Engineered Resilient Systems (ERS) S&T Priority Description and Roadmap

Dr. Robert Neches

ERS PSC Lead

Director, Advanced Engineering Initiatives, ODASD SE

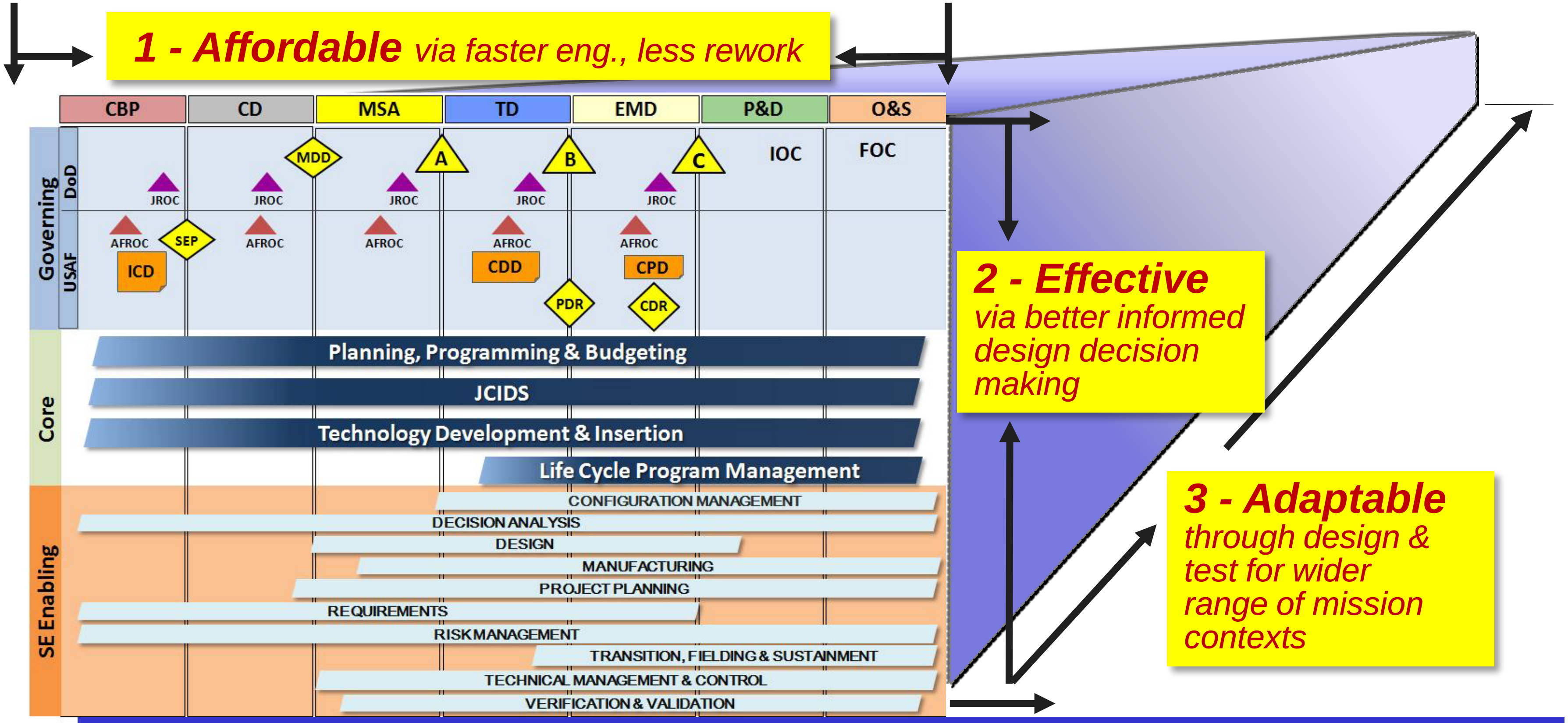
NDIA 8th Annual Disruptive Technologies Conference

8 November 2011

Distribution Statement A: Approved for public release; distribution is unlimited.

Engineered Resilient Systems Spans the Systems Life cycle

Resilience: Effective in a wide range of situations, readily adaptable to others through reconfiguration or replacement, with graceful and detectable degradation of function



Uncertain futures, and resultant mission volatility, require affordably adaptable and effective systems – done quickly

Distribution Statement A: Approved for public release; distribution is unlimited.

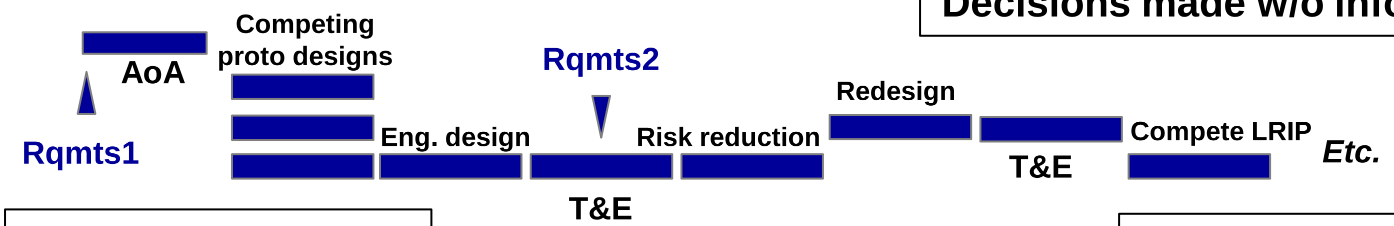
Engineered Resilient Systems

Today

50 years of process reform haven't controlled time, cost, and performance

Rapidly necks down alternatives

Decisions made w/o info



Sequential and slow

Information lost at every step

Ad hoc reqmts refinement

New tools help engineers and users understand interactions, identify implications, and decide how to manage consequences

Fast, easy, inexpensive up-front engineering:

- **Automatically consider many variations**
- **Propagate changes, maintain constraints**
- **Introduce and evaluate many usage scenarios**
- **Analyze to compare and understand technical & operational tradeoffs**
- **Iteratively refine requirements in light of feasibilities and opportunities**
- **Learn and update**

Where We Need to Go

Distribution Statement A: Approved for public release; distribution is unlimited.

Engineered Resilient Systems: Needs and Technology Issues

Creating & fielding affordable, effective systems entails:

- **Deep trade-off analyses across mission contexts**
  - **Adaptability, effectiveness and affordability in the trade-space**
  - **Maintained for life**
- **More informative requirements**
- **Well-founded requirements refinement**
- **More alternatives, maintained longer**

Doing so quickly and adaptably requires new technology:

- **Models with representational richness**
- **Learning about operational context**
- **Uncertainty- and Risk- based tools**

Starting point: Model- and Platform- based engineering

Distribution Statement A: Approved for public release; distribution is unlimited.

System Representation and Modeling: Technical Gaps and Challenges

Technology	10-Yr Goal	Gaps
Capturing • ***Physical and logical structures*** • ***Behavior*** • ***Interaction with the environment and other systems***	**Model 95% of a complex weapons system**	• Combining live and virtual worlds • Bi-directional linking of physics-based & statistical models • Key multidisciplinary, multiscale models • Automated and semi-automated acquisition techniques • Techniques for adaptable models

We need to create and manage many classes (*executable, depictional, statistical...*) and many types (*device and environmental physics, comms, sensors, effectors, software, systems ...*) of models

Distribution Statement A: Approved for public release; distribution is unlimited.

Characterizing Changing Operational Environments: Technical Gaps and Challenges

Technology	10-Yr Goal	Gaps
Deeper understanding of warfighter needs ***Directly gathering operational data*** ***Understanding operational impacts of alternatives***	**Military Effectiveness Breadth Assessment Capability**	• Learning from live and virtual operational systems • Synthetic environments for experimentation and learning • Creating operational context models (missions, environments, threats, tactics, and ConOps) • Generating meaningful tests and use cases from operational data • Synthesis & application of models

"Ensuring adaptability and effectiveness requires evaluating and storing results *from many, many scenarios* (including those presently considered unlikely) *for consideration earlier* in the acquisition process."

Distribution Statement A: Approved for public release; distribution is unlimited.

Cross-Domain Coupling: Technical Gaps and Challenges

Technology	10-Yr Goal	Gaps

Better interchange between incommensurate models
 	
Resolving temporal, multi-scale, multi-physics issues
	Weapons system modeled fully across domains	• Dynamic modeling/analysis workflow
		• Consistency across hybrid models
		• Automatically generated surrogates
		• Semantic mappings and repairs
		• Program interface extensions that:
		  • Automate parameterization and boundary conditions
		  • Coordinate cross-phenomena simulations
		  • Tie to decision support
		  • Couple to virtual worlds

Making the wide range of model classes and types work together effectively requires new computing techniques (not just standards)

Distribution Statement A: Approved for public release; distribution is unlimited.

Tradespace Analysis: Technical Gaps and Challenges

Technology	10-Yr Goal	Gaps
Efficiently generating and evaluating alternative designs ***Evaluating options in multi-dimensional tradespaces***	**Trade analyses over *very large* condition sets**	• Guided automated searches, selective search algorithms • Ubiquitous computing for generating/evaluating options • Identifying high-impact variables and likely interactions • New sensitivity localization algorithms • Algorithms for measuring adaptability • Risk-based cost-benefit analysis tools, presentations • Integrating reliability and cost into acquisition decisions • Cost-and time-sensitive uncertainty management via experimental design and activity planning

Exploring more options and keeping them open longer, by managing complexity and leveraging greater computational testing capabilities

Distribution Statement A: Approved for public release; distribution is unlimited.

Collaborative Design & Decision Support: Technical Gaps and Challenges

Technology	10-Yr Goal	Gaps
Well-informed, low-overhead collaborative decision making	**Computational / physical models bridged by 3D printing** ***Data-driven* trade decisions executed and recorded**	• Usable multi-dimensional tradespaces • Rationale capture • Aids for prioritizing tradeoffs, explaining decisions • Accessible systems engineering, acquisition, physics and behavioral models • Access controls • Information push-pull without flooding

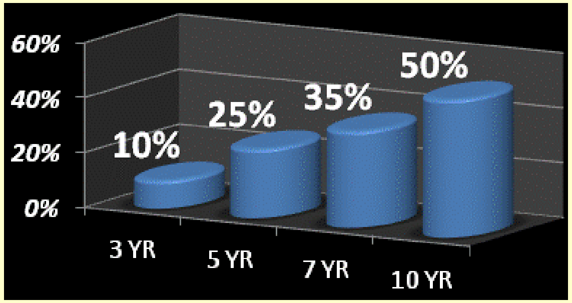
ERS requires the transparency for many stakeholders to be able to understand and contribute, with low overhead for participating

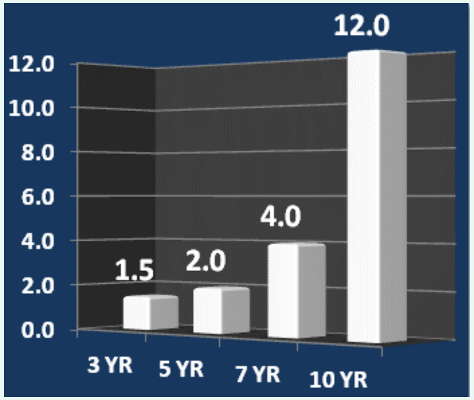
Distribution Statement A: Approved for public release; distribution is unlimited.

What Constitutes Success?

<u>Adaptable</u> (and thus robust) designs

– Diverse system models, easily accessed and modified
– Potential for modular design, re-use, replacement, interoperability
– Continuous analysis of performance, vulnerabilities, trust
– ***Target: 50% of system is modifiable to new mission***



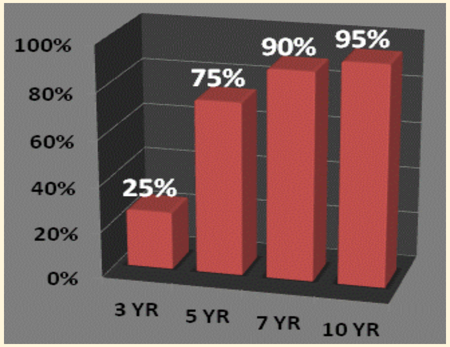


<u>Faster</u>, more efficient engineering iterations

– Virtual design – integrating 3D geometry, electronics, software
– Find problems early:
– Shorter risk reduction phases with prototypes
– Fewer, easier redesigns
– Accelerated design/test/build cycles
– ***Target: 12x speed-up in development time***

Decisions <u>informed</u> by mission needs

– More options considered deeply, broader trade space analysis
– Interaction and iterative design among collaborative groups
– Ability to simulate & experiment in synthetic operational environments
– ***Target: 95% of system informed by trades across ConOps/env.***



<u>Distribution Statement A</u>: Approved for public release; distribution is unlimited.

Opportunities to Participate

DoD Needs Innovative Tools and Algorithms from Industry and Academia

Organization	BAA Title	Closing Date	Reference #
ONR	Energetic Materials Program R&D	23-Dec-11	12-SN-0001
Dept of Army	Adaptive Vehicle Management System (AVMS) Phase II	6-Jan-12	W911W6-11-R-0013
NAWC Lakehurst	BAA Reconnaissance and Surveillance payloads, sensors, delivery systems and platforms	14-Feb-12	N68335-11-R-0018
NAVFAC	BAA Expeditionary technologies	2-Mar-12	BAA-09-03-RIKA
US Army USACE	2011 BAA	31-Mar-12	W912HZ-11-BAA-02
NRL	NRL-Wide BAA	16-Jun-12	BAA-N00173-01
US Army RDECOM-ARDEC	Technology Focused Areas of Interest BAA	15-Sep-12	W15QKN-10-R-0513
ARL	Basic and Applied Scientific Research	31-Dec-12	W911NF-07-R-0003-04 & -0001-05
Dept of Army	Army Rapid Innovation Fund BAA	29-Sep-12	W911NF11R0017
ONR	BAA, Navy and Marine Corp S&T	30-Sep-12	ONR 12-002
NASC Training Sys Div	R&D for Modeling and Simulation Coordination Office	4-Dec-12	N61339-08-R-0013
AFRL Kirtland	STRIVE BAA	Draft Posted	FA945311R0285
WHS	DoD Rapid Innovation Fund	n/a	HQ0034-RIF-11-BAA-0001
AFRL WPAFB	Reasoning, Comprehension, Perception and Anticipation in Multi-Domain Environments	n/a	BAA-10-03-RIKA
AFRL Rome	Emerging Computing Technology and Applications	n/a	BAA-09-08-RIKA
AFRL Rome	Cross Domain Innovative Technologies	n/a	BAA-10-09-RIKA
AFRL Rome	Computing Architecture Technologies BAA	n/a	BAA-09-03-RIKA
WHS	Systems 2020	n/a	Subject to Presidential Budget Approval

Distribution Statement A: Approved for public release; distribution is unlimited.

Envisioned End State

Improved Engineering and Design Capabilities

- More environmental and mission context
- More alternatives developed, evaluated and maintained
- Better trades: managing interactions, choices, consequences

Improved Systems

- Highly effective:
  better performance,
  greater mission effectiveness
- Easier to adapt,
  reconfigure or replace
- Confidence in graceful
  degradation of function

Improved Engineering Processes

- Fewer rework cycles
- Faster cycle completion
- Better managed
  requirements shifts

Distribution Statement A: Approved for public release; distribution is unlimited.