Terminal Area Air-Ground Communications CNS Requirements Study Project

ACAST/SBT Workshop Review

August 16, 2005

Agenda

- **Project Summary**
- **MIA TRACON**
- **Communications Traffic Load Modeling**
- **2015 &2030 ConOps – Load Modeling**
- **Logical Architecture**
- **Conclusions & Summary**

Project Summary

- **Customer: NASA Glenn Research Center, Cleveland, Ohio**
- **Title: Terminal Area Air-Ground Communications -ACAST**
- **Project: Perform a description and requirements assessment for Terminal Class B (MIA) and Terminal Class C (FLL) Airspace. Develop a logical architecture for existing and future terminal area technical CNS infrastructure.**
- **NASA Leads: Rafael Apaza (FAA), Nam T Nguyen**
- **Deliverables:**
  - **Kickoff Meeting and Monthly Status Telcons**
  - **Assessment Document (Draft and Final)**
  - **Key Stakeholder Meetings**
  - **Mid-term and Final Review**
- **Schedule/Plan: Ten basic tasks, 8 month period (6 Dec 04 start)**
- **Today's Objective:**
  - **Overview of results – limit today's discussion to MIA and Communications**

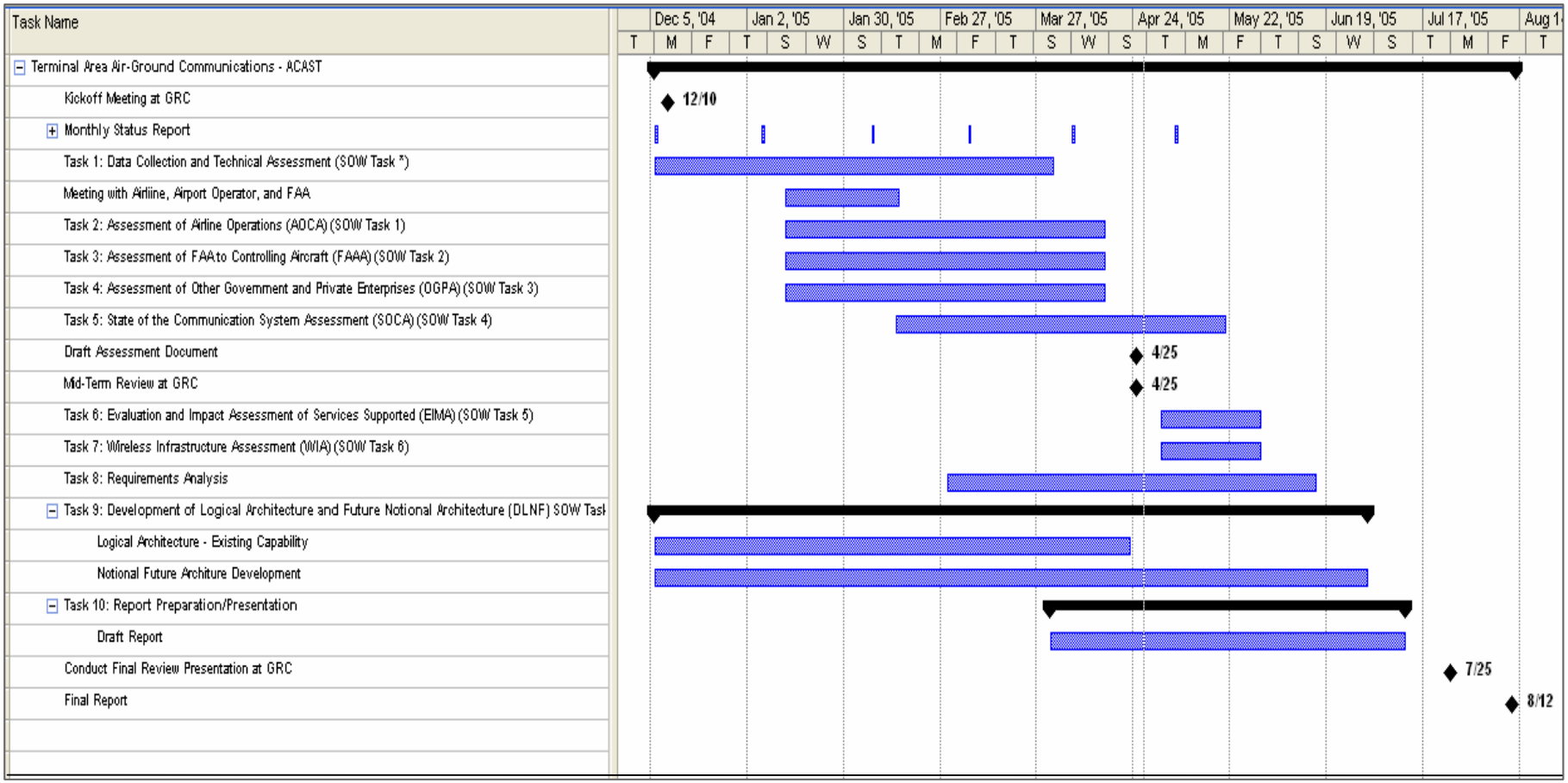
Project Team Organization

- **NASA Glenn Research Center**
  - **Rafael Apaza – FAA, ACAST Sub Project Lead**
  - **Nam T Nguyen – NASA COTR**
  - **Thanh Cong Nguyen - Analex**
- **Computer Networks & Software, Inc.**
  - **Chris Wargo – Program Manager**
  - **Chris Dhas, Ph.D – Technical Director**
  - **Crispin Netto – Senior Engineer**
  - **Gregory Jones – System Engineer**
  - **Sanil Vidyanandan – Software Engineer**
- **Raytheon Network-Centric Systems**
  - **Edward Stevens – Program Manager**
  - **Mary Ellen Miller – Consulting Technical Lead**
  - **Pavan Reddy – Principle Engineer**

Acknowledgements

- **United Airlines:**
  - **Mr. Marc Brodbeck**
  - **Mr. Joe Burns**
- **Worldwide Integrated Flight Support Corporation:**
  - **Mr. Dave Knerr**
- **MAI:**
  - **Mr. Tom Mulkerin**
  - **Mr. Ralph Dority**
  - **Mr. Bruce Paul**
- **SITA Corporation:**
  - **Ms. Kathleen Kearns**
- **Microflight, Inc.:**
  - **Mr. Jim Meer**
- **Organizations:**
  - **Airline Frequency Committee (ARINC)**
  - **FAA Potomac TRACON**
  - **FAA Miami TRACON**
  - **Signature Flight Support, Dulles International Airport (IAD)**

Project Schedule



Study Activity Summary

- **Two Phase Approach:**
  - **Phase 1**
    - » Draft Mid-term Document is the data collection results
      - FAA Miami TRACON Visit Airline Visit
      - Description of C, N, & S Systems and use in MIA & FLL
      - Working Session at United Airlines Flight Dispatch Center
      - FBO Visit
      - Application message related profiles developed
      - Draft Document prepared
    - » Additional Survey Activities
      - Working meetings held at the Potomac TRACON, with former ATC Controller and GA pilot or additional information.
      - Visit to Cleveland Enroute Center
      - FAA supported obtaining aircraft traffic data from FAA labs and Frequency data
  - **Phase 2**
    - » Developed Concept of Operations for 2015 and 2030
    - » Projected use of CNS and requirements for envisioned operational concepts
    - » Performed communications loading modeling using FASTE-CNS
    - » Depiction of several future notional architecture approaches
    - » Final Report

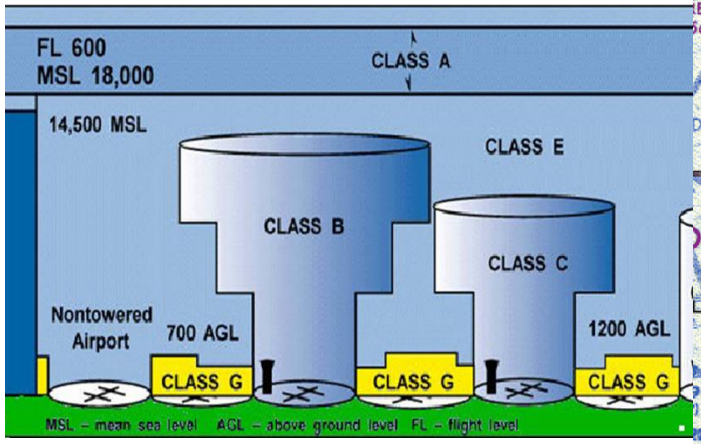
Final Report Overview

- **Section 1. Introduction**
- **Section 2. Applicable References**
- **Section 3. Operational Overview**
- **Section 4. CNS Systems Descriptions**
  - » Existing, Emerging & Future (detailed CNS DESCRIPTIONS Appendix)
- **Section 5 & 6. MIA & FLL Existing CNS Systems**
- **Section 7 & 8. MIA & FLL Requirements**
  - **Existing, 2015 and 2030**
- **Section 9. Architectures**
- **Section 10 & 11.Conclusions & Recommendations**
- **Appendices**

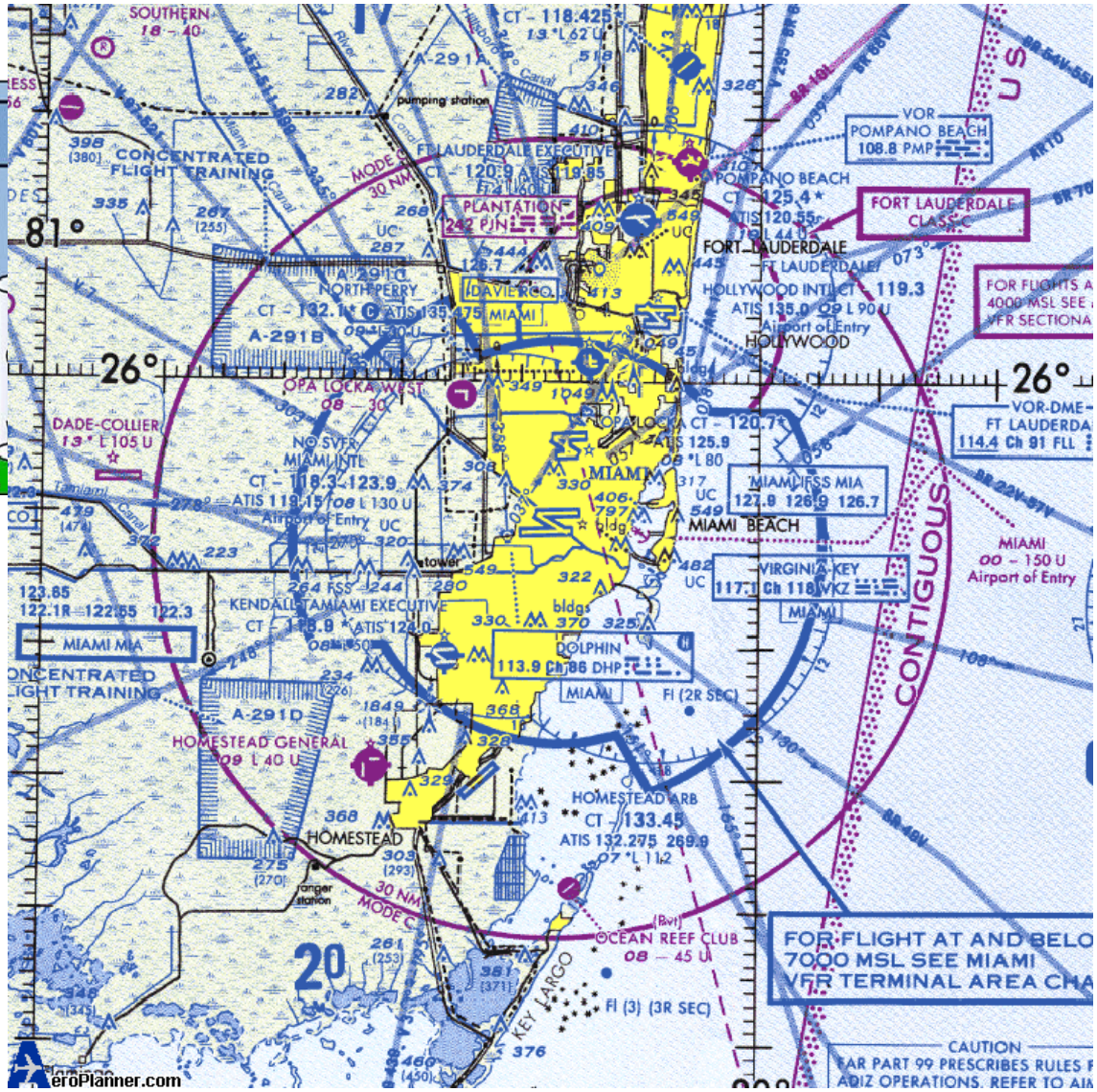
ATC Operational Overview

- Miami ARTCC
  - responsible for provide separation between, and expedite the movement of, IFR traffic, both civilian and military, airspace delegated to it
- Miami TRACON
  - The main function of a Terminal Radar Approach Control Facility (TRACON) is to control the airspace around airports with high traffic density. The TRACON area of coverage is approximately 35-mile radius from the airport.
  - Approach & Departure Control for both MIA, FLL and various satellites airports.
  - Radar controller use vectoring technique to guide aircraft during approach.
  - Coverage up to 16000 ft
- Miami/FLL ATCT/Tower
  - Local Control aircrafts arrive or departing,
  - Ground control at airports

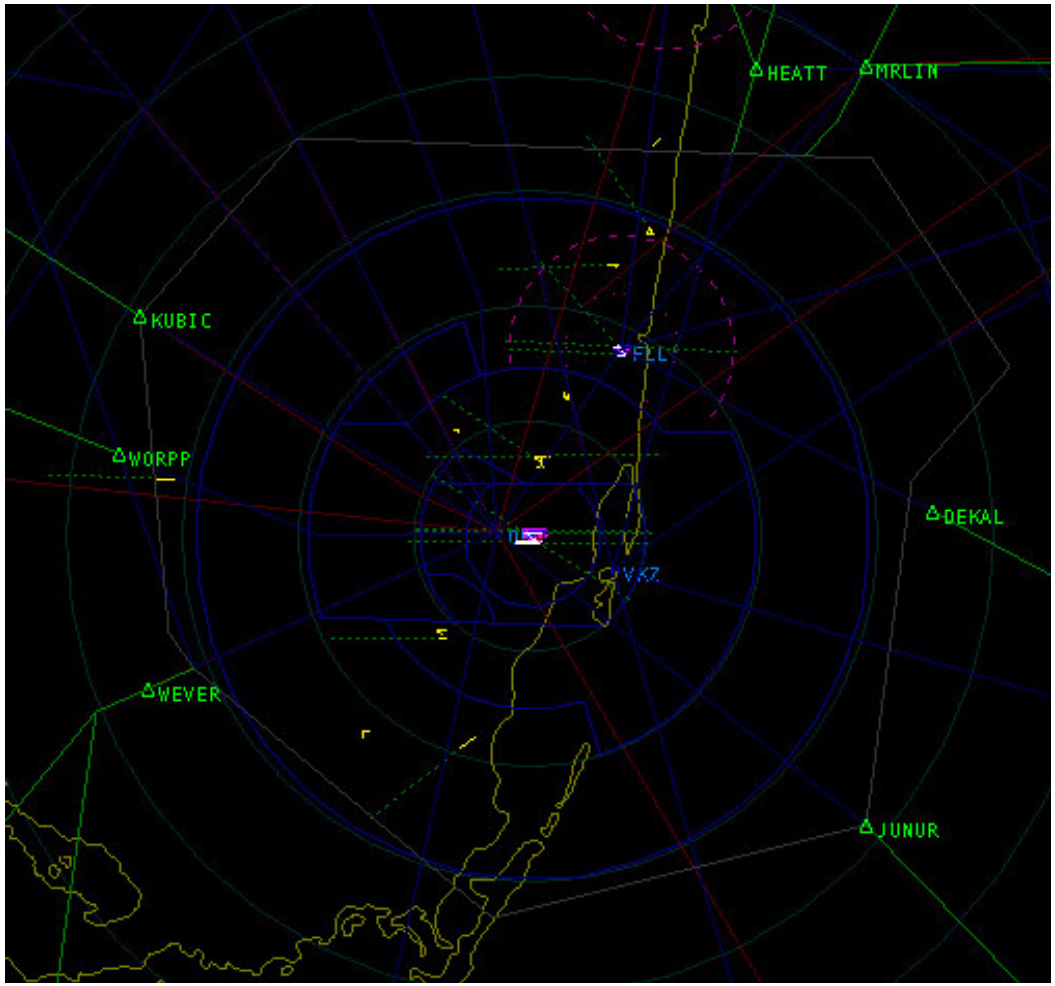
Miami TRACON Airspace



- **Total Passengers FY 03: 29.6 million passengers (13.9 Intl.)**
- **Other Airports under/near Class B Miami Airspace**
  - **Kendall-Tamiami Executive**
  - **Miami Opa Locka Airport**
  - **North Perry Airport**
  - **Opa Locka West**
- **Ranked 12th in the Us and 20th in the World (FY03)**

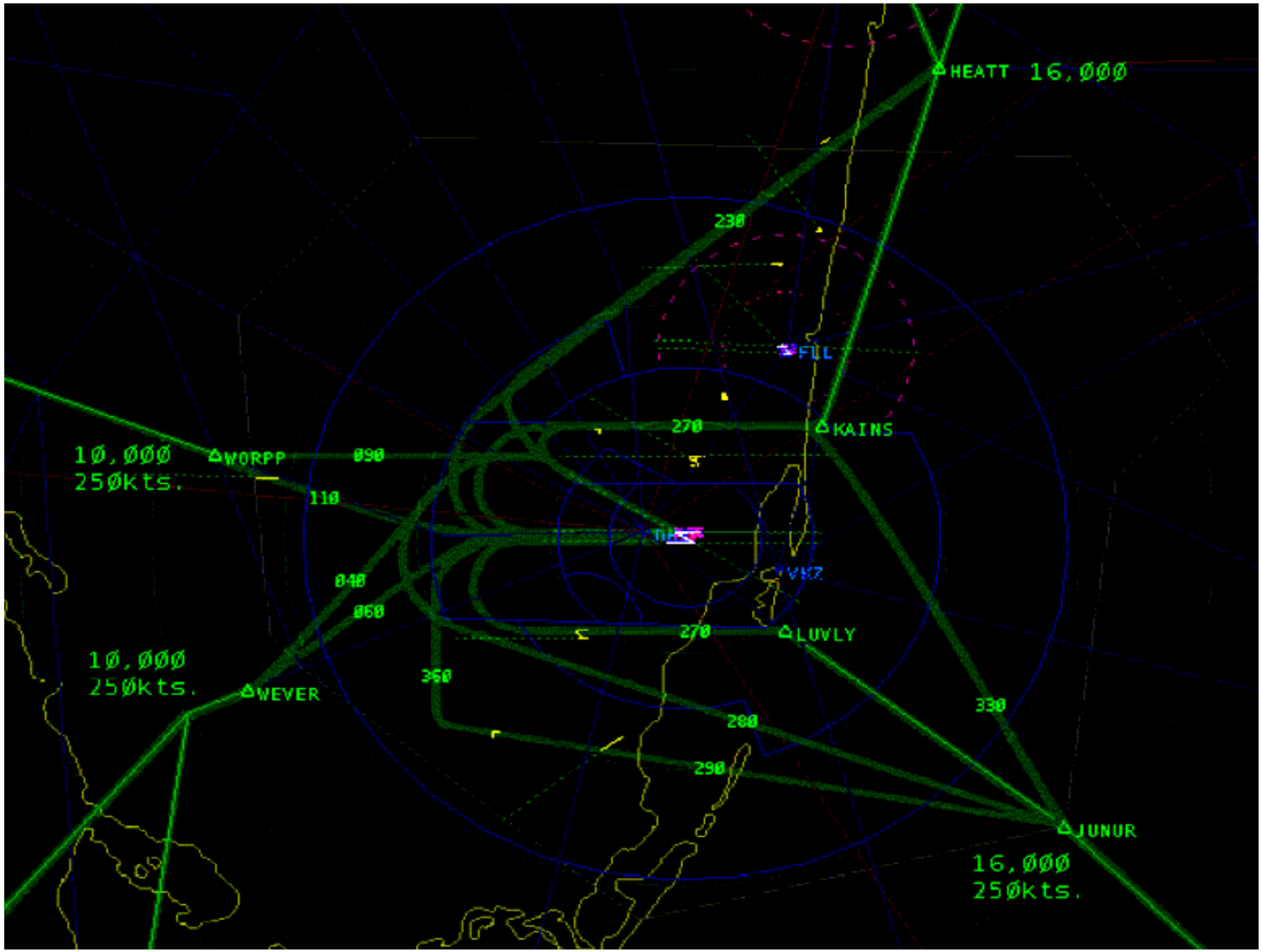


Miami & FLL Arrival Fixes



- **7 Arrival Fixes at the Miami TRACON-ARTCC sector boundary**
- **Arrival Fixes act as gateways into Miami/FLL Approach**
- **Most Traffic arrives from the Northeast (HEATT/MRLIN)**

Miami Approach Paths (West)



CNS Systems Included in the Study

Communications	Navigation	Surveillance
Area Control facility	Non Direction Beacon (NDB)	Short Range Radar (SRR)
Remote Communications Facility	VHV Omni-directional Range (VOR)	Airport Surveillance Radar (ASR)
DSB AM Radio	Distance Measuring Equipment (DME)	Mode S
Leased Interfacility NAS Communications system (LINCS)	Tactical Air Navigation (TaCAN)	Precision Approach Radar (PAR)
Radio Communications Link (RCL)	VOR + TACAN (VORTAC)	Fixed Based Precision Approach Radar (FBPAR)
FTS2001	Instrument Landing System (ILS)	Precision Runway Monitor (PRM)
Low Density RCL (LDRCL)	Localizer Directional Aid	Air Route Surveillance Radar (ARSR)
FAA Telecommunications Satellite (FAATSAT)	Simplified Directional Facility (SDF)	Airport Surface Detection Equipment (ASDE)
ACARS	Microwave Landing System (MLS)	Airport Movement Area Safety System (AMASS)
VDL Mode 0/A	Long Range Navigation-C (LORAN)	Airport Surface Detection Equipment (ASDE-X)
VDL Mode 2	Global Navigation Satellite System (GNSS)	Automatic Dependence Surveillance (ADS)
VDL Mode 3	Global Positioning System (GPS)	Automatic Dependence Surveillance – Broadcast (ADS-B)
VDL Mode 4	Wide Area Augmentation System (WAAS)	Traffic Alert and Collision Avoidance System (TCAS)
UAT	Local Area Augmentation System (LAAS)	Traffic Information Service – Broadcast (TIS-B)

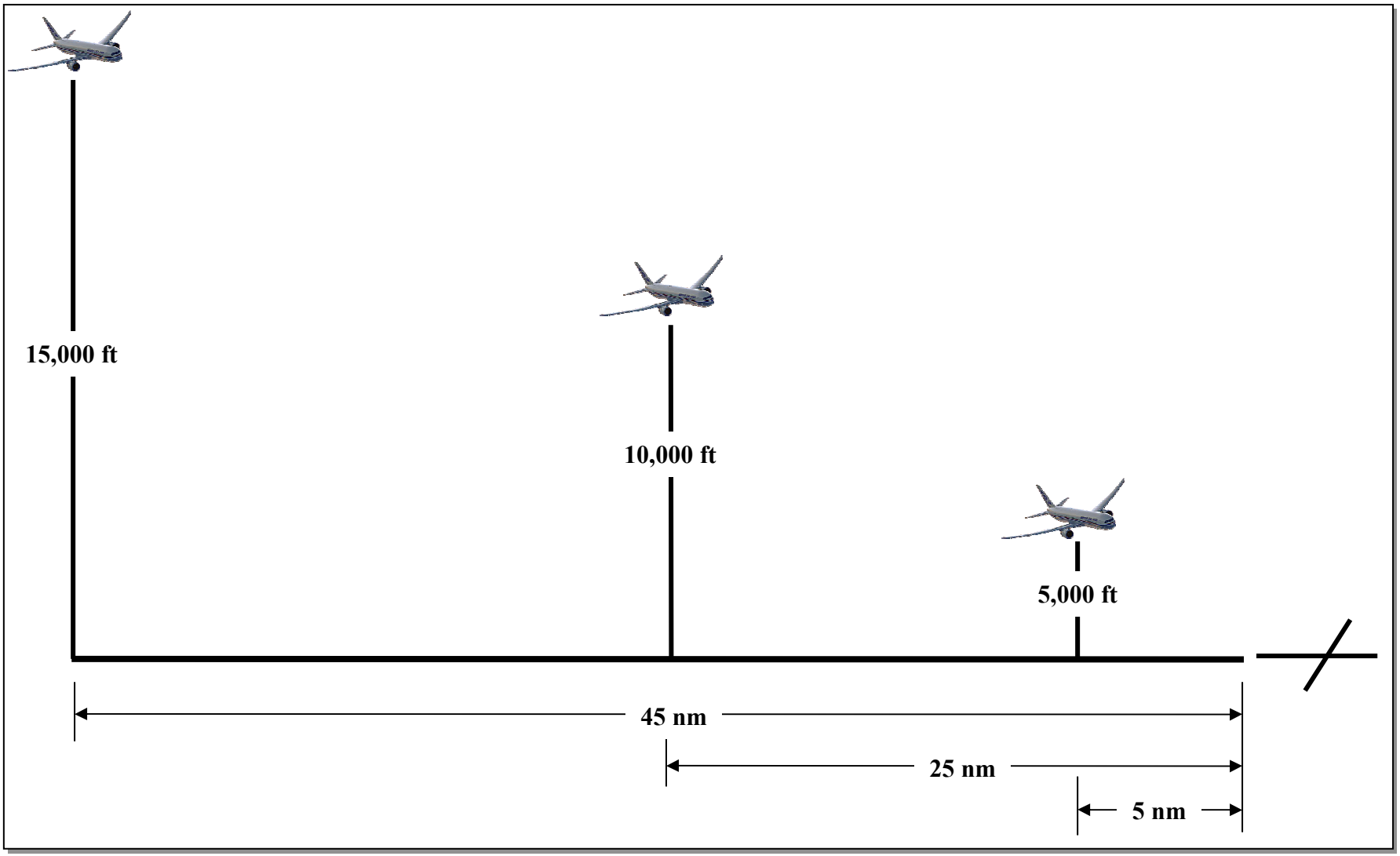
2005 - Terminal Airspace Operations Profile

Operations	MIA		FLL	
	Arrival	Departure	Arrival	Departure
ATC	542	318	442	356
AOC	524	302	374	321
FBO	18	16	68	35
Total		860		798

Near Term Communications Profile

MIA Terminal Area Existing Communications Profile					
Services	# Flights/ day	Applications	Transmission duration	Data – kbits/sec	Technology
ATC	860	ATS - 25 KHz - 8.33 KHz		Not supported	VHF (25 KHz DSB AM)
AOC	826	ACARS – Flight Ops – Maintenance – Scheduling – D-ATIS (ATS)		22.5 Kbits per flight operation	VDL M 0/A
FBO	34	FBO Services – 2 calls per flight	15 – 20 seconds call holding time per call	Not supported	VHF
Passenger Services	860	Telephony			Cell

Approach - Terminal Airspace



ATC Message Exchange - Approach

23. Approach, UA917 is with you out of one three thousand descending to one zero thousand, ten thousand, heading three three zero.

26. UA917, roger, right to three six zero and maintain four thousand

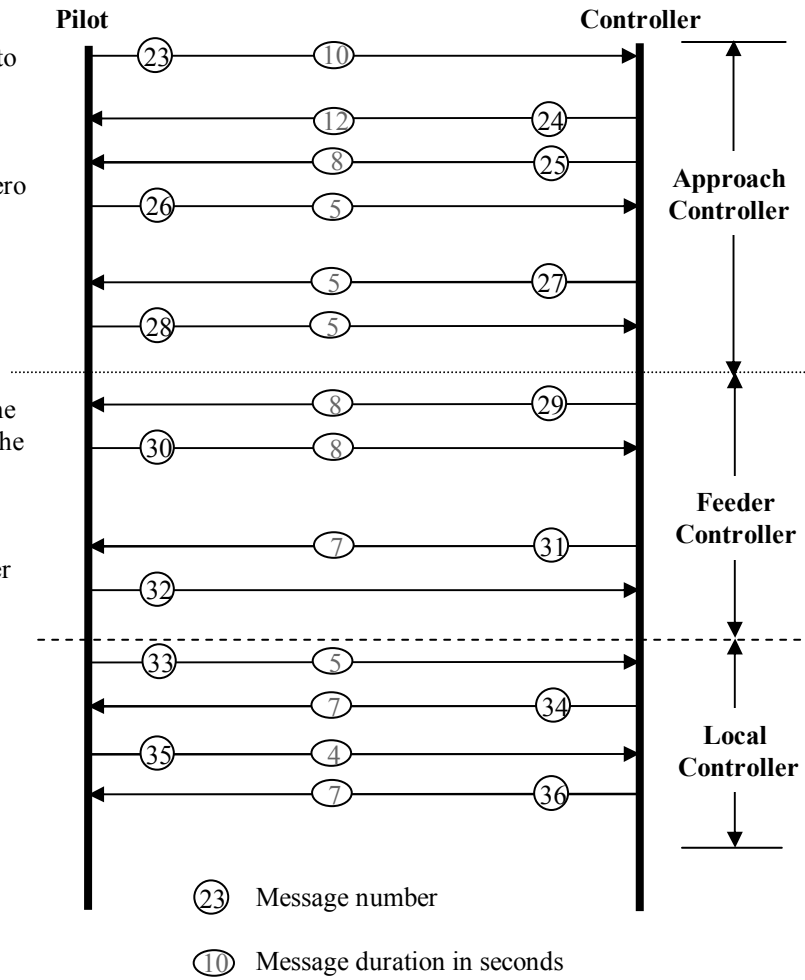
28. UA917, turn left heading two six zero, descend and maintain three thousand.

30. UA917, roger, left heading two one zero, three thousand until joining the localizer, and cleared for the ILS runway one niner right approach.

32. UA917, roger, tower one one niner point three and report the marker inbound.

33. Tower, UA917 is with you on the approach marker inbound.

35. UA917, roger, cleared to land runway one niner right.



24. Roger, UA917, Approach radar contact continue descent to four thousand heading three three zero vectors for an ILS runway one niner right approach.

25.UA917, Approach, turn right heading 360 three six zero and maintain four thousand

27. UA917, turn left heading two six zero, descend and maintain three thousand.

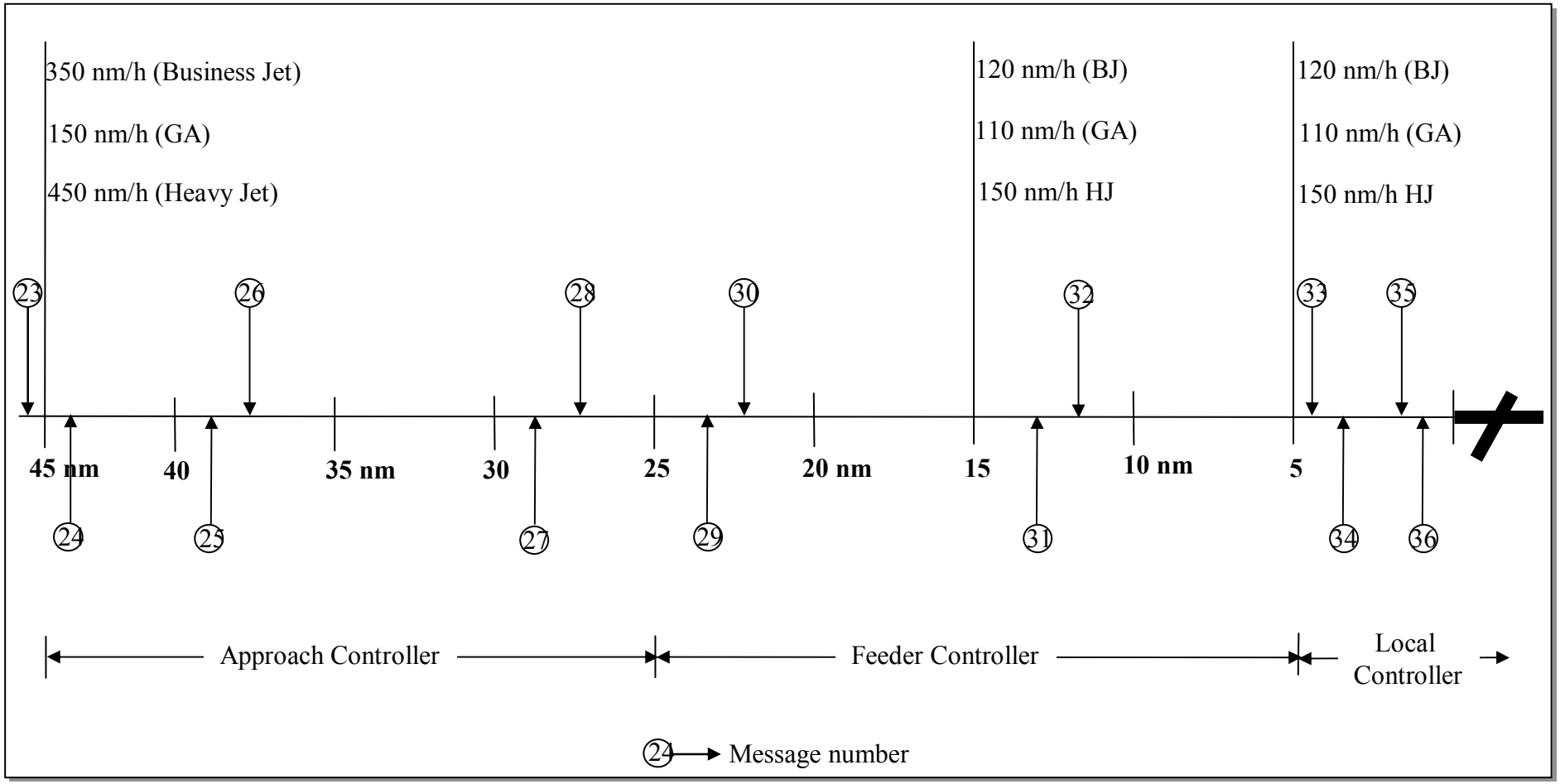
29. UA917, turn left heading two one zero, cleared ILS runway one niner right approach, maintain three thousand until joining the localizer runway one niner right.

31. UA917, roger, contact Tower on one one niner point three and report the marker inbound.

34. UA917, Tower, roger, cleared to land runway one niner right, wind one seven zero at one five knots.

36. UA917, Tower, left turn at the next intersection, contact Ground Control point niner.

Approach Flight Profile



Modeling Using FASTE-CNS Tool

Raytheon Network Centric Systems

Industry

Government

IE / Netscape

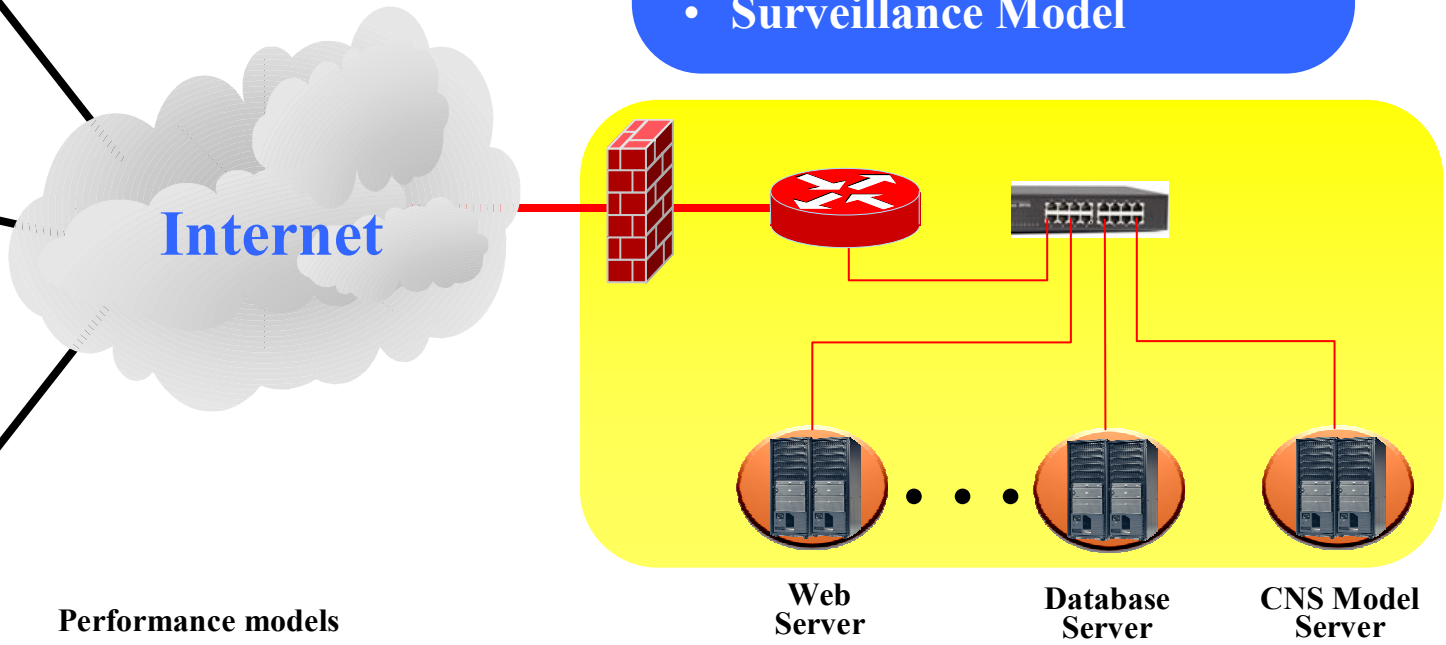
Universities

Steps

- Define message set
- Media selection
- Communications Profile
- Communications load profile

Capabilities

- User Management
- Load/ Frequency Calculation
- Communication Model
- Navigation Model
- Surveillance Model



Performance models
C: VHF Voice, ACARS and VDL Mode 2
N: VOR/DME, GPS
S: Secondary Radar, ADS-B (UAT)

Message Set

Opening Message Set - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://localhost/faste/PreTerminalComAMSOpen.aspx

FASTE - CNS MODELING TOOLS

Home Loading Help Tech Support Logout

Message Sets | Application Profiles | Flight Data Sets | RGS Sets | Modeling | User Services

Pre-Analysis Terminal Communication
Open / Edit Message Set
(VOICE)

Creator : Sanil Vidyanandan
Email Id: sanil.vidyanandan@cnsw.com
Message Set : HeavyJetDepature (Private - VOICE)
Description : Heavy Jet Departure Message Sets

Note: In the table below for departures 'Msg Time' indicates time since take off for arrivals 'Msg Time' indicates time before landing

Message	Size (Secs)	Msg Time MMM:SS	Mode	Type	Priority Level	Security	Response (secs)	Comments	Delete
msg1	5	04:00	Human	Receive	None	None	5		☐
msg2	3	05:19	Human	Transmit	None	None	5		☐
msg3	3	06:13	Human	Receive	None	None	5		☐
msg4	3	06:42	Human	Transmit	None	None	5		☐
msg5	4	07:33	Human	Transmit	None	None	5		☐
msg6	10	07:57	Human	Receive	None	None	5		☐
msg7	5	14:48	Human	Transmit	None	None	5		☐
msg8	3	15:02	Human	Receive	None	None	0		☐
msg9	3	17:59	Human	Transmit	None	None	0		☐
			Human	Transmit	None	None			☐

Add New Rows | Save | Print | Save As

Done | Local intranet

Flight Data Set

Opening Terminal Communication Flight Data Set - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://localhost/faste/PreTermComCFDSOpenEdit.aspx

FASTE - CNS MODELING TOOLS

Home Loading Help Tech Support Logout

Message Sets | Application Profiles | Flight Data Sets | RGS Sets | Modeling | User Services

Pre-Analysis Terminal Communication
Open / Edit Flight Data Set
(VOICE)

Creator : Sanil Vidyanandan
Email Id: sanil.vidyanandan@cnsw.com

Select a Radio Ground Station Set:
Miami Feb 7 2005 -One (Private - VOICE)

Description :
Miami Feb 7th 2005 data

Time HH:MM	Arrival/ Departure	Run Way	Airport	Flight	Id	Aircraft	Application Profiles	Copy X Times	Delete
00:00	Arrival	8L-26R	TPA	N238CXA		Airbus 300	HeavyJetArrival (Private - VOICE)		
00:11	Departure	12-30	ABE	EGF831		Airbus 300	HeavyJetDeparture (Private - VOICE)		
00:26	Departure	9-27	SDF	GCO4614		Airbus 300	HeavyJetDeparture (Private - VOICE)		
00:41	Departure	9-27	ABE	TAI315		Airbus 300	HeavyJetDeparture (Private - VOICE)		
01:00	Departure	9-27	ABE	TPA714		Airbus 300	HeavyJetDeparture (Private - VOICE)		
02:06	Departure	8R-26L	ABE	CAL228		Airbus 300	HeavyJetDeparture (Private - VOICE)		
02:47	Departure	9-27	ABE	FWL774		Airbus 300	HeavyJetDeparture (Private - VOICE)		
02:59	Departure	9-27	ABE	LCO1104		Airbus 300	HeavyJetDeparture (Private - VOICE)		
03:12	Departure	9-27	ABE	AAL904		Airbus 300	HeavyJetDeparture (Private - VOICE)		
03:17	Arrival	12-30	ABE	AJT817		Airbus 300	HeavyJetArrival (Private - VOICE)		

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63
64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84

Done | Local intranet

Flight Data Set

Raytheon
Network Centric Systems

Select a Radio Ground Station Set:

Miami Feb 7 2005 -One (Private - VOICE)

Description :

Miami Feb 7th 2005 data

Time HH:MM	Arrival/ Departure	Run Way	Airport	Flight	Id	Aircraft	Application Profiles	Copy X Times	Delete
00:00	Arrival	8L-26R	TPA	N238CXA		Airbus 300	HeavyJetArrival (Private - VOICE)		
00:11	Departure	12-30	ABE	EGF831		Airbus 300	HeavyJetDeparture (Private - VOICE)		
00:26	Departure	9-27	SDF	GCO4614		Airbus 300	HeavyJetDeparture (Private - VOICE)		
00:41	Departure	9-27	ABE	TAI315		Airbus 300	HeavyJetDeparture (Private - VOICE)		
01:00	Departure	9-27	ABE	TPA714		Airbus 300	HeavyJetDeparture (Private - VOICE)		
02:06	Departure	8R-26L	ABE	CAL228		Airbus 300	HeavyJetDeparture (Private - VOICE)		
02:47	Departure	9-27	ABE	FWL774		Airbus 300	HeavyJetDeparture (Private - VOICE)		
02:59	Departure	9-27	ABE	LCO1104		Airbus 300	HeavyJetDeparture (Private - VOICE)		
03:12	Departure	9-27	ABE	AAL904		Airbus 300	HeavyJetDeparture (Private - VOICE)		
03:17	Arrival	12-30	ABE	AJT817		Airbus 300	HeavyJetArrival (Private - VOICE)		

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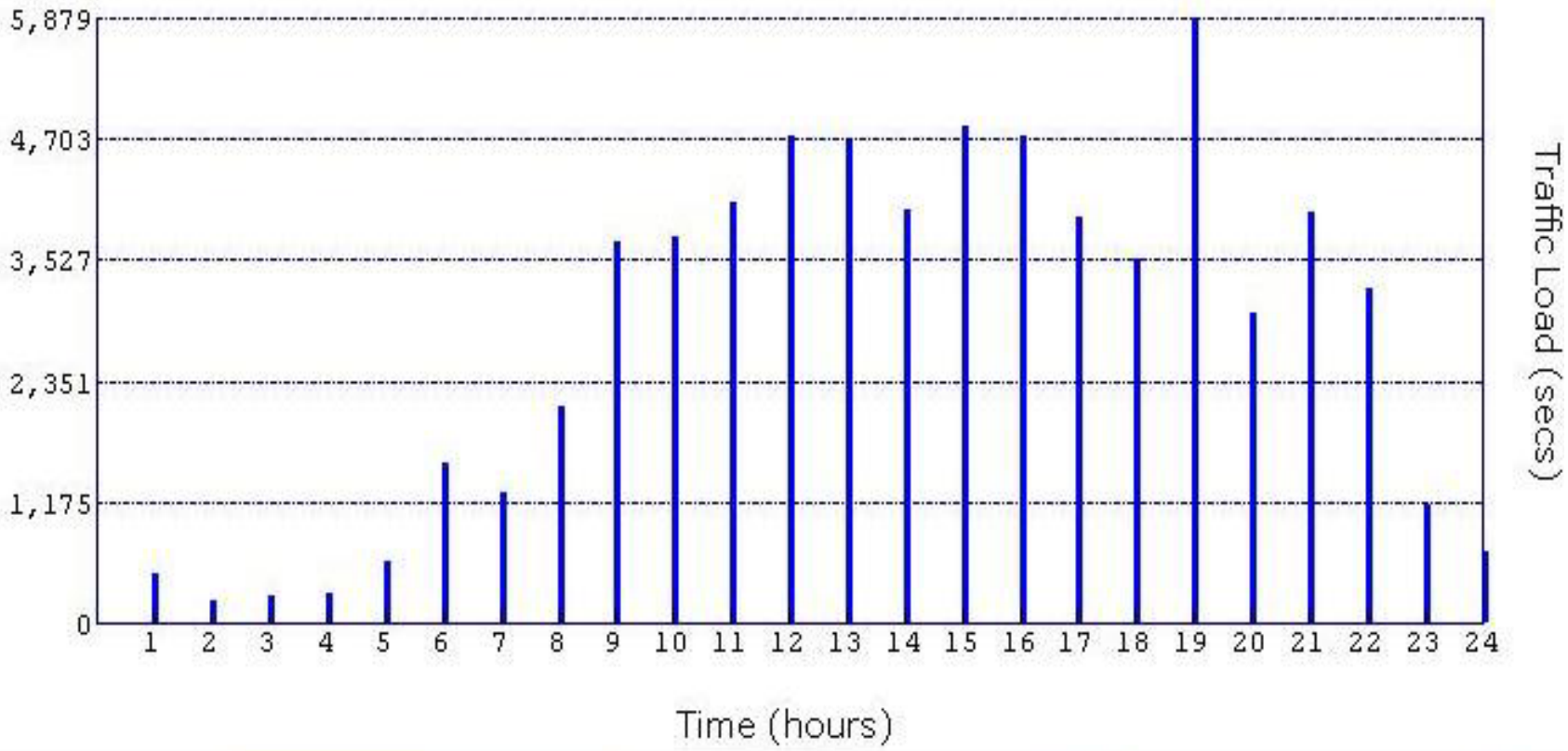
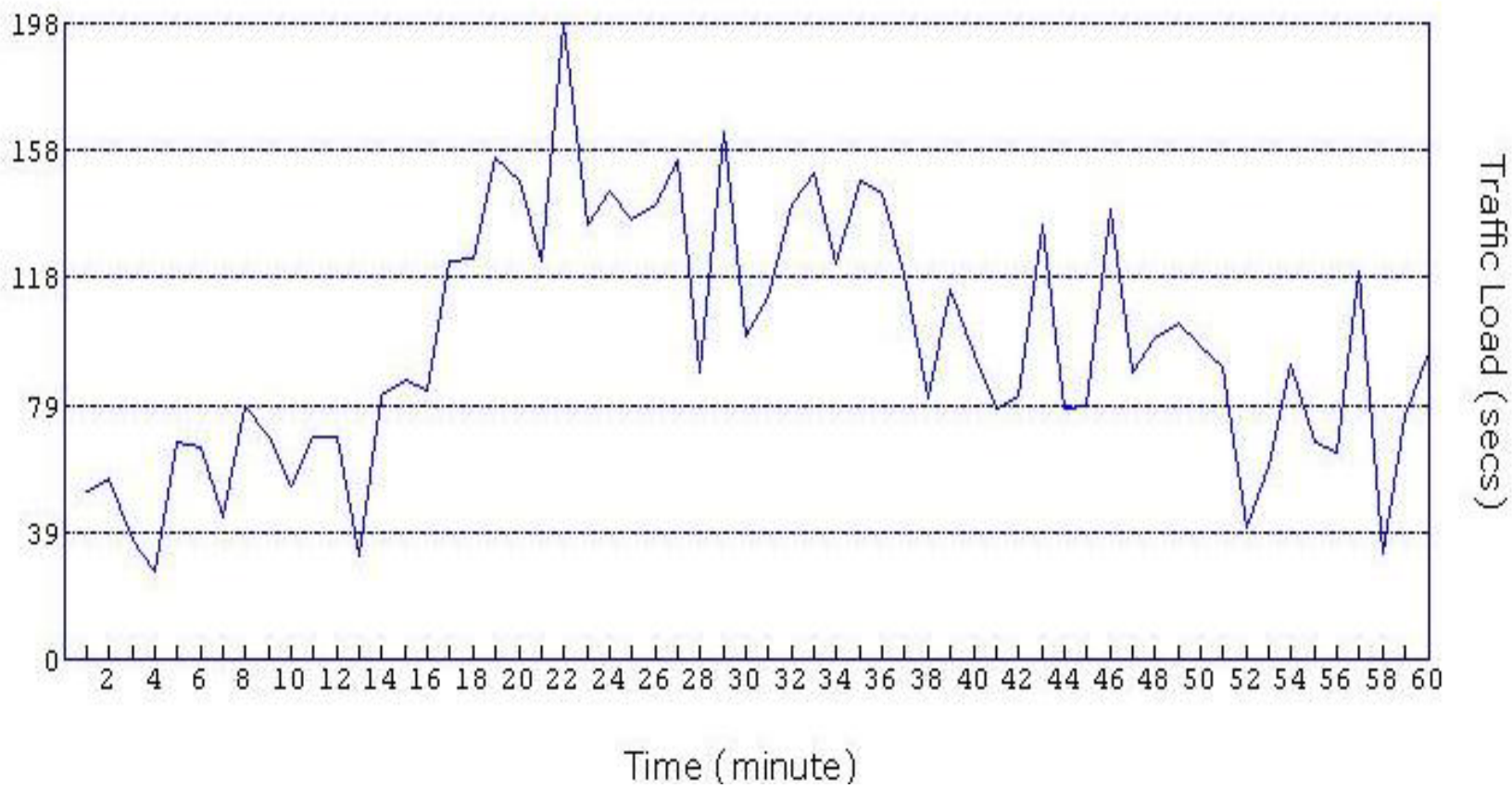
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63
64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84

MIA ATC Traffic Load Over 24 Hour Period



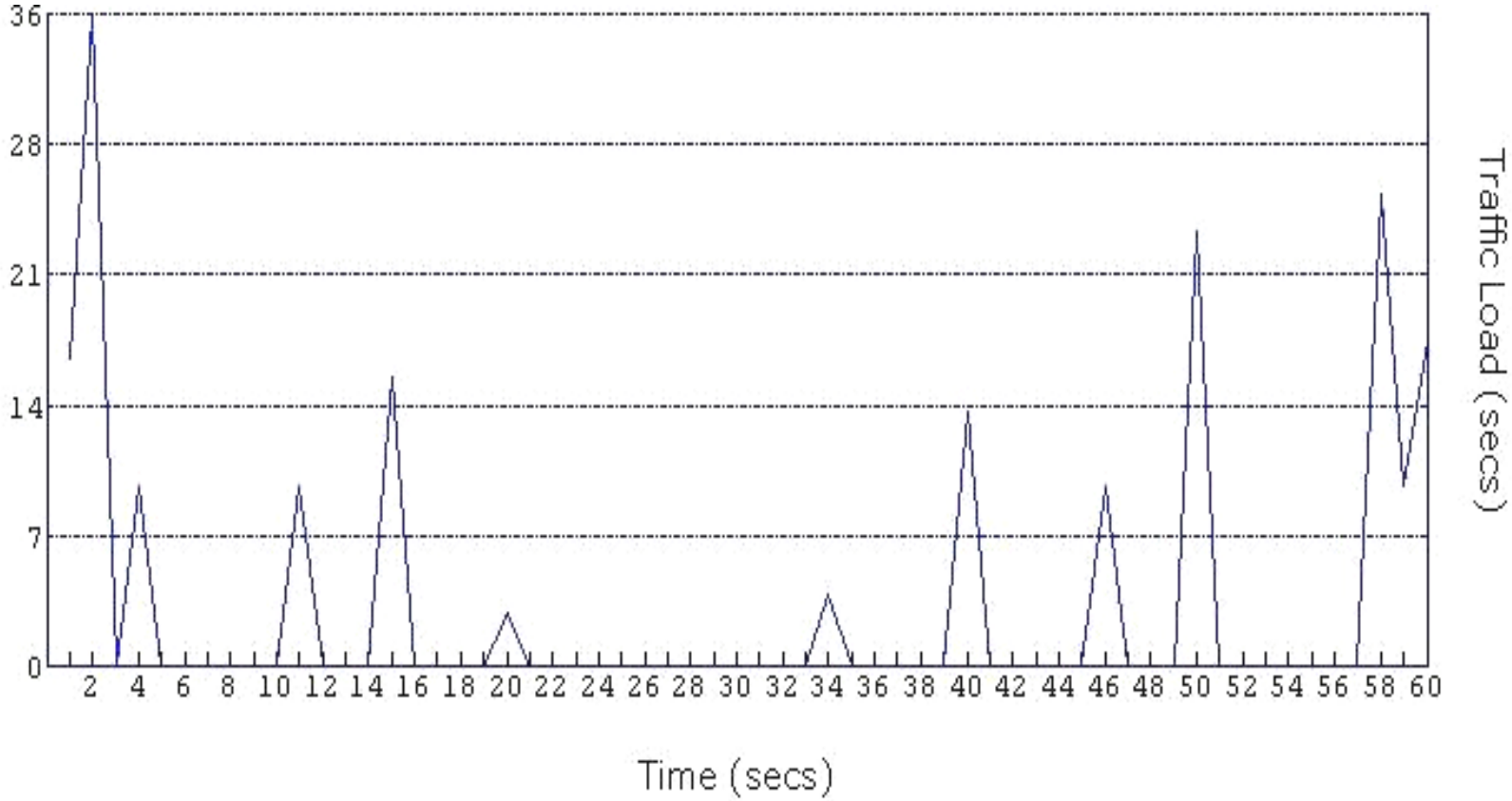
Total Number of Messages	–	*10,339*
Total Communications load	–	*66,758 seconds*
Average Communications load	–	*46.36 seconds/minute*

MIA ATC Peak Hour Traffic Load



Total Number of Messages	–	*894*
Total Communications load	–	*5,879 seconds*
Average Communications load	–	*97.98 seconds/minute*

MIA ATC Peak Minute Traffic Load



All Terminal Area Sectors		
Total Number of Messages	–	28
Total Communications load	–	198 seconds
Average Communications load	–	198 seconds/minute

Terminal Airspace Voice Communications Requirements

- **25 KHz DSB voice channel**
  - **20 VHF frequencies**
  - **14 UHF frequencies**
- **Performance Requirements**
  - **Capacity:**
    - » non blocking
    - » sufficient frequencies to avoid :
    - » co-channel, adjacent channel and co-site interference
  - **Availability: 99.99%**
  - **Delay: end-to-end delay <= 250 msec**
  - **Integrity: clear and acceptable quality**
- **Functional Requirements**

Terminal Airspace AOC Message Exchange

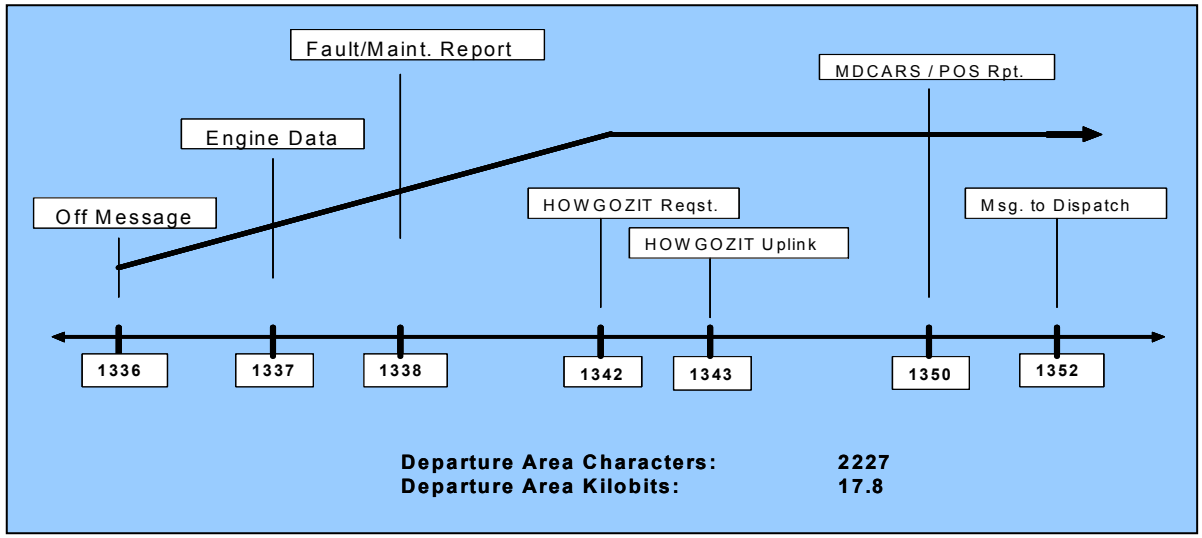
Departure Phase

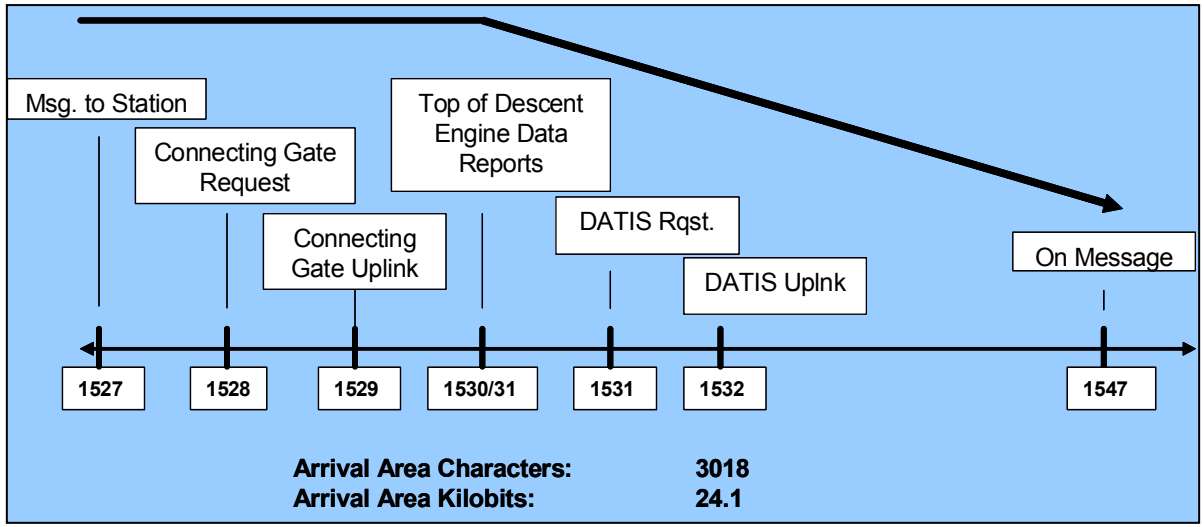
#	Message	Size (characters)	Size (bits)
1	Off Event D-Link	73	584
2	Engine Data D-Link	965	7720
3	Fault/Maintenance Data D-Link	863	6904
4	HOWGOZIT Request D-Link	79	632
5	HOWGOZIT Report U-Link	279	2232
6	Message to Dispatch D-Link	128	1024
		2,387	**19,096**

Approach Phase

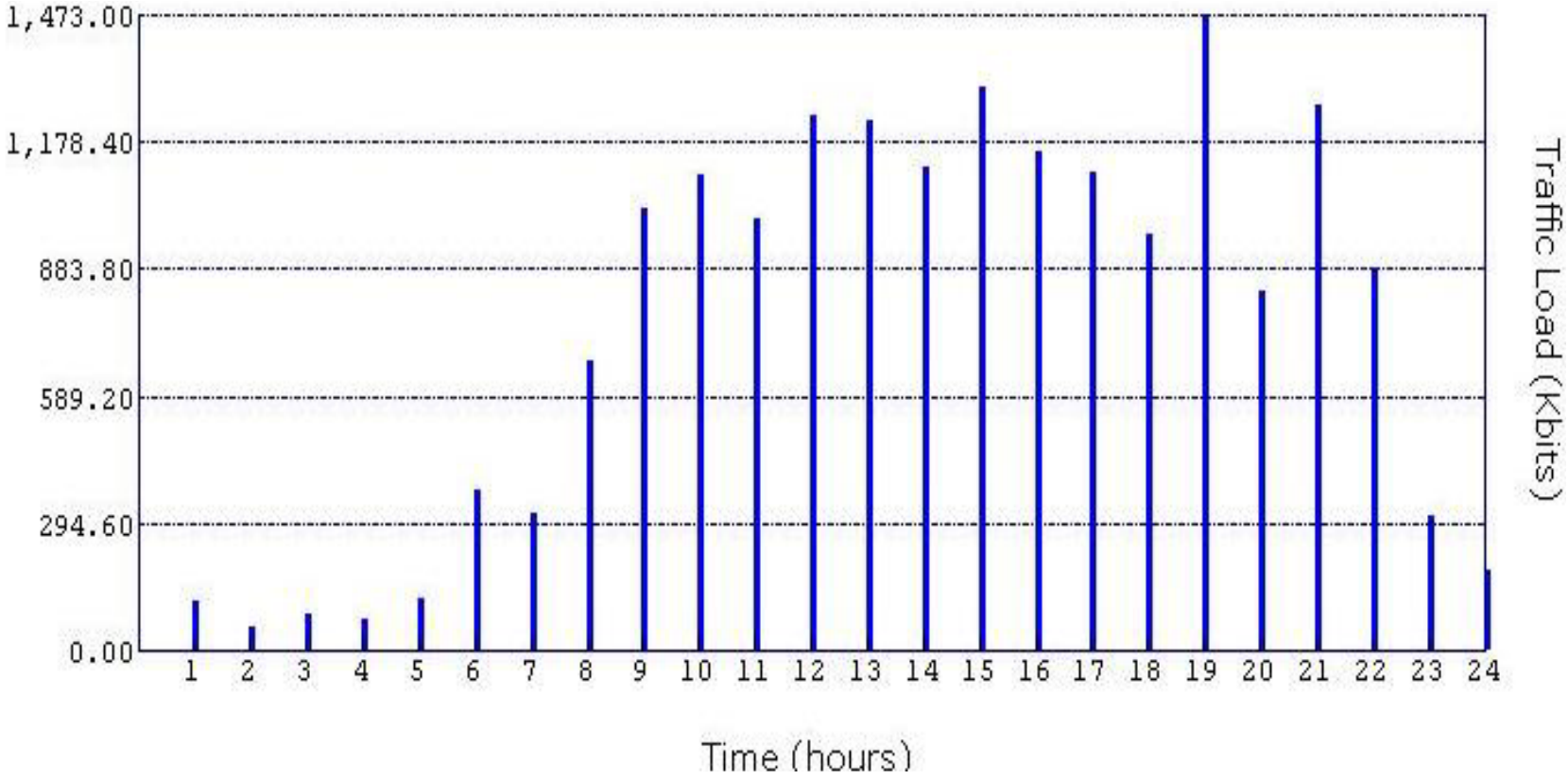
#	Message	Size (characters)	Size (bits)
7	Message to Destination Station D-Link	92	736
8	Connecting Gate Message Request D-Link	67	536
9	Connecting Gate Message U-Link	235	1880
10	Top of Descent Engine Data Report D-Link	1440	11520
11	Digital ATIS Request D-Link	75	600
12	Digital ATIS U-Link	741	5928
13	ON Event D-Link	67	536
		2,717	**21,736**

Terminal Airspace AOC Load Profile



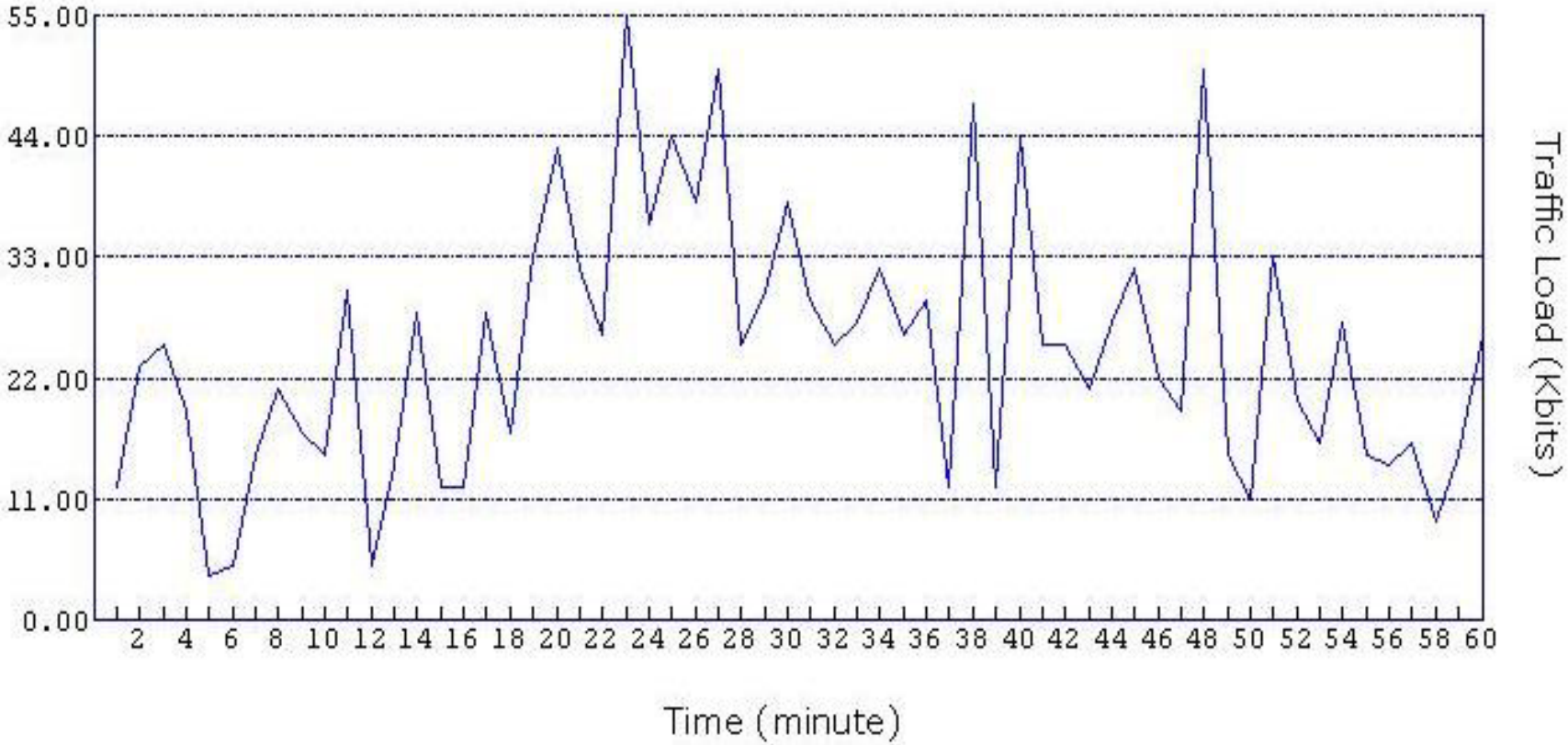


MIA Terminal Airspace AOC Load Distribution Over a Day



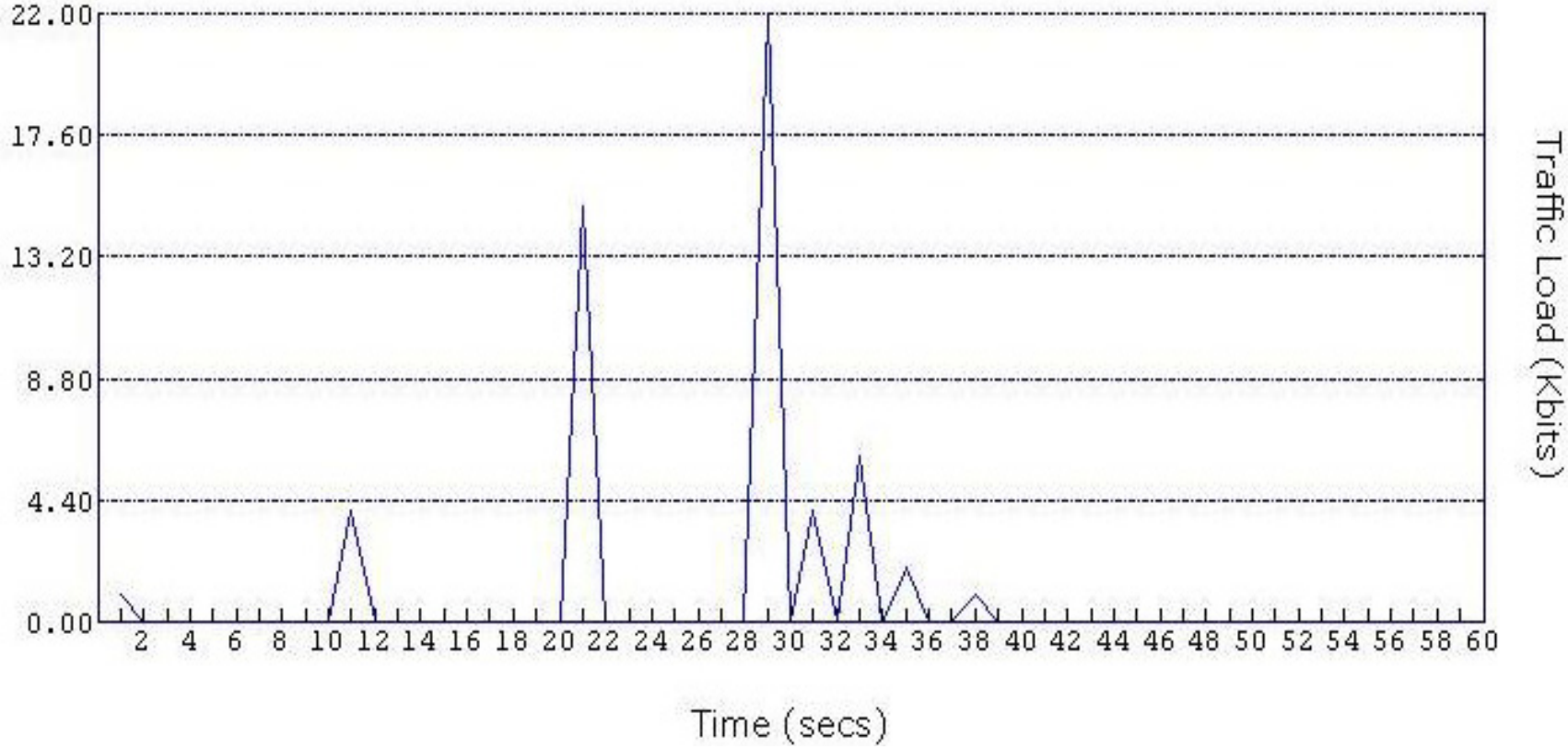
Total Number of Messages	–	*5,546*
Total Communications load	–	*18,008 Kbits*
Average Communications load	–	*0.21 Kbit/sec*

MIA Terminal Airspace AOC Peak Hour Load Distribution



Total Number of Messages	–	*448*
Total Communications load	–	*1,473 Kbits*
Average Communications load	–	*0.41 Kbit/sec*

MIA Terminal Airspace AOC Peak Minute Load Distribution



Total Number of Messages	–	*15*
Total Communications load	–	*55 Kbits*
Average Communications load	–	*0.91 Kbit/sec*

Terminal Airspace AOC Communications Requirements

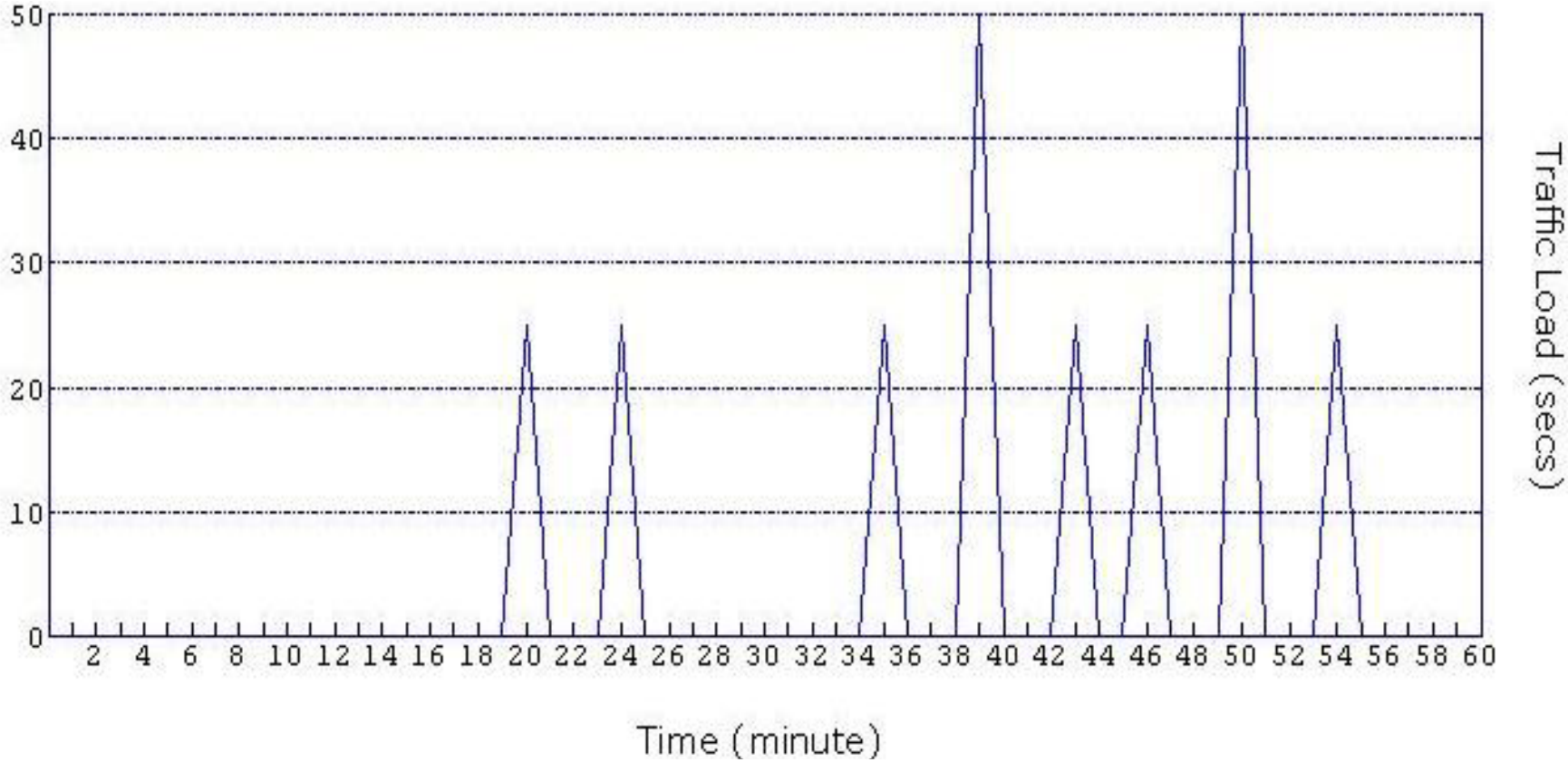
- **MIA All VHF Freq Used: 62 airlines (voice), 18 data link, 8 FBO (voice) – however, these are not all strictly terminal airspace use only**
- **ACARS - VDL Mode 0/A**

Parameter	Value
Access Delay	N/A
Transit Delay	90 seconds
Availability	94%
Accuracy	10^{-6}

Terminal Airspace FBO Message Exchange

- **25 KHz DSB AM**
- **Voice**
- **2 messages during the approach phase**
- **Call holding time approximately 15-20 seconds**

MIA Terminal Airspace FBO Peak Hour Load Distribution



Total Number of Messages	–	*10*
Total Communications load	–	*250 seconds*
Average Communications load	–	*4.16 seconds/minute*

Terminal Airspace Passenger and Other Communications

- **Passenger Communications**
  - **Telephony**

- **Air Defense Identification Zone (ADIZ)**
  - **Not yet implemented in MIA terminal airspace**
  - **30 mile radius, 18,000 ft**
  - **File a flight plan**
  - **Assigned unique beacon code**

2015 and 2030 CONOPS Summary

Sources and References

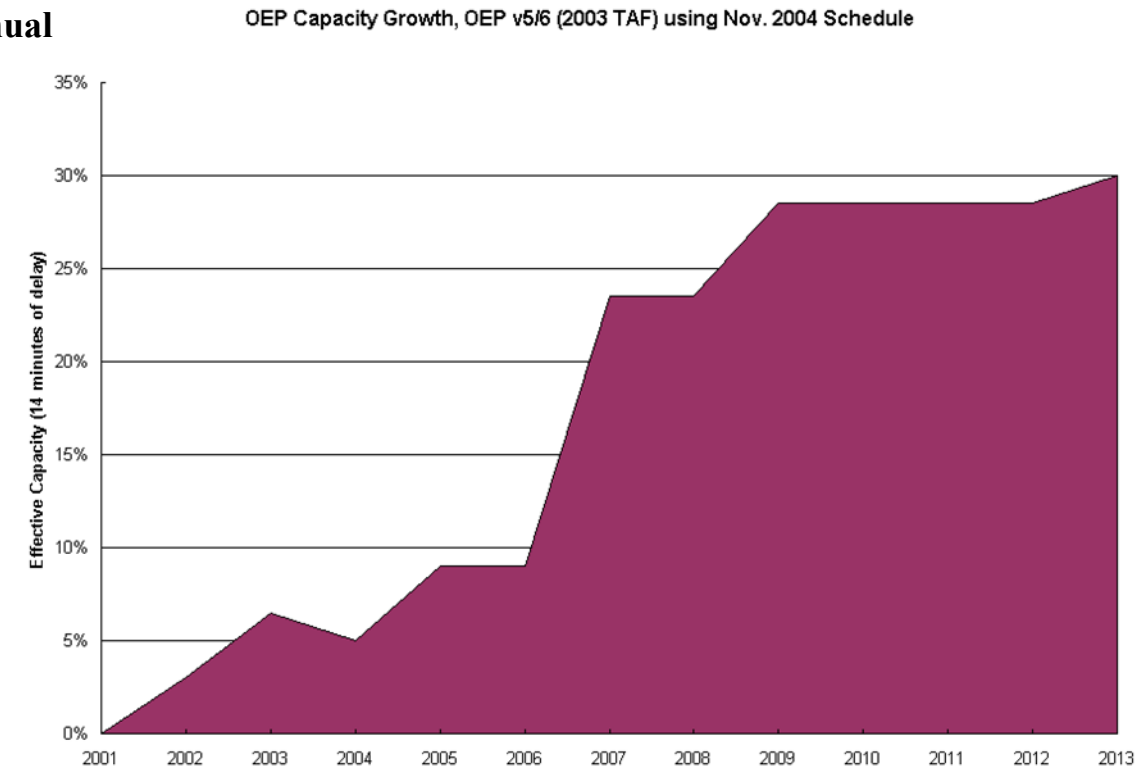
- **4 Reference Sources used for these CONOPS**
  - **FAA Operational Evolution Plan (OEP) V7: 2015**
  - **FAA/EuroControl Future Communications Study Initial Communications Operating Concept and Requirements (ICOCR) for the Future Radio System: 2015 and 2030**
  - **JPDO Next Generation Air Transportation System (NGATS) Integrated Plan: 2025**
  - **NASA Virtual Airspace Modeling & Simulation (VAMS) Blended Concepts: 2030**

Traffic Predictions

- **Will OEP Improvements Meet 2015 Traffic Demand?**
- **2015 - Terminal Area Forecast (TAF) predicts an average annual growth rate of 2.2% at All Hubs**
  - **All tower airports average annual growth rate of 1.3%**
  - **MIA – 1.3% average annual growth rate**
  - **FLL – 2.7% average annual growth rate**

Effective Capacity Increase

- **2015 - Terminal Area Forecast (TAF) predicts an average annual growth rate of 2.2% at All Hubs**
  - **All tower airports average annual growth rate of 1.3%**
  - **MIA – 1.3% average annual growth rate**
  - **FLL – 2.7% average annual growth rate**



OEP keeping pace with mid-term traffic loads According to FAA Forecast thru 2015

FCS Study: Terminal Airspace 2015

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Network Centric Systems

- **Net-Centric Information Exchange/Layered Planning Process**
  - **Most significant evolution implemented through SWIM**
    - » Achieves a stable demand/capacity balance through prediction, management, and re-planning
    - » Ground nets only in 2015. Mobile Air/Ground comms post 2015.
- **Communications**
  - **Voice**
    - » Primary controller/flight crew tactical exchanges and backup to datalink service
    - » 60% of ATS Traffic
  - **Datalink**
    - » Primary means for routine and repetitive messages with equipped aircraft
      - ATC Communications Management (ACM) transfers
      - Approach Information
      - Clearances

FCS/ICOCR has a more optimistic prediction wrt datalink

2030 CONOPS

- **The paradigm change from "management by intervention" to "management by planning and intervention by exception" will be complete by 2030**
- **The chart on the next slide highlights the common components from the referenced studies**

2030 Core Idea Comparison

	OEP PPP Trn Rng	OEP SPPA Trn Rng	ICOCR (2030)	JPDO (2025)	VAMS (2025)
4D Traj Nego			X	X	X
Broad Area Prec Nav				X	X
CDTI Enh Vis Sep (CAVS)	X		X	X	X
Imp Wx Pred	X (CIWS)		X	X	X
Datalink		X	X	X	X
Dyn Airspace Config			X	X	X
Free-Flight			X (to w/in 20 miles)	X	X (not in Class B/C)
Wake Initiatives		X (Mid-Term)		X	X
New AC Types			X	X	X
RNP		X (SAAR only)		X	X
Super Density Ops				X	X
SWIM/CDM	X		X	X	X
Term AS Redesign		X			

2030 Core CNS Features

- **Net-Centric System of Systems**
  - **Sharing of data (flight plan/intent, user preferences, demand/capacity, weather, etc) between Ground/Air and ATS/AOC for common Situational Awareness and improved planning**
- **Reduced Separation through RNP**
- **CDTI enables Self Separation and Merging**
- **Ground Automation uplink of conflict free 4D routes**

2015 - Terminal Airspace Operations Profile

Operations	MIA		FLL	
	Arrival	Departure	Arrival	Departure
ATC	823	466	653	543
AOC	797	443	553	488
FBO	26	23	100	55
Total		1,289		1,196

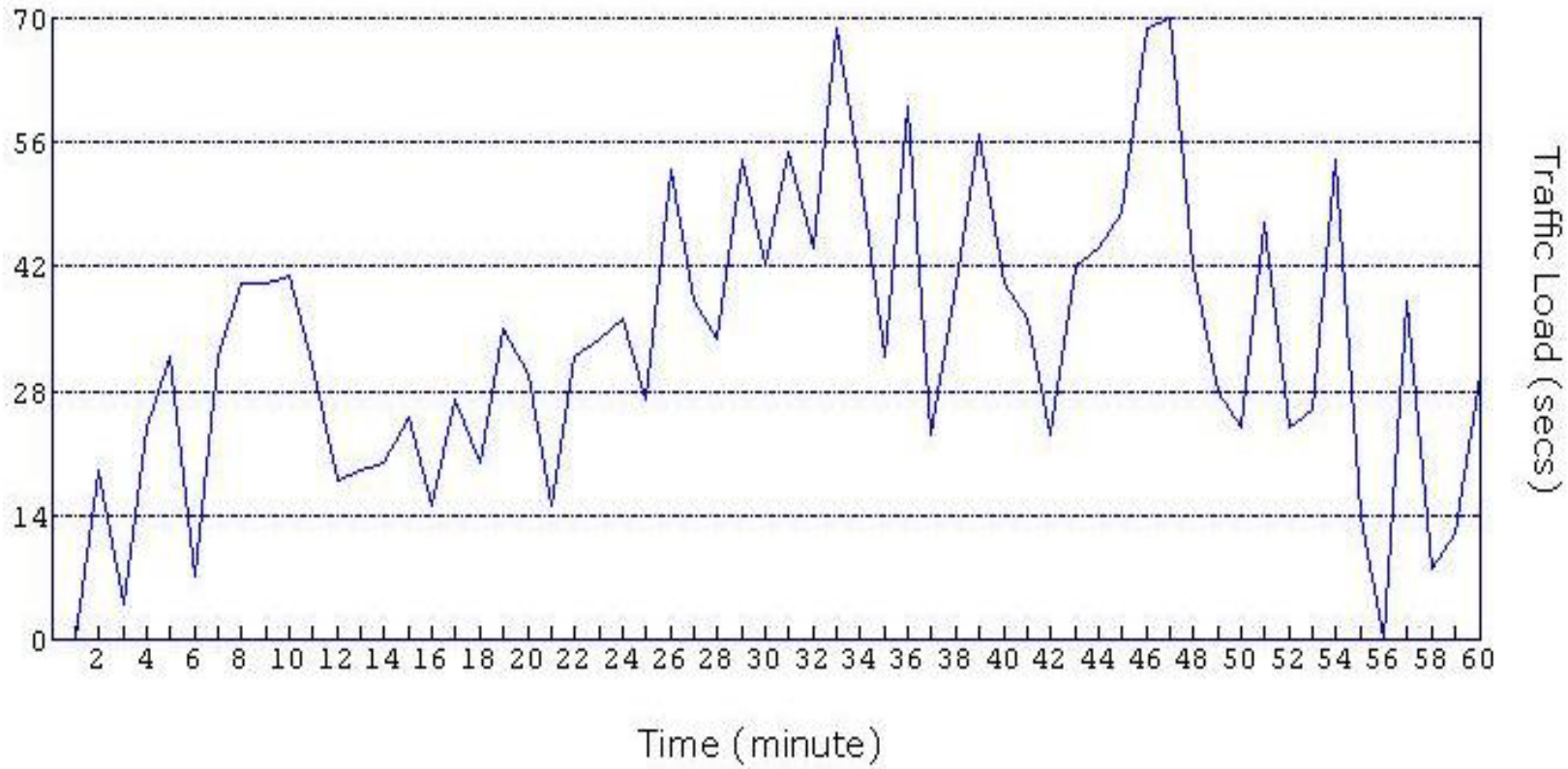
2015 ATC Communications Overview

- **Terminal airspace communication**
  - **60% voice communication**
    - » 25 KHz SDB AM
    - » Local control airspace
  - **40% data communication**
    - » VDL Mode
    - » CPDLC like ATC application
    - » Single logical channel
    - » Approach, feeder, and departure control airspace
- **Number of operation**
  - **150% the near term**
- **Voice message mapped to equivalent CPDLC messages**

Mid Term Communications Profile

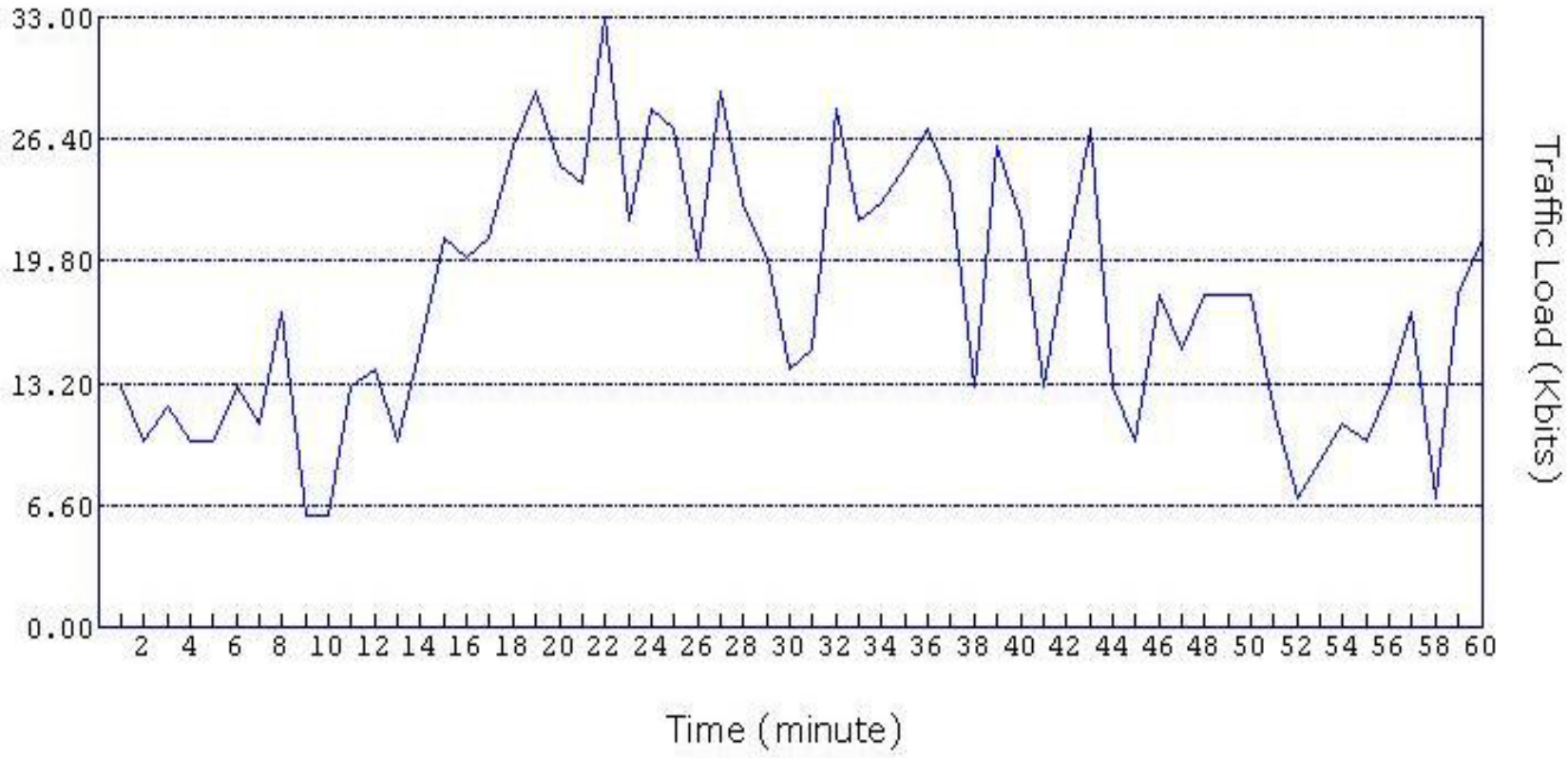
MIA Terminal Area Mid Term Communications Profile					
Services	# Flights/ day	Applications	Transmission duration	Data – kbits/sec	Technology
ATC	150 % current baseline	ATS Voice (60%) - 25 KHz - 8.33 KHz			VHF
		Data Link Apps (40%) – CPDLC – CM – ADS – FIS		10 Kbits per flight operation	VDL M 2
AOC	150 % current baseline	ACARS – Flight Ops – Maintenance – Scheduling – D-ATIS – New App 1		122.5 Kbits per flight operation	VDL M 0/A VDL M 2
FBO	150 % current baseline	FBO Services – 2 calls per flight	15 – 20 seconds call holding time per call	Not supported	VHF
Passenger Services		Telephony		16 Kbits/sec/ passenger	SATCOM
		Email		640 Kbits/ passenger	SATCOM
		Internet browsing		1.33 Kbits/ sec	SATCOM
		TV		3 Mbits / channel	SATCOM

MIA ATC Peak Hour Voice Traffic Load



Total Number of Messages	–	*394*
Total Communications load	–	*1,996 seconds*
Average Communications load	–	*33.27 seconds/minute*

MIA ATC Peak Hour Data Traffic Load



Total Number of Messages	–	*829*
Total Communications load	–	*1,062 Kbits*
Average Communications load	–	*0.30 kbits/sec*

Terminal Airspace Voice Communications Requirements

- **25 KHz DSB voice channel or digital voice**

- **Performance Requirements**
  - **Capacity:**
    - » non blocking
    - » sufficient frequencies to avoid :
    - » co-channel, adjacent channel and co-site interference
  - **Availability: 99.99%**
  - **Delay: end-to-end delay <= 250 msec**
  - **Integrity: clear and acceptable quality**

- **Functional Requirements**

Terminal Airspace Data Communications Requirements

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Network Centric Systems

- **RCP based**

Application	Availability	Integrity	Reliability	Continuity
DLIC	99.9%	10^{-6}	99.9%	99.9%
ADS	99.996%	10^{-7}	99.996%	99.996%
CPDLC	99.99%	10^{-7}	99.99%	99.99%
FIS	99.9%	10^{-6}	99.9%	99.9%
AIDC	99.996%	10^{-7}	99.9%	99.9%
ADS-B	99.996%	10^{-7}	99.996%	99.996%

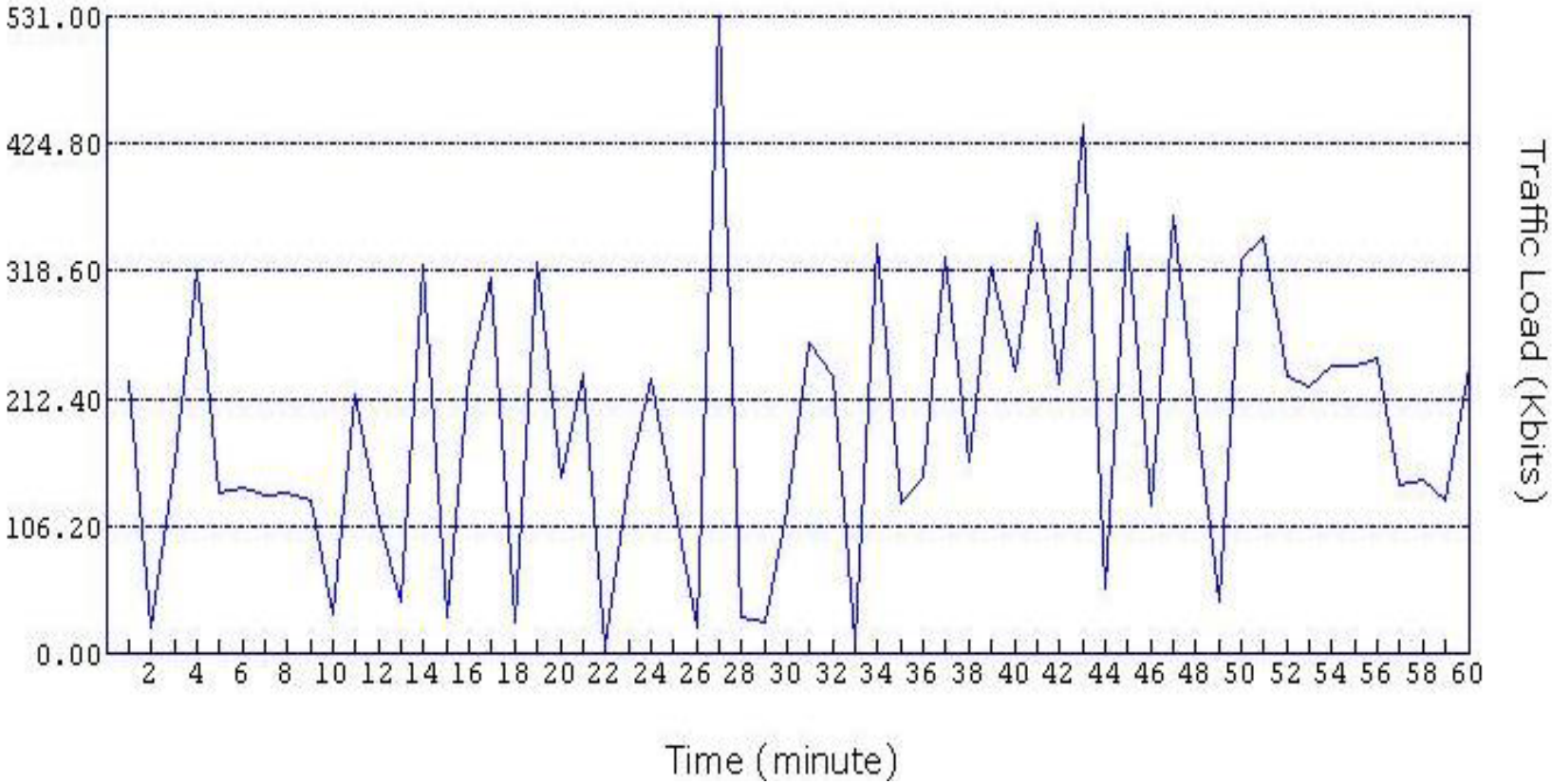
Transit Delay Requirements

Performance Levels	Mean End-to-End Transfer Delay (Seconds)	95% End-to-End Transfer Delay(Seconds)	99.996% End-to-End Transfer Delay (Seconds)
A	0.5	0.7	1
B	1	1.5	2.5
C	2	2.5	3.5
D	3	5	8
E	5	8	12.5
F	10	15	22
G	12	20	31.5
H	15	30	51
I	30	55	90
J	60	110	180

2015 AOC Communications Overview

- **Same as near term (2005) applications**
- **Number of operation**
  - **150% the near term**
- **One (1) bandwidth intensive application**

MIA Terminal Airspace AOC Peak Hour Load Distribution



Total Number of Messages	–	*797*
Total Communications load	–	*11,499 Kbits*
Average Communications load	–	*3.19 Kbit/sec*

2030 - Terminal Airspace Operations Profile

Operations	MIA		FLL	
	Arrival	Departure	Arrival	Departure
ATC	1,623	954	1,323	1,068
AOC	1,569	906	1,119	963
FBO	54	48	204	105
Total		2,577		2,391

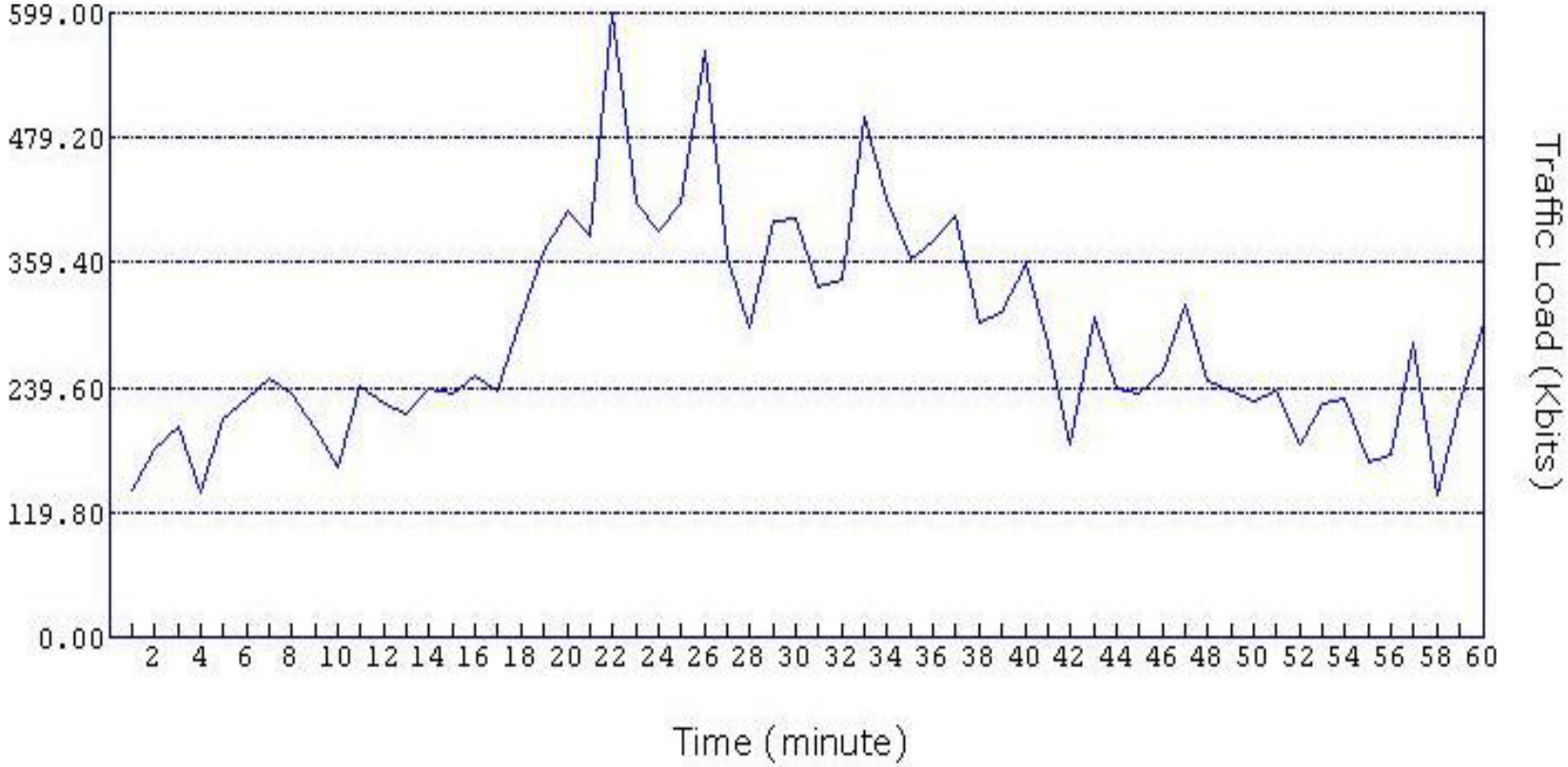
2030 ATC Communications Overview

- **Terminal airspace communication**
  - **Voice communication back up**
  - **Data communication primary**
    - » Broadband
    - » Swim
    - » Single logical channel
- **Number of operation**
  - **300% the near term**
- **Voice messages mapped to equivalent CPDLC messages**

Far Term Communications Profile

MIA Terminal Area Far Term Communications Profile					
Services	# Flights/ day	Applications	Transmission duration	Data – kbits/sec	Technology
ATC	300 % current baseline	ATS Voice (15%) - 25 KHz - 8.33 KHz			VHF VDL M 3
		Data Link Apps (85%) – CPDLC – CM – ADS – FIS – SWIM		25 Kbits per flight operation	VDL M 2
AOC	300 % current baseline	ACARS – Flight Ops – Maintenance – Scheduling – D-ATIS – New App 1 – New App 2		222.5 Kbits per flight operation	VDL M 2 SATCOM
FBO	data not available	FBO Services – 2 calls per flight	15 – 20 seconds call holding time per call	Not Supported	VHF
Passenger Services		Telephony		16 kbits/sec/ passenger	SATCOM
		Email		640 kbits/ passenger	SATCOM
		Internet browsing		1.33 kbits/ sec	SATCOM
		HDTV		12 Mbits/ channel	SATCOM

MIA ATC Peak Hour Data Traffic Load

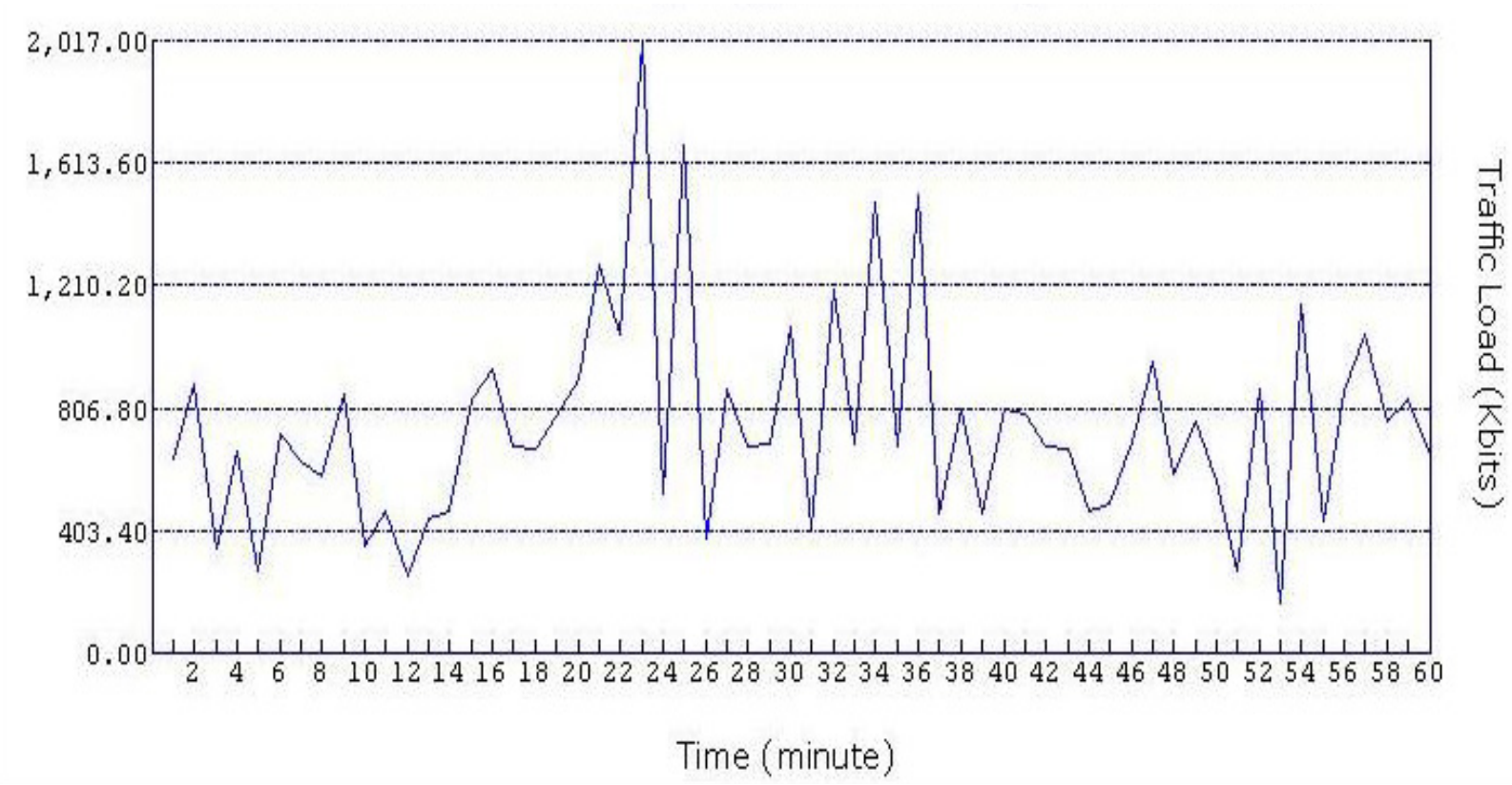


Total Number of Messages	–	*2,647*
Total Communications load	–	*17,319 Kbits*
Average Communications load	–	*4.81 Kbits/sec*

2030 AOC Communications Overview

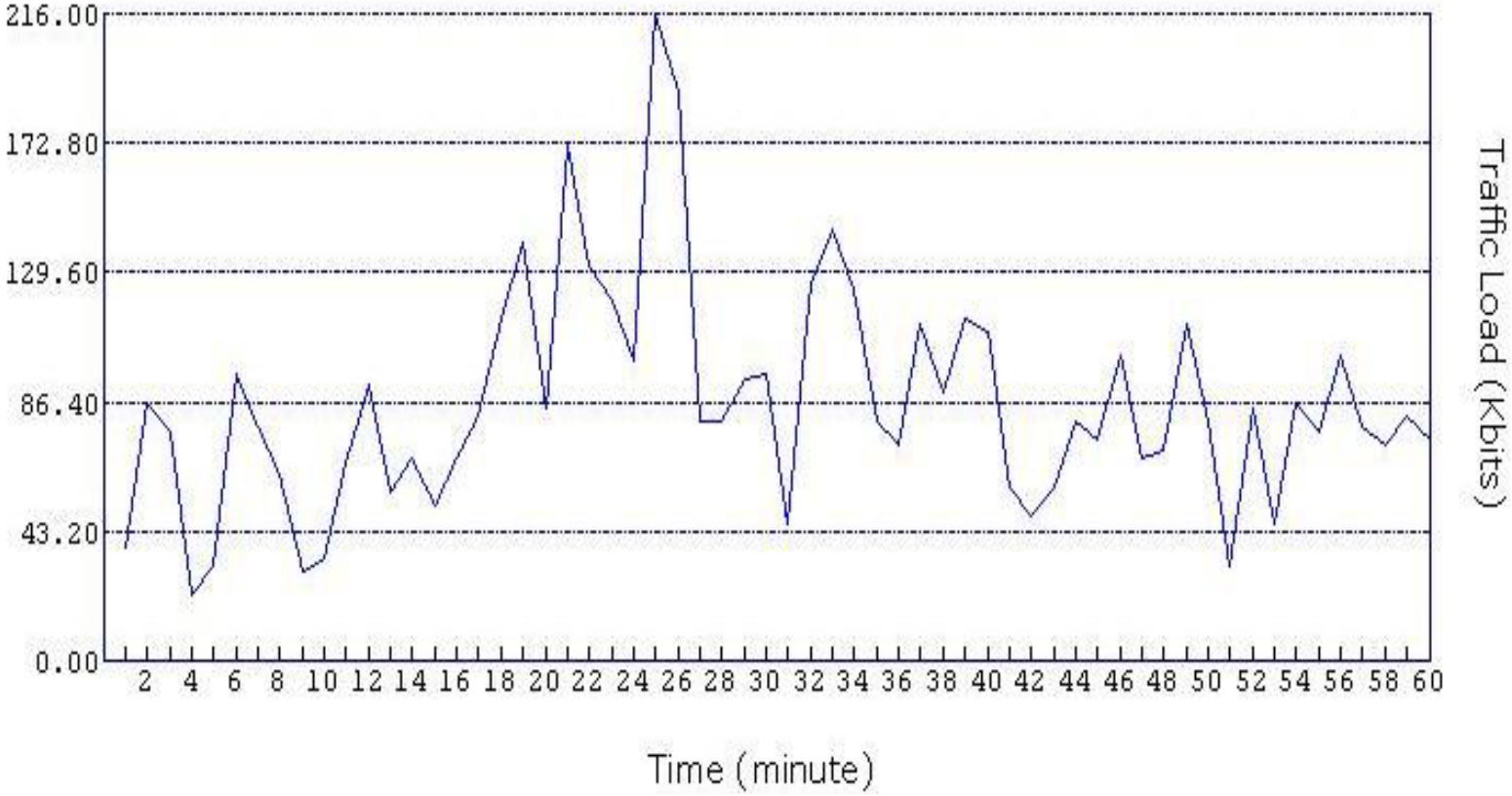
- **Same as mid term (2015) applications**
- **Number of operation**
  - **300% near term**
- **Broadband communications technology**
- **Innovative AOC apps in addition to existing apps**
- **One (1) bandwidth intensive application**

MIA Terminal Airspace AOC Peak Hour Load Distribution



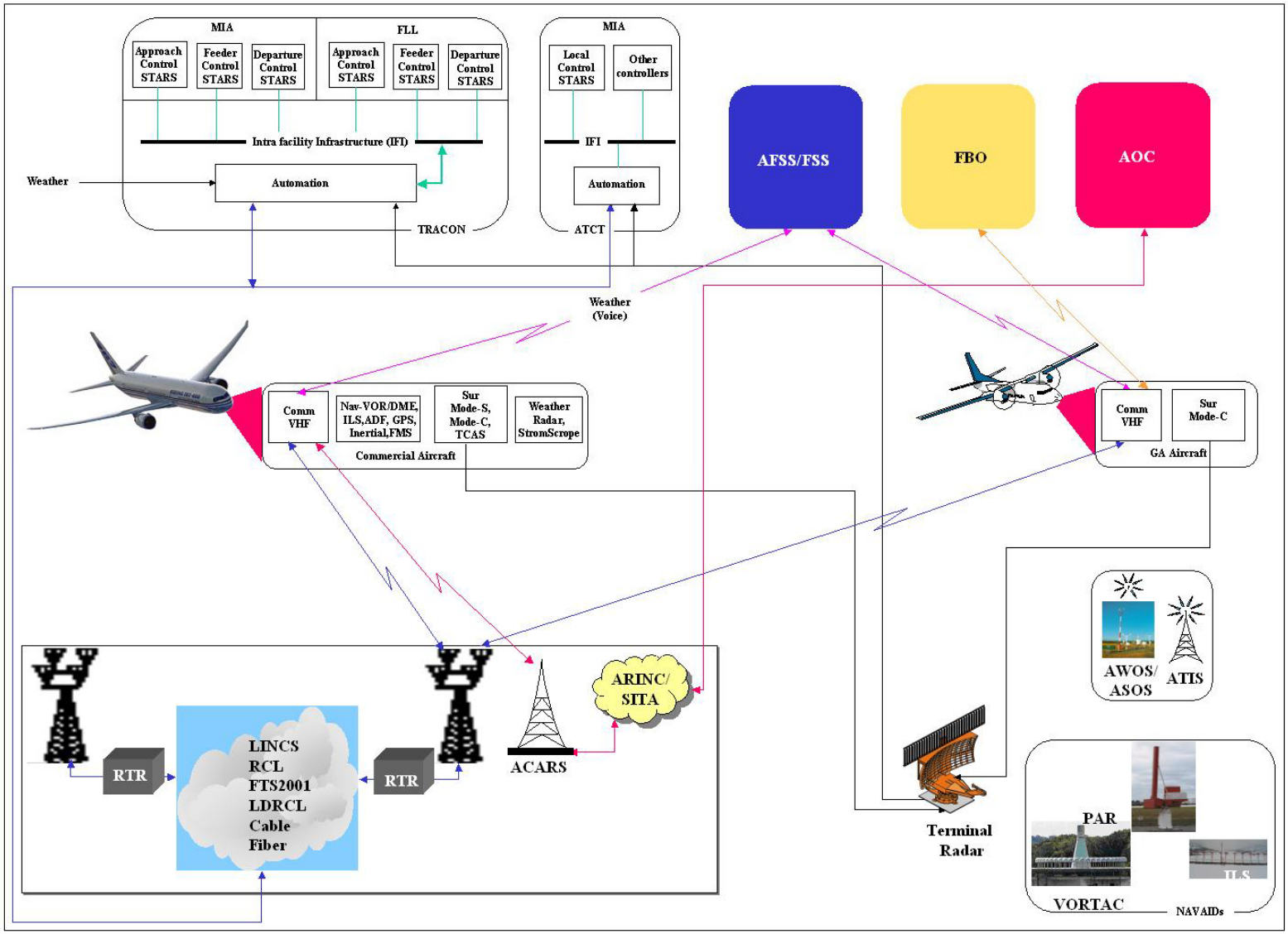
Total Number of Messages	–	*2,252*
Total Communications load	–	*44,825 Kbits*
Average Communications load	–	*12.45 Kbit/sec*

MIA Terminal Airspace SWIM Peak Hour Load Distribution

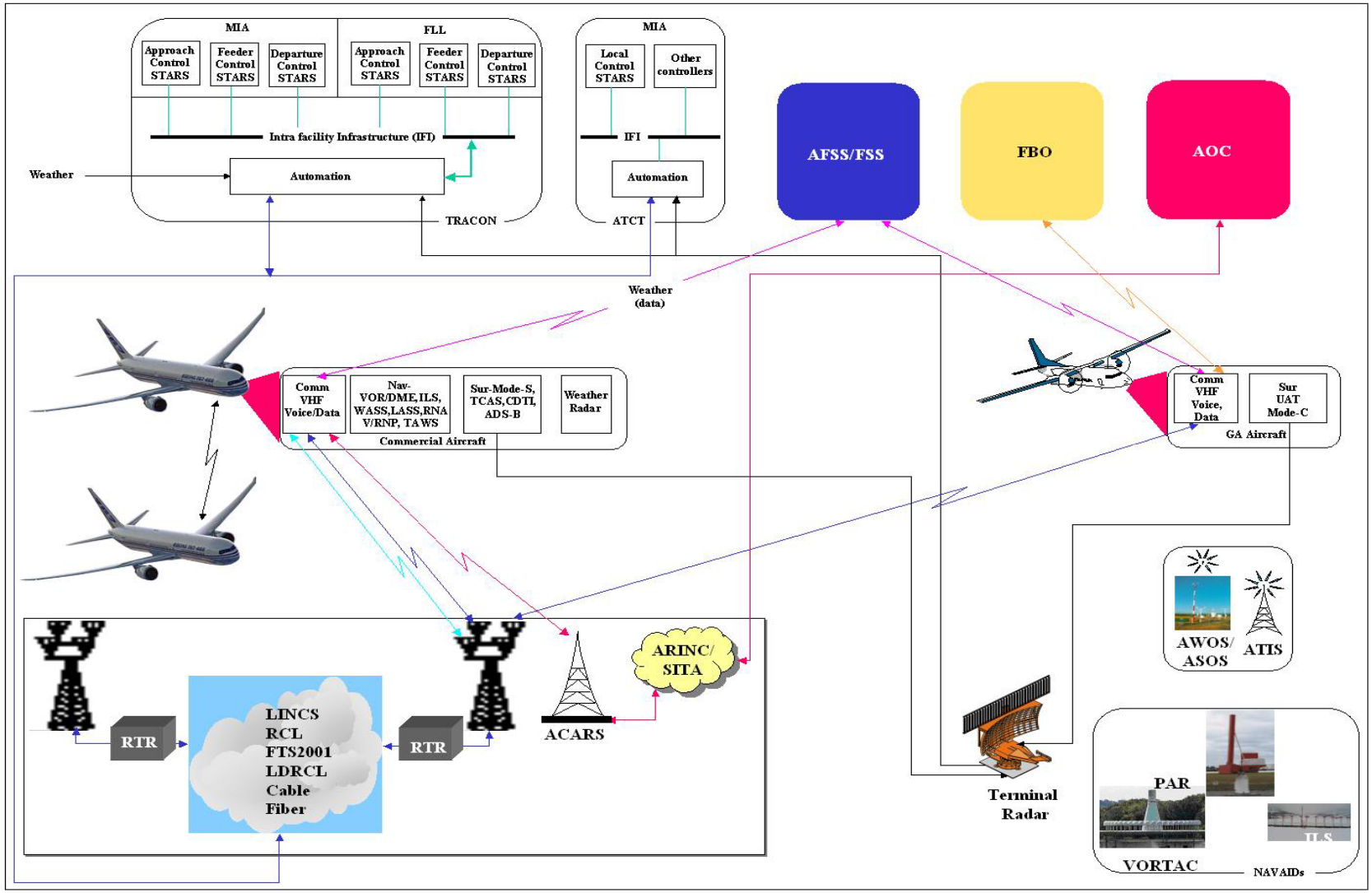


Total Number of Messages	–	*858*
Total Communications load	–	*5,156 Kbits*
Average Communications load	–	*1.43 Kbits/sec*

Near Term Logical Architecture



Mid Term Logical Architecture



Far Term Logical Architecture

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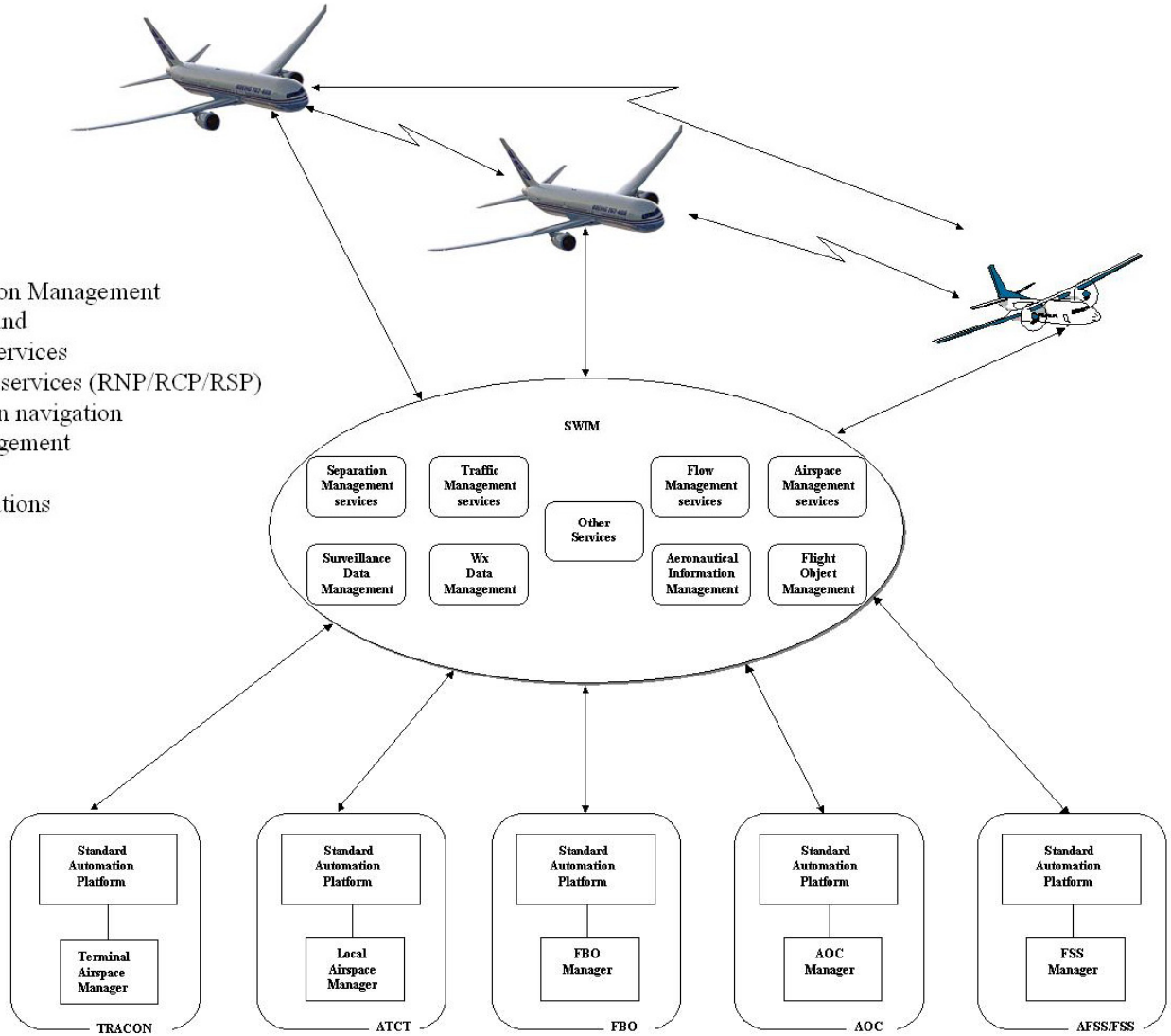
Network Centric Systems

Common Information Management
Broad-area broadband
Secured access to services
Performance based services (RNP/RCP/RSP)
Broad area precision navigation
4D trajectory management
Dynamic airspace
Super density operations



Conclusion

- **Study developed a "deterministic" method to forecast traffic loads**
  - **Responsive to arrival and departure schedule**
  - **Operations load is driven by ATC and AOC; unless, passenger related traffic is also integrated**
  - **Made use of NASA GRC FASTE-CNS**
- **Requirements are typical for Class B Airspace**
  - **Caution, of course, for terminal area sectorization**
- **Requirements are about average for Class C**
- **Future system designer must take into account loading for the selected network and media:**
  - **I.e. selected protocol**
    - » QoS requirements
    - » related layer to layer framing and messaging
  - **Link layer and physical layer effects**
- **Forecast for 2030 is subject to continued ATM concept development – 4D trajectory and SWIM**

MIA Traffic Analysis Summary

MIA Terminal Area Airspace Traffic Analysis Summary						
	Near Term (2005)		Mid Term (2015)		Far Term (2030)	
	# Flights /day	Peak Hour Load	# Flights /day	Peak Hour Load	# Flights /day	Peak Hour Load
ATC	860		1,289		2577	
Voice		98 secs/min		33.27 secs/min		N/A
Data		N/A		0.30 Kbits/sec		4.81 Kbits/sec
AOC	826	0.41 Kbits/sec	1,240	3.19 Kbits/sec	2475	12.45 Kbits/sec
FBO	34	5.83 secs/min	49	8.17 sec/min	102	16.33 sec/min
Swim		N/A	1,289	N/A	2577	1.43 –134 kbits/sec
Passenger	860	N/A	1,289	200-500 Mbits/sec	2577	1 Gbits/sec

FLL Traffic Analysis Summary

FLL Terminal Area Airspace Traffic Analysis Summary						
	Near Term (2005)		Mid Term (2015)		Far Term (2030)	
	# Flights /day	Peak Hour Load	# Flights /day	Peak Hour Load	# Flights /day	Peak Hour Load
ATC	798		1,196		2,391	
Voice		84 secs/min		28.20 secs/min		N/A
Data		N/A		0.27 Kbits/sec		3.83 Kbits/sec
AOC	695	0.33 Kbits/sec	1,041	2.75 Kbits/sec	2,082	9.58 Kbits/sec
FBO	103	16.45 secs/min	155	18.20 secs/min	309	43.17 Kbits/sec
Swim	798	N/A	1,196	N/A	2,391	1.20 – 106 Kbits/sec
Passenger	798	N/A	1,196	200-500 Mbits/sec	2,391	1 Gbits/sec

Recommendations

- **Use the forecast and requirements from this study**
  - **Wireless system design for the terminal area**
  - **Continue to track the NGATS approaches to terminal airspace management and control**
- **Conduct a task to integrate the surface and terminal into a "specification"**
  - **Benefit – save time and focus the efforts of the developer of new RF media design**
- **Support continued availably of the FASTE-CNS system**
  - **Add features for terminal and surface domains**

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