



Anticipation

Rapid Fieldings

Technology Tools for Rapid Capability Fielding: *Final Outbrief*



Superior Capabilities

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Agenda

- Executive Summary
- Background
 - Terms, objectives, study approach
- Findings
 - Points of leverage in rapid capability life cycle
 - Specific technology areas - engineering, M&S, manufacturing
 - Concept to Capability Engineering
- Conclusion



Executive Summary

Findings

- Significant opportunities exist to develop and deploy technologies to strengthen the Department's ability to conduct rapid capability fielding
 - However, non-technical challenges (e.g. cultural, budgetary, contracting, etc) must be simultaneously addressed
- Greatest leverage in the “front end” of the life cycle
 - Concept Engineering: Rapidly elucidating the need, exploring solutions, developing CONOPs, and deriving requirements for materiel solutions
 - Virtual environments and rapid physical prototyping are linchpin technologies
- Opportunities exist to increase design, test, and production efficiencies
 - Examples include physics-based M&S to reduce testing and model-based engineering and manufacturing approaches

Recommendations

- A concept engineering center should be implemented immediately that leverages the substantial existing capabilities across the Department
- A strategic R&D roadmap should be developed and implemented to mature and transition emerging tools and promising innovative ideas
- A set of potential pilots is recommended to demonstrate the application of today's toolset to relevant rapid capability challenges



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Terms of Reference

- **Objective:** Provide specific recommendations to DDR&E regarding **technological opportunities** to significantly **decrease the development time** and **increase the operational effectiveness** of rapidly fielded capabilities.
- **Study Questions:** What are the current technical tools used in both the defense and commercial industries to rapidly design, fabricate, test and validate new systems?
 - Pay particular attention to **modeling and simulation** tools to support rapid design, fabrication, and testing; **system engineering** tools to rapidly design and re-design complex systems; and **manufacturing** processes and tools to speed development.
 - Are there tools that would allow for end to end rapid development, to include such functions as CONOPS development, interoperability, and testing?
- For each of these tools, assess their current capabilities and limitations for DoD rapid fielding needs.
- What are the **emerging technology opportunities**? Identify the technical leaders in these areas and propose approaches to validate the impact of these tools.
- How might these technology opportunities best be developed? **Program scope, scale, and schedule**? Suggestions as to how this might best be done, and by whom are invited.
- Is there any way to **tailor current tools**, techniques, models, methodologies, best practices, etc, to achieve better rapid fielding capability immediately?



Defining Terms

- Rapid Capability Fielding: *Streamlined projects seeking to field capability in less than 24 months.*
 - *This could be in response to a stated need of a combatant commander or in anticipation of a potential need*
- Technology Tools: *Software, algorithms, models, simulations, manufacturing hardware/software, and associated processes that support the full life cycle of rapid development*
 - *In general, organizational, contracting, budgeting, and other non-technical aspects of rapid fielding are off the table*
 - *To the extent human resources, organizational issues and processes are integral to technical recommendations, they should be addressed*



Panel Membership



- *Jim Carlini (Study Lead):* Consultant, former Vice President for Advanced Development, Northrop Grumman Electronic Systems
- *Mark Burgess:* Chief Engineer, Boeing Research and Technology
- *Dennis Roberson:* Vice Provost, Illinois Institute of Technology and former CTO, Motorola
- *Yngvar Tronstad:* Executive Vice President and Chief Scientist, Cogility Software
- *Dinesh Verma:* Dean, School of Systems and Enterprises, Stevens Institute of Technology
- *Bran Ferren:* Co-founder, Applied Minds and former President, Walt Disney Imagineering
- *Study Coordination and Support:* ANSER Corporation, Dr. Mike McGrath and team



Caveats



- Technology tools are not the primary answer to the challenges of rapid fielding
 - Contracting, organizational, cultural, budgeting, and other problems are paramount and must be tackled
- Nevertheless, technology has a role and if integrated into a composite overall solution can have great impact
- Gaining full insight into all relevant Department efforts and technology areas impossible within timeframe
 - Some recommendations require additional research and coordination across the Department



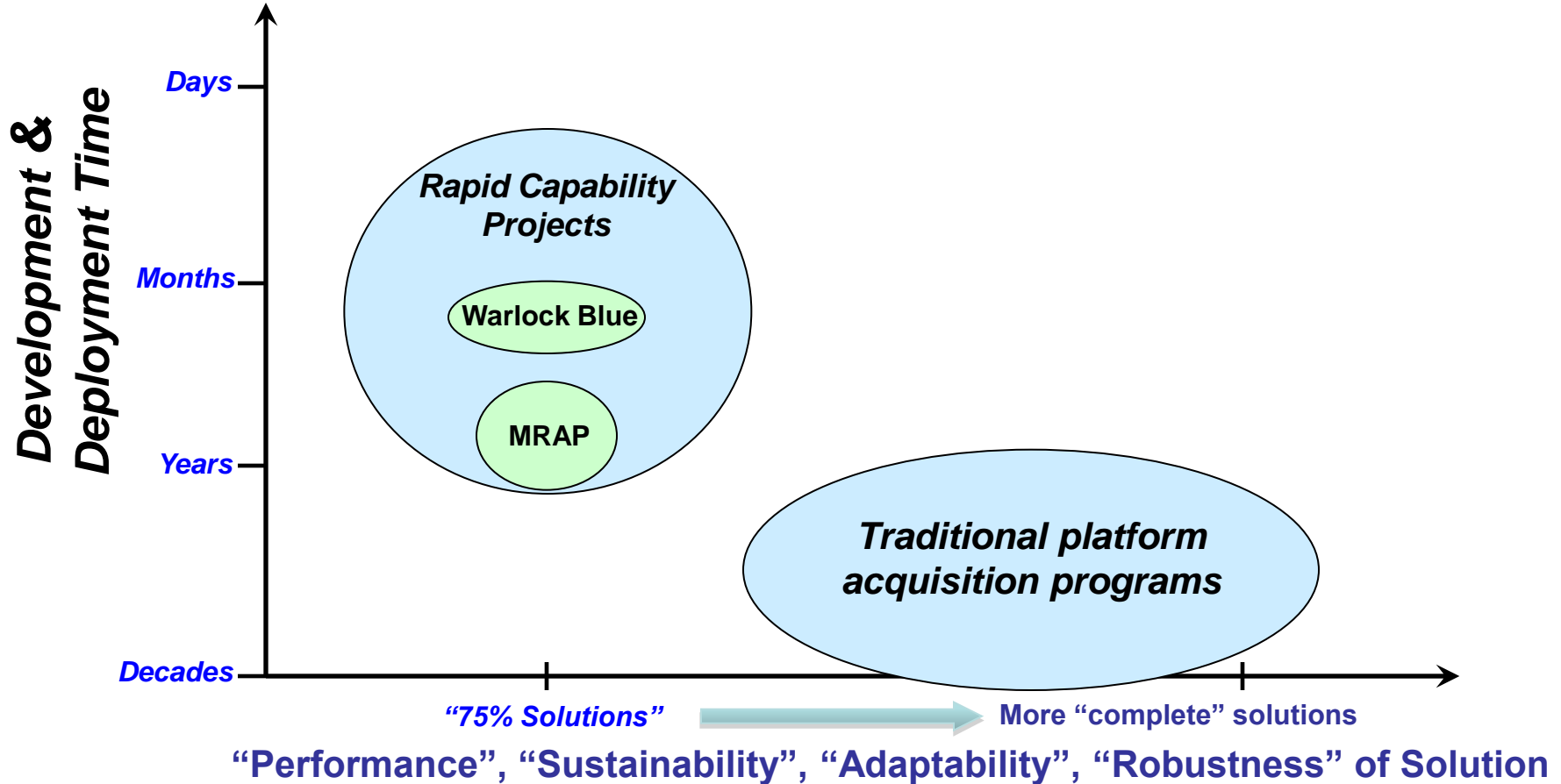
What are we trying to help enable with “technology tools”?



- Shorten time from need to fielding
 - Reduce time for individual steps in the life-cycle
 - Reduce number of iterations of “design-build-test-produce-field”
- Anticipate and prevent emergence of urgent needs
- Ensure the solution adequately addresses the “need” and has the desired operational longevity
- Move rapid capability fielding from heroic to routine
 - May not decrease the time of an individual project, but enable moving toward a “steady diet” of rapid projects
- Ease transition to a POR
 - Prevent starting from scratch again



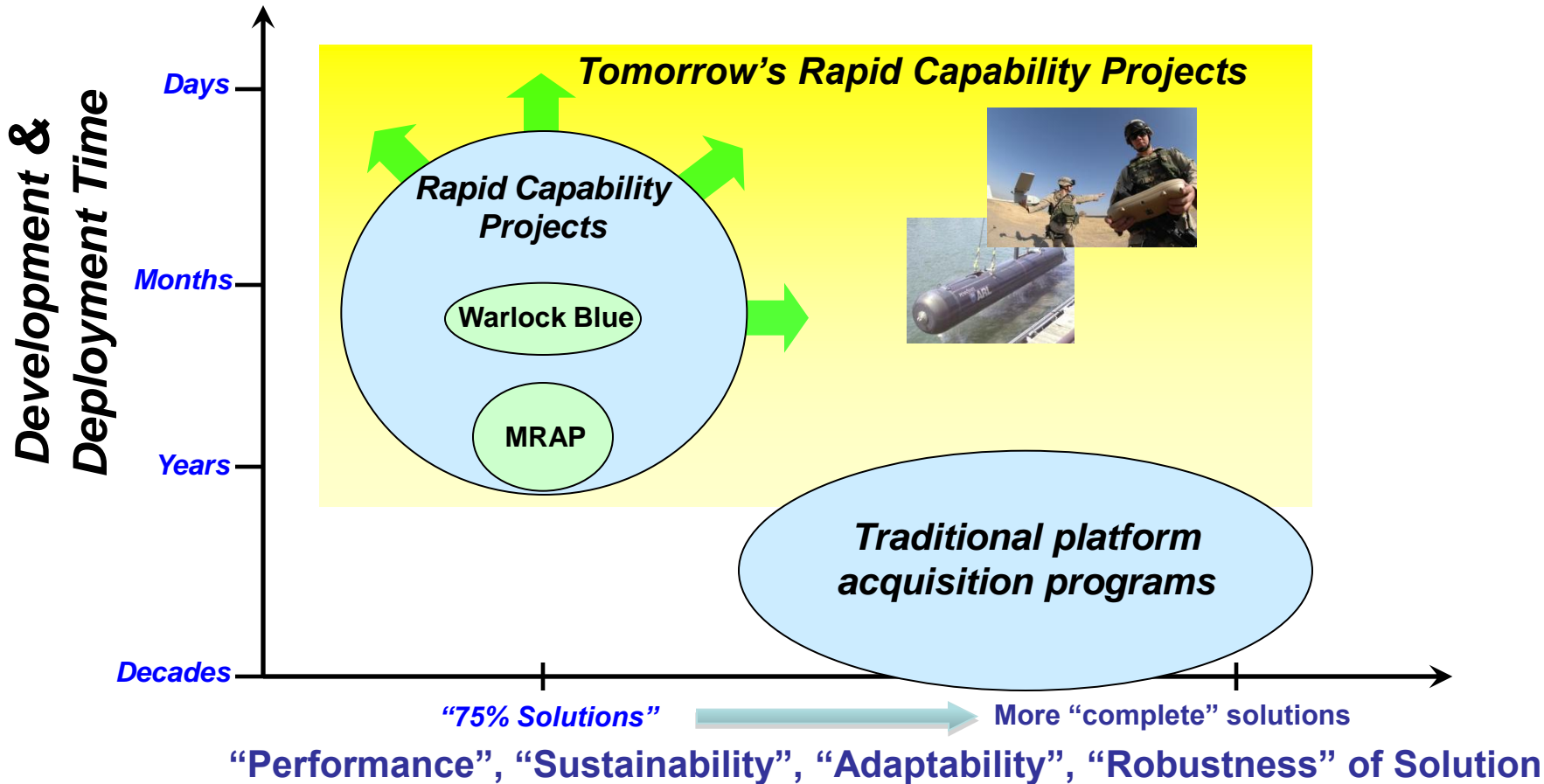
Enabling Better Rapid Capability Fielding



DDR&E Rapid Capabilities Technology thrust will develop capabilities to enable more rapid, adaptive, robust, and sustainable solutions to the warfighter



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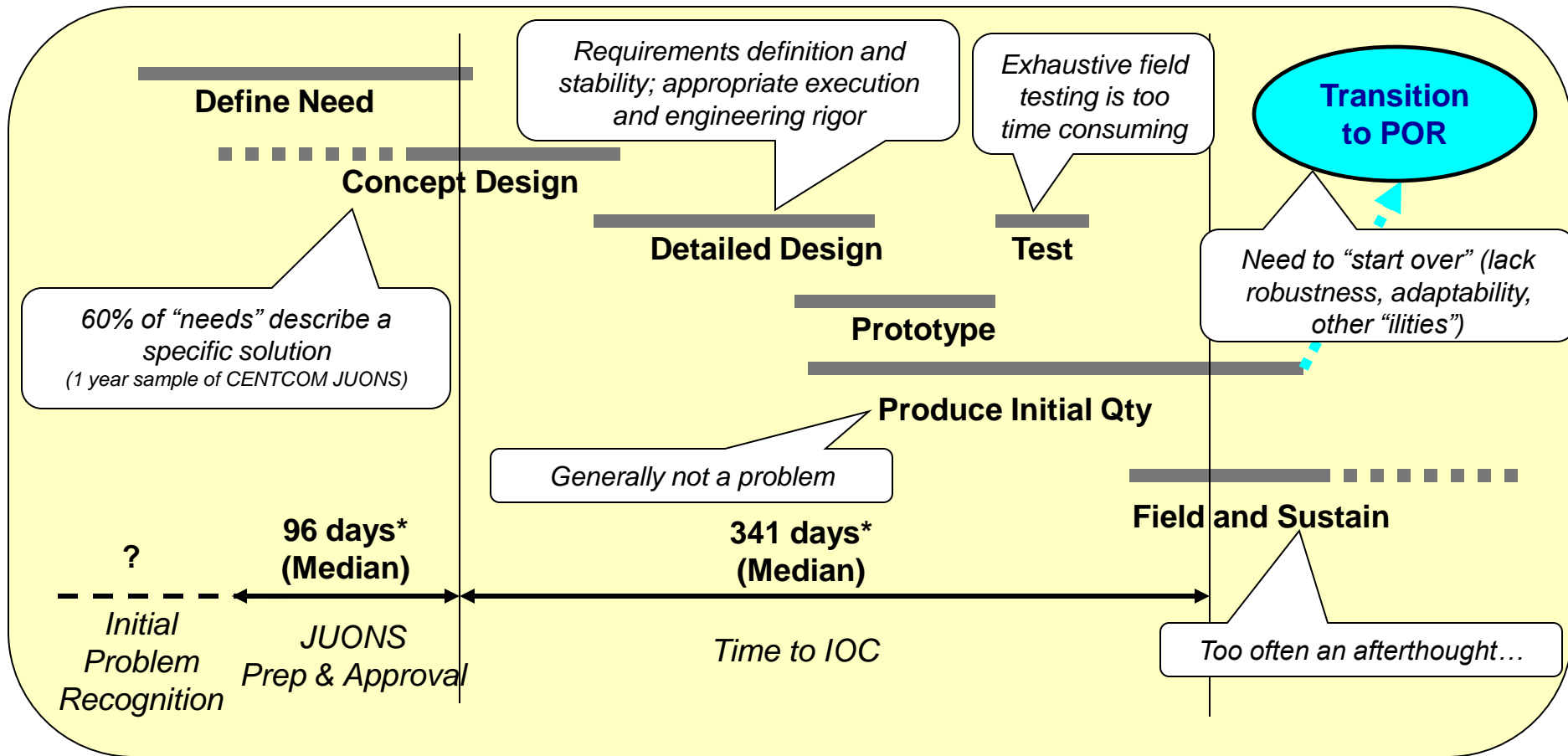


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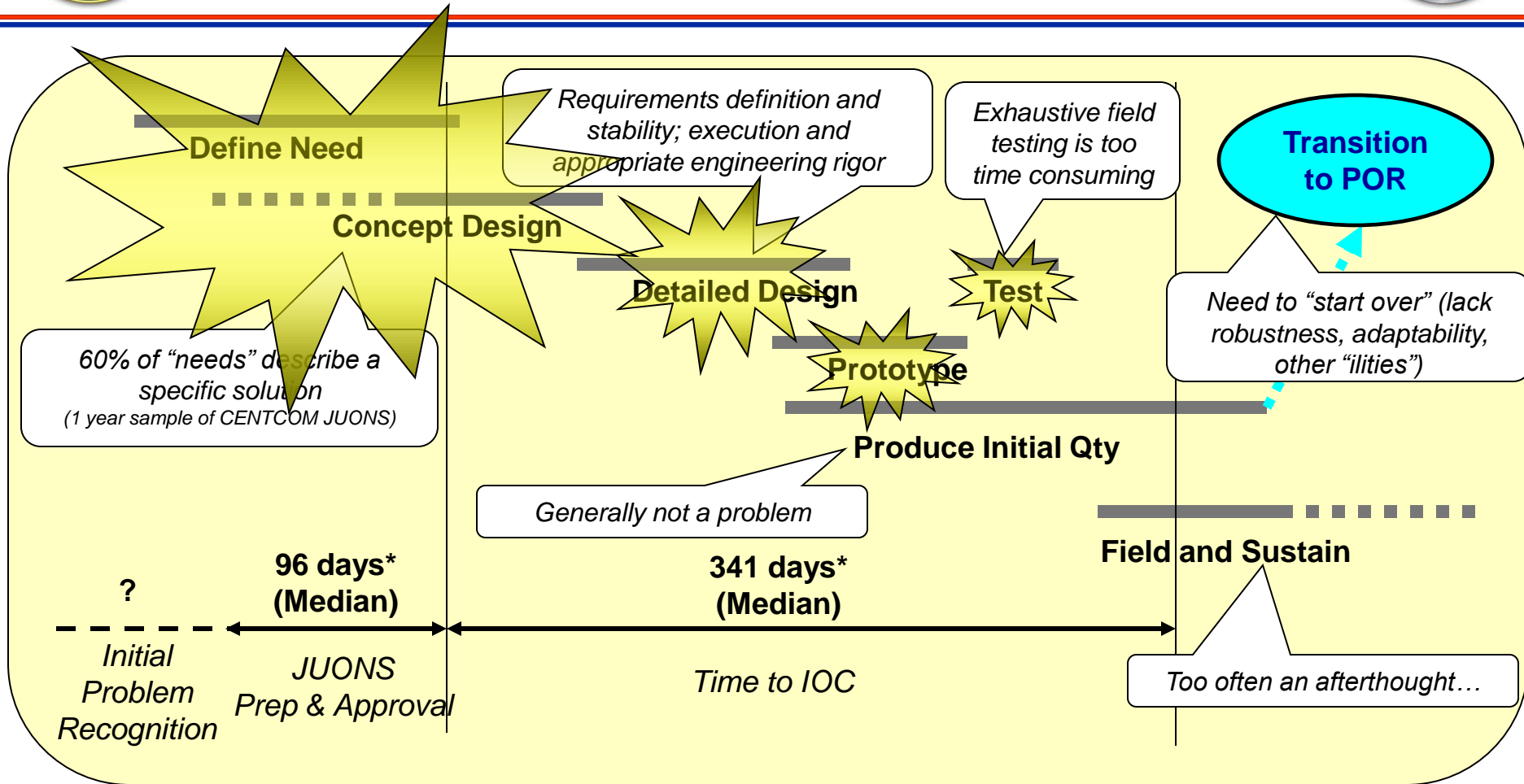
General Observations



Extraordinary work is being done across the Department to fulfill warfighter needs, but opportunities abound to strengthen rapid capability fielding



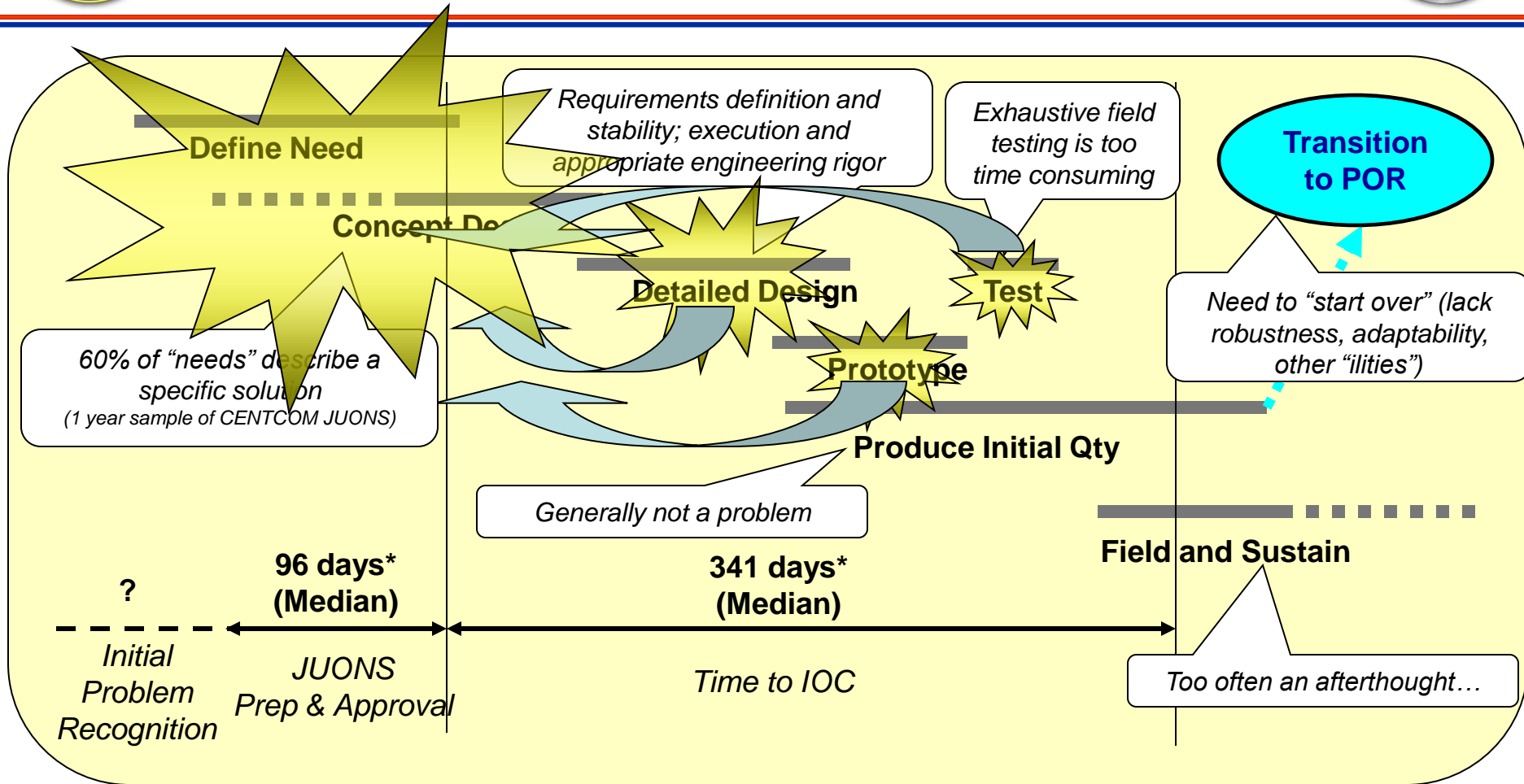
Where is the Leverage?



Get it right up front: anticipate, properly define the need and technical requirements, assess options/CONOPS, account for sustainment (or obsolescence).....



Where is the Leverage?



.....and invest in the tools and training to help speed/automate detailed design, test, and fabrication to compress the development life cycle



Spectrum of Rapid Capabilities Solutions



Air/Land/Sea Vehicles



Unmanned Systems



Electronics



Info Systems (C2, Decision Support, Social Networking, etc)



CBRNE Defense, Forensics



Domain-specific challenges abound – a well-populated toolbox with extremely flexible processes and dedicated, top-notch personnel is essential



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Engineering Findings

- Engineering discipline in rapid capability projects is mixed
 - Ranges from virtually none to “5000-lite”
 - No standard method for determining the appropriate level
- Starting from existing engineering processes is not the best approach:
 - One size fits all systems engineering, focused on comprehensiveness, not agility
 - Process-focused vice outcomes-focused (documenting versus creativity)
 - Front end is particularly lacking in tools leveraging advances in visual modeling, virtual environments, and rapid prototyping
- Cross-cutting challenges
 - Inability to rapidly assess “-ilities” (reliability, producibility, testability, etc.)
 - Accreditation times can limit the ability to field rapidly
 - Reverse engineering tools needed (important for integration with legacy systems)
- Trends
 - Commercial use driving progress in Model Based Engineering
 - Tools and tool interoperability getting better, but ways to go
 - Software: Advances have been made in autogeneration of code, however effective and efficient translation from CONOPS (use cases) to executable models requires more work
 - Hardware: Translation of abstract high level system models (architecture models) to CAD/CAM not there yet (except for microelectronics), but needed....
 - Proposed research in design using hierarchical abstraction (i.e. Eremenko, DARPA) can be a catalyst
 - Increasing use of virtual environments and digital threads (design through manufacturing)



Modeling and Simulation Findings



- Community is vast, with a good deal of excellent work occurring in pockets
- Training community leveraging emerging technologies (e.g. gaming, virtual, mixed, augmented reality)
 - Appears to be little exploitation in acquisition communities
- Ability to easily and rapidly develop gaming scenarios is impressive
 - Work still needed in enhancing realism and physics-based effects
- Physics-based simulation applied to engineering design holds the promise of having a substantive impact on rapid capability fielding
 - Reducing design-build-test cycles (e.g. Goodyear, P-3 sensor integration)
 - Development efforts are expensive and lengthy
- Platform EMI and battlefield communications modeling efforts exist, however a rapid battlefield electromagnetic modeling effort should be explored
- Ability to model human/cultural behavior limited
 - Agent-based modeling coupled to Monte Carlo with real world calibration may hold promise
- There is limited visibility into existing DoD-wide M&S capabilities that might be applied to rapid capability fielding efforts
 - Interoperability also an issue



Manufacturing Findings

- Manufacture of modest quantities is not usually a rapid capability challenge, but:
 - Many examples are “heroic” and not a sustainable business model
 - Quick-reaction production capacity when large numbers are needed may be an issue
- DoD Labs have substantial in-house capabilities
 - Distributed across many sites – need to make visible and accessible
 - Need to keep current with emerging tools and technology
- Focus for rapid prototyping should be:
 - Physical mockups to aid in user-centered design and CONOPS development
 - Functional prototypes to aid in validating engineering concepts
- Focus for limited production should be on total manufacturing time, not just time-on-tool -- leverage is above the shop floor and in supply chain
- Emerging tools:

Rapid (Functional) Prototyping

- Additive Manufacturing (3-D printing, laser sintering, etc) for mechanical parts
- Ink-jet printing of circuit boards and solderless circuit card assembly

Limited Production

- Model Based Enterprise – visualizations and physics based process simulations to generate mfg controls and acceptance test programs
- Tool-less processes (e.g. composites sans autoclave)
- Collaborative Mfg Architectures and standards for discovery and integration of mfg services



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Tool-enabled Rapid Capability Development

Near

Needs
(Stated and Unstated)
Red Teaming Tech Opportunities

Concept Engineering

- Conceptual Design
- CONOPS/TTPs
- Input to detailed design and cost/benefit trades
- Prototype(s)

Capability Engineering

- Performance and Materiel Trades
- Prototype(s)

Fielded Capabilities

Far

Needs
(Stated and Unstated)
Red Teaming Tech Opportunities

Concept to Capability Engineering (C2E)

Fielded Capabilities

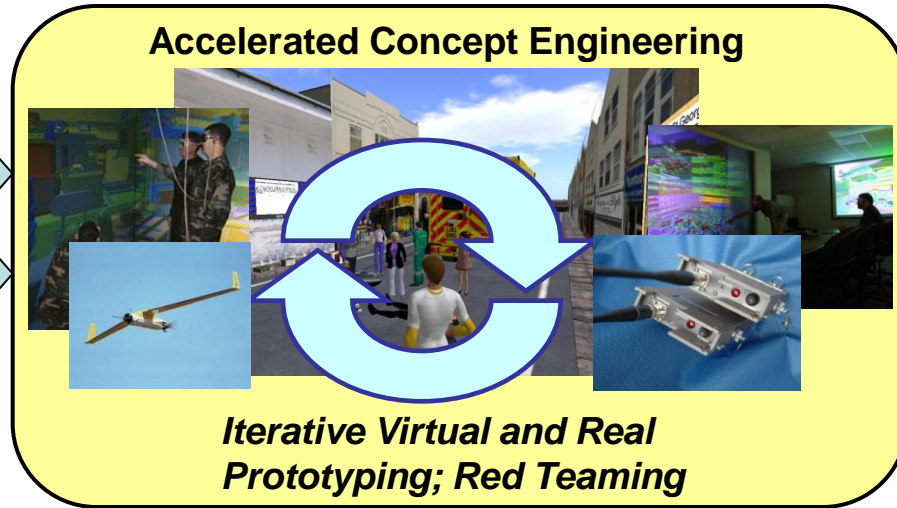


Concept Engineering

Warfighter Needs



Anticipatory Opportunities



- Conceptual Designs
- CONOPs
- TTPs
- Input to Detailed Design
- Prototype(s)

- Need/mission focused (the right tool(s) to answer the question)
- Warfighter-centric (CONOPS integral, real prototypes where possible, user-centered design and development)
- A persistent environment that favors speed over fidelity
 - Responsive to needs, but also anticipatory
 - Work collaboratively with higher fidelity simulations (e.g. SIMEX), physical exercises, and field experiments

Immerse Users/Developers in a Rapidly-Configured Environment with Real and Virtual Prototypes: Accelerated Concept Engineering



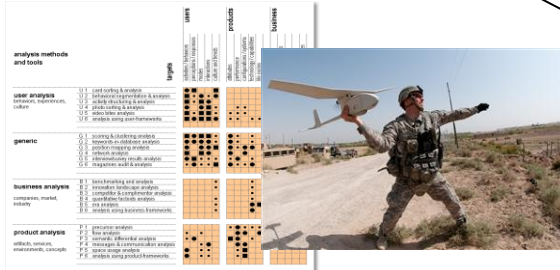
Concept Engineering Tools

Virtual Environments



- Persistent, virtual environment
- Gaming, virtual/mixed/augmented reality, 3-D visualization
- Rapidly create relevant environment to explore concepts and CONOPS
- Couple to physical prototyping where user interaction important
- Real-time user feedback
- Bootstrap training
- Remote users

User-centered Design

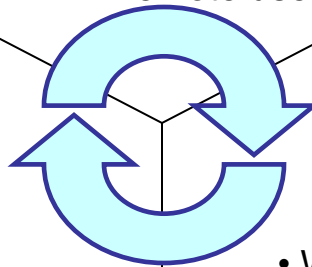


- Create routine user-centered feedback
- Employ selected tools and techniques from “design” community (i.e. IIT, Stanford, Ideo Inc)
- Build upon DARPA TIGR and network of forward-deployed S&T personnel
- Systematically anticipate needs and user-centered design factors
- Iterate with CONOPS

Rapid Prototyping



- Where possible, rapidly develop physical prototypes of candidate concepts
 - Physical mockups and functional prototypes as technology permits
- Inform CONOPS development, user interfaces, logistics and maintenance driven changes
- Leverage vast array of capabilities across DoD
- Over time, seamlessly integrate with virtual environment

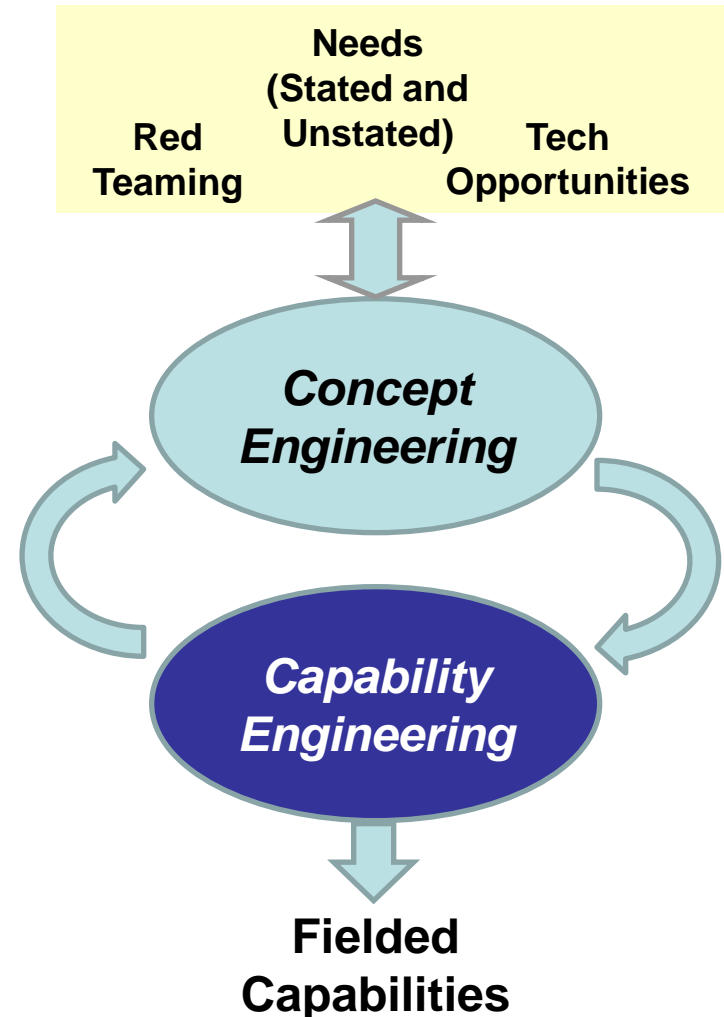




Capability Engineering



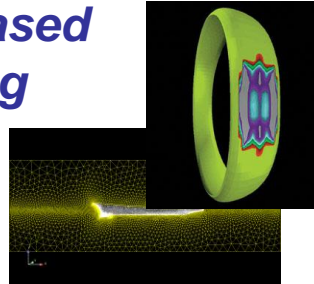
- Rapidly move from concept engineering (conceptual design, CONOPS/TTPs, prototypes) through detailed design, production, and test
- As needed, iterate with concept engineering
- Explicitly account for “ilities”
- Where possible, use physics based models
 - Inform the design and minimize re-work
 - Reduce testing time
- Over time, move to model-based engineering and manufacturing
 - Greatly enhance future system modification speed and efficiency
- Automate the seam between concept engineering and capability engineering (“C2E”)
 - Move from documents to models, virtual environments to CAD





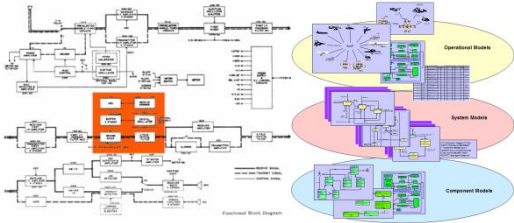
Capability Engineering Tools

Physics-based Modeling

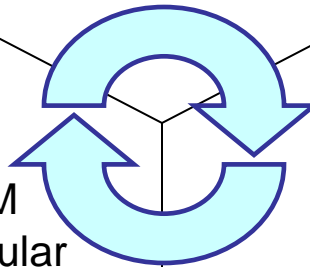


- Minimize rework and speed T&E
- Key enablers: physics understanding, reusable models, interoperability, VV&A
- Domain specific: weapons, platforms, electromagnetics

Model-based Engineering



- Increase automation, efficiency, CM
- Key enablers: pre-architected modular solution patterns, design libraries and design rules, DfX tools, reverse engineering tools, standards for tool interoperability, increasing abstraction and autogeneration capabilities, CAD-to-VE interface
- Domain specific: mechanical, electronics, software domains



Model-based Manufacturing



- Increase automation, efficiency
- Key enablers: physics based process models, auto-generation of manufacturing controls, auto-inspection, robotic assembly, advanced visualization
- Domain specific: flexible processing and fabrication technologies, “tool-less” where possible

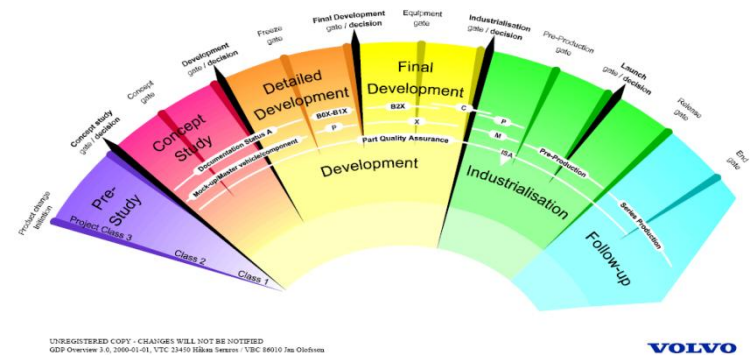


Tailored Systems Engineering and Execution Strategy

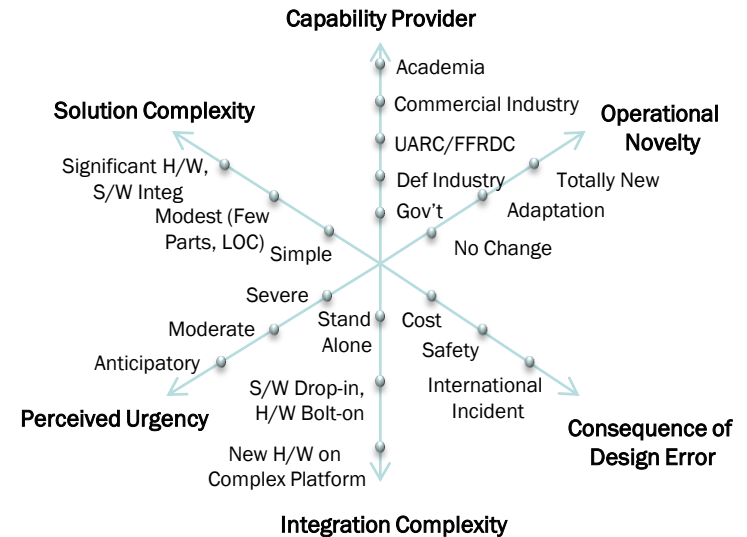


- Early, small execution strategy workshop
 - < 10 very seasoned people; < 4 hrs
- Qualitatively assess risk (technical, execution, acceptance)
- Consciously impose desired operational longevity
- Start from zero process and work up (not 5000 and work back)
- Hybrid of a la carte and “packaged strategies”
 - Review gates, personnel requirements
- Depend on judgment, not process
- Capture “packaged strategies” over time with honest assessment of utility/outcome

Commercial Industry Example...



...Unique DoD Rapid Capability Challenges





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