Test & Demonstration Facilities Study

ACAST/SBT Workshop

August 17, 2005

Agenda

Accelerating CNS

- **Project Overview**
  - **Simulation/Emulation/Test/Demonstration**
- **Analysis Process Used**
- **"Snapshot" of the Work Products Produced**
- **Conclusions**

ACAST Sub Project Areas

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Transitional Architecture and Global Air/Ground Network

Spectrum Efficiency and Advocacy

Efficient Oceanic/Remote Communications & Surveillance

Improved Air/Ground Communications

Airport Surface &Terminal Network

High-Payoff CNS Technologies

Need for a CNS TDF

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- **ACAST Project**
  - **Foster the cross project efficient use of resources**
  - **Establish technology consensus through simulation/emulation modeling and system test & demonstration**
- **CNS research and development**
  - **Provide a clear demonstration of benefits to the operational services that are part of the new concepts for the National Airspace System**
  - **Provide a means for ATM designers to get answers on CNS questions**
    - » National Level system modeling
    - » Engineering assessment
- **Future Directions of implementation**
  - **Support the "Demonstrated" Business Value and ROI of new CNS capabilities**
  - **Requires a massive "Fly before buy" through modeling and simulation before investments are will be made**

Project Summary

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Project Purpose: Determine what should be considered as part of the ACAST CNS Test & Demonstration Facility?

- **Title: Advanced CNS Architectures and System Technologies (ACAST) Test & Demonstration Facility Requirements (ACAST-TDF).**
- **Project: Requirements assessment and systems engineering design Study for the development of the "objective system" ACAST-TDF.**
- **Deliverables: Seven System Engineering Documents and step by step reviews**
- **Plan: Ten main tasks over 7 month period**

Top 10 GRC TDF Needs Summary

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- **Incremental build of capability towards GRC CNS Test bed that supports the ACAST/SBT Subprojects**
- **Flexible to support testing of numerous CNS/ATM Concepts using multiple wireless channels (subnetworks) with new technology selected and inserted over time**
- **Provide an affordable approach to large scale testing by capitalizing on prior government investments**
- **Able to generate communication traffic loads of realistic, operational scenarios (flight plan driven – 4d trajectory)**
- **Performance evaluation of throughput, delay and other channel effects of aeronautical subnetworks**
- **Performance evaluation of selected N&S systems under load**
- **Include the RF effects and environment of mobile emitters**
- **Support mobile van or aircraft testing (Unit Under Test)**
- **Support repeatable experimental trials**
- **Support a facility infrastructure for command and control and analysis**

Project Task Flow Diagram

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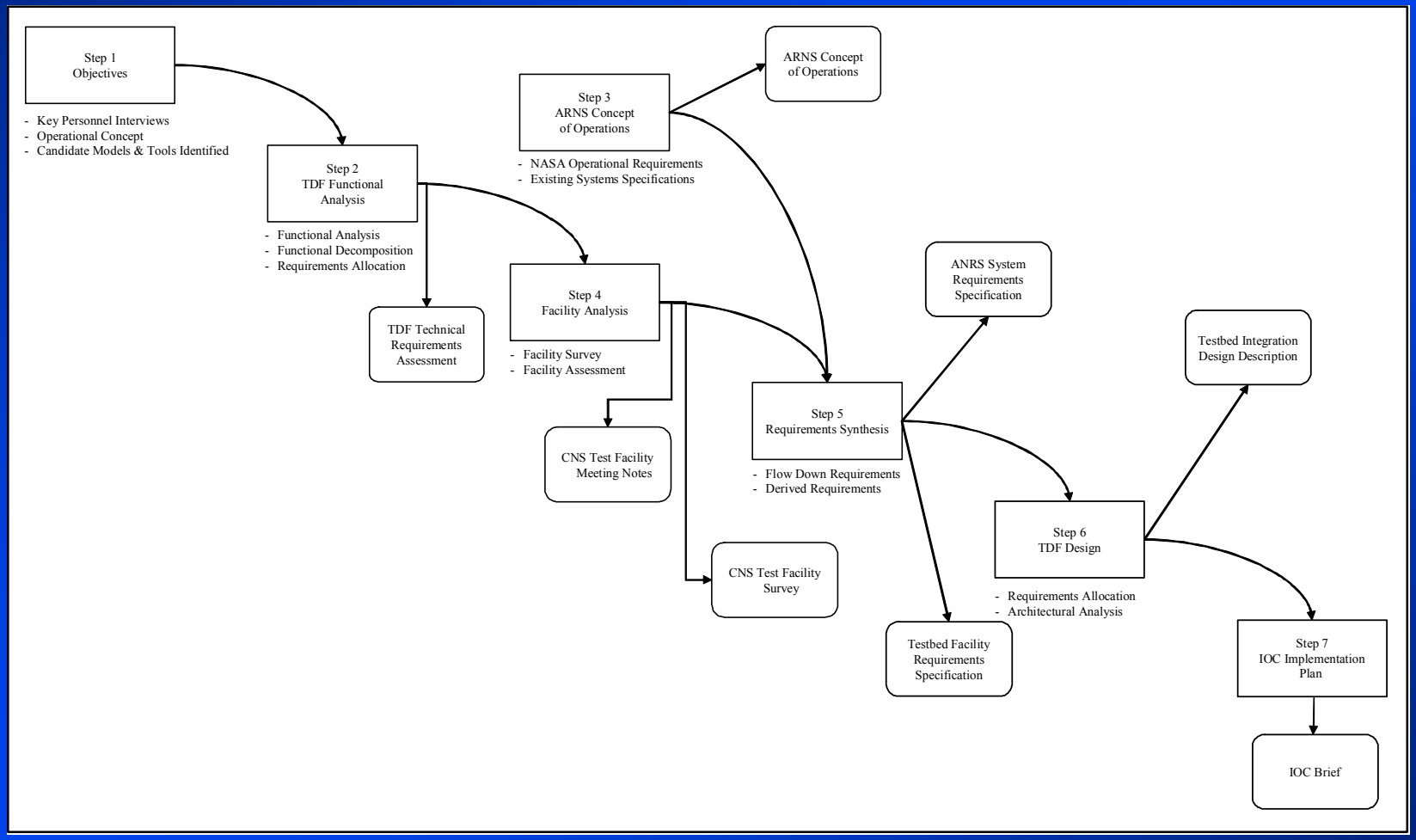

Study Work Products

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- **Technical Assessment**
  - **Each Sub-project reviewed and test needs mapped to logical architecture requirements and system test components**
- **TDF Requirements Specifications**
  - **System level functional and performance requirements organized according to the logical architecture**
- **Facilities/Organizations Site Survey Reports**
- **CNS Facilities Assessment**
  - **Study of about 80 CNS models, tools, and testbeds across 13 different government and university organizations**
  - **Identified existing core set of tools from the NASA Ames VAMS Project, NASA GRC Virtual Aircraft and Controller test system and the USAF Joint Communications Simulator**
- **TDF Design Description**
  - **Provides the logical system facility design**
- **ANRS Concept of Operations and System Specification**
  - **Integrates the GRC VAC and USAF JCS and traces requirements to ACAST TDF requirements**
  - **The ANRS performs 60% of the ACAST TDF requirements**
- **ANRS Initial Operating Capability Plan**
  - **Establishes the first functionality for ANRS**

Reports compromise approximately 1000+ pages

F2D2 - Analysis Methodology

- **Functional Flow – Description Diagrams (F2D2)**
- **Consistent method of summarizing requirements**
- **Requirements defined with a system context**

TDF Tier 0 Functions

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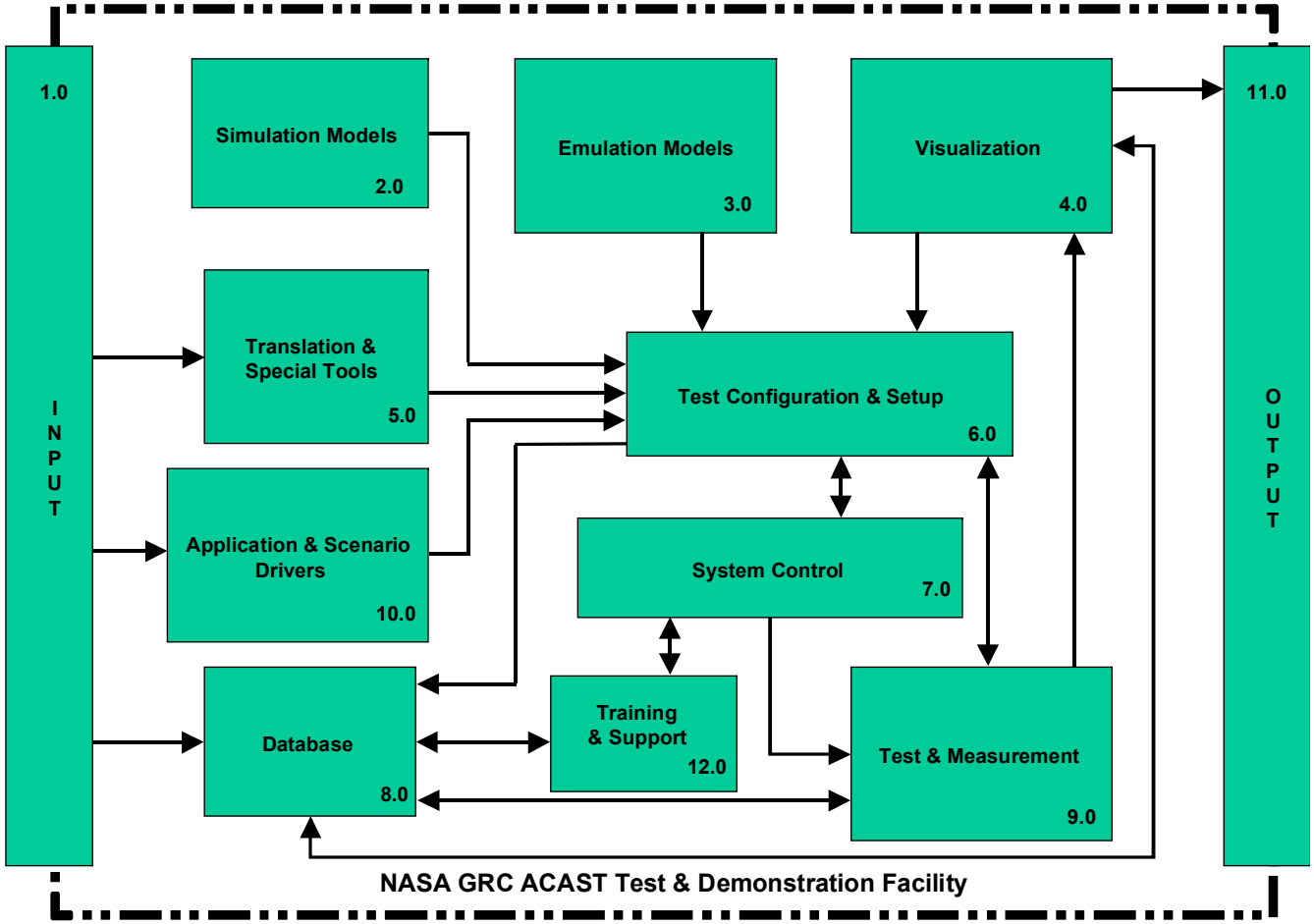

ACAST-TDF Functional Capabilities

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- **Communication Input/Output function is the boundary between the ACAST-TDF and external entities. These functions support communication with agencies and platforms that may supply CNS/ATM or other data communication inputs to or output from the ACAST-TDF.**
- **Simulation/Emulation Models provide the modeling capability for the ACAST-TDF. These functions are used to perform research on the characteristics and performance of air-ground communications links in the global CNS/ATM and AOC environments.**
- **Visualization Function provides the capability to record and maintain test events. A database of these events is the source for data reduction and analysis to develop technical and management reports.**
- **Translation and Special Tools provide support for data exchange and special requirements. They provide the capability to accept inputs from other entities and translate them into formats that can be used by other models and tools.**
- **Test Configuration and Setup supports experiment design and testing of communication scenarios. This function will be used to set up model parameters, desired density (e.g., number of aircraft, centers, etc.), types of scenario, communication links used, communication parameters, configuration, etc.**
- **System Control is the central nervous system of the ACAST-TDF. It provides the capability to monitor the health of the test facility and provide alerts when malfunctions occur.**

ACAST-TDF Functional Capabilities

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- **Database provides the capability for storing all data associated with the ACAST-TDF. This includes, but is not limited to: raw data from experiments, error logs, transmission logs, archives, a library (e.g., refined data, COTS or other documentation, map data, aircraft configurations (e.g., type, equipage, performance characteristics, etc.), flight plans, routes, schedules, coverage maps, ground facility configurations (e.g., type, equipage, etc.), reports, Configuration Management versions of any models used, CM backup (offsite storage), etc.), scripts and scenarios, and administrative records.**
- **Test and Measurement Function provides the capability to conduct end-to-end performance tests under load on various communication links, with the ability to measure loads, capacity, throughput, bandwidth used, latency, availability, link characteristics, link performance, network statistics, etc. These include physical demonstrations (i.e., use of the van or other communication source), link-level tests (loading, throughput, etc.), and entity tests (e.g., component, subnetwork, network, etc.)**
- **Application and Scenario Drivers support the modeling effort by providing variable inputs to the model runs. This function also includes message drivers, which will provide the ability to load circuits and applications by generating large numbers of applicable messages. Message drivers will also reduce or eliminate the requirement for a tester to compose and respond to message traffic. The inputs (drivers) may be automated or feature tester-in-the loop.**
- **Training and Support provides training and other administrative support. This may be embedded, computer-aided, or on-line support, or simply provide the capability to record and maintain training and administrative data in the database.**
- **Intra-facility Network provides internal network connectivity for the ACAST-TDF.**

Test/Demonstration System Components

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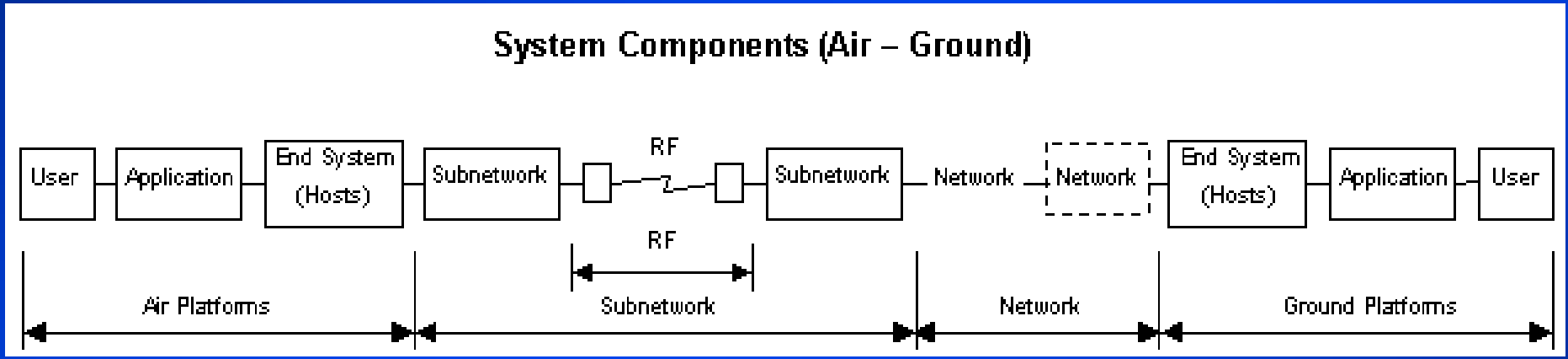

Interview Contact List (fall 2004)

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Robert J. Kerczewski	3-3434	ACAST Project Lead
Ronald J. Sicker	3-6498	ACAST Deputy Project Lead
Dave A. Buchanan	3-5228	ACAST Chief Engineer
Calvin T. Ramos	3-9391	Architecture and Networks, Technical Lead
Israel Greenfeld	3-5305	Oceanic Communications and Surveillance, Technical Lead
Monty Andro	3-3492	MMDA and VHF Technologies, Technical Lead
Rafael D. Apaza	3-5904	Surface ICNS and Terminal Area Communications, Technical Lead
Lawrence R. Foore	3-2346	Spectrum Research, Technical Lead
James Budinger	3-4396	Senior Engineer
William Ivancic	3-3494	Senior Engineer

Conducted key personnel interviews using questionnaire form

Extract Example - Analysis Matrix 1/

Accelerating CNS

Table D-1: End Systems (Air) Functional Requirements Pre-Assessment Matrix

Functional Architecture	(Please Note: L=Lead, I=Investigator)	Jim Budinger – FAA/Eurocontrol FCS	Larry Foore – Spectrum Research	Rafael Apaza – Terminal Area A/G Communications	Rafael Apaza – Surface Integrated CNS Networks	Monty Andro – Multifunction Multimode Digital Avionics	Monty Andro – VHF Systems Optimization	Dave Buchanan – CNS Technologies	Steve Mainger, C. Sheehe – Transitional CNS Architectures	Steve Mainger, C. Sheehe – Global Air/Ground Networks	Isi Greenfeld - Oceanic/Remote Communications and Surveillance	Isi Greenfeld – Space-Based Surveillance
	End Systems (Air)											
(1) Input	B-VHF	L		I		L	I		I	I		
	AOC/ATS Data link Service Provider (ARINC/ACARS)	L		I	I		I		I	I		
	AOC/ATS Data link Service Provider (ARINC/VDL Mode 2)	L		I	I		I		I	I		
	AOC/ATS Data link Service Provider (SITA/ACARS)	L		I	I		I		I	I		
	AOC/ATS Data link Service Provider (SITA VDL Mode 2))	L		I	I		I		I	I		
	Able to Capture Scripts/ Scenarios			I	I	I			I	I	I	
	Eurocontrol (LINK 2000+)				I	I			I	I	L	
	SDLS (ARINC 741 DL3)	L		I	I				I	I		
	Connexion By Boeing	L		I	I				L	I		
	Aero B-GAN & Inmarsat Family	L	L	I					I	L	L	
	3GPP UMTS (FDD)	L		I	L				I	I		
	CDMA2000 1xRTT	L		I	L		L		I	I		
(2) Simulation Models	Virtual Aircraft (Performance)	L			L	L			I	L	I	
	Aircraft Traffic	L			L	L			I	L	I	
	Other Special Tools				I	L			I	I	L	
	Terrain Model			I	I					I		
	Route/Traffic Model	L	I		I	L			I	L	I	

Extract Example - Analysis Matrix 1/3

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Functional Architecture	(Please Note: L=Lead, I=Investigator)	Jim Budinger – FAA/Eurocontrol FCS	Larry Foore – Spectrum Research	Rafael Apaza – Terminal Area A/G Communications	Rafael Apaza – Surface Integrated CNS Networks	Monty Andro – Multifunction Multimodenics	Monty Andro – VHF Systems Optimization	Dave Buchanan – CNS Technologies	Steve Mainger, C. Sheehe – Transitional CNS ctures	Steve Mainger, C. Sheehe – Global Air/Ground works	Isi Greenfeld - Oceanic/Remote ommunications and Surveillance	Space-Based Surveillance
	Weather		I		I	I	I		I	I	I	
	Virtual Aircraft (CPDLC MCDU MMI)	I	I	I	I				I	I	L	
	Virtual Aircraft –ADS-B/CDTI	I	I	I	I				I	I	L	
	Aircraft Flight plan Generator	I	I	I	I				I	I	L	
(3) Emulation Models	Virtual Aircraft (Performance)	L			L	L			I	L	I	
	Aircraft Traffic	L			L	L			I	L	I	
	Other Special Tools				I	L			I	I	L	
	Terrain Model			I	I					I		
	Route/Traffic Model	L	I		I	L			I	L	I	
	Weather		I		I	I	I		I	I	I	
	Virtual Aircraft (CPDLC MCDU MMI)	I	I	I	I				I	I	L	
	Virtual Aircraft –ADS-B/CDTI	I	I	I	I				I	I	L	
	Aircraft Flight plan Generator	I	I	I	I				I	I	L	
(4) Visualization	End of Simulation (experiment) Reports	I	I	I	I	L	I		I	I	I	
	Real Time Monitoring	I	I	I	I	L	I		I	I	I	
	Record Test Events	I	I	I	I	I	I		I	I	I	
	Maintain Logs Databases	I	I	I	I	L	I		I	I	I	
	OTS/PC-based Tools	I	I	I	I	I	I		I	I	I	
	Unique Display (GUI) show 3D tracking	I	I	I	I	L	I		I	I	I	
(5) Translation & Special Tools	Inputs from others											
	Format for our scenarios drivers			I	I	I				I		

Extract Example - Analysis Matrix 1/3

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Functional Architecture	(Please Note: L=Lead, I=Investigator)	Jim Budinger – FAA/Eurocontrol FCS	Larry Foore – Spectrum Research	Rafael Apaza – Terminal Area A/G Communications	Rafael Apaza – Surface Integrated CNS Networks	Monty Andro – Multifunction Multimode nics	Monty Andro – VHF Systems Optimization	Dave Buchanan – CNS Technologies	Steve Mainger, C. Sheehe – Transitional CNS ctures	Steve Mainger, C. Sheehe – Global Air/Ground works	Isi Greenfeld - Oceanic/Remote ommunications and Surveillance	Isi Greenfeld – Space-Based Surveillance
	Scripts/Scenarios			I	I	I			I		I	
	Administrative			I	I	I			I	I	I	
(9) Test & Measurement	End-to-end		L	I	I	I			I	I	I	
	Performance under load		L	I	I	L			I	L	I	
	Physical demonstration capabilities (e.g., drive van around, test aircraft)		L	I	I	I			I	I	I	
	Inject errors		L	I	I	I				I		
	Compare with previous trials		L	I	I	I				I		
	Comparison testing of one Subnetwork to another		L	I	I	I				I	I	
(10) Application & Scenario Drivers	Application Drivers											
	CPDLC (ATN-Baseline 1)			I	I				I	I	I	
	FANS CPDLC										L	
	ATN ADS										L	
	FANS ADS										L	
	ADS-B			I	I				I	I	L	
	TIS-B			I	I				I	I	I	
	ATN FIS										I	
	FIS-B			I	I				I	I	I	
	CM			I					I	I	I	
	FAA PDC				I					I		
	ARINC 620 and ARINC 623 fielded applications (D-ATIS, TWIP, OCD, DDTC, etc.)			I	I				I	I	I	
	DGPS-LAAS, WAAS			I	I				I	I	L	

Extract Example - Analysis Matrix 1/3

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Table D-2: Subnetwork Functional Requirements Pre-Assessment Matrix

Functional Architecture	(Please Note: L=Lead, I=Investigator)	Jim Budinger – FAA/Eurocontrol FCS	Larry Foore – Spectrum Research	Rafael Apaza – Terminal Area A/G Communications	Rafael Apaza – Surface Integrated CNS Networks	Monty Andro – Multifunction Multimodes	Monty Andro – VHF Systems Optimization	Dave Buchanan – CNS Technologies	Steve Mainger, C. Sheehe – Transitional CNS ctures	Steve Mainger, C. Sheehe – Global Air/Ground works	Isi Greenfeld - Oceanic/Remote ommunications and Surveillance	Isi Greenfeld – Space-Based Surveillance
	Mode S (ADS-B/TIS-B)				I	L	I		I	L	I	
	SATCOM Data 3		I			L	I		I	I	I	
	Other SATCOM (Swift-Broadband)		I			L	I		I	I	I	
	HF RLS					L			I	I	L	
	Other HF					L			I	I	L	
	DGPS		I	I	I	L			I	I	L	
	GPS		I	I	I	L			I	I	L	
	Link 16					L						
	UHF				I	L			I		L	
	MLS (using future scheme)	I	L		I	I			L	I	L	
	802.11			I	I				I	I		
	802.16			I	I				I	I		
	VDL over IP			I	I	I	I		I	I		
	Voice			I	L	L	I		I	I	I	
	Model Connectivity				L	L	I		I	I	I	
	Model Mobility											
	Hand-off				I	I	L		I	I	I	
	Auto transfer from one coverage area to another coverage area (roaming)				I	I	L		I	I	I	
	Routing				I	I	I		I	I	I	
	Simultaneous Multiple Instantaneous Subnetwork				I	I	L		I	I	I	
	Any plane can connect to Multiple Subnetwork				I	I			I	I	I	
	Any ground center can connect to plane by multiple Subnetwork				I	I			I	I	I	
	Mobile network within mobile network (virtual aircraft)				I	I			I	I	I	

…….. Plus 25 pages

TDF Specification

- **Need for components ranked**
- **High and medium ranked items included in the development of specification statements for the ACAST TDF**
- **Specification developed by Mulkerin Associates, Inc.**

Table B-1. Input Functional Entity

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TDF Specification Development

Functional Entity	End Systems (Air)	Req	Radio Frequency (RF)	Req	Network	Req	End Systems (Ground)	Req
(1) Input	B-VHF	1-1	Capture Traffic by Monitoring VHF, HF, Satellite, etc.	1-13	Refer to End System I/O	N/A	Collaborative Decision Making System (CDMS)/ Flow Control Facility	1-15
	AOC/ATS Data link Service Provider (ARINC/ACARS)	1-2	RF emissions for mobile and fight demos (potentially for all RF/waveforms)	1-14			ATC Centers (ATOP, ARTCC, Tower, Terminal)	1-16
	AOC/ATS Data link Service Provider (ARINC/VDL Mode 2)	1-3					Real World AOC Systems	1-17
	AOC/ATS Data link Service Provider (SITA/ACARS)	1-4					ARINC	1-18
	AOC/ATS Data link Service Provider (SITA VDL Mode 2))	1-5					SITA	1-19
	Able to Capture Scripts / Scenarios	1-6					Cellular (i.e., Singular or others)	1-20
	EUROCONTROL (Link 2000+)	1-7					Broadband service providers	1-21
	SDLS (ARINC 741 DL3)	1-8					Iridium	1-22
	Connexion By Boeing	1-9					Inmarsat providers (Swift 64, Swift-Broadband)	1-23
	Aero B-GAN & Inmarsat Family	1-10					FAA Networks - NADIN	1-24
	3GPP UMTS (FDD)	1-11					FAA Networks - FTI	1-25
	CDMA 2000 1xRTT	1-12					DHS/TSA	1-26
							ETMS (Aircraft Tracking Reports)	1-27
							Weather service provider	1-28
							FIS information source	1-29

- **Example: Statements turned into dimensioned requirement sentences**

TDF Requirements Specification Outline

1. INTRODUCTION
   - 1.1. Identification
   - 1.2. ACAST-TDF Development Process
   - 1.3. Testbed Facility Overview
   - 1.4. Document Overview
   - 1.5. Terms and Acronyms
2. APPLICABLE DOCUMENTS
3. METHODOLOGY
   - 3.1. Logical Model Used in Assessment Report
   - 3.2. ACAST-TDF Functional Architecture
   - 3.3. Identified and Derived Requirements
4. FACILITY REQUIREMENTS
   - 4.1. ACAST Testbed Facility Overall Vision
   - 4.2. Input Functionality
   - 4.3. Simulation/Emulation Models Functionality
   - 4.4. Visualization Functionality
   - 4.5. Translation and Special Tools Functionality
   - 4.6. Test Configuration and Setup Functionality
   - 4.7. System Control Functionality
   - 4.8. Database Functionality
   - 4.9. Test and Measurement Functionality
   - 4.10. Application and Scenario Drivers Functionality
   - 4.11. Output Functionality
   - 4.12. Training and Support Functionality
5. QUALITY ASSURANCE

APPENDIX A: ACRONYMS

APPENDIX B: ACAST-TDF TECHNICAL REQUIREMENTS ASSESSMENT REPORT FUNCTIONAL REQUIREMENTS

APPENDIX C: REQUIREMENTS TRACEABILITY MATRIX *(616 Requirements)*

Sites/Facilities Included

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- FAA William J. Hughes Technical Center (WJHTC)
- MITRE Center for Advanced Aviation Systems Development CAASD)
- Ohio University NASA Ames Research Center
- Joint University Program (Massachusetts Institute of Technology Lincoln Laboratory, Ohio University, and Princeton University
- Department of Defense Technical Labs
- Embry-Riddle Aeronautical University
- Mike Monroney Center (MMAC)
- MIT Lincoln Laboratory
- NASA Glenn Research Center
- NASA Langley Research Center
- Northwestern University
- The John A. Volpe National Transportation Systems Center (Volpe Center

Result: Produced Survey and Evaluation Report

Identified Key Systems/Facilities

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- **Decision to form the TDF Core from existing system set**
- **NASA Investment:**
  - **Virtual Airspace Modeling & Simulation System (VAMS)**
    - » Airspace Concept Evaluation System (ACES) with CNS Models
  - **ACAST Project goal to develop national resource for CNS testing**
    - » Virtual Aircraft and Controller (VAC) Communications Test System
- **DoD Investment**
  - **USAF Joint Communications Simulator (JCS)**

CNS TDF Concept

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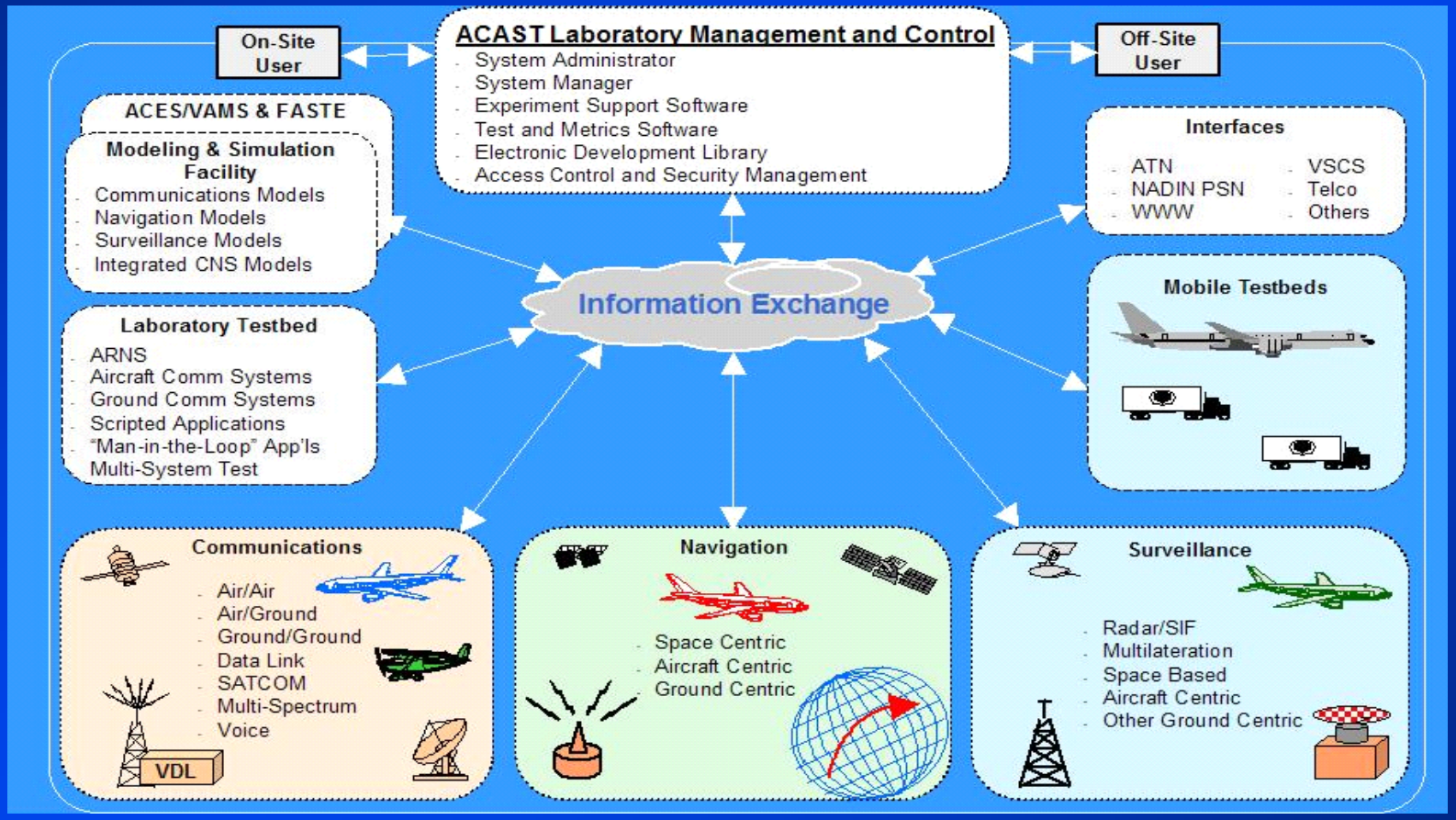

Aviation System Reference Architecture

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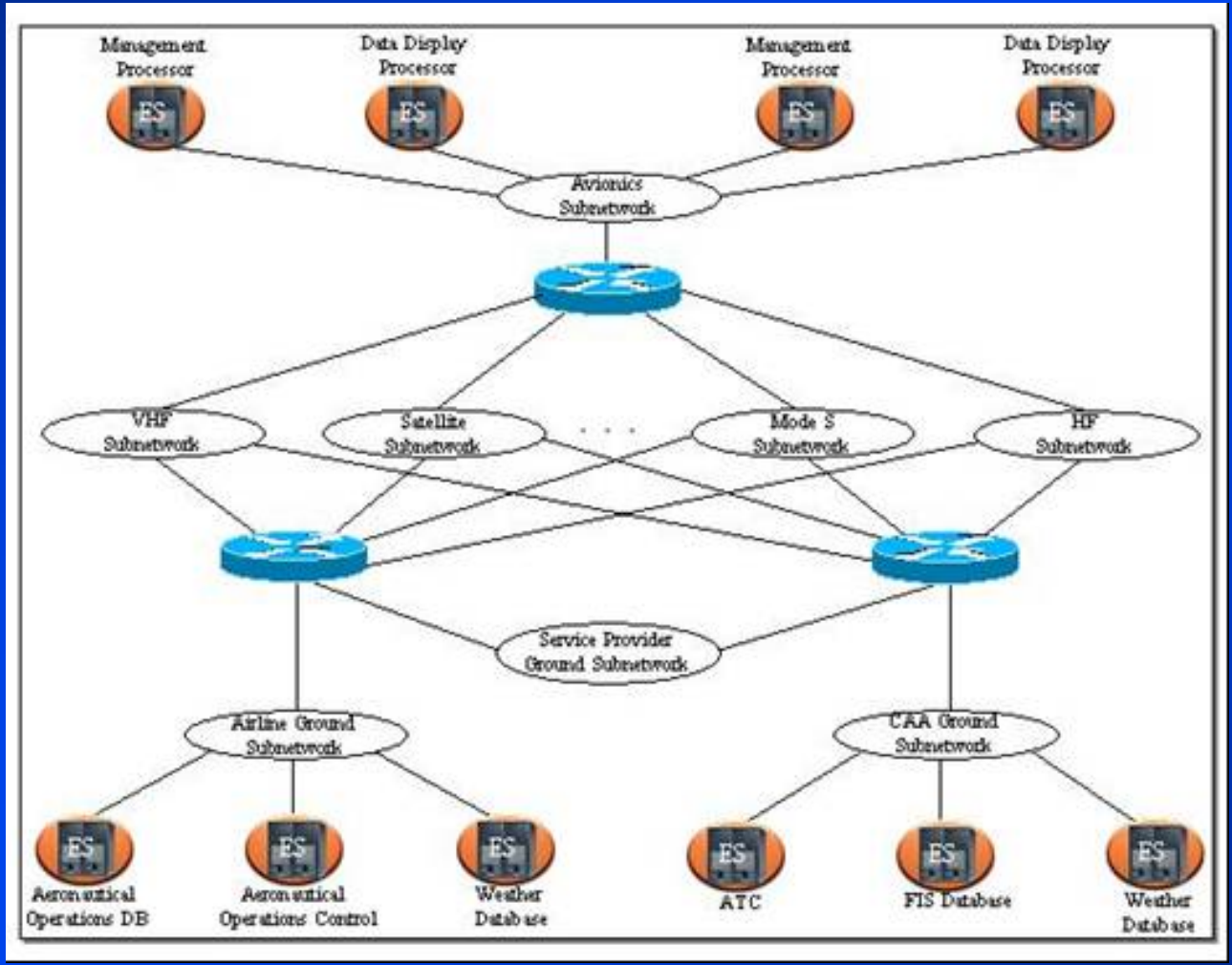

ACAST-TDF Functional Architecture

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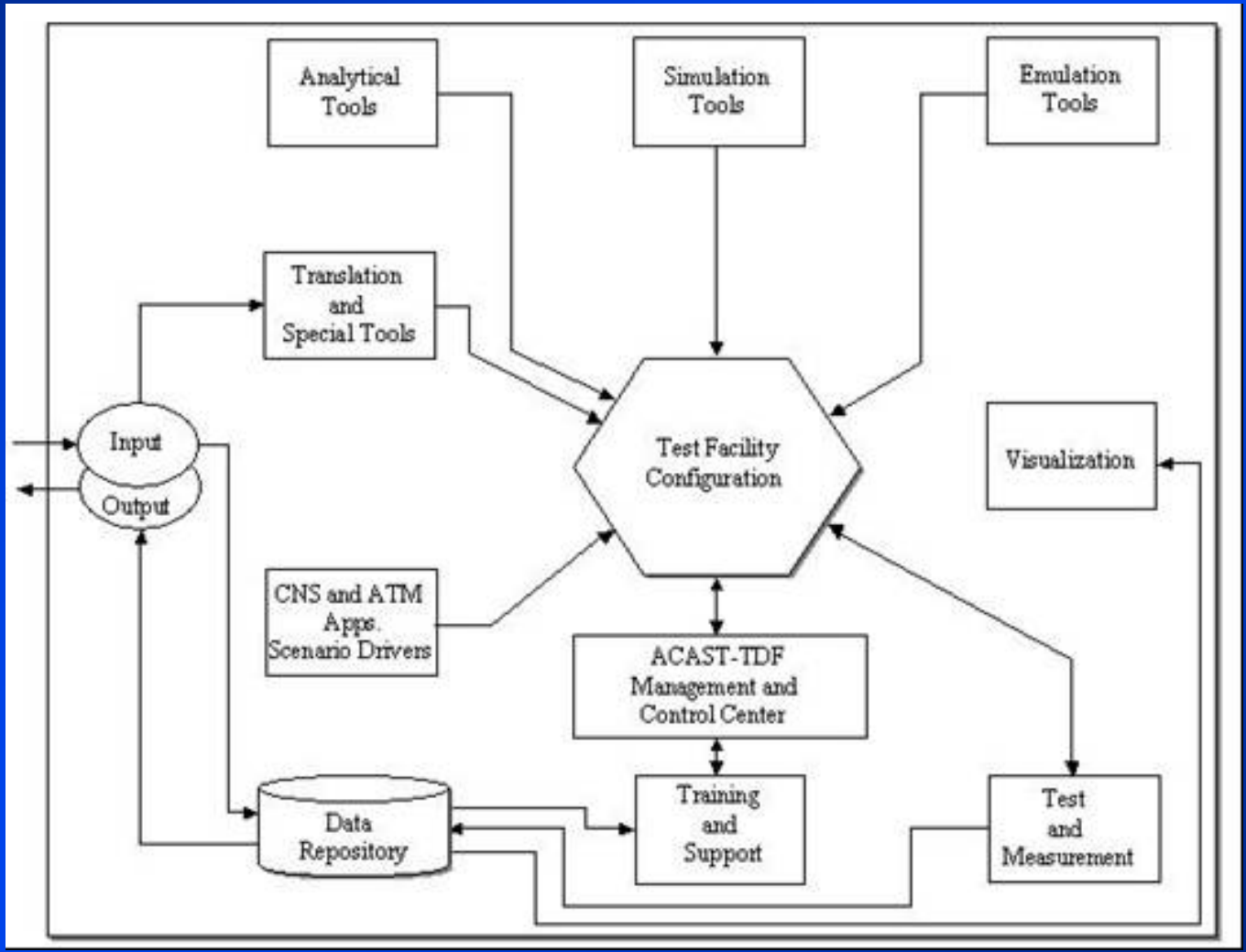

ACAST TDF Design Description 1/3

Accelerating CNS

- 1. INTRODUCTION
- 1.1. Purpose
- 1.2. Project Description
- 1.3. Methodology
- 1.4. ACAST-TDF Development Process
- 1.5. ACAST Test and Demonstration Facility Overview
- 1.6. Report Organization
- 2. APPLICABLE DOCUMENTS
- 3. NAS OVERVIEW
- 3.1. NAS Architecture
- *3.1.1. Communications*
- *3.1.2. Navigation Systems*
- 3.1.2.1. Navigational Aids
- 3.1.2.2. Global Positioning System
- *3.1.3. Surveillance Systems*
- 3.1.3.1. Mode-S Transponder
- 3.1.3.2. Mode-C Transponder
- 3.1.3.3. Tracking Radar
- 3.1.3.4. Automatic Dependent Surveillance-Broadcast
- 3.1.3.5. Traffic Information Service
- 3.1.3.6. Traffic Collision Avoidance Service
- 3.2. NAS Proposed Capabilities
- 3.3. CNS Reference Architecture
- *3.3.1. End Systems*
- *3.3.2. Subnetworks*
- *3.3.3. Air-Ground (Mobile) Subnetworks*
- *3.3.4. Ground-Ground Subnetworks*
- *3.3.5. Avionics Subnetworks*
- 4. ACAST TEST AND DEMONSTRATION FACILITY CAPABILITIES
- 4.1. System Overview
- 4.2. ACAST-TDF Design Parameters
- *4.2.1. Test and Demonstration Attributes*
- 4.2.1.1. Generality
- 4.2.1.2. TDF Dimension
- 4.2.1.3. Flexibility
- 4.2.1.4. Scalability
- 4.2.1.5. Virtualization
- 4.2.1.6. Performance Measurement Capability
- 4.2.1.7. System Control
- 4.2.1.8. Security

ACAST TDF Design Description 2/3

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- 5. ACAST-TDF FUNCTIONAL ARCHITECTURE
- **5.1. ACAST-TDF Overall Vision**
- ***5.1.1. Input Function***
- ***5.1.2. Analytical, Simulation and Emulation Models***
- **5.1.2.1. Subnetwork Models**
- **5.1.2.2. Network Models**
- **5.1.2.3. RF Models**
- **5.1.2.4. End System Models Function**
- ***5.1.3. Translation and Special Tools***
- **5.1.3.1. Translation Tools Function**
- **5.1.3.2. Special Tools Function**
- ***5.1.4. Test Facility Configuration***
- ***5.1.5. CNS and ATM Application Scenario Drivers***
- **5.1.5.1. Message Generator Function**
- **5.1.5.2. Application Drivers Function**
- **5.1.5.3. Scenario Drivers Function**
- ***5.1.6. Test and Measurement Capability***
- **5.1.6.1. End System Toolbox Function**
- **5.1.6.2. Subnetwork Toolbox Function**
- **5.1.6.3. RF Toolbox Function**
- **5.1.6.4. Network Toolbox Function**

- ***5.1.7. Visualization***
- **5.1.7.1. Display Function**
- **5.1.7.2. Report Generation Function**
- ***5.1.8. ACAST-TDF Management and Control Center***
- **5.1.8.1. Configuration Management Function**
- **5.1.8.2. Associated Configuration Function**
- **5.1.8.3. Control Function**
- **5.1.8.4. Monitor Function**
- **5.1.8.5. Fault Isolation and Diagnostic Function**
- **5.1.8.6. Preventive Maintenance Function**
- **5.1.8.7. Help Desk Function**
- **5.1.8.8. Scheduling Function**
- **5.1.8.9. Security Function**
- ***5.1.9. Data Repository***
- **5.1.9.1. Data Storage Function**
- **5.1.9.2. Data Retrieval Function**
- **5.1.9.3. Data Reduction and Analysis Function**
- **5.1.9.4. User Management**
- ***5.1.10. Training and Support***
- ***5.1.11. Output Capability***

ACAST TDF Design Description 3/3

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- 6. ACAST EXISTING AND NEAR TERM TEST AND DEMONSTRATION CAPABILITIES
- 6.1. Existing Capabilities
- *6.1.1. Analytical Modeling Tools*
- 6.1.1.1. Future Aeronautical Subnetworks Traffic Evaluator for CNS (FASTE-CNS) Communications Load Analysis Tool
- 6.1.1.2. Summary
- *6.1.2. Simulation Tools*
- 6.1.2.1. Cleveland State University OPNET Models
- 6.1.2.2. FASTE-CNS With CNS Model
- *6.1.3. Emulation Tools*
- 6.1.3.1. Virtual Aircraft and Controller Testbed
- 6.2. Near Term Capabilities
- *6.2.1. Simulation Tools*
- 6.2.1.1. Airspace Concept Evaluation Systems (ACES) With CNS Modeling Extensions
- *6.2.2. Emulation Tools*
- 6.2.2.1. Aeronautical Network Research Simulator
- 6.3. External Capabilities

- 7. ACAST-TDF DESIGN DESCRIPTION SUMMARY
- **8. APPENDIX A. TERMS AND ACRONYMS**
- **9. APPENDIX B: Allocation of the ACAST-TDF functional entities to the architectural elements.**
- 10. APPENDIX C **Facility Requirements Matrix**

Top ANRS Capabilities

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- **Emulation of end-to-end system effects using real world NAS scenario and CNS equipage.**
- **Flexible to support testing of numerous CNS/ATM Concepts using multiple wireless channels (sub networks)**
- **Allows multiple emitters interacting on one platform**
- **Include the RF effects of mobile emitters. Incorporates the "physics of wireless" including signal propagation, antenna patterns, aircraft shadowing, terrain effects in dynamic (mobile) environment**
- **Capable of incremental build of capability towards GRC CNS TDF**
- **Provides an affordable approach to large scale testing**
- **Able to generate CNS communication traffic loads of realistic, operational scenarios (flight plan driven)**
- **Performance evaluation of throughput, delay and other channel effects of aeronautical subnetworks**
- **Performance evaluation of selected N&S systems under load**
- **Support mobile van or aircraft testing (UUT) includes man in the loop**
- **Support repeatable experimental trials**
- **Provides an infrastructure for command and control and analysis**

Conclusion

- **No comprehensive COTS CNS test facility to accomplish the ACAST goals exists**
- **All the ACAST Sub-Projects can benefit from the envisioned Simulation/Emulation/TDF**
- **The ACAST TDF can be seen as national asset as it allows flexibility to scale ATM concepts and RF solutions**
  - **Supported by interconnectivity to other organizations**
- **NASA has an opportunity to leverage its past investment and that of DoD in developing the ANRS as a core capability for the TDF**
- **The CNS TDF can be built incrementally to follow funding profiles of the ACAST Project**
- **Does not preclude project specific testbeds or demonstration activities – nor additional of other existing and new tools**

Contacts

Accelerating CNS

Computer Networks & Software, Inc.
Chris A. Wargo
7405 Alban Station Ct.
Suite B-215
Springfield, VA 22150-2318
703-644-2103
443.994.6137 (cell)
Chris.Wargo@CNSw.com

ViaSat Corporation
Mike Kocin
6155 El Camino Real
Carlsbad, CA 92009-2318
(760) 476-2342
mike.kocin@viasat.com