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Software for Space, Defense & Intelligence

NDIA Systems Engineering Conference - 2013

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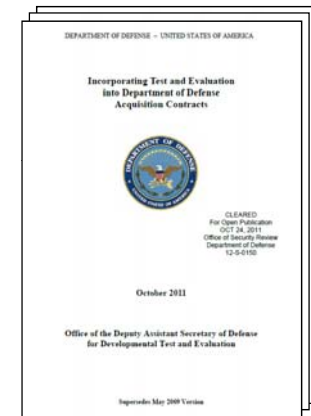Methods in the DT & OT Execution Phase

Oct 30, 2013

DOD, AT&L, DTE, DOT&E Policy Directives

- **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   DAG – Chap 9 – T&E   DOT&E TEMP Guidebook

STAT in the Execution Phase
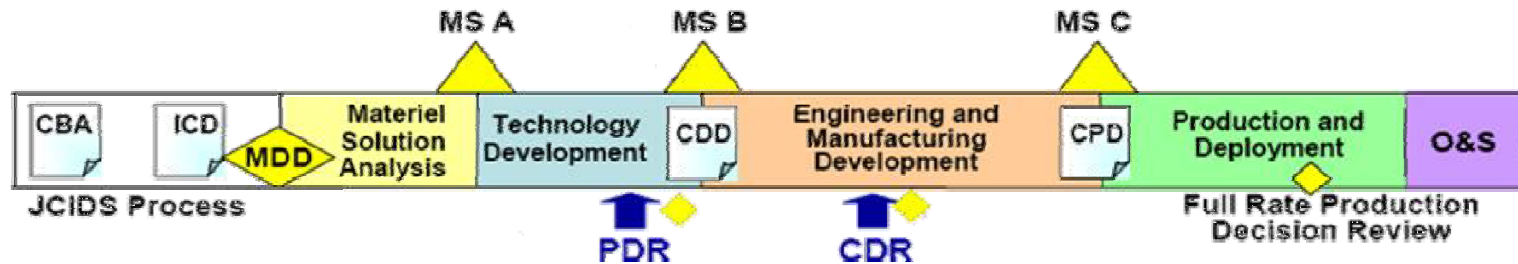
Planning

Test Planning

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

Execution

Detailed Test Planning

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

Test Execution

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**
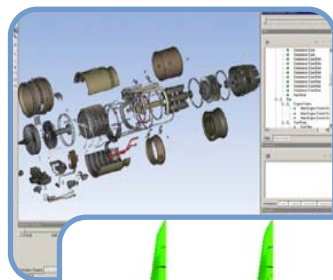
Design
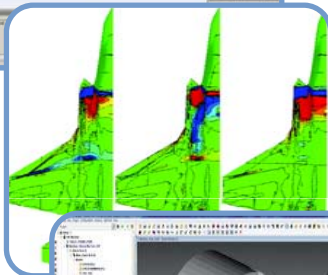
Analysis
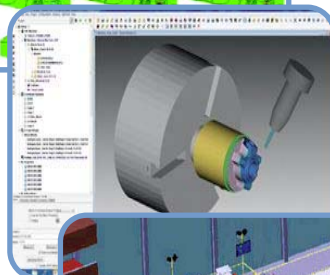
Manufacturing

Assembly

Training

Operations

Maintenance

T&E Execution Phase Detailed Planning Tools

- **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
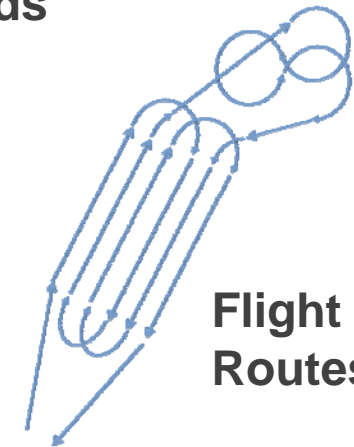
Flight Routes

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

Combine into system model

Define measures of mission effectiveness
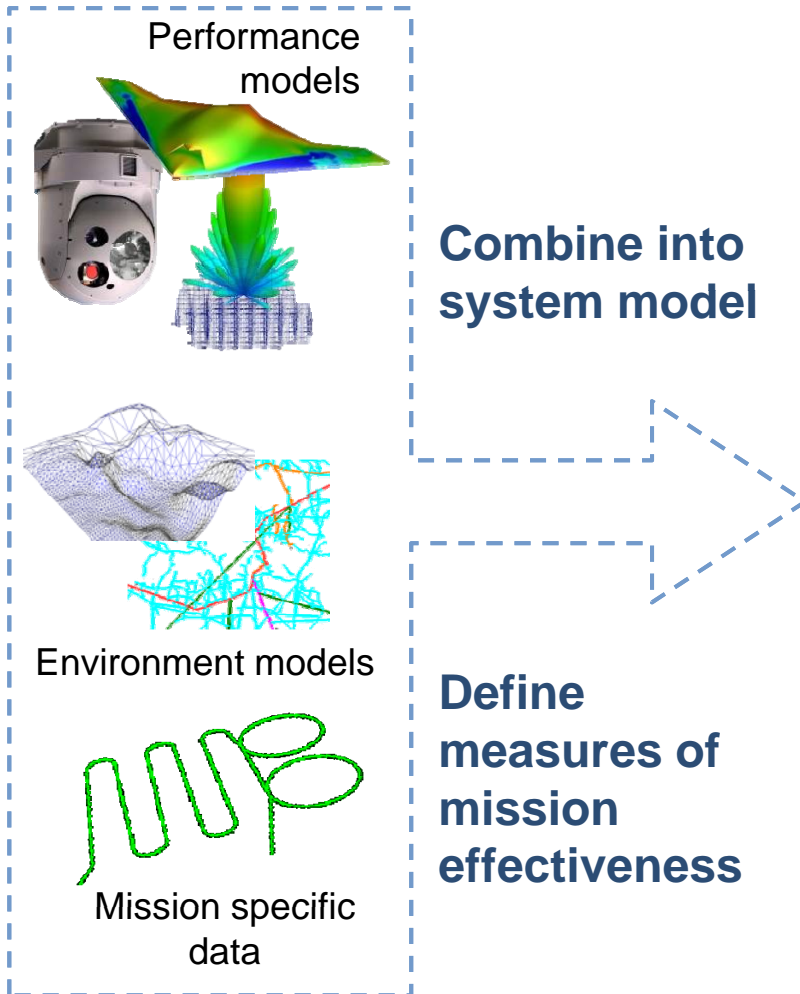
Run simulations and evaluate performance

Iterative design & analysis
Evaluate mission performance
Test Planning
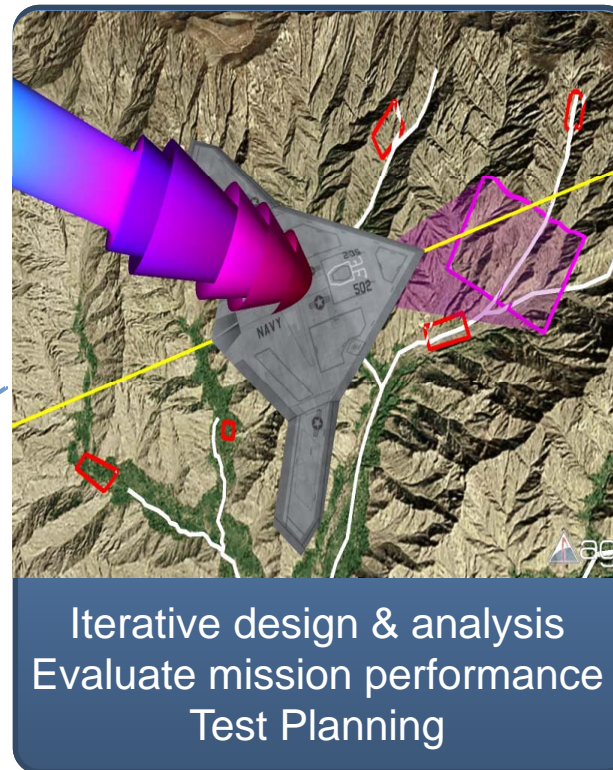
Convey results
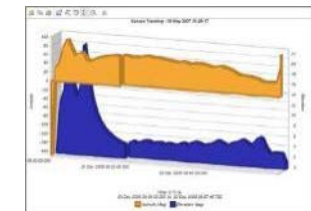
Reports & graphs
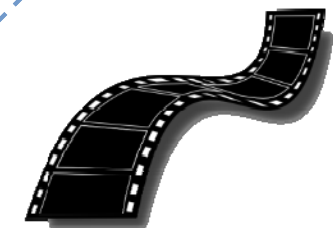
Video
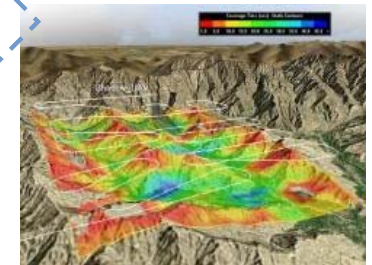
Mission results or status

- ## Which route is "better" ?
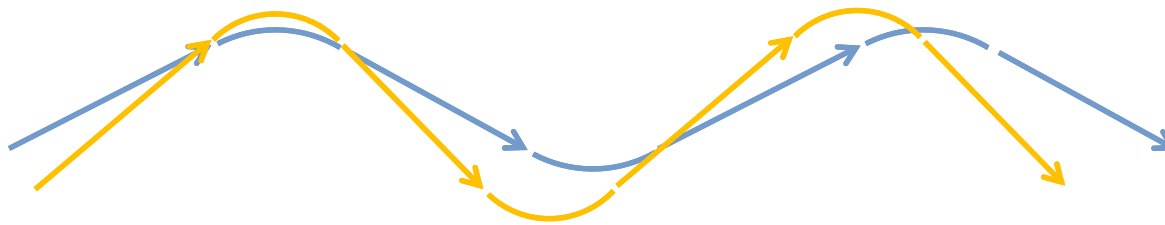
☀ Comm emitter

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
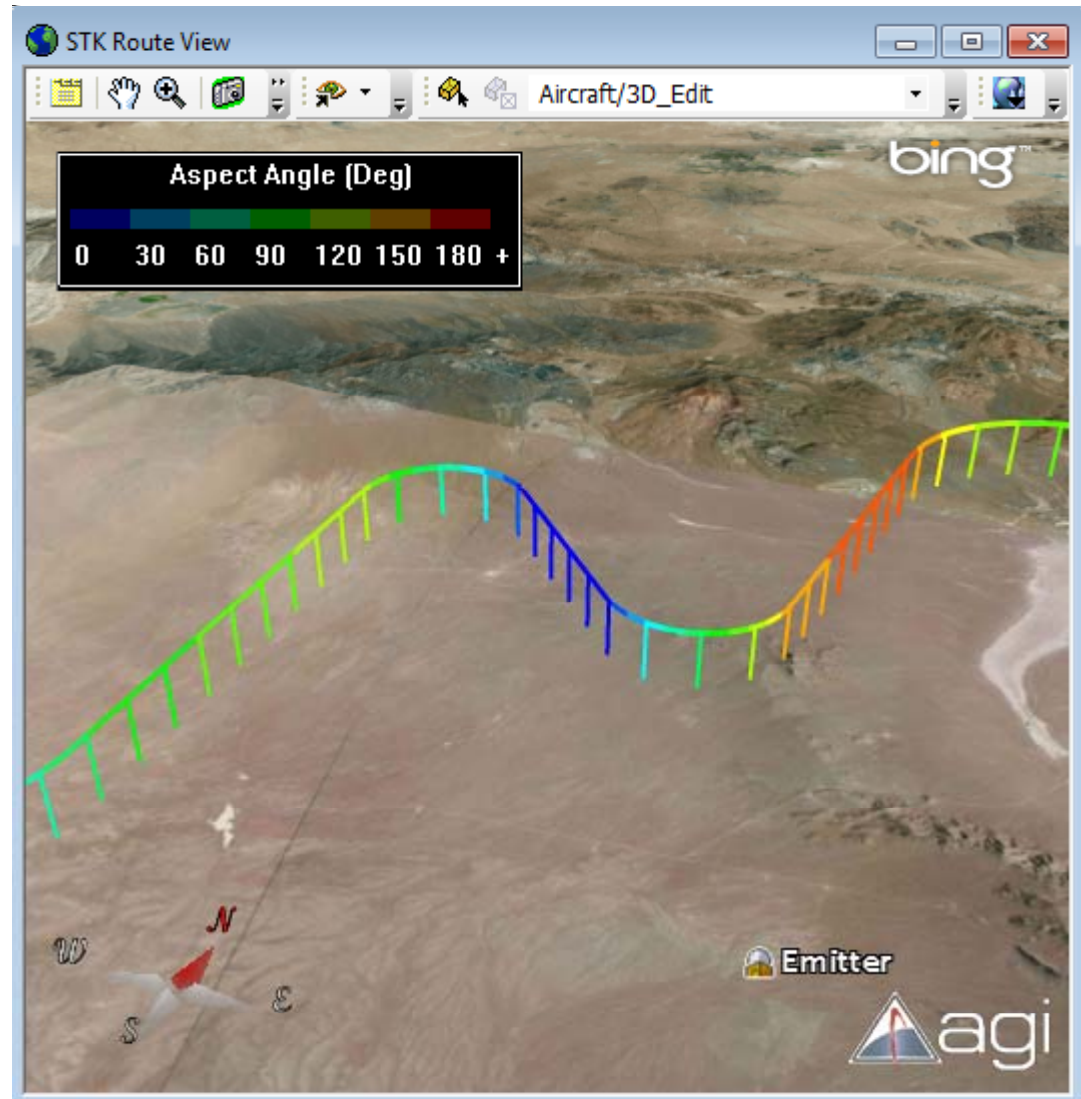
Route Design / Optimization
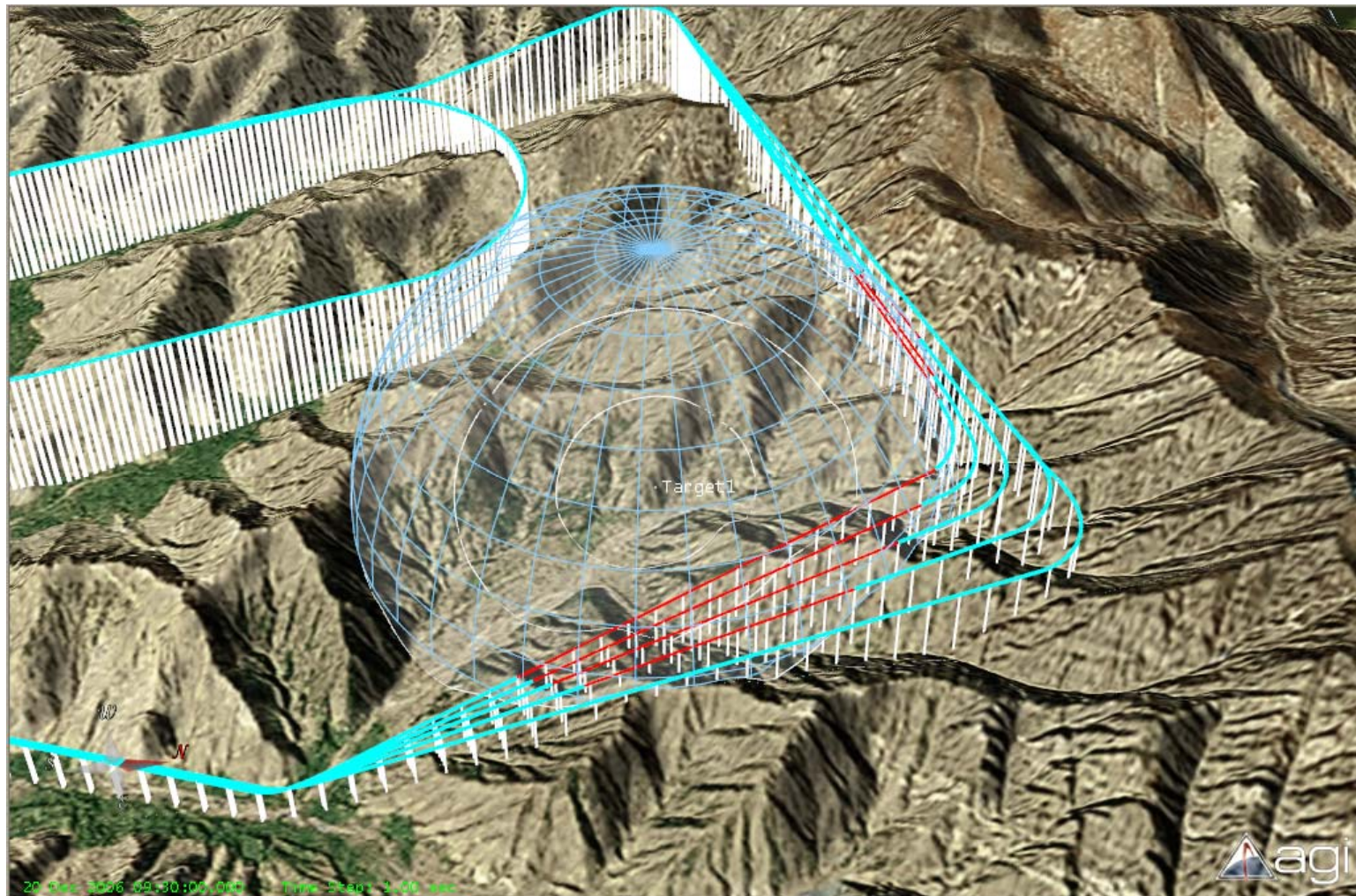
Multi-Constraint Prediction

Timeline

Constraint 1

Constraint 2

Constraint 3

C1+C2+C3
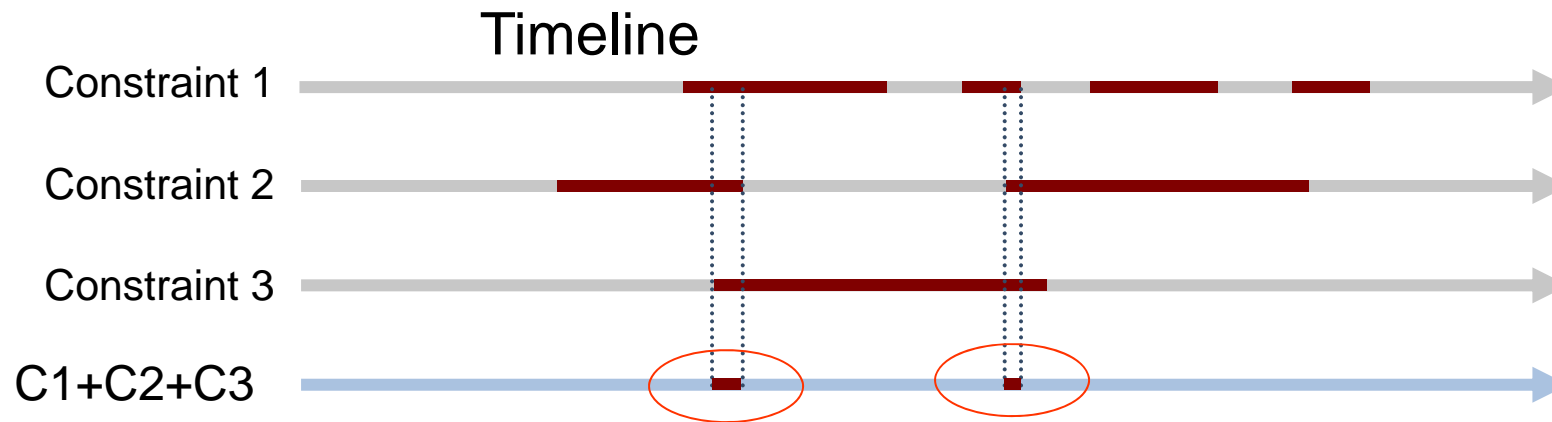
- **Determination of "multi-constraint" satisfaction times**

Increasing Test-point Density per Flight

Coordination holds & refuel waits

Designed test-point routes

En route & return

"white-space"

"green-space"

"white-space"

Post-Flight Analysis
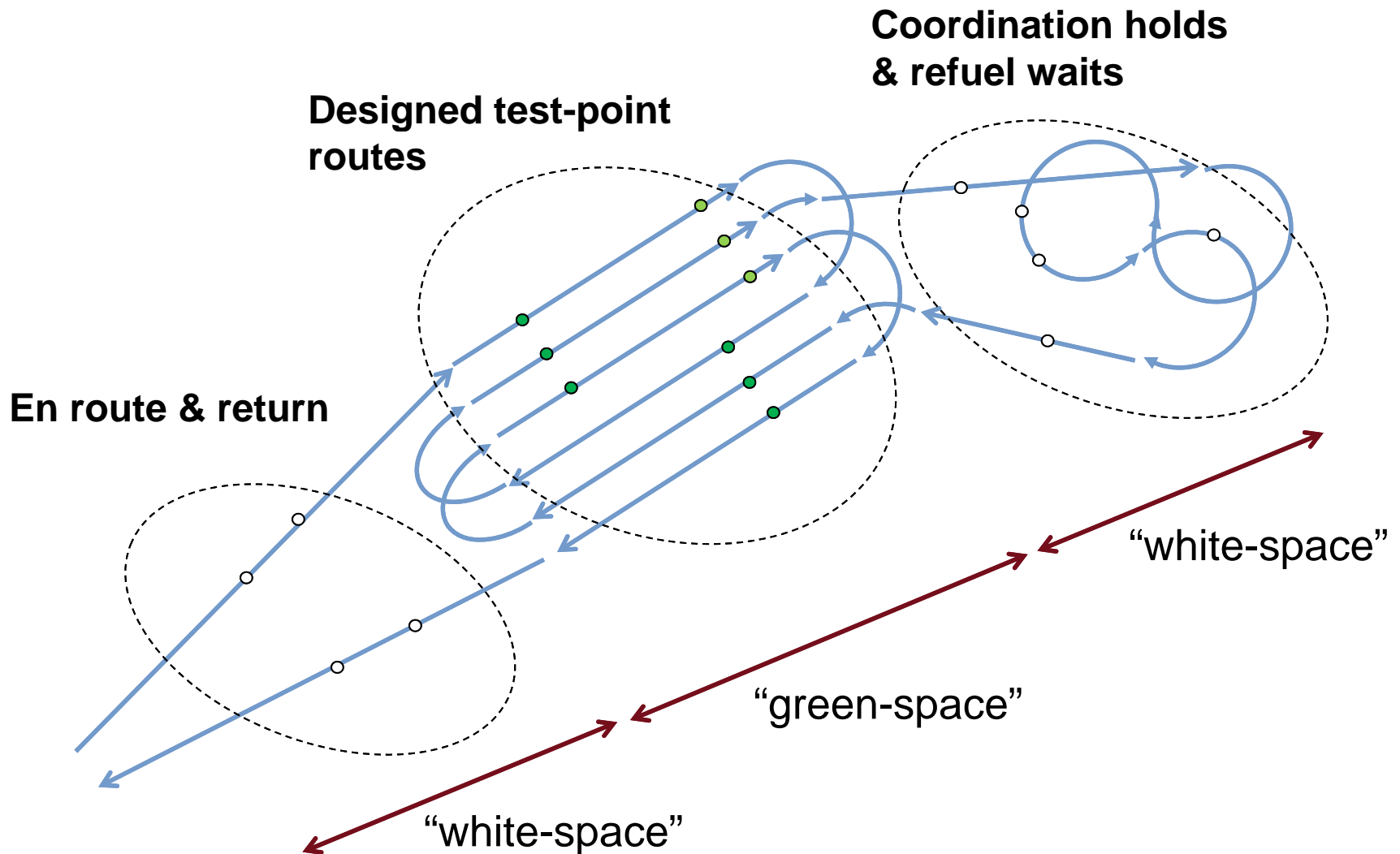
- **Quick import of telemetry data**

- **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)**

Post-Flight Analysis

How? - When? - How Hard? - How much? - Why?
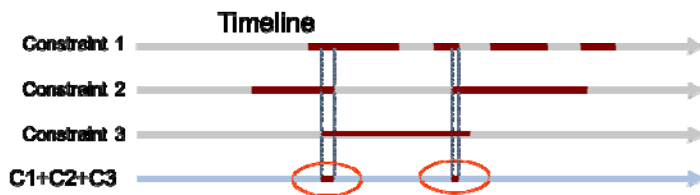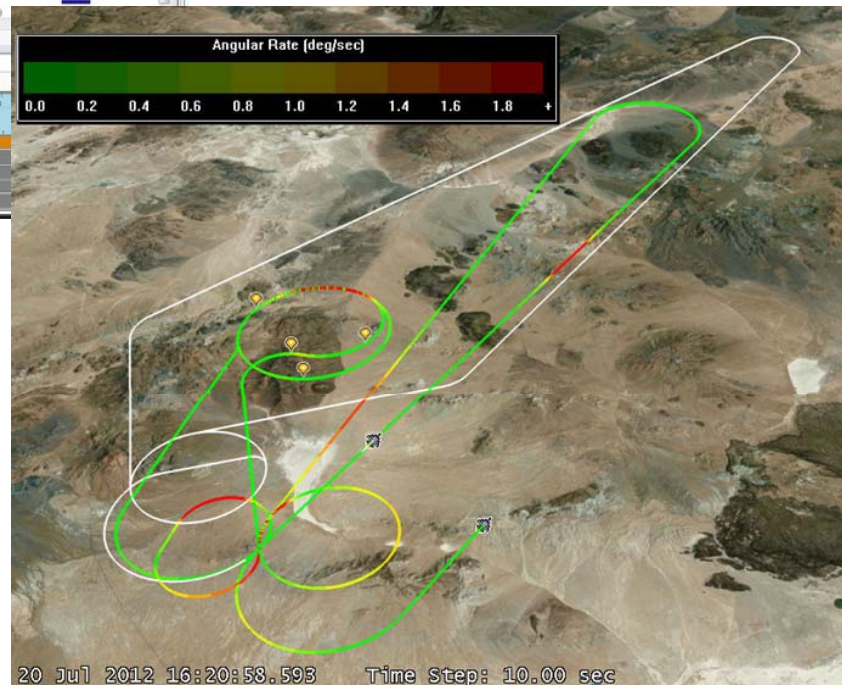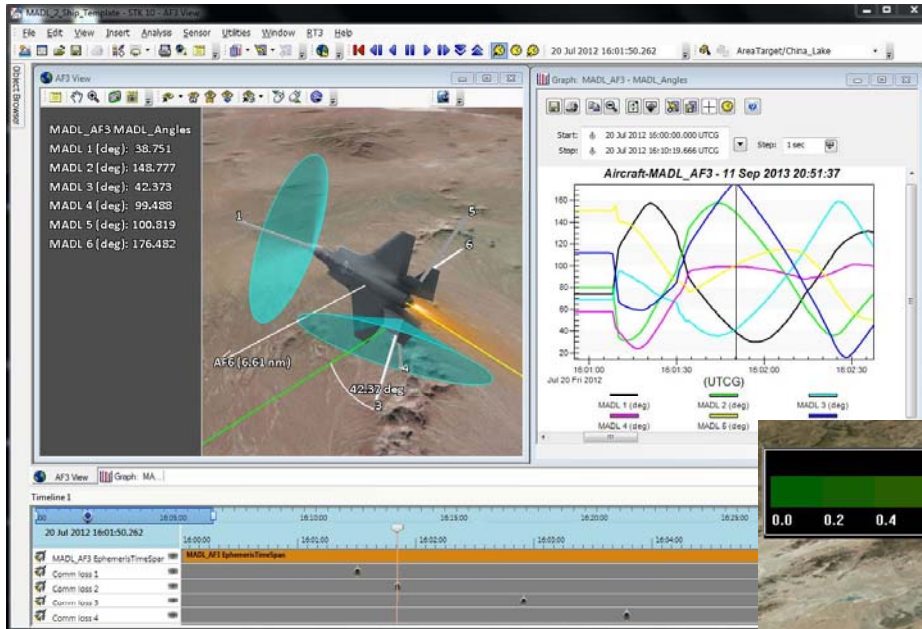
- **How do you do this?**

- **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?)
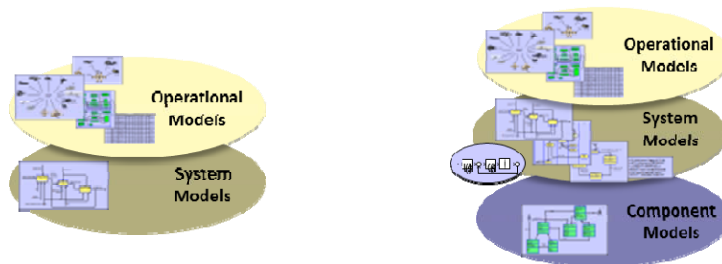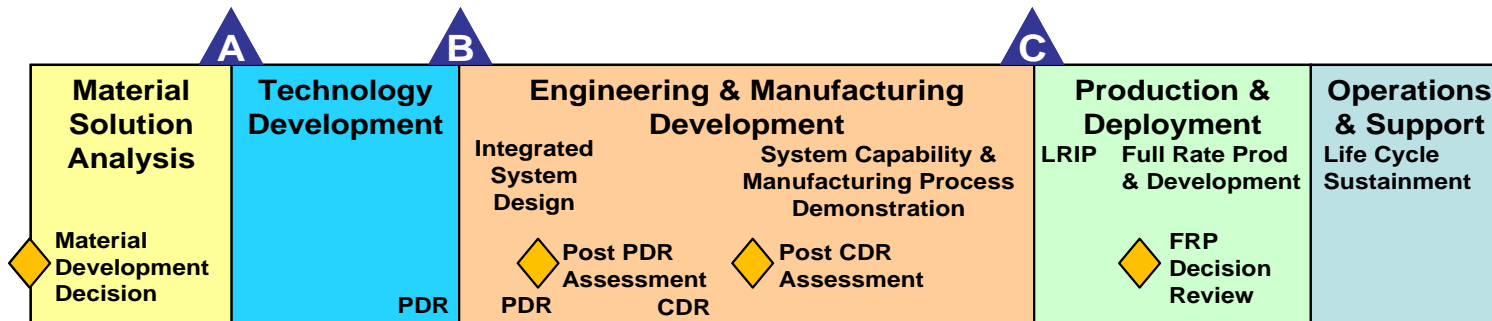
Material Solution Analysis	Technology Development	Engineering & Manufacturing Development		Production & Deployment	Operations & Support
		Integrated System Design	System Capability & Manufacturing Process Demonstration	LRIP Full Rate Prod & Development	Life Cycle Sustainment

A B C

◆ Material Development Decision

PDR

◆ Post PDR Assessment   ◆ Post CDR Assessment

PDR   CDR

◆ FRP Decision Review

Radar   Communications   EOIR   EW   Software

Vehicle Systems   Ground Systems   Emitters

HWIL   Systems Integrations Labs

MBE Initiation & Evolution – (When?)

Material Solution Analysis	Technology Development	Engineering & Manufacturing Development		Production & Deployment	Operations & Support
		Integrated System Design	System Capability & Manufacturing Process Demonstration	LRIP Full Rate Prod & Development	Life Cycle Sustainment

A **B** **C**

◆ Material Development Decision

PDR

◆ Post PDR Assessment
PDR

◆ Post CDR Assessment
CDR

◆ FRP Decision Review

Operational Models
System Models

Operational Models
System Models
Component Models

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
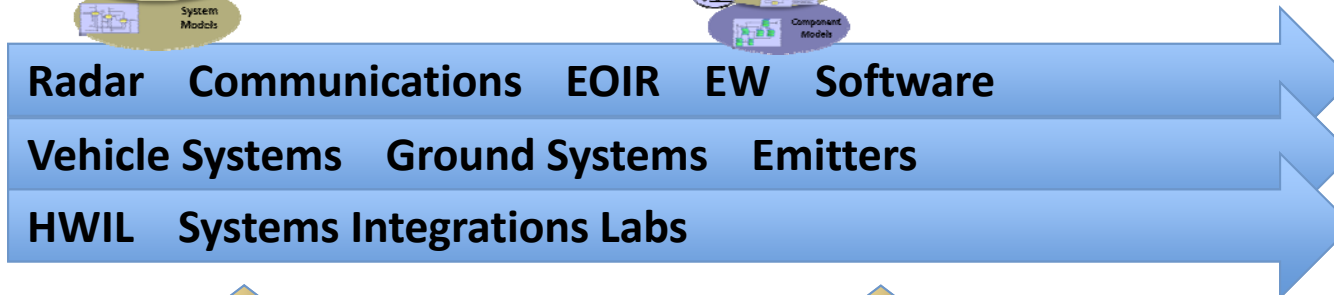
T&E Tool Kit Formulation Example – (How?)

Program Test Requirements

- Air Veh performance description
- Physical 3D model
- sensor attach points
- xmtr and 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

Custom work-flow UIs:
Target scheduling
Comm link assessment
Test points assessment
…

Specifically Configured M&S Tool Set for T&E Execution
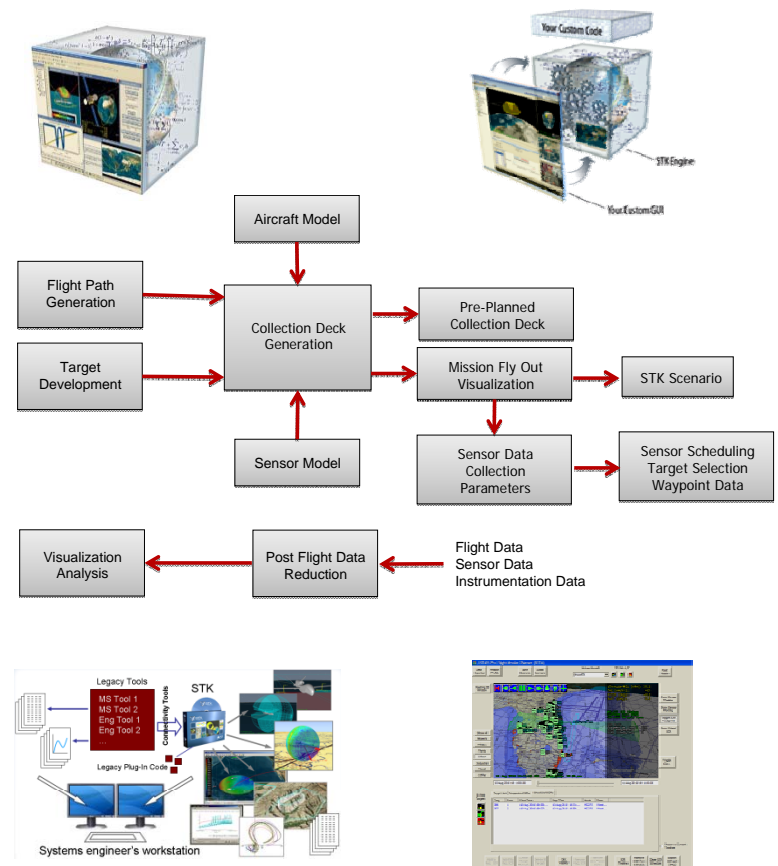
MBE Development for Test Planning
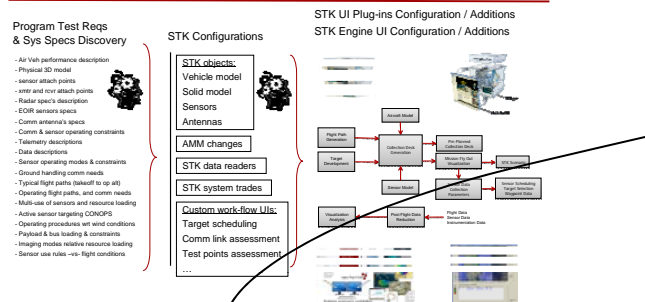
Design/Planning Tool Development

- **STK Configuration**

- **System/Subsystem Characterization**

- **Workflow Specific UI Development**

- **Implementation & Iterative Improvement**

Test Series

Toolset and process Improvement Iterations

People
Tools
Process
Methods
Metrics

Knowledge DB

Summary of Proven ROI Potential – (Why?)

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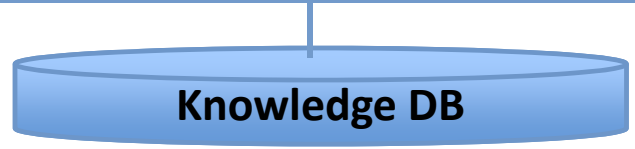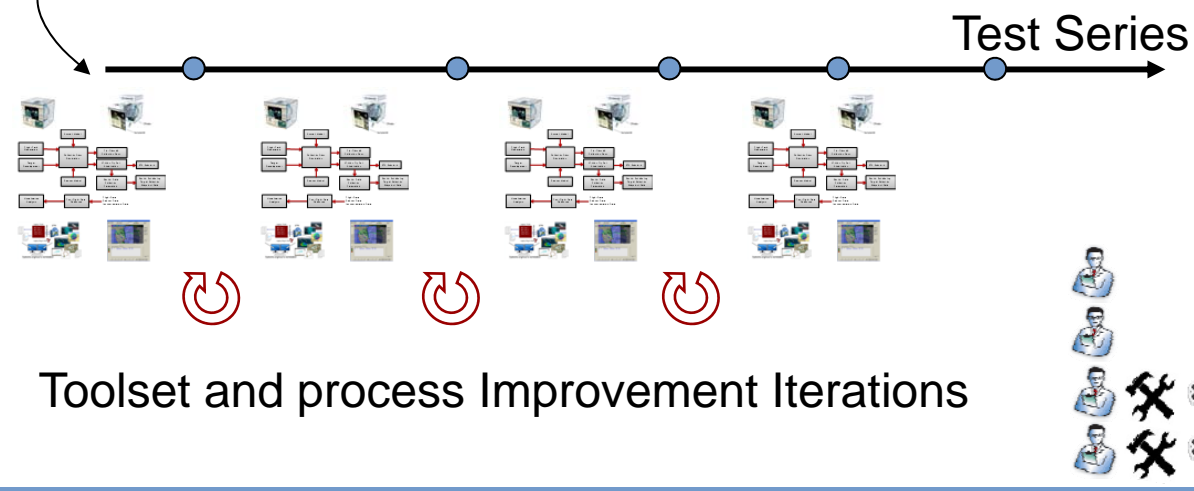 - Reduced time for test-force process elements
    - Test-plan process, test-card development process, post-test process **$$**
  - Shortened and more effective meetings, pre-flight reviews, etc. **$**

- **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

F-35 Flight Testing   - Case Study

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.
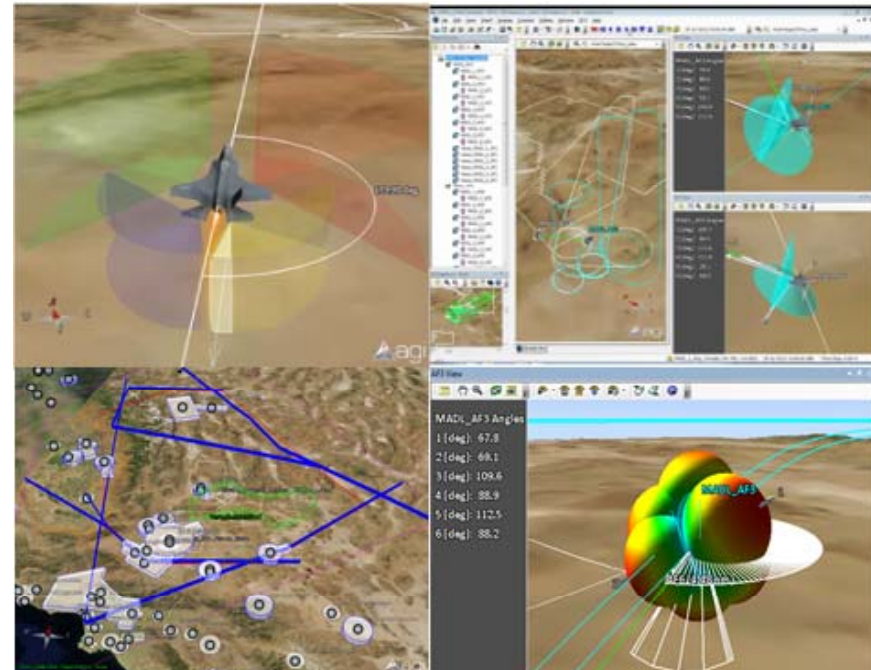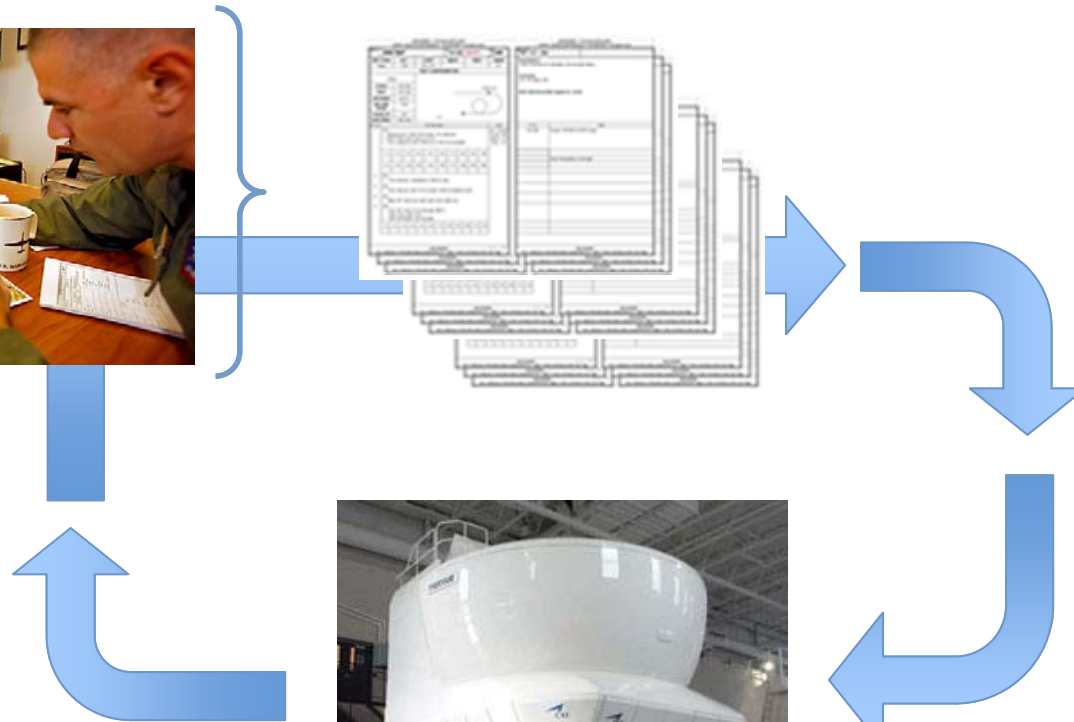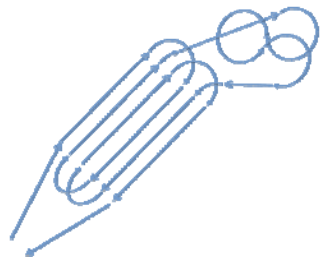

Outcome: Proof-of-Concept demonstrated improved flight test plans, designs and analysis for mission systems testing.

**Accelerated & optimized test planning,
Increased flexibility in test event execution and
Faster post-test analysis**
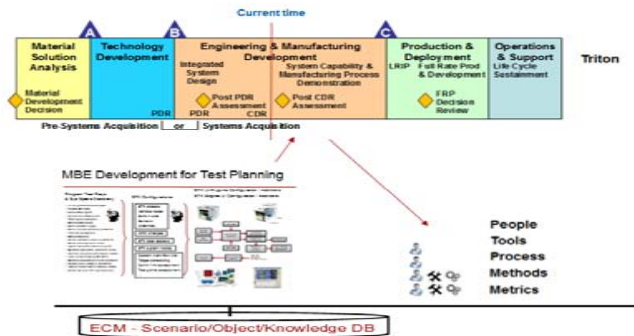
Optimizing Simulator Time – (Why?)

Mission Deck Test Cards

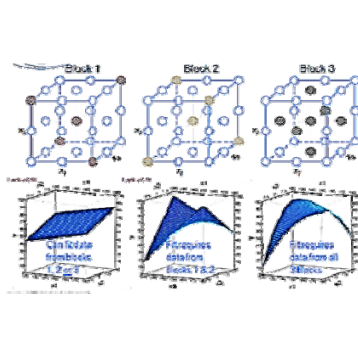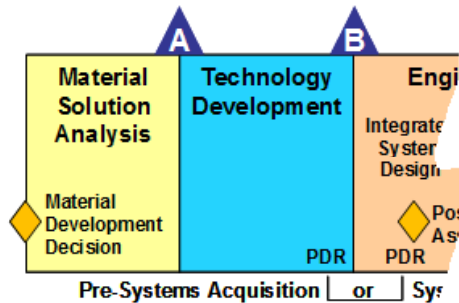# New Metrics Factored into Test Plan Cost & Schedule Forecast – (Why?)

Execution Phase Program

New improved metrics

- Test-points per flight
- Re-flight rate
- Practitioner's efficiency

New Start Program

STAT/DOE yields "right sized" Test Plan

New metrics factored in to 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?