Systems Engineering for Rapid Capability Development

NDIA 12th Annual Systems Engineering Conference

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US Secretary of Defense Robert M. Gates:

The Department of Defense's conventional modernization programs seek a 99 percent solution over a period of years. Stability and counter-insurgency missions require 75 percent solutions over a period of months. The challenge is whether these two different paradigms can be made to coexist in the U.S. military's mindset and bureaucracy… The issue then becomes how to build this kind of innovative thinking and flexibility into the rigid procurement processes at home.

Robert M. Gates, "A Balanced Strategy, Reprogramming the Pentagon for a New Age," *Foreign Affairs*, January/February 2009

DSB Study on Fulfillment of Urgent Operational Needs:

- *All of DoD's needs cannot be met by the same acquisition processes*
- *"Rapid" is countercultural and will be undersupported in traditional organizations*
- *Any rapid response must be based on proven technology and robust manufacturing process*
- *Current approaches to implement rapid responses to urgent needs are not sustainable*
- *An integrated triage process is needed*
- *Institutional barriers – people, funding, and processes – are powerful inhibitors to successful rapid acquisition and fielding of new capabilities*

Report of the Defense Science Board Task Force on Fulfillment of Urgent Operational Needs, OSD/AT&L; July 2009

What we are Sharing Today

- **Rapid Capability Development is rooted in sound Systems Engineering**
- **There are Best Practices Proposed, Founded in Commercial Rapid Product Development**
- **Specific Metrics Can (& Must) be Applied**
- **Application to DoD Acquisition**
- **Practices Applied to Selected Case Studies**
- **Conclusions and Recommendations**

Prerequisites to Rapid

1. There is a business case
2. There is a vendor with a product portfolio
3. There is an organizational focus on rapid development
4. Product risk is manageable

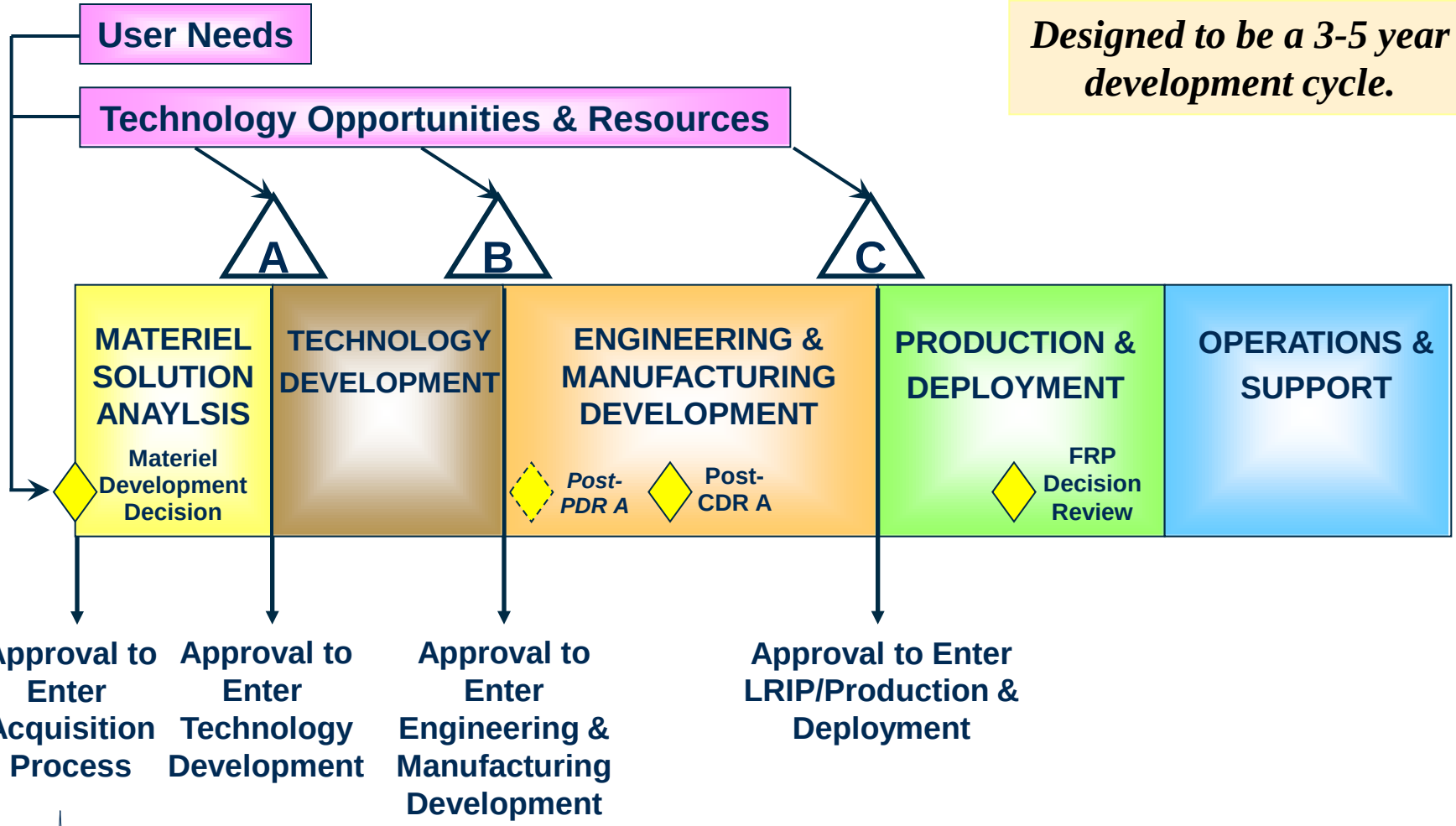
10 Best Practices for Rapid Development

1. Adhere to the Rapid Capability Development Lifecycle
2. Separate Technology Development and Product Development
3. Capture New Opportunities Frequently
4. Introduce New Capabilities as part of a System Architecture
5. Align Product (Customer) and Engineering Requirements
6. Product Scheduling Reflects Rapid Development
7. Use Risk Management Effectively
8. Organize in Teams to Operate More Rapidly
9. Incrementally Develop and Test
10. Use Fundamental Decision Metrics for Management of Rapid Development

1: Adhere to the Rapid Capability Development Lifecycle

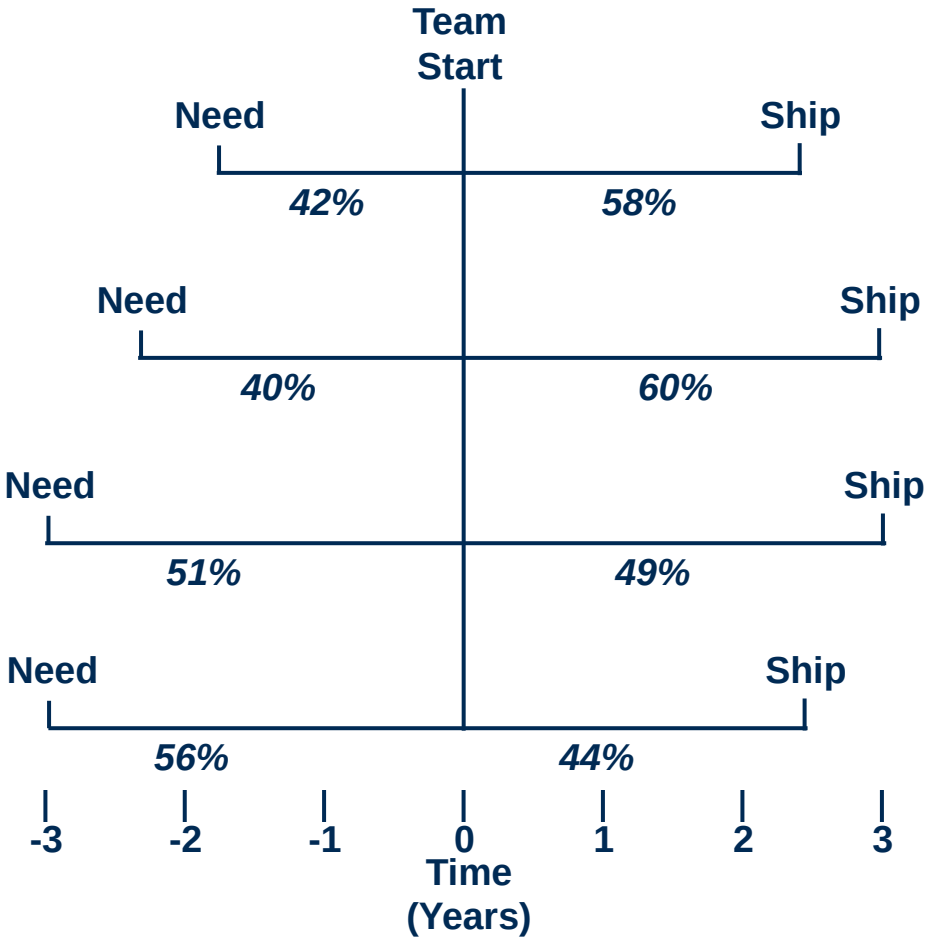
- Two fundamental rules for starting a rapid project:
  - Idea is matched to opportunity
  - Technology exists to implement the idea
- Lifecycle is driven by "time-to-market" as opposed to satisfaction of requirements
  - There is a time window to satisfy user need
  - If you cannot define a time window, there is no need to be rapid
- Rapid Capability Development begins with mature technology

DOD Systems Life Cycle Today
per the DoD 5000 Acquisition Model



Designed to be a 3-5 year development cycle.

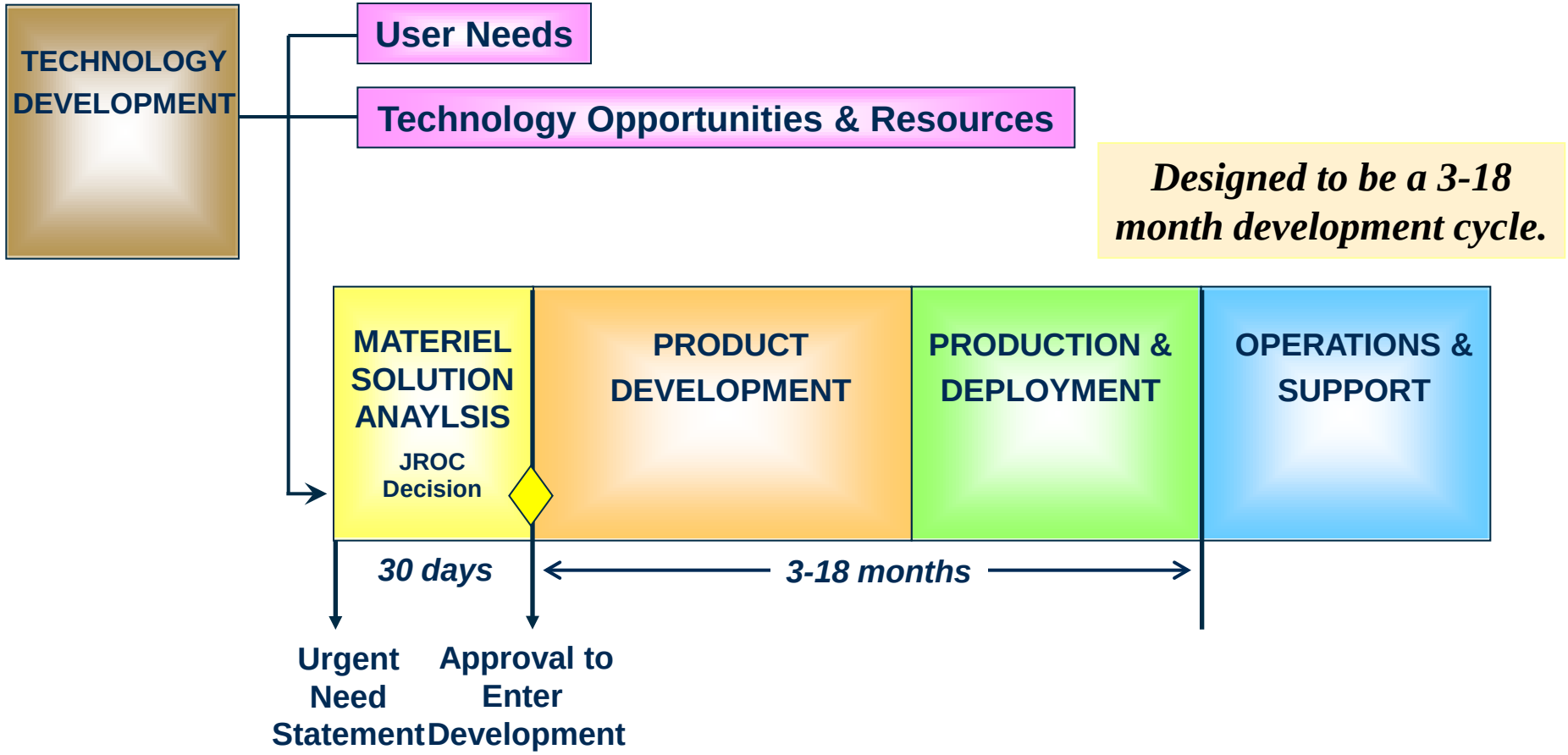
Saving Time in the "Fuzzy Front End"



- Understand and address project "cycle time"
- Best opportunity to save time is at the front end
- 1 week delay in starting has the same cost in market need as 1 week at the end
- Typically urgency increases as "burn rate" goes up
- As a result, urgency ends up highest when the market need is decreasing

page 51, figure 3-1; Smith, Preston and Reinertson, Donald; Developing Products in Half the Time, 2nd Edition; John Wiley and Sons, 1998

Rapid Capability Development Life Cycle
tied to Joint Urgent Operational Needs

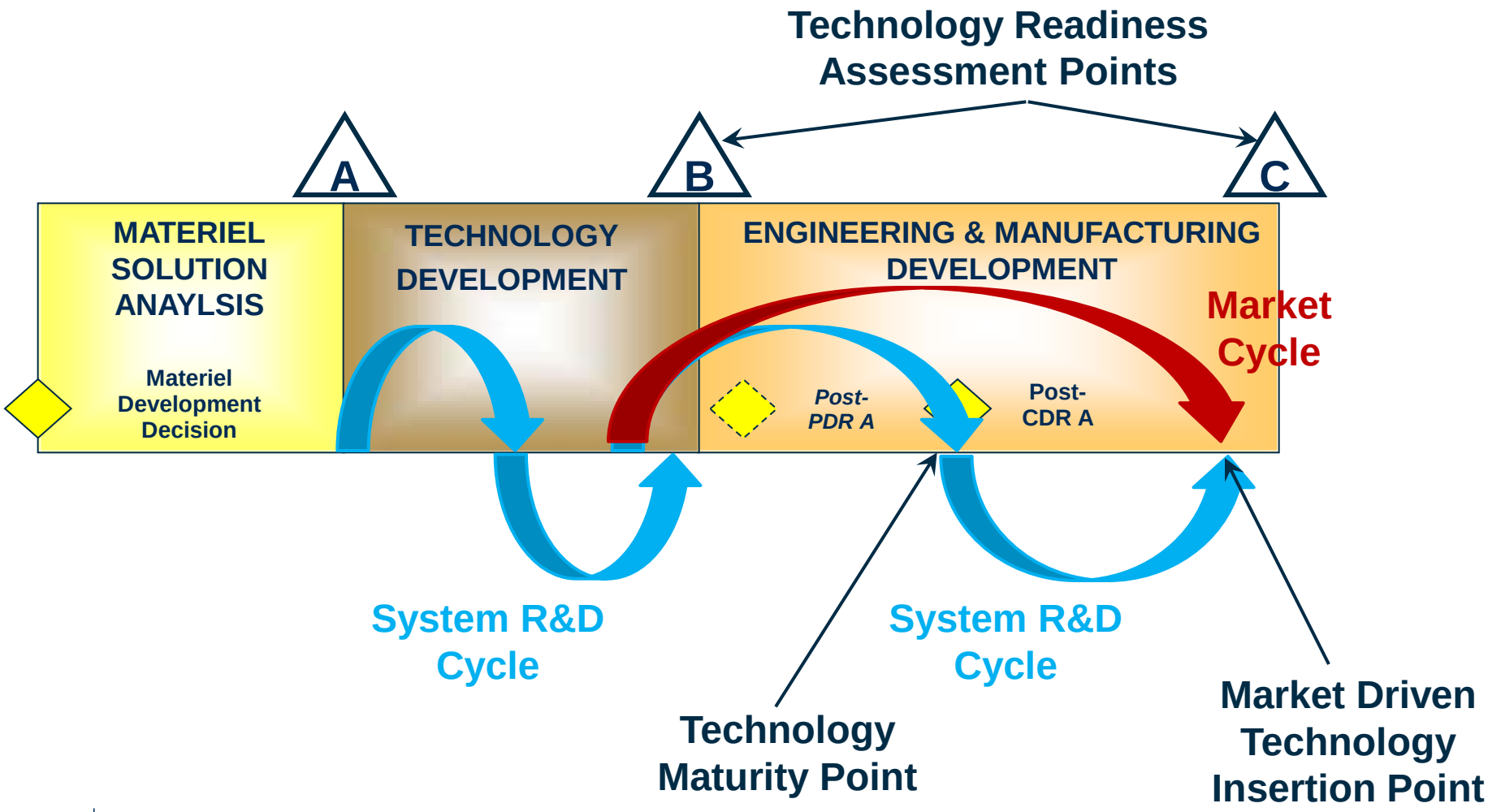


Chairman of the Joint Chiefs of Staff instruction CJCSI 3470.01, Rapid Validation and Resourcing of Joint Urgent Operational Needs (JUONS) in the Year of Execution, 15 July 2005

Technology Insertion Planning

- **Technology Maturity is the fundamental factor in most schedule delay**
- **Technology development brings uncertainty and undermines schedule accountability**
- **To be rapid, technology must be developed outside of the project**
- **Technology readiness assessment is a necessary decision process**

Technology Insertion in a Typical Development



Rapid Capability Development Life Cycle
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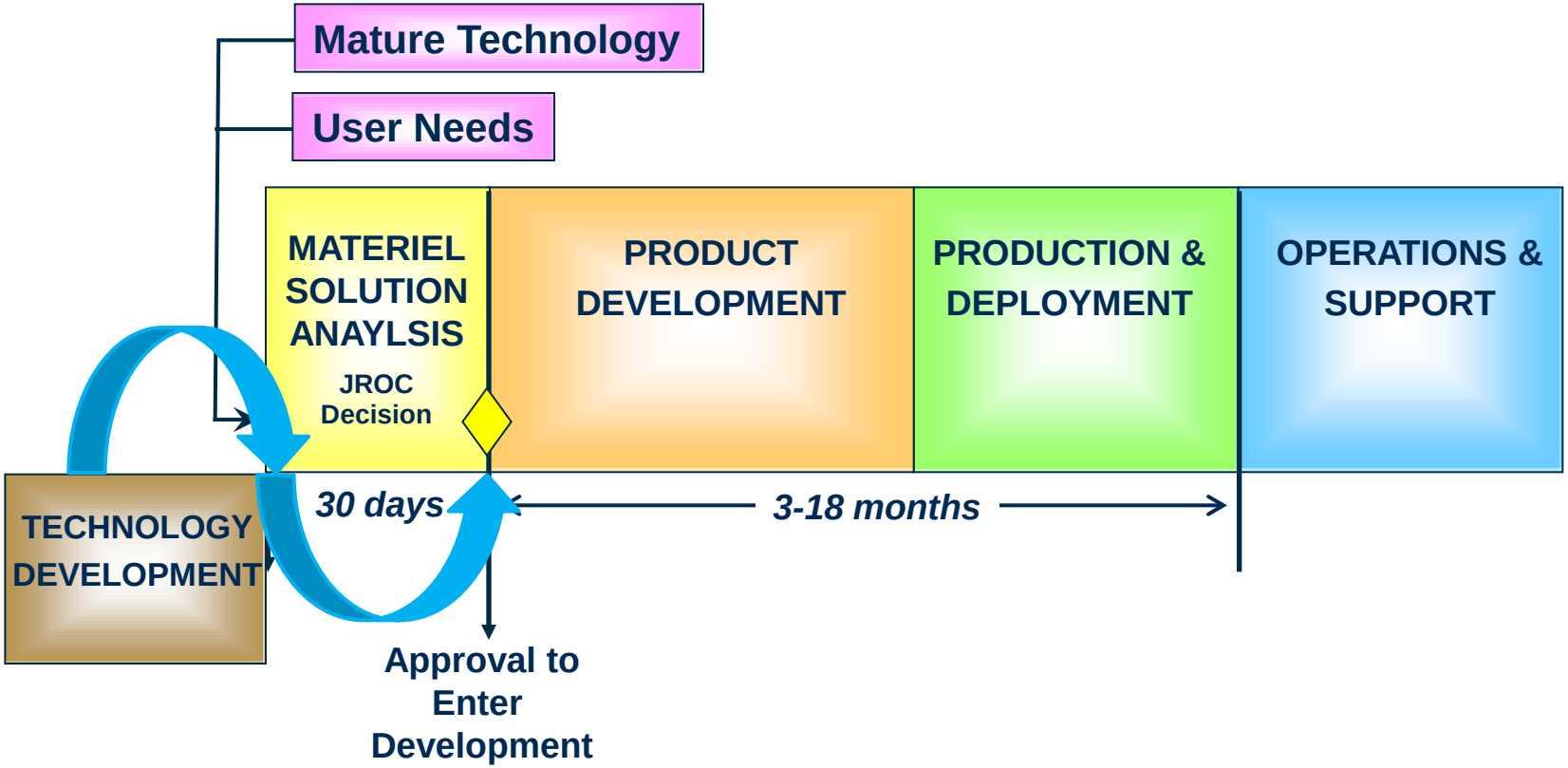
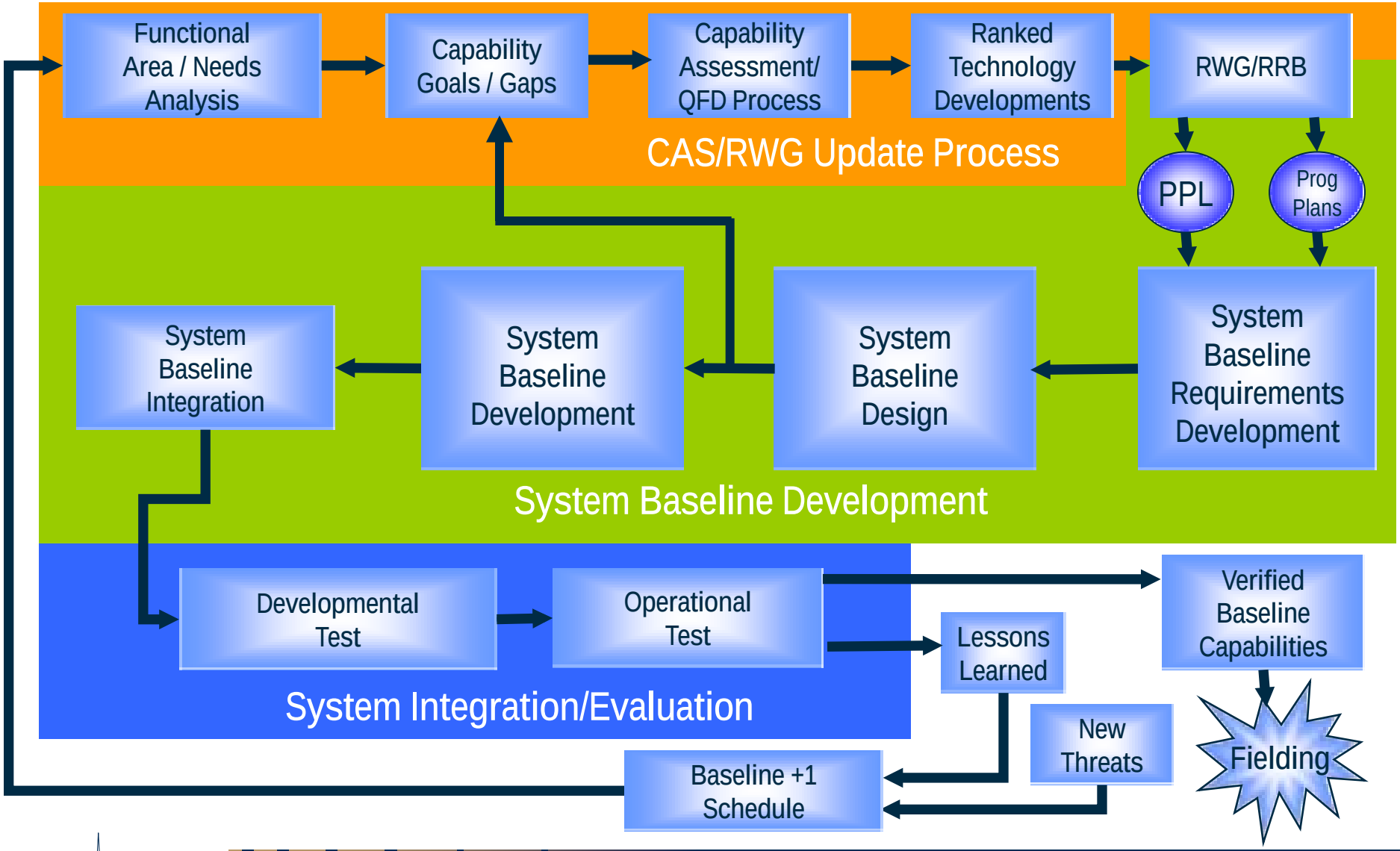


2: Separate Technology Development and Product Development

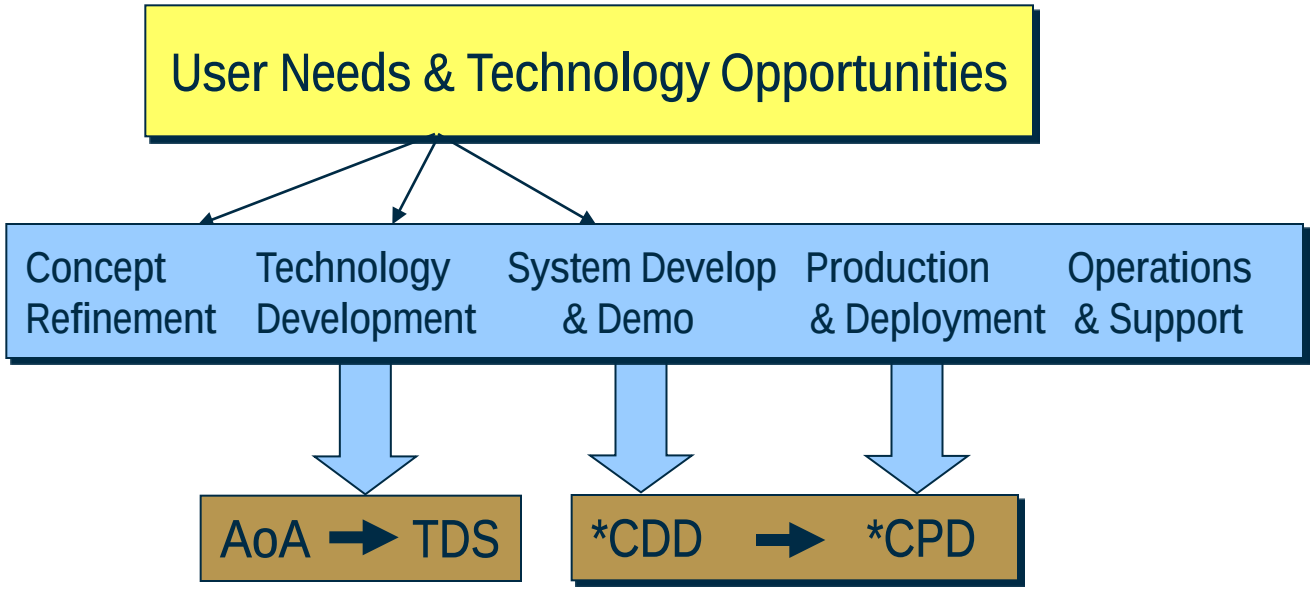
- **Technology development is organizationally separated from product development**
- ***Technology development or acquisition is driven by needs of a product portfolio***
- ***The technology development organization is separately and consistently funded***
- **Effective technology transfer moves the technologists into the product team, then returns them**
  - **Side benefit: improves technology organization's understanding of product portfolio and customers**

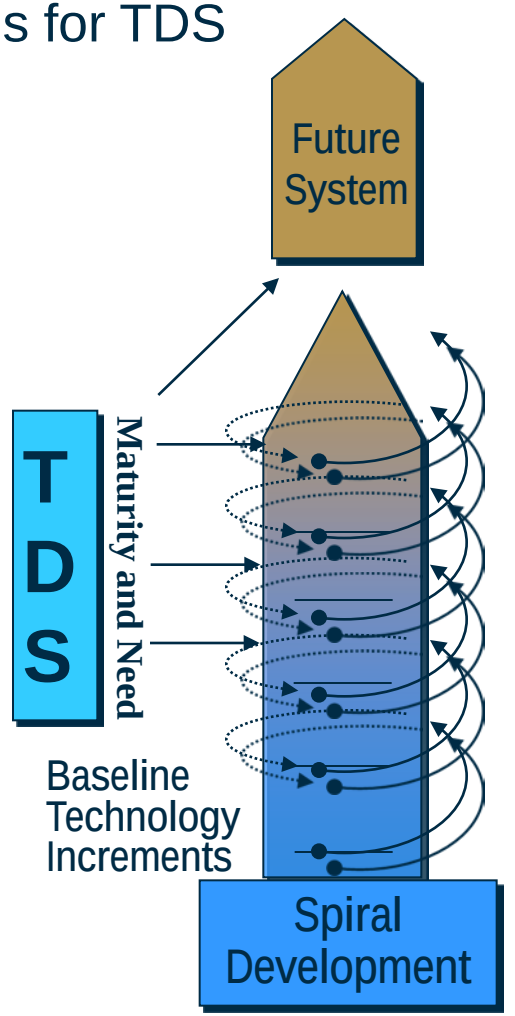
Air Force Big Safari Portfolio Baseline Process



Air Force Big Safari Technology Development Strategy (TDS)

- Analysis of Alternatives refines concept, provides basis for TDS
- TDS focuses technology efforts and feeds Baselines to optimize capability evolution

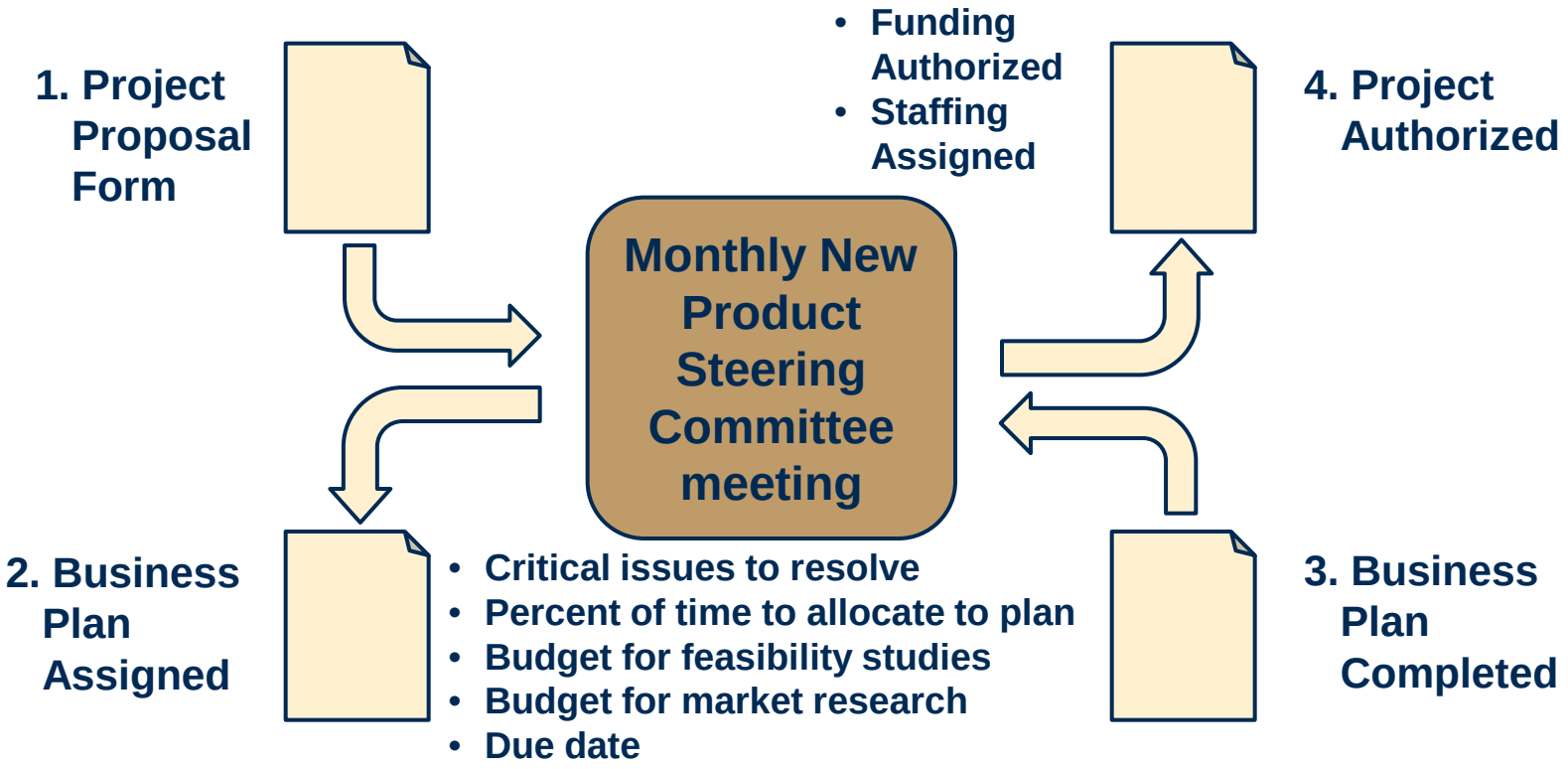




Reference:
- Defense Acquisition Management Framework (DoDI 5000.2)
- CJCSM 317 0.01A, CJCSI 3170.01d

3: Rapid Development Organizations Capture New Opportunities Frequently

- **Assign stable funding lines to product portfolios, regularly collect and review fundable opportunities.**



page 64, figure 3-5; Smith, Preston and Reinertson, Donald; Developing Products in Half the Time, 2nd Edition; John Wiley and Sons, 1998

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Different ways to do business with DoD

4. System Defined as a Product Architecture

- **Solid architecture definition allows:**
  - **a looser coupling of designs and technologies**
  - **more concurrent tasks to be scheduled**
  - **incremental development and delivery**
- **Designate a system architect and recognize architecture as a primary management tool, not an engineering design**

5. Align Engineering and Product Requirements

- ***One spec for product forces agreement up front by user, acquirer, and developer***
- **Gain clear alignment of user need and available technology**
  - **Use QFD to assess alternatives of need versus technology**

6. Project Scheduling Reflects Rapid Development

- **Keep a critical path mindset, let schedule be the primary goal**
- **Develop measures and triggers to allow next stage activities to proceed. Overlap activities and start on design triggers not completion of previous activity**
- ***Do not delay development on formal stage gates, consider periodic reviews instead or milestone reviews***
- **Use incremental prototyping wherever possible (spiral development for SW)**
- **Detailed planning is essential, but keep schedule status at a higher level. Adapt EVMS to key completion points or activities and not a rollup of detailed work packages. Shift focus of schedule control to lower levels**
- ***Adapt metrics focused on speed of progress (i.e. time to release eng'g, not #eng'g releases)***

7. Exercise Risk Management

- **Assume risk only where it provides an advantage toward customer need**
- ***Projects that concentrate risk in one area generally achieve faster development times that those that distribute risk broadly***
- **Tie risk to the project decision rules**
- **Balance technical and market risk, or technical and operational risk in the DoD case**
- **In areas with significant unknowns, model and test**

8. Teams Operate More Rapidly

- **Do real integrated product development – organize around physical or logical subsystems, create cross-functional design teams**
- **Organize teams for rapid communication, push decisions down where possible**
- **Co-location is important, particularly in early phases**

9: Incrementally Develop and Test

- **Concentrate risk within the system**
- **Strong system architecture**
- **Contract with a small set of target customers to pilot and mature the design**
- **Integrated product development: consider DOTMLPF throughout the process**

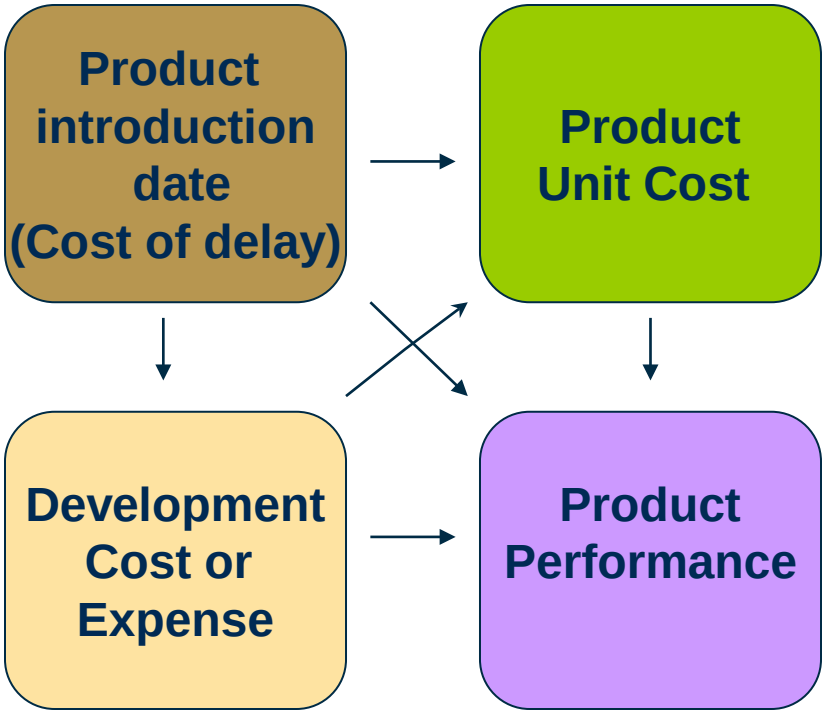
MRAP Lessons Learned:

1. ***Develop a long-term sustainment plan***
2. ***Integrate with existing vehicle programs***
3. ***Ensuring Best Value***
4. ***Competition***

Lewis, Ryan, A Case Study of the Mine Resistant Ambush Protected Vehicles (MRAPs), University of Maryland School of Public Policy, PUAF 699N: PPPE in National Defense, April 27, 2009

10: Decision Metrics for Management of Rapid Development

- **Business models will have sensitivities based on the following 4 objectives:**
  (Smith and Reinertsen, Developing Products in Half the Time)
  - **Market introduction date (project delivery date)**
  - **Product Performance**
    - **Includes Quality requirement**
  - **Product Unit Cost**
  - **Development Expense**



Four possible sensitivities yields six different tradeoffs

page 23, figure 2-1; Smith, Preston and Reinertson, Donald; Developing Products in Half the Time, 2nd Edition; John Wiley and Sons, 1998

Establish a Decision Metric for Rapid Development

- **Success of a rapid product development can be tied to an essential decision metric which can be used to develop decision rules for project trades**
- **“Time to market” can be defined by the decision metric as follows:**
  - **There is a knowable cost of delay that can be quantified by the decision metric.**
  - **The cost of delay can be used to trade schedule versus other objectives using decision rules.**
  - **Program management must consistently apply these decision rules.**

Establish a Decision Metric for Rapid Development

- **For commercial product development, decision metric is normally tied to profit**
- **For DoD acquisition, the JUONS Decision Process states:**
  - **“Could result in loss of life,”**
    “could endanger completion of a near term mission”
  - **Also recommend “innovate idea that could be a game changer and should be tried as soon as practical”**
- **Possible “Time to market” decision metrics:**
  - **Casualties per month (MRAP example).**
  - ***Targeted mission success goals (deployment times, etc.).***

Summary

1. Adhere to the Rapid Capability Development Lifecycle
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2. Defense Science Board, Report of the Defense Science Board Task Force on Fulfillment of Urgent Operational Needs, July 2009
3. Lewis, Ryan, A Case Study of the Mine Resistant Ambush Protected Vehicles (MRAPs), University of Maryland School of Public Policy, PUAF 699N: PPPE in National Defense, April 27, 2009
4. Smith, Preston and Reinertson, Donald; Developing Products in Half the Time, 2nd Edition; John Wiley and Sons, 1998