Opportunities for Lean Thinking in Aircraft Flight Testing & Evaluation

January 31, 2002

Researcher: Carmen Carreras
Advisor: Prof. Earll M. Murman
Outline

- Objective
- Key Questions
- Research Methodology
- 5 Principles of Lean Thinking
- Next Steps
Determine whether Lean principles can be applied to aircraft flight testing and evaluation
Key Questions

- Where are the opportunities for the application of Lean principles to flight testing?
- What are the sources of preventable non-value added activities?
- What impact do these activities have on the program?
- What are the key enablers and barriers to a testing program with minimal delays?
Research Methodology
Aircraft Testing

- Flutter
- Loads
- Carrier Suitability
- Performance
- Weapons Separation
- Handling Qualities
- Signature
- Avionics & Systems
- Noise & Vibration
Flutter: A potentially destructive self-excited oscillation

- Prevention: Eliminate by design
- Test technique: Vibrate the aircraft and measure damping
Flutter Testing Value Stream

- Theoretical Structural Dynamics Calculations
- Theoretical Unsteady Aerodynamics Calculations
- Scaled Vibration Tests
- Scaled Wind Tunnel Tests
- Ground Vibration Tests (GVT)
- Flight Tests
Case Studies

C130J

F22

Horizon

737-NG

T-6A

F/A-18E/F
How does Lean thinking apply to the overall flight testing process?

Data collected through interviews

What allowed the testing program to progress smoothly?

What were the major barriers/ sources of delays?

Where are the opportunities for process improvement in flight testing?

Data used to map general value stream and identify opportunities
How does Lean thinking apply to the daily flight testing process?

Data collected:
- Daily flight logs/test cards (~2 wks worth)
- Daily FTE/Ops summarizes of each flight

Analyze daily flight logs and notes to identify sources and impact of delays during testing

Data used to map detailed value stream and perform numerical analysis
Principles of Lean Thinking
5 Principles of Lean Thinking

- Specify value by specific product
- Identify the value stream for each product
- Make value flow without interruptions
- Let the customer pull value from the producer
- Pursue perfection

Starting point for framework, adapted based upon the LAI book
#1 Specify *value as defined by the customer*
Delivery of the aircraft on \emph{schedule}, with \emph{full confidence}, and within \emph{budget}.
Other Key Stakeholders

- Oversight Agency
- Test Team
- Customer
Conducting a test program with the minimal amount of risk to ensure full confidence in the aircraft
Undertaking rewarding work, in a stable environment with an aura of respect
#2 Identify the **value stream** ...

- Value-adding activities
- Type 1 waste: Non-value adding, but necessary activities
- Type 2 waste: Non-value adding, and unnecessary activities

... and eliminate Type 2 waste
#3 Make value *flow* without interruptions
The test and evaluation “value stream” is the end-to-end set of all tests, modeling and simulations, and related processes and interactions, which are executed to reduce the risk of not achieving the end goal of delivering an aircraft to the customer which meets the end user’s expectations.
Unreliable components caused delays in system test.

System Integration Lab (SIL) not operating at full capability led to integration problems in system test.
Test article delivered on time, testing completed near scheduled date

Late delivery of test article had significant effect on testing program.
Intersecting Value Streams

Opportunities for improvements are at the intersections

Construction of test article → Flight Test → Delivery of a/c to customer

Certification Agency

Other Test Aircraft

Flight Support

Test Range
Ground Facilities (Telemetry)
Aircraft Maintenance
Tankers
Chase Plane
SAR
Certification Agency

- Obtaining signatures on paperwork in timely manner
- Waiting on availability of agency personnel for required briefings

Other Test Aircraft

- Maintenance not having a/c ready in time because working on other a/c in the program
- Unable to perform ground test, because instrumentation being used by another a/c
Intersecting Value Streams

Flight Support

- Ground Facilities (Telemetry)
  - TM goes down for an hour, may miss flight window

- Tankers
  - Unavailable tankers limit test efficiency
  - Limited ceiling of tankers disrupts testing. Need to drop from test altitude to tanker altitude.

- Chase Plane
  - Lose test time waiting for the chase to refuel
  - Lose test days when chase needs unscheduled maintenance
Opportunities for improvements are at the interfaces
Biggest problem is late releases

Non-weather sources of delays

- Late Release: 46%
- Aircraft Equipment: 34%
- Onboard Test Instr.: 8%
- Ground Equipment: 5%
- Human Error: 3%
- Waiting for chase: 4%

Daily Opportunities
#4 Let the customer *pull* value from the producer

Research shows, principle #4 is not applicable to flight testing
#5 Pursue perfection

There is always room for improvement
Next Steps

- Finish remaining 3 case studies
- Continue codifying enabling practices
- Continue data analysis
- Write Thesis