

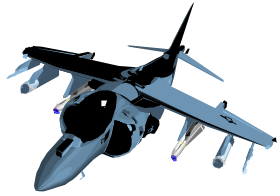
OSAT

Open Systems Ada Technology (OSAT) Program

Don Winter

Boeing - Phantom Works

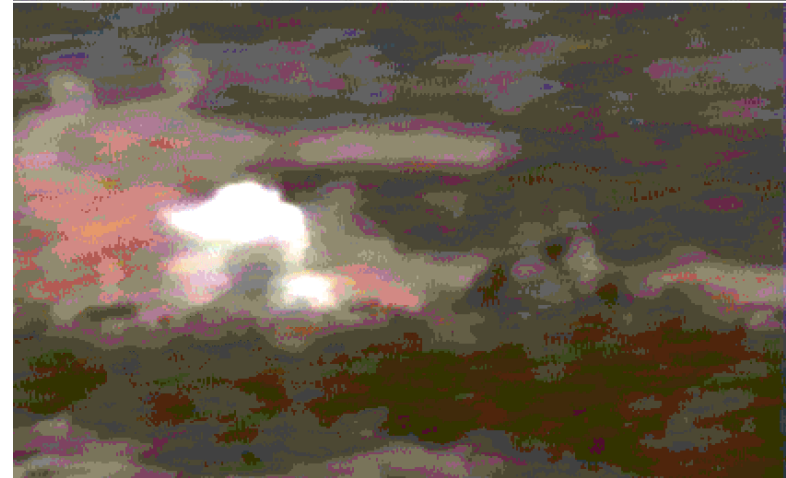
REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
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1. REPORT DATE (DD-MM-YYYY) 01-06-2002		2. REPORT TYPE Briefing		3. DATES COVERED (FROM - TO) xx-xx-2002 to xx-xx-2002	
4. TITLE AND SUBTITLE Open Systems Ada Technology (OSAT) Program Unclassified				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Winter, Don ;				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME AND ADDRESS Boeing Phantom Works xxxxx xxxxx, xxxxxxxx				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME AND ADDRESS Open Systems Joint Task Force (OSJTF) 1931 Jefferson Davis Highway Crystal Mall 3, Suite 104 Arlington, VA22202				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT APUBLIC RELEASE ,					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT See Report.					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:		17. LIMITATION OF ABSTRACT	18.	19. NAME OF RESPONSIBLE PERSON	
		Public Release	NUMBER OF PAGES	http://www.acq.osd.mil/osjtf/library/library_alpha.html (blank) lfenster@dtic.mil	
a. REPORT	b. ABSTRACT	c. THIS PAGE	19b. TELEPHONE NUMBER		
Unclassified	Unclassified	Unclassified	International Area Code Area Code Telephone Number 703767-9007 DSN 427-9007		
				Standard Form 298 (Rev. 8-98) Prescribed by ANSI Std Z39.18	

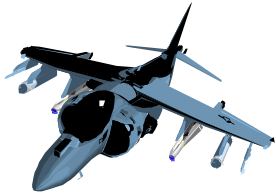


Open Systems Ada Technology Program

OSAT

- Dual emphasis - Ada95 and POSIX
 - Proved mixed language support attributes of software architecture (Ada95, C, C++)
 - First flight application of Ada95
 - Utilized POSIX features of VxWorks, collected metrics
 - First live demo of Common OFP 30-step ballistics integrator
 - First flight of Computing Devices International (CDInt) PowerPC mission computer
 - Accuracy was not an explicit test objective, but scored 6/6 hits
 - Pilot feedback very favorable

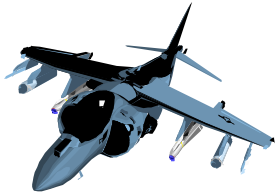




Project Objectives

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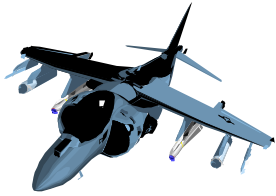
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- Convert the mission computer of an AV-8B to a COTS, open standards-based platform
 - PowerPC 604 Processor
 - Wind River VxWorks POSIX-compliant RTOS
 - Boeing's Common Operational Flight Program (COFP)
 - Ada95 (AV-8B compatible) F-15 Ballistics Algorithm
 - Develop / demonstrate an HOL OFP
 - Basic Navigation, Communications and HUD display functions (C++ from Common OFP)
 - A / G Ballistics and Stores Management functions (new Ada95)
 - Continuously Computed Impact Point (CCIP) calculation
 - Release of Mk-76 Bombs



Objectives - Continued

OSAT

- Compare the observed CEP from this demonstration with the AV-8B Fleet OFP CEP
- Integrate the Data Fusion Integrity Process (DFIP) Algorithm into the AV-8B OFP
 - Test DFIP functionality in the AV-8B Flight Simulator
 - Report results in Final Report
- Collect and report lessons learned:
 - POSIX
 - Ada95, mixed language OFPs
 - DFIP



Project Participants

OSAT

- Sponsors

- ❑ Ada Joint Program Office: Demo flight application of Ada95
- ❑ Open Systems Joint Technology Force: Demo COTS, POSIX
- ❑ JSF Program Office: Avionics risk reduction
- ❑ Wright Laboratory: Demo of DFIP, reuse adapter

- Contractors

- ❑ Boeing / McDonnell: System analysis, development and test
- ❑ Computing Devices International: COTS MC, support S / W
- ❑ Green Hills Software: Ada95 / C++ Development Tools
- ❑ Wind River: VxWorks Real Time Operating System

- Project Management and Technical Evaluation

- ❑ NAWC-WD, China Lake: Aircraft integration and flight test



Flight Test Results

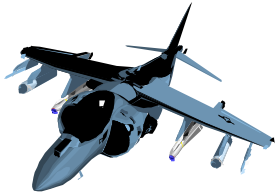
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● Flight Test Data

- Weapons Delivery Flight (20 March 1997, Baker Range)
 - 6 X MK-76 all South-North runs
 - 3 X MK76 @ 10 Degree Dive
 - First @ xx Feet
 - Second @ xx Feet
 - Third @ xx Feet
 - 3 X MK-76 @ 45 Degree Dive
 - First @ xx Feet
 - Second @ xx Feet
 - Third @ xx Feet

● Data Evaluation

- Based on limited number of releases, bomb impacts were as good as current fleet AV-8B Night Attack software

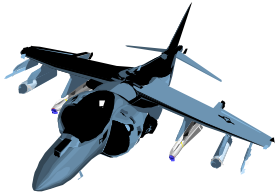


Open Systems Components

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- Computing Devices International Mission Computer
 - Single card has PowerPC 604e Processor, program memory, two 1553 channels, Ethernet, RS232, and discrete I/O
 - Sun Laptop used as support computer - OFP compile, reload
- Baseline C/C++ MC OFP
 - Microsoft Visual C++ Desktop Development
- C++ Executive, POSIX-compliant
- Green Hills MULTI Ada95 and C++ Tool Set
 - Mixed language OFP linking, loading, and debugging
- Wind River VxWorks RTOS

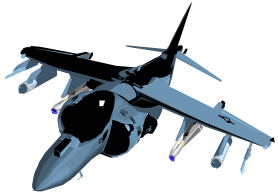
Gaining experience with commercial tools and POSIX API contributes to the maturation process of open systems avionics



OFP Configuration

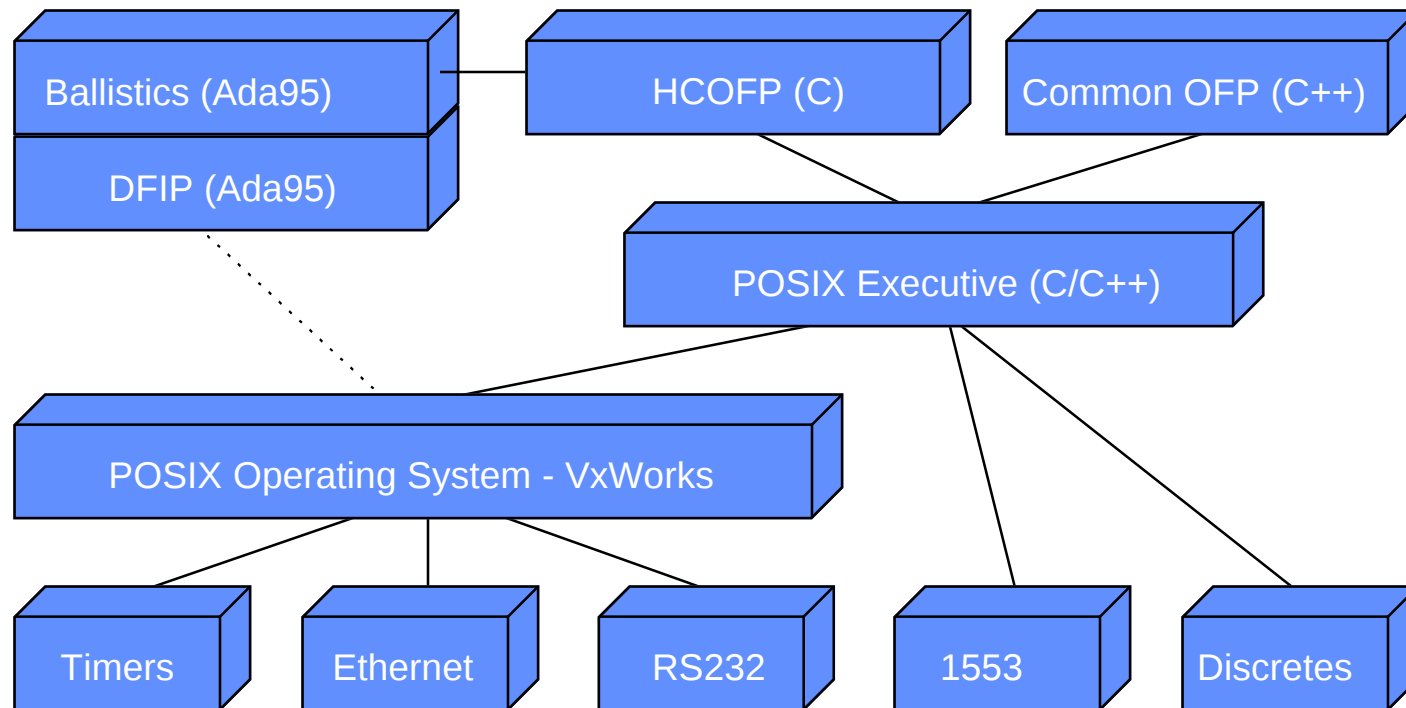
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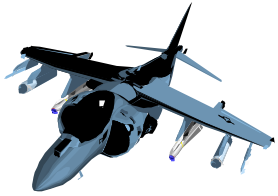
- Rehosted “C” OFP (Common OFP) from AV-8B Flight Simulator
 - AV-8B Night Attack functionality
- VxWorks RTOS With POSIX
- C++ Executive utilizing VxWorks POSIX calls
- COFP C++ Navigation components
 - Same as used in F-15 and F/A-18 flight demonstrations
- AV-8B C++ Communication components
- Re-engineered F-15 Ada95 Ballistic Integrator
- Ada95 DFIP Algorithm



OFP Components

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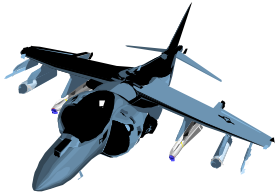




POSIX Usage

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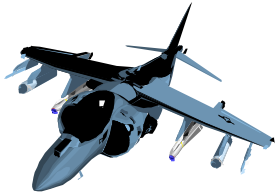
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- Message queues for communication between interrupt service routines and rate group tasks
 - Semaphores in bus controller services to protect simultaneous access of scheduled I/O chain linked list
 - Timers and synchronous real-time signals in tasks to perform scheduling of I/O
 - Retained VxWorks native specific calls
 - Tasking
 - Interrupts
 - System set-up



POSIX Lessons Learned

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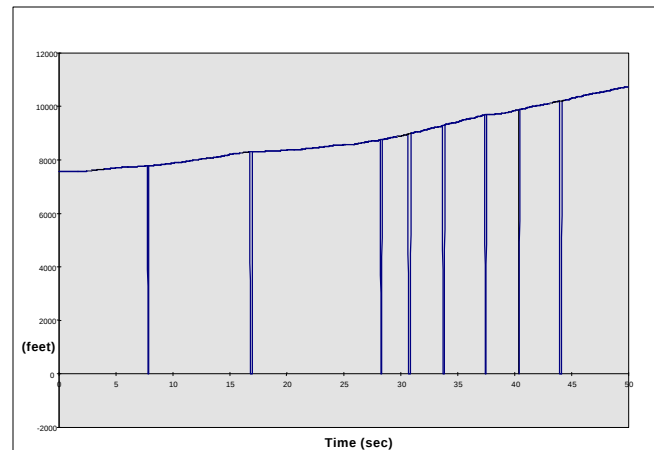
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- Execution times of POSIX and VxWorks features are similar
 - POSIX features were easy to employ and intermingle with native features within VxWorks
 - VxWorks POSIX is not complete; it doesn't support POSIX threads
 - For future projects, recommend that POSIX options be used wherever possible
 - Utilize any individual native OS calls where needed for additional functionality or increased efficiency.

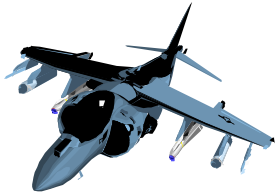


Data Fusion Integrity Process

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- Wright Lab's / TASC DFIP algorithm provides detection, limiting and recovery from intermittent data errors
- Ada95 DFIP filter was applied to four Ballistics input data channels and the Weapon Range output
 - Filter can be used to stabilize CCIP solution
- Typical results when applied to Weapon Range output, given input data drop-outs:





DFIP Evaluation

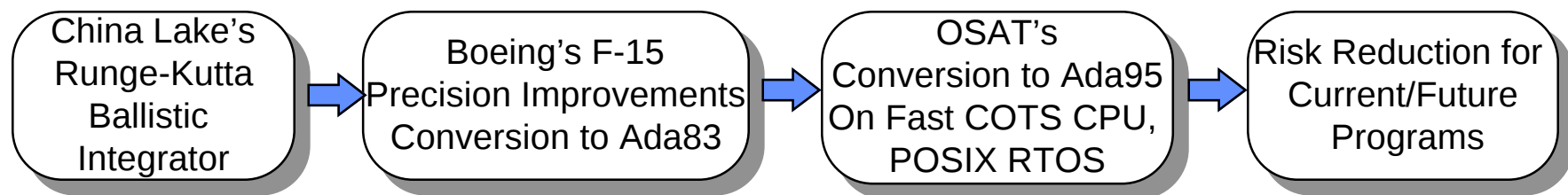
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-
- Performance was tested in AV-8B Flight Simulator
 - Short-duration (induced) data drop-outs were managed
 - Longer-term drop-outs and highly dynamic valid data would require a compromise design
 - Matrix style filters are expensive with respect to memory and execution time
 - Execution time for five channels was approximately 1 MSec
 - Current algorithm requires further refinement to add value to Boeing's ballistics applications
 - Short-term drop-outs not seen in simulators, rarely in flight
 - Other protection methods are already in place in fleet OFPs

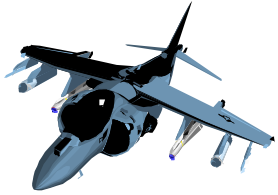


Ballistic Algorithm Design

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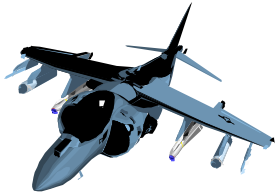
- Re-engineered F-15 Runge-Kutta Ballistics Algorithm (BA) from Ada83 to Object Oriented Ada95
 - Employed Rational Rose design tool and OO methodology
 - Higher performance processor allowed improvements to the accuracy of the Ballistics solution over AV-8B
 - Position differential equation solved
 - Velocity differential equation solved
 - Throughput available to run 30 steps rather than 10, 3D rather than 2D
 - Trajectory completed in one frame at 20 Hz
 - Step size picked every trajectory step
 - Last step adjusted to complete trajectory at target elevation



Ada95 Feature Usage

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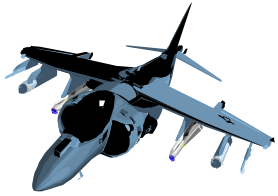
- Tagged types - including extension of tagged type
- Abstract types and functions
- Aliased types
- Access-to-constant types
- Reused legacy Ada83 generics for vector operators



Ada 95 Annex Feature Usage

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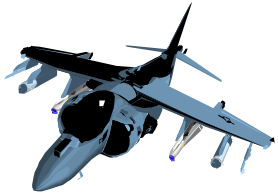
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- Annex A - Predefined Language Environment (Numerics)
 - package `Ada.Numerics.Long_Elementary_Functions`
 - Annex B - Interfaces to Other Languages
 - pragma Import and Export
 - package `Interfaces.C`
 - Annex C - Systems Programming
 - pragma Preelaborate
 - Machine Code Insertion - used in Timing builds only
 - Ada not the Main Program
 - Ada95 components were called from a C++ main program



OO/Ada95 Evaluation

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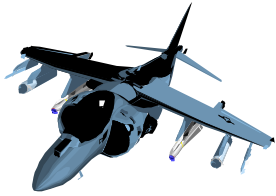
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- Encountered very smooth language transition for experienced Ada83 engineers
 - New object oriented features are a natural extension to the language
 - Learning OO design methodology can be difficult, especially for structured top-down programmers
 - Good training leads to success - Designers attended AJPO's *Transitioning to Ada95* course (Ada95 for Ada83 Programmers & Embedded / Real-Time Programming)



OO/Ada95 Evaluation - Continued

OSAT

- Features for mixed language support were easy to implement
 - Interfacing to C software was simple with the new Ada95 features
 - Interfacing to C++ was more difficult since C++ is not standardized, and so no package Interfaces.Cpp exists yet.
- Ada95 is very portable
 - OSAT OFP Ada95 components were run on Sun Workstation (Rational), PC / Pentium Workstation (Object Ada), Motorola PowerPC Card (Green Hills), DY-4 PowerPC Card, and the CDInt MC PowerPC Card
 - Conversion of Ada83 software to use Ada95 compiler (without re-engineering) was relatively simple
 - Changes were isolated to low-level design areas such as processor-dependent data formats



Conclusions

OSAT

OSAT demonstrated Ada95 and OO methodology in a flight-worthy avionics application

The demonstration included an application of POSIX with a COTS real-time operating systems

Multi-language OFP components were combined and reused, demonstrating the capability of COTS tools, OO architecture and wrappers (adapters)

The DFIP Algorithm was implemented and evaluated in a flight-worthy application

A commercial processor and board support package was flown in an avionics Mission Computer

The performance of the prototype MC and software in flight test was equivalent to AV-8B fleet performance