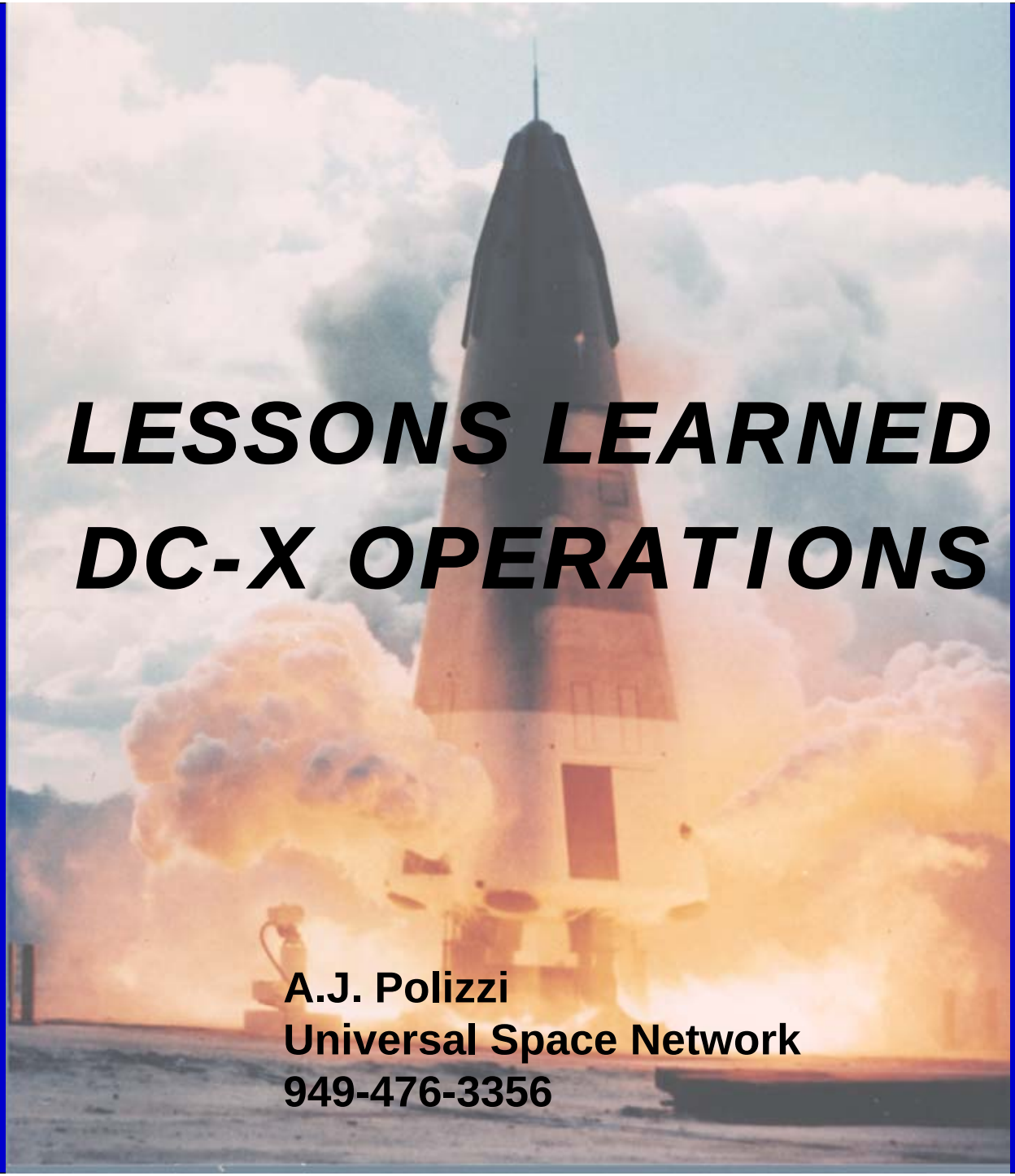

LESSONS LEARNED
DC-X OPERATIONS

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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

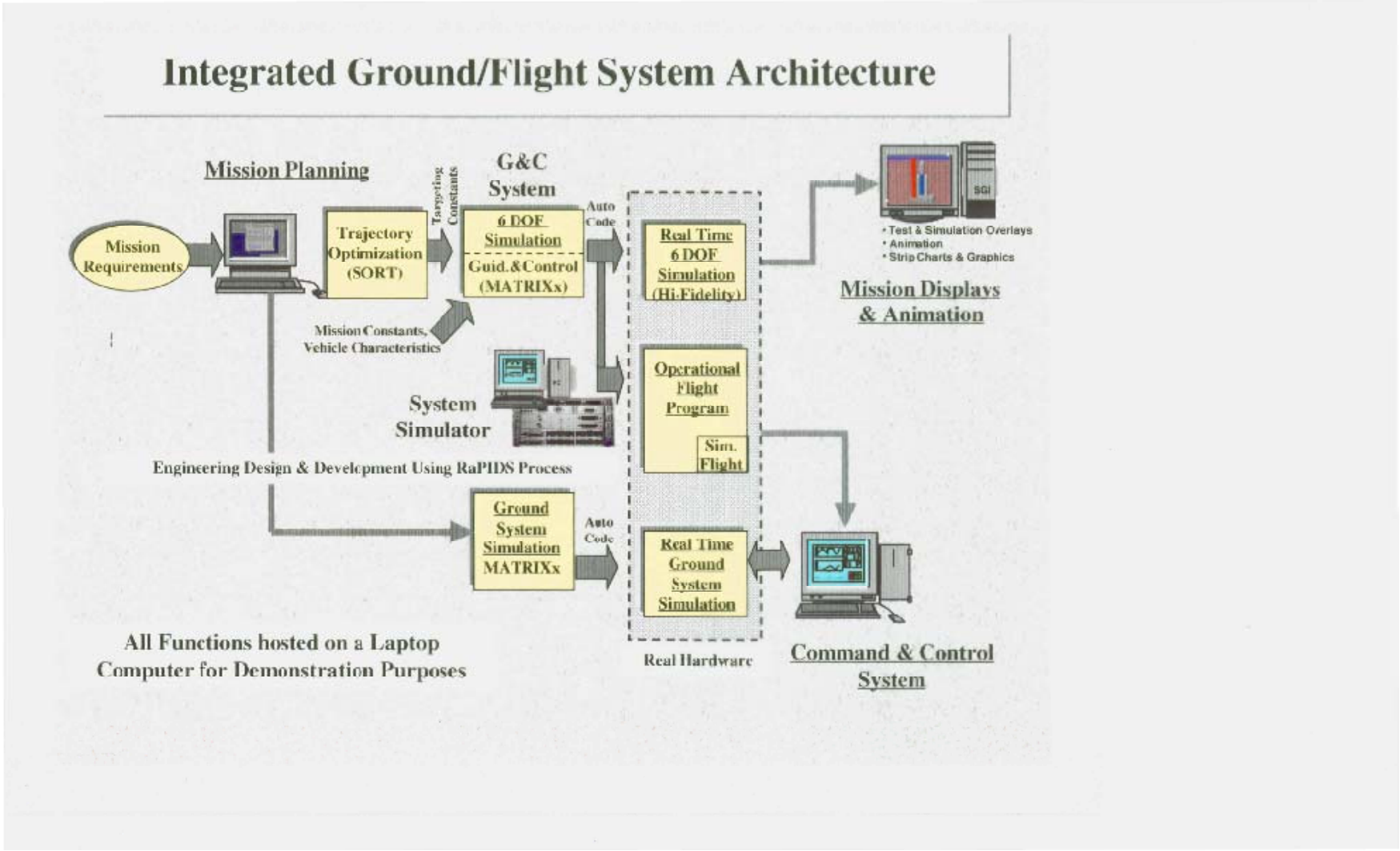
Small Crew: Flight and Maintenance
Minimal Facilities: Operating “way uprange”
Low Maintenance/MTTR
Quick Turnaround Time
Procedures/Manuals: “Flight Crew OPERATING Manual” (not launch procedures)
Flight Cards: Used to authorize/control mission-unique procedure and/or configuration changes
Automated 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

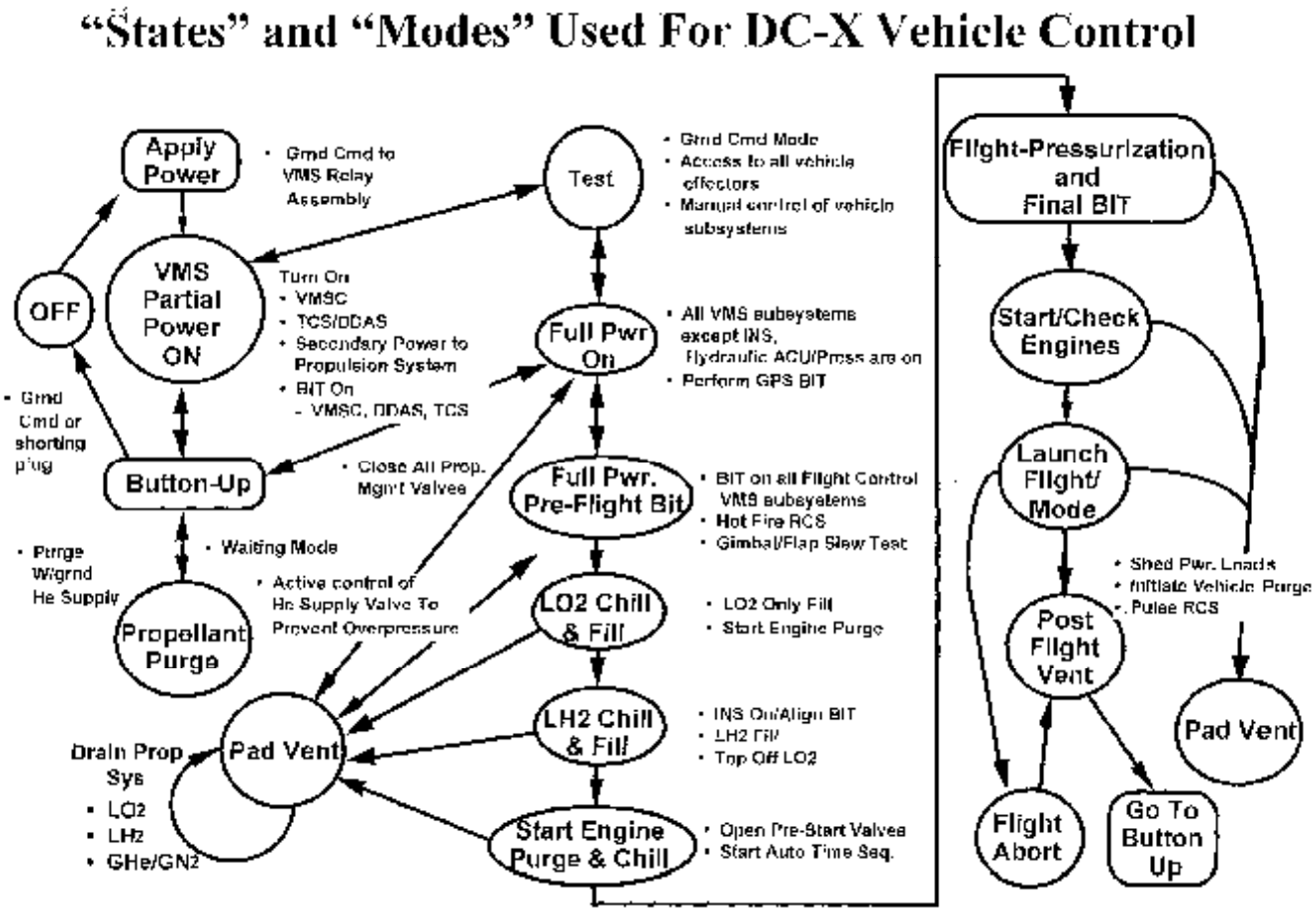


AUTOMATED TEST & CHECKOUT

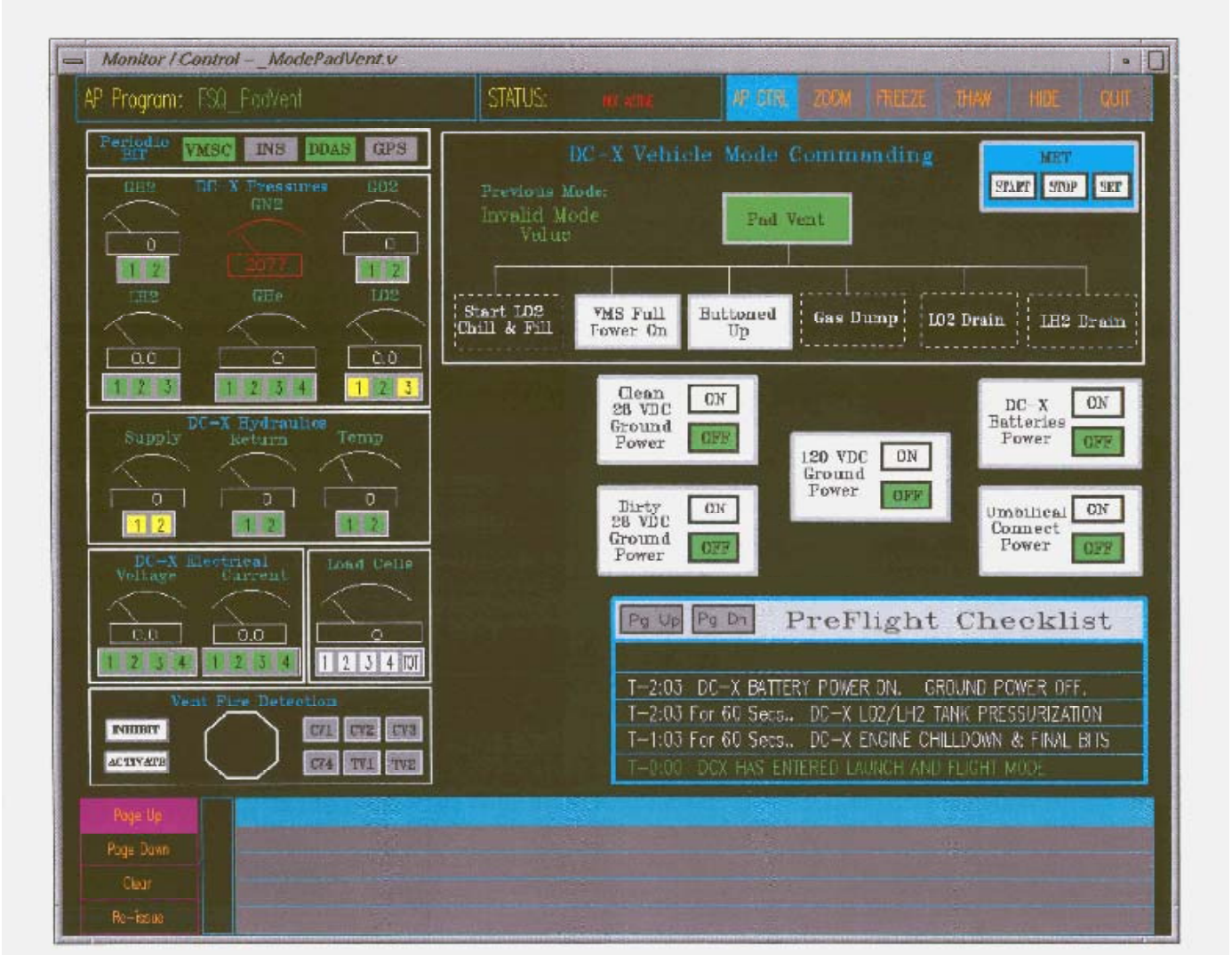
GROUND

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



MONITOR/CONTROL- PAD VENT



FLEXIBLE SOFTWARE- RAPIDS

RAPIDS (**Ra**pid **P**rototyping and **I**ntegrated **D**evelopment **S**ystems Process)

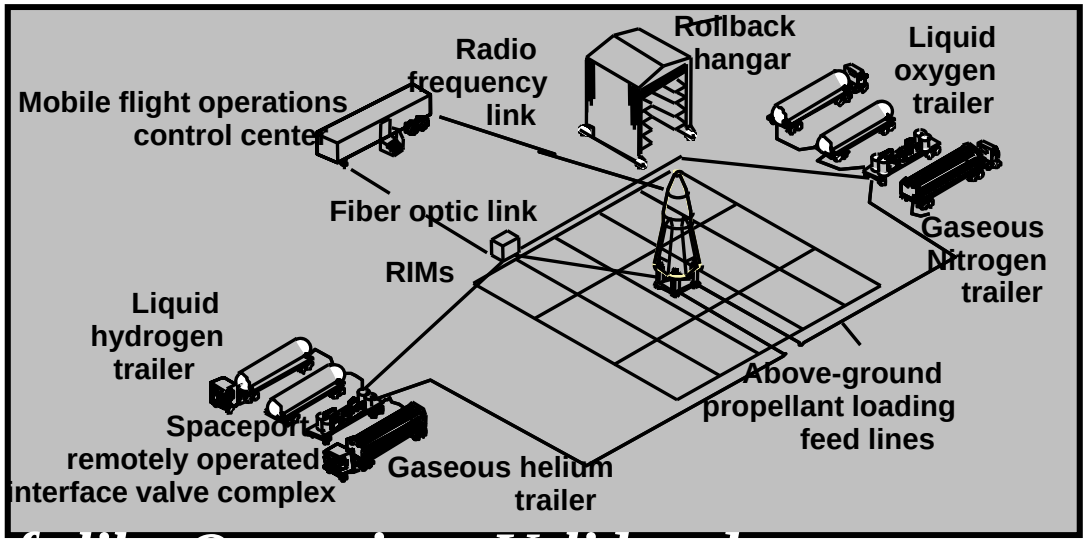
Based on the "Build a little, test a little" approach, RAPIDS was an iterative approach that enabled shorter development cycles through early integration and test. Benefits:

- **Reduced Risk**
  - Schedule: Reduced Software and Simulation development schedule by a factor >2
  - Technical: Validated design & software early in the development process

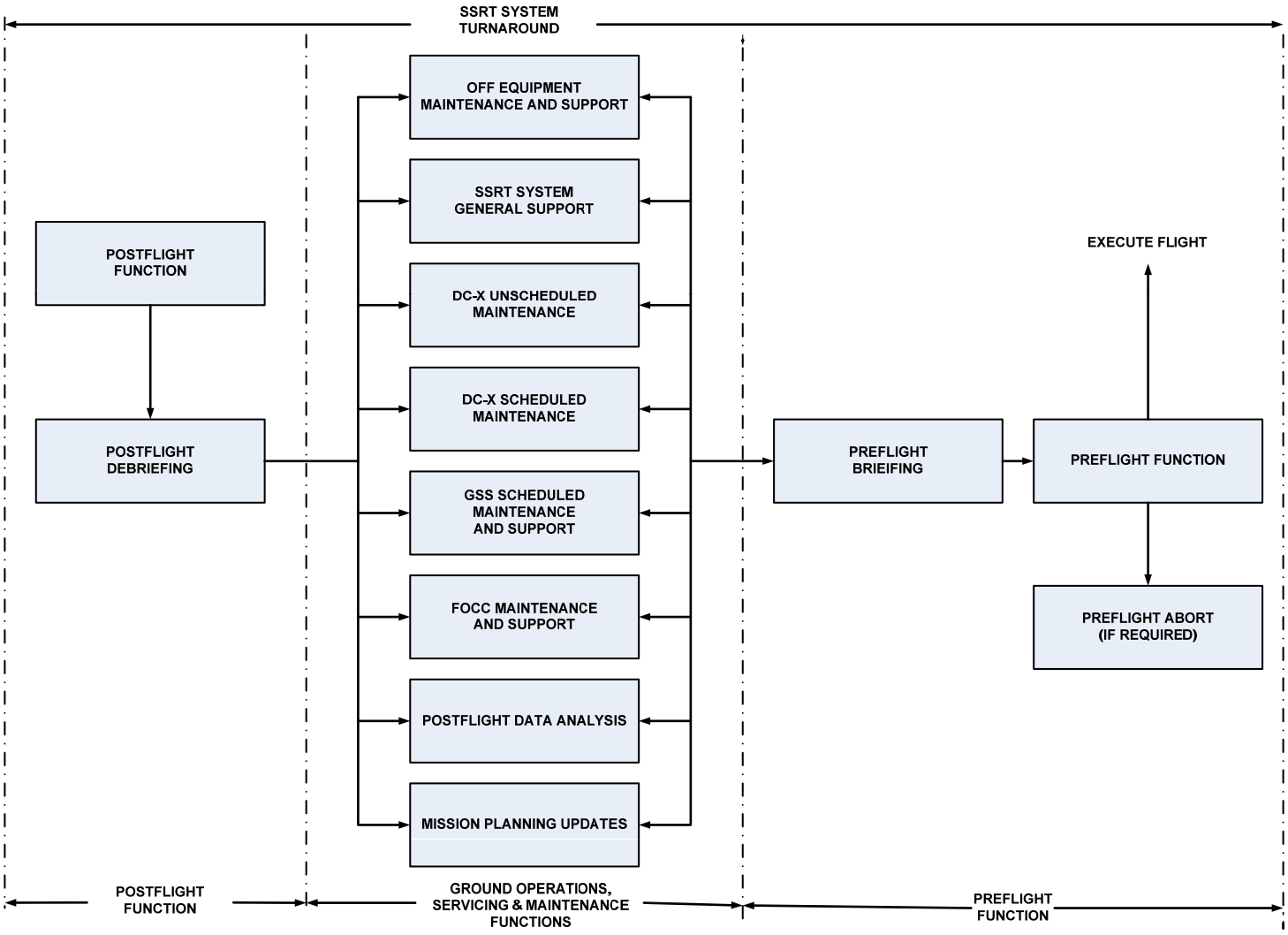
- **Reduced Cost:** Reduced software development & maintenance costs by factor > 2

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

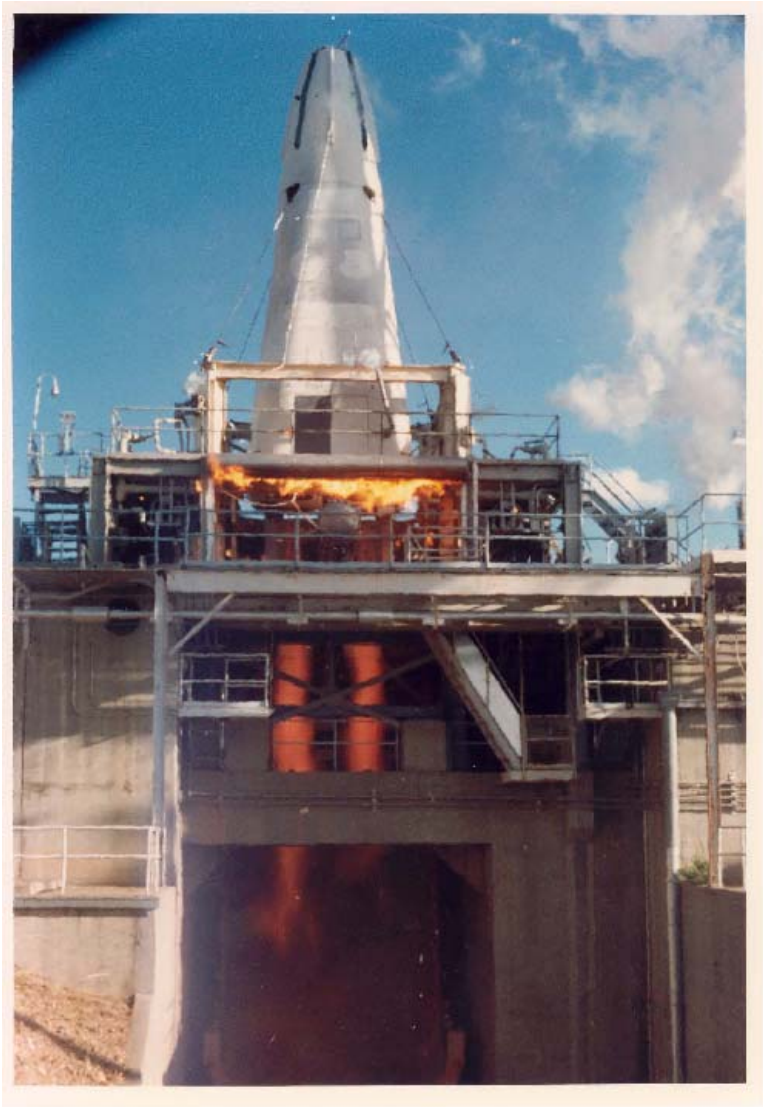
DC-X FLIGHT AND GROUND OPERATIONS



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