9th Annual NDIA Systems Engineering Conference
October 23-26, 2006, San Diego, CA

Cost Efficient Risk Management through Integrated T&E throughout the Systems Engineering Life-Cycle

Josh Tribble
MILITARY ANALYST
AVW TECHNOLOGIES

Phone: 757-361-9587
E-mail: tribble@avwtech.com
860 Greenbrier Circle, Suite 305
Chesapeake, VA 23320
http://www.avwtech.com

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Agenda

- Introduction
  - Acquisition humor
  - Complexity challenge = increasing risk
  - Intro to Integrated T&E
- Integrated T&E within systems engineering to manage risk
  - Alignment of T&E processes within systems engineering process to identify risks early and often
  - Integration of T&E organizations/processes within iterative systems engineering throughout acquisition life cycle as a key component of risk mitigation
- Enablers to implement IT&E within a program
  - Risk based T&E planning and reporting
  - AVW IT&E Database Toolset
  - Other recommendations for implementing IT&E
- Conclusion/ Q&A

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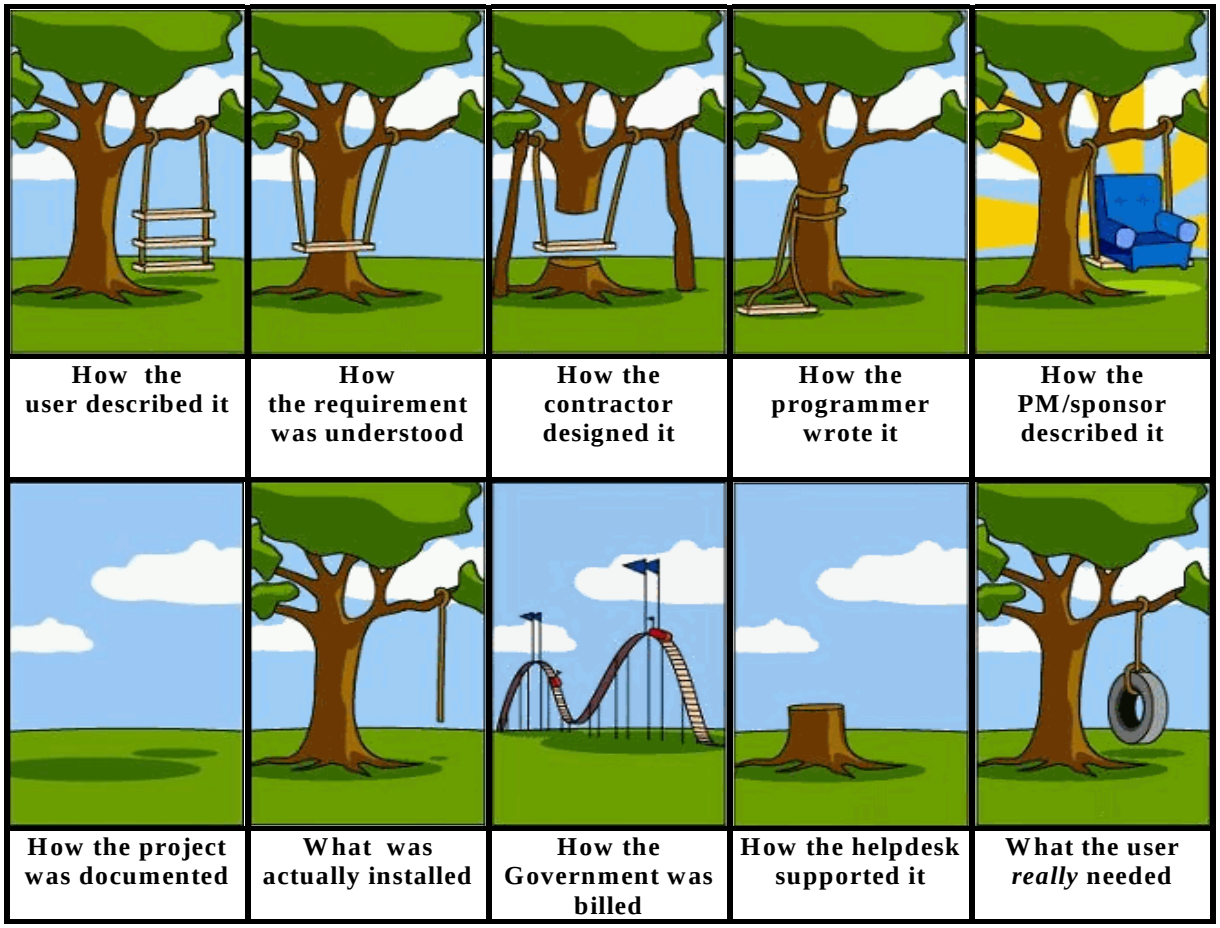
Acquisition 101?



How do we avoid this?

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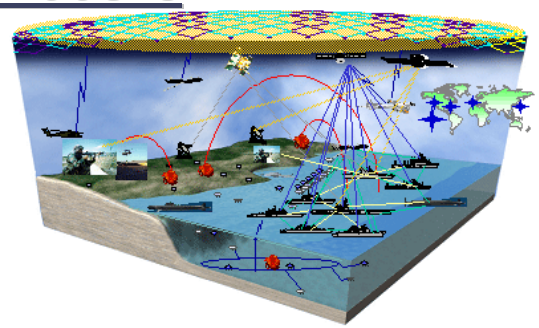
Complexity Challenge

?

- Open Architecture/Systems
- Complex C4I—GIG/FORCEnet
- Joint Interoperability
- Emerging Technology & Materials
- Capabilities Based Requirements
- CAIV

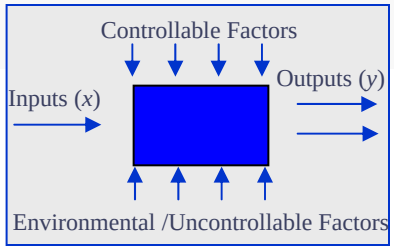
- More difficult to develop
- More difficult to test
- Compressed timelines
- Compressed budgets
- ***MORE RISK…& HIGHER COSTS***



~~DT vs. OT (vs. LFTE, etc..)~~ → IT

DT

- Test to specs.
- Limited test environment perhaps in lab
- Focused on a specific set of criteria.
- Test threshold values not capability
- Critical technical parameters
- Integration testing designed around minimum performance criteria and interface spec.
- May not address all threats or missions.
- CT adds contractual issues



OT

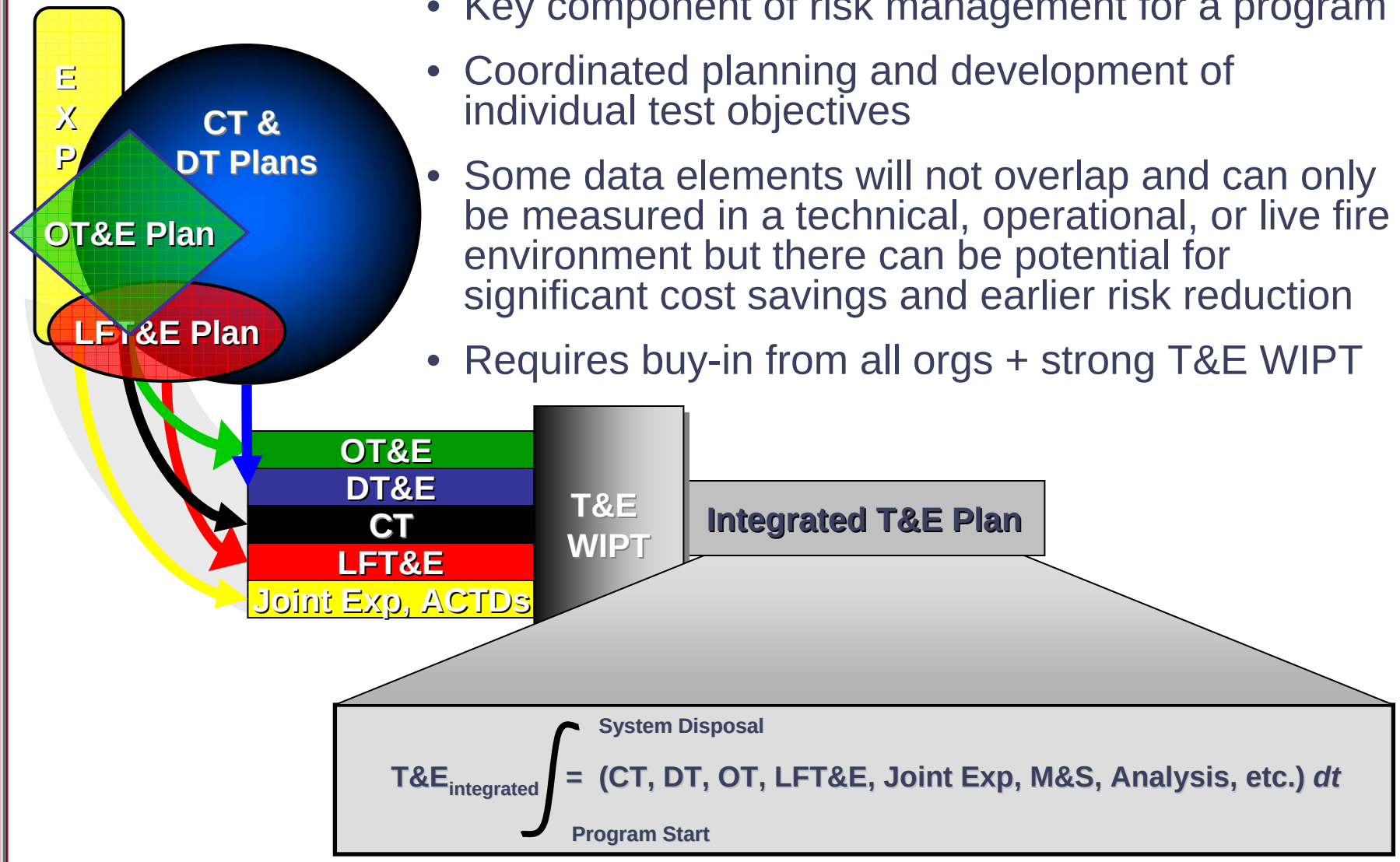
- Operational environment & threat with end users & support
- End-to-end mission perf. & support
- Production representative; system/ family of systems
- Test overall capability of an item to meet user's mission needs and value added for mission accomplishment.
- Test the limitations and capabilities of an item so that:
- Employ and assess doctrine/TTP
- Independent IOT&E & LFT&E mandates (Title X)

THIS MUST TRANSFORM INTO A CONTINUUM OF TESTING

- **Increasing fidelity of technical and operational assessments**
- **Cooperating organizations**
- **Reduced budget and timeline ?**
- **Team/IPT structure not competitive**

Integrated T&E

- Key component of risk management for a program
- Coordinated planning and development of individual test objectives
- Some data elements will not overlap and can only be measured in a technical, operational, or live fire environment but there can be potential for significant cost savings and earlier risk reduction
- Requires buy-in from all orgs + strong T&E WIPT



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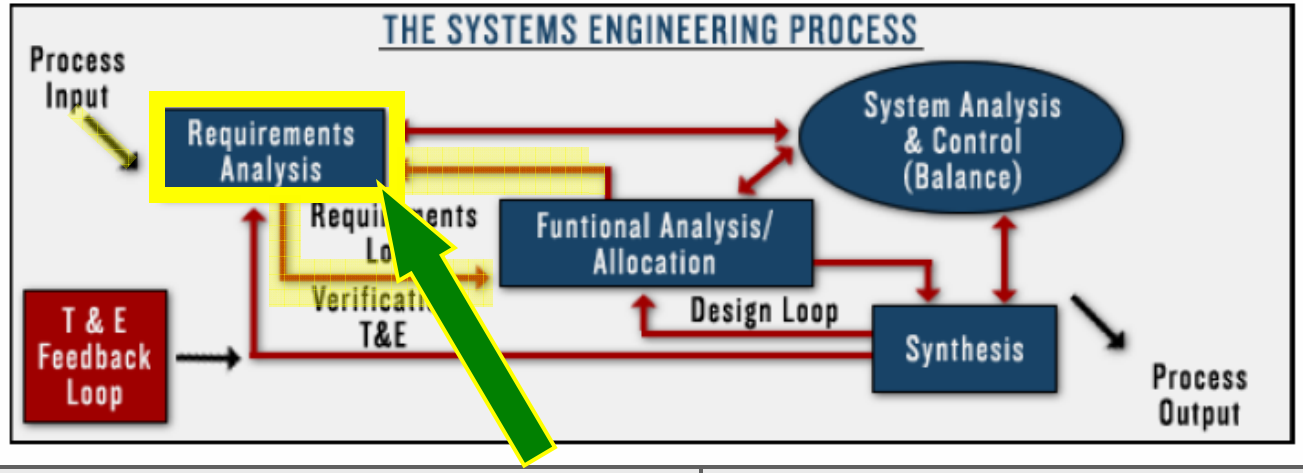
T&E During Sys Eng Tasks



Testers support by influencing:

- Measurable, objective, meaningful reqs
- Reqs context & op scenarios
- Bounding system (technical/operational)
- Assisting mission / functional breakdown
- TPM selection
- Influencing HSI
- Prioritization of reqs (critical / need / want)
- IV&V of reqs flowdown + delivered technical and operational capabilities

T&E is supported by insight into various aspects of project to facilitate efficient test planning:

- Customer expectations
- Project & external constraints (CAIV…) Reqs context and intentions
- Life cycle support planning
- HSI planning/design
- Physical / logical architecture drivers
- Prioritization of requirements

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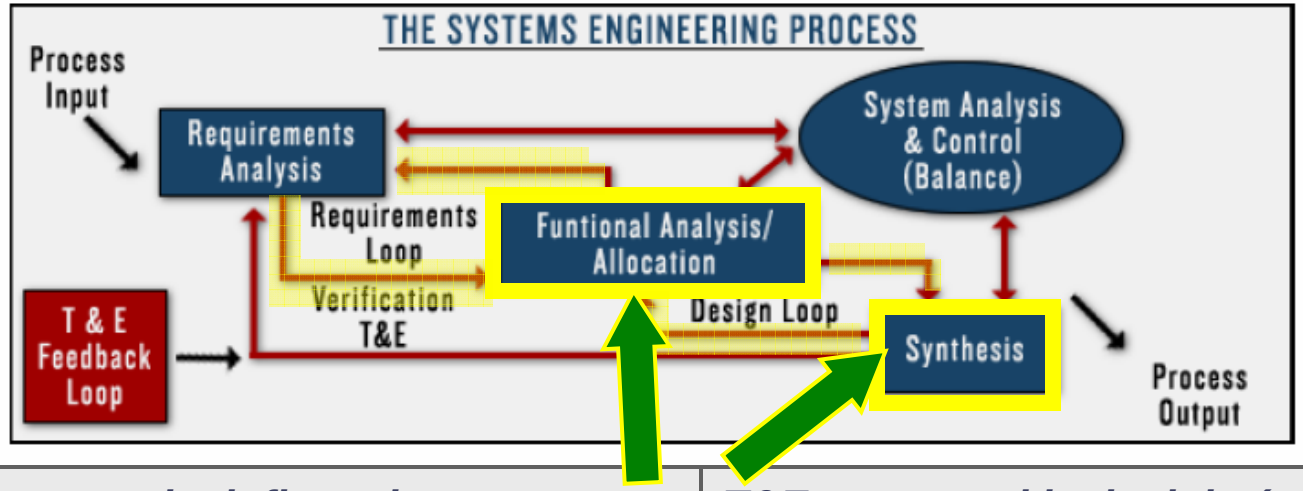
T&E During Sys Eng Tasks (Cont')



Testers support by influencing:

- Consistency in reqs/functional flowdown based on original intentions and op context
- Influencing HSI in detailed design including user reviews of HCI & functionality
- Verification of requirements implementation through limited component level tests
- Interface definition
- Prioritization of lower level requirements
- IV&V of reqs flowdown + delivered technical and operational capabilities
- M&S planning/development

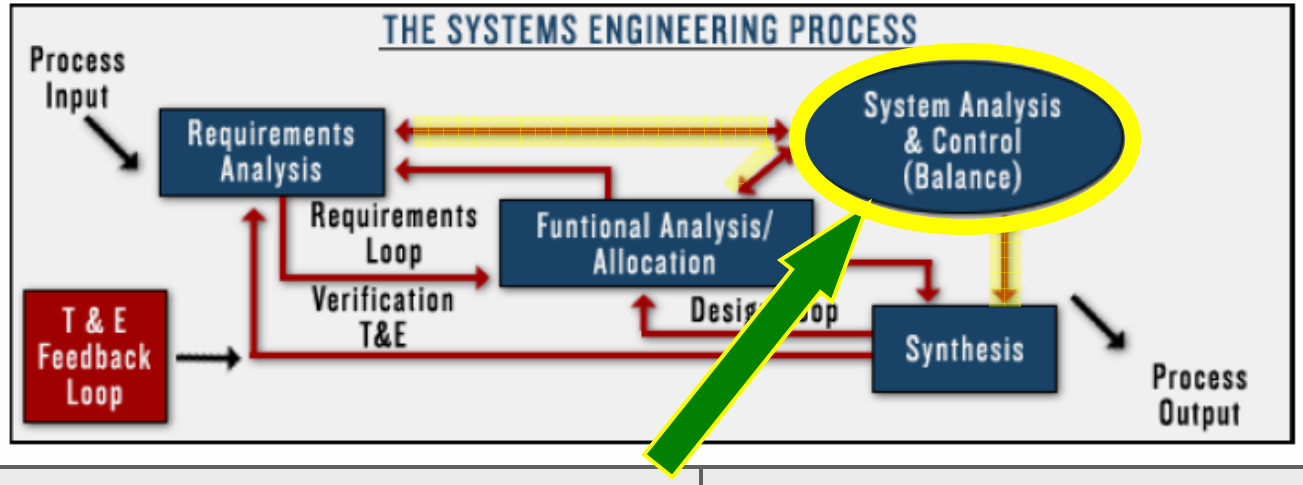
T&E supported by insight (which improves test planning efficiency) into:

- Detailed reqs flowdown and prioritization
- Detailed life cycle support planning
- HSI planning/design
- Detailed architecture drivers

& early collection of evaluation data:

- Life cycle planning
- HSI design implementation
- Software eng. process assessment
- M&S V&V
- SCI/Component & interface test data

T&E During Sys Eng Tasks (Cont')



Testers support by influencing:

- M&S analysis planning
- Monitoring M&S development
- Assisting in M&S analysis execution
- Independent evaluation of analysis results
- Evaluation of systems and software engineering process/process improvement
- Independent review of risk management and input of T&E issues as new/updated risks
- Objective TPM tracking
- Design for safety, life-cycle, interoperability, & survivability (instead of merely testing)

T&E is supported by insight into:

- Capabilities and limitations from analysis that points to need for live testing
- Pre and post-test predictions
- Test design and noise factors selection (design of experiments), sensitivity studies
- System & component trade-offs

& collection of evaluation data:

- Analytical and M&S based evaluation of system performance
- M&S V&V

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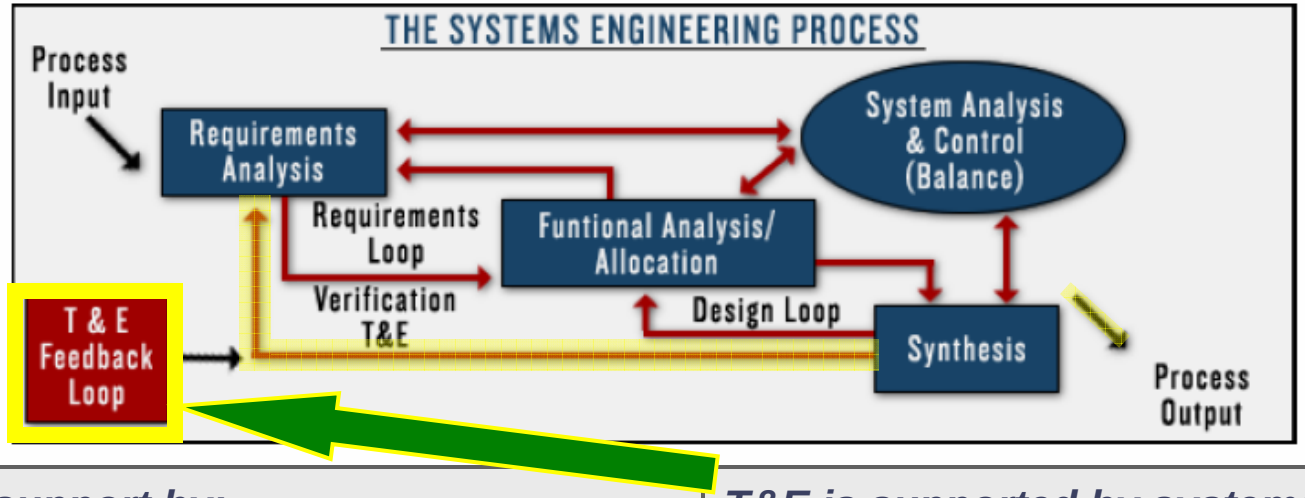
T&E During Sys Eng Tasks (Cont')



Testers support by:

- Planning and executing tests to verify requirements and validate functions and mission capabilities
- Giving engineers insight into performance of system
- Independent internal and external agencies evaluation of the system

[traditional T&E – with greater participation from systems engineers & increased use of standard engineering methodology for planning efficient tests

T&E is supported by systems engineers:

- Interpretation of technical results
- Determining impacts on HSI, life-cycle planning, IA, etc.
- Categorization of issues and problems

T&E supports accurate decision making:

- Proceeding with output to next acquisition phase, or
- Proceeding to next phase of testing, or
- Repeat of previous tasks while holding at this point in the acquisition cycle

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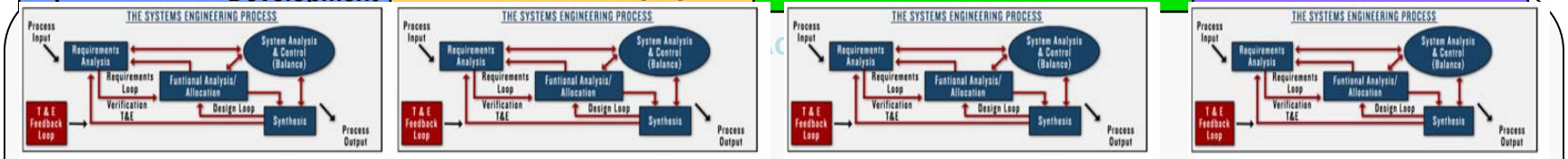
Systems Engineering + T&E
within the Acquisition Cycle

A | B (Program Initiation) | C | IOC | FOC

Concept & Technology Development	System Development & Demonstration	Production & Deployment	Operations & Support
Concept Exploration / Technology Development	Critical Design Review	LRIP/OT&E / FRP Decision Review	

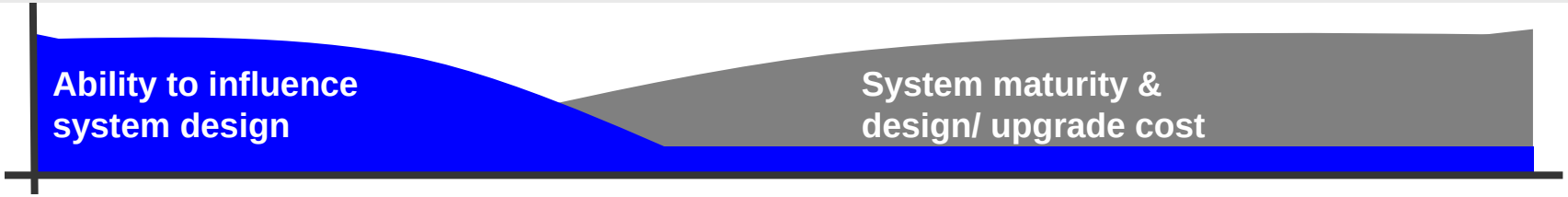


•Requirements te •Concept studies •CONOPS devel •Mission/Functio •Joint Experimentation/	•Technology Feasibility •EDM DT •Design Revie •EOA •M&S	•Detailed Desig •Design OA •Detailed CON •User reviews •TTP developn •Trade studies	•Lab/Land Based Te •Limited field/at-sea •Testbed/surrogate L •Supportability analy •RAM analysis & test •Certification proces	•Production Readiness R •Detailed CONOPS •Production H/W, S/W re •Detailed TTP review/ref •Production in-process re w/ users & verification te	•Federated Simulation Tes •Production acceptance + validation DT & OT •HSI, Manpower, Personn •System LFT&E & Shock •Final Independent Logistic	•TTP refinement •Software/System prob characterization & trac •Upgrade/ P3I / spiral development requirem analysis	•Testing software upgrades •M&S/DT/FOT&E for system fixes / upgrades / new increments •RAM & supportability data collection •Additional LFT&E/shock qual

MORE THAN TESTING ... CONTINUOUS EVALUATION

RISK MANAGEMENT… → **MISSION CAPABILITY DELIVERY…**

INTEGRATED T&E & SYSTEMS ENGINEERING



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Systems Engineering + T&E
within the Acquisition Cycle

A | B (Program Initiation) | C | IOC | FOC

Concept & Technology Development

Concept Exploration | **Technology Development**

System Development & Demonstration

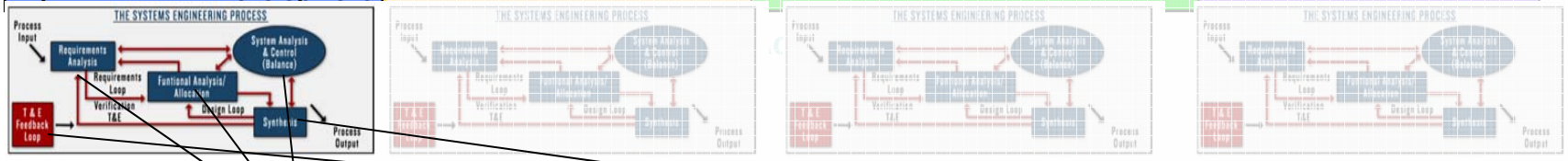
Critical Design Review

Production & Deployment

LRIP/OT&E

FRP Decision Review

Operations & Support



T&E ACTIVITIES DURING C&TD PHASE	•Requirements testability review •Concept studies and analysis •CONOPS development •Mission/Functional analysis •Joint Experimentation/ACTD/ATD	•Technology Feasibility •EDM DT •Design Reviews •EOA •M&S	***Testers & engineers not involved enough in this phase***

RISK MANAGEMENT…

MISSION CAPABILITY DELIVERY…

INTEGRATED T&E & SYSTEMS ENGINEERING

Ability to influence system design

System maturity & design/ upgrade cost

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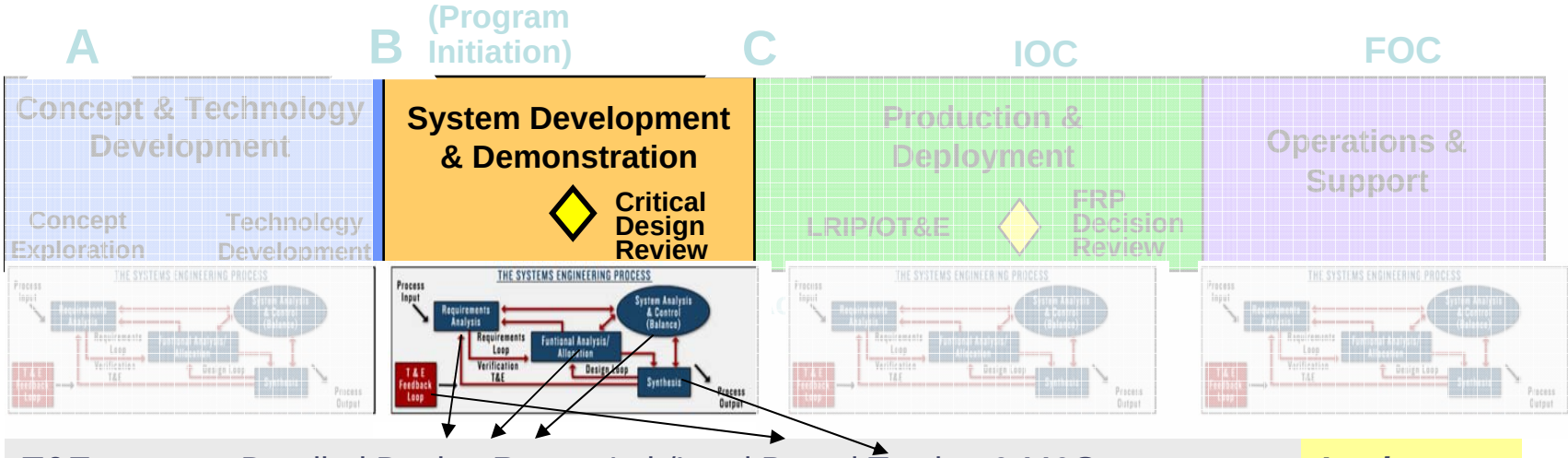
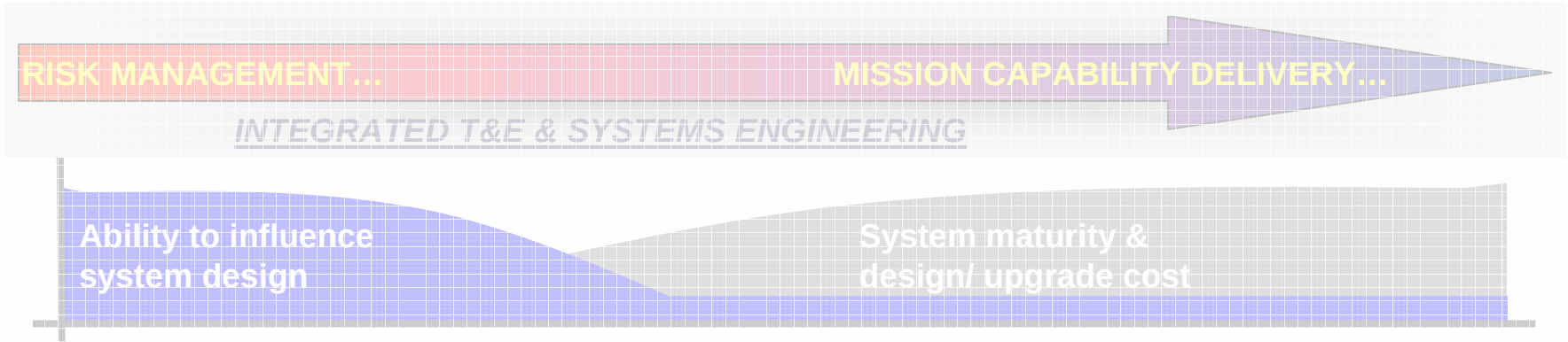
Systems Engineering + T&E within the Acquisition Cycle



T&E ACTIVITIES DURING SDD PHASE	•Detailed Design Rvw •Design OA •Detailed CONOPS •User reviews •TTP development •Trade studies	•Lab/Land Based Testing & M&S •Limited field/at-sea testing & usability testing •Testbed/surrogate LFT&E •Supportability analysis/ initial logistics audit •RAM analysis & testing (reliability growth) •Certification process	***Inadequate linkage to C&TD mission and reqs analyses***



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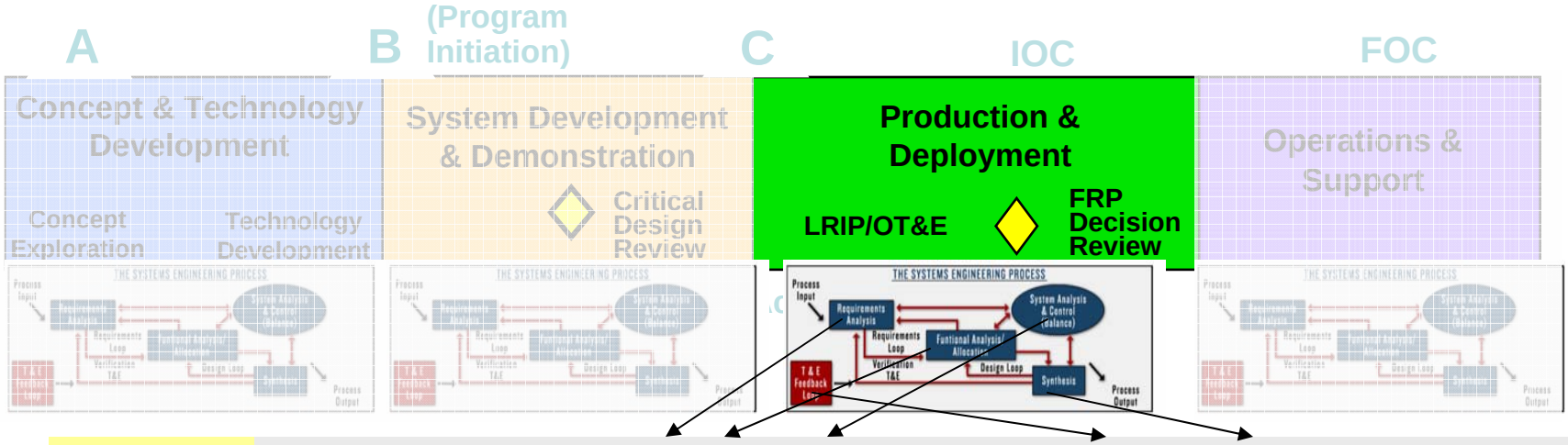
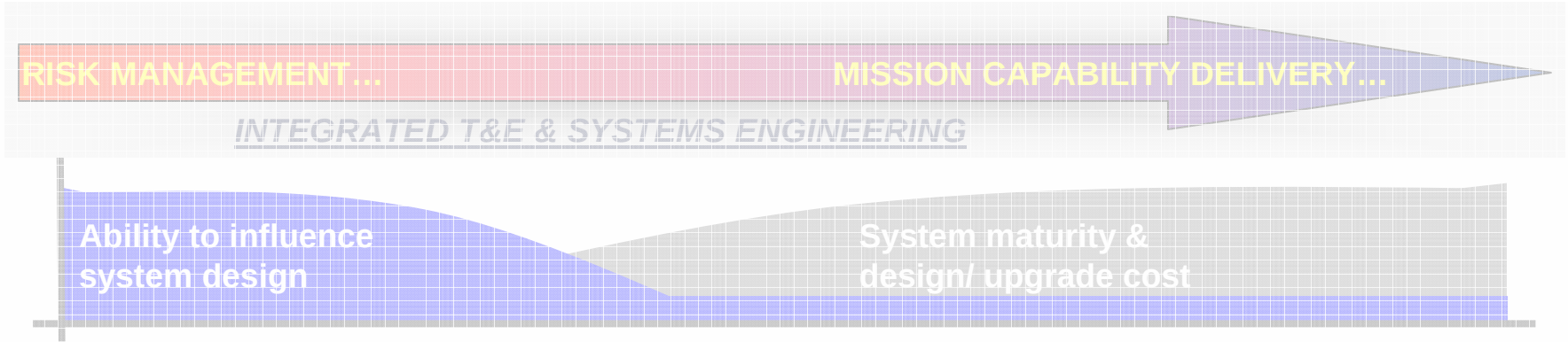
Systems Engineering + T&E within the Acquisition Cycle



Need to push as much of this to the left as possible	**T&E ACTIVITIES DURING P&D PHASE**	•Production Readiness Reviews •Detailed CONOPS •Production H/W, S/W review •Detailed TTP review/refinement •Production in-process review w/ users & verification team	•Federated Simulation Testbed •Production acceptance + mission validation DT/TECHEVAL and IOT&E •HSI, Manpower, Personnel, Trng Eval •System LFT&E & Shock Qual •Final Independent Logistics Audit



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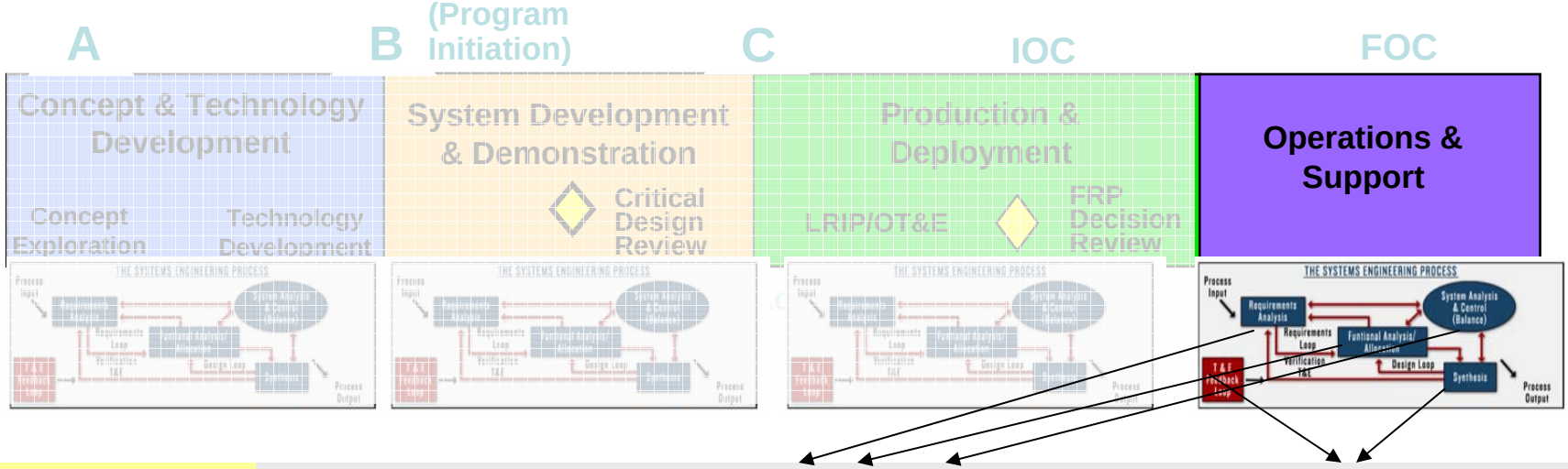
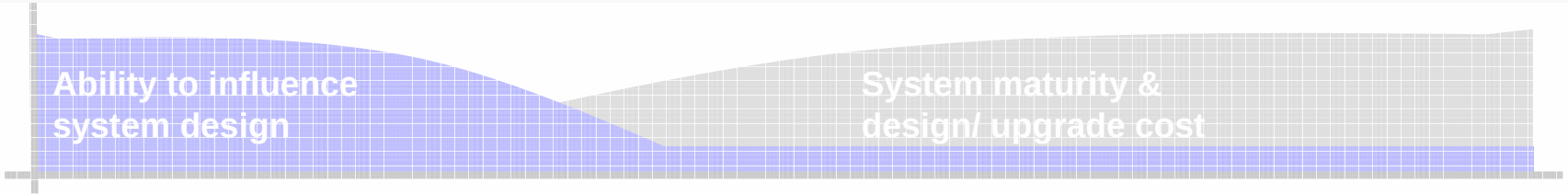
Systems Engineering + T&E within the Acquisition Cycle



Upgrades/ increments need better tie to req capability & tech maturity	**T&E ACTIVITIES DURING O&S PHASE**	•TTP refinement •Software/System problem characterization & tracking •Upgrade/ P3I / spiral development requirements analysis	•Testing software upgrades •M&S/DT/FOT&E for system fixes / upgrades / new increments •RAM & supportability data collection •Additional LFT&E/shock qual

RISK MANAGEMENT… MISSION CAPABILITY DELIVERY…

INTEGRATED T&E & SYSTEMS ENGINEERING



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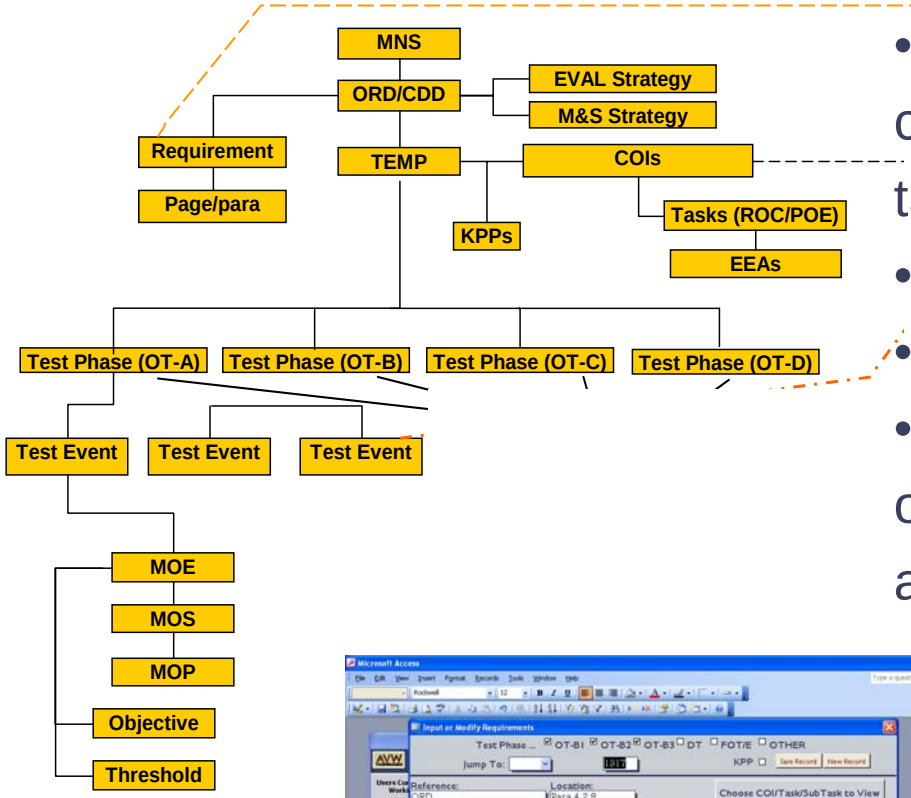
Enablers to implement in IT&E for risk-management

- Actually implementing a process for IT&E with adequate buy-in is the first step
- Use software tools to step through planning and reporting processes and document IT&E
- Implement risk based test planning and reporting
- Other recommendations to follow…

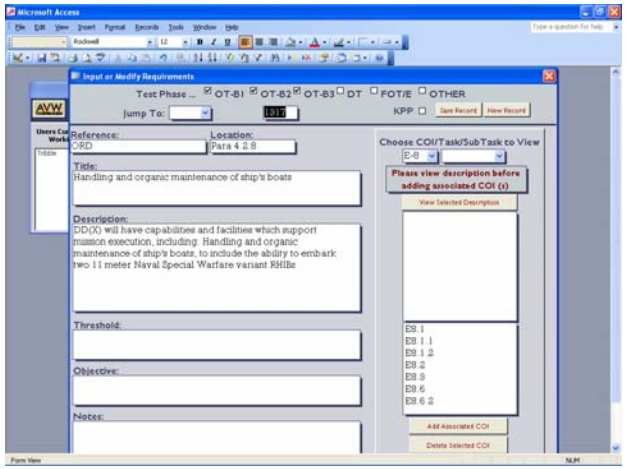
AVW IT&E Database Toolset Architecture

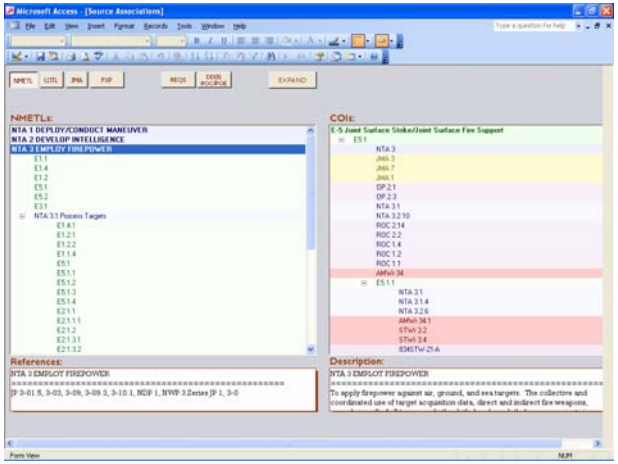
Test Event Lessons Learned

AVW IT&E Database Capabilities

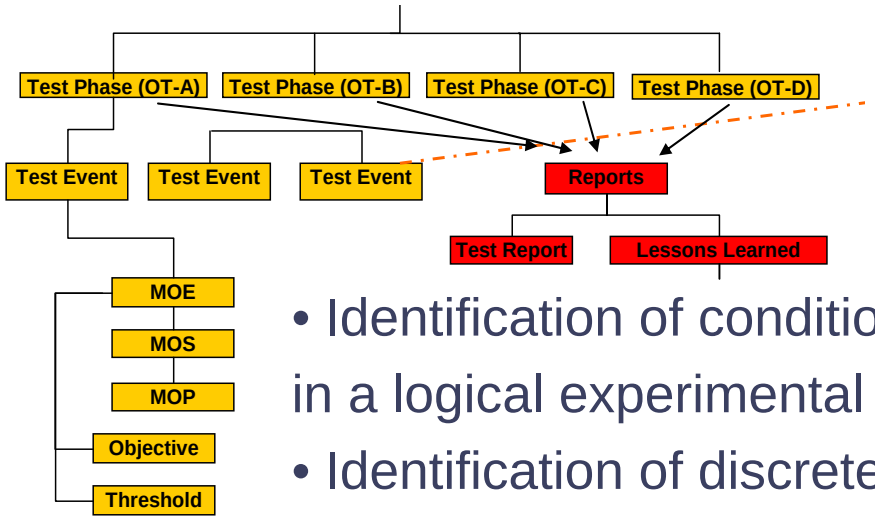


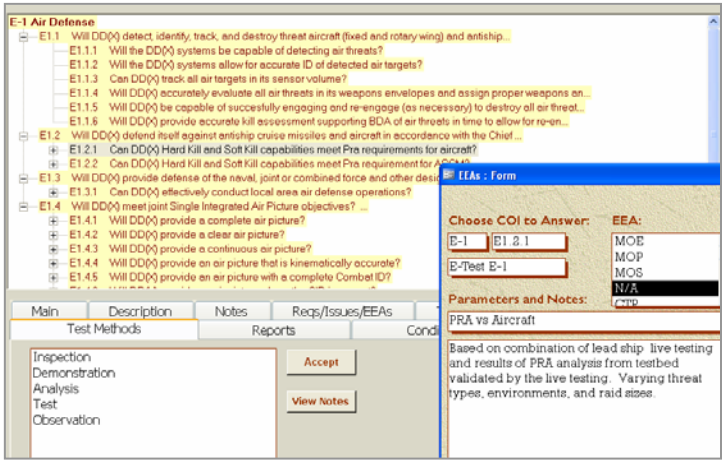
- Review of requirements, capabilities, operational/mission tasks, and functional tasks
- Development of COIs/CTPs
- Determining MOE/MOS/MOP
- Traceability between test objectives and their measures with annotated requirements/references





AVW IT&E Database Capabilities

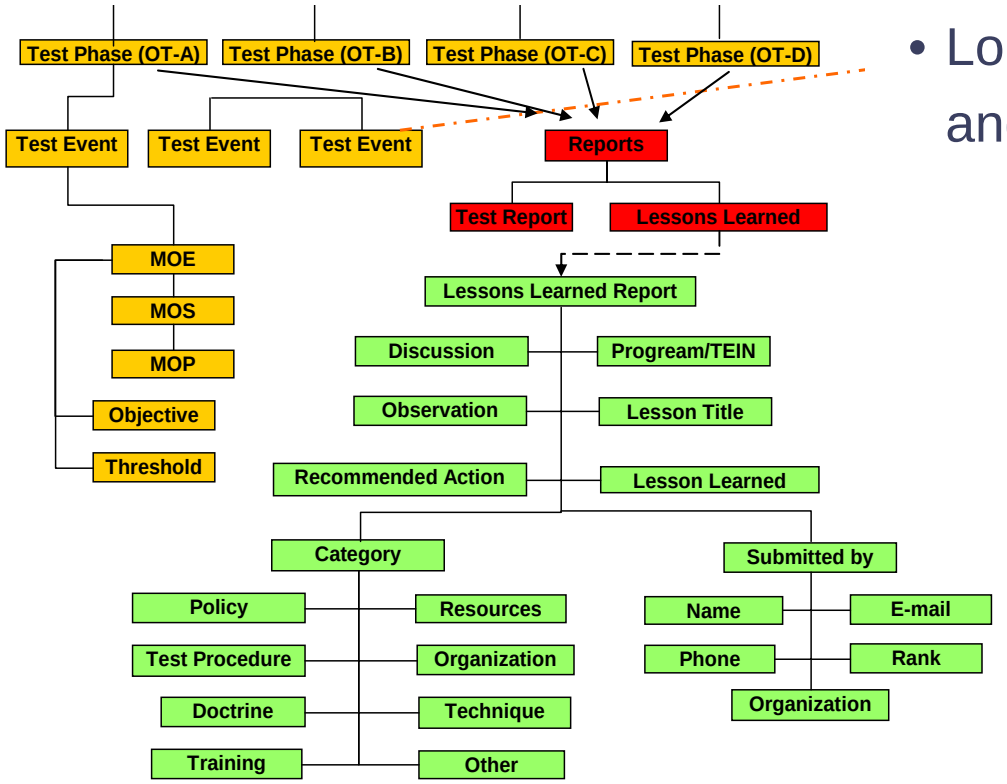


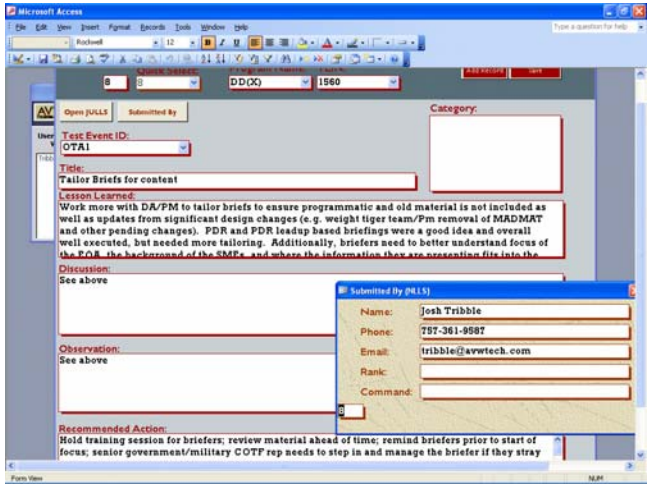


- Identification of conditions for development of test matrices in a logical experimental design
- Identification of discrete data elements and requirements for a given test objective linked to various test events/scenarios
- Resource and cost estimation to support TEMP, budget programming, test planning, and other efforts including ties for each resource to test objectives.

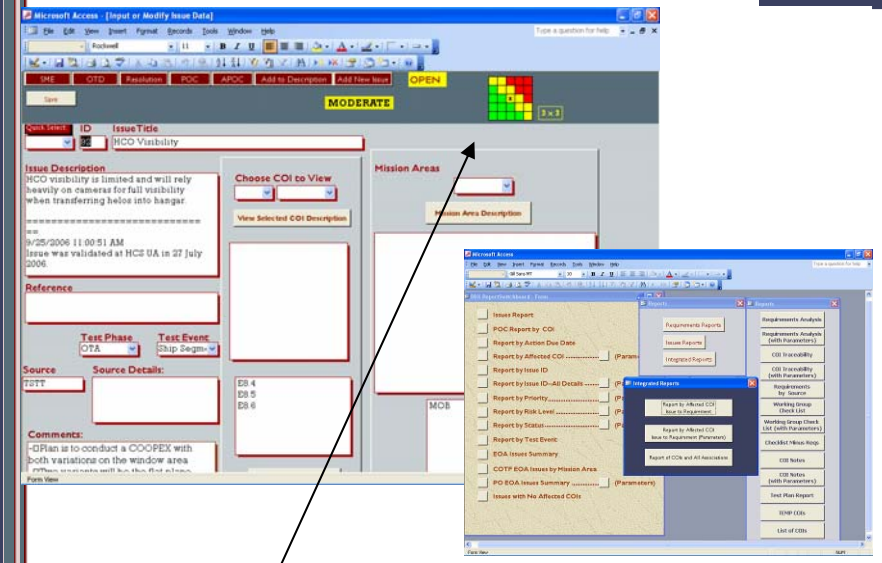
AVW IT&E Database Capabilities

- Rapid test reporting
- Lessons learned tracking in standard Joint/Service Lessons Learned formats
- Long term archiving of test results and program status

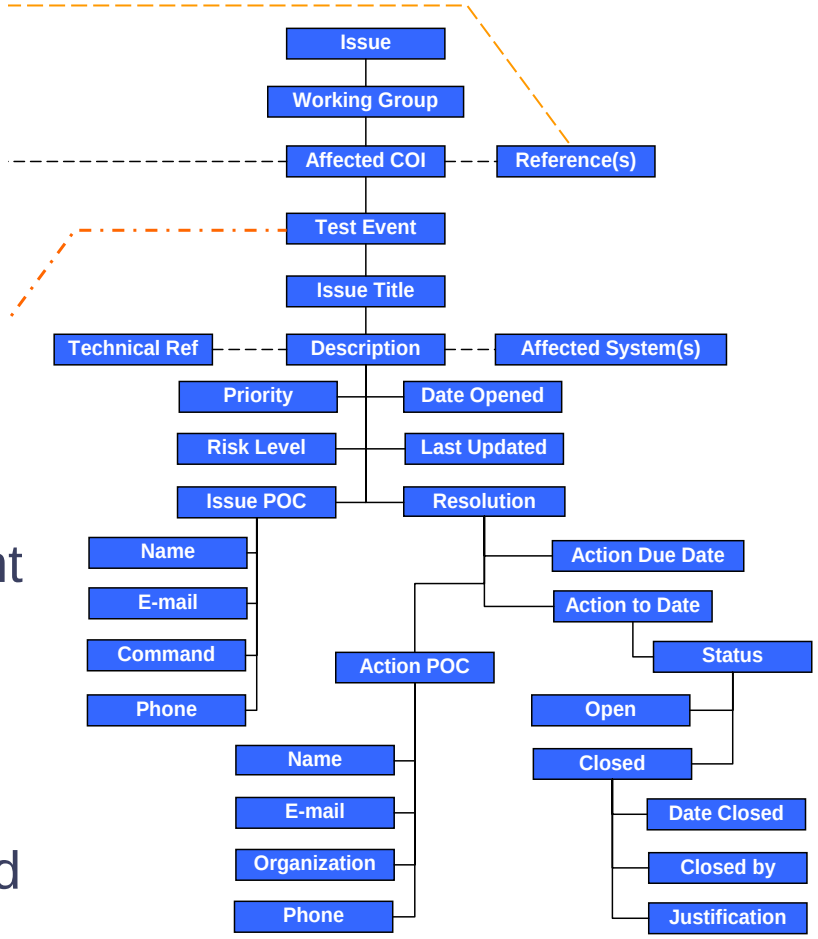




AVW IT&E Database Capabilities



- Traceability of test results to test event to objectives to parent requirements
- Risk based issue assessment
- Rapid reporting of issues
- Long term archiving of test results and program status
- User tailored reports to assess risks by function, mission area, system, req., etc.



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Risk Based Test *Planning & Resourcing*

Probability of Occurrence / Consequence	5	4	3	2	1
A – Frequently occurs during tests/operations (prob ~ 1.0)	II	II	I	I	I
B – Probably will occur during tests/operations	II	II	II	I	I
C – Occasionally may occur during tests/operations (prob ~ 0.5)	III	II	II	II	I
D – Remote chance to occur during tests/operations	III	III	II	II	II
E – Not likely to occur during tests/operations (prob ~ 0)	III	III	III	II	II

Consequence Levels:

1: prevents accomplishment of primary mission or presents a serious safety hazard
2: sig pri mission degradation w/o a work-around, secondary mission failure, or mod safety hazard
3: major secondary mission degradation w/o work-around; pri mission degradation w/ work-around
4: minor degradation/impact to primary and secondary missions
5: no impact to mission but operator annoyance or recommended enhancement

Risk Levels:

I: High Risk – The spec/req/capability req significant CT, some independent DT and OT; highest pri for resource allocation; more test runs/ conditions permutations than other tests; most scrutiny required before integrating tests

II: Moderate Risk – Requires some dedicated DT and OT; medium resource priority; less scrutiny before integrated tests completely

III: Low/Manageable Risk – Little to no independence between CT, DT, OT, and LFT&E req; strong candidate for fully leveraging a small set of integrated tests for all data; lowest priority for resource allocation.

This supports TEMP test event and resource allocation + detailed test planning; removes much of subjectivity surrounding allocation of scarce testing funding.

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Risk Based Test *Reporting*

Probability of Occurrence / Consequence	5	4	3	2	1
A – Frequently occurs during tests/operations (prob ~ 1.0)	II	II	I	I	I
B – Probably will occur during tests/operations	II	II	II	I	I
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5: no impact to mission but operator annoyance or recommended enhancement

Risk Levels:

I: High Risk – resolve prior to fielding & conduct major re-test of mission area prior to fielding with the most resources applied

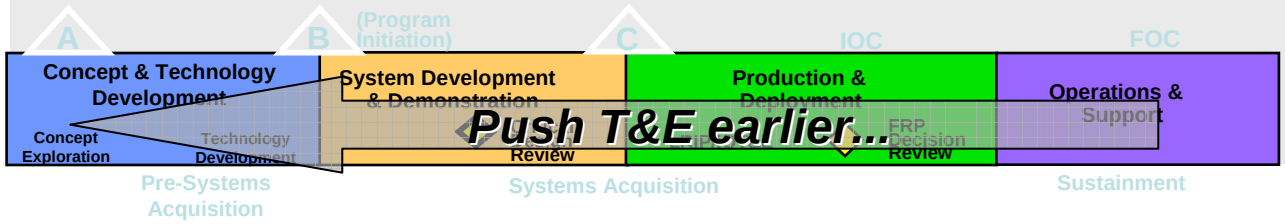
II: Moderate Risk – resolve prior to fielding and re-test the specific requirement as soon as possible (depending on the requirement, re-test may be allowed to be conducted during follow-on T&E after fielding); apply moderate amount of resources to re-test

III: Low/Manageable Risk – resolve when possible but does not impact fielding; re-test at next available previously planned test event; lowest prioritization for test resources

This could be tied directly to risk register and supports reporting of CT, DT, OT, LFT&E, M&S Runs, or any other analysis or test

Additional Recommendations

- Fully implement IT&E top-down and institutionalize with PEO/PM orgs
- closer align T&E Strategy/TEMP, Systems Engineering Management Plan, and Acquisition Strategy
- Maximize test data and usage of that data across test programs and fully align results to the program's risk registry
- Conduct assessment and testing as early as possible and with all organizations to support risk mitigation
- More test objective to requirements traceability in the TEMP
- Service T&E reorganize to Enterprise business model to drive IT&E plus alignment with JT&E, DOT&E



Additional Recommendations (cont')

- Implement more systems engineering rigor across T&E
- Collect metrics on early risk mitigation efforts of T&E
- Develop and field in consolidated baselines to reduce testing, integrate across programs not just within
- Stress to threats and operating environments early and often
- Change T&E score-card to a risk assessment vs. capabilities; continuous feedback throughout tests; foster more cooperation including leveraging JT&E, Experimentation, Training Exercises
- Increase PM focus on life cycle, HSI, other factors beyond technical mission performance
- Coordinate use of standard statistical methodology for T&E including DOE, Lean 6 Sigma, etc.

(See paper from 2005 conference for discussion)

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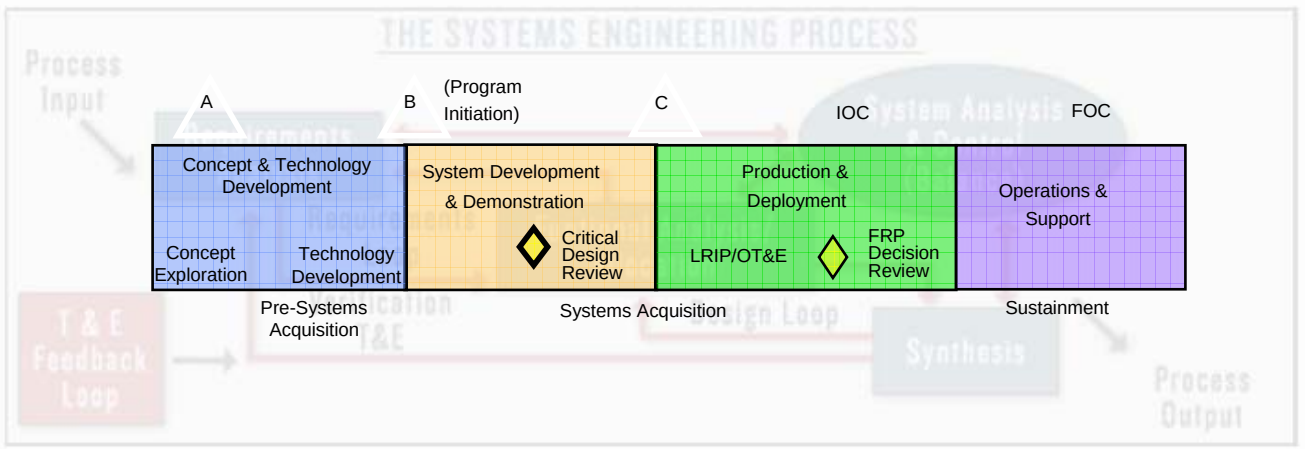
Conclusion



Questions?

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Backups

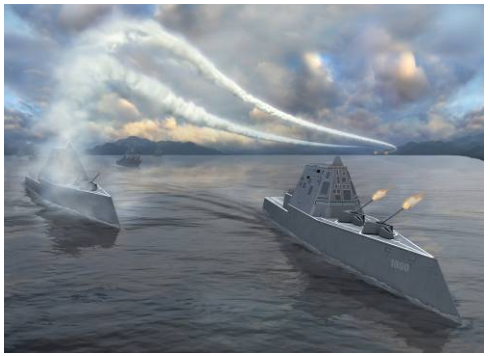
Author Bio

- Former Naval office
  - Active Duty: Surface Warfare Officer
    - Tomahawk, Aegis warfare experience + HM&E
    - COMOPTEVFOR Operational Test Director for land attack warfare systems
  - Reserve: OIC of Navy Reserve Embarked Security Det
- Current AVW experience
  - LPD-17 air defense (P_{RA}) M&S management
  - Amphibious ship combat systems T&E
  - Joint Maritime Assault Connector JCIDS analysis
  - Current project: DD(X) OT&E support focusing on IOT&E planning, OA execution, M&S, and total ship test management

~6 years acquisition experience focusing on T&E and systems engineering

Josh Tribble
Military Analyst

Phone: 757-361-9587
E-mail: tribble@avwtech.com
860 Greenbrier Circle, Suite 305
Chesapeake, VA 23320
http://www.avwtech.com



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Company Profile

Professional Engineering Services

ORD, ICD, CDD, TEMP, Systems Engineering, Systems Integration, M&S Management

Test and Evaluation Support

TEMP, DT/OT, Test Management, Test Plans, Execution, Data Collection, Analysis

Shipbuilder Engineering Management Consulting

Systems Engineering, Systems Integration, M&S Management

Contract Vehicles:

Obtained GSA PES schedule CY04
NAVSEA MAC member thru JJMA and CSC
NAVSEA Seaport

Corporate Highlights:

Total Ship / System of Systems Focus
Expeditionary Warfare Expertise
Mission Focused Systems Engineering and Analysis
Matrix support leverage full corporate capabilities
35 military analysts and IT/admin support
Small veteran owned business since 2002
Headquarters in Chesapeake, VA

INNOVATIVE SOLUTIONS TO THE CHALLENGES OF THE FUTURE