th>SCC</th>
<th>FYU</th>
<th>ORT</th>
<th>BORAN</th>
<th>YAK</th>
<th>BSR</th>
<th>SNS</th>
<th>HENCE</th>
<th>CATHE</th>
<th>KARNN</th>
<th>WINDY</th>
<th>PATYY</th>
<th>MOD</th>
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</tbody>
</table>

- **Airway Identifier**
- **Airway Waypoints/Navigational Aids**
### NAVAID identifier

<table>
<thead>
<tr>
<th>NAVAID identifier</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Elevation</th>
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<tr>
<td>HET</td>
<td>N35</td>
<td>24</td>
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<tr>
<td>HEU</td>
<td>N42</td>
<td>51</td>
<td>10.674</td>
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</table>

The table above lists the identifiers, latitude, longitude, and elevation for two NAVAIDs: HET and HEU. The map below visualizes the distribution of NAVAIDs across the United States, with markers indicating their locations.
### FACET Inputs :: Flight Information Region (FIR) / Center Boundary Example

<table>
<thead>
<tr>
<th>FIR/Center</th>
<th>FIR/Center Identifier</th>
<th>Min/Max Altitude</th>
<th>Latitude/Longitude of Vertex 1</th>
<th>Latitude/Longitude of Vertex N</th>
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<tbody>
<tr>
<td>Albuquerque Center</td>
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<tr>
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<td></td>
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<tr>
<td>N37</td>
<td>30 00.00 W102 33</td>
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<tr>
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<td>30 00.00 W102 33</td>
<td>00.00</td>
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### FACET Inputs :: Sector Example

<table>
<thead>
<tr>
<th>Sector Name</th>
<th>Min/Max Altitude</th>
<th>Latitude/Longitude of Vertex 1</th>
<th>Latitude/Longitude of Vertex N</th>
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</thead>
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<td>N47</td>
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<td>22.21 W102 33</td>
<td>30.00</td>
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<tr>
<td>N47</td>
<td>30</td>
<td>00.00 W102 33</td>
<td>00.00</td>
</tr>
</tbody>
</table>

- Sector Name
- Min/Max Altitude
- Latitude/Longitude of Vertex 1
- Latitude/Longitude of Vertex N
FACET Inputs :: Air Traffic Example

**TRACK_TIME** 1124841777

- Unix epoch time in seconds since Jan. 1 1970 (midnight UTC/GMT)

<table>
<thead>
<tr>
<th>TRACK</th>
<th>NASA1</th>
<th>B772</th>
<th>375900</th>
<th>835700</th>
<th>516</th>
<th>366</th>
<th>69</th>
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<th>ZID93</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>aircraft identifier</td>
<td>aircraft type</td>
<td>current latitude</td>
<td>current longitude</td>
<td>ground speed</td>
<td>flight level</td>
<td>heading</td>
<td>current center</td>
<td>current sector</td>
</tr>
</tbody>
</table>

**FP_ROUTE** KDFW...MEM359067...RBV...RIFLE...ACK...TUSKY...YQX...NATY...LIMRI...DOLIP...CRK...EXMOR...GIBSO...EGKK

- flight plan route
FACET Application Programming Interface

- FACET Application Programming Interface (API) enables scripting of FACET functionality from Java, Jython, Matlab, etc.
- Over 600 methods for accessing FACET functionality
FACET Outputs

- Predefined FACET output capabilities provide:
  - Aggregate aircraft counts in FIRs/Centers/Sectors, arrivals, departures and user defined traffic streams
  - Aircraft-level statistics available for displaying aircraft state information (e.g., heading, speed, altitude, etc.) versus time, fuel burn, path distance and length, etc.

- FACET Application Programming Interface (API) provides complete access to all aircraft state information for user defined metrics calculations