NASA Simulation Capabilities

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ver. 072517b
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
- Traffic & Route Analyzer
- User Interface

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

#### Airway Identifier

<table>
<thead>
<tr>
<th></th>
<th>YYC</th>
<th>ALOMO</th>
<th>YEA</th>
<th>YQV</th>
</tr>
</thead>
<tbody>
<tr>
<td>J476</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J507</td>
<td>BRW</td>
<td>SCC</td>
<td>FYU</td>
<td>ORT</td>
</tr>
<tr>
<td>V111</td>
<td>BSR</td>
<td>SNS</td>
<td>HENCE</td>
<td>CATHE</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>KARN</td>
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<td>WINDY</td>
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<td></td>
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<td></td>
<td>PATYY</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MOD</td>
</tr>
</tbody>
</table>

#### Airway Waypoints/Navigational Aids

- **MAP**: A map of the United States depicting airway networks and navigational aids.
### FACET Inputs :: Navigational Aids (NAVAIDS) Example

#### NAVAID identifier

<table>
<thead>
<tr>
<th>NAVAID identifier</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>HET N35 24</td>
<td>16.366</td>
<td>W096 00</td>
<td>49.997</td>
</tr>
<tr>
<td>HEU N42 51</td>
<td>10.674</td>
<td>W073 56</td>
<td>03.448</td>
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</tbody>
</table>

#### Map of NAVAIDS

[Map image showing distribution of NAVAIDS across the United States]
### FACET Inputs :: Flight Information Region (FIR) / Center Boundary Example

<table>
<thead>
<tr>
<th>FIR/Center Name</th>
<th>FIR/Center Identifier</th>
<th>Min/Max Altitude</th>
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</thead>
<tbody>
<tr>
<td>Albuquerque Center</td>
<td>ZAB</td>
<td>0 450000</td>
</tr>
<tr>
<td>N36</td>
<td>43 00.00 W105 20 30.00</td>
<td></td>
</tr>
<tr>
<td>N36</td>
<td>43 00.00 W105 00 00.00</td>
<td></td>
</tr>
<tr>
<td>N37</td>
<td>18 30.00 W103 09 00.00</td>
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</tr>
<tr>
<td>N37</td>
<td>30 00.00 W102 33 30.00</td>
<td></td>
</tr>
<tr>
<td>N37</td>
<td>30 00.00 W102 33 00.00</td>
<td></td>
</tr>
</tbody>
</table>

- FIR/Center Name
- FIR/Center Identifier
- Min/Max Altitude
- Latitude/Longitude of Vertex 1
- Latitude/Longitude of Vertex N

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![Map Image](image-url)
### 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>
</tr>
</thead>
<tbody>
<tr>
<td>ZAB90</td>
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<tr>
<td>24000</td>
<td>60000</td>
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<tr>
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<td>01 18.33 W105 54</td>
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<td>N46</td>
<td>43 05.56 W105 30</td>
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<td>N47</td>
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<td>N47</td>
<td>30 22.21 W102 33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N47</td>
<td>30 00.00 W102 33</td>
<td></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

- **Unix epoch time in seconds since Jan. 1 1970 (midnight UTC/GMT):** 1124841777

<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>
<th>ZID</th>
<th>ZID93</th>
</tr>
</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

- **Flight plan route:** KDFW.,MEM359067..RBV..RIFLE..ACK..TUSKY.YQX.NATY.LIMRI.DOLIP.CRK.EXMOR.GIBSO.EGKK

### Map

- The map shows the flight plan route over a section of the United States, with various airports and routes marked.

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*Note: The table and map are included to illustrate the data points used for analyzing air traffic.*
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