Open Systems Ada Technology (OSAT) Program

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Open Systems Ada Technology Program

• 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

- 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
Comparing the observed CEP from this demonstration with the AV-8B Fleet OFP CEP

Integrating 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

Collecting and reporting lessons learned:
  - POSIX
  - Ada95, mixed language OFPs
  - DFIP
Project Participants

- 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

● Flight Test Data
  • Weapons Delivery Flight (20 March 1997, Baker Range)
    • 6 X MK-76 all South-North runs
    • 3 X MK-76 @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

- 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

- 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
POSIX Usage

- 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

- 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

- 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

- 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

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

- 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

- 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
• 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)
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 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.