

An Open Architecture for Air Transport

ABSTRACT: This document has been prepared with the objective of defining an open architecture for inter-operable air transport systems within an environment based upon the OMA and adopted OMG specifications.

An architecture aims to identify important players, roles and relationships of air transport participants. It defines the major components needed to support participants in the execution of air transport transactions. Through the definition of interfaces and semantics of supporting services and facilities, an architecture provides an object framework to software developers that allows the implementation of coherent parts of an overall air transport system. The external interfaces permit interoperability with other means of transport, i.e. intermodal transport. The internal interfaces are intended where possible to support reuse across other domains.

DATE: 9 April 1997

AUTHORS: members of the Transport Air Working Group of the Transport SIG

RELEASE: 1 (DRAFT)

Table of Contents

FOREWORD	6
PREFACE	7
About this Document	7
Purpose	7
Intended Audience	7
Acknowledgments	7
OVERVIEW	9
An Interoperability Framework for Open Air Traffic Control Architecture	9
The Enterprise Model	9
The Architecture	12
Relationship to ongoing Technology Adoption Processes (C4I, ...)	14
Air Transport Requirements	14
Air Traffic Control Requirements	15
REFERENCES	16
AIR TRANSPORT SERVICES AND FACILITIES	17
AIR TRAFFIC CONTROL SERVICES AND FACILITIES	17
ATC COMMUNICATIONS SERVICES AND FACILITIES	17
Overview of Communication requirements	18
Communication protocols	18
Services required	18
Object Oriented Architecture	18
Objects	18
Services Common to all objects	18
Problems to be solved	18
Communication protocols	19
Surveillance Radar	19
Interfacility Communications	20
Communications protocols for peripheral and external domains	21
Physical Interfaces	22
Services Required	23
Object Oriented Communication Architecture	27
Objects	27

Sensor Object	29
Device Object	30
Port Objects	31
Common Services required of all objects	32
Problems to be solved	33

Table of Figures

<i>Figure 1 Strategic to Tactical Levels Operational ATC portion of Air Transport Architecture</i>	<i>9</i>
<i>Figure 2 Strategic to Tactical Levels Weather portion of ATC section of the Air Transport Architecture</i>	<i>10</i>
<i>Figure 3 Strategic to Tactical Levels Maintenance portion of ATC section of the Air Transport Architecture</i>	<i>11</i>
<i>Figure 4 Use of CORBA in FAA William J. Hughes Technical Center Integration and Interoperability Facility</i>	<i>12</i>
<i>Figure 5 Current En Route Architecture</i>	<i>25</i>
<i>Figure 6 Future En Route Architecture</i>	<i>26</i>
<i>Figure 7 Object Oriented Communications Architecture</i>	<i>28</i>

Foreword

The interests of the present attendees are concentrated in the air traffic control portion of air transport. This includes an interest in free scheduling, free routing and eventually free maneuvering. Free scheduling might present an interface to the reservation activity, in the sense of strategic planning for scheduling based upon statistics of reservations, and possibly in the area of small business aircraft whose schedules are adaptive to passenger demand on a relatively short time scale.

The current state of air traffic control system architecture is that several heterogeneous platforms are employed, interoperating, but that the communications between the platforms is not based upon widely available general purpose communications software standards. The life-cycle maintenance costs of the current software might be reduced if commercial off the shelf software could be employed that would meet the needs of air traffic control systems.

The ability to “plug-and-play” with products from a variety of vendors is limited by the present implementation of the air traffic control algorithms. A vision of a new air traffic control system in which it is straightforward to upgrade the system incrementally, by the replacement of relatively small software components, available from multiple vendors, guides the development of this open architecture.

Preface

About this Document

This document is divided into several sections, permitting concentration on different areas within air transport.

One section of this document presents a high level specification of requirements for an air traffic control system. It identifies those interfaces, component interfaces, necessary to interoperate with other components comprising the air traffic control system. This document proposes, either by reference to other documents or by material contained herein, high level requirements specifications relating to:

- air traffic control operations
- air traffic control infrastructure maintenance
- air traffic control related weather measuring and predicting systems

Purpose

The purpose of the open architecture document, as it evolves, is to develop a consensus among the partners: suppliers, users, maintainers, administrators, interested in the air transport business about the computer automation architecture to support air transport. Interface syntax and semantics identify products which can be used as components with which to construct the air transport system.

As the evolution rate of the document slows, the purpose of the document is to describe the interface syntax and semantics of components (which would be products) which are useful in the construction of the air transport system.

Intended Audience

The intended audience is the suppliers and users of air transport, including the regulatory agencies involved with air traffic control.

Acknowledgments

The preparation of this document reflects the contributions of many people, some of whom have attended meetings of the Transport_Air Working Group, and others of whom are contributors to the field whose work has been recognized herein.

Overview

An Interoperability Framework for Open Air Traffic Control Architecture

The Enterprise Model

An enterprise model for the operational air traffic control system is shown in Figure 1.

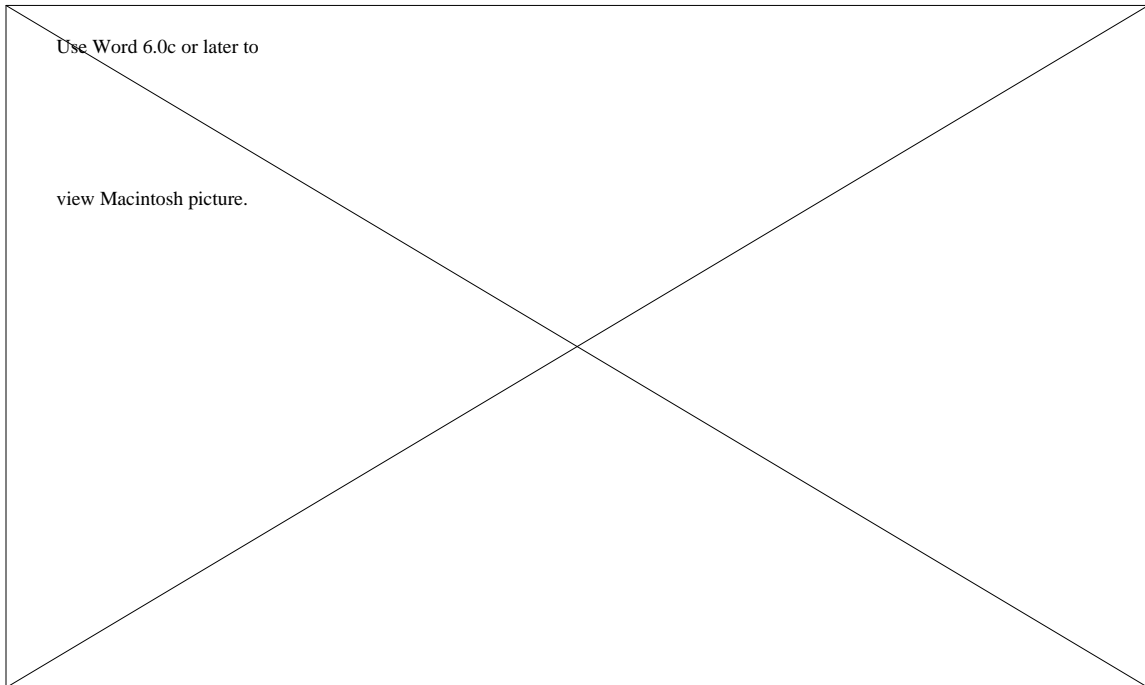


Figure 1 Strategic to Tactical Levels Operational ATC portion of Air Transport Architecture

An enterprise model for the weather related to the air traffic control system is shown in Figure 2.

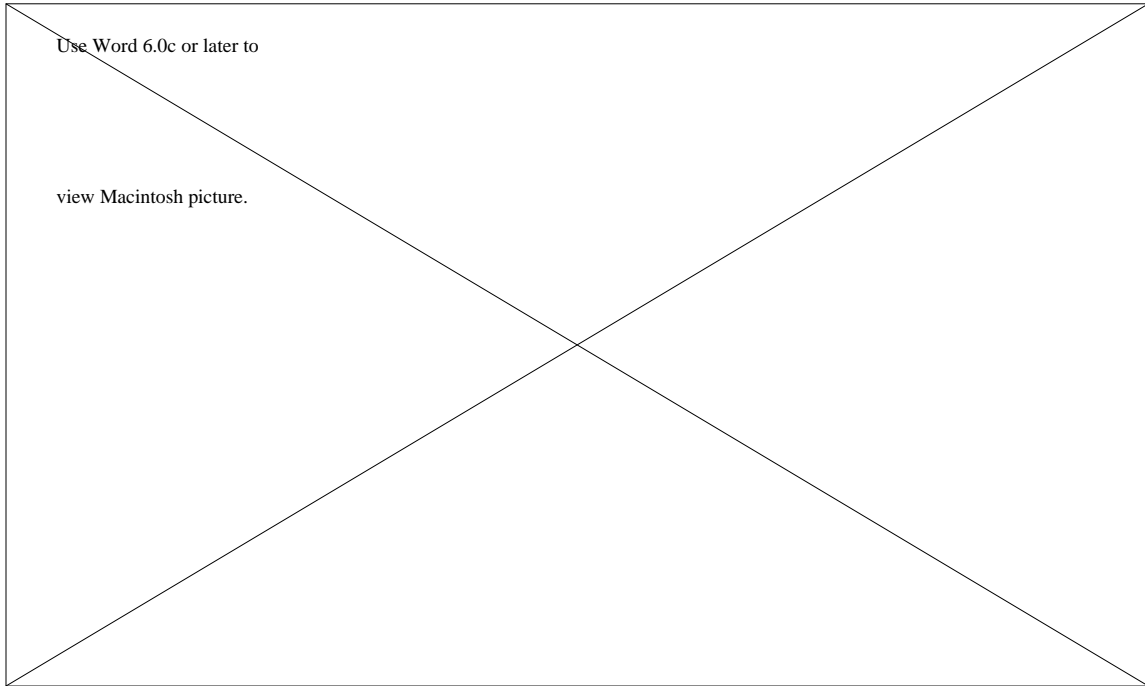


Figure 2 Strategic to Tactical Levels Weather portion of ATC section of the Air Transport Architecture

An enterprise model for the weather related to the air traffic control system is shown in Figure 3.

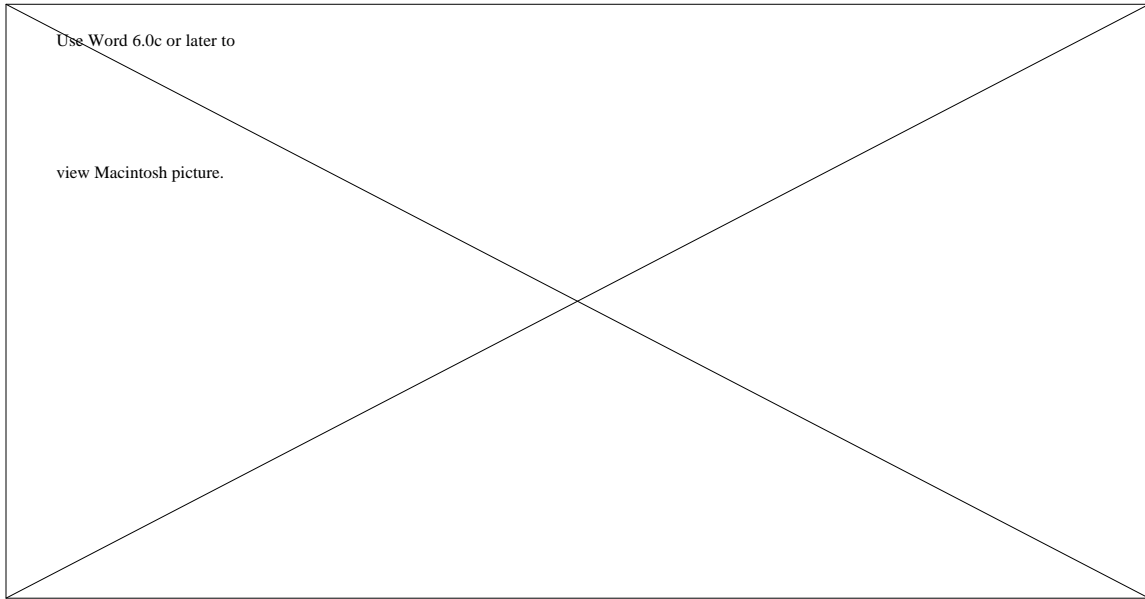


Figure 3 Strategic to Tactical Levels Maintenance portion of ATC section of the Air Transport Architecture

The scope of the joint enterprises includes simulation, for example, as shown in Figure 4.

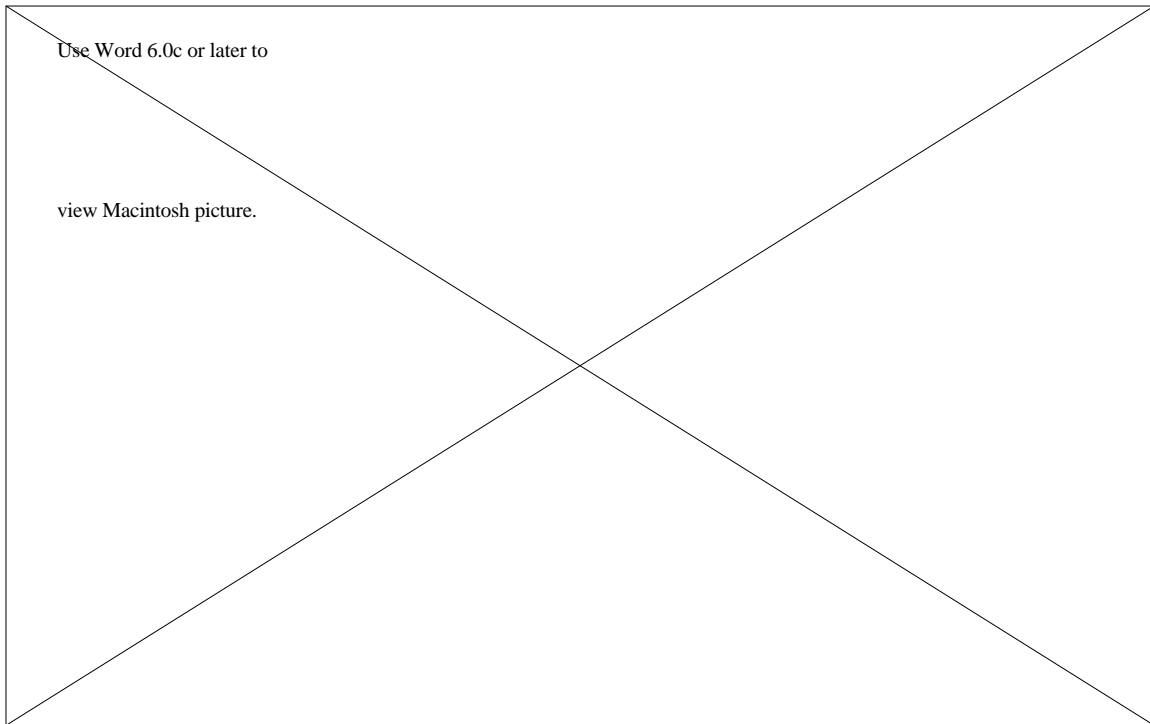


Figure 4 Use of CORBA in FAA William J. Hughes Technical Center Integration and Interoperability Facility

The Architecture

The work undertaken in developing this architecture is driven by the interest of enabling the Federal Aviation Administration (FAA) to utilize the products of many vendors in the construction and upgrading of air traffic control systems. Many existing standards are adopted herein, and some new ones are proposed.

Operational ATC Enterprise

Communications Services

The work by Camber/DSC has been received with interest by the ORB Object Services (ORBOS) group. Possibly the Object Services will be augmented to use the architecture, which would then be made available through ORBOS to application domains including air transport.

Recording Services

Display Services / Display Facilities

There is a user interface CORBAfacility.

ISA Systems and Orthogon System have interoperating products used by Eurocontrol, built upon X-windows that provide ATC related windowing/display system.

(Untracked) Aircraft State Facilities

The representation of an aircraft in the computers supporting Air Traffic controllers could be an object, created with a factory object using the Object Lifecycle Service. This implies that the implementer of an aircraft object support the Lifecycle operations move, copy and remove. Use of move might accompany a handoff, use of remove might accompany remove track and remove strip, and use of copy might accompany the processing of a stereo flight, especially if such a flight is metered across a fix as individual aircraft.

System Resources Corporation has begun to model aircraft as objects, in a way consistent with the NAS Architecture.

Tracking Facilities

Intention Facilities

Aircraft Model Facilities

Trajectory Facilities

Airspace Facilities

The relationship CORBAservice provides a means of representing a containment relationship, with container and contained roles which might be useful in representing subdivisions of airspace.

Sectorization Facility

Special Use Airspace Facility

This facility might be able to take advantage of work being done in the CORBAgis working group.

Terrain Facility

This facility might be able to take advantage of work being done in the CORBAgis working group.

Conflict Detection Facilities

Conflict Resolution Facilities

Scheduling Facilities

Sequencing Facilities

Spacing Facilities

Handoff Facilities

There is an information management CORBAfacility which might be generalizable to be relevant to the exchange of information between ATC facilities in handoffs. The CORBA relationship service might also be useful here.

ATC-related Weather Enterprise

Nowcast Facilities

Forecast Facilities

ATC Infrastructure Enterprise

Utilization Statistics Facilities

The task management CORBAfacility which was under

Relationship to ongoing Technology Adoption Processes (C4I, ...)

Component Definition Language Specification

Air Transport Requirements

Air Traffic Control Requirements

References

Source	Document
FAA, AUA-200	FAA's En Route Architecture Study Findings, May 16, 1997
FAA, ASD-100	NAS Architecture and revisions
FAA, ASD-100	FAA: http://asd.orlab.faa.gov/files/menu.ht
MITRE/CAASD	http://www.mitre.org/centers/caasd/Papers/WP/90W542/section1.htm
Eurocontrol	http://www.eurocontrol.be
RTCA	SC-162, SC-147, SC-182
Camber/DSC	communications architecture
System Resources Corporation	conversion from NAS Architecture functional model to object oriented model
Lockheed Martin Air Traffic Management	En Route Infrastructure Design Document, March 3, 1997

Air Transport Services and Facilities

Air Traffic Control Services and Facilities

Introduction

The Air Traffic Control Services and Facilities are described in more detail below. They are, in some cases, descriptions of completed work or work in progress.

ATC Communications Services and Facilities

This work has been received with interest by ORBOS.

Ideal World

Provide services transparent to the underlying infrastructure with infinite extensibility over wide range of protocols.

Allow the plug and play of commercial communications subsystems to be utilized without software changes.

Maintain compatibility with legacy systems while building for the future.

Communication objects are instantiated based on a service that they can provide. Communication objects provide a common, transparent way to receive and transmit information from many different types of interfaces.

Overview of Communication requirements

Communication protocols

- Radar
- Interfacility
- Communication to peripherals
- External Systems and Domains

Services required

- Send/receive data
- Broadcast/connection
- Data recording
- Status and statistics
- Fault tolerance redundancy
- Extensibility

Object Oriented Architecture

Objects

- Sensor Objects
- Device Objects
- Port Objects

Services Common to all objects

- Configuration
- Status and statistics
- Message transfer

Problems to be solved

- Need to utilize COTS Communication controllers
- Need message encapsulation and delineation

Communication protocols

Surveillance Radar

Synchronous data transfer 2400 - 19,200 baud

Radar - Characterized by continuous small packets and varying protocols and message formats.

Variety of message types

- Beacon
- Weather
- Search

Radar Communication Protocols

- CD-2 12 bits + parity, 13 bit sync, 4, 7 fields per message
- ASR3 ADCCP
- ASR4 ADCCP
- ASR9 Enhance CD2 4, 7, 32 fields per message
- Asterix HDLC (Currently four versions)

Utilizes EIA 422, 485, 232, EIA 530

Interfacility Communications

Utilized for communication with other Air Traffic Facilities to exchange flight plans and facility hand-offs of planes from one center to another.

Communication format

- Currently proprietary synchronous
 - 17 bit sync, 8 bits + parity, LRC, SOM, EOM
- HDLC - Planned for use in the future to replace Interfacility

Communications protocols for peripheral and external domains

- **FDIO - Flight Data Input/Output**
 - Modified ADCCP used to send remote Flight Strips.
 - Protocol was implemented wrong and NS and NR fields are reversed.
- **CTS - Coded time source** Asynchronous interface to time source.
- **X.25** - Utilized to receive weather data, and communicate with NEXRAD and NADIN.
- **GPI/GPO** Utilized for custom parallel interface

Physical Interfaces

- Synchronous and Asynchronous
- EIA - RS 485
- EIA - RS 530
- EIA - RS 232
- Custom

Currently most interfaces are running at 2400 baud synchronous. Would like new interfaces to run at 9600 baud or higher.

Services Required

The following capabilities are required of the interfaces.

Data Transfer

- Basic Send/Receive of data messages
- Data Filtering
- Data reformatting and conversion
 - Radar conversion, ASCII to EBCDIC, etc.

Protocol handling

- Automatic switch - over to backup ports if an adapted error rate is exceeded.
- Adjustable data rates
- Flow Control

Port Control

Line Control - The port should be able to disable itself to allow modem sharing devices to work.

- Baud Rate
- CRC
- EOM characters
- link level protocol
- time-outs
- Physical Media

Performance and statistics

Each port object must be capable of reporting the current statistics.

- Total number of messages
- Total number of bytes
- Line Utilization
- Number of Errors

Data recording

- All data need to be recorded with time stamp.
- Simulation - recorded data should be capable of being played back.
- Adaptation should control what gets recorded and where.

Current EnRoute Architecture

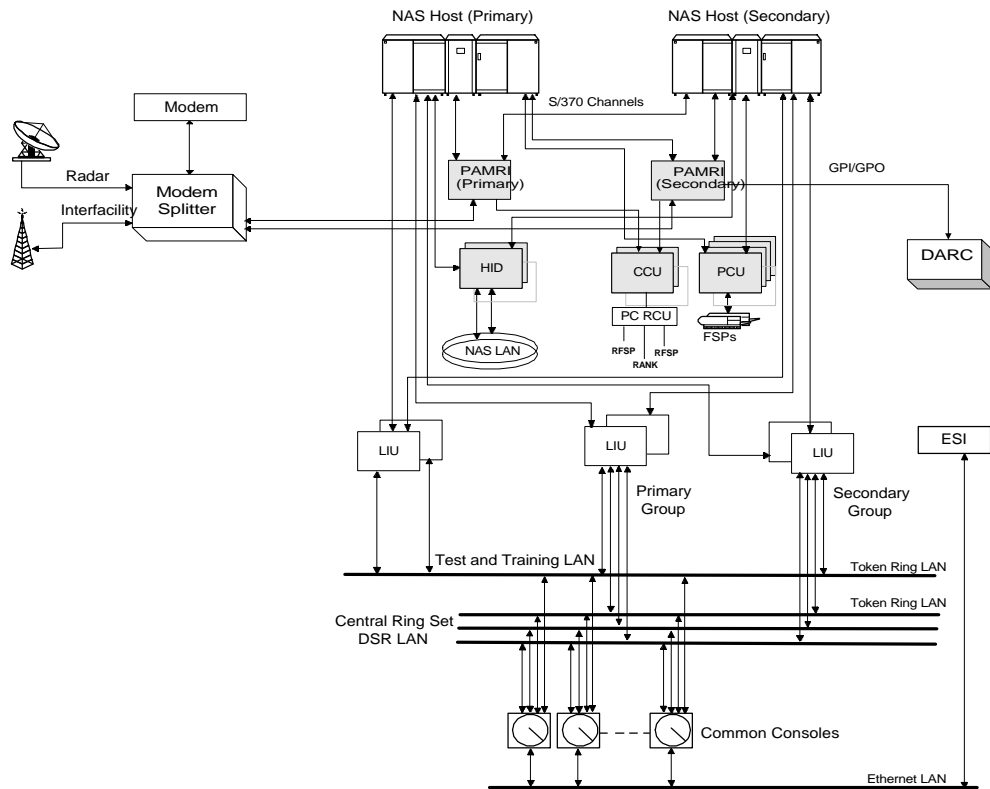


Figure 5 Current En Route Architecture

Future EnRoute Architecture

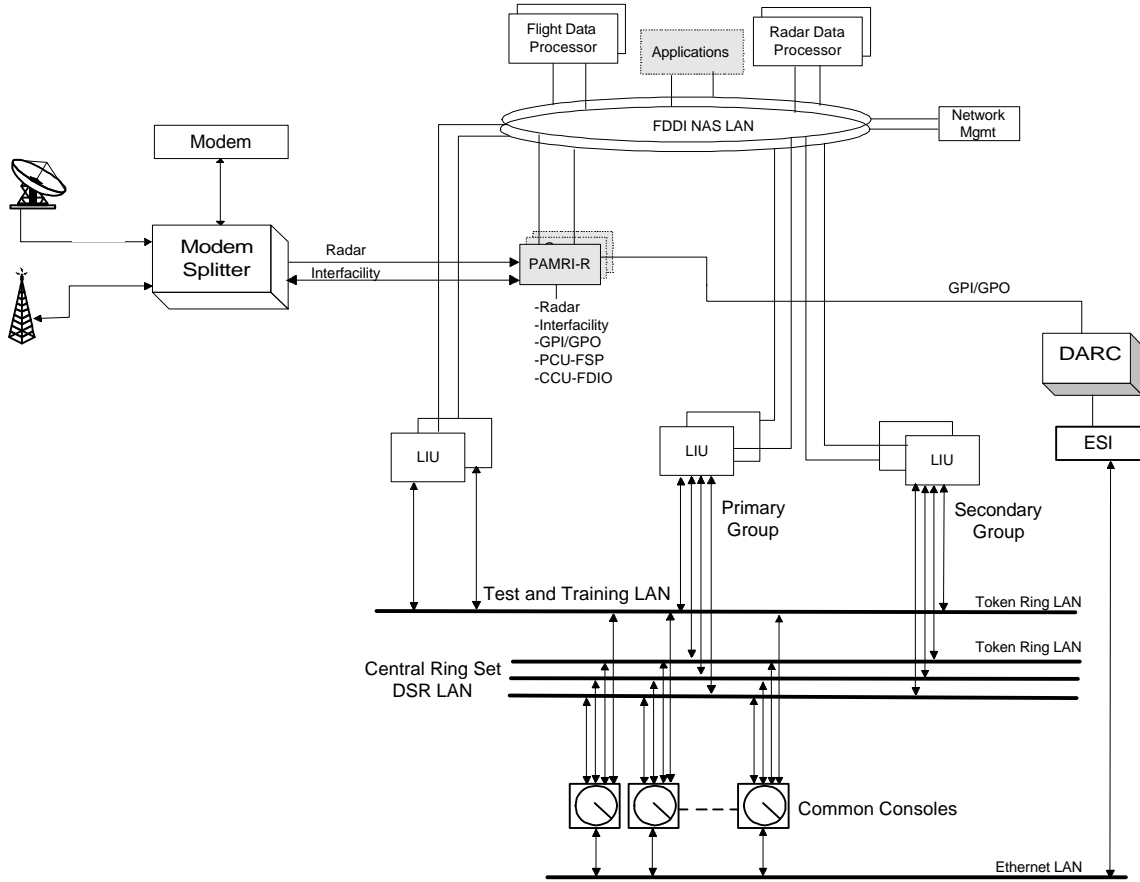


Figure 6 Future En Route Architecture

Object Oriented Communication Architecture

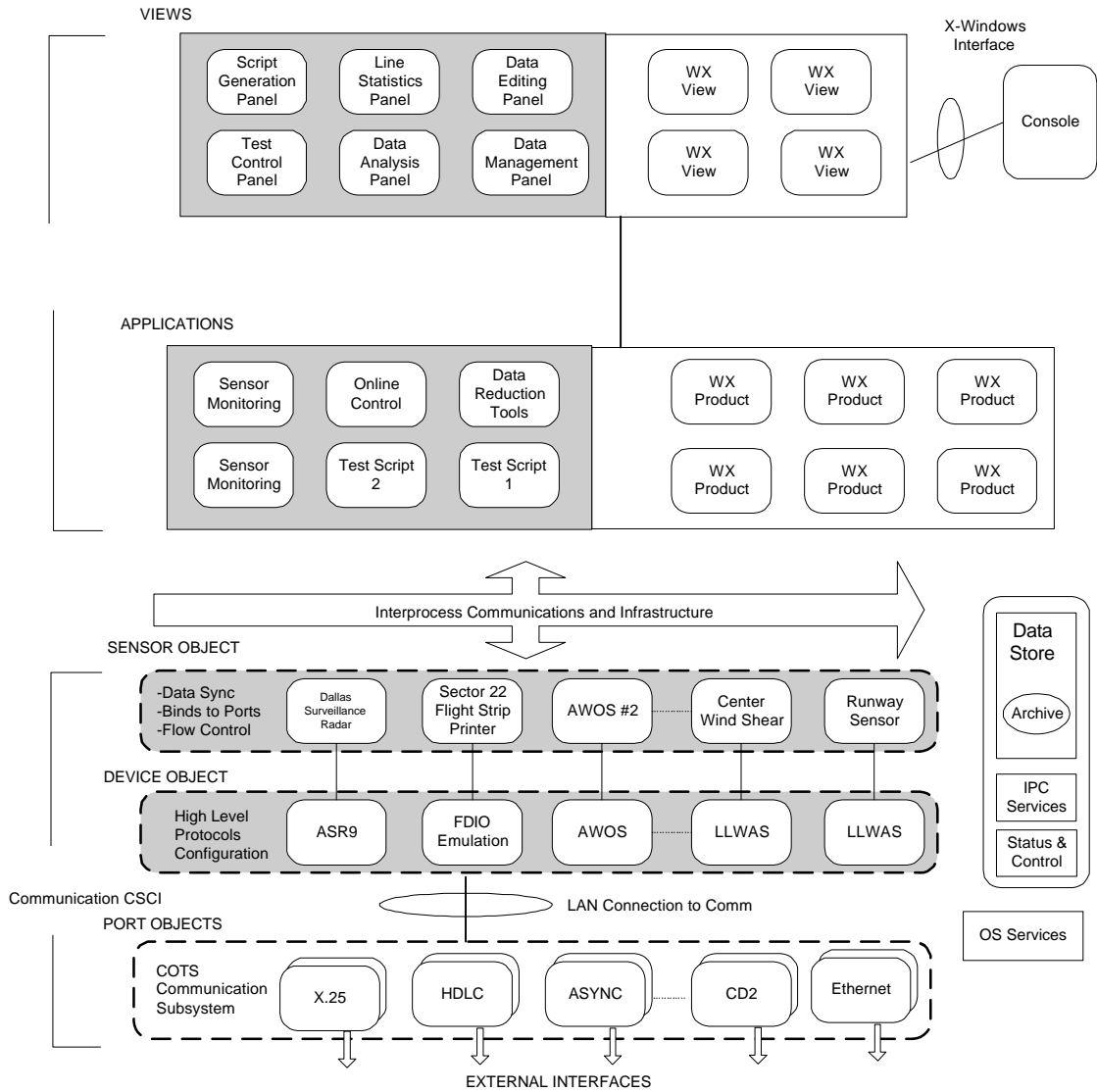
Objects

Sensor Objects - Application services for sensors or communication services

Device Objects - Provides Network transparency and device protocol specific handling

Port Objects - Represents physical or logical communication channels and ports.

Object Oriented Communication Subsystem Example



Communication Architecture

Figure 7 Object Oriented Communications Architecture

Sensor Object

The sensor object provides a consistent common interface to the application.

The application instantiates objects to provide services that it requires.

Capabilities and Services

- Data Transfer
- Data Conversion
- Flow Control
- Filtering
- Message Encapsulation
- Support for transport connections
- Message Notification

Device Object

Provides a consistent interface between the Sensor and the Ports

May be considered as a Network Layer providing transparent redundancy, backup paths, and message routing.

Capabilities and Services

- Responsible for higher level protocol (example may poll for data, handle acknowledgments)
- May bind to one or multiple Port objects
- May bind to one or multiple sensor objects
- May provide proxy capabilities for some port objects
- Provides data recording interfaces
- Provides statistics and performance monitoring capabilities.
- Message delineation

Port Objects

This object encapsulates all of the physical and link level control required by the interface.

There exist a single port object for each physical or logical communication line.

Capabilities and Services

- Data transfer
- Configuration
- Hardware control capabilities
- Link level protocol
- Status and error monitoring

Common Services required of all objects

- Configuration
- Status and statistics
- Data recording capabilities including time-stamping
- Flow Control

Problems to be solved

The current system must support a wide variety of interfaces and must be capable of being expanded with additional ports and types of interfaces.

The communication capabilities must be available to separate diverse applications without impact on existing applications or functionality.

The two main issues involving the current architecture are:

1. Common access to information for Applications. (Message encapsulation) of diverse data streams.

2. Ability to utilize COTS communication controllers to:
 - Allow the utilization of the latest protocols and technology
 - Easily increase the number of ports and resources
 - Reduce development time
 - Reduce maintenance and logistical cost.