THE VALUE OF PERFORMANCE.
NORTHROP GRUMMAN

Test Planning – Advancing the Science Tutorial

17th Annual Systems Engineering Conference

Waterford at Springfield Va.

October 26th, 2014

Stephen Scukanec
Manager Test Planning & Requirement
High Altitude Long Endurance Enterprise
Northrop Grumman
Aerospace Systems

THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN

Why Develop a Test Plan ?

How Do Plans Help The Program?

NORTHROP GRUMMAN

- Identifies the test program and test program resources
- Provides a method to manage the test program

- Optimized test plan saves program cost
- Ensures the test program is traceable to the product architecture (requirements)

- Test plan can help manage program changes
- Test plans foster communications

Advancing the Science

NORTHROP GRUMMAN

- Test planning typically relies on
  - Experience
  - Requirements
  - DWWDLT (Did What We Did Last Time)
  - Lessons learned
  - Working teams / meetings
  - Schedules

- Test planning must advance using:
  - Experience
  - Doing what is required (optimizing the test program)
  - Working teams / meetings
  - Schedules
  - Test plan modeling (utilizing SE based tool set)
  - Appropriate application of design of experiments
  - Collaborative techniques and tools to encompass the entire programs test program
  - Support rapid evaluation based on programmatic changes

THE VALUE OF PERFORMANCE.
NORTHROP GRUMMAN

What is a Test Plan?

What Do We Plan ?

NORTHROP GRUMMAN

- Features of a Good Test Plan
  - Defines Test Strategy
  - Establishes Test Program Management
  - Documents the Test Program
  - Identifies the Needed Resources

- Tenets of a Good Test Plan
  - Can be used to manage the test program lifecycle
  - Covers all program level test responsibilities
  - Traceable
  - Adjustable
  - Is used as the requirements document for test procedures
  - Avoids obsolescence

The Test Plan is the Test Procedure's Requirement Document

THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN

When Do You Test Plan?

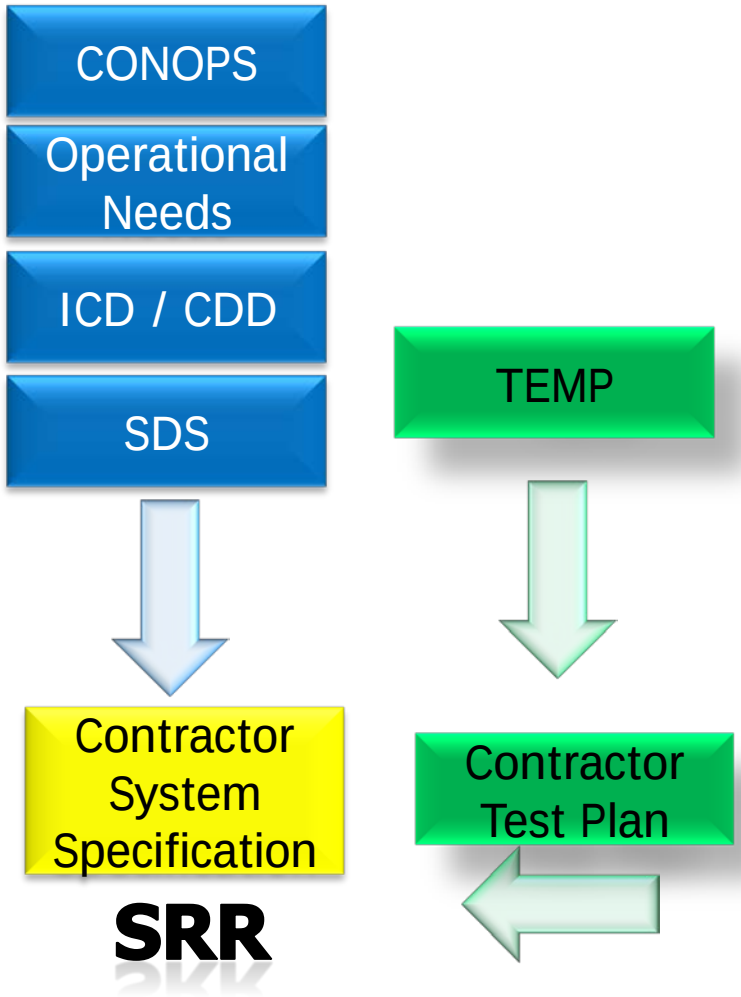
THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN

A Controversy Do We or Don't We?

Testing Techniques Drives Product Requirements

- The Test Plan can and often does drive product requirements
  - Flight termination system
  - Instrumentation
  - Weight
  - Power
  - Space / volume
  - Communications protocol
  - Frequency allocations
  - Others?
- T&E does generate requirements
  - Identify requirements early to avoid design impacts
    - Don't be late to need



Test Planning – Advancing the Science

NORTHROP GRUMMAN

- Test planning starts at program inception
- Test planning support the development of product architecture and requirements
- Test planning requires the proper skill mix with lifecycle experience
- Test planning is a lifecycle task
- Test planning requires a collaborative, program integrated, model based tool set.
- Test planning should look front to back and not back to front
- Test planning should help decide the test techniques, not the other way around.
  - Just because you used a laboratory last time doesn't mean you need it this time.

THE VALUE OF PERFORMANCE.
NORTHROP GRUMMAN

How Do We Plan ?

How Do We Plan?

NORTHROP GRUMMAN

- Consider an improved air-to-air missile system that requires testing—Missile A Improved. Suppose the original Missile A had an historical hit rate of 70%. The test design must evaluate whether the improved missile is at least equal to or better than the original in “target hit” success. How many shots do we need to make to determine the performance of the improved Missile A?

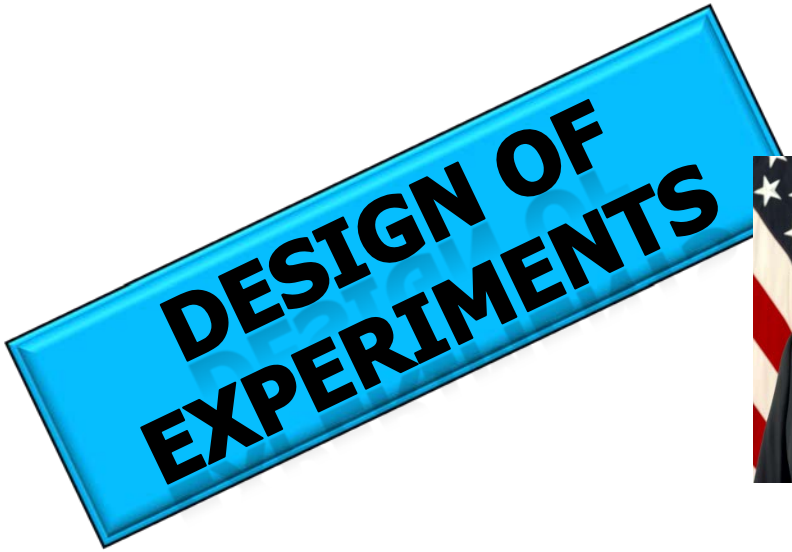
- Starting with a blank sheet of paper, the test engineer must define the appropriate number. But what is the number of shots necessary to verify the improved Missile A. Maybe the number is 3, because that is what the available time or money will support. Maybe the number is 8 because the engineer just likes 8. Maybe the number is 10 because the engineer is challenged by fractions. Or maybe the number is 30 because in life something good happens at 30! There is no statistical backing for any of these numbers, but all remain possibilities. For no particular reason, the engineer chooses 10.

Design of Experiments Applied to Flight Testing - Leslie L. Bordelon
U. S. Air Force Senior Executive Service Retired - RTO-EN-SCI-176

Traditional Test Planning Methods

NORTHROP GRUMMAN

- Test Team Planning Approach
  - Intuition – SME opinions, Quick and Easy, Not Much Detailed Planning Required
  - Do What We Did Last Time (DWWDLT) – Defined Trade Space, Cost and Schedule, May Not Examine New Capabilities Under Changed Environment
  - One Factor at a Time (OFAT) – Organized, repeatable, Non-interactive
  - Best Guess – Cost and Schedule Driven
  - Use Comparable Data – Adds Supporting Data, Lacks Fidelity to New Case



"As I review Test and Evaluation Master Plans (TEMPs) and Test Plans, I am looking for specific information. In general, I am looking for substance vice a 'cookbook' or template approach -each program is unique and will require thoughtful tradeoffs in how this guidance is applied. A "designed" experiment is a test or test program, planned specifically to determine the effect of a factor or several factors (also called independent variables) on one or more measured responses (also called dependent variables)."

Guidance on the use of Design of Experiments (DOE) in Operational Test and Evaluation J. Michael Gilmore Director OT&E 10-19-2010

Test Tools

Test Planning Tools

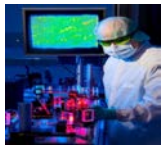
NORTHROP GRUMMAN

- What is the T&E Test Planning Tool Kit?

Planning	Test Design	Metrics	Assumptions
Control A Control C Control V			
Complete Model Based Test Planning – Re-plan Test Planning Streamlining Costing / Scheduling Auto Test Plan Documentation	Event Planning Test Design Test Plan Validation	Test Program Work Flow / Metrics	Test Planning Assumption Corroboration Apply and maintain Lessons Learned

If you keep doing what you're doing
You'll keep getting what you're getting!

Why These Techniques? – Some Examples



LABORATORIES

Off Nominal
Initial Integration
Interface Development
Problem Resolution
Functional Checkout

TEST RANGES

Installed Performance – Static
External Interface – Operational Fit Checks
Low Speed Dynamics
Initial System Control
External Communications

FLYING TEST BEDS

Dynamic Integration
Dynamic Functional Design Development
High Risk Safety Activities
TRL development in Operational Environment
Targeted Off-Nominal Tests

FLIGHT TEST

Operational Environment
Operational Performance

Pick the Right Tools for the Right Job

The Test Planning Variables

- Collaborative
- Integrated
- Traceable
- Schedule
- Tools
- Resources
- Risk
- Techniques
- Adaptable
- Dependencies

- Facilities
- Verification
- Lifecycle Activities
- MoEs, KPPs
- Realistic Environments
- Operationally Relevant
- Deliverable
- Managed
- Sequences

AND NOW YOU WANT TO KNOW THE PROGRAM IMPACT TO A CHANGE?

Conclusions

- The DNA of T&E must Change
  - Need a complete lifecycle experience
- Test planning must be recognized as the requirements set for the test program
  - Document is not just a deliverable
  - Plan does not become extinct
- Test verification and planning techniques
  - Links the systems engineering team with the test team
  - Enables collaboration
  - Fosters communication
  - Supports development of early lifecycle products
- Test tools kit must be evolved
  - Model based test plans (know you have the right plan)
  - Physics based test event validation (know your plan is right)
  - Tools must be program sizable (big to little)
  - Tools must be connected to the requirements process
  - Tools must be collaborative

Testing is More Science Than Art.


NORTHROP GRUMMAN