IDA

When Does It Make Sense to Buy *That*?

The Business Case for "Optionally Manned"

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Acquisition Context: Rapidly Changing But Constrained Environments

Environments are challenged

"Everywhere" is a front

Moving from COIN to Great Power

Multiple adversaries

Distinct operating environments

Emerging technologies (e.g., drones, AI, quantum…)

But physics and economics have not changed that much,

so what are the trade-offs?

Operational community and Services have to consider multiple angles

Weapon system: What am I getting/giving up with manned, unmanned, or optionally manned?

- SWAP, environmental differences, etc. all factor in

Fleet level: Do I need mixed fleets to do my missions, or is an "average" multi-purpose system acceptable?

- Benefits of specialization vs. benefits of commonality
- Costs, fleet size, availability, adaptability, effectiveness, etc.

How do we go about assessing these issues ***before*** committing, so that leaders and operators can make informed decisions? Avoid lost time, credibility, and resources.

The Outline of an Approach:

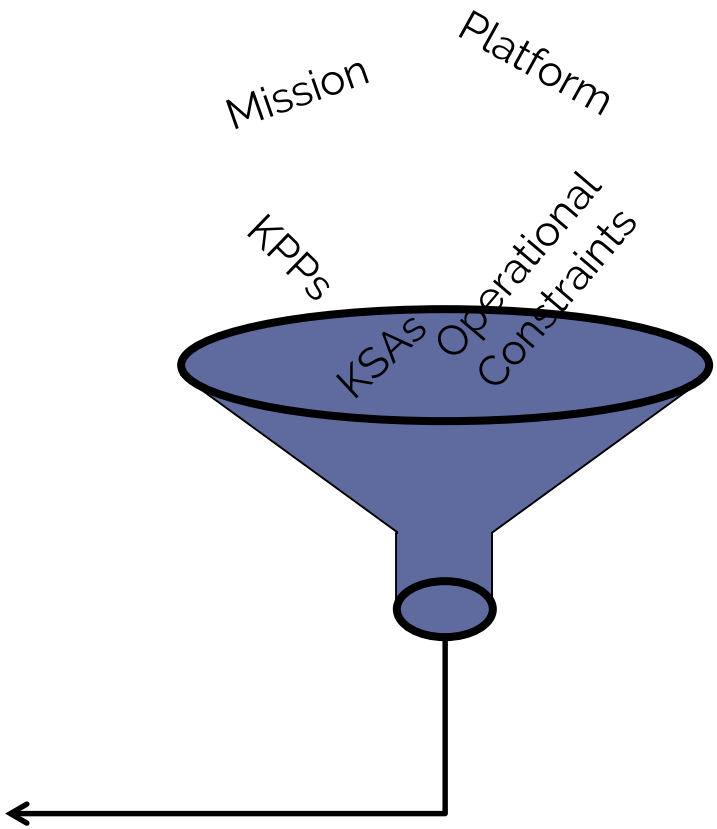
Select important capabilities that compete for resources

Establish relationships about how capabilities determine weapon system physical properties

Link resource analysis to physical properties of weapon system

Provide insights and trade space quantified in terms of physics, performance, measures of effectiveness, and resources

Focus on big drivers and decisions to illuminate potentially conflicting choices that have to be resolved to achieve a successful program



Illustrative Example: Infantry Fighting Vehicle

6 dismounts
Limited upgradability
~30 tons
C-17 transportable

9 dismounts
More armor & upgradable
<=65 tons
C-17 transportable

What is the effect of requirements choices on costs, feasibility, and mission?
(Interaction of requirements may produce unintended and undesired outcomes)

Defining the Weapon System: IFV Traceability Matrix

Performance		Specifications (Desires)	Analytical Implication
Force Protection	Ballistic	Trade space	Integral ballistic armor must be able to passively defeat ballistic threats.
	Explosive	Survive an X class of IED and a Y RPG	Supports 45 pounds/square foot (psf) of integral underbody armor and 95 psf of add-on EFP armor.
Passenger Capacity		Trade space	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	Structure, engine, transmission, etc. must be sized to support add-on EFP armor.
	Power	Increased exportable power	Has a 50-horsepower generator for electrical power.
Timing		Field system quickly	Uses currently producible armor materials, engines, etc.
Transportability		Transportable by C-17	IDA-defined combat weight limited to 130,000 lbs and must fit inside compartment E of C-17.
Mobility		Speed of X up a grade of Y	Uses an Abrams-like track and has 20 horsepower/ton of engine power.
Lethality		Lethal to a similar class of vehicles	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			Has sensors/electronics similar to Abrams and Bradley.
General			Includes other fixed vehicle components (e.g., wiring, bolts, weld material). Weight allocated to these types of items is 2.5 tons.

Technical assumptions are clearly documented and linked to capabilities

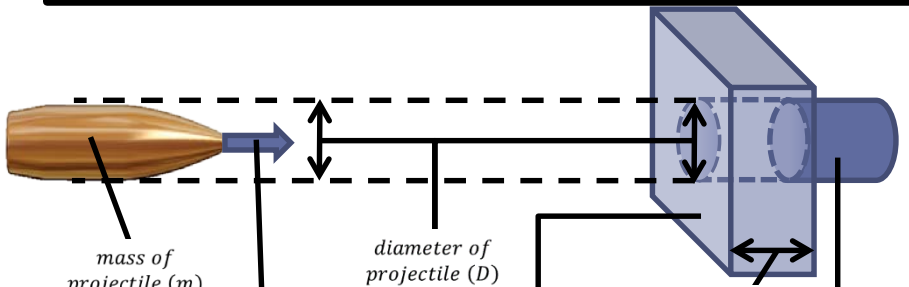
Defining the Weapon System: Cost Analysis

Cost Element	Description / Sources / Methodology
Hull/Frame	Cost estimating relationship depends on material type and weight. Assumed a buy-to-fly of 1.
Suspension, Engine, Transmission, Auxiliary Automotive, Integration, Assembly, Test, and Evaluation	Army Ground Vehicle Systems Bluebook (2006).
Add-on EFP armor	Estimated as cost per ton from budget data and publicly reported contract values.
Electronics/sensors	Estimated from President's Budget submissions for ground vehicle upgrade programs. Focused on sensors and electronic upgrades.
Contractor non-prime mission product cost elements	Estimated using historical contractor cost data reports. Applied as a multiplication factor on the prime mission product.
Support	Estimated using Selected Acquisition Reports. Applied as a factor on contractor costs.
Deflation/inflation rates and conversions	Joint Inflation Calculator (http://www.asafm.army.mil/offices/office.aspx?officecode=1400).

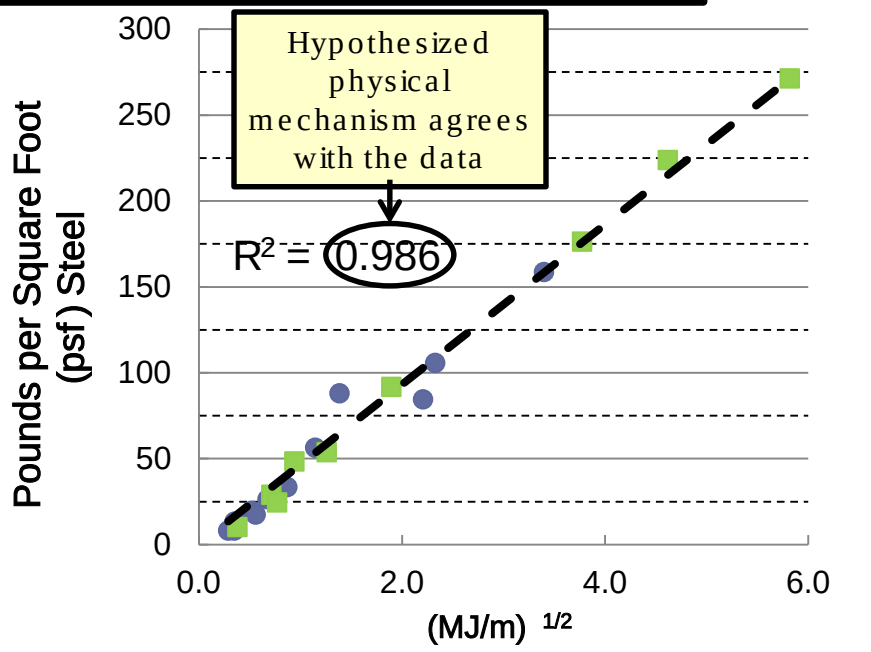
Data used in cost model is traceable

Defining the Weapon System: Armor-Defeating Ballistic Projectiles Analysis

Energy of threat projectile must be less than energy required to dislodge "plug of armor."



$$\frac{1}{2} m v^2 < D \tau \pi t^2 \frac{1}{2}$$

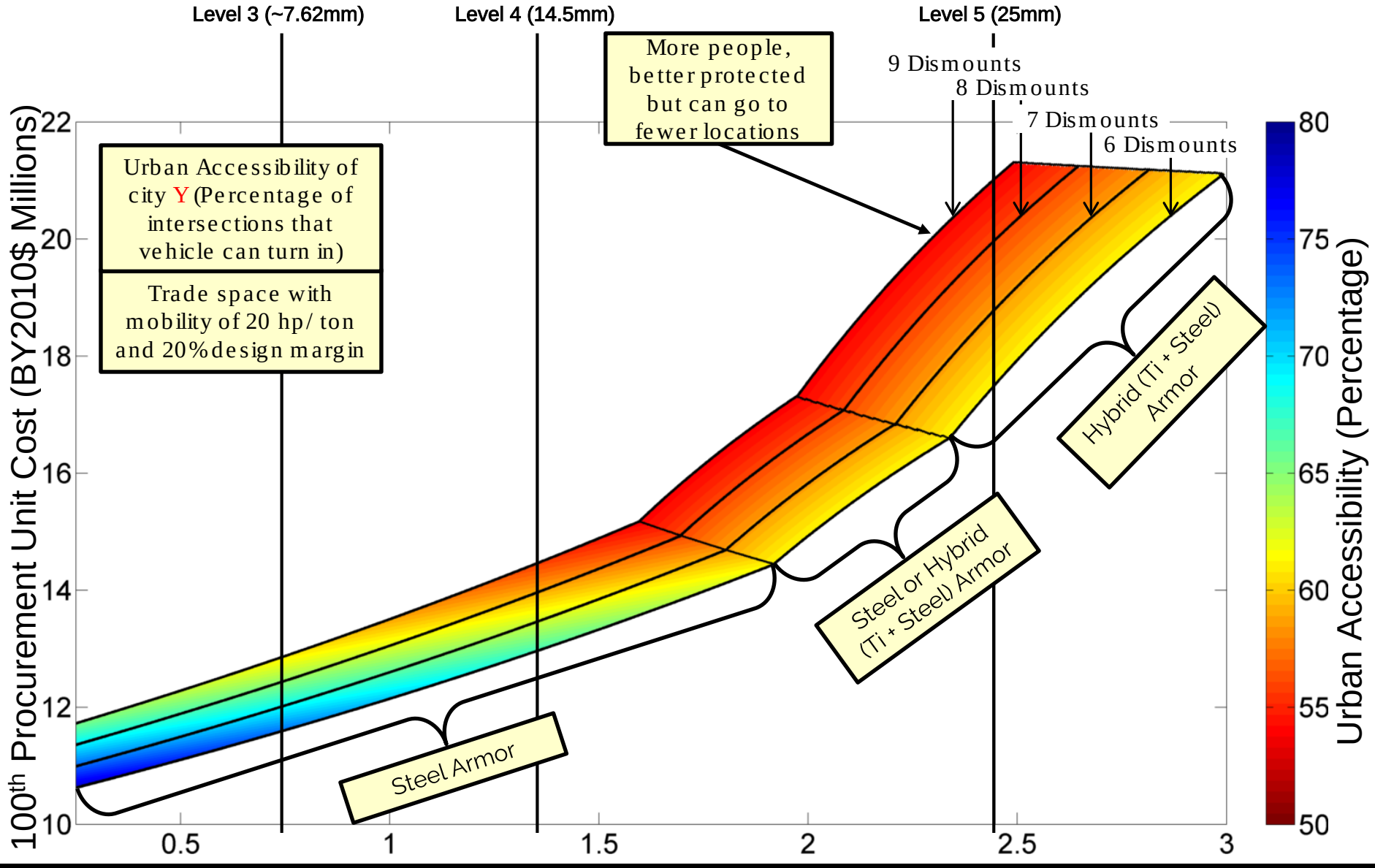


# of dismounts
# of crew
Turret type
Size of engine
etc.

$$\$ = F(Material, Thickness, Area, \ldots)$$

Armor cost estimate is an implicit function of the threat and other system capabilities

Example Cost-Capability IFV Decision Space



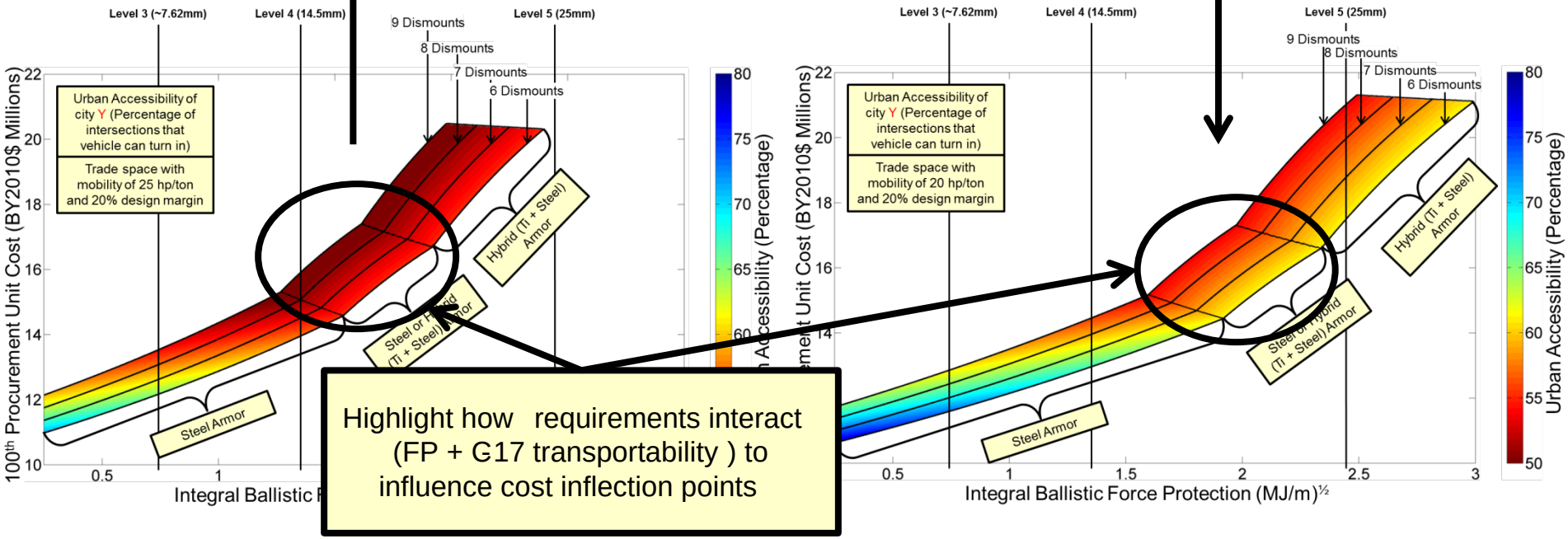
Multi -Dimensional Trade-Space Maps

Trade space for an infantry fighting vehicle with mobility of 25 hp/ton and 20% design margin

Trade space for an infantry fighting vehicle with mobility of 20 hp/ton and 20% design margin

Primary effect: Smaller engine

Secondary effects: More mass available to armor because of smaller engine and reduced engine compartment volume



Highlight how requirements interact (FP + G17 transportability) to influence cost inflection points

Creating cost -performance -effectiveness maps enables quick reaction capability

Thought Experiment "Optionally Manned"

DoD is already using remotely -piloted aircraft with limited autonomy, and is working on expanding that to other domains and enhanced autonomy enabled by artificial intelligence

When does an *optionally* manned design preferable?

What are the costs and benefits for optionally manned?

Consider the design rules laid out previously

Implications for “Optionally Manned”

Incurs full armor penalty for protection of humans

Incurs additional SWAP penalty for sensors, actuators, comms to support remote/autonomous operations (and a data support tail)

The design gets more complex – there is potential for sensors/actuators/etc. to interfere with manned operations

What is the envisioned use case?
When is a “pure” unmanned version dominant?
Is it worth the opportunity costs?

These trades can be quantified

Map the feasible limits early

Know what you are proposing to buy

Sanity check contractor estimates

Inform senior decision-makers about true opportunity costs