



***LESSONS LEARNED
DC-X OPERATIONS***

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LESSONS LEARNED DC-X OPERATIONS

- **“OPERATIONS” was integrated into the DC-X design from the outset; not “added on after the fact”**
 - Aircraft-like operations
 - Automation for testing and launch
 - Integrated vehicle and launch systems
 - Flexible software process “RAPIDS”

DC-X FINAL ASSEMBLY AT MD HB



**Maintainability, Operability
HEAVILY emphasized in
design phase**

AIRCRAFT-LIKE OPERATIONS

Small Crew: Flight and Maintenance

Minimal Facilities: Operating “way uprange”

Low Maintenance/MTTR

Quick Turnaround Time

Procedures/Manuals: “Flight Crew OPERATING Manual” (not launch procedures)

Flight Cards: Used to authorize/control mission-unique procedure and/or configuration changes

Automated Checklist: Used to conduct launch operations with the computer acting as QC.

AUTOMATED TEST & CHECKOUT

VEHICLE:

BIT (Built In Test) used extensively

Simplified procedures and checklists

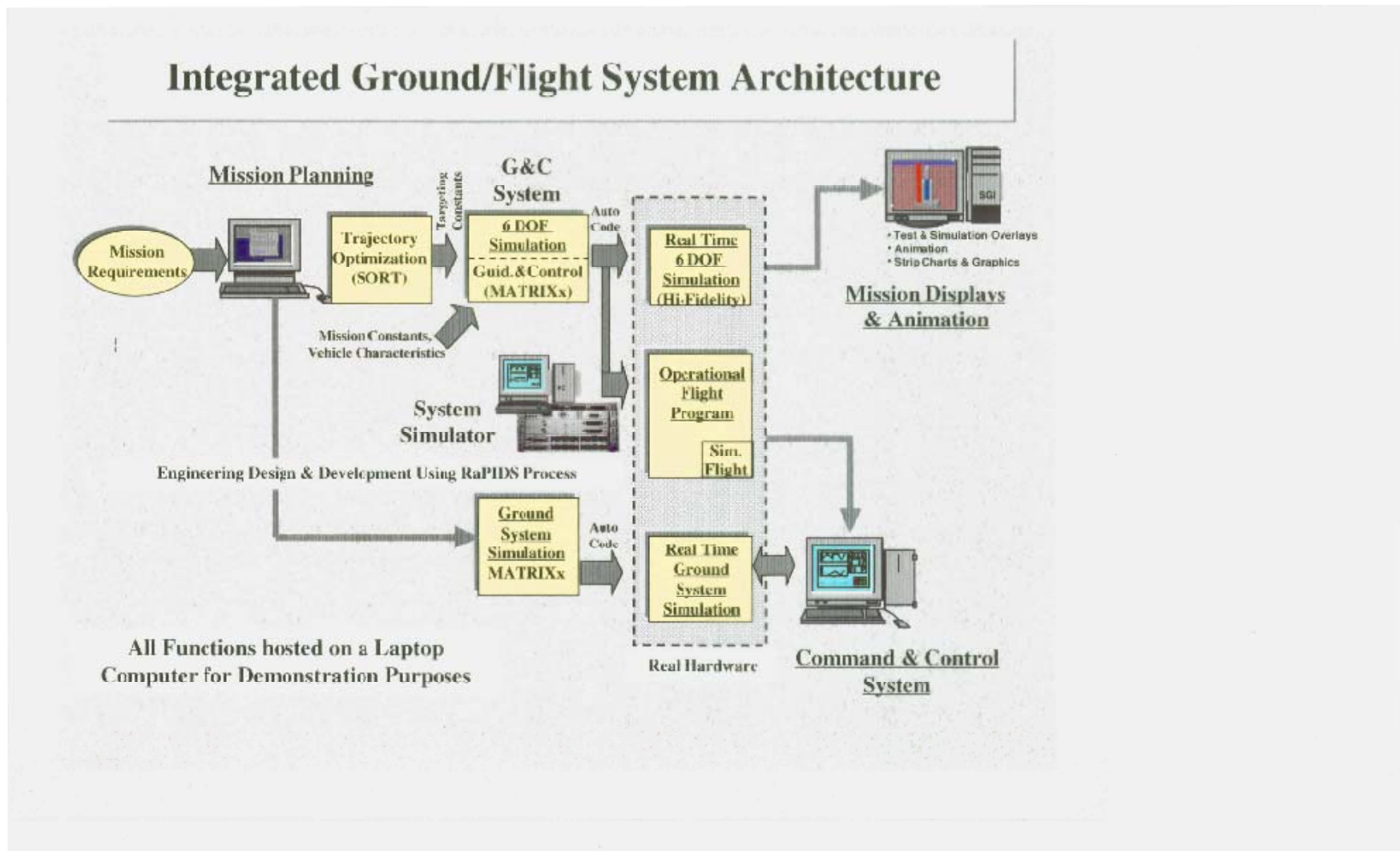
Allowed parallel testing of subsystems

Improved system reliability and availability

Reduced processing time

Reduced personnel required for test, checkout, launch and post-launch processing

INTEGRATED GROUND/FLIGHT ARCHITECTURE



AUTOMATED TEST & CHECKOUT

GROUND

Integrated Flight/Ground system design

Simplified flight/ground database development

Simplified ground processing procedures

Allowed parallel testing of subsystems

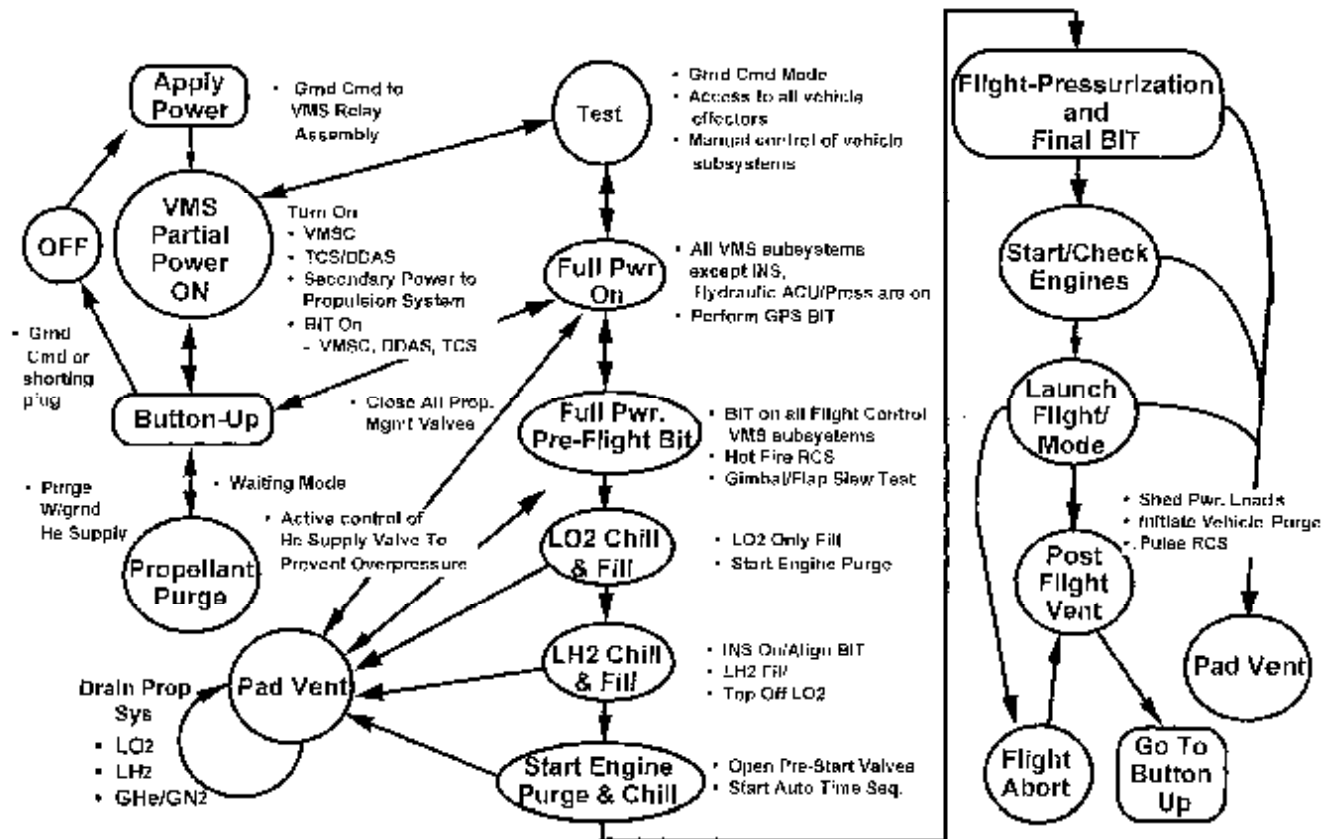
Improved system reliability and availability

Reduced processing time for test, checkout, launch
and post-launch processing

Reduced personnel required

STATES & MODES VEHICLE CONTROL

“States” and “Modes” Used For DC-X Vehicle Control



MONITOR/CONTROL- PAD VENT

Monitor / Control - ModePadVent.v

AP Program: FSQ_PadVent STATUS: not active AP CTRL ZOOM FREEZE THAW HIDE QUIT

Periodic BIT VMSC INS DDAS GPS

DC-X Vehicle Mode Commanding

Previous Mode: Invalid Mode Value

Pad Vent

Start LO2 Chill & Fill VMS Full Power On Buttoned Up Gas Dump LO2 Drain LH2 Drain

Clean 28 VDC Ground Power ON OFF

120 VDC Ground Power ON OFF

DC-X Batteries Power ON OFF

Dirty 28 VDC Ground Power ON OFF

Umbilical Connect Power ON OFF

DC-X Hydraulics

Supply Return Temp

DC-X Electrical

Voltage Current Load Cells

Vent Fire Detection

INHIBIT ACTIVATE C/F1 C/F2 C/F3 C/F4 T/F1 T/F2

PreFlight Checklist

- T-2:03 DC-X BATTERY POWER ON. GROUND POWER OFF.
- T-2:03 For 60 Secs., DC-X LO2/LH2 TANK PRESSURIZATION
- T-1:03 For 60 Secs., DC-X ENGINE CHILLDOWN & FINAL BITS
- T-0:00 DCX HAS ENTERED LAUNCH AND FLIGHT MODE.

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FLEXIBLE SOFTWARE- RAPIDS

RAPIDS (Rapid Prototyping and Integrated Development Systems Process)

Based on the “Build a little, test a little” approach, RAPIDS was an iterative approach that enabled shorter development cycles through early integration and test. Benefits:

- Reduced Risk**

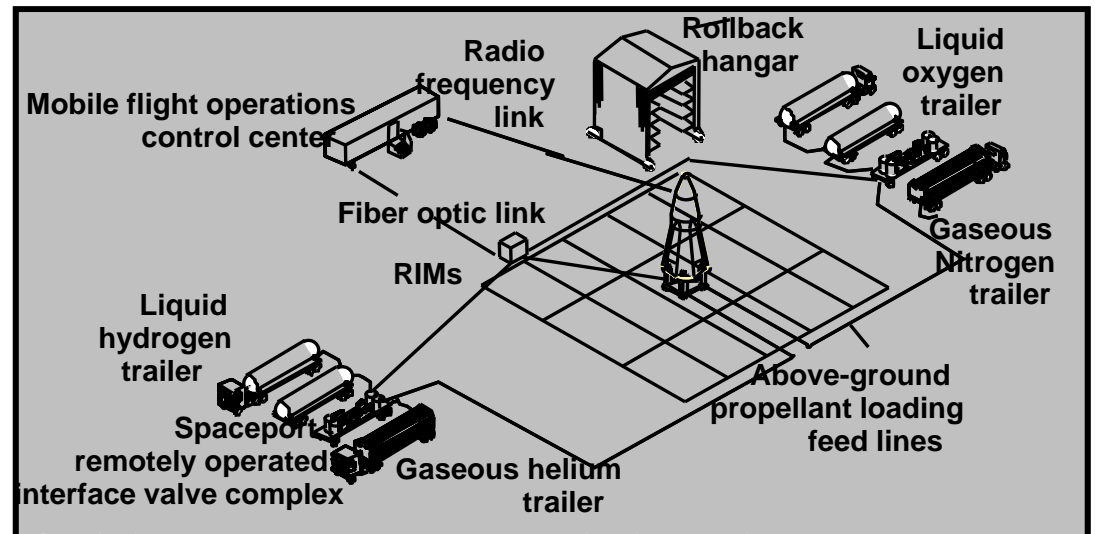
 - Schedule: Reduced Software and Simulation development schedule by a factor >2

 - Technical: Validated design & software early in the development process

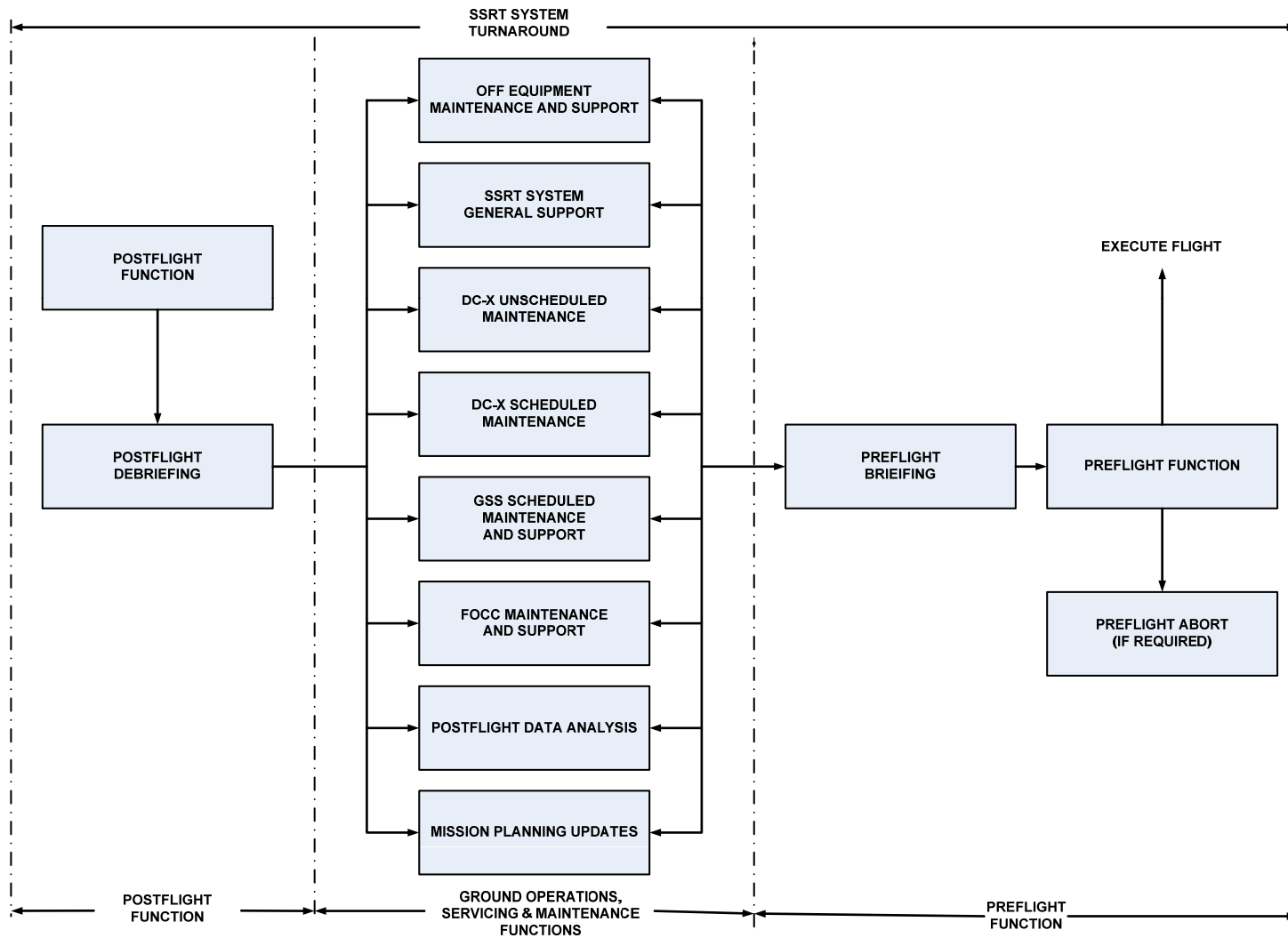
- Reduced Cost:** Reduced software development & maintenance costs by factor > 2

- Improved Quality:** Iterative design cycles improve the process and product quality with each cycle

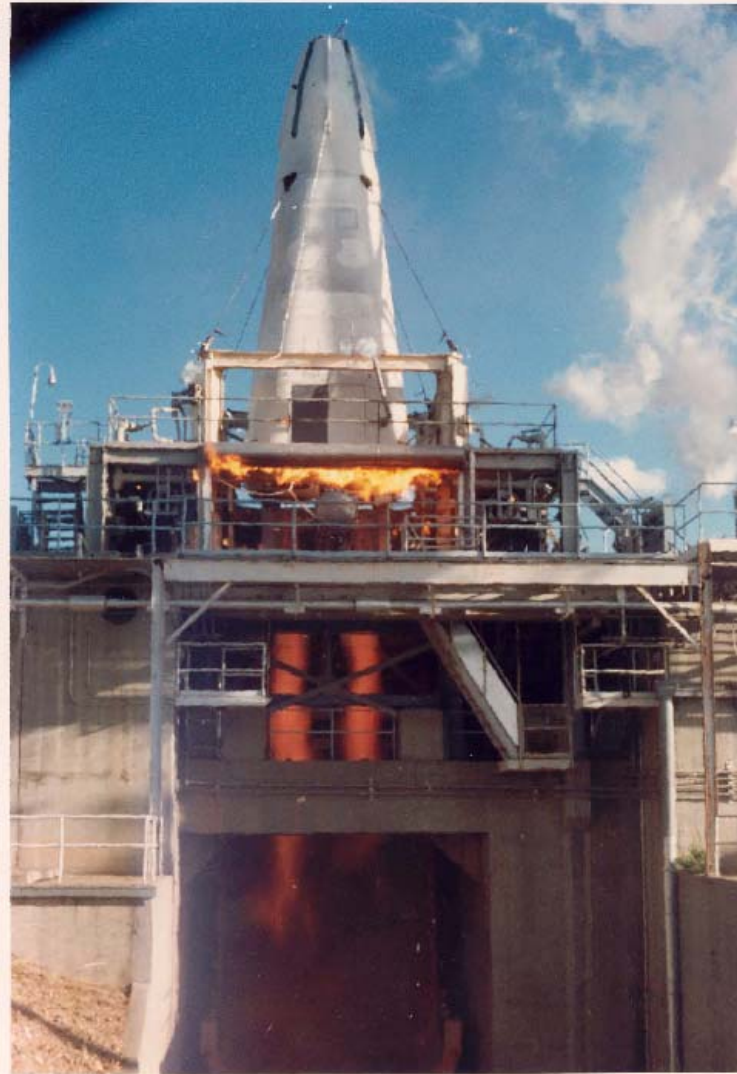
DC-X FLIGHT AND GROUND OPERATIONS



LAUNCH OPERATIONS PROCESS



STATIC FIRING AT WSTF



POST-FLIGHT SERVICING



DC-X/XA Demonstrated Rapid Development, Responsive Operations and Robust Flight Performance



- Aircraft-like operation
 - 3 person flight crew (FM/DFM/GSM)
 - Small support crew (10 O&M techs)
- Rapid system turnaround
 - 7 days (Flt 4/5 = 6 days)
 - 3 day demo goal (Flt 10/11 = 26 hrs.)
- Vertical takeoff and landing (12 flights)
 - Design for supportability
 - Autonomous operation (Inflight abort)
 - All-weather operation
 - Concrete, gypsum, grate/trench
- Rapid prototyping of H/W and S/W
 - Short schedule (2 years & 2 days to FT#1)
 - Limited budget (~ \$60M to 1st flight)
 - Ground effects ‘surprise’ 10 weeks before first flight
 - ‘Just-in-time’ abort capability
 - Back-to-back flight gain/landing coordinate changes in 4 hours

RESIDUAL ISSUES

Engine Out

APU

TAKE TO THE NEXT STEP- ORBIT!

DC-X LEGACY



**DC-X PROVED
SAFE, RELIABLE,
ROBUST,
AIRCRAFT-LIKE
SPACE VEHICLES
WERE POSSIBLE**

