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Preparing to Be Wrong

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Challenge and Response

Uncertain future threats, operating environments, and fiscal constraints

DoD could minimize impacts of consequences by preparing to be wrong

This briefing focuses on defining, quantifying, analyzing, and embedding adaptability, flexibility, and responsiveness in weapon systems

Why Focus on Weapon Systems?

Long-gestation, long-lived assets whose design constraints are enduring

Can be rigorously analyzed and assessed, as they are subject to physical laws

Consistent with DoD's approach to capability development and acquisition

Working Definitions

Adaptability: a measure of the potential set of missions (or possible states within a mission space) that can be supported

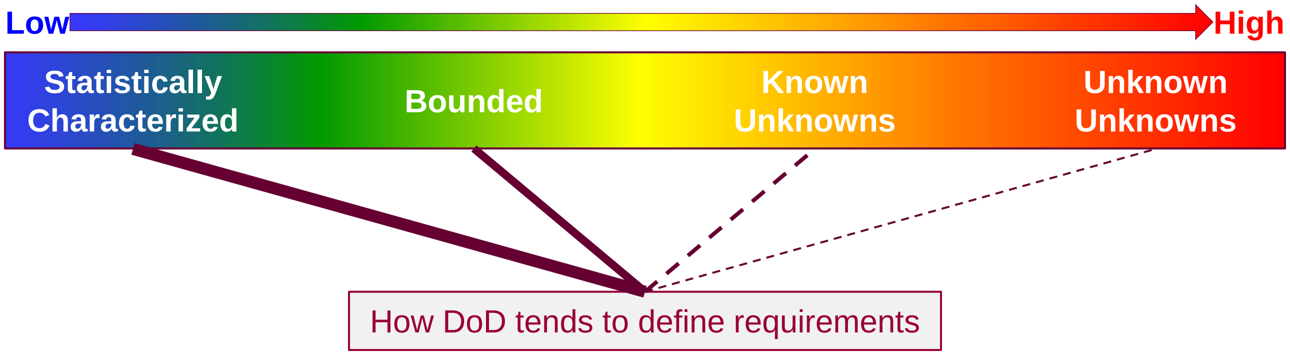
Flexibility: an inverse measure of the costs of adapting (effort, capability tradeoffs, and dollar costs) - the greater the costs to adapt, the less flexible the weapon system

Responsiveness: an inverse measure of the time required to adapt, i.e., transition within a mission space or between missions

These definitions are rigorous and quantifiable

Uncertainty and Requirements

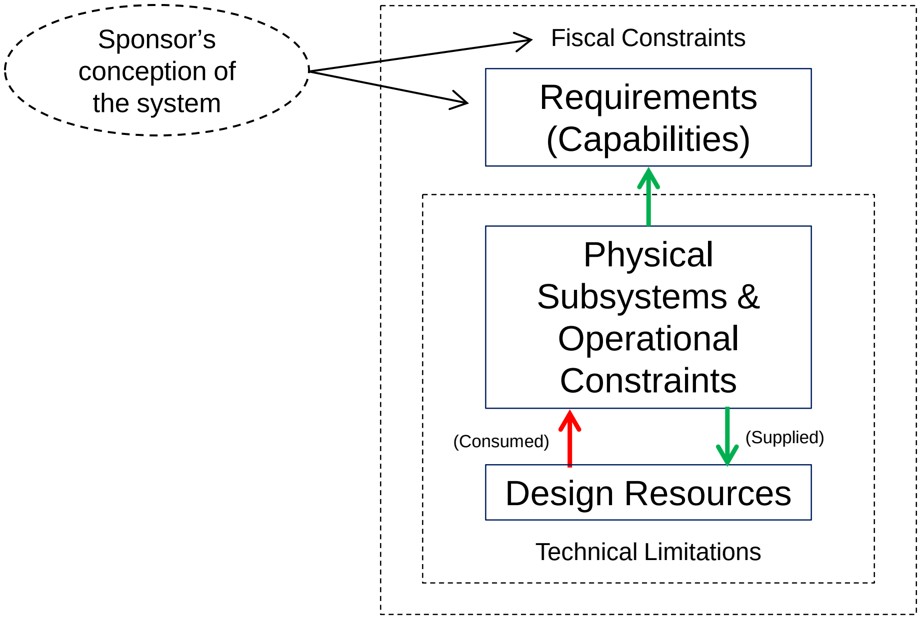
Uncertainty regarding future adversaries, capabilities, missions, and operational and fiscal environments



Framework for Analysis and Design

Identify a system's:

- Mission requirements
- Design resources
- Operational constraints
- Technical limitations
- Fiscal constraints
- Coupling of physical and engineering relationships



These factors comprehensively describe the system from user and technical perspectives

System capabilities depend on how design resources are consumed and supplied by physical subsystems and operational constraints (technical limitations) and are further bounded by fiscal constraints

The framework is used to identify existing and explore future embedded *design margins* that could support system adaptability

What About Standards?

Standards are a claim on design resources

Standards can provide “business” performance across multiple platforms/ enterprise

- Can be open or implicit

Standard has to be supported by sufficient design resources to accommodate future requirements

Physics-based Cost-Capability Tradespace Analysis: Nominal IFV - Optimized vs. Adaptable Design (1 of 2)

- Specific adaptability objective
  - Enable the vehicle to remain operationally effective in increased-threat environments (STANAG 4 – STANAG 5) while continuing to satisfy the performance objectives in Table 1
- Design approach
  - Vehicle structure/ suspension able to support growth up to 130K lbs. (C-17 op. constraint)
- Why this margin?
  - The *weight* design resource dominates the force protection requirement

Table 1: Performance Objectives and Technical Assumptions

Performance		Capabilities (Desired)	Design Resource	Analytical Implication
Force Protection	Ballistic	Trade space	Weight	Integral ballistic armor must be able to passively defeat ballistic threats.
	Explosive	Survive an X class of IED and a Y RPG	Weight	Supports 45 pounds/square foot (psf) of integral underbody armor and 95 psf of add-on EFP armor.
Passenger Capacity		9 pax	Volume (length)	Interior volume scales based on human factors and number of passengers (32 cubic ft/person and 450 lbs/person).
Full Spectrum	Weight	Desire system to be reliable	Weight	Structure, engine, transmission, etc. must be sized to support add-on EFP armor.
	Power	Increased exportable power	Power, Weight, Volume	Has a 50-horsepower generator for electrical power.
Mobility		Speed of X up a grade of Y	Weight, Volume	Uses an Abrams-like track and has 15 horsepower/ton of engine power up-armored. Uses currently producible armor materials, engines, etc.
Lethality		Lethal to a similar class of vehicles	Weight, Volume	Has a manned turret. Reserved 2.1 tons for non-armored turret weight and 120 cubic feet of volume. Also, 2.5 tons for ammunition and fuel.
Electronics and Sensors		Similar to Abrams and Bradley	Power, Cooling, Volume (internal)	Has sensors/electronics similar to Abrams and Bradley.
Transportability (Operational constraint)		Transportable by C-17	Weight restriction	Combat weight limited to 130,000 lbs and must fit inside compartment E of C-17.

Physics-based Cost-Capability Tradespace Analysis: Nominal IFV - Optimized vs. Adaptable Design (2 of 2)

- Adaptability: adaptable design (AD) superior to optimized design (OD) because it accommodates a larger range of threat environments without sacrificing performance objectives
- Flexibility: AD superior to OD at FP > STANAG 4 + 10% as nominal program costs are less
- Responsiveness: AD superior to OD as time required to upgrade is far less

Table 2: Performance and Relative 100th Unit Procurement Costs ($K of BY2012)

Operating Environment Force Protection Level Requirement	Opt. Vehicle Performance	Adapt. Vehicle Performance	Optimized Vehicle Cost, Δ Reference	Adaptable Vehicle Cost, Δ Reference
STANAG 4	Nominal	Nominal	Reference Cost	$900
STANAG 4 + 10% STANAG 5	Nominal	Nominal	$1,000 + RDT&E	$1,000
STANAG 4 + 20% STANAG 5	Nominal	Nominal	$1,800+RDT&E	$1,200
…				
STANAG 4 + 60% STANAG 5	Nominal	Nominal	$4,200+RDT&E	$1,800
STANAG 4 + 70% STANAG 5	System failure	Nominal	N/A	$2,000
…				
STANAG 5	System failure	Nominal	N/A	$2,400

Strategic Value vs. Tactical Cost

Strategic value of adaptable designs should not be calculated solely from “tactical” costs (nominal program costs)

Value (as with insurance) should be calculated based on contributions of designs in all possible futures; adaptability (and insurance) are justified by the value they bring when relevant events occur, not by their continual use

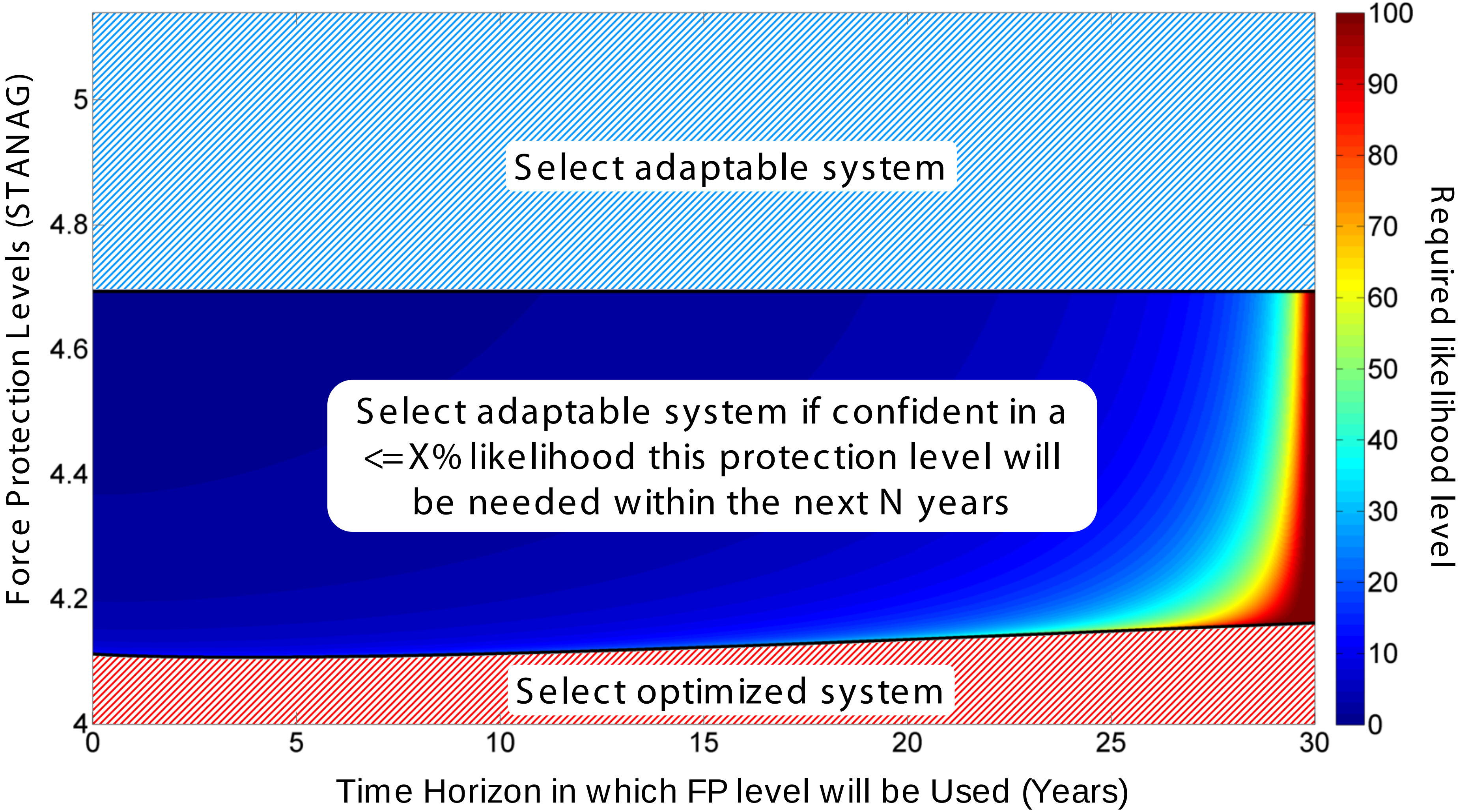
Relevant events, i.e., responding to emergent threats or opportunities, inevitably occur over a system’s service life

At the “right price,” we willingly buy insurance as a hedge against an uncertain future

How do decision makers decide what is a reasonable price to pay for adaptability to provide a hedge against an uncertain future?

Strategic Value Decision-Support Tool

Strategic value is quantifiable. It is a function of a decision maker's confidence in potential events occurring and the Present Values of competing systems at those events.



Conclusion

The planning challenges posed by uncertainties – threats, operating & fiscal environments – are unlikely to wane

Use trade space tools to rigorously quantify and asses the value of adaptability and design margin

Significant organizational challenges