M&S Applied to Improved Test Planning & Analysis Methods in the DT & OT Execution Phase

Oct 30, 2013
Current mandates from offices of:
- DOT&E & DT&E/TRMC
  - Smarter Test Planning methods - Scientific Test and Analysis Techniques (STAT)
    - Design of Experiments
    - Other M&S and Statistical based methods
  - DAG directed use of M&S in T&E
  - Initiatives to push OT and DT considerations to the beginning stages of systems requirements development
  - Initiatives to perform OT as early in the DT cycle as possible
  - TRMC initiative - Identify high-payoff areas for potential savings

DoDI 5000.2

DOD Temp Guidebook – Feb 14, 2012
- M&S for Test Planning, Prediction, Preclusion, and Evaluation - Guidance
  - The modeling and simulation (M&S) workforce should address how M&S will be employed in the overall test strategy and how the M&S will be calculated, validated and analyzed (CV&A). Openly, the T&E should identify M&S expected to be used, the intended goals of the test objectives, the test assumptions to be addressed, and the core test measurement hypotheses used. The M&S employed should be validated and analyzed (CV&A) before the test objectives are issued. The CV&A should be conducted in the planning phase of the test and during the test execution phase. This should be accomplished through test planning, test execution, and test analysis. The CV&A should be conducted in the planning phase of the test and during the test execution phase. This should be accomplished through test planning, test execution, and test analysis.
STAT in the Execution Phase

**Planning**

- Gross system trades
- Detailed system trades
- Process knowledge
- Selection of factors
- Sensitivity of factors
- Design of Experiments
- Other statistical methods

**Execution**

- Test-point requirements
- Test-point resources
- Route planning
- Sequencing and choreographing vehicles and resources

**Post Test Analysis & Verification**

- Quick-look reconstruction
- Measures of performance assessment
- Test-point attainment verification
- Post-test data package visualization supplement
Execution Phase Challenges

- Increasing complexity of mission systems
- Increasing mission software complexity
- Budget constraints (living with overruns to date)
- Low test-point density?
- High re-fly rates?
- Challenge of achieving test-point parallelization
- Challenge of communicating capability attainment along with test-point completion
- Post-test facing ever increasing data quantity
- Verification complexity
T&E Compared to Other Eng Disciplines

- Product life-cycle & engineering disciplines taking advantage of well established computer aided engineering (CAE) methods
Great opportunity in the T&E discipline to reap similar benefits by using CAE-like methods in test-event design, execution & post-flight analysis

- **Traditional methods**
  - Excel
  - PowerPoint
  - Word
  - Custom MATLAB
  - “Planes-on-sticks”
  - “Flying wrist watches”
“Planes-on-a-stick” is a common method for detailed mission systems test plan route design.
Detailed Test Event Planning Considerations

- Available aircraft & condition of systems
- Readiness of software block version
- Sequencing of subsystem tests for parallelization
  - Modes, targets, emitters, integrated operation, ...
- Choreographing of multiple aircraft tests
  - Aircraft, targets, emitters, operating conditions
- Sequencing to minimize fuel usage and tanker use
Detailed Test Event Planning – closer look

**Test Plans**

**Test-point details**
- Requirements
- Objectives
- Resources
- Evaluation Criteria
- MOPS
...

**Test Cards**

**Data Links**
- Radar
- EW
- EO/IR

**Mission Deck Test Cards**

**Flight Routes**
How can we:

- Ensure test-point success?
- Fly more test-points per flight?
- Reduce planning cycle time?
- React quickly to evaluate anomalies?
- Capitalize on “white-space” effectively?
- Streamline communications?
- Reduce program test costs?
M&S for Interactive Detailed Test Design

Build/import models
Characterize system

- Performance models
- Environment models
- Mission specific data

Run simulations and evaluate performance

Combine into system model

Define measures of mission effectiveness

- Iterative design & analysis
- Evaluate mission performance
- Test Planning

Convey results

- Reports & graphs
- Video
- Mission results or status

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Which route is “better”? 

Comm emitter
Test Event Route Assessment

- Interactive route design
  - Fuel remaining
  - Aspect angle
  - Comm performance
  - Telemetry assurance
  - Dynamic geometry
  - Lighting directionality
  - RF directionality
  - Safety of flight
  - Multi-ship choreographing
  - Number of test-points
Route Design / Optimization
Multi-Constraint Prediction

Timeline

- Constraint 1
- Constraint 2
- Constraint 3
- C1+C2+C3

- Determination of “multi-constraint” satisfaction times

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Increasing Test-point Density per Flight

- Designed test-point routes
- Coordination holds & refuel waits
- En route & return

“white-space”
“green-space”

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Post-Flight Analysis

- Quick import of telemetry data
- Colorized routes based on:
  - Various operating parameters
  - Various performance parameters
  - AGI generated analytical parameters
  - Events
- Markers on routes or ground (static and time-based)
- Supplemental composable routes to assess variations on effectiveness
- Analytically derived supplemental visual aides
  - Vectors, angles, range lines, head-up data displays, parameter graphs
- Flight playback (quick forward/reverse scroll)
How do you do this?

Is it too late for my program to do this?

How much time does this take?

How detailed do my models need to be?

What is the implementation cost?

Is it worth the effort?
MBE Initiation & Evolution – (When?)

Material Solution Analysis
Technology Development
Engineering & Manufacturing Development
Production & Deployment
Operations & Support

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### MBE Initiation & Evolution – (When?)

<table>
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<tr>
<th>Material Solution Analysis</th>
<th>Technology Development</th>
<th>Engineering &amp; Manufacturing Development</th>
<th>Production &amp; Deployment</th>
<th>Operations &amp; Support</th>
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<tr>
<td>Material Development Decision</td>
<td>PDR</td>
<td>Post PDR Assessment Post CDR Assessment</td>
<td>LRIP Full Rate Prod FRP Decision Review</td>
<td>Life Cycle Sustainment</td>
</tr>
</tbody>
</table>

#### Key Systems
- Radar
- Communications
- EOIR
- EW
- Software
- Vehicle Systems
- Ground Systems
- Emitters
- HWIL
- Systems Integrations Labs

**MBE planned early and carried through to T&E**

**Systems modeling specific to T&E Execution Phase**

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**Program Test Requirements**
- Air Veh performance description
- Physical 3D model
- Sensor attach points
- xmt & rcvr attach points
- Radar spec's description
- EOIR sensors specs
- Comm antenna’s specs
- Comm & sensor operating constraints
- Telemetry descriptions
- Data descriptions
- Sensor operating modes & constraints
- Ground handling comm needs
- Typical flight paths (takeoff to op alt)
- Operating flight paths, and comm needs
- Multi-use of sensors and resource loading
- Active sensor targeting CONOPS
- Operating procedures wrt wind conditions
- Payload & bus loading & constraints
- Imaging modes relative resource loading
- Sensor use rules –vs- flight conditions

**M&S Configurations**
- **STK objects:**
  - Vehicle model
  - Solid model
  - Sensors
  - Antennas

- **AMM changes**
- **STK data readers**
- **STK system trades**

**Specifically Configured M&S Tool Set for T&E Execution**
- **Custom work-flow UIs:**
  - Target scheduling
  - Comm link assessment
  - Test points assessment
  - Active sensor targeting CONOPS
  - Operating procedures wrt wind conditions
  - Payload & bus loading & constraints
  - Imaging modes relative resource loading
  - Sensor use rules –vs- flight conditions

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Program Specific Implementation – (How?)

MBE Development for Test Planning

Design/Planning Tool Development
- STK Configuration
- System/Subsystem Characterization
- Workflow Specific UI Development
- Implementation & Iterative Improvement

Test Series

Toolset and process Improvement Iterations

Knowledge DB

People
Tools
Process
Methods
Metrics

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Summary of Proven ROI Potential – (Why?)

- **Efficiency of Test Force operations**
  - Reduced time for test-force process elements
    - Test-plan process, test-card development process, post-test process
  - Shortened and more effective meetings, pre-flight reviews, etc.

- **Effectiveness and efficiency of test flights**
  - Improved robustness of test-card designs – validation against test plan objectives
  - Increased number of test-points per flight
  - Improved scheduling of refuel operations
  - Positive overall test-force flight schedule impact
  - Enabling the complicated choreographing of four-ship flights

- **Communications within the program and with customer**
  - Illustration of complex concepts and issues at all stages of the execution T&E lifecycle
  - Enable greater collaboration
  - Shortened and more effective meetings, pre-flight reviews, etc.
  - Positive impact to test-point sign-off activities

- **Flight safety**
  - Rich material enabling added insight to pre-flight briefings
  - Robust treatment of multi-ship flight choreographing and event scheduling
**Problem:** Flight test planning is largely manual, relying on talent and intuition of experienced engineers.

**Solution:** Use STK MS&A Environment to improve flight test efficiency, effectiveness and repeatability.

**Outcome:** Proof-of-Concept demonstrated improved flight test plans, designs and analysis for mission systems testing.

Accelerated & optimized test planning,
Increased flexibility in test event execution and Faster post-test analysis

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Optimizing Simulator Time – (Why?)

Mission Deck Test Cards
New Metrics Factored into Test Plan Cost & Schedule Forecast – (Why?)

- New improved metrics
  - Test-points per flight
  - Re-flight rate
  - Practitioner’s efficiency

New metrics factored in to plan

- STAT/DOE yields “right sized” Test Plan

Improved Cost & Schedule Forecast
M&S for T&E Execution Phase – Summary

- Nimble M&S can be effectively used in test execution
- Methods can usually be applied at any point in the cycle given the significant ROI potential
- Benefits attained with requisite level model fidelity
- COTS tools can enable and accelerate implementation
- New methods and metrics can be applied to improve future programs
Questions?