F-35 Lightening II

Case Study - On-Board Mission Systems Software

F-35 JSF Program Status - 2010

Joint Strike Fighter Program had **lost the trust** of US Congress, US Defense Leadership & Eight Other Countries' Ministries of Defence

Schedule and cost growth had been persistent and breached a threshold that required cancellation or re-assessment of the requirement and management (Nunn-McCurdy Breach)

The US and eight partner nations confirmed their need for the JSF capability (all three variants)

The basic need was the establishment of the cost and schedule to completion that had reason to be trusted.

Vice Admiral David Venlet, U.S. Navy (Retired)
F-35 Program Executive Officer 2010-2012

F-35 JSF Program Status - 2010

Admiral Venlet also identified two other factors that are essential to restoring trust in a troubled, complex program

Realism

- In this context, realism relates to cost and schedule to achieve the desired capability outcome

Fundamentals

- High tech capability requires the application and engagement of multiple disciplines, (e.g. science, materials, engineering, manufacturing and production, etc)
- Disciplines are learned & practiced on a basis of physical and process fundamentals
- All of these disciplines then contribute by practicing their fundamentals to creation of capability

Vice Admiral David Venlet, U.S. Navy (Retired)
F-35 Program Executive Officer 2010-2012

Development Issues

Mission Systems Software

Low morale within development team

Unpredictable software cost and schedule performance

Constantly changing program priorities

F-35 JSF Program Status - 2011

Defence Minister directives:

- No capability gap
- Independent Australian assessment required
  - SCRAM team dispatched to Washington & Fort Worth, Texas by CEO DMO
  - SCRAM review conducted
    - Significant number of issues identified:
      - Software scale, complexity - identified as “the watch item”
      - Panoramic Cockpit Display
      - Helmet - Latency, Night Vision
      - Processor - Capacity, Budgets & Allocations
      - Integration Lab Capacity
      - Software build times excessive (187 hours)
      - Peer Reviews (waived due to schedule pressure)
        - Loss of an **engineering fundamental**

Lockheed Martin Leadership

CTO & COO Directive

New Leader Required

Vice President Level

Experience in Software

Lead Mission Systems Recovery

Immediate Move to Texas in 2011

The Assessment

Determine Root of Schedule Issues

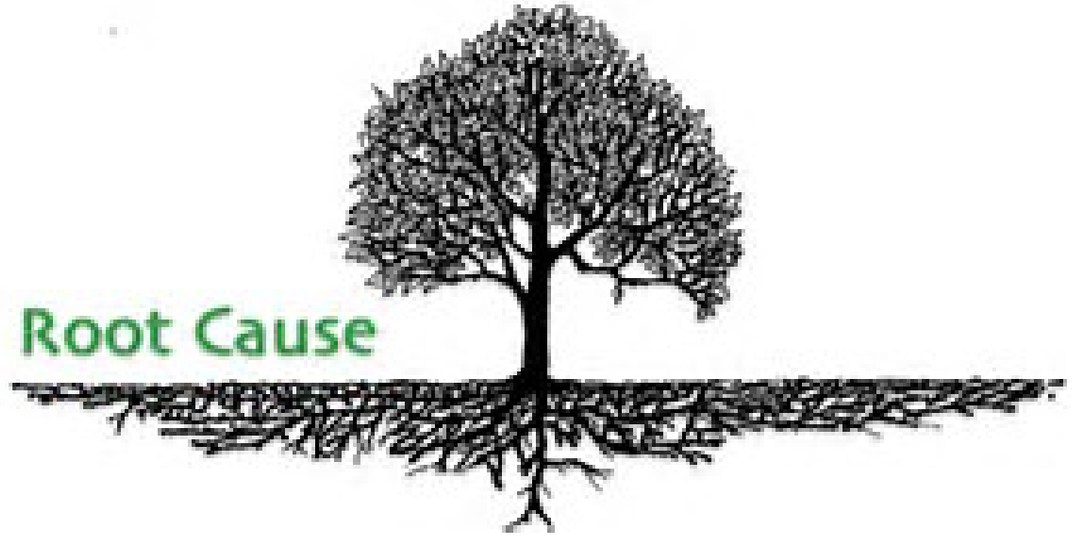
Interview 40 Engineers (1-on-1)

- “What Slows You Down?”
- “How Do You Determine What To Do?”
- “What Should My Priorities Be?”

Non-Attribution

Record Responses

Conducted a Root-Cause Analysis



The Findings

Multiple Change Control Systems

Extremely Long Software Build Times

Lack of Rigorous Regression Testing

Inadequate Integration Planning

Poor Defect Detection & Isolation

Changing Priorities

Slow Network Performance

No Common Approach to EVM

High Numbers of Defects Found In Labs

The Initiatives

Briefed Assessment Findings to Team

Established 6 “Initiatives”

Each “Initiative” Led By Senior Manager

“Initiatives” Development Plan

- Phase I - Problem Definition, Driving Requirements
- Phase II - Prototype Solution, Cost Estimate, ROI
- Phase III - Develop, Train, Deploy

Briefed “Initiatives” Plans to Leadership

Briefed Team Mates (BAE Systems & Northrup Grumman)

Follow-Up SCRAM Review

- New VP, Mission Systems assigned
  - Known to SCRAM Lead Assessor from Jeff's previous appointment as Development Leader for Jindalee Operational Radar Network (JORN) in Australia for Lockheed Martin at RLM - Instilled confidence
- Improvement initiatives related to original software findings had been identified and were in progress
- SCRAM team was provided open access to software development metrics for the purpose of parametric modeling (This **built trust** through openness and transparency)
- Revised **schedule realism** was established via independent modelling
- SCRAM Review findings reported IOC achievable within schedule timeframe

The Initiatives (con't)

Change Management

Need: Consolidate Into A Single CM System

Build & Release

Need: Reduce Software Build Times to Field Binaries

Regression Testing

Need: Lights-Out Automatic Software Regression Testing

Integration

Need: Establish Processes, Plans & Tools to Integrate MS

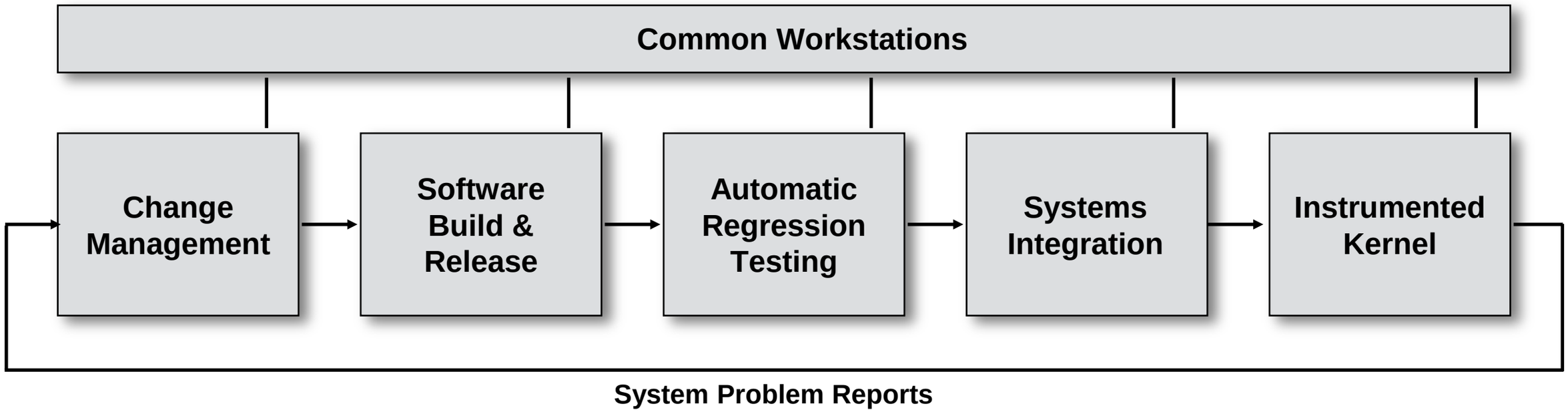
Instrumented Kernel (Tooling)

Need: Diagnostic Event Capture at T-0

Common Workstation

Need: Converge All Developers Onto A Single Workstation Image

The “Initiatives” - An Integrated Approach



- The System Problem Report (SPR) “Kill Chain”
- SPR Life Cycle: Detect → Isolate → Repair → Re-Test
- Common Workstations Serve To Integrate Processes & Tools

The Results

Software Build Times Reduced

- From 187 Hrs to <5 Hrs

Defect Escapes to Integration Reduced

- 5 SPRs/KSLOC to <2.5 SPRs/KSLOC

Regression Test Cases Increased

- Non-existent to 13,000+

Schedule Performance Stabilized

- Full Schedule Achievement for Remaining Blocks

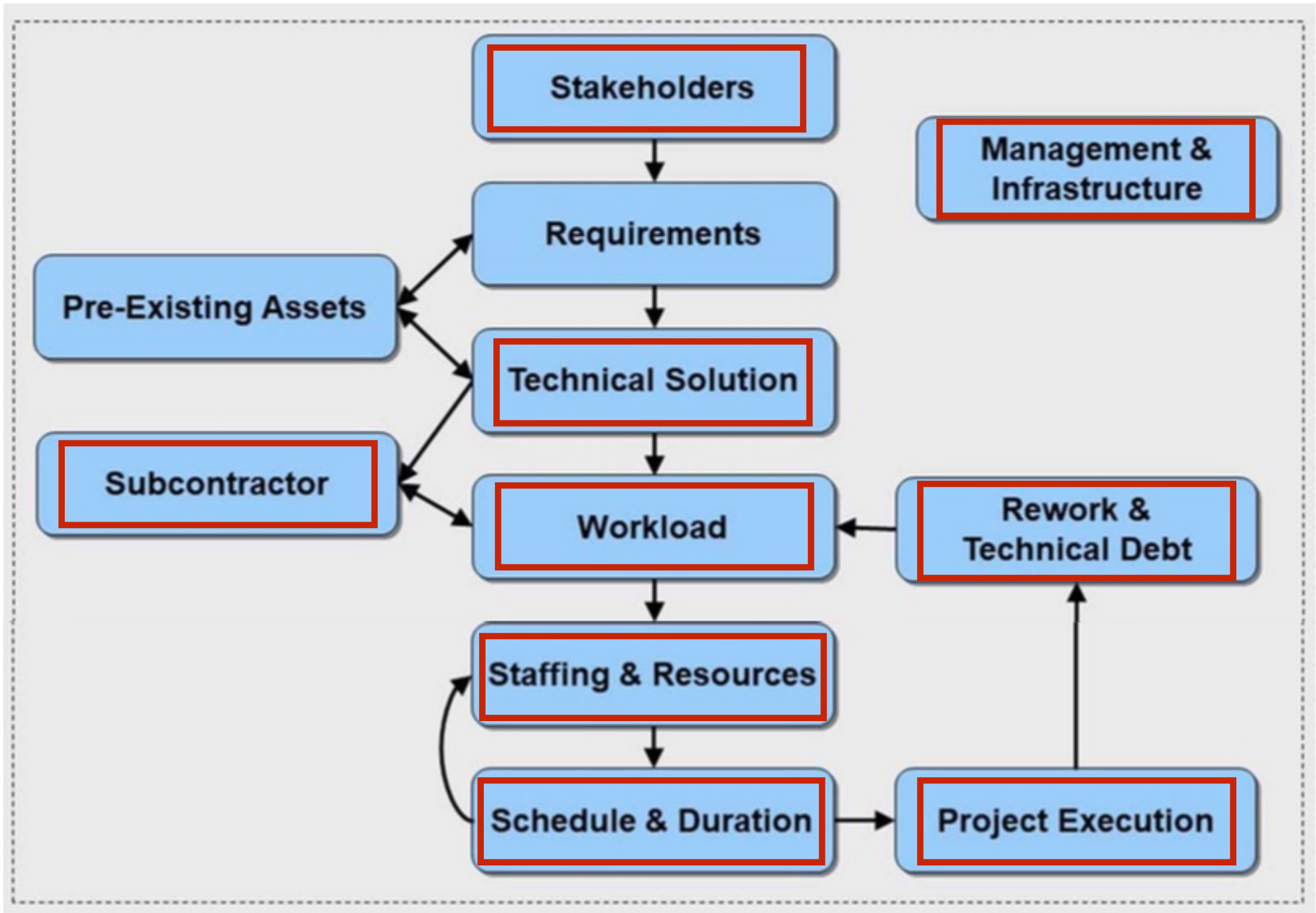
Stakeholders Happy!

- Cross Organizational Recognition of Success

Next SCRAM Review

- Software improvement initiatives assessed and determined to be effective
- Software parametric modeling validated results were in-line with predicted performance
- ALIS (Autonomic Logistics Information System) subject to SCRAM review
- SCRAM determined Marine IOC was unachievable
- JPO responded by renegotiating the Marine IOC baseline
- IOC subsequently achieved per plan in 2015

- Testimonial from Lt. Gen. Chris Bogdan, Program Executive Officer, F-35 Program (24 March 2017)
  - "The SCRAM reviews on the F-35 Program were extremely helpful to us. SCRAM gave us new techniques that allowed us to better understand the complexities of our software development. Within two weeks of coming in, the SCRAM reviews were able to point out areas where we were going to have problems. SCRAM also gave us new techniques for measuring the progress of software development and for predicting how long the software development was going to take. In 2014, I briefed the SCRAM results to the Defense Acquisition Board. Of all the organizations that were making estimates, the SCRAM estimates, in hindsight, were the most accurate."


Stakeholders
Requirements
Pre-Existing Assets
Technical Solution
Subcontractor
Workload
Staffing & Resources
Schedule & Duration
Management & Infrastructure
Rework & Technical Debt
Project Execution

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ASSESSMENT METHODOLOGY

Questions?