CSSI's NARIM Suite of Airspace Analysis Tools

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NARIM

- National Airspace Resource and Investment Model (NARIM)
  - Series of air traffic operations analysis tools developed by CSSI (and others) for FAA and NASA
  - For analysis of effects of proposed advances in NAS
    - Local
    - Systemwide

The Tools

- CSSI-developed tools
  - OPGEN—Optimal Trajectory Generator
  - OPGEN-Fuel
  - T^3—Total Traffic Tool
  - Find Crossings
  - ETMS Data Parser
  - Architecture and infrastructure models
- Other tools
  - FDG—Future Demand Generator
  - RAMS—Re-organized ATC Mathematical Simulator developed for Eurocontrol

OPGEN

- Calculates optimal four-dimensional flight profiles that obey…
  - Operational constraints
  - Aircraft-specific performance constraints
- Uses genetic algorithm to find optimal trajectories
  - Minimize fuel consumed to meet desired time en route
  - If can't meet desired time, then time en route is minimized

OPGEN (continued)

- Operational constraints
  - Rules for direction of flight (CVSM, RVSM)
  - Special-Use Airspace (SUA)
  - Rules on routes of flight on departure and arrival
- Performance constraints
  - Ceiling as a function of aircraft weight
  - Climb rate versus maximum power setting
  - Maximum operational mach number
  - Minimum speed
  - Maximum descent rate

OPGEN (continued)

- Can vary constraints to calculate benefits of various scenarios
- Also, can model constant-mach/CAS (calibrated airspeed) descents
- Products
  - Flight times
  - Fuel burned
  - Inputs to T^3 and Find Crossings

OPGEN-Fuel

- OPGEN version that calculates fuel burned
  - Calculates fuel burned for existing trajectories
  - Models 70 aircraft types

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T^3—Total Traffic Tool

- Calculates potential conflicts
  - Does this very efficiently
  - Identifies conflicts for entire NAS in 10-15 minutes
- Identifies conflicts between pairs of aircraft based on user-specified horizontal and vertical separation criteria
- Requires set of four-dimensional flight trajectories as input (from OPGEN or ETMS)
- Produces for each conflict
  - Location
  - Conflict geometry
  - Closing velocity

Find Crossings

- Identifies each flight's use of NAS resources
  - Sectors
  - Radar coverage areas
  - Communications frequency coverage
  - Any other service volume
- Most often used to identify times and locations of sector entries and exits
- Can also used to determine SUA activity prior to generating OPGEN trajectories

Find Crossings (continued)

- Products
  - Instantaneous loads
  - Average loads
  - Crossing times and locations
  - Throughput
  - By subsector or sector

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ETMS Parser

- Parses raw Enhanced Traffic Management System (ETMS) data and puts it into a useful format
- Creates demand scenarios (flight profiles for entire NAS) that reflect current operations
- Two parsing output options:
  1. How aircraft actually flew, including all controller interventions
  2. Flights as filed and subsequently amended by flight operators

ETMS Parser (concluded)

- Further option: analyst can select level of amendments included, such as
  - Last amendment prior to departure
  - All amendments

Architecture and Infrastructure Modeling

- Users can determine effects of changes in demand on NAS infrastructure components under different operational scenarios
- Informal tools consist of simulations of NAS components and demand on them

FDG—Future Demand Generator

- Originally developed by MITRE in support of NASPAC
  - User enters demand forecasts
  - FDG distributes demand throughout day using Frataring algorithm
  - CSSI has improved its performance

RAMS

- Detailed air traffic simulation developed for Eurocontrol
- Resolves conflicts through conflict-resolution rule base
  - Default rule base supplied, but can be modified by analyst
  - CSSI analysts consulted with controllers and modified en-route rule base for use in U.S.
- CSSI has demonstrated prototype dynamic OPGEN-RAMS integration
  - Enables analysts to conduct fast-time simulation of in-flight re-planning tools

Recent Applications

- NASA Distributed Air/Ground Traffic Management (DAG-TM) work
  - Generated optimized trajectories for baseline case (similar to EDA)
    - Computed fuel burn of trajectories
    - Computed conflicts and severity
    - Assigned fuel costs of conflicts
  - Repeated process for Concept Elements 5 and 6

Recent Applications (continued)

- CPDLC benefits analysis
  - Manually reviewed radar and voice data for transition airspace
    - Found conflicts resolved less than optimally
    - Also found inefficient level-offs
    - Determined relationship between inefficiencies and voice-channel utilization
  - Then generated 2001 NAS-wide scenario
    - Parsed ETMS data and assigned RVSM data for future scenarios
    - Used Find Crossings to generate sector crossings
    - Used T^3 to generate conflicts

Recent Applications (continued)

- CPDLC Benefits (continued)
  - Calculated NAS-wide voice-channel utilization rates using Find Crossings and T^3 results
  - Using relationship determined earlier, calculated reduced voice-channel utilization resulting from CPDLC
  - Determined reduction in fuel and time costs
- Used updated Future Demand Generator to create schedules for 2010 and 2020
  - Created trajectories for new demand
  - Ran tools to generate sector counts and conflicts
- Then repeated process of estimating benefits for 2010 and 2020

Recent Applications (continued)

- "Big Iron" infrastructure study
  - Wrote simulation to determine communication requirements for ground-based DST supporting airborne self-separation concepts
    - "Big Iron" concept is ground-based tool that resolves conflicts and supplies pilots with data
    - Modeled entire exchange of info between DST and cockpit
    - Measured latency
    - Determined that there is enough bandwidth to put DST on ground and allow aircraft to separate themselves

Recent Applications (concluded)

- VOR discontinuance study
  - Study supported FAA's development of discontinuance methodology for VORs
  - Using ETMS "as-filed" parser, extracted 54 days of fully-amended IFR flight plans
  - Amended routes from those flight plans were then expanded to identify all fixes that were crossed
    - DPs and STARs were also included, when filed
    - VORs used to define those fixes were counted, then grouped by filed equipment code and type of operator