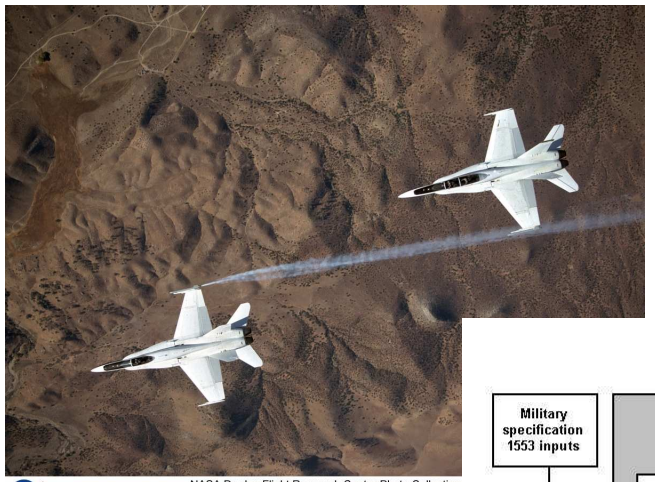
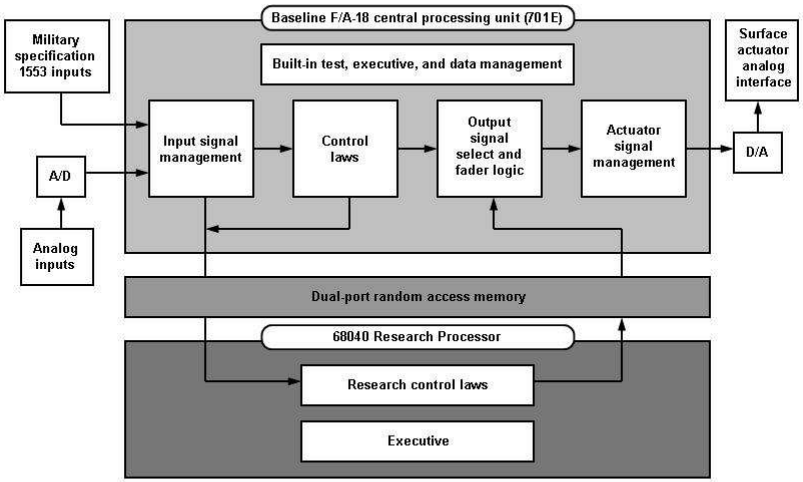
IRAC F/A-18 RFCS on NASA 853



NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: EC01-0328-12 Date: November 9, 2001 Photo by:
Smoke generators show the twisting paths of wingtip vortices behind two NASA D
Autonomous Formation Flight (AFF) program during flight #

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/Gallery/Photo/index.html
NASA Photo: ED05-0223-07 Date: October 25, 2005 Photo By: Jim Ross

345 behind 707 Omega tanker during an Autonomous Airborne Refueling Demonstration
(AARD) flight.



NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: EC96-43479-5 Date: March 22, 1996 Photo by: Dan Murri

F-18 HARV configured with nose strakes during smoke test

IRAC F/A-18
February 2009

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: EC02-0264-3 Date: November 15, 2002 Photo by: Carla Thomas
The modified F/A-18 being flown in the joint NASA/Air Force Active Aeroelastic Wing research program shows off its colors during its first checkout flight from NASA's Dryden Flight Research Center.

Scope

⇒F/A-18 Testbed Development⇔⇔⇔F/A-18 Flight Research⇒

2008: F-15 IFCS
Stability
MS IRAC 4.1.1

2010: ACFS Simulation
Stability + Maneuverability
MS IRAC 4.1.2.1

2011: F/A-18 IFS
Stability + Maneuverability
MS IRAC 4.1.2.2

Baseline
IVHM
Option A

Adaptive Flight Control

Engine Control
Flight Planning and Guidance
Adaptive Flight Control
Airframe and Structural

3.2.2.1 (Option A)
Engine Control
Flight Planning and Guidance
Adaptive Flight Control
3.3.1.2
3.3.2.2
V&V Methods
IVHM Data Mining Lab
Airframe and Structural

IVHM 4.3.1
IPP DASP or IVHM 3.4.1 Successor

F/A-18 RFCS History

- Quad 1750A RFCS addition to F/A-18 production FCS allowed by 701B to 701E upgrade (1987-1989)
  - Almost all I/O routed through production Input and Actuator Signal Management
    - (1) analog channel to RFCS I/O
  - Addition of TVCS ASM (6 aileron actuators), later added Forebody Strakes (2)
  - RFCS integrated with F/A-18 version 10.1 Control laws
  - Production Mission Computer (MC) modified to provide additional inputs to RFCS, increased rate (80 Hz)
  - Class-B RFCS S/W environment and envelope
  - System design stressed flexibility and testability (validated by 20 year legacy)
  - Shared S/W development and testing (NASA, BAE (GE), Boeing (McAIR))

- Programs that utilized 1750A RFCS
  - HARV (1989-1996)
  - PSFCC (1997-1999) [demod TVCS and FBS actuation, include RFCS CCDL]
  - Mini-stick (1998-1999)
  - AFF (2000-2002)
  - AARD (2006-2007)

Pace 1750A : 16 bit

Speed: 40 Mhz

Memory available for control laws: 32K

F/A-18 RFCS History (cont.)

- Quad 68040 RFCS upgrade to allow more capable Claws for AAW (1995-1999)
  - All I/O routed through production Input and Actuator Signal Management
  - RFCS integrated with 10.1 Claw (same as 1750A)
  - Addition of OutBoard Leading Edge Flap Actuator Signal Management
  - First RFCS Class-A S/W environment and envelope
  - Boeing RFCS S/W development, shared S/W testing (NASA, Boeing, BAE)
- Programs that utilized 68040 RFCS
  - AAW

68040: 32 bit

Speed: 40 Mhz (?)

Memory available for control laws: 2Mb

Next Generation RFCS

Next generation RFCS Assumptions

- Useful system lifespan between 5 and 10 years
- Most time-critical flight control processing done within RFCS
- Maximize use of Matlab/Simulink and features such as RTW, autotest, etc.
- Bulk of RFCS S/W testing done at NASA or NRA partners
- RFCS interface to each engine
- External high-speed datalink (Ethernet to ARTS) for eventual instrumentation feedback (structural, IVHM, etc.) into flight control
- Incorporate lessons learned from past RFCS programs and other research flight systems (ARTS II (IFCS on 837), ARTS III, AAW, etc.)

Requirements Framework

- RFCS and ARTS H/W
  - Provide throughput, memory, and computational resources to support current and future research control laws (2x to 10x the memory and complexity/computation of F/A-18 replication control laws)
  - Provide external I/O to RFCS/701E with external high-speed datalink (minimize time delay)
- RFCS and ARTS S/W
  - Design for level B and the potential for Level A

RFCS/ARTS “use cases”
How may this architecture be used

- Mini-stick, AFF, AARD – RFCS/ARTS
  - External stick or sensor inputs into ARTS, F/A-18 claws in RFCS
- PSFCC – RFCS primary or RFCS/ARTS
  - F/A-18 replication control law mods
  - Also USN reconfigurable retrofit
- IFCS Gen II (837) - RFCS/ARTS or ARTS primary
  - Claws in RFCS or ARTS, Adaptive control law elements in ARTS
- FADS, IVHM – RFCS primary or RFCS/ARTS
  - External I/O processed in ARTS
- HARV, AAW not represented
  - Not possible without significant FCS modifications (level A)

One Set of Potential RFCS Upgrade Options

Baseline

701e / 1750A

- **Already exists** 10.1 CLAWS in the 701E (used for HARV, PSFCC, mini-stick, AFF, AARD)
- Limited throughput and memory
- Very limited external I/O (2 analog A/D channels)
- Ancient TLD Ada compiler and no/limited S/W support

68040 Demod

701e / 68040

- **Already exists**, 10.1CLAWS in the 701E (modified for AAW)
- Better throughput and memory than 1750A
- Very limited external I/O
- No flight qualified compiler at DFRC and limited S/W support. Tartan compiler at Boeing?
- Requires mod to 701E to remove additional AAW LEF commands

Concept Selected

68040 upgrade

701e / 68040 ↔ 1553 ↔ ARTS

- 1553 on 68040 already exists but not activated, 10.1 CLAWS in the 701E
- Better throughput and memory than 1750A
- Untested compiler at DFRC and limited S/W support
- Requires mod to 701E to remove additional AAW LEF commands
- Requires H/W and S/W mod to box and RFCS to allow 1553

RFCS upgrade

701E or upgrade / RFCS upgrade

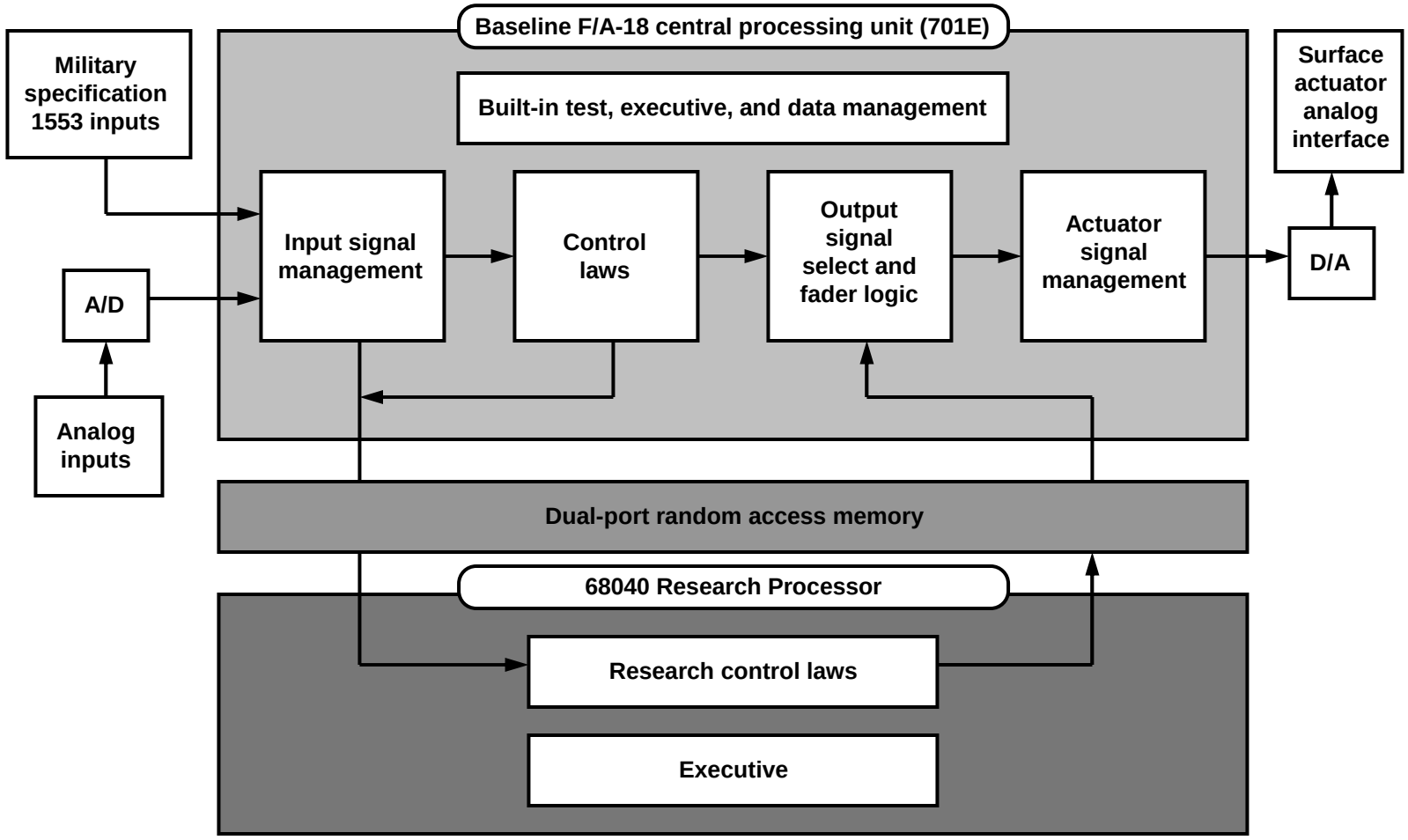
- 10.7 CLAWS in the 701E
- Best throughput and memory within the RFCS
- No compiler yet at DFRC, S/W support likely available
- Very limited external I/O

RFCS+HSDL upgrade

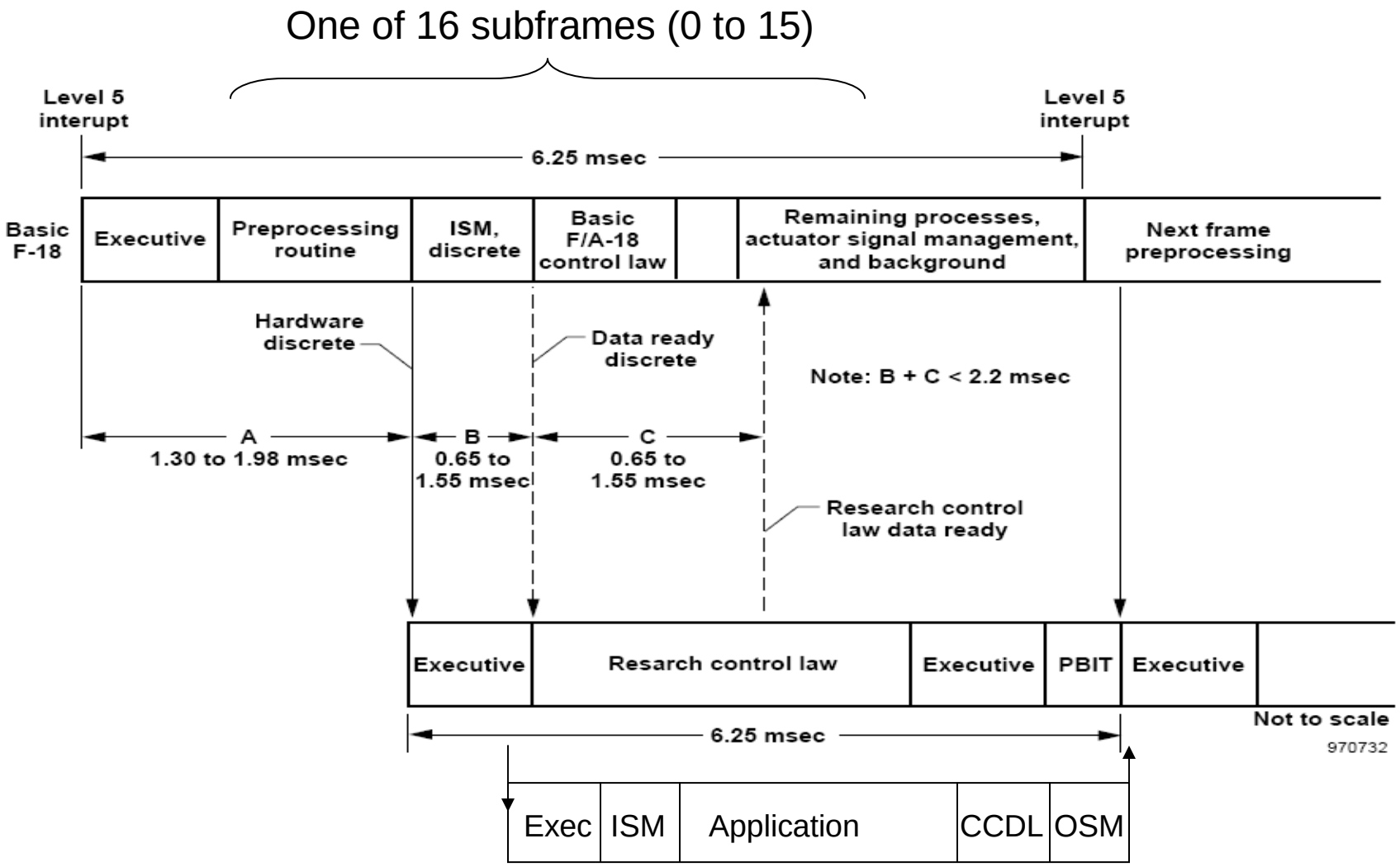
701e / RFCS upgrade ↔ HSDL ↔ ARTS

- 10.7 CLAWS in the 701E
- Best throughput and memory within the RFCS and ARTS
- No compiler yet at DFRC, S/W support likely available
- extensive external I/O using the ARTS
- Potential for sharing IFCS computation within the ARTS and PPC/RFCS

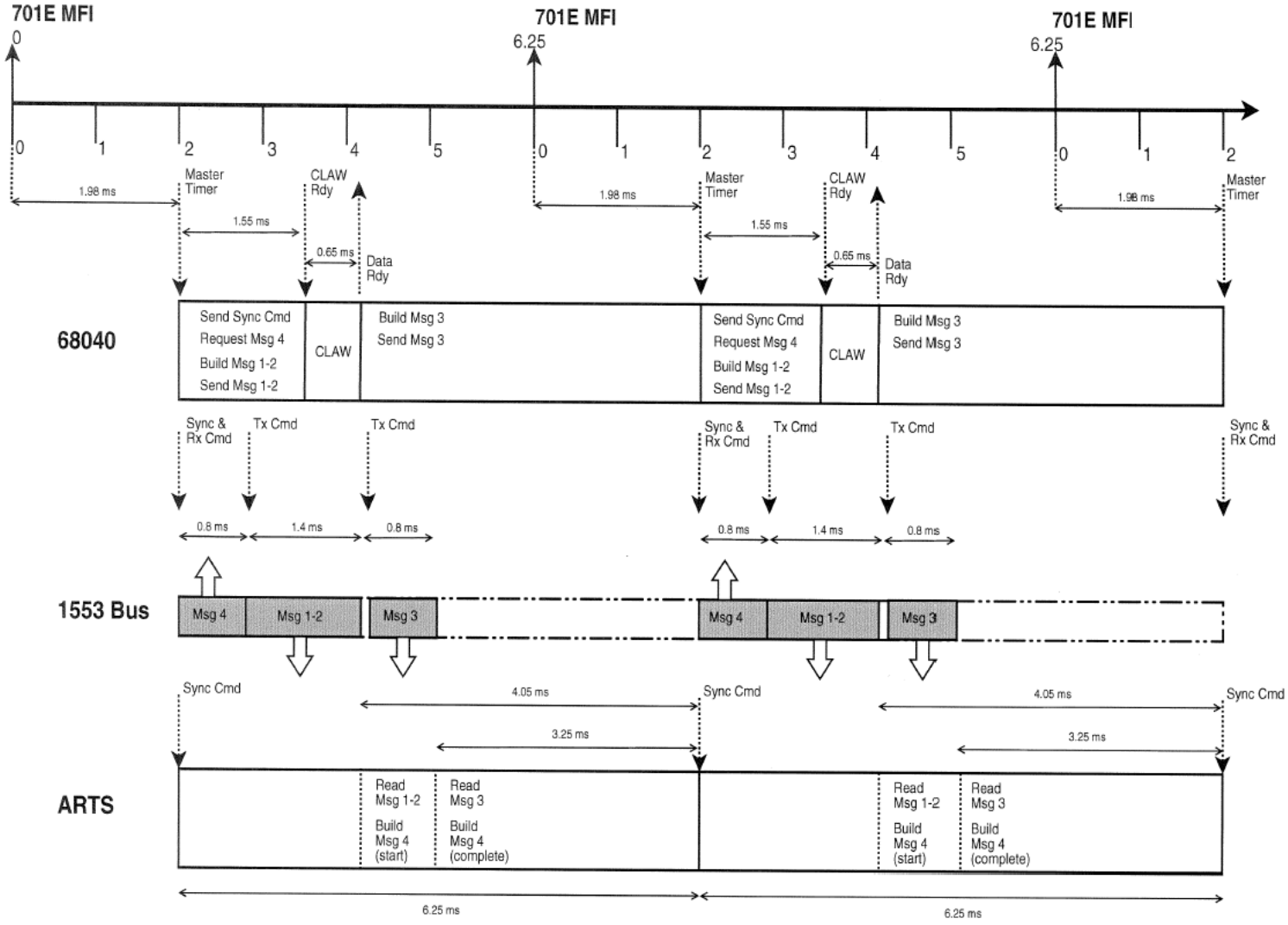
701E and RFCS integration



Notional RFCS and ARTS Timing



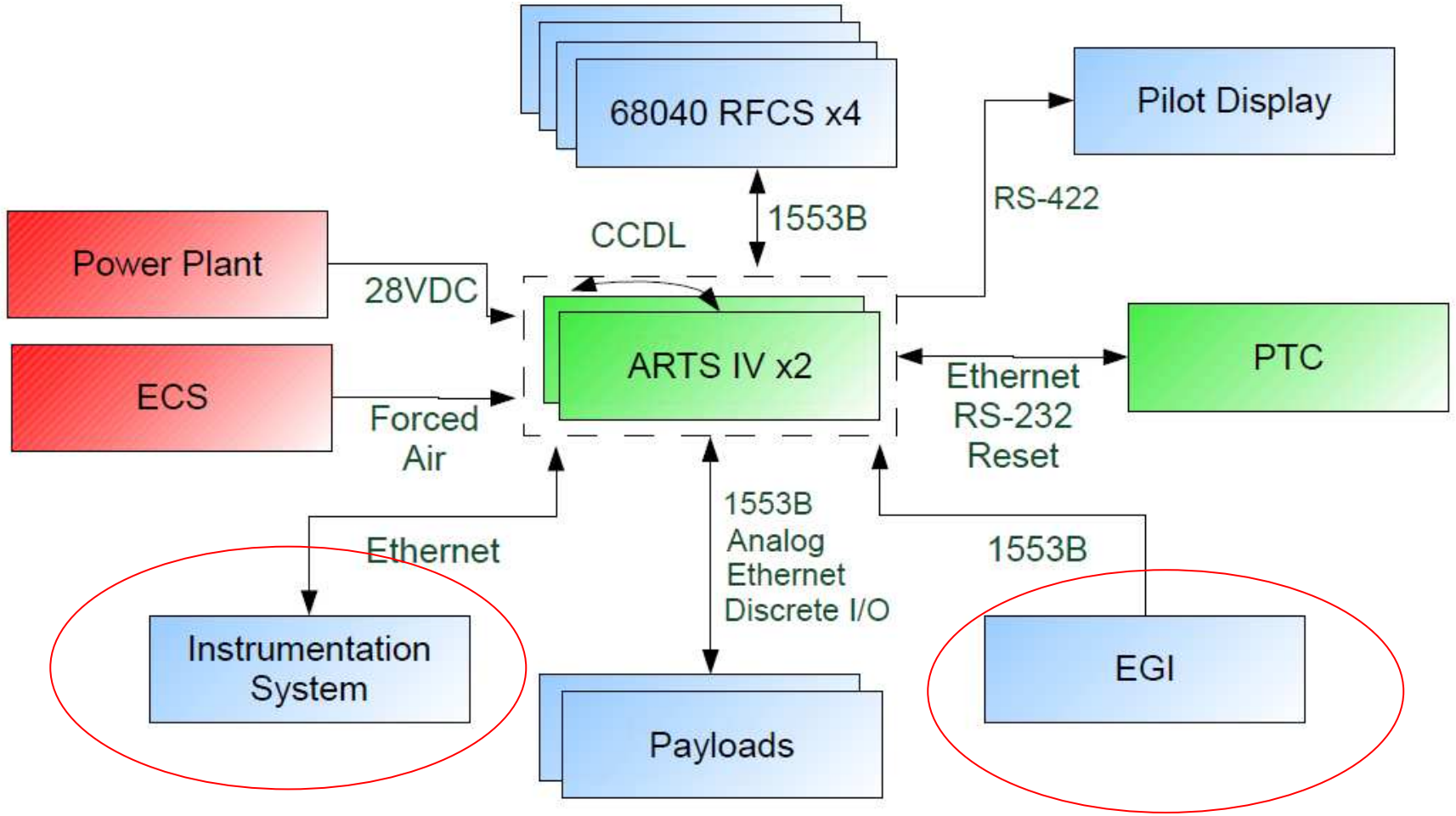
701E/RFCS and ARTS Timing



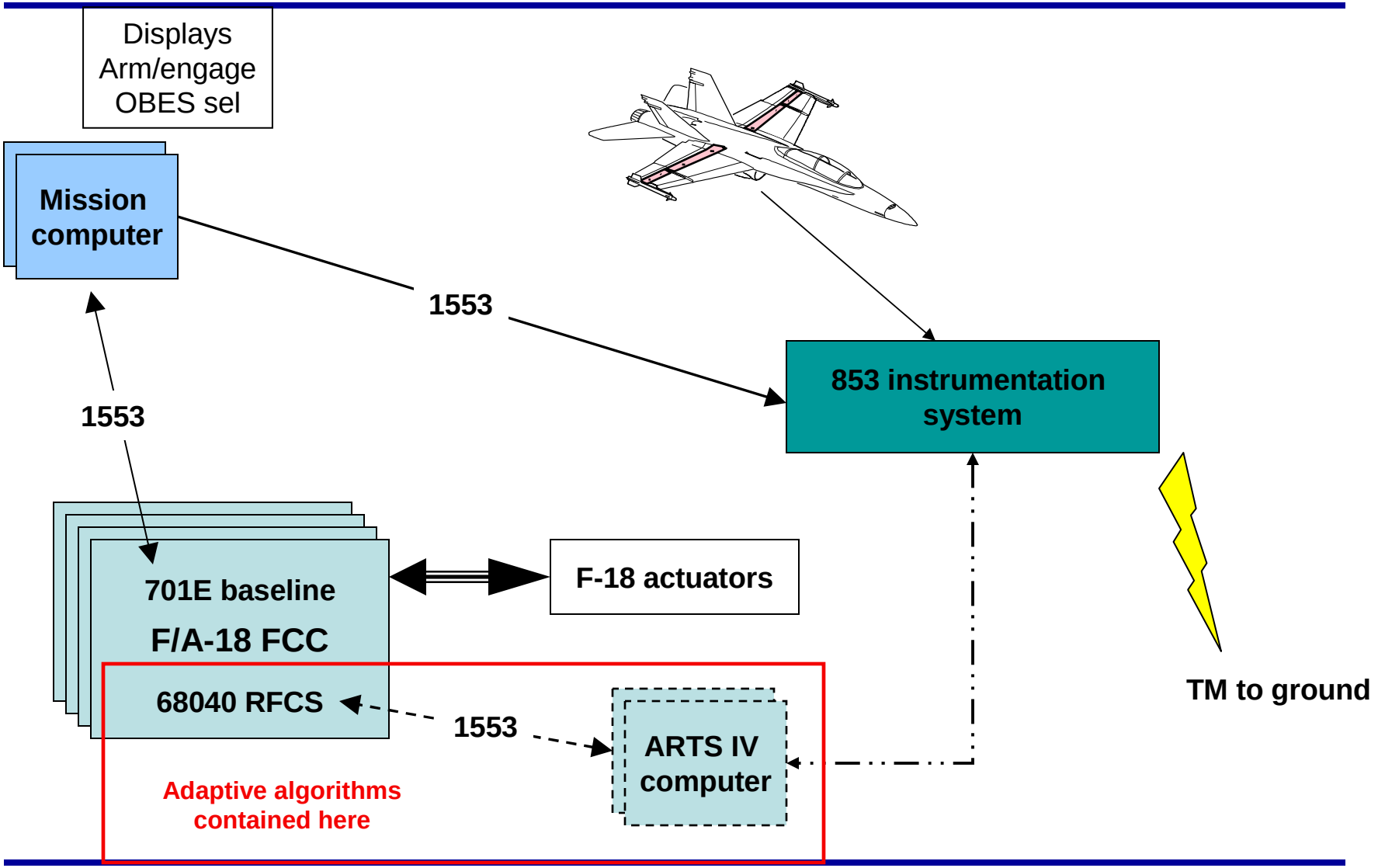
ARTS IV

- Curtiss-Wright 183 PowerPC
- 3 SBCs per unit (2 units)
  - SBC 2 and SBC 3 are dedicated to research.
  - SBC1 performs critical I/O and host safety critical software.
- Specifications:
  - 6U VME based computer
  - 512 MB RAM
  - 1 Gigahertz PowerPC CPU
  - Discovery III System Controller
- On board I/O:
  - Ethernet, USB, RS-232
  - 2 PCI Mezzanine Card (PMC) Sites

RFCS/ARTS IV integration



F/A-18 Research System Components



Current IRAC Schedule

- FCCs (with 68040) and ARTS IV to DFRC in April/May ‘09
- Integration on the DFRC Test Bench in Aug ‘09
- Testing on the DFRC Bench with F-18 Sim Aug-Nov ‘09
- Install RFCS and ARTS IV in F-18 TN 853 Jul-Aug ’09
- Peer review of IRAC controls experiment Sept ‘09
- Ground Tests Sept-Nov ‘09
- FRR for 1st Flight (RFCS & ARTS w/o Research S/W) Nov ‘09
- 1st Flight (RFCS & ARTS w/o Research S/W) Feb ‘10
- Select Adaptive Research Control Laws Sept ‘10
- IRAC Milestone 4.1.2.2 Mar ’11 (adaptive integrated flight/propulsion control experiment)

Potential IRAC Experiments

- Integrated aero/propulsion control
- Integrated adaptive structural control
- Adaptive aeroservoelastic experiments
- Adaptive guidance / mission management
- Adaptive algorithm validation
- Upset recovery control validation
- Pilot interaction with adaptive system