

*Analysis of a Meta - Trade Study Interpretation of Decision- Making
with a Value Proposition for Space Programs*

AIAA Space 2006

Space Economic Analysis

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Edward B. Rockower
Lockheed Martin Space Systems Company
Advanced Technology Center

Value of Space: The Challenge

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- n **"The Value Proposition for Space"**
 - "Space ... remains a new frontier whose value to humanity is still being discovered"
 - "... largely unrecognized by the majority of people"
 - Need to "... convey the importance of space"
 - "... identify the investments",
 - "... maximize space's value"... "prosperity for humanity"
- n **Not trying to *answer* the question**
 - Rather, define terms, usefully *reframe* the question
- n **Use Trade Studies as model**
 - how to think about question; a guide, "organizing principle"
 - see it "fresh", where and how to *extend* Trade Studies
 - deal with scope of Space Value & Sustainability

"The greatest challenge to any thinker is stating the problem in a way that will allow a solution"
-- Bertrand Russell

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--Cast our net widely -- Analyze it from the ground up, start from Basics -- Credo: "when tackling a very complex, even speculative subject, begin by being very conservative in the approach, use well-known, proven Methods *at first!*"

"Space ... economics is crucial to ... intelligent decision making"

-- why is determination & recognition of value so difficult?

-- how might we deal with that difficulty?

-- How to more completely & persuasively Value & Market Space Program?

Trade Studies as Operations Research Decision Analysis "where the rubber meets the road", familiar, practical, effective

Begin by reframing the Problem (cf. Drawing Class exercise, copy upside-down picture of face to really "see" it ⇒ better proportions, better drawing)

My method of teaching problem solving in undergrad & graduate Physics & OR courses:

⇒ Avoid getting wrapped around the axle by trying to solve problem prematurely

⇒ First, translate the verbal problem into symbols, equations, figures, and diagrams ("mechanically", w/o prejudice regarding how to solve it)

⇒ Manipulate the symbols, equations, diagrams: "See" the problem in "Transformed Space", look for connections, patterns, new insights

⇒ Similar to Fourier Transform Space.... A very difficult problem may become easy to solve in Transform Space

⇒ I always solved problems using this method, always emphasized this was most important part of course ("how to solve problems")

⇒ Made me sweat a few times to solve problems in front of class using this method... but the method never failed!

Value Proposition, elements

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n An ostensibly provable *proposal* for a suggested course of action

- Justified by a specific Value to the customer

n Focus on customers (stakeholders)

- Sell benefits and value *for* the customer, not products
- Promises, if you buy “A” you’ll receive “B” in value.



n Suggested template for a Value Proposition

– 1st sentence: identify

- a) target customer,
- b) their wants and needs,
- c) description of product or service,
- d) statement of benefit.



– 2nd sentence (“positioning statement”): describe

- e) primary alternative products or services, and show
- f) how our product is differentiated from, and presumably better than, the competing alternatives.



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MIT Sloan School of Management

•“The conventional wisdom is to put the focus on your product, when the real source of profitability in a networked economy is to develop better value propositions for your customers.”

•“To survive and prosper today, you must shift your attention from products to customers”

•“delivering a value proposition that places the customer at the center of your strategy”

A Trade Study Process

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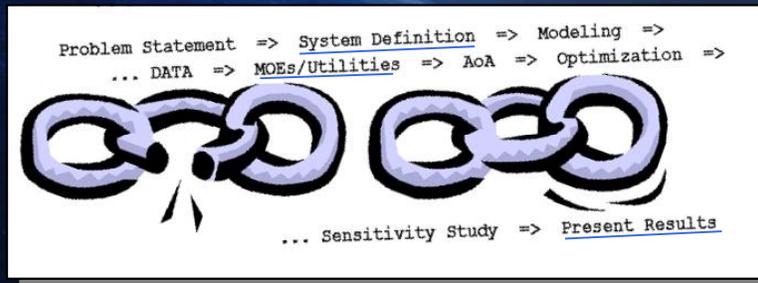
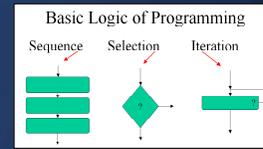
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n A "Trade Study Process"

- A Process for Decision Analysis
- Suggested simple, coherent Process
- Easy to visualize and remember
- Elements combined with sequence, selection, iteration ⇒ arbitrarily complex TS Planning



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"Chain is no stronger than its weakest link"

We suggest "elements" of a simple, coherent Trade Study Process that is easy to visualize and easy to remember (order of execution may vary)

- inevitable embellishments of convoluted logic from Sequence, Selection, & Iteration
- The actual execution of the Trade Study will necessarily proceed in an iterative, spiral development fashion as new information and better understanding is gained from prior steps in the process
- emphasize the importance of the initial setting up of the Trade Study so as to 1) agree within the team and with the customer(s) as to the Problem Statement, and 2) not limit ourselves by prematurely trying to solve the problem without adequately defining the problem, the relevant "System", the Measures of Effectiveness, and our modeling of the agreed upon system. We resist the urge to "premature closure". The importance of a coherent process increased by the fact that we're typically dealing with highly complex systems, in a complex and political world, with many unknowns and probabilities that must be handled.
- avoid "Errors of the 3rd Kind" (solving the wrong problem, precisely)

Map "Value Proposition" to Elements in Trade Study Report

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- Suggestion: relate Trade Study Report ⇔ Value Proposition.
- Map Value Proposition template to elements in a "Meta – Trade Study" as follows:

Value Proposition Template	Mapping to Trade Study Elements
a) target customer(s)	identifies entire spectrum of stakeholders & customers, including Decision Makers (DMS).
b) customers' wants and needs	complex hierarchy of MOE's for all stakeholders that quantify relative desirability (or utility) of outcomes from developing and using System, product, or service; includes weightings of benefits and stakeholders' interests and priorities
c) description of product or service	Models, Data, Drawings, pictures, and operation of the System, product or service
d) statement of the benefit	quantitative values of MOE's along with sensitivity studies from optimization or Analysis of Alternatives (AoA), showing our System, product, or service meets stated requirements, and is better than the alternatives
"positioning statement"	
e) primary alternative product(s) or service(s)	complete list of alternative products, the extent of the Trade Space, including constraints on design parameters and resources
f) how product is differentiated from the competition	Analysis of near-optimal MOE's, tables and carpet plots, results of the AoA, sensitivity studies, and a robustness calculation for the optimal design solution (i.e. Risks that it will prove NOT feasible or NOT superior to the alternatives).

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We suggest that the **Trade Study Report** is related to the written and verbal communication of a **Value Proposition**. Value Proposition template maps to elements in a "Meta – Trade Study" as follows (**Note 3 elements we underlined**):

- a) => Identifies the entire spectrum of stakeholders and customers, including the Decision Makers.
- b) => The complex hierarchy of Measures of Effectiveness for all stakeholders that quantify the relative desirability (or utility) of outcomes from developing and using the System, product, or service. This includes the weightings of benefits and stakeholders' interests, and their priorities.
- c) => Models, Data, Drawings, pictures, and operation of the System, product or service.
- d) => The quantitative values of the MOE's along with the sensitivity studies from optimization or Analysis of Alternatives (AoA), showing that our System, product, or service meets the stated requirements, and is better than the alternatives.
- e) => A complete list of alternative products, the extent of the Trade Space, including constraints on design parameters and resources.
- f) => Analysis of the near-optimal MOE's, tables and carpet plots, results of the AoA, sensitivity studies, and a robustness calculation for the optimal design solution (i.e. Risks that it will prove NOT feasible or NOT superior to the alternatives).

Leverage the Suggested Mapping

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- Pick apart concepts, issues, and problems
- Use resulting Meta- Trade Study to inform our planning
 - Follow where it leads
- Emphasize elements significantly different for Space Program
 - System Definition, MOE's/Utilities, "Present Results"
- Many, in a sense, non-standard considerations
 - Probably well-known
 - Considered *implicitly* in most engineering Trade Studies
 - Psychology, Marketing, Myth, Entertainment
 - Nonlinear, Network interactions

"It is the theory that decides what can be observed."
-- Albert Einstein

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Leverage Mapping to:

- Aid our thinking, investigation
 - Help to more fully identify, even quantify values
 - Better communicate the Benefits, Story, & Vision
-
- Force us to *explicitly* and scientifically deal with the marketing, political, psychological aspects that are now dynamical parts of the System
 - Nobel Prize winner in Physics, I. I. Rabi: "If I've been able to accomplish more than others, it's because I've been able to maintain fuzzy thinking longer"
 - Cf. "System Dynamics", explicitly include all important factors in quantitative and diagrammatic analyses

Trade Study Process Step: "System Identification"

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- Consciously choose:
 - What's inside System, endogenous variables
 - What's outside, exogenous variables
 - What's available to dial-in optimum System Performance, decision variables
- Prefer tightest System definition
 - Would allow use of sharpest tools
 - That luxury is denied us
 - Forced out of our comfort zones
- Vision not just about Space Program
 - Rather, it's part of System
 - Ditto: Values, Group Identification, Stakeholders

When we try to pick out anything by itself, we find it hitched to everything else in the Universe.
-- John Muir

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--"Loose coupling" of subsystems would allow us to simplify our problems, whereas "tight coupling" often makes our job harder.

--"Systems theory focuses on organization and interdependence of relationships"

-- The Stakeholders, especially the Public, are heavily influenced by the Vision. Hence *previously predetermined* factors such as desirability/utility curves, goals, and group identifications may change, preferences and priorities may evolve

è param's used in evaluation of MOE's and utility no longer just "about the System", but included *in the dynamical System*.

è Stakeholders are more dynamically *inside* the System, not just outside and using the system, or merely reaping the benefits of the system.

Trade Study Process Step: "MOEs/Utilities"

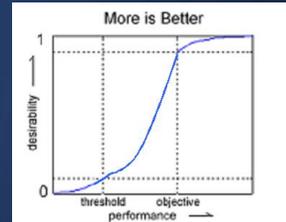
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- n Who cares -- how much do they care
- n What metrics/costs/performance-parameters are of interest
- n What are the units of measure of performance/cost
- n What is the "Threshold" and "Objective" specified
- n What is the "desirability" at "Threshold"
 - Minimum acceptable performance value
- è Affordability as customer defines it
- n Different stakeholders may have different utilities, weightings, goals



Risk averse individuals è risk neutral or preferring in a group

"Happiness does not depend on outward things, but on the way we see them".
-- Leo Tolstoy

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Also "less is better" curves ... e.g. weight, RCS, Cost ...

Concave downward è risk averse; concave upward is risk preferring

Note the stakeholder is risk preferring near threshold, and risk averse near the 'objective'

Note: increased group identification è possibly less risk averse, maybe even risk neutral or preferring near objective

-- A cynic is a man who knows the price of everything and the value of nothing.

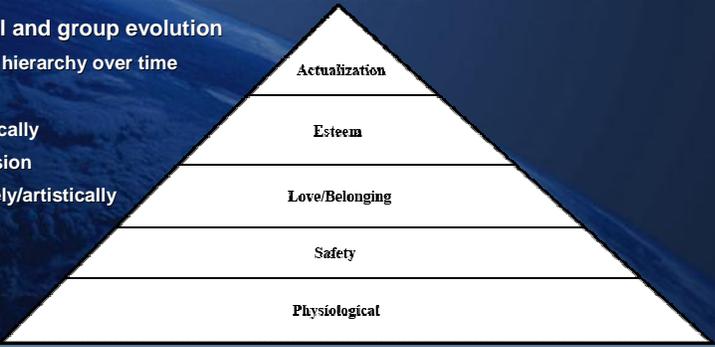
-Oscar Wilde

Stakeholders as truly part of the Dynamical System

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- n Public Engagement, Many diverse constituencies, multi-generational
- n Sustainability over many decades
 - Look at, but also beyond immediate economic and political needs
 - *Additionally*, consider deep, lasting motivations (basic human archetypes)
- n Maslow's hierarchy of needs:
 - Each layer takes precedence over the layer above it;
 - a need does not become *salient* until the needs below it are met.
- n Factor in individual and group evolution
 - Up and down the hierarchy over time
 - Determine Value
 - è Analytically
 - Communicate Vision
 - è Intuitively/artistically



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Considerations of System Def'n, MOE's, Long time scale, and Large, heterogeneous Stakeholders è consider *usually implicit Values of Humans*

What needs, and wants, will endure over decades?

Lower to Upper needs in hierarchy:

- physiological - immediate survival of the individual
- safety – continuing, future survival
- Love/belonging - Enabler of Health/identity of the Community
- Esteem, Actualization – commitment to, focus on 'Self' as contributor to Community (future-oriented?)

• Myth, Basic Human Archetypes

- Joseph Campbell "Hero with a thousand faces"
- screenwriters guide by Vogler, books, etc.
- George Lucas' "Star Wars" movies (consciously, intentionally used "Hero" book; credited Joseph Campbell)

Evaluate Emergent Benefits

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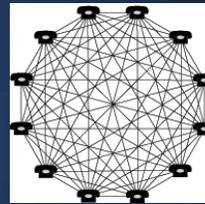
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n “Network Effect” (Metcalfe’s Law or Reed’s Law)

- Internet economy
- Long-tailed distributions, Zipf’s Law



n “Friction- Free Economy”

- “Increasing Returns” (not “diminishing returns”)
- Encourages risk-taking (cf. concave upward desirability curves)

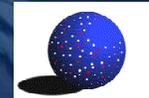
n Horizontal Integration

n Nonlinear, positive feedback effects



n Stimulating National and Global Economies

- Increased Global arbitrage
- Economies of scale
- Possible “tipping point” into more productive, Global identity?



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Large System ⇒ additional Benefits from Enhanced interconnectivity, Horizontal Integration, positive and negative feedback loops...

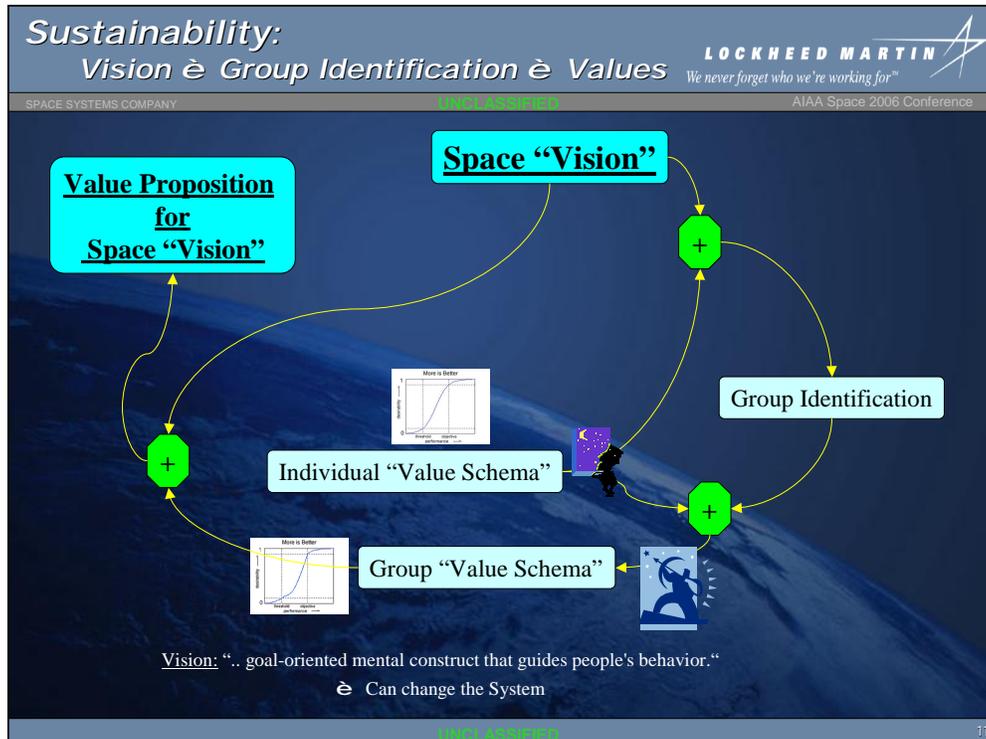
How to quantify these potential benefits and effects?

Suggest a list of thesis topics for investigation?

Too many important and large scale benefits to shrink from the fuzziness of the problems

⇒ Because the payoff from these effects is likely to be so great, we must address these very complex questions in spite of the fact that they are very difficult to answer definitively.

⇒ “The **Law of Unintended Consequences** holds that almost all human actions have at least one unintended consequence. In other words, each cause has more than one effect, including *unforeseen effects*.”



"Influence Diagram" ... **"SUSTAINABILITY"** -- A Vision can change the System, including the "Value Schemas" of individuals and groups (not just Parameter, or generic Endogenous Variable; but maybe also a "Decision Variable")

-- risk averse individuals may become less so, or even risk neutral or preferring (cf other slide)

--Maslow's later Hierarchy included the need to know, understand, and transcend one's individual needs through connecting to something beyond oneself.

--Extend the calculation and Hierarchy of MOE's to include dynamic desirability curves, value of Vision, values from Maslow's hierarchy

--"Vision is a picture of the future for which people are willing to work"

--Sun Tzu *the Art of War* "He will win whose army is animated by the same spirit throughout all its ranks." (5 essentials for victory)

--Nanus (1992) maintains that the "right vision" has five characteristics:

- attracts commitment and energizes people,
- creates meaning in workers' lives,
- establishes a standard of excellence,
- bridges the present to the future, and
- transcends the status quo.

-- a vision inspires people to work to make it come true. It motivates people to join the campaign to realize the desired vision. A leader's efforts to develop a shared vision have been described as "bonding"

--visionary leadership is dynamic and involves a three stage continuum:

- an image of the desired future for the organization (vision) is
- communicated (shared), which serves to
- "empower those followers so that they can enact the vision."

•"with small men no **great thing** can really be **accomplished**". John Stuart Mill

**Trade Study Element:
"Present Results"**

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- n Foundation for *Proposing* the Value Proposition
- n Trade Study Final Report:
 - Auditable trail of analysis
 - Credibility of analysts, process, assumptions, methods, and data
 - Cognizant of audience backgrounds
 - Includes Political and Marketing considerations
- è Now, craft and present the *Value Proposition*
- n Media experts, storytellers to fully engage the Public, all stakeholders
 - Help create and communicate the Vision
 - Continually, over many decades
 - Weave Vision into images, symbols, and a powerful story
- n Yet, grounded in coherent, engineering Meta - Trade Study Process

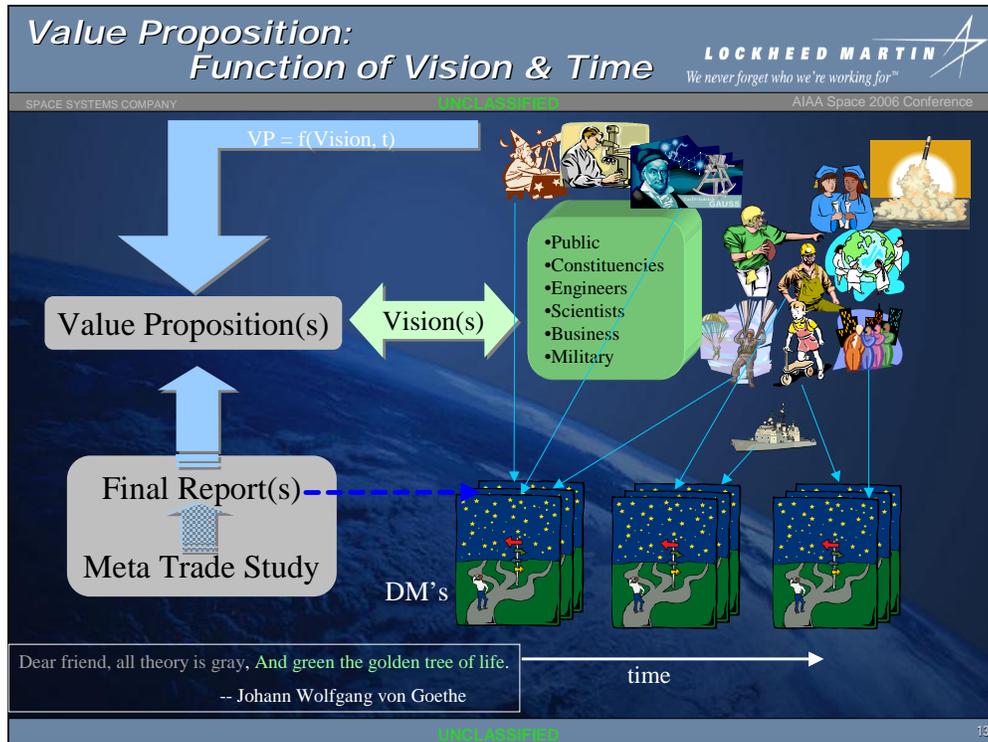
Just because you do not take an interest in politics doesn't mean politics won't take an interest in you.
-- Pericles (430 B.C.)

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Leaders, politicians communicate the Vision & helps to *market* Value Proposition, *based on* analysis in Meta-Trade Study, which itself *includes* the Vision, Public Engagement, and Sustainability as *dynamic variables* (including the Budget Process)

-- Emphasize that, although possibly in rather different forms, the Vision must be shared by all the stakeholders, no matter the level of technical, political, or business savvy

-- using elements of successful stories, movies, Myths, as well as fundamental human needs (Maslow's Hierarchy). (as George Lucas for help!)



Emphasize that this modeling, optimizing, planning, and envisioning Process is *highly organic*. *Organic* implies flexible, growing and changing, fraught with mistakes, recovering, constantly evolving. "Meaning" is important! (my own aphorism: "Power is the Meaning of the Outer World, Meaning is the Power of the Inner World", ebr 1993).

Study ... the art of science

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- n **Non-standard Trade Study Elements**
 - System Identification
 - MOE's/Utilities (Desirabilities)
 - Presenting Results
- n **Explicitly tackle the “imponderables”**
 - Along with usual Engineering MOE's
 - Include Vision, Archetypes, Stories
- n **Less precise methods**
 - May give higher accuracy
 - Enable quantifying human values?

*Study the science of art and the art of science.
Learn how to see and remember that everything is connected to everything else.
-- Leonardo da Vinci*

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We've presented one perspective on how to think about a Value Proposition for Space Programs using a Meta-Trade Study Process as a guide.

Following the Trade Study Process leads us to *explicitly* deal with seeming imponderables, although always implicit in engineering, marketing, etc. we're forced to confront them and map out a program of investigation because *here* they cannot be avoided without missing the essential elements of sustainability, Vision, and continuing Public engagement.

--to deal with the Real-world Challenge, accurately, must explicitly analyze and synthesize the full domain of the System.

-- if our comfort zone looks like ... (circle), then need to expand personal comfort zone AND add needed skills/personnel to our analysis and communication Team.

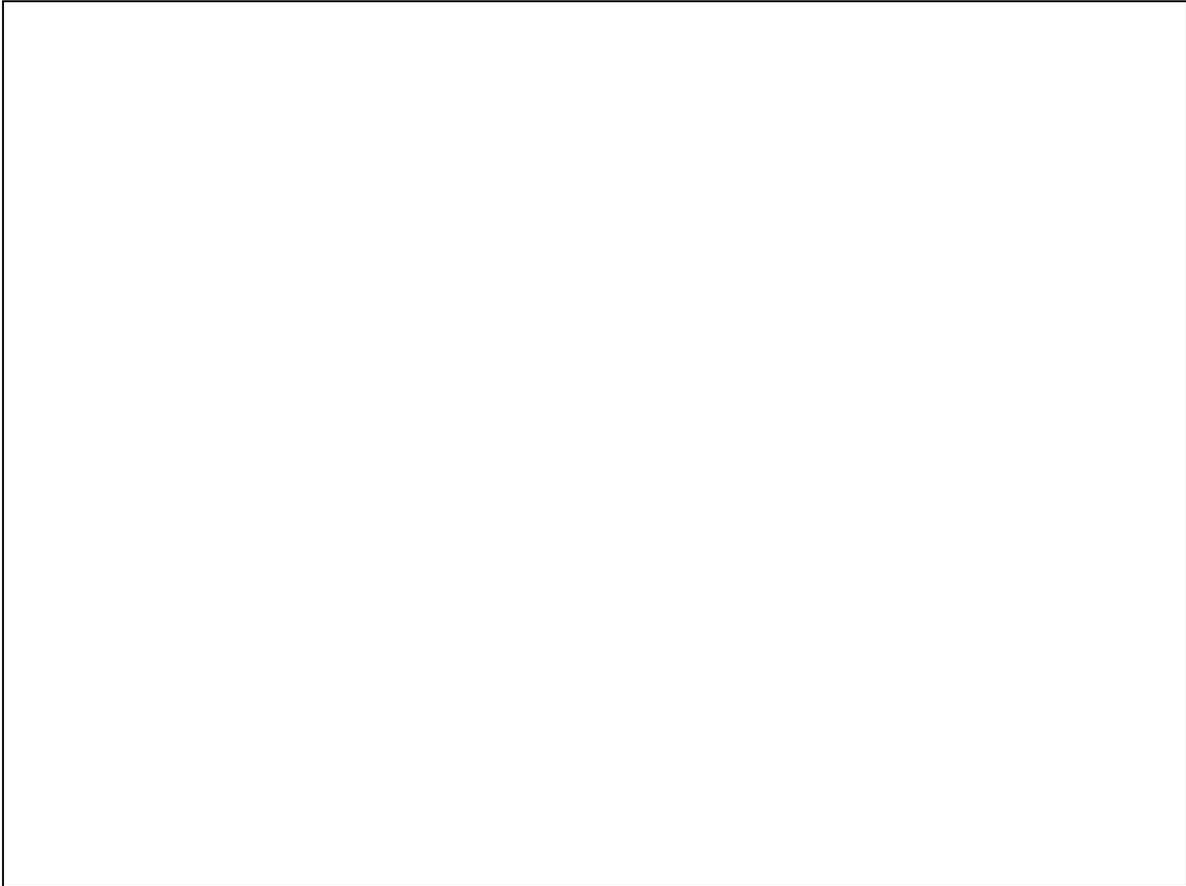
--'if you want to foretell the future' (or know what people will do), think in terms of basic human archetypes

"a myth is a story that never happened but was always true" Joseph Campbell (vision, myth, hero, ...)

--"... the shortest distance between truth and a human being is a story." Anthony de Mello



Backup Slides



Map Value Proposition ç è Trade Study

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