Beyond T&E

Is that system still Fit For Purpose?

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Educe llc

Presentation to
Enchantment Chapter, INCOSE
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Certified for Public Release.

You don't know Jack ?

- 1955 – Present.
- Proctor: College Physics Lab
- System Test & Evaluation (Atlas ICBM Radio Guidance System) → System Engineering (State-determined → Stochastic → Non-deterministic Systems).
- Inaugural chair, GE-wide workshop on Software Engineering
- More than 50 systems, most including humans as active components. Involved Newbies, Crossovers, Remedial cases, Geniuses and wonderful Mentors.
- GE 20, Honeywell 10, Edelbrock 3, Ascent Logic 2, IBM OTP 1.
- Tutorials, Papers and Panels; INCOSE, INCOSE IL, ITEA, ICSEng, ISSS, IEEE SMC, IEEE SysCon, NIST.
- Co-chair, INCOSE WG's for
  - Intelligent Enterprises, 2002-2007
  - Motor Sports as learning environment, 2008 –
  - Autonomous Systems T&E, 2009 -
- Kennen Technologies LLC, OntoPilot LLC, Educe LLC.

1960 -- Real-time Range Safety

MOE = P(injuring indigenous native) < 10^{-9}

Measure Range, Azimuth, Elevation, Udot, Vdot, Wdot @ 20/sec

Apply corrections, e.g. refraction

Predict impact if thrust continues t+0.05 seconds

Predict uncertainty of Impact prediction (size of red ellipse)

? Issue abort command?

> 250 launches of Atlas, Titan, Minuteman I & II
@ ZERO DEFECTS.

Example F4P ConOps

Operators e.g., Warfighters

1

Problematic Situation

2

Effects Capabilities MOE's

3

Operational System Engineering

4

Application Knowledge Base

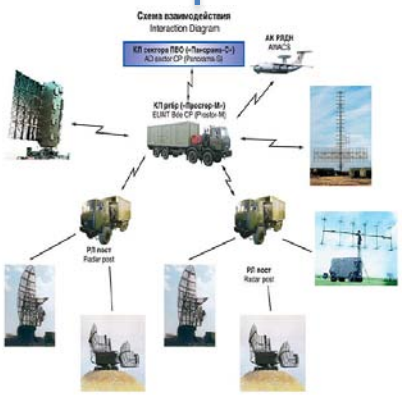
Acquisition Phase

Inventory of Components

5

System Realization & Resilience

6



F4P?

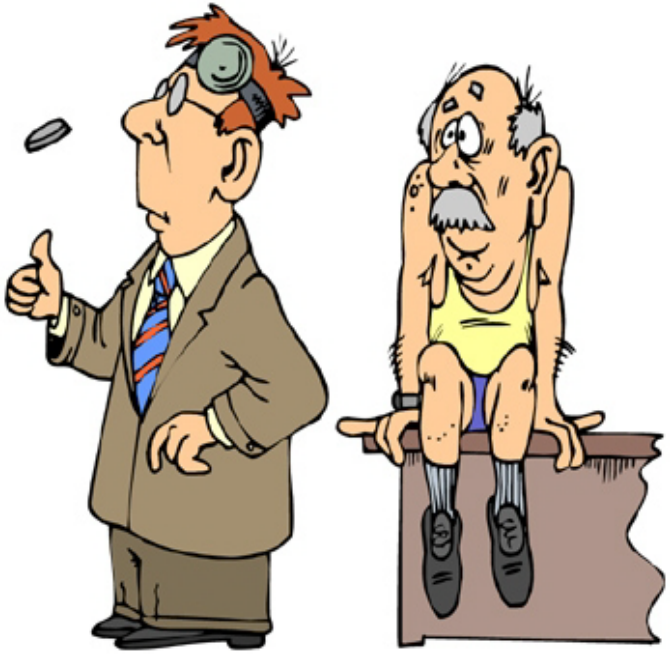
N

Y

7

Anticipated Engagement

System Operators Deserve To Know



Is This System *Still* F4P?

POSIWID: the purpose of a system is what it does, regardless of designer or operator intent.

F4P is not Proof of Correctness, IV&V, or Live, Virtual, Constructive

The Mean Time to Configuration Change of a brigade-scale system or $ billion/yr. industrial supply chain may be < 15 minutes.

Current T&E Shortfalls

Goal: Sufficient user knowledge and trust regarding the dynamic and integrity limits of multi-node networks of heterogeneous, autonomous systems.

Status: The T&E we know, teach and practice a) Finds only errors, not all faults, not limits. b) Is 10X – 100X too expensive and time consuming

Talent: T&E community competencies have dwindled toward instrumentation and data technicians, e.g., which of you are fluent in Design of Experiments? Scenario Generation? Mission Effects Evaluation? Data Visualization?

Remediation: The current recipes for system engineering and system of systems engineering do not provide for adequate, accurate and timely T&E and Fit For Purpose Readiness Assessment.

Our Opportunity ---
10X Better, Faster, Cheaper

Fit 4 Purpose
Effects, Modes, Limits

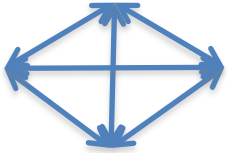
Design of Experiments

Test System
Design/Architect

Test Readiness
(Preclude Aborts)

Blue Force

Grey Force



Red Force

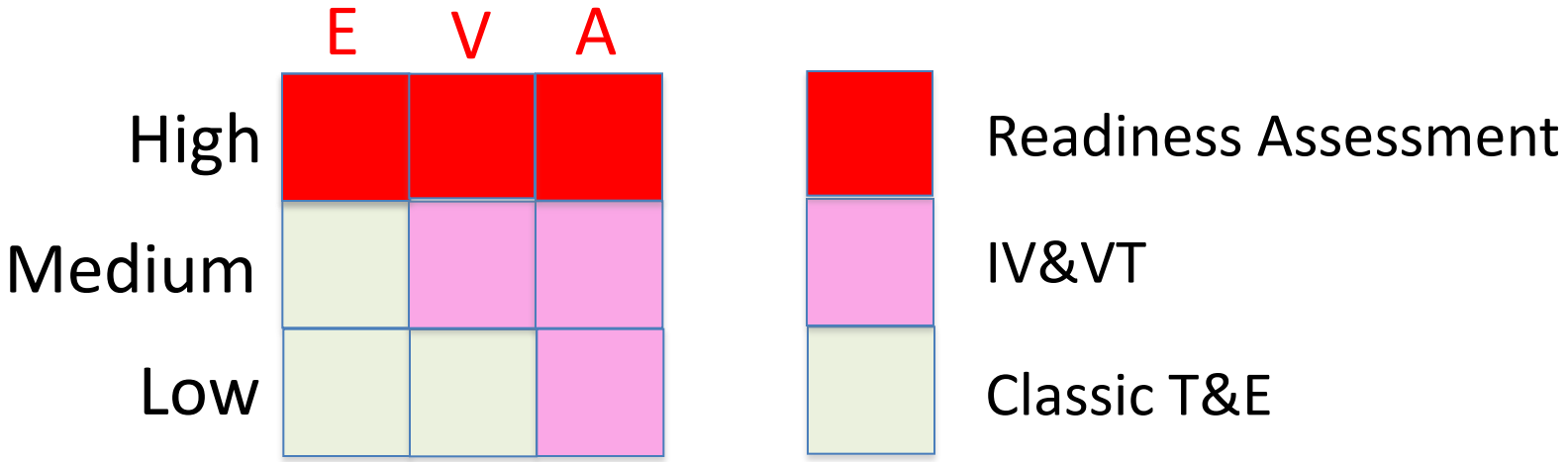
Green Force

Necessary and Sufficient
Cadre of Systemists

Key F4P Principles

1) Systems exist only when deployed and activated.
2) Effects & Capabilities > Requirements and Functions.
3) Orchestration of "N" self-adapting systems.
4) The dynamic and integrity limits of any system are determined by
   a) Progress properties: starting from some state reach a desired state in a finite number of steps.
   b) Safety properties: maintain *invariants* that ensure correct progress.

Anticipated Engagement Dimensions ---



E = Extent: # of cognates

V = Variety: # of unique cognates, semiotic and temporal

A = Ambiguity: fog, conflicting data, indeterminate context. Cognitive Overload → Underconceptualization

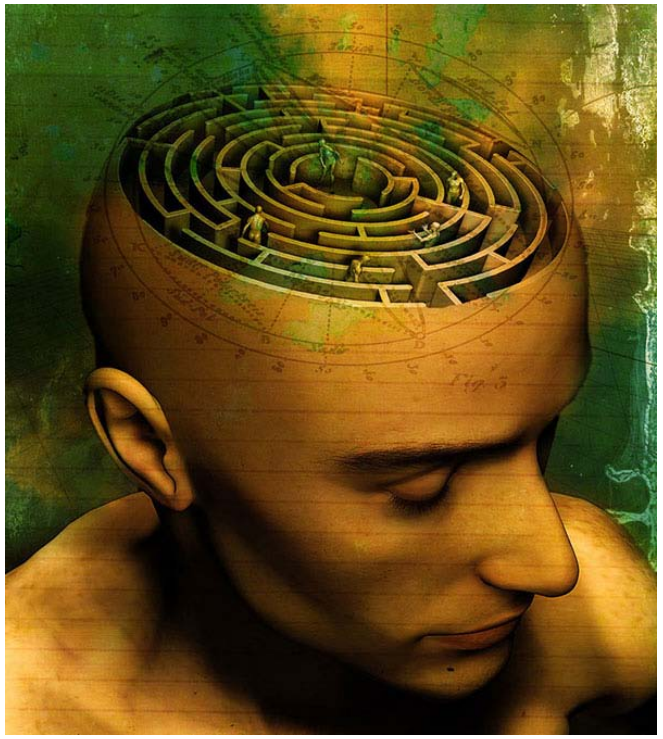
Ring, J., Modeling a Systems Engineering Enterprise, 2007 Conference on SE Research, Hoboken, NJ

- - - - - - Extent - - - - - -

- - - Variety - - -

- - - Ambiguity - - -

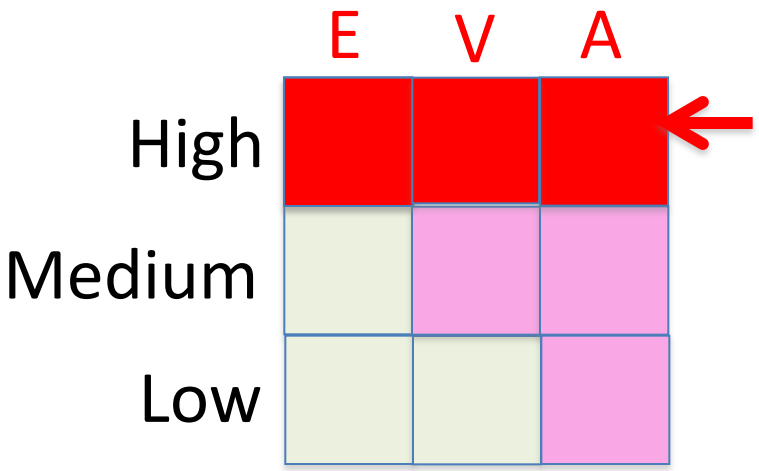
indeterminant systems territory



Cognitive Overload

http://www.inspiremonkey.com/wp-content/uploads/2011/02/MazeinMyMind.jpg

The High EVA Case



Agile, indeterminate ‘enemy’ operating multi-node networks of heterogeneous, autonomous systems.

Tens to hundreds of asynchronous changes by system administrators.

Necessary and Sufficient Systemists

a) Conduct 12-15 person expeditions that implement ConOps. 3X100 day cycles. 20 teams in five years.

b) Adept at all degrees of Extent, Variety, Ambiguity.

c) Executable models enable system composition.

d) Ensures requisite information is provided by acquisition programs.

e) Accelerates co-learning of all involved.

Work Program of Complexity, WPOC

Discovery: **Description is done in a group process. focus on problematic situation and underlying problem system.**

Diagnosis is done by an experienced individual professional, who iterates with the group until the description is fully understood and accepted.

Resolution: **Design is done in a group process. involves both formal logic and behavioral pathologies.**

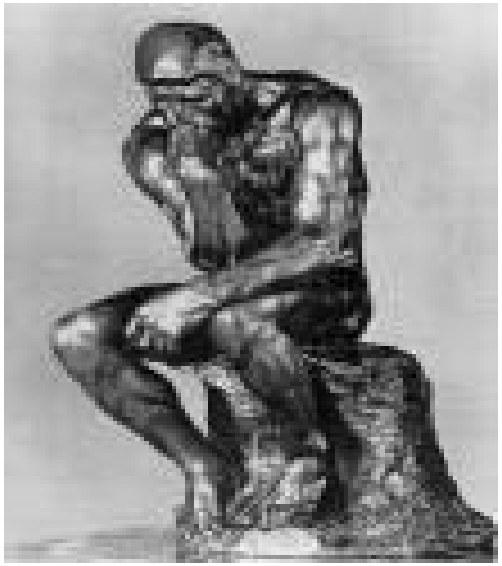
Implementation is carried out by whatever means the design specifies.

UNDERSTANDING COMPLEXITY: THOUGHT & BEHAVIOR, 2002, www.jnwarfield.com
A HANDBOOK OF INTERACTIVE MANAGEMENT, 1990/1994, www.jnwarfield.com

Model-based SE v.2

The truth,
the whole truth,
and nothing
but the truth.

Informatics
Thermodynamics
Biomatics
Teleonomics
Social Dynamics
Economics
Ecologics



Intended: Emergence &
Prevention of Emergence

Model must be
- ✓ directly executable.
- ✓ based on a formal ontology.
- ✓ reflexive.

Minimal Implicate Order

Confirm Coherent Change

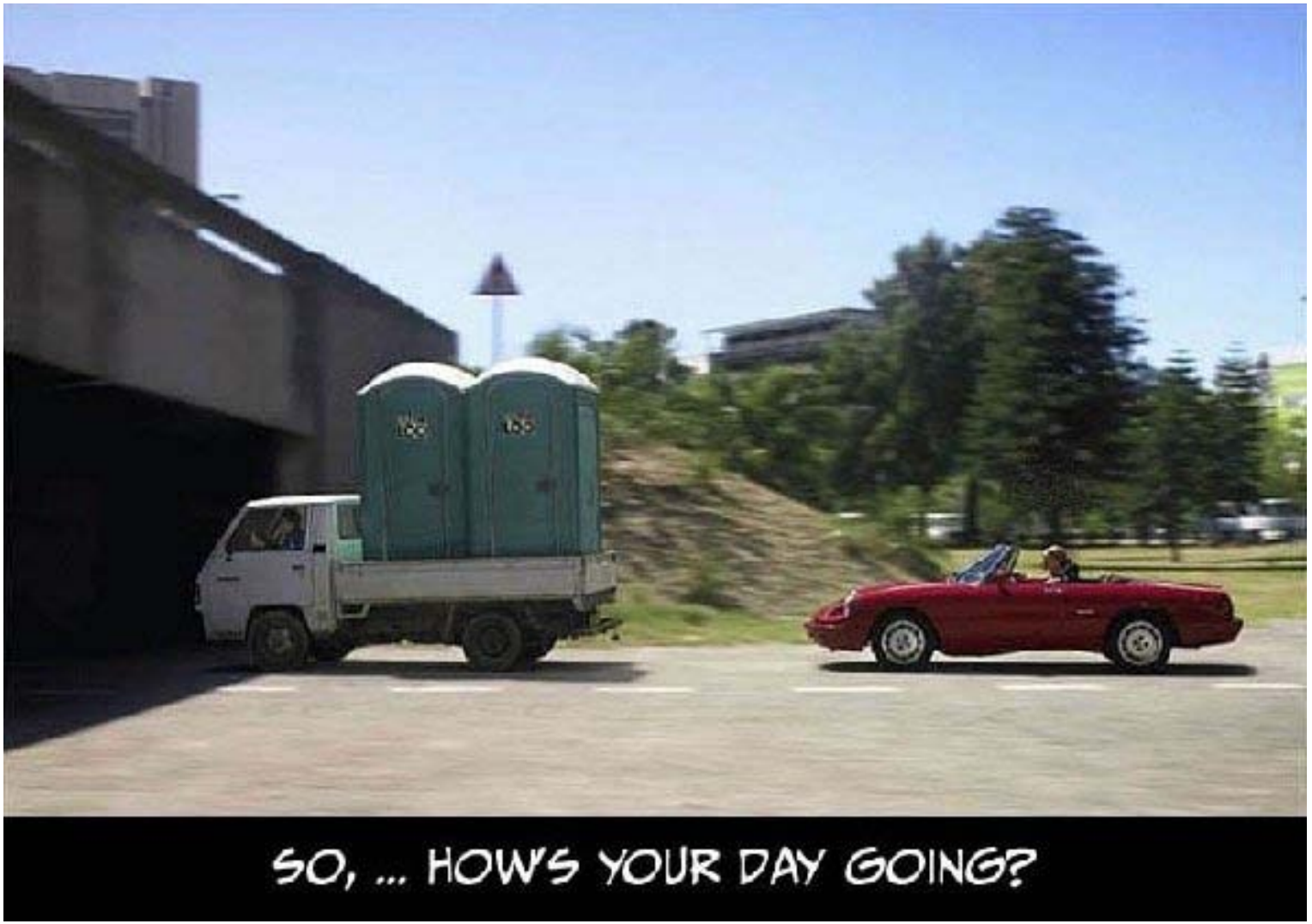
Adjust: Gradients on relationships
Arrange: Pattern of relationships
Co-align: Content of system with context and resources.

Within Dynamic and Integrity Limits

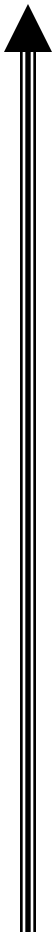
$X, d(X)/dt, d^2(X)/dt^2$

Thermodynamics: mass, momentum and energy
Informatics: data, information and knowledge
Teleonomics: skills, rate of learning, and rate of invention
Human social dynamics: trust, enthusiasm, co-evolution
Economic: Investment, ROI, Liquidity
Ecology: Waste, Fads, Unintended Consequences

Design for Prevention Precludes Unintended Consequences



Interoperability of Systemists



Relationship	Meaning	Mediators
Co-evolve	Morphing toward Win-Win-Win	Joy-enabled Level of Consciousness
Co-facilitate	Value Out/Value In ≈ e^N	Stewardship by N participants
Co-learn	Meaningful reflection	Shared knowledge claims
Collaborate	Help one another	Desire to serve
Co-celebrate	En-joying one another	Time & Space, F2F
Cooperate	Compatible Actions	Willing to wait
Commit	Principled relationship	Courage to plan
Converge	Common compelling purpose	Shared self-respect
Communicate	Share interests and values	Common language
Connect	Two discover one another	Accessible attributes

Beware of Re-use?

~~IV&V~~ ~~T&E~~

Readiness Assessment

1) Ensure Acquisition a) describes progress properties and safety properties of components and b) Includes sufficient self-test of their systems.
2) Leverage new technology to automate System Integrity Assessment.
    - c.f., Fellows Issue #3, INCOSE INSIGHT, June, 2010
    - c.f., System of Systems Readiness Assessment, The T&E of System of Systems Conference, ITEA, 1/24/2012, El Paso, Texas
1) Apply from Day 2 of a new project through Year N of the system usage/evolution cycle.

Readiness Assessment Benefits

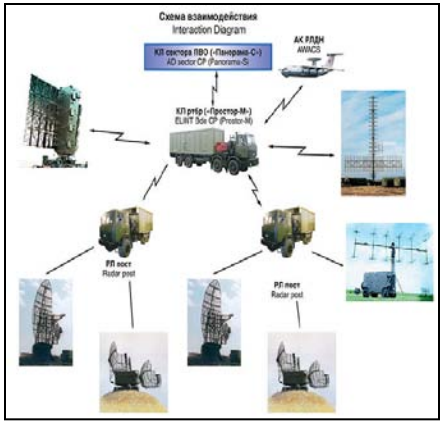
1) Fit For Purpose: Continuous Estimate across multiple engagement scenarios.
2) Software problems: Reduced by > 100-fold
3) System Integration cost/time: Reduce ≈ 80%.
4) Test aborts: Reduce ≈ 40% of T&E costs.
5) Cybersecurity: Reduce vulnerability.
6) T&E of dynamic and integrity limits: Inform Design of Experiments.

Outlook

1) Effective in at least defense, aviation, homeland security, industry supply chains, knowledge discovery/vetting networks, and human activity systems.
2) Free. Return >> Investment.
3) Initial cadre of next generation of systemists.

Remember ---

The Readiness Assessment challenge concerns both the fielded system and the whole realization system.



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Y

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Application
Knowledge
Base

4

5

Acquisition
Phase

6

Inventory of
Components

System
Realization
& Resilience

Clarifications?
Questions?
Comments?

The castle, Jack, besiege the CASTLE!

Thank you!