

The Processing of Airspace Concept Evaluations Using FASTE-CNS as a Pre- or Post-Simulation CNS Analysis Tool.

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As NASA speculates on and explores the future of aviation, the technological and physical aspects of our environment increasing become hurdles that must be overcome for success. Research into methods for overcoming some of these selected hurdles have been pursued by several NASA research partners as concepts. The task of establishing a common evaluation environment was placed on NASA's Virtual Airspace Simulation Technologies (VAST) project (sub-project of VAMS), and they responded with the development of the Airspace Concept Evaluation System (ACES). As one examines the ACES environment from a communication, navigation or surveillance (CNS) perspective, the simulation parameters are built with assumed perfection in the transactions associated with CNS. To truly evaluate these concepts in a realistic sense, the contributions/effects of CNS must be part of the ACES.

NASA Glenn Research Center (GRC) has supported the Virtual Airspace Modeling and Simulation (VAMS) project through the continued development of CNS models and analysis capabilities which supports the ACES environment. NASA GRC initiated the development a communications traffic loading analysis tool, called the Future Aeronautical Subnetwork Traffic Emulator for Communications, Navigation and Surveillance (FASTE-CNS), as part of this support. This tool allows for forecasting of communications load with the understanding that, there is no single, common source for loading models used to evaluate the existing and planned communications channels; and that, consensus and accuracy in the traffic load models is a very important input to the decisions being made on the acceptability of communication techniques used to fulfill the aeronautical requirements.

Leveraging off the existing capabilities of the FASTE-CNS tool, GRC has called for FASTE-CNS to have the functionality to pre- and post-process the simulation runs of ACES to report on instances when traffic density, frequency congestion or aircraft spacing/distance violations have occurred. The integration of these functions require that the CNS models used to characterize these avionics system be of higher fidelity and better consistency than is present in FASTE-CNS system.

This presentation will explore the capabilities of FASTE-CNS with renewed emphasis on the enhancements being added to perform these processing functions; the fidelity and reliability of CNS models necessary to make the enhancements work; and the benchmarking of FASTE-CNS results to improve confidence for the results of the new processing capabilities.

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4th ICNS Conference and Workshop

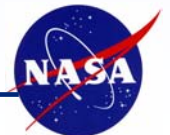
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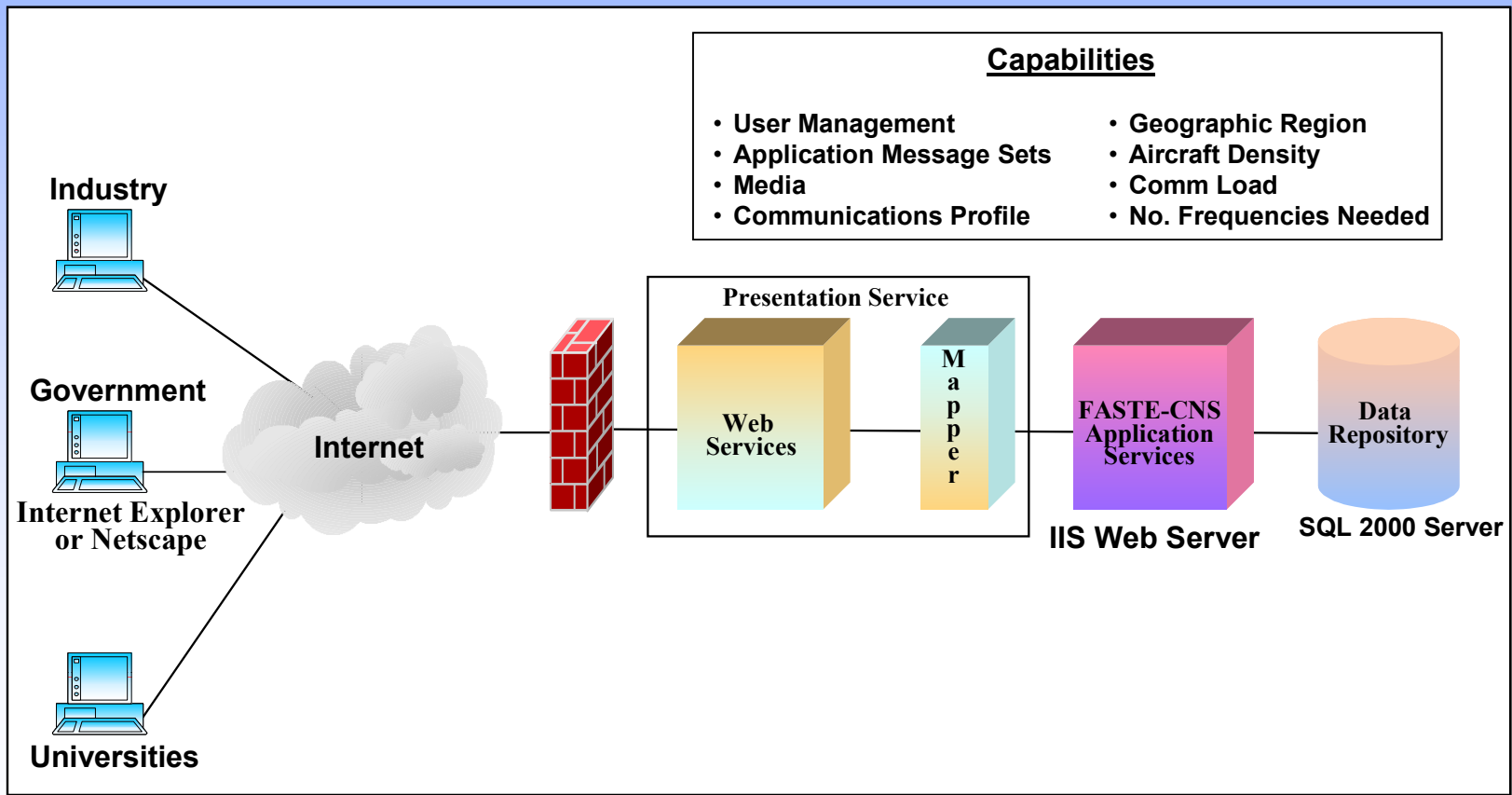


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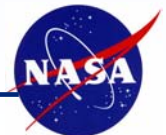


Future Aeronautical Subnetwork Traffic Emulator – Communications, Navigation and Surveillance (FASTE-CNS)

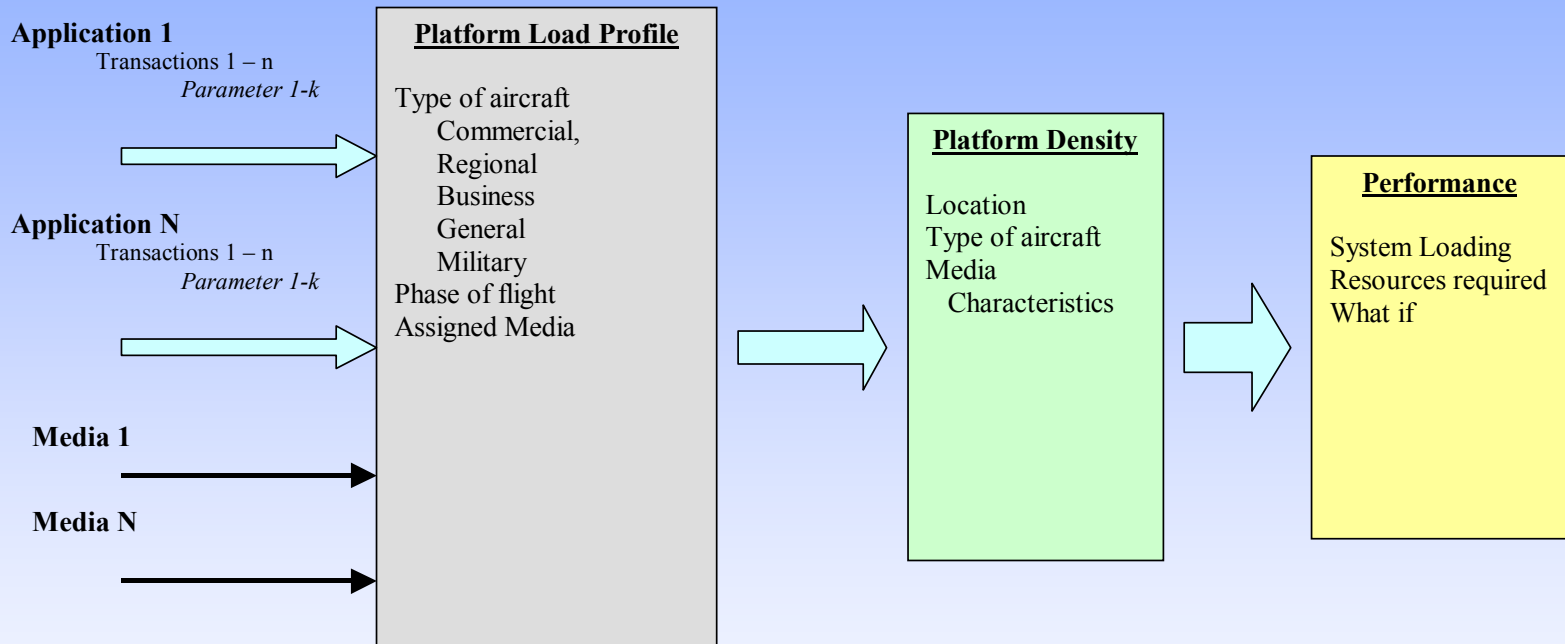


FASTE-CNS Features

- Internet-based
 - Accessible using common web browsers through Internet
- User Accounts
 - User has flexibility to dynamically define geographically regions, number of aircraft, and media; as well as, file management.
- Application Message Sets
 - Define application specific communicated messages
- Communication Traffic Profiles
 - Define series of applications and their associated media
- Communications Forecast Data Model
 - Define geographic region to describe the communications traffic within the selected region
- Frequency and Transmitter Requirements
 - Calculates the frequencies and transmitters needed to support regions defined in density profile

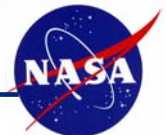


FASTE-CNS Generic Loading Analysis



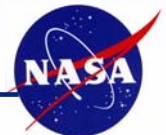
Airspace Concept Evaluation System (ACES)

- Used to evaluate operational concepts for improving the NAS
- Agent-based simulation of the NAS
- Focuses on representing the physical entities of the NAS (flights, air traffic services, environment).
- No integrated air-ground communication modeled
- Messaging is handled perfectly and instantaneously



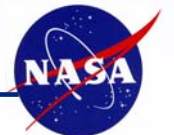
Data Sets Generated by ACES

- Aircraft
- Air Traffic Control System Command Center including Monitor Alert
- En Route Traffic Flow Management (TFM) and Air Traffic Control (ATC) including Conflict Detection & Resolution (CD & R) or Advanced Airspace Concepts (AAC)
- Terminal TFM & ATC
- Airport TFM & ATC including Surface Traffic Limitations (STL)
- Airline Operations Center (AOC)
- Traffic Demand
- Winds
- Airspace



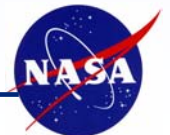
Data of Interest from ACES

- Data sent between the Aircraft and En Route TFM/ATC agents is of interest.



FASTE-CNS Performance Models

- Better alignment of the Pre-Analysis Communication capability with ACES.
- Establish Pre-Analysis Navigation and Surveillance
- Post-processing of ACES simulation runs to analysis of C-N-S characteristics.



ACES Pre-Analysis - Communication Model

- Model Inputs:
 - Communication Flight Data set
 - Radio Coverage Area set
 - Communication Media (VDL2, ACARS, Voice)
 - Time period for analysis
 - Amount of acceptable delay
- Model Output:
 - Graphical by RCA, number of frequencies needed for acceptable delay.
 - Tabular by RCA:
 - o Average and 95th percentile delay values
 - o Number of communication errors

ACES Post-Analysis - Communication Model

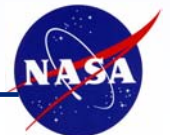
- Model Inputs:
 - ACES Output Data set
 - Radio Coverage Area set
 - Communication Media (VDL2, ACARS, Voice)
 - Time period for analysis
 - Amount of acceptable delay
- Model Output:
 - Graphical by RCA, number of frequencies needed for acceptable delay.
 - Tabular by RCA:
 - o Average and 95th percentile delay values
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ACES Pre-Analysis – Navigation Model

- User designates: flight plan and Navigation system
- Graphically displays two tracks
 - true position of the aircraft;
 - reported position of aircraft after the effects of navigation system are considered (pilot view)
- Flight plan of aircraft is determined from take-off to landing in one minute segments
- One flight plan considered at a time.
- Navigation systems modeled are Global Positioning System and VHF Omnidirectional Range/Distance Measuring Equipment.

ACES Post-Analysis - Navigation Model

- AircraftStateMessage generated by ACES Simulation form basis for performing post analysis navigation modeling
- Minute-by-minute aircraft location information
- ACES generates 4D reported locations of all of the aircraft
- Navigation System systems available to the user are GPS and VOR/DME.
- Aircraft separation violation reported based on the horizontal and vertical user-defined separation criteria



Navigation Model Details

- GPS
 - AircraftStateMessage reports the aircraft's true position components (latitude, longitude and altitude).
 - Aircraft's true position used as the mean in a normally distributed random number generator with standard deviation for latitude and longitude of 3.15 meters and altitude of 4.75 meters.
- VOR/DME
 - The VOR accuracy of course alignment is considered generally to be within ± 1 degree of the true heading.
 - This error shall be normally distributed around the aircraft heading with a standard deviation of ± 0.5 degrees.

ACES Pre-Analysis - Surveillance Model

- User designates: flight plan and Surveillance System
- Graphically displays two tracks
 - true position of the aircraft;
 - position of aircraft as presented to ATC controller
- Flight plan of aircraft is determined from take-off to landing in one minute segments
- Surveillance systems modeled are Secondary Surveillance Radar - SSR and Automatic Dependent Surveillance-Broadcast – ADS-B.
- Aircraft separation – user-defined

ACES Post-Analysis - Surveillance Model

- AircraftStateMessage generated by ACES Simulation form basis for performing post analysis surveillance modeling
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- Aircraft separation

Surveillance Model Details

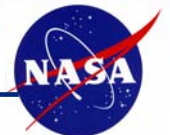
- **Secondary Surveillance Radar – SSR**
 - Accounting for SSR precision, smoothing of tracks and display delays.
 - Inaccuracy in radar precision is dependent on the CD-2 message field resolution which equates to $\pm 1/8$ nm for en-route radar.
 - Track smoothing keeps transitions between radar sweeps from “jumping” on the controllers console; it will occur about 10% of time.
 - True position (latitude and longitude from AircraftState Message) is mean in a normally distributed random number generator with standard deviation determined by RMS technique, combining errors from radar precision, smoothing and display delay.

Surveillance Model Details

- **Automatic Dependent Surveillance-Broadcast – ADS-B**
 - Accounting for ADS-B precision, smoothing of tracks and display delays.
 - Navigation system precision categorized into 12 values; passed as an accuracy code (NAC_p) – based on navigation system.
 - Track smoothing will occur about 10% of the time – using uniformly distributed random number generator.
 - Display Delay error associated with elapsed time between receiving ADS-B message and aircraft position displayed for controller – normal distribution with standard deviation of 1.7 sec.
 - True position from AircraftStateMessage is the mean in a normally distributed random number generator with standard deviation determined by RMS technique, combining errors from Nav. System precision, smoothing and display delay.

ACES Post-Analysis - Reporting

- Graphical display showing subregion distribution of separation violations.
- Tabular results by subregion of the evaluation of separation criteria – based upon a comparison of the location of each aircraft with those around it; determine if the separation criteria was violated



Conclusion

- Integrated CNS models into ACES is next step
- FASTE-CNS provides opportunity to meet August 2004 VAMS milestone and develop our knowledge of ACES

