Development of Controller Pilot Automatic Data Communication (DataComm) System

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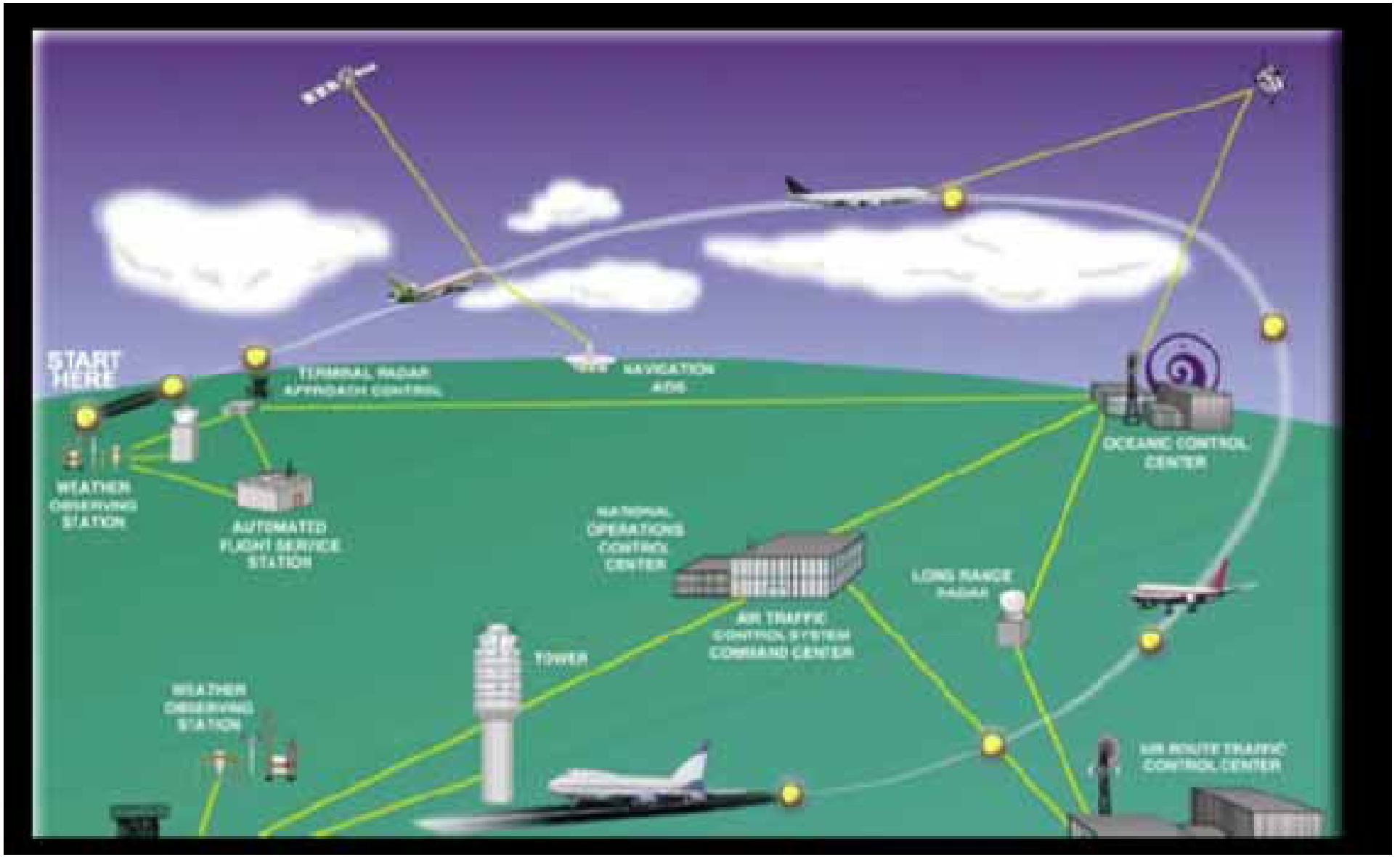
FAA Runs the Largest and Safest ATC System in the World



What is NextGen?

- NextGen is a wide ranging transformation of the entire national air transportation system - not just certain pieces of it - to meet future demands and to avoid gridlock in the sky and in the airports while improving safety and protecting the environment.
- NextGen moves away from ground-based surveillance and navigation to new, more dynamic satellite-based systems. These changes are well beyond our legacy modernization programs.
- NextGen will change the way the system operates, reduce congestion, expand capacity, reduce noise and emissions and improve the passenger experience.

What Changes Improve Services?

Today		NextGen
Ground-based navigation and surveillance	→	Satellite-based navigation and surveillance
Air Traffic Control communications by voice	→	Routine information sent digitally
Disconnected information systems	→	Networked Information systems
Air traffic "control"	→	Air traffic "management"
Fragmented weather forecasts	→	Forecasts embedded into decisions
Airport operations limited by visibility conditions	→	Operations continue into lower visibility conditions

NextGen aircraft will have more onboard capabilities to perform airborne self-separation, precisely navigate and execute four-dimensional trajectories and improved surveillance technologies. Unmanned aircraft systems will operate among regular aircraft and domestic supersonic cruise operations will be more prevalent.

NextGen is Already Underway !

Five (5) NextGen Transformational Programs

- ***Automatic Dependent Surveillance Broadcast (ADS-B)***
- ***Data Communications***
- ***NextGen Network Enabled Weather (NNEW)***
- ***NAS Voice System (NVS)***
- ***System Wide Information Management (SWIM)***

Other

- ***NextGen Goal: Performance - Based Navigation***
- ***Runway Safety***
- ***Airport Surface Detection Equipment, Model X (ASDE-X)***
- ***Wide Area Augmentation System (WAAS)***

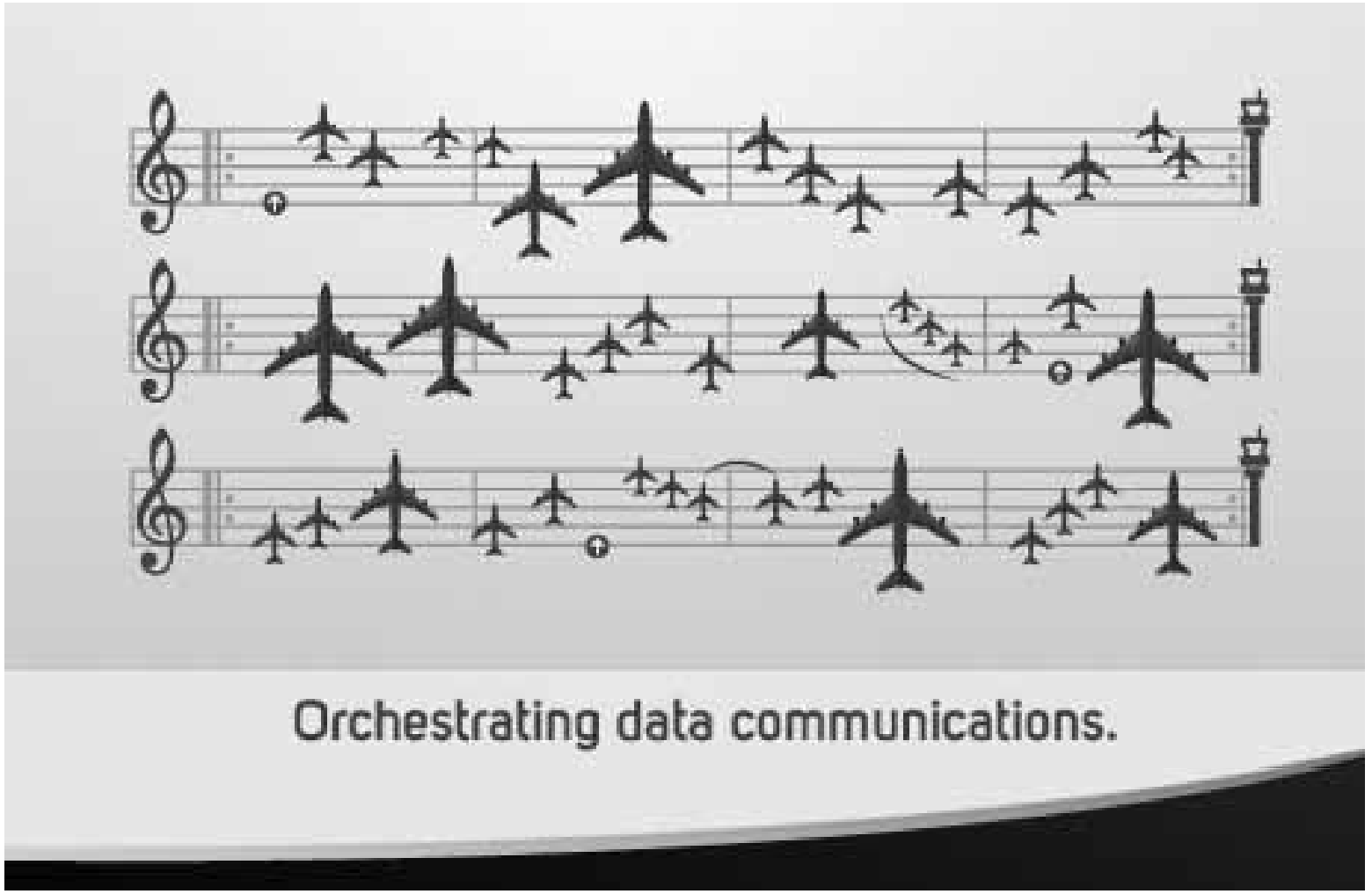
Data Comm Program Overview

- ***Data Communications (Data Comm) will assume an ever increasing role in controller to flight crew communication***
- ***Based upon the incremental implementation of advanced communication capabilities; Data Comm represents the first phase of the transition from the current analog voice system to an International Civil Aviation Organization (ICAO) compliant system in which digital communication becomes an alternate and eventually predominant mode of communication.***
- ***Data Comm, as well as other components of NextGen, depends on efficient data communications between aircraft and air traffic management. Data Comm program is a key element in the implementation of NextGen.***

Data Comm Benefits for NAS Operations

- Reduced *congestion through implementation of new procedures*
- *Reduced gaps and more efficient metering of aircraft to the airport*
- *Reduced controller workload, which allows them to handle more aircraft and increase capacity*
- *Reduced aircraft noise and emissions due to more efficient flight profiles*
- *Improved safety that results from reduction of communications-related operational errors.*

Harmonizing the aircrafts



Picture Source: Lockheed Martin http://www.lockheedmartin.com/us/products/data-comm.html

Data Comm Network

- ***Establish infrastructure that takes advantage of existing equipage***
- ***Support NextGen/SESAR and in accordance with the U.S. agreed support to the ICAO Harmonization Strategy to stop partial implementation of Data Communications services i.e., message sets***
- ***Acquire a service for the Data Comm network that meets the performance requirements specified by SC-214/WG-78***
- ***Enable aircraft with FANS 1/A+ and ATN equipped aircraft to get Data Comm services***

Data Comm Segments

- ***Data Comm will be deployed in two segments:***
  - *Segment 1, including ATC towers and En route centers, in the 2014 timeframe, and*
  - *Segment 2, including TRACONS and full aircraft Flight Management System (FMS) integration, in the 2017-2018 timeframe*
- ***Data Comm network will have G/G authentication in Segments 1 and 2; and A/G network during Segment 2***

Data Comm Participants

ERAM

- Processes logon information
- Performs Logon-to-FP Correlation
- Provides Flight Strip, Flight Data, Logon Data for proposed flights to TDLS
- Provides security gateway (PGW FEP & DCGS BEP)

TDLS

- Sends DCL to aircraft
- Initiates session with the aircraft
- Requests correlated data from ERAM

Tower Controller

- Processes initial DCL
- Processes revised DCL
- Picks flight from Pick List
- Solves the issue of multiple proposed flight plans if it occurs

AOC/FOC

- Files FPs
- Populates subscriber list
- Sends Gate ID when Courtesy Copy is received

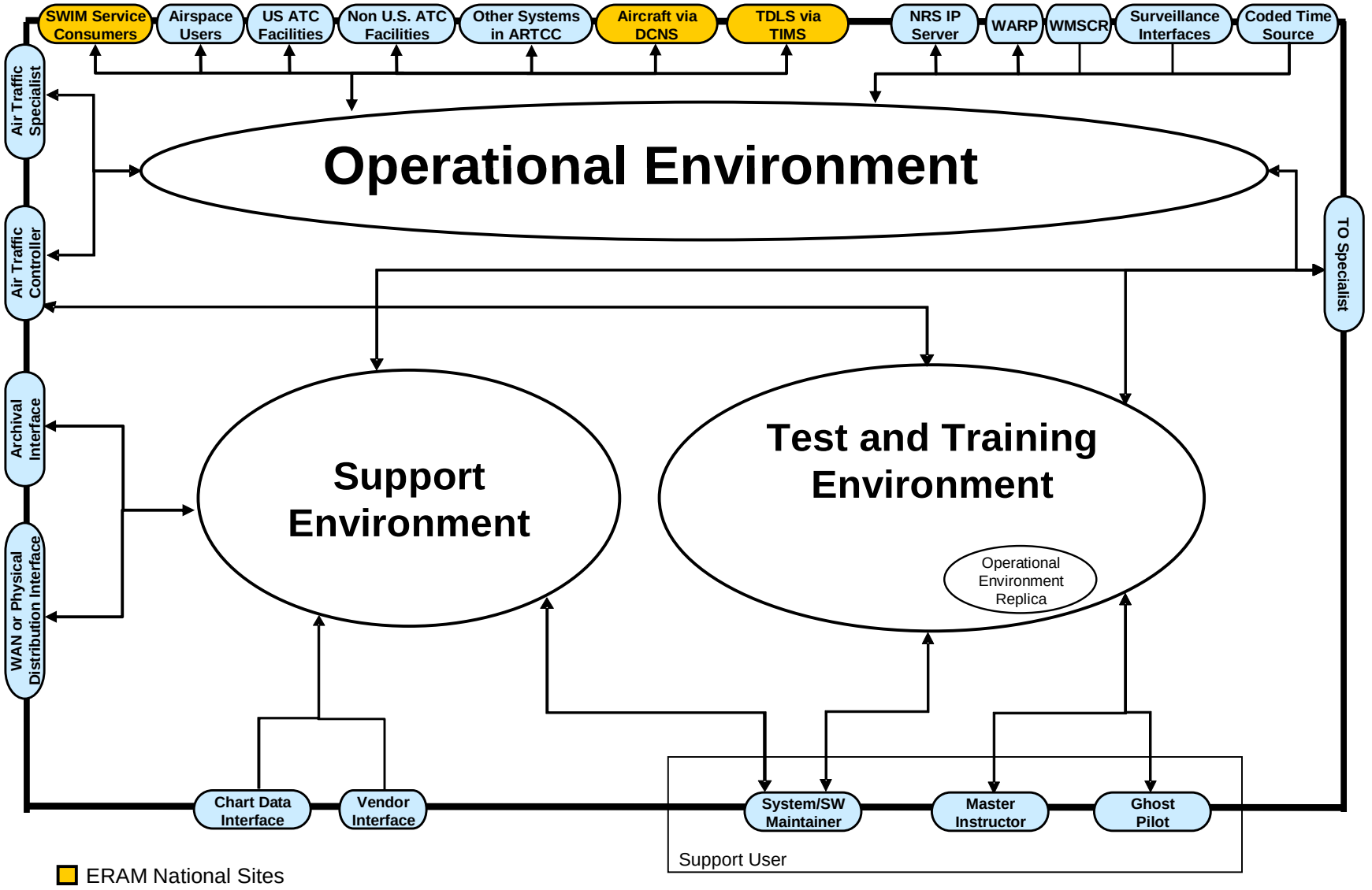
Aircraft

- Processes Logon, Requests & Response
- Establishes Session
- Processes Pilot DCL Requests & responses
- Sends indications to Pilot

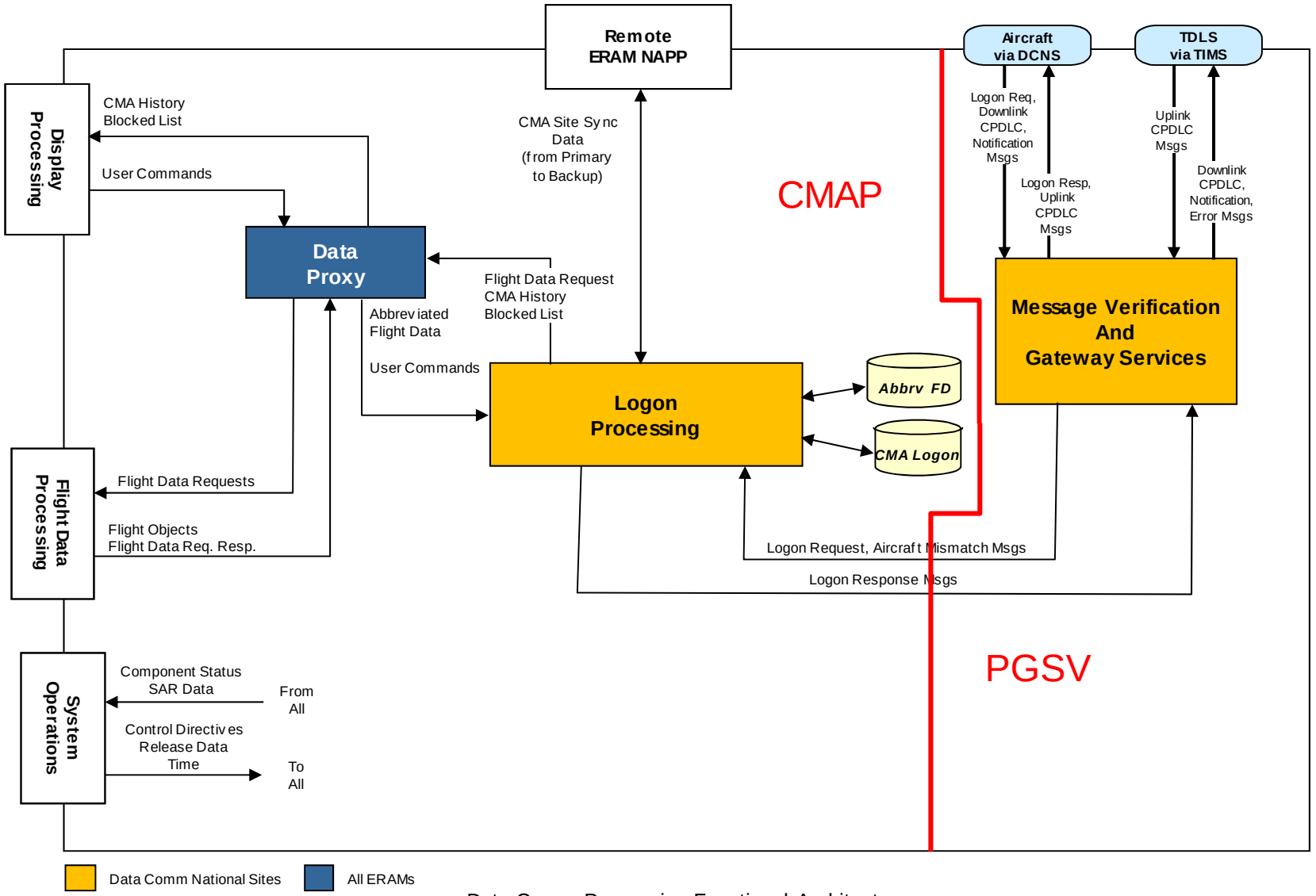
Pilot

- Initiates Logon
- Requests initial DCL
- Responds when DCL or Revised DCL is received

ERAM Environments



Data Comm Processing Functional Architecture

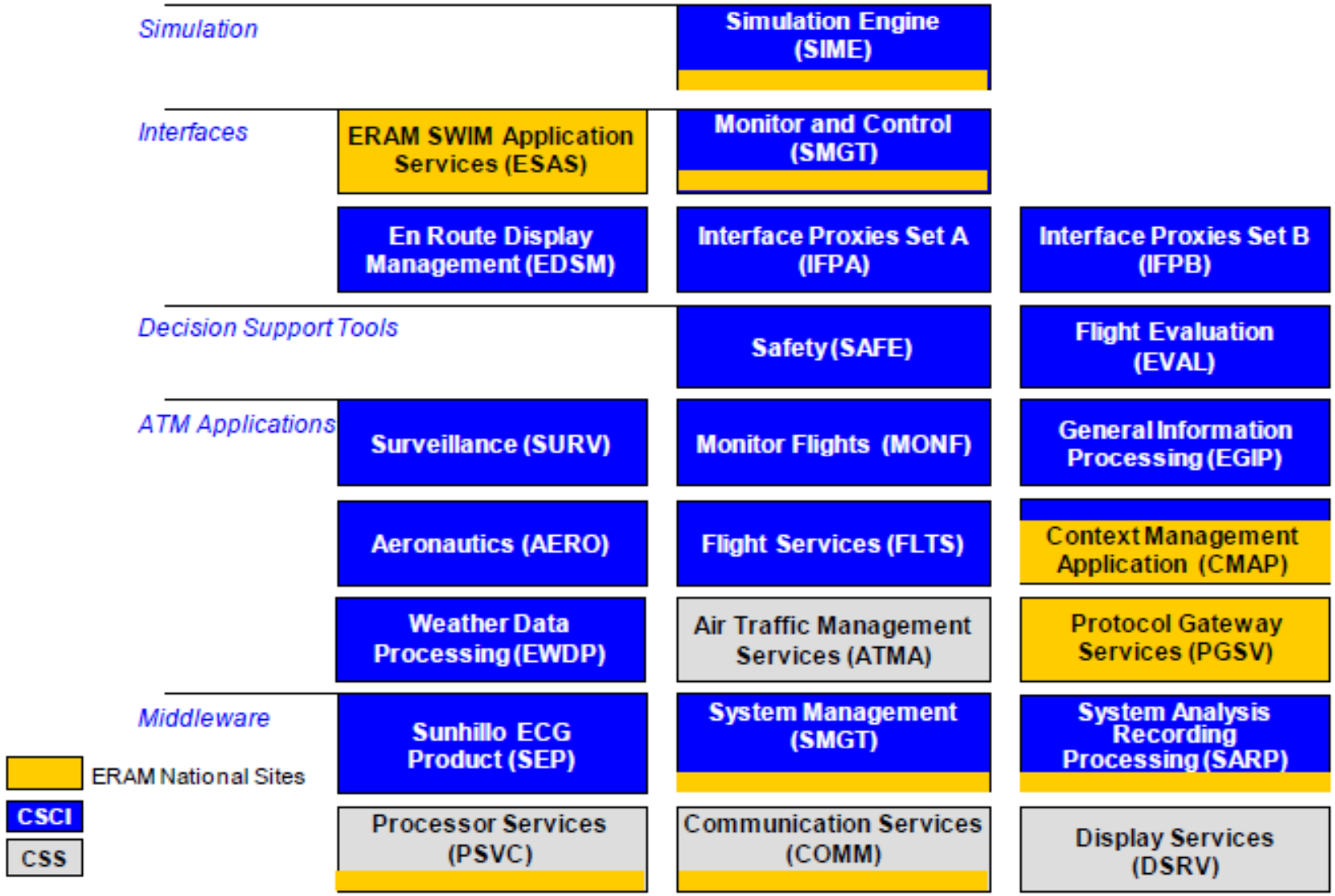


Data Comm Processing Functional Architecture

Impact on ERAM Software

- **Total SLOC size for the initial ERAM DataComm release is 111K**
- **New CSCIs**
  - Context Management Application Processing (CMAP)
  - Protocol Gateway Services (PGSV)
- **General Paradigms**
  - CMAP CSCI is responsible
    - To validate initial logon requests from an aircraft
    - Validate exchange flight data between CMAP and FLTS
    - For the query interface
    - CMAP Data Proxy (CDP) responsible for exchanging data with CMAP Base Processing (CBP) to build up CBP flights database from each ERAM
    - For the communication with PGSV
  - IFPB CSCI is responsible for the TDLS Adapter Interface (TAI)
  - Will use ERAM Common Functions to the greatest extent possible
    - FlightDeck control & Publisher Framework extensions

Software Layers



Software Assurance Level

- **Higher assurance level of DO-278 AL3 on ERAM Data Comm Automation software and on the overall Data Comm Program S1P1 architecture**
- **Architecture Error Protection and Control Features**
  - *Data Error Protection Features*
  - *Deactivated and Dead Code*
  - *Other Safety Control Features*
- **The DO-278 AL3 assurance level also aligns with the DO-178 software level C for similar "Major" severity hazards identified for both airborne and ERAM Data Comm software.**
- **FAA has performed a DO-278 Gap Analysis on the legacy ERAM software and changes to the ERAM architecture under the Data Comm scope.**

DO-278 Objectives

- **Software assurance provides a level of confidence that the potential for anomalous software behavior has been identified and mitigated. RTCA/DO-278 identifies software design assurance objectives for:**
  - Software Planning and Approval
  - Software Development
  - Software Integration
  - Software Verification and Validation
  - Software Configuration Management
  - Software Quality Assurance
  - Adaptation Data
  - Commercial-of-the-Shelf (COTS)-specific Processes for Planning, Acquisition, and Configuration Management (CM)

COTS and FOSS Software Tool Qualification

- **All ERAM COTS and FOSS Software Tools being assessed**

Compliant	Partially Compliant	Non-Compliant	Not Applicable	Future Consideration
75	0	0	2	1

- **Ada specific tools**
  - Ada-ASSURED
    - part of Gramma Tech's Ada-Utilities toolset
    - supports the software standards enforcement and inspection
  - Aprobe
    - OC Systems Aprobe is a software development and testing tool for Ada, C/C++, and Java software
  - PowerAda V5.5
    - Compiler is an integrated environment for developing, testing, integrating and maintaining complex Ada applications on AIX

Lessons Learned in Developing Systems in Ada

Positive

- ASIS interface is very useful and we're utilizing it heavily for data exchange
  - Operational software (recording data) and Support software (interpreting recorded data)
  - Support software (generating adaptation data in compact, binary data) and operational software (reading in the adaptation data)
  - Ada software exchanging data with C++ software (crossing language boundary and passing data along)
- Ada results in code that is easier to debug due to strong typing / range checking. Much easier to debug an index which is out of range when an exception is raised on the first attempt to use it as opposed to stomping on random areas of memory.

Challenges

- Ada Reuse
- The perception of that Junior personnel are working with "old" technology and that the skill acquired are not transferable/marketable
- There is a related issue about "Calling" languages (like C) that do not support exceptions

What Does Ada Offer to Support These Qualities?

- Strong Typing to improve integrity and security at compile time
- Predictability: able to prohibit polymorphism and eliminate side effects
- Packaging abstraction for Information Hiding and Modularity to manage complexity and contain errors
- Strong Error Handling / Low Overhead – quick recovery
- Concurrency and scheduling support for performance and scalability
- Standardized syntax and semantics that supports software engineering principles
- Portability essential for long-lived systems
- Initialization support and mechanisms for controlling memory and I/O
- Complete model of mathematics (precision integer/floating point operations) for algorithms (expressive power with efficiency, flexibility, and accuracy)

What else is there to do?

- Improved Compilers / Optimizers
- Enhanced analysis tools – especially at compile time
- Improved interface specification with compiler validation
- Enhanced support for certification of assurance standards
- Improved integration of design models to code - execute the design specification and constrain the implementation to the design
- Improved productivity support: reuse, port, automated code generation
- Enhanced cross language support in compilers and tools (not everything needs or should be in Ada even in mission critical applications

Acknowledgements:

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References:

FAA's NextGen Initiative Website
http://www.faa.gov/about/initiatives/nextgen/

Lockheed Martin's Products ERAM & Data Comm
http://www.lockheedmartin.com/us/products/eram.html
http://www.lockheedmartin.com/us/products/data-comm.html

Jeff O'Leary's Keynote Lectures at

- ACM SIGAda 2007 International Conference, Washington DC (USA)
- Ada Europe 2012 International Conference, Edinburgh, (UK)

Alok Srivastava's invited talks at

- National Technical University, Taipei Taiwan (IEEE Sponsored) 2011
- Technical University system of Madrid, Madrid (ACM Sponsored) 2009

Questions ?

Thank you for the invitation & the opportunity