2nd International Conference on Operations Research and Enterprise Systems (ICORES) 2013
Barcelona, Spain

"Transforming a Complex, Global Organization: Operations Research and Management Innovation for the US Army's Materiel Enterprise"

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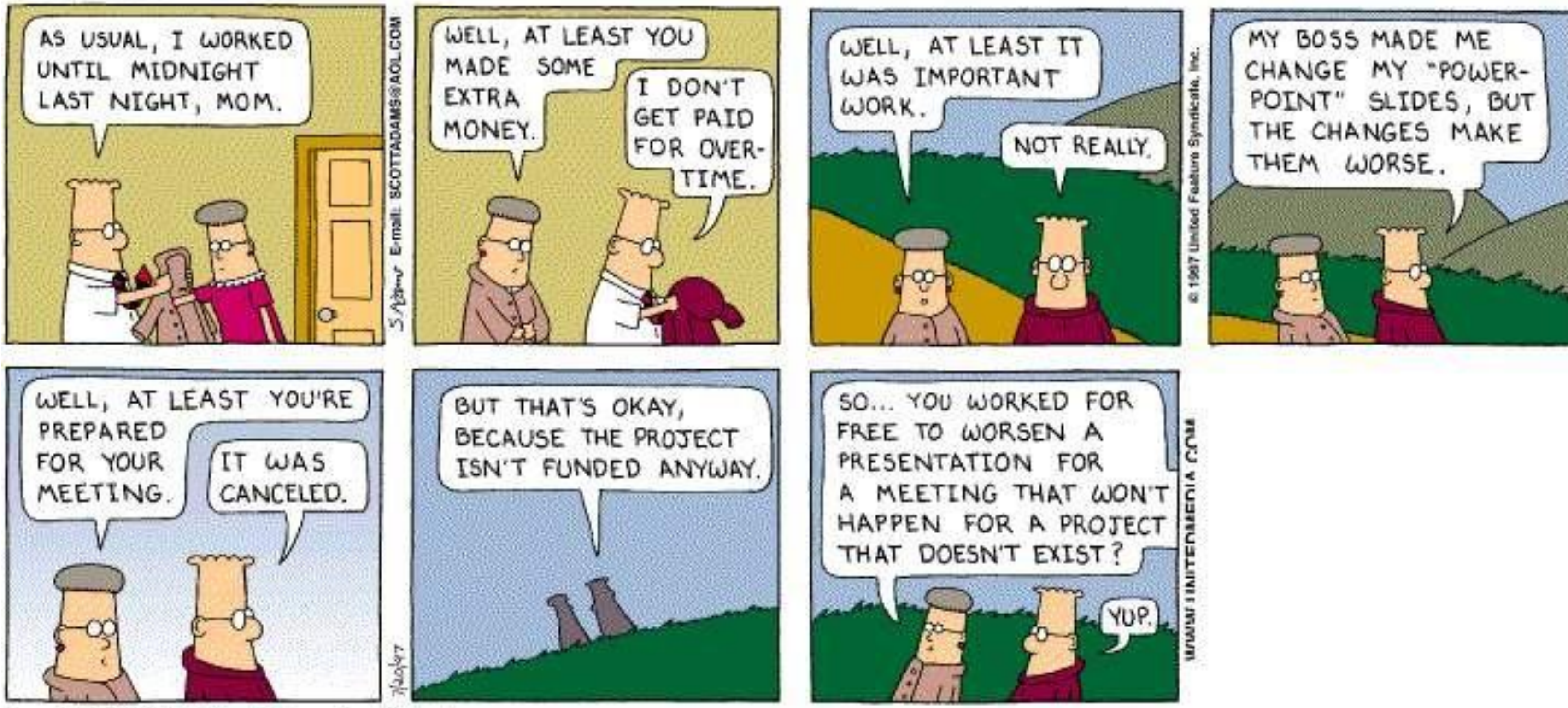
Colonel, US Army, Ret
gparlier@knology.net

18 February 2013

DILBERT **BY SCOTT ADAMS**



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Motivating Conditions

- **The changed geopolitical landscape resulting in the Army's transition to an expeditionary, globally deployable organization supported by a new force management concept (ARFORGEN);**

- **The opportunity to consider, adapt, and extend integrating supply chain design concepts and management principles, and to apply "advanced analytics" methods;**

- **A clear understanding of the enabling potential offered by information technology (so-called "IT solutions") and analytically-based decision support systems (DSS);**

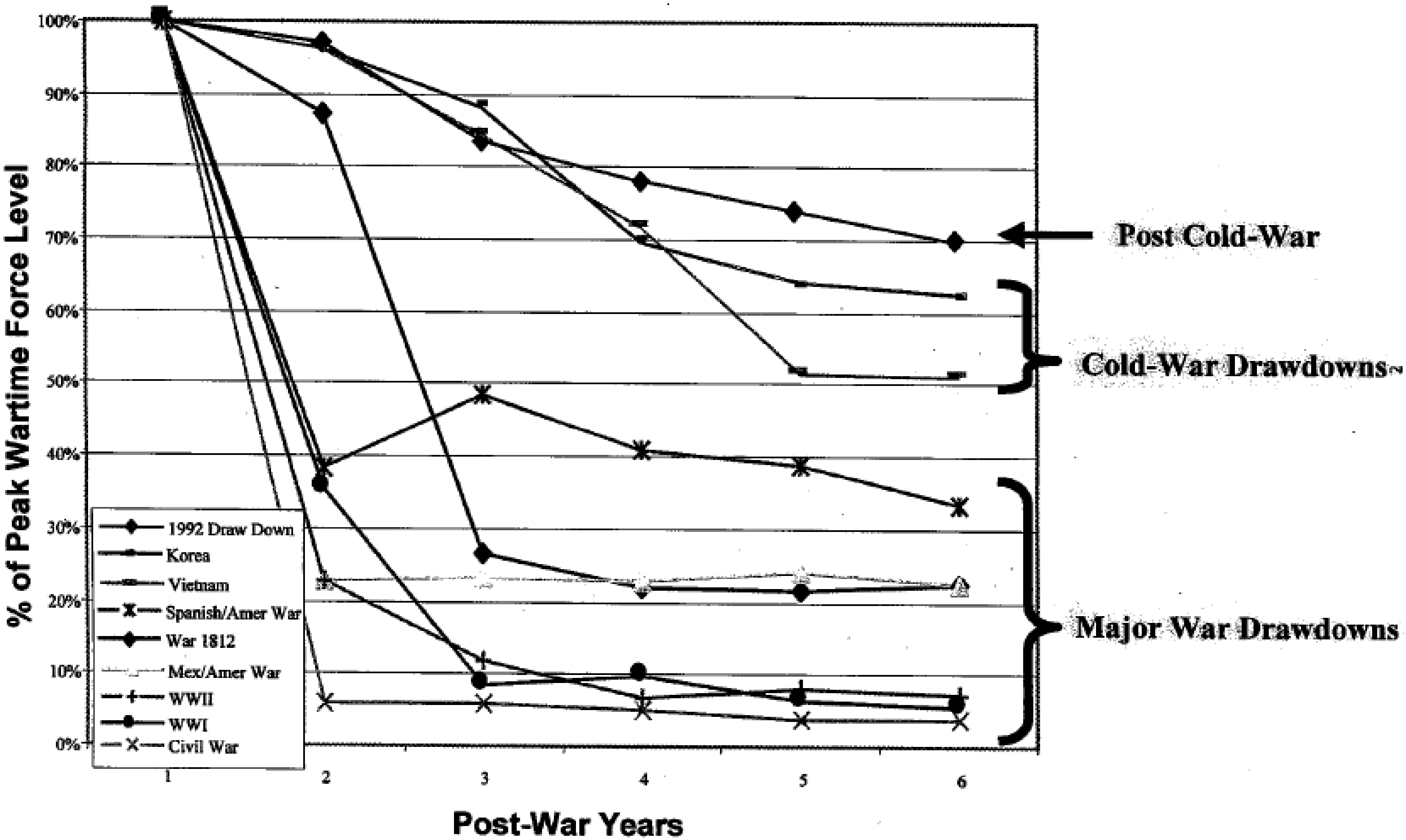
- **The DoD mandate for Performance Based Logistics (PBL), a major change in defense logistics management philosophy;**

- **And, an obvious and *compelling need driven by current fiscal realities, inevitable budget cuts, and the search for "efficiencies" . . . along with the ongoing quest for solvency in US public policy.***

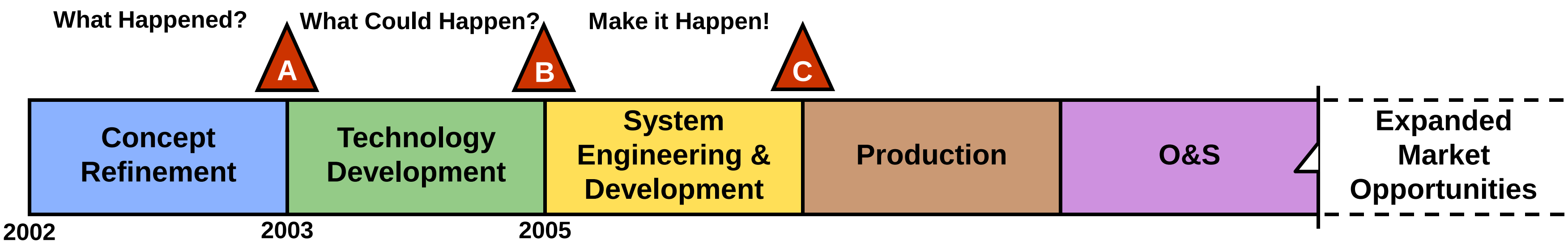
A unique opportunity to develop and implement an "analytical architecture," in conjunction with a newly emerging management innovation paradigm, to guide Materiel Transformation toward a "resources to readiness" framework

Historical Inertia:
Breaking America's Post-War Drawdown Pattern

Resource Planning Analysis Division



Transforming US Army Logistics: Project Phases



Phase 1
- Segment the Logistics Structure & Processes for Analysis
- Adapt Enterprise Supply Chain Framework for Integration

[~$200K]

Phase 2
- Identify "Readiness Production Function"
- Develop "Mission Based Forecasting"
- Validate "Readiness Based Sparing"
- Incorporate Multi-Echelon Optimization & "Synchronized Retrograde Operations"
- DDSN & LEWS

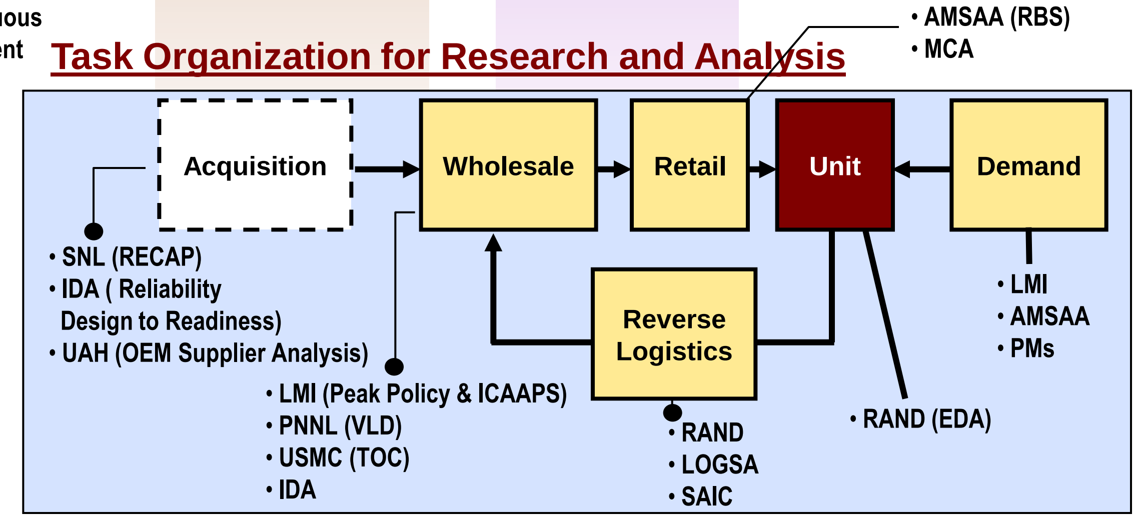
[$1.0M]

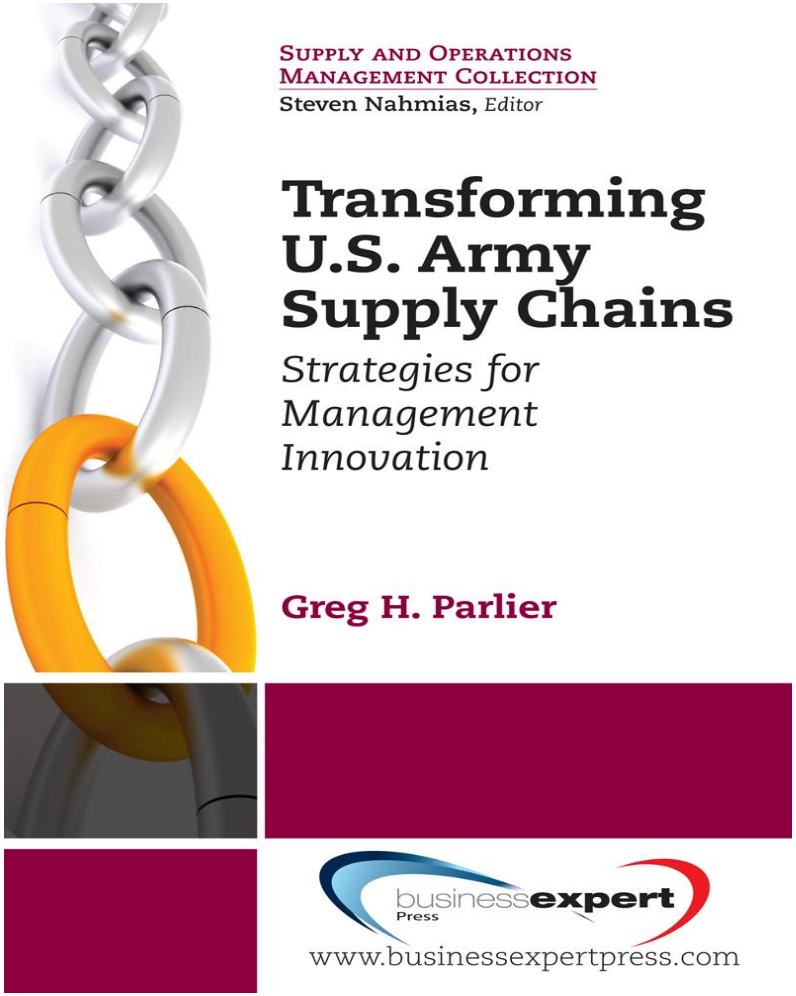
Phase 3
- Provide COTS RBS Solutions for PSI
- Develop Large-Scale MOD & SIM Capacity for SC Enterprise
- Implement CILS Organizational Design
- Strategic outreach & Research Partnerships for Continuous Improvement

[$2.2M]

CILS Provides:
- Product Support Integration
- Supply Chain Optimization
- Logistics System Readiness

Task Organization for Research and Analysis





Reasons for the Book (from Preface):

1. Resurrect traditional Operations Research (OR) for the US Army.
2. Apply “advanced analytics” to our materiel enterprise challenges.
3. Link operational, technical, educational, scientific, and analytical communities.
4. Demonstrate “Management Innovation as a Strategic Technology”.
5. Document a case study for:
   analytically-driven, transformational change;
   a comprehensive, collaborative effort by many contributors.

Transforming US Army Supply Chains: Strategies for Management Innovation

I. Project Overview

1. Background
2. The Immediate Problem
3. Current Logistics Structure
4. Supply Chain Concepts - Analytical Foundations for Improving Logistics System Effectiveness

II. Multi-stage Analysis of Systemic Challenges

5. Readiness Production Stage
6. Operational Mission and Training Demand Stage
7. Retail Stage
8. Reverse Logistics Stage
9. Wholesale Stage
10. Acquisition Stage
11. Summary

III. Multi-stage Integration for Efficiency, Resilience, and Effectiveness

12. Achieving Efficiency: An Integrated Multi-Echelon Inventory Solution
13. Designing for Resilience: Adaptive Logistics Network Concepts
14. Improving Effectiveness: Pushing the Logistics Performance Envelope

IV. Design and Evaluation: An “Analytical Architecture” to Guide Logistics Transformation

15. Multi-Stage Supply Chain Optimization
16. System Dynamics Modeling and Dynamic Strategic Planning
17. Operational and Organizational Risk Evaluation
18. Logistics System Readiness and Program Development
19. Accelerating Transformation: An “Engine for Innovation”

V. Management Concepts for Transformation

20. Organizational Redesign for Army Force Generation
21. Contributions of Information Systems Technology and Operations Research
22. Strategic Management Concepts for a Learning Organization
23. PBL and Capabilities Based Planning for an Expeditionary Army
24. Financial Management Challenges to “Business Modernization”
25. Human Capital Investment for a Collaborative Organization
26. Final Thoughts

Transforming US Army Supply Chains: Strategies for Management Innovation

"Advanced Analytics" = Descriptive + Predictive + Prescriptive Analytics

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Descriptive Analytics: Where are we now?

III. Multi-stage Integration for Efficiency, Resilience, and Effectiveness
12. Achieving Efficiency: An Integrated Multi-Echelon Inventory Solution
13. Designing for Resilience: Adaptive Logistics Network Concepts
14. Improving Effectiveness: Pushing the Logistics Performance Envelope

Prescriptive Analytics; Where do we want to go?

IV. Design and Evaluation: An "Analytical Architecture" to Guide Logistics Transformation
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Predictive Analytics: How can we get there?

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Managing Enterprise Transformation: What will it take?

Management Innovation as a Strategic Technology (MIST):
OR + BI[MIS + DSS] + TSP[EfI + STAAMP] + IMS = MIST

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Operations Research "Advanced Analytics" (Sections I–IV)

BI = Business Intelligence
DSS = Decision Support Systems
TSP = Transformational Strategic Planning
EfI = Engine for Innovation
STAAMP = Strategic Architectures for Analysis, Management, and Planning
IMS = Integrated Management Science

TSP[EfI + STAAMP] → 19, 22

BI[MIS + DSS] → 21

IMS → 23–26

Part I: Project Overview

1. Background
2. The Immediate Problem
3. Current Logistics Structure
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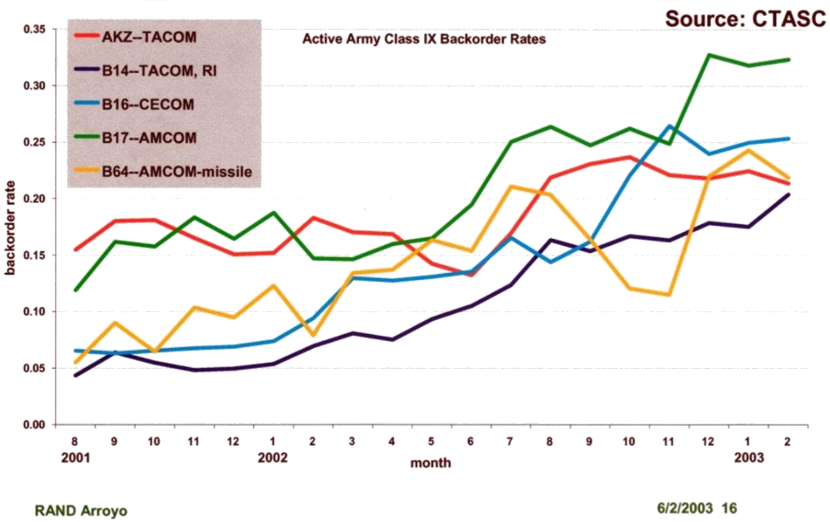
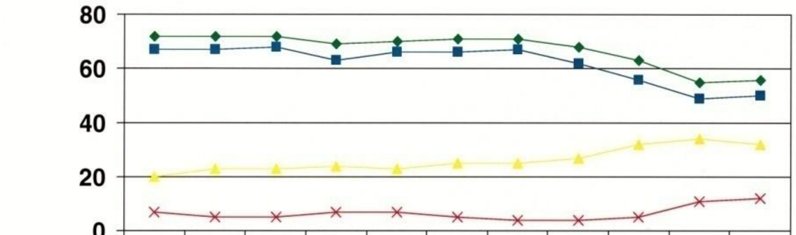
The Immediate Problem: Circa 2002

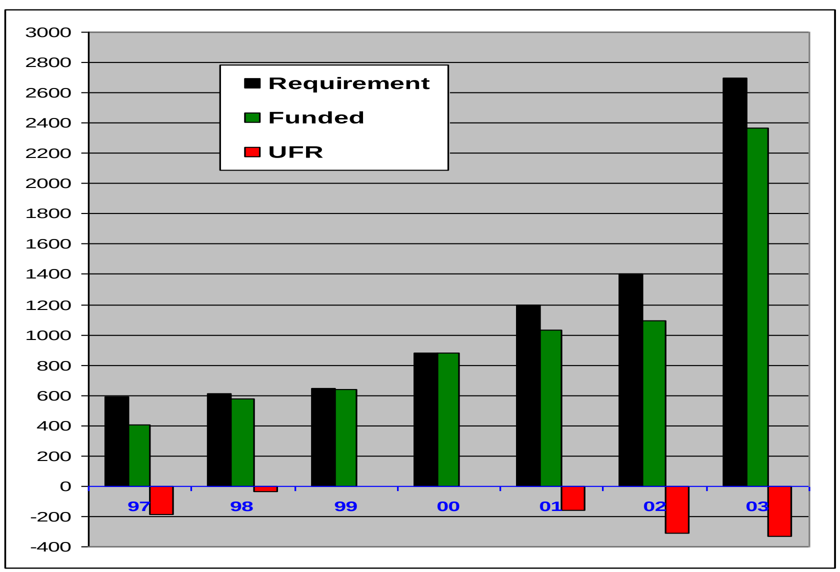


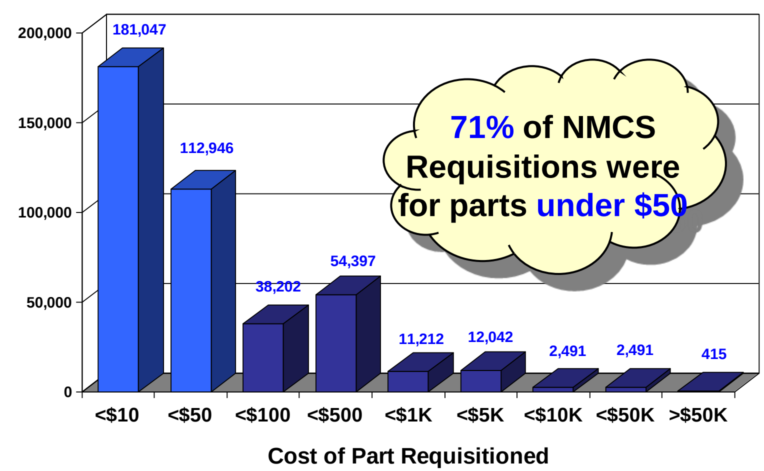


	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
MC	72	72	72	69	70	71	71	68	63	55	56
FMC	67	67	68	63	66	66	67	62	56	49	50
NMCM	20	23	23	24	23	25	25	27	32	34	32
NMCS	7	5	5	7	7	5	4	4	5	11	12

Goal = 75%

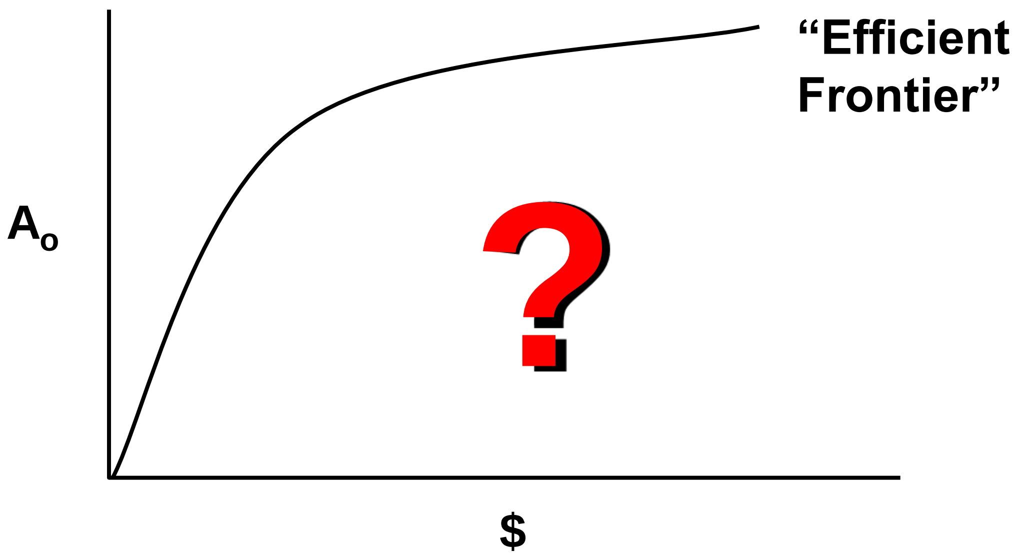
4/28/2003 LMI/CNA





Assessment: Circa 2002

- Investment is increasing, yet back orders are growing and UFRs are increasing
- "Workarounds" are increasing, readiness is slowly declining
- Readiness reporting appears suspicious, lacks credibility
- Systems are non-operational for relatively inexpensive parts



Situation: Selected (Anonymous) Comments

Following the Cold-War drawdown, as of late 2002 . . .

"All signs are bad"

"Huge disconnect between Log & Ops"

"Wholesale and retail are not integrated"

"There is growing fear that we do not have enough to ensure readiness; that fear is accompanied with perceptions of tremendous inefficiencies in our system"

"We could spend $100M on spares and see no readiness improvement, or we could spend $10M on spares (differently) and see it improve!"

"Why am I still throwing billions down this black hole called Spares?"

"We don't believe the aviation spares requirements numbers"

"The financial system is undermining our ability to do things smart"

"Our incentives are all in the wrong places…"

But then . . . .

"The attacks of September, 11th, 2001, opened a gusher of spending that nearly doubled the base budget over the last decade, not counting the supplemental appropriations for the wars in Iraq and Afghanistan. . ."

And now . . . .

Situation: Selected (Anonymous) Comments

And now (2012), a decade later . . .

"... today we face a very different set of American economic and fiscal realities . . . The gusher has been turned off and will stay off for a good period of time . . . The culture of endless money that has taken hold must be replaced by a culture of savings and restraint"

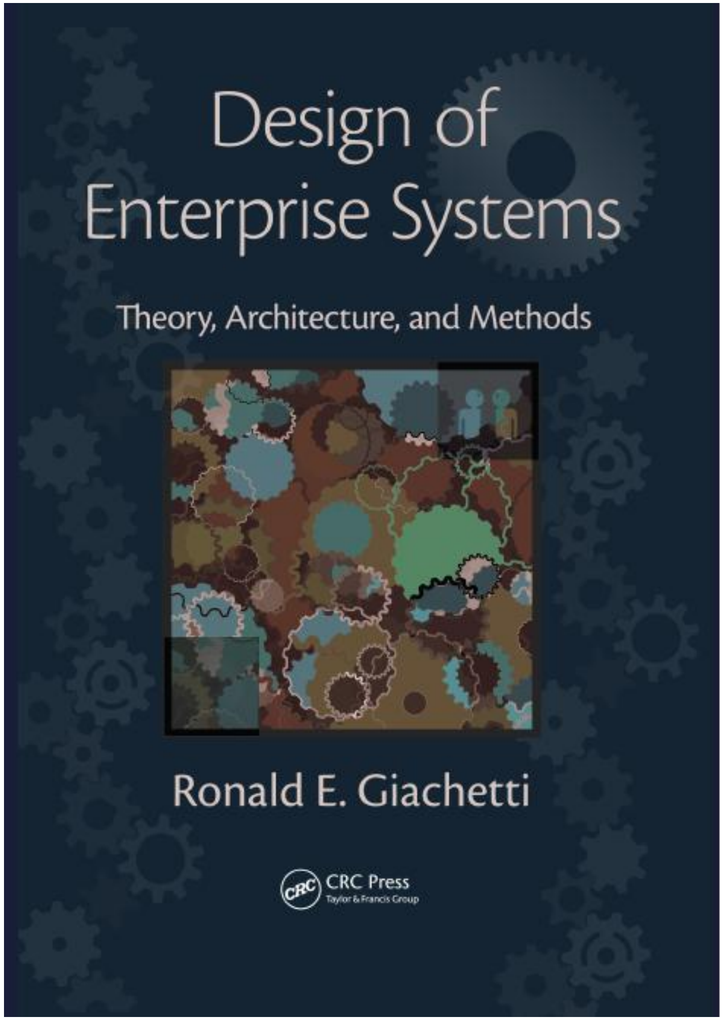
"[DoD must] . . . maximize value across the defense enterprise . . . [make] better use of information technology and inventory management"

"An era of blank-check defense spending is over . . ."

Yet . . .

". . . DoD does not do a world-class job with logistics by any measure . . . [there] is little cost visibility or performance accountability [and] weapon system readiness is not linked to supply chain responsibility."

"DoD's supply chain system has remained stuck in a 20th Century model because of . . . resistance to change."



Design of Enterprise Systems: Theory, Architecture, and Methods **takes a system-theoretical perspective of the enterprise, and describes a systematic approach, called the enterprise design method, to design the enterprise. The enterprise design method demonstrates the principles, models, methods, and tools needed to design enterprise systems.**

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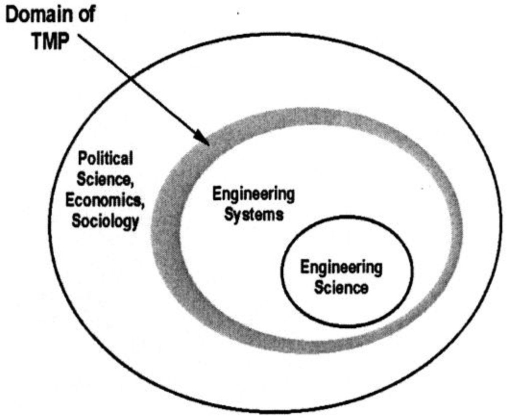
PRAESTANTIA PER SCIENTIAM

Enterprise (Engineering) Systems

- **Some Definitions:**
  - An emerging way to think about how to model, analyze, and design large-scale, complex, socio-technical systems.
  - An effort to better integrate engineering with management science, the social sciences, and the humanities.
  - A class of systems characterized by a high degree of technical complexity, social intricacy, and elaborate processes, aimed at fulfilling important functions in society.
  - Enterprise engineering is the body of knowledge, principles, and practices to design an enterprise.
  - An Enterprise is a complex, socio-technical system that comprises interdependent resources of people, information, and technology that must interact with each other and their environment in support of a common mission.

An emerging field at the intersection of engineering, management, and the social sciences.



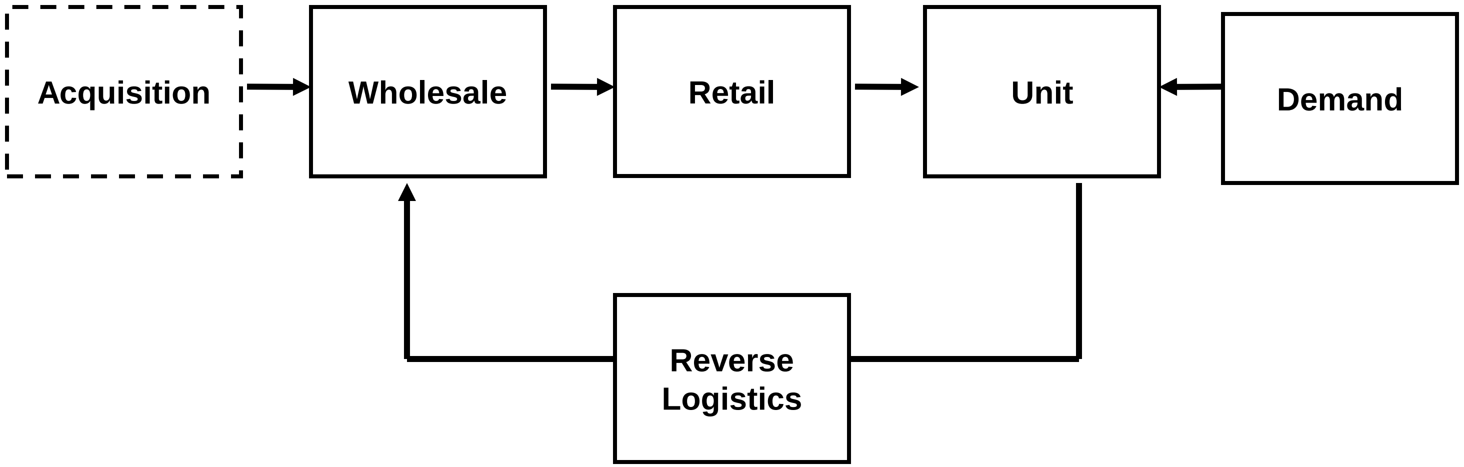
Enterprise (Engineering) Systems

- **Evolutionary "Epochs":**
  - Great inventions and artifacts
  - Complex systems
  - Engineering systems
- **Characteristics:** system "architecture"
- **Modeling and Analysis**
- **Design "levels" (project; enterprise; societal)**
- **Systems Perspectives:**
  - abstraction - decomposition for understanding
  - "viewing angles" - multidisciplinary views
  - perspectives - scale/scope, function, structure, temporality
  - properties - the "ilities": quality; reliability; flexibility; adaptability; agility; modularity ….. sustainability …..affordability ….. "reversibility"

Structural elements and interactions cause system attributes, functions, & behaviors. Architecture drives behavior, and governs systems performance and value – both short and long term.

"Enterprise engineers specialize in integration: the process of making subsystems work together harmoniously in a way that optimizes the performance of the entire enterprise."   Ron Giachetti

Part II: Multistage Analysis of Systemic Challenges - Abstracting/Decomposition for Descriptive Analytics



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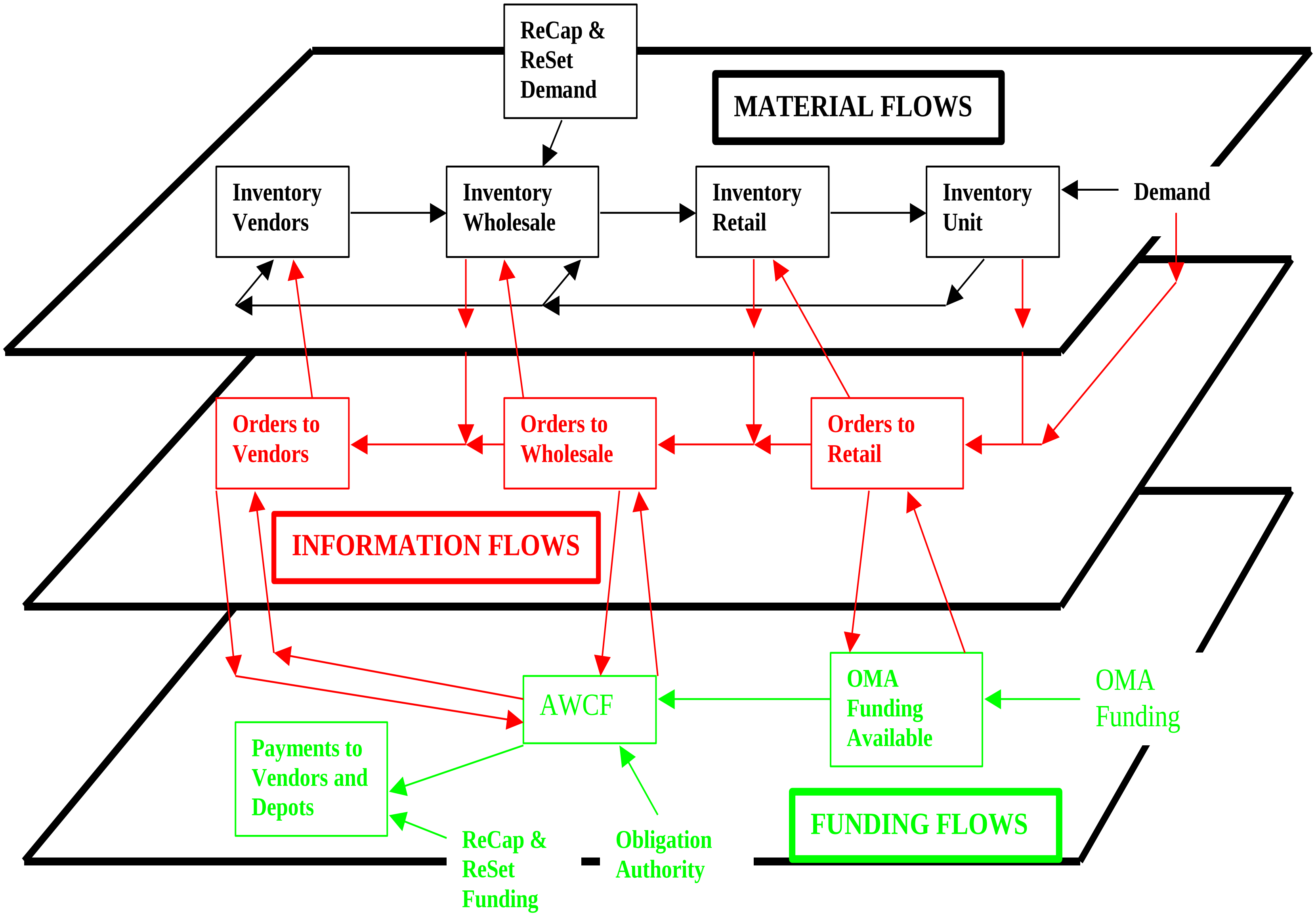
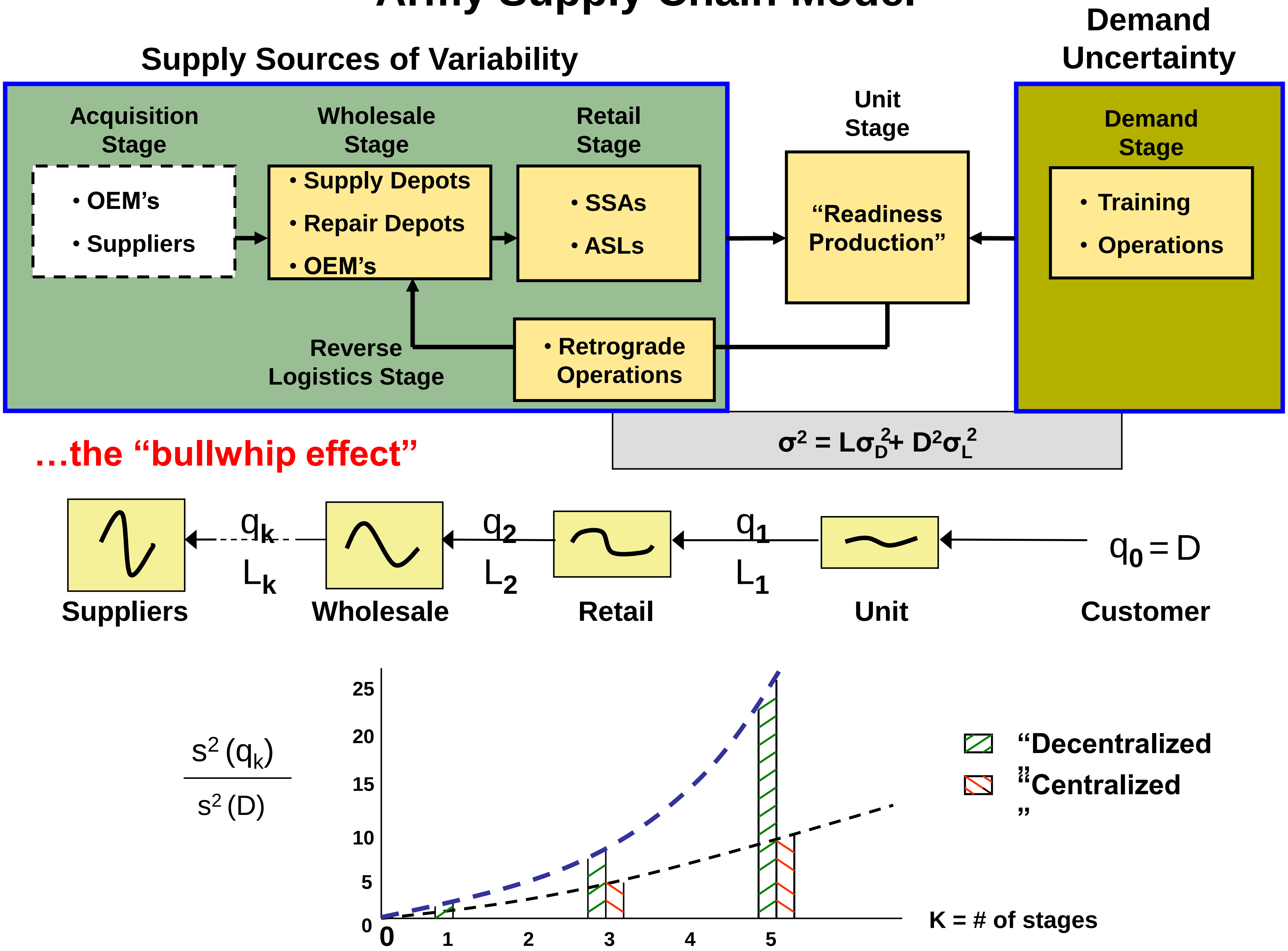
Supply Chain Framework: Organization, Process, and Information “Views” of the Materiel Enterprise



Supply Variability and Demand Uncertainty: Army Supply Chain Model



Summary of Systemic Challenges: Identifying Fundamental Cause-Effect Relationships

To summarize generally, these causal disorders and their respective effects include:

(1) lack of an aviation readiness production function which induces both uncertainty and variability at the point of consumption in the supply chain resulting in inappropriate planning, improper budgeting, and inadequate management to achieve readiness objectives;

(2) limited understanding of mission-based, operational demands and associated spares consumption patterns which contribute to poor operational and tactical support planning and cost-*in*effective retail stock policy;

(3) failure to optimize retail stock policy to achieve cost-efficient readiness (customer) objectives which results in inefficient procurement and reduced readiness;

(4) failure to proactively synchronize and manage reverse logistics which contributes significantly to increased DLR RO, excess inventory, increased delay times (order fulfillment), and reduced readiness while simultaneously precluding the enormous potential benefits of a synchronized, closed-loop supply chain for DLRs;

(5) inability to "see" – and to adapt to and anticipate changes in – actual customer demand, causing inefficient procurement actions within an unresponsive wholesale stage characterized by abysmal demand plan forecast accuracy thereby precluding enterprise-wide "cost-wise readiness";

(6) limited visibility into and management control over disjointed and disconnected OEM and key supplier procurement programs which are vulnerable to boom and bust cycles with extremely long lead times, high price volatility for aerospace steels and alloys, and increasing business risk to crucial, unique vendors in the industrial base resulting in diminishing manufacturing sources of materiel supplies, and growing obsolescence challenges for aging aircraft fleets;

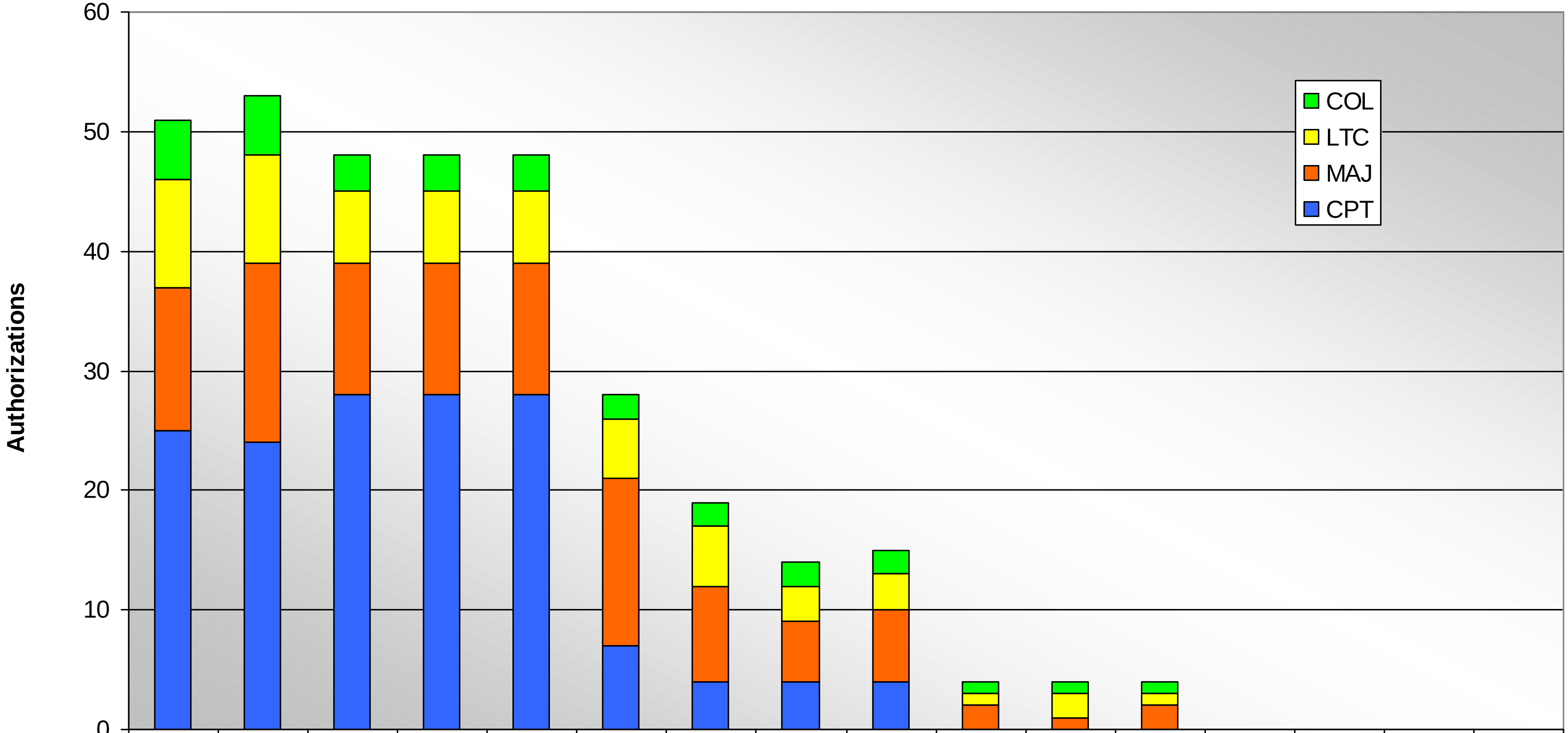
(7) independently operating, uncoordinated and unsynchronized stages within the supply chain creating pernicious "bullwhip" effects including large RO, long lead times, and declining readiness;

(8) fragmented data processes and inappropriate supply chain MOEs focusing on interface metrics which mask the effects of efficient and effective alternatives, and further preclude an ability to determine "readiness return on net assets" or to relate resource investment levels to readiness outcomes;

(9) lack of central supply chain management and supporting analytical capacity results in multi-agency, consensus-driven, bureaucratic workarounds hindered by lack of an Army supply chain management science and an enabling "analytical architecture" to guide Logistics Transformation; and

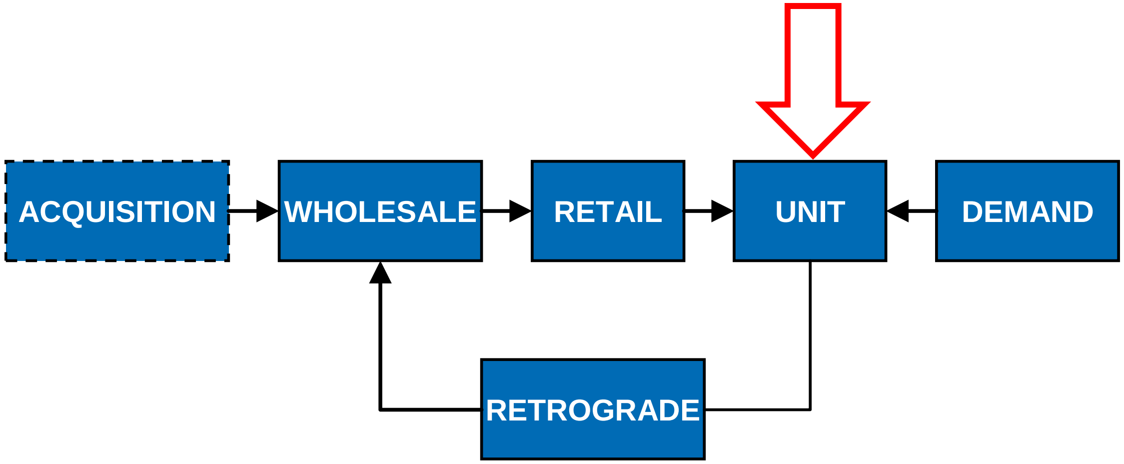
(10) lack of an "engine for innovation" to accelerate then sustain continual improvement for a learning organization.

Officer ORSA (FA49) Strength in AMC



	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03
COL	5	5	3	3	3	2	2	2	2	1	1	1	0	0	0	0
LTC	9	9	6	6	6	5	5	3	3	1	2	1	0	0	0	0
MAJ	12	15	11	11	11	14	8	5	6	2	1	2	0	0	0	0
CPT	25	24	28	28	28	7	4	4	4	0	0	0	0	0	0	0

Analyzing Root Causes and Prescribing Innovation Catalysts Across the Supply Chain

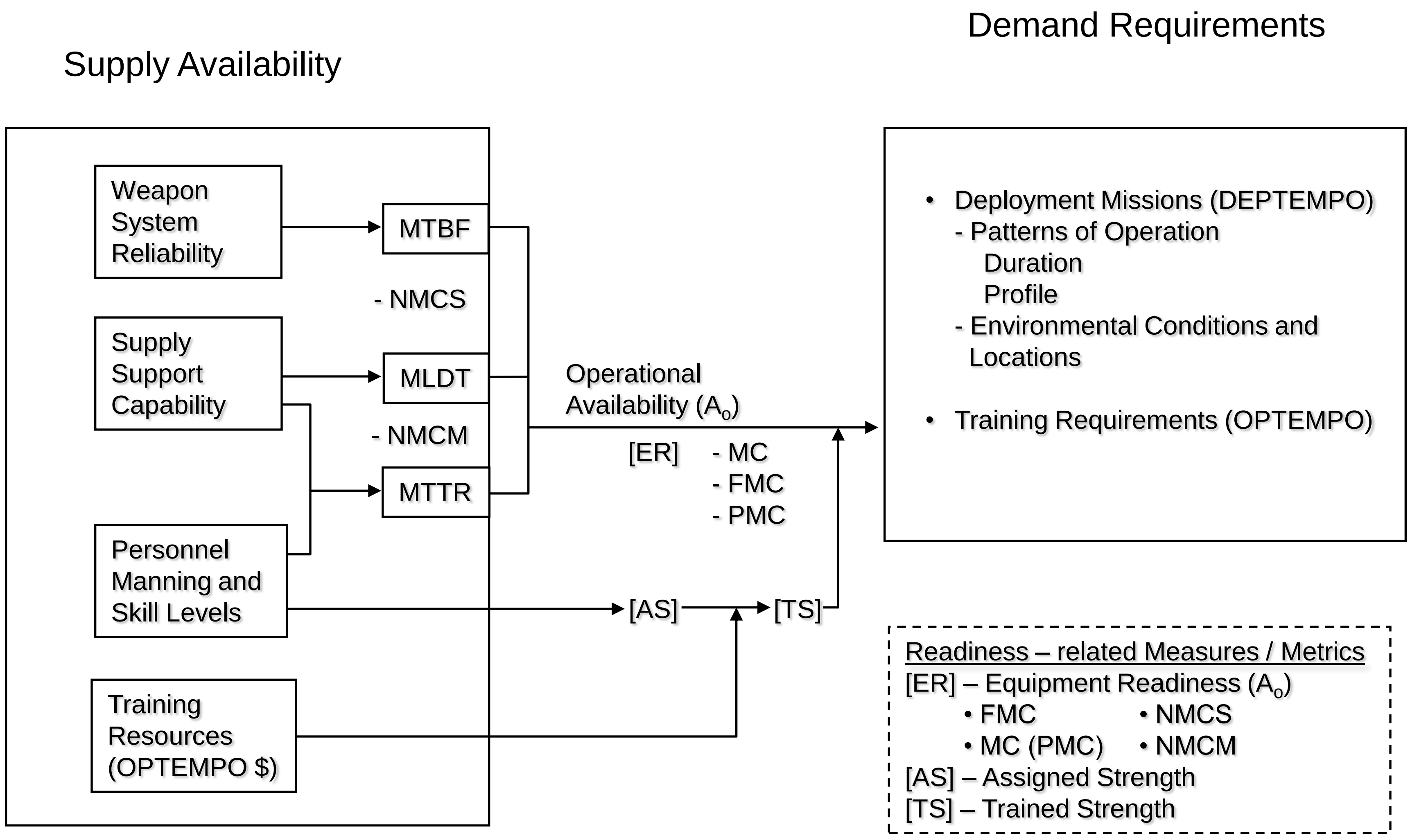


(1) lack of an aviation readiness production function which induces both uncertainty and variability at the point of consumption in the supply chain resulting in inappropriate planning, improper budgeting, and inadequate management to achieve readiness objectives;

<u>Innovation Catalysts</u>:

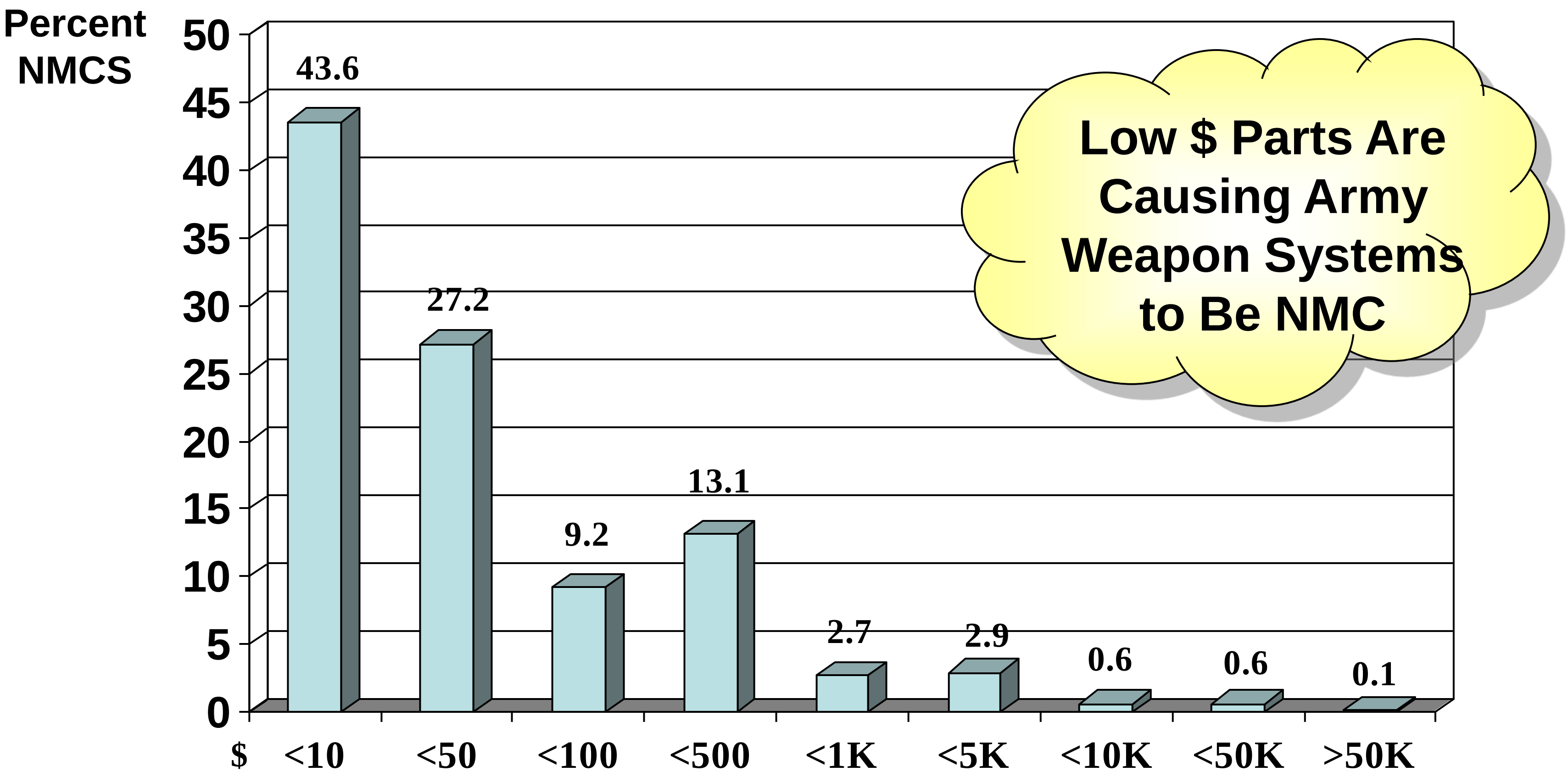
- **Defining the Readiness Equation**
- **Connect CBM to the Supply Chain**
- **Mission Based Forecasting**
- **Readiness Based Sparing**
- **Readiness Responsive Retrograde**
- **Leveraging Lessons Learned & Best Practices**

“Production Function”: Components of Readiness



Cost of Part vs Percent of Not Mission Capable Supply/ Anticipated Not Mission Capable Supply Requisitions

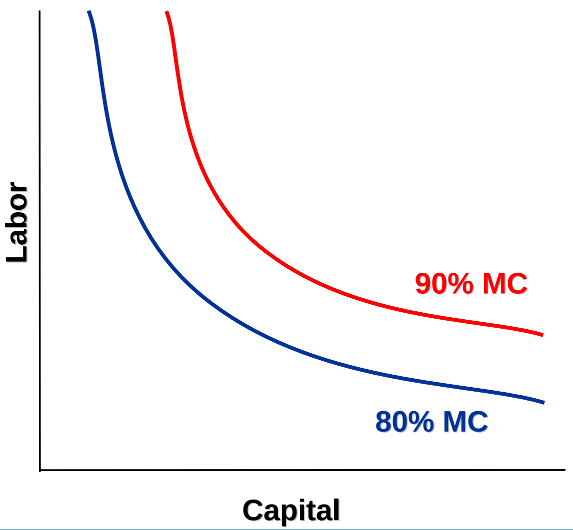
(All Army LIF Records Nov00 to Oct01)



80% of NMCS/ANMCS Requisitions at Wholesale Were for Items <$100

Source: AMSAA

Innovation Catalyst: Analyzing the Readiness Equation and Measuring True "Customer Demand"



$$A_O = \frac{\text{Uptime}}{\text{Total Time}}$$

$$= \frac{\text{MTBF}}{\text{MTBF + MTTR + MLDT}}$$

Where

MTBF = Mean Time Between Failures (Reliability)

MTTR = Mean Time To Repair (Maintainability)

MLDT = Mean Logistics Delay Time (Supportability)

Research Goals:

- Define and empirically measure the "readiness equation" for Ao

- Determine readiness "driver" marginal values, and evaluate contributions and costs for potential solutions.

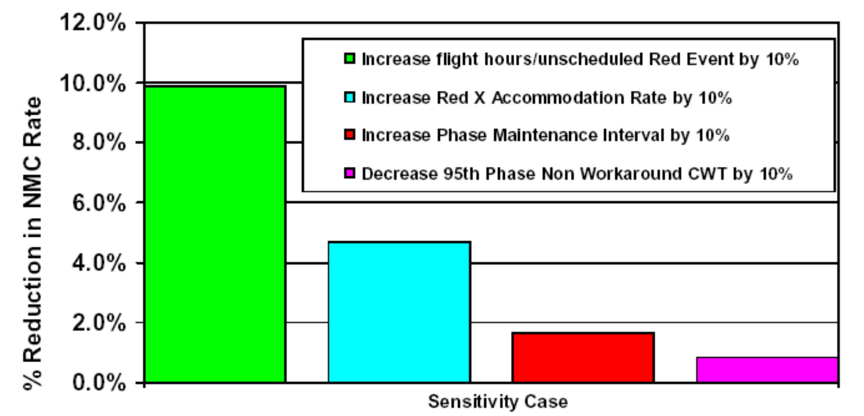
Extract from research results:

- The longer the delay, the more likely a workaround . . .15% of deadline requisitions for wholesale backorders were satisfied by workarounds.

- "Labor" (MMH) increasingly substituting for "Capital" . . . If workarounds were eliminated, readiness would decline by 33%.

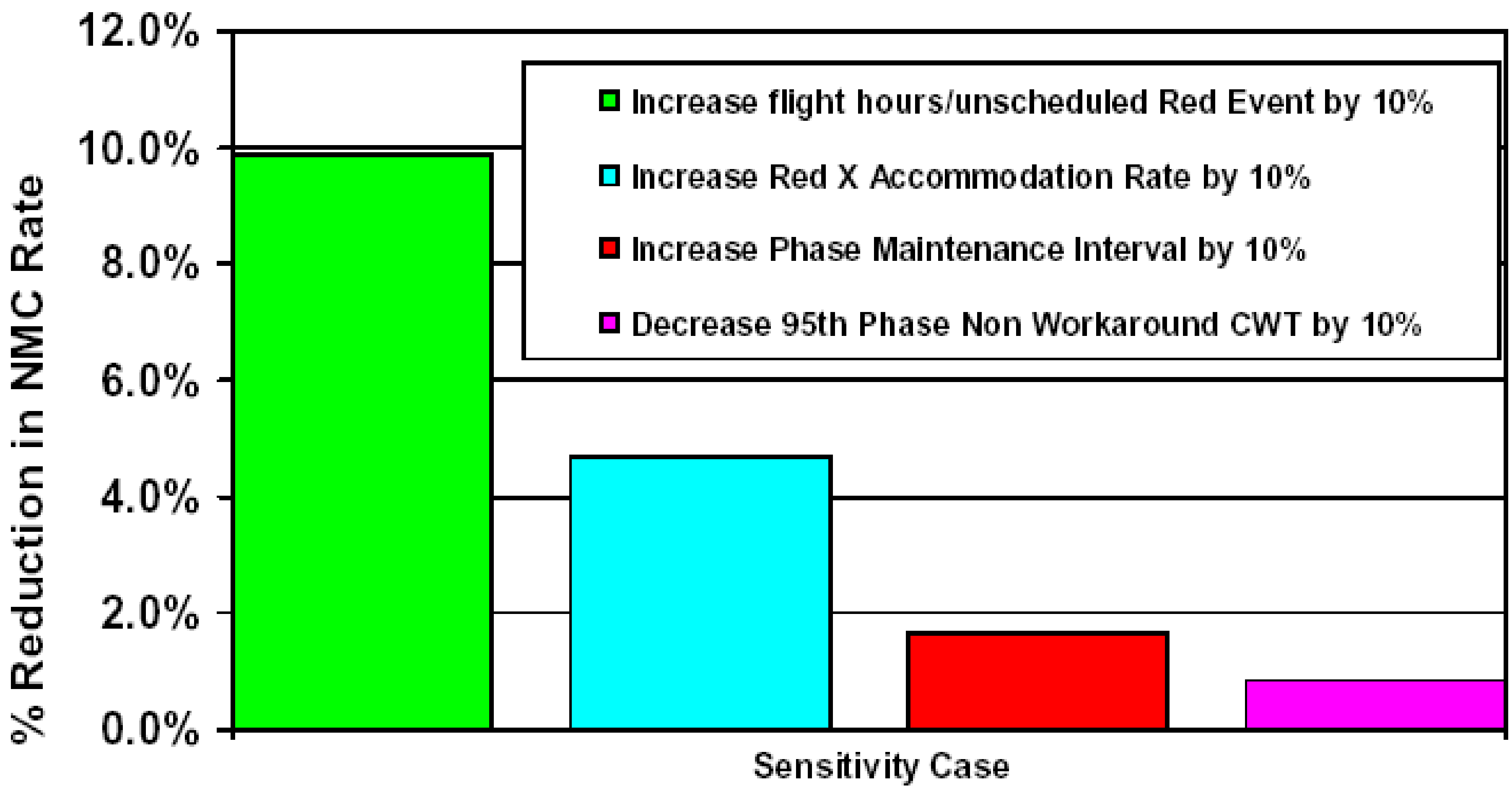
- "Consumption" data is not systematically collected by current MIS

Decreasing Failure Rate and Increasing ASL Breadth Have the Greatest Impact on Readiness



Data for AH-64D at Iraq OPTEMPO of 28 hours/month, 25% Accommodation Rate

Decreasing Failure Rate and Increasing ASL Breadth Have the Greatest Impact on Readiness



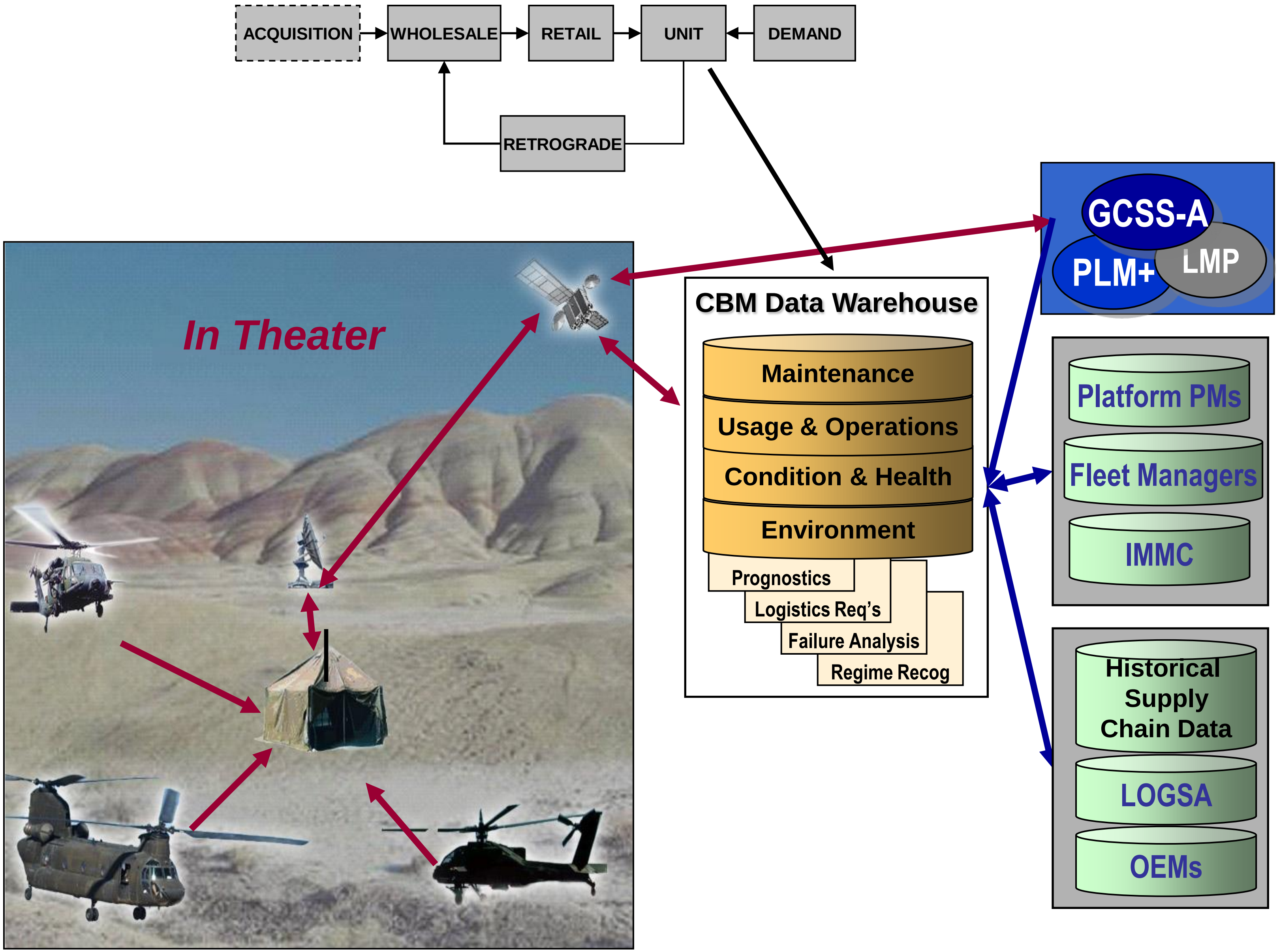
Data for AH-64D at Iraq OPTEMPO of 28 hours/month, 25% Accommodation Rate

Center for Systems Reliability
Readiness & Sustainment Department

Sandia National Laboratories (SNL)
Albuquerque, NM 87185

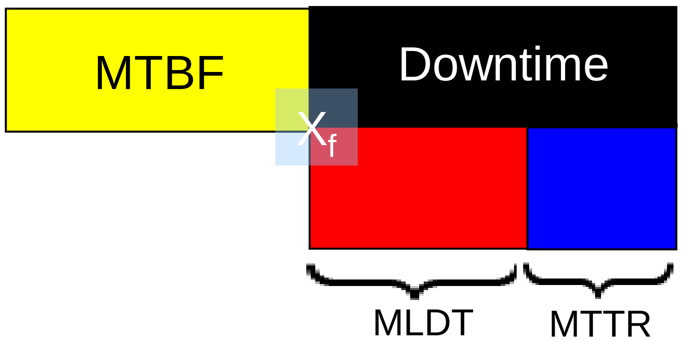
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

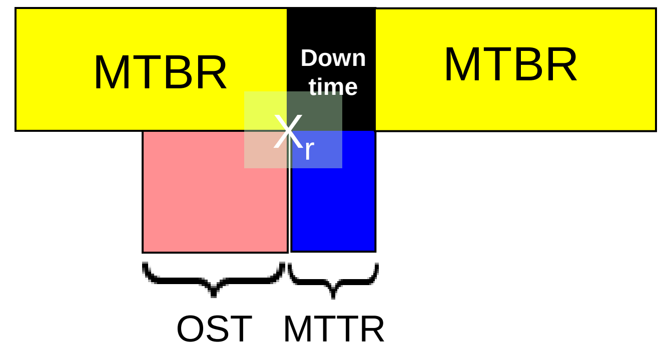
“Connecting” CBM to the Supply Chain: A Conceptual View



“Connecting” CBM to the Supply Chain: A Mathematical View

Reactive Repair vs. Proactive Replacement





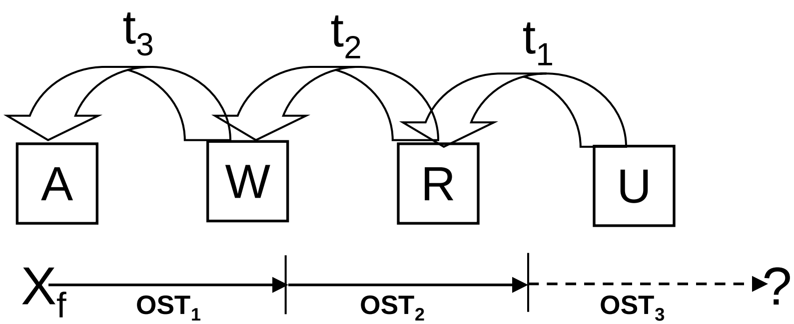
$$MLDT = \sum_{\forall i} t_i + \sum_{\forall i} ost_i$$

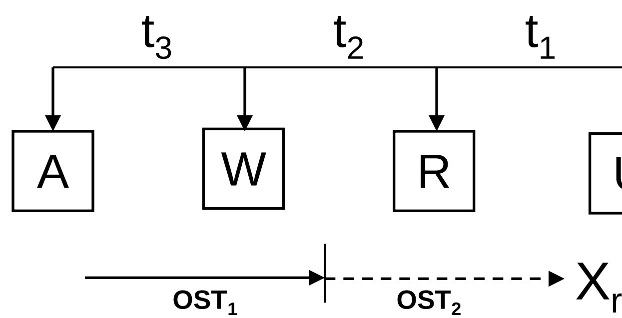
$$A_o = \frac{\text{MTBF}}{\text{MTBF} + \text{MLDT} + \text{MTTR}}$$

$$MLDT \cong 0$$

$$MTTR_r < MTTR_f$$

$$\sigma_{\text{TTR}_f} > \sigma_{\text{TTR}_r}$$





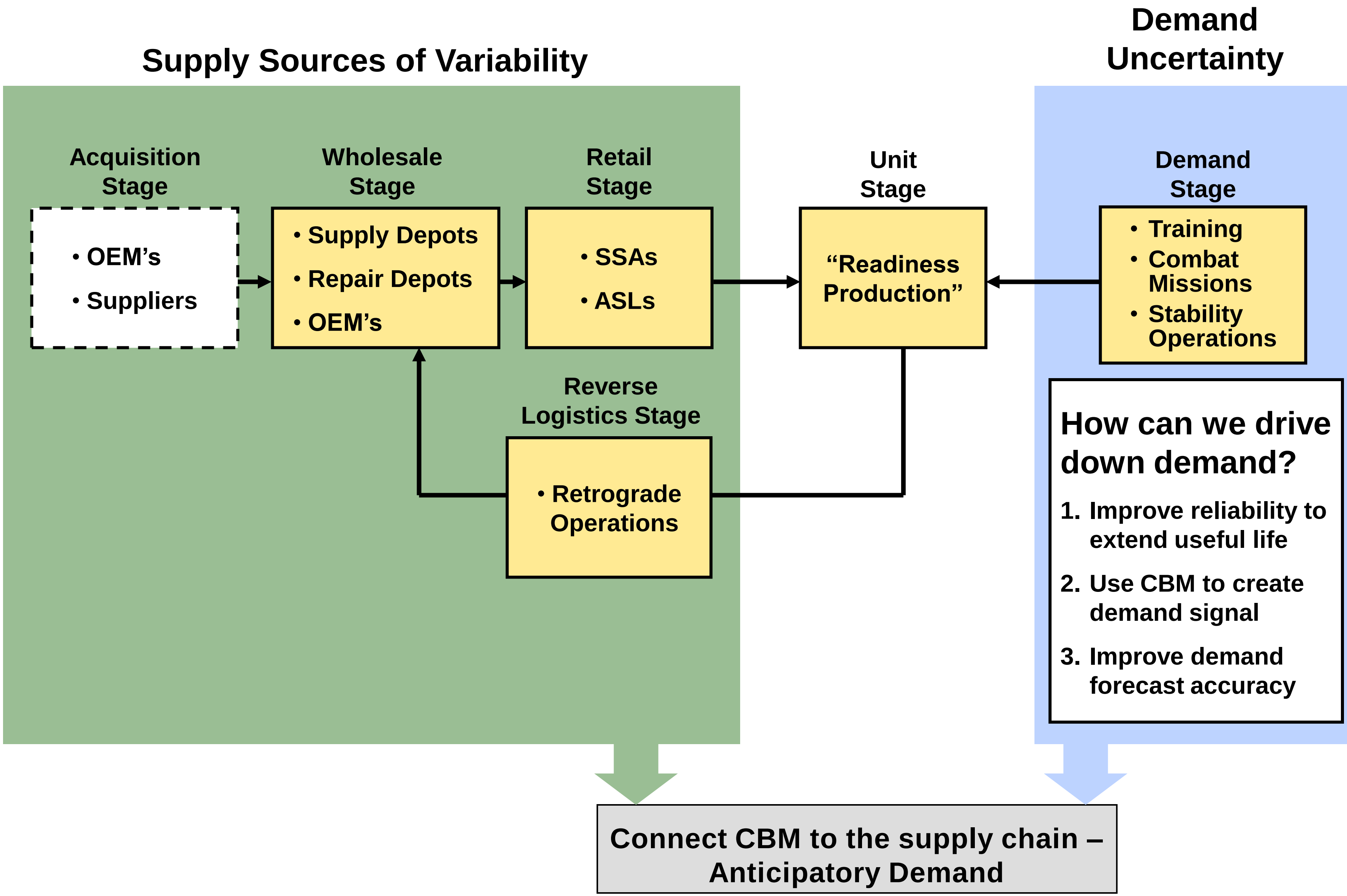
$$\sum_{\forall i} t_i \geq t_1 > 0$$

$$\sum_{\forall i} ost_i \geq X_f$$

$$\sum_{\forall i} t_i \cong 0$$

$$\sum_{\forall i} ost_i < X_r$$

Supply Chain Improvement Opportunities:
Reducing Demand Uncertainty in the Army Supply Chain Model



Connecting CBM to the Supply Chain:
A Six Month Pilot Project

Purpose: Analyze and link existing Army logistics and CBM datasets to a new forecasting method/model to better predict DLR replacement

Benefits:

- **Improves Forecast Accuracy**
  - Enables "right-sizing" component inventory levels

- **Reduces Operation & Support Costs and Facilitates Efficiencies**
  - Improve visibility of the reliability state of aircraft components, giving advance warning of demand
  - Reduces inventory footprint and operating costs versus personnel

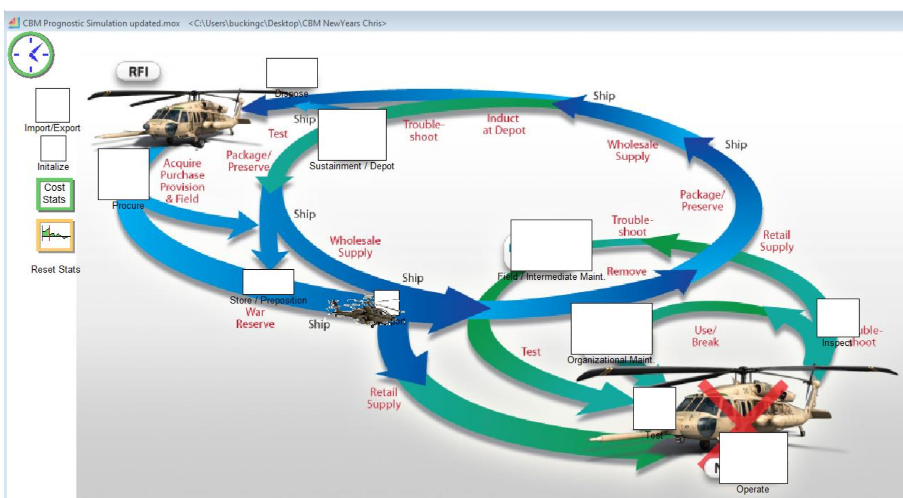
- **Increases Component Availability/Readiness Levels**
  - Reduction in NMCS results in improved readiness and cost avoidance (premium purchases, shipping, etc.)

Connecting CBM to the Supply Chain
Project Process

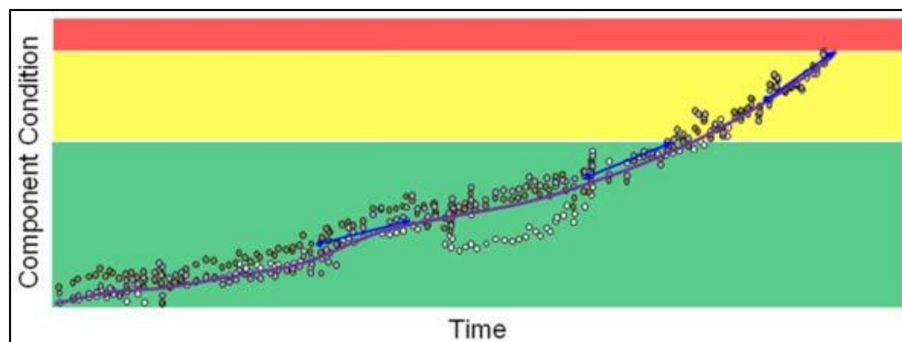
Project/Process Flow:

- **Analyze Existing, Actual Data**
  - DSC
  - 2410
  - ASAP Data
  - RIMFIRE
  - LMP
  - Inventory
- → **Baseline Metrics**
- → **Develop Prognostic Simulation** ↔ **Develop Predictive Algorithm**
- → **Validate Algorithm**

Prognostic Simulation Tool



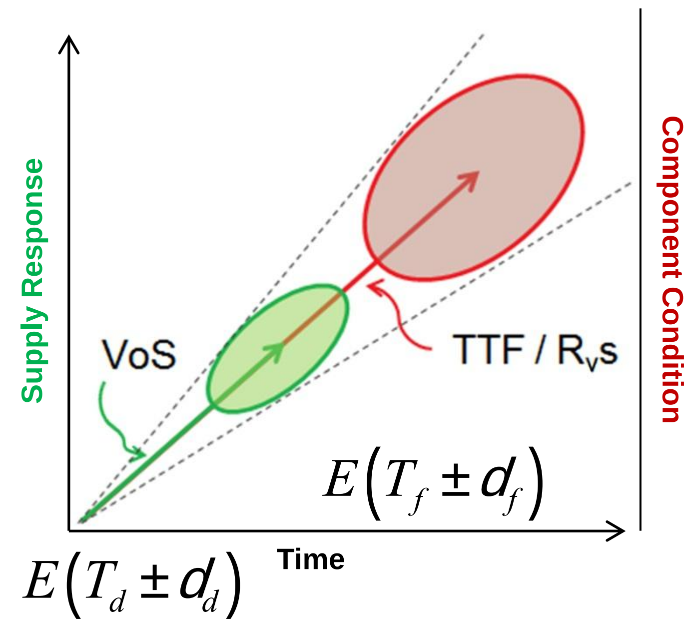
Failure Rate Curve: Component Health



Connecting CBM to the Supply Chain
Prognostic Algorithms

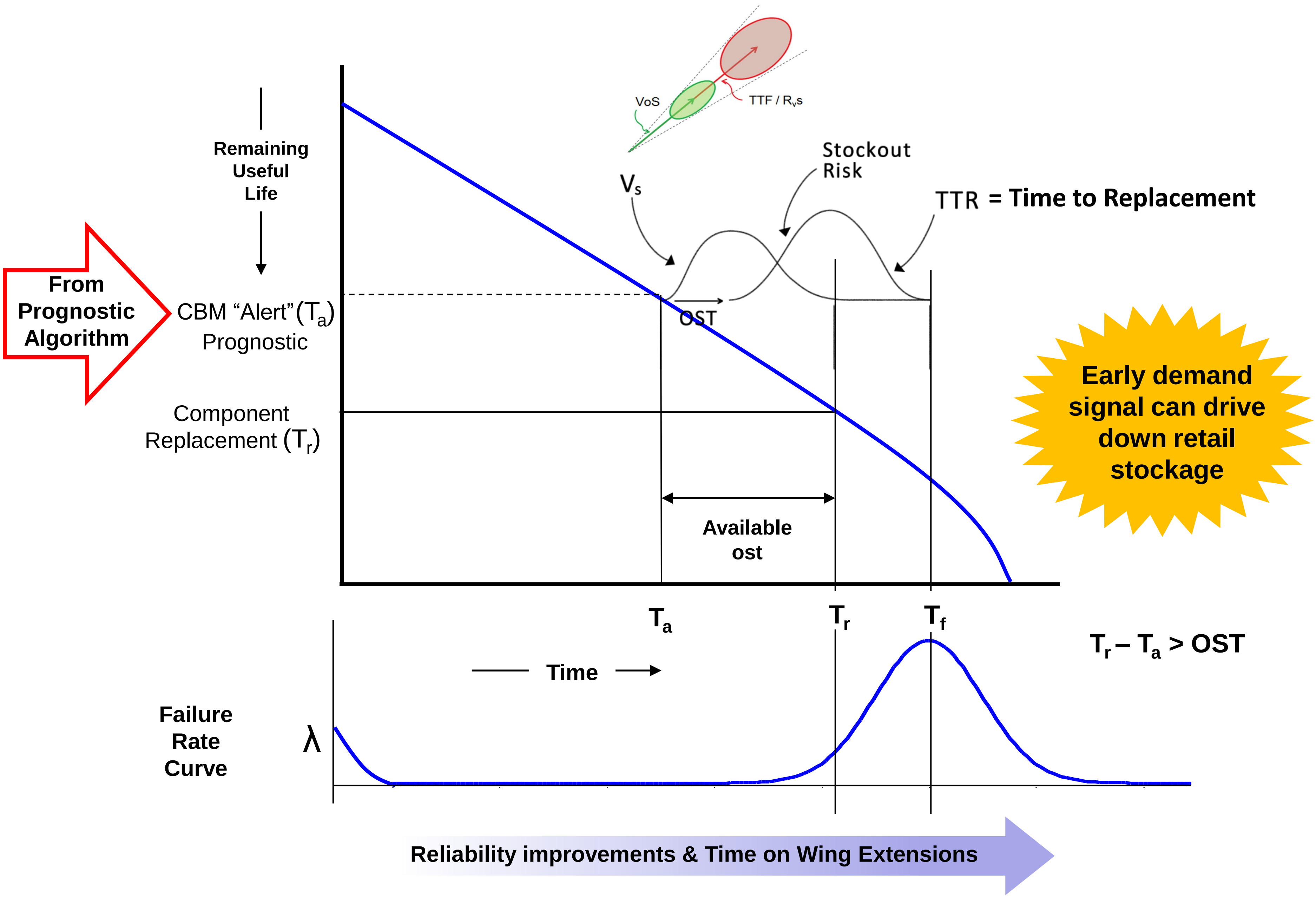
Engineering and Logistics Components

- **Reliability State Algorithms**
  - Identifying current reliability state (R_vs) to predict time to failure
  - Predicting Failures (DSC data)
  - Associating to maintenance events (2410 data)
- **Logistics Side Algorithm**
  - Predicting Supply Chain Performance
  - Velocity of Supply (VoS)
  - Based on supply chain history



Goal:
Component arrives before actual failure

Connecting CBM to the Supply Chain



Connecting CBM to the Supply Chain

CBM Prognostics Simulation Model - Initial Results

Primary Metrics		Nose Gearbox (NGB)
Component Availability (# of times Aircraft down >1/day)	Lower 95% Confidence	108.73
	Estimate	**109.30**
	Upper 95% Confidence	109.88
Inventory Cost ($)	**Current Level**	**$1,916,637**
Supply Response Time (Days)	Lower 95% Confidence	16.79
	Estimate	**20.10**
	Upper 95% Confidence	23.41
Forecast Improvement (RMSE)	**Current Level**	**3.8**

Expected Results Based on Improved Predictive Ordering

# of Times an Aircraft was Down for More Than One Day

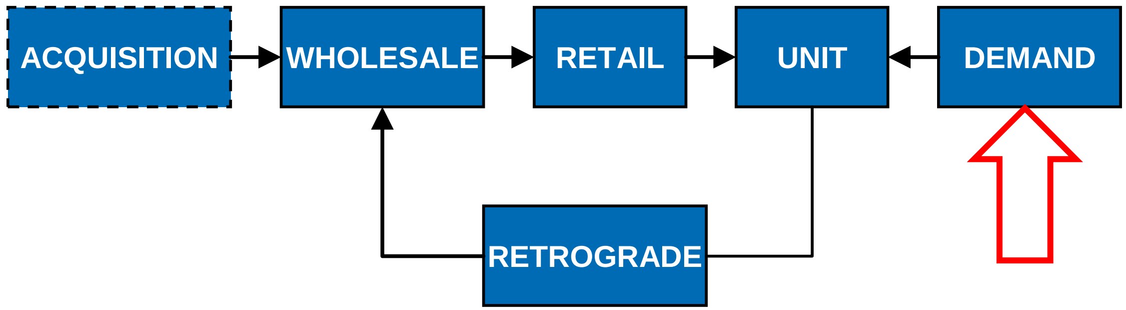
Days Ordered Early (compared to historical requisition times)

Inventory Reduction	0	2	4	6	8	12	16	Actual Inventory Level ↓	Inventory Cost Savings ↑
0%	110.7	77.4	48.1	34.9	22.8	7.4	1.6	37	$0
2%	130.1	99.6	66.3	45.8	27.1	12.0	2.9	36	$51,801
5%	150.7	120.5	81.9	52.0	36.6	13.1	5.6	35	$103,602
10%	196.4	155.6	113.4	89.2	61.1	27.3	9.2	33	$207,204
15%	230.7	196.4	166.4	134.8	105.4	51.9	22.3	31	$310,806
20%	256.2	232.8	201.8	180.2	147.7	78.7	44.9	29	$414,408
25%	287.4	265.4	244.1	223.7	180.6	128.0	59.2	27	$518,010

Calibrated using actual 2410 data for AH-64D Nose Gear Box

- **2 Variables, 7 levels each, 49 options, 90 simulation runs per option = 4410 total runs**

Analyzing Root Causes and Prescribing Innovation Catalysts Across the Supply Chain

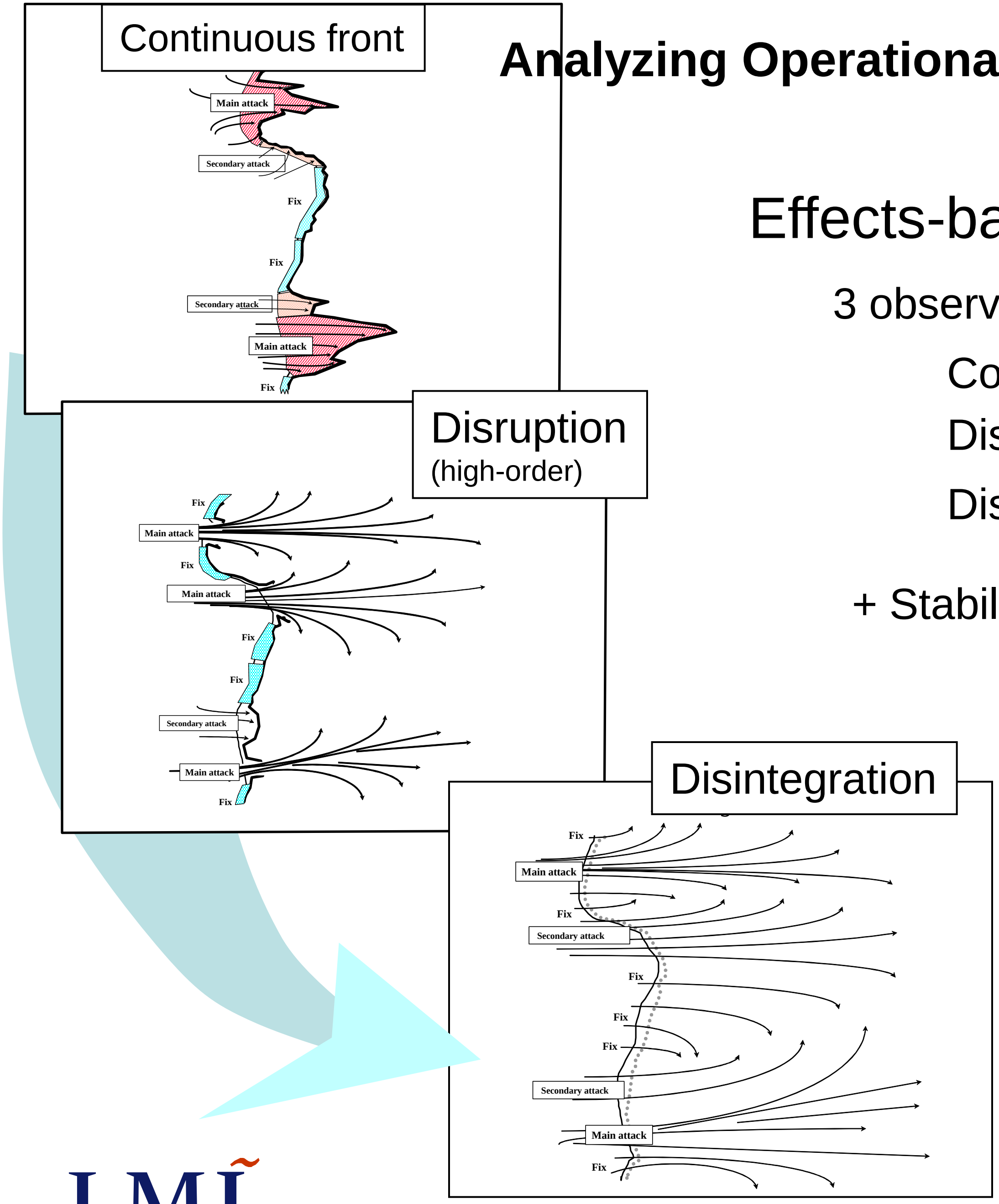


(2) limited understanding of mission-based, operational demands and associated spares consumption patterns which contribute to poor operational and tactical support planning and cost-*in*effective retail stock policy;

Innovation Catalysts:

- **Defining the Readiness Equation**
- **Connect CBM to the Supply Chain**
- **Mission Based Forecasting**
- **Readiness Based Sparing**
- **Readiness Responsive Retrograde**
- **Leveraging Lessons Learned & Best Practices**

Analyzing Operational Forms and Empirical Patterns

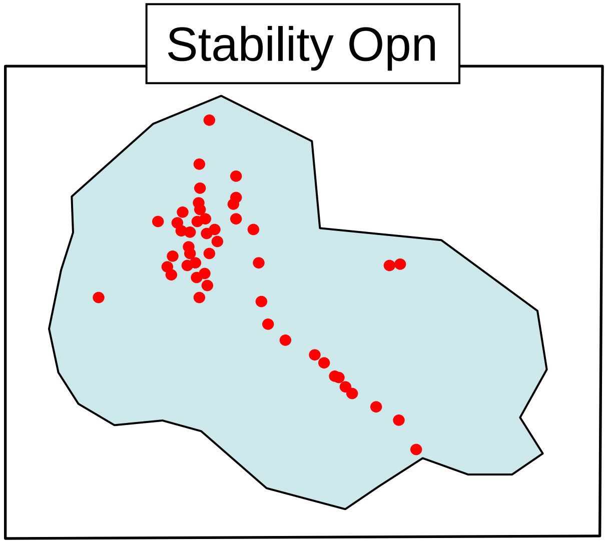


Effects-based operational forms:

3 observed force-on-force forms

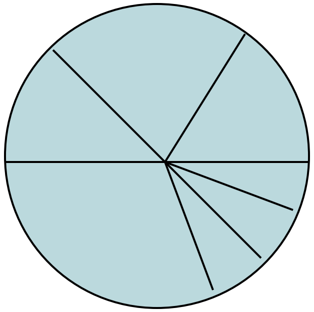
- Continuous fronts
- Disruptions
- Disintegrations

+ Stability operations



LMI

STRATIFIED SAMPLING



POPULATION OF SIZE **N** DIVIDED INTO **K** STRATA

RANDOM SAMPLING: $\hat{P}_{RSM} = \frac{x}{n}$

STRATIFIED SAMPLING: $P_k^1 = \frac{x_k}{n_k}$

THEN:

$$\hat{P}_{STRAT} = \frac{\sum_{i=1}^{k} N_k P_k^1}{N}$$

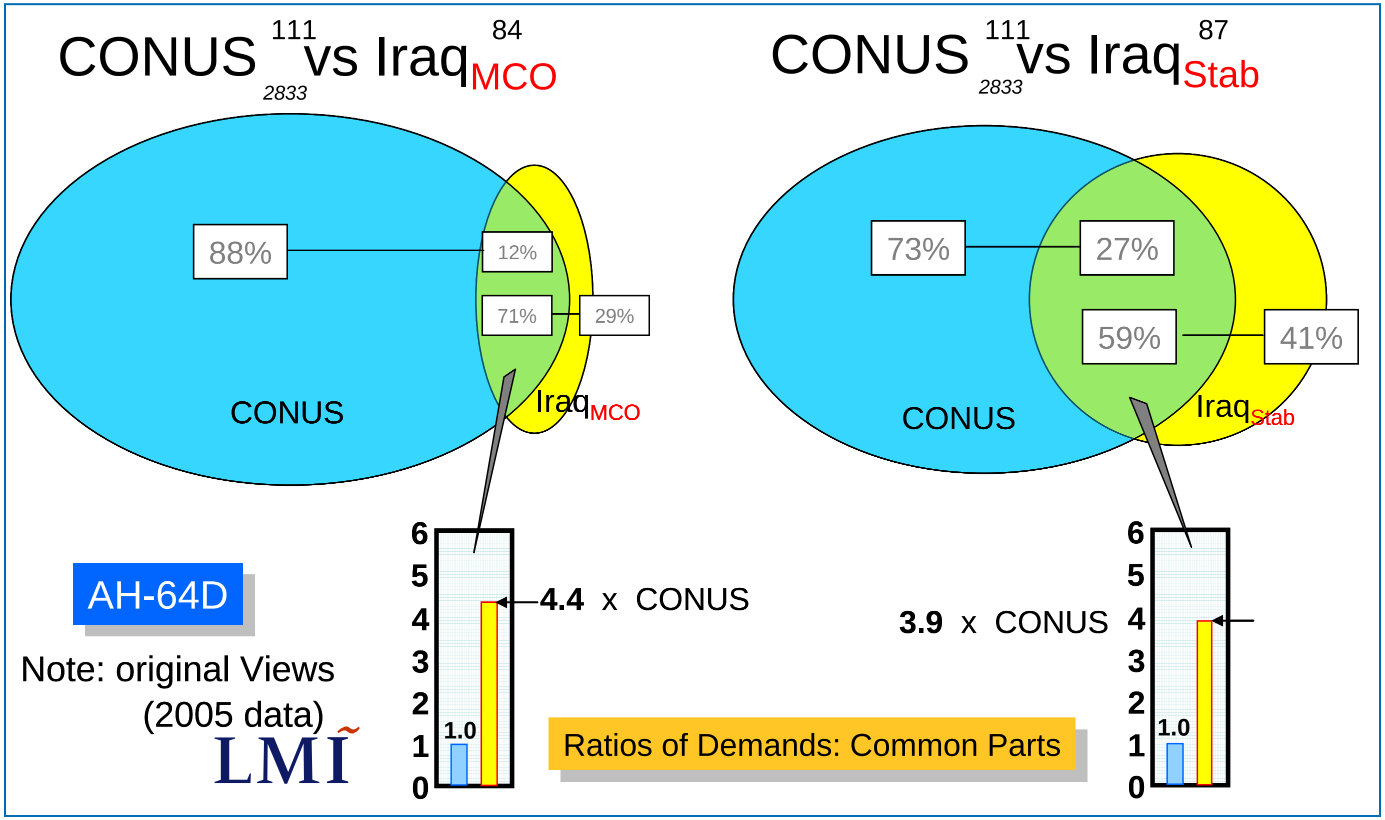
USUALLY:

$$Var\left(\hat{\Theta}_{STRAT}\right) \leq Var\left(\Theta_{POP}\right) \leq Var\left(\hat{\Theta}_{RSM}\right)$$

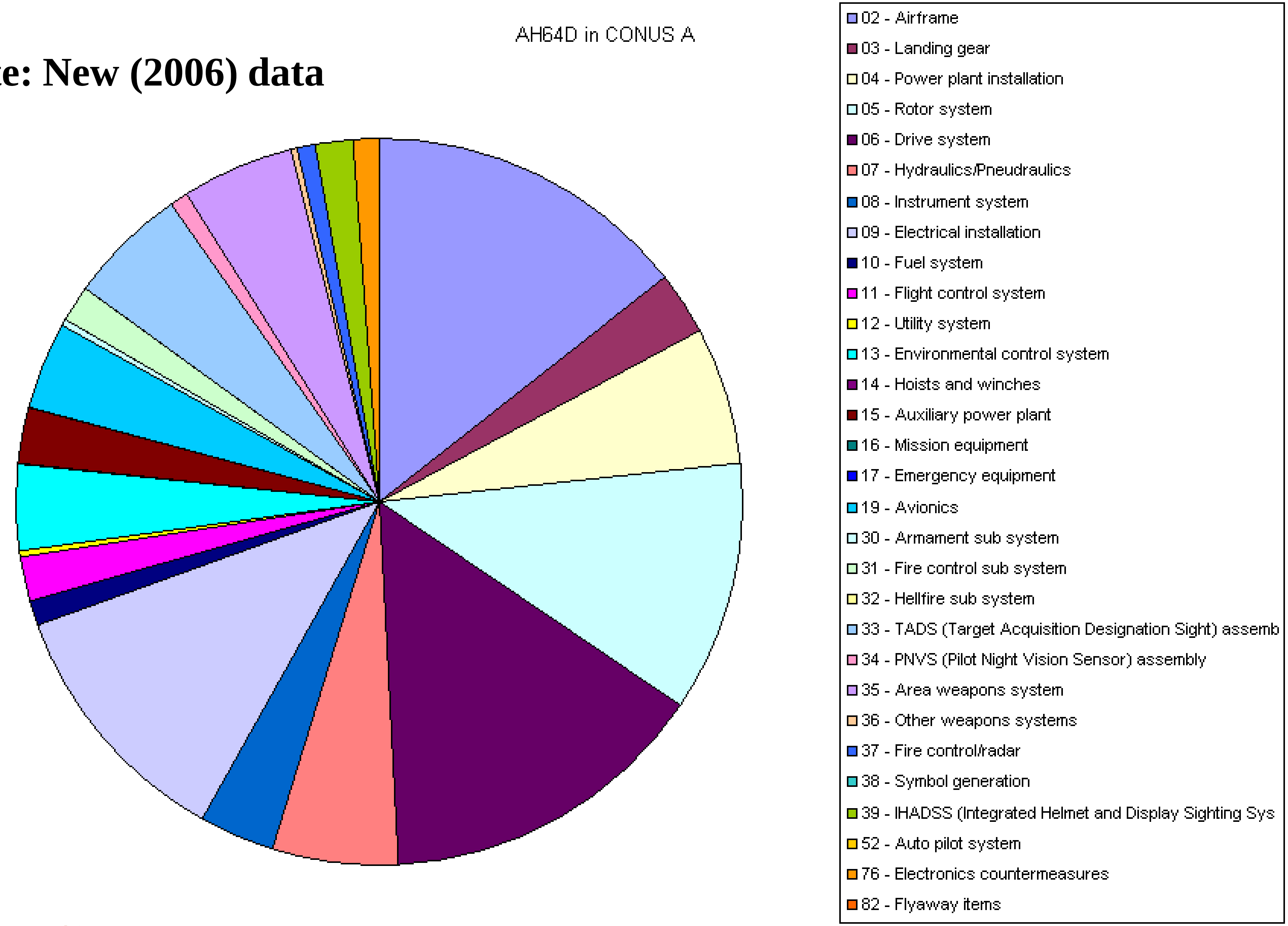
Innovation Catalyst: Mission-Based Forecasting (MBF)

Research Goal:

Our major hypothesis states: "If empirically-derived Class IX usage patterns, profiles and/or trends can be associated with various operational mission types and environmental conditions, then operational planning, demand forecasting, and budget requirements can be significantly improved to support a capabilities based force".

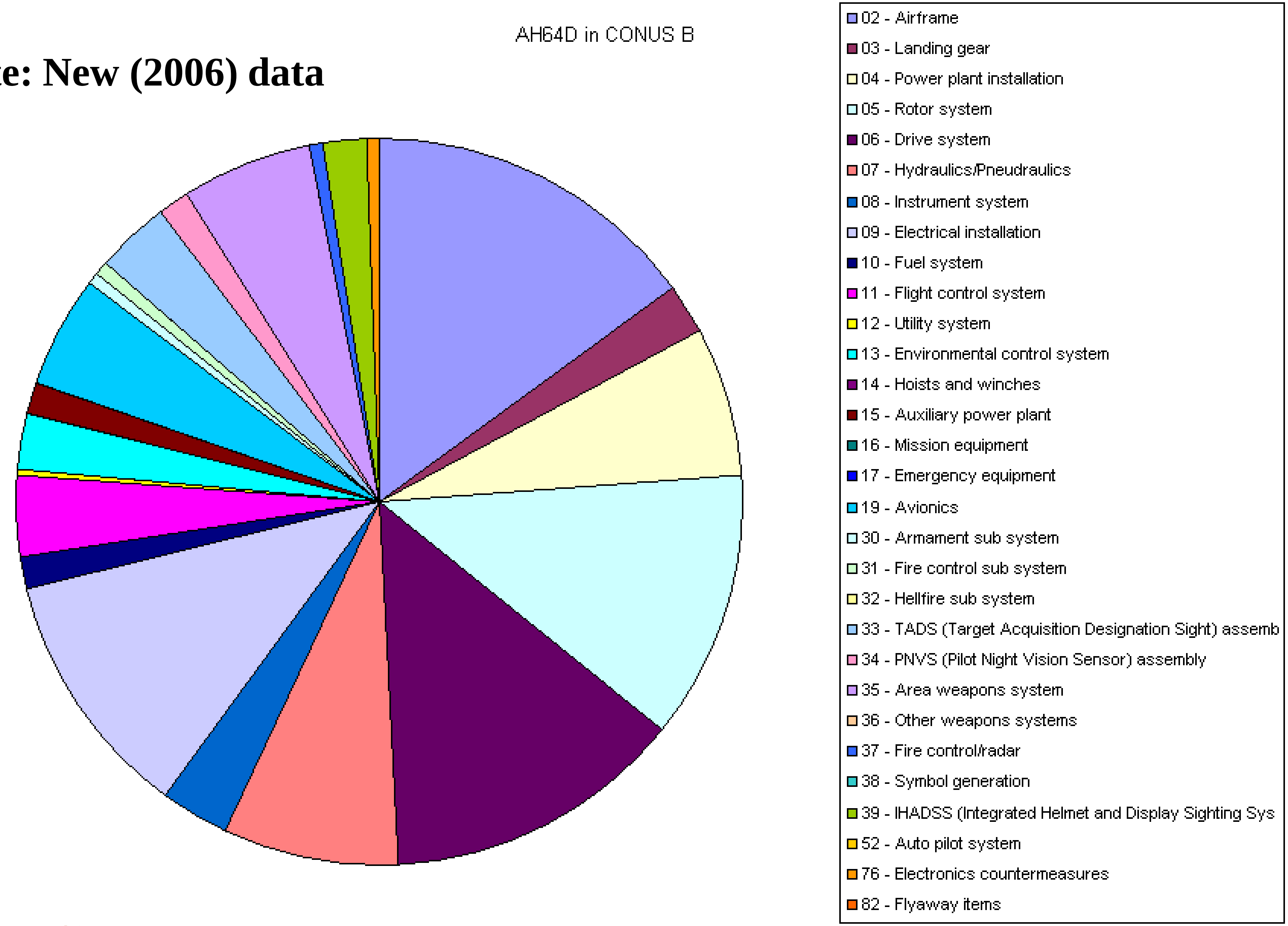


Note: New (2006) data



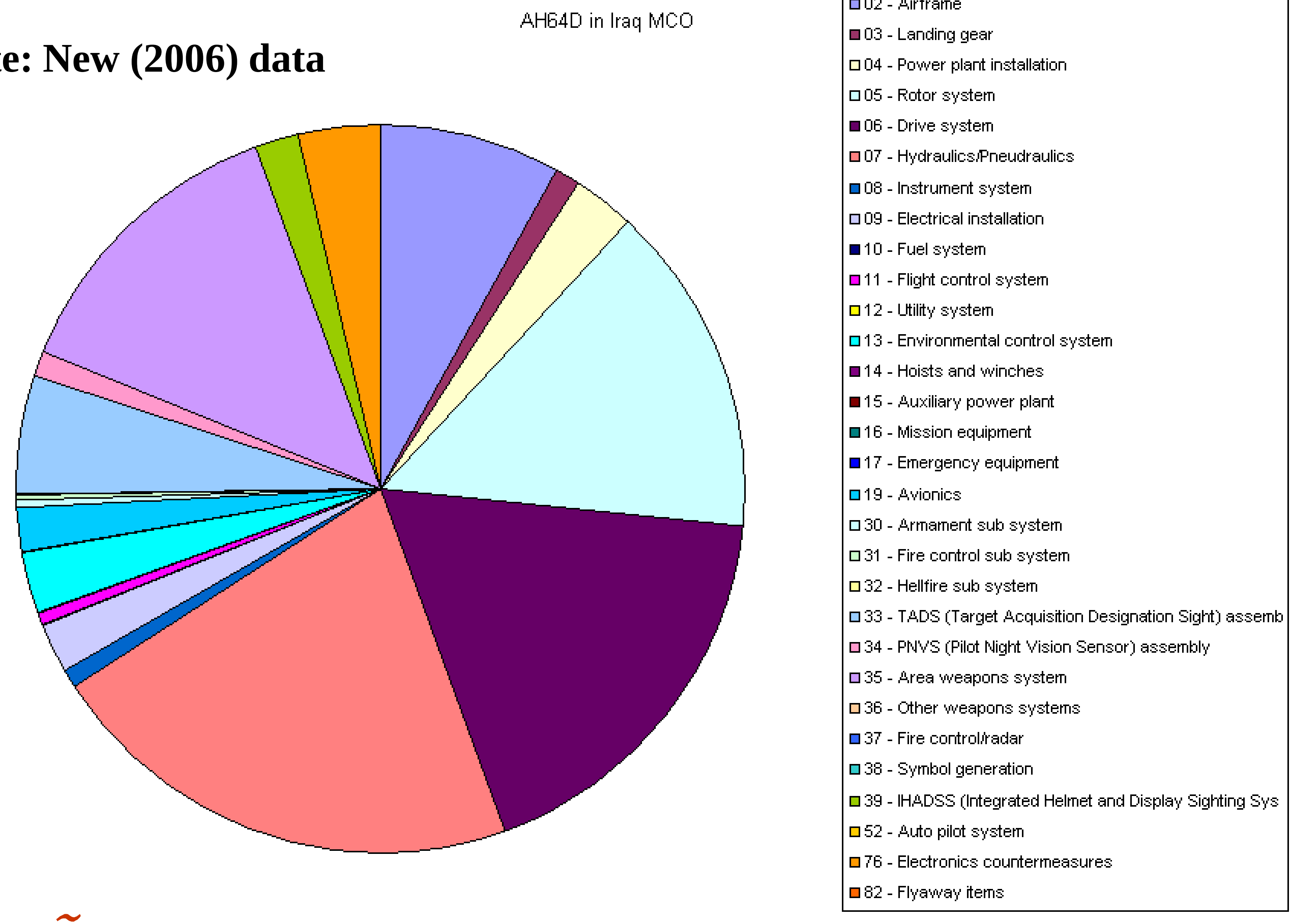
LMI

Note: New (2006) data



LMI

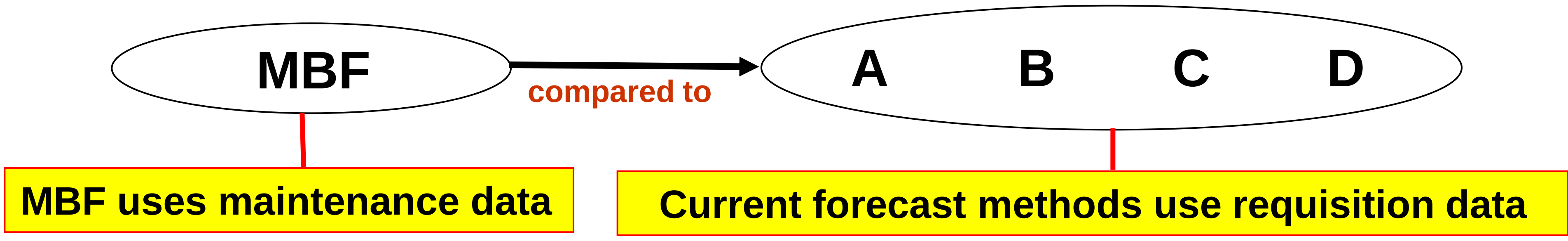
Note: New (2006) data



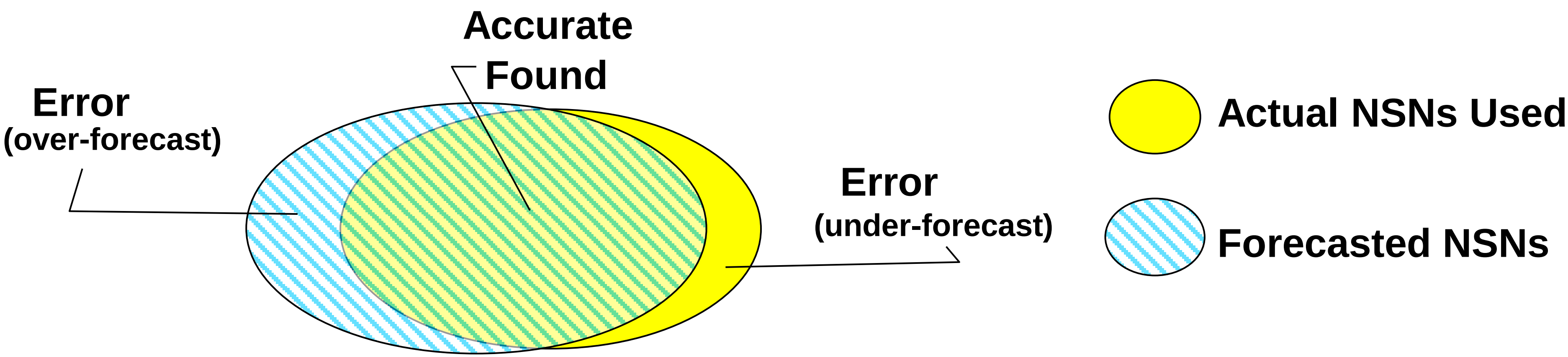
LMI

Tested MBF Method Using Real Data from Four Operational Cases

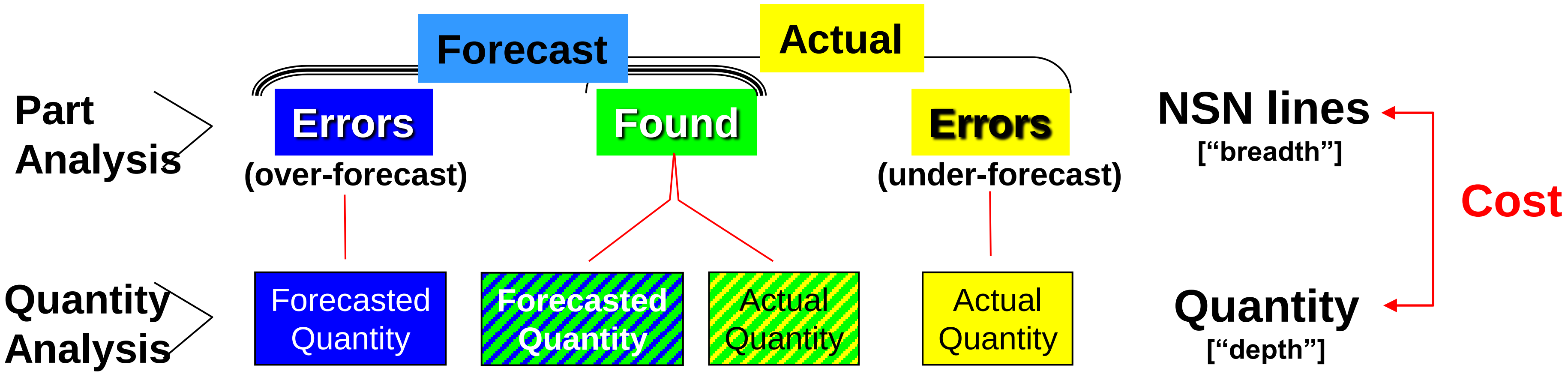
	Operation (OpTempo)	Duration	AH-64D	UH-60
Case 1	Stability Ops (high threat)	6 months	24 tails	22 tails
Case 2	Stability Ops (mid-level)	6 months	79 tails	10 tails
Case 3	Stability Ops (mid-level)	12 months	104 tails	
Case 4	Garrison (Training, CONUS)	12 months	54 tails	40 tails



Comparing Forecast Approaches:
Accuracy versus over- and under-forecast

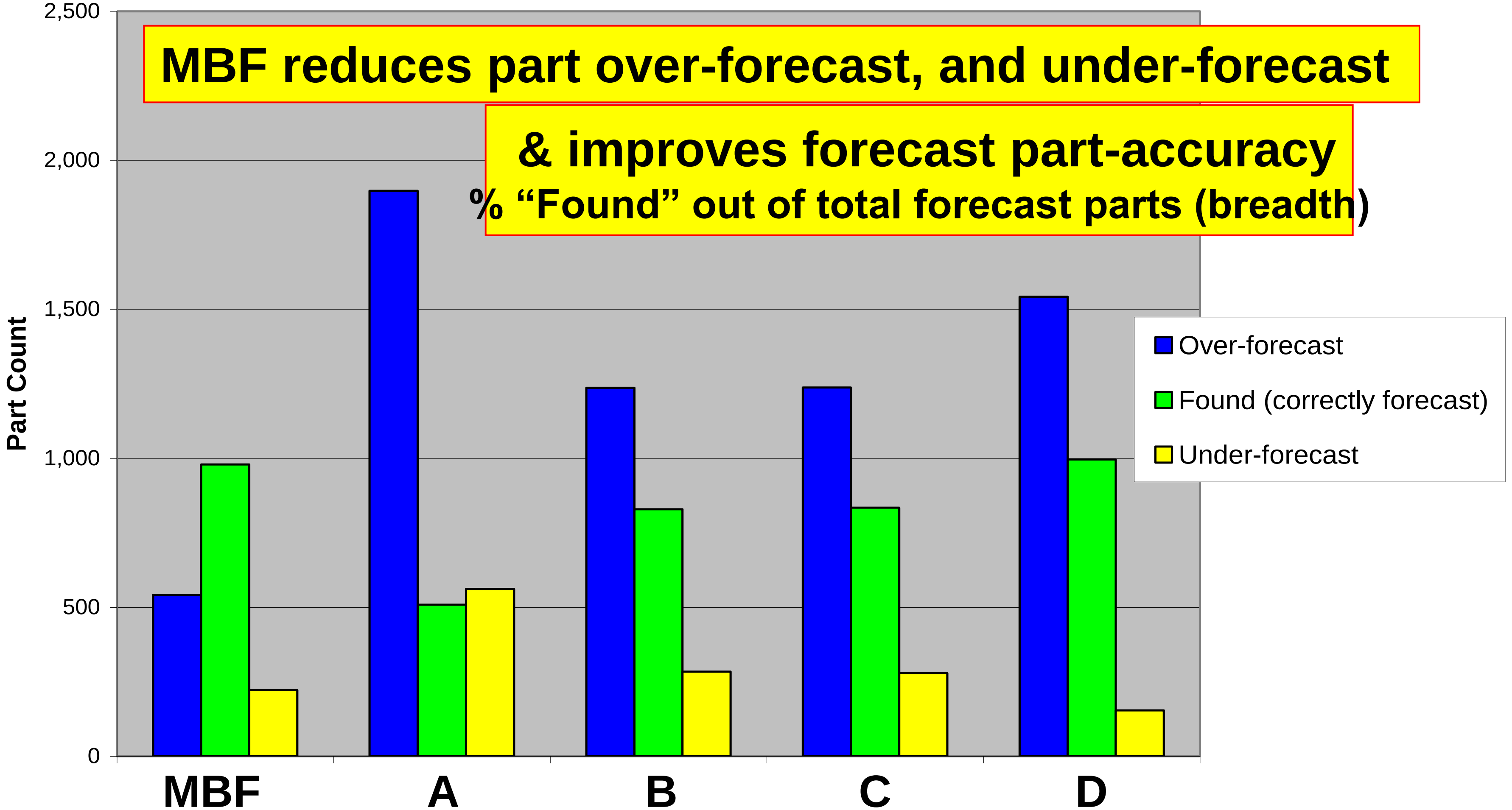


The Analysis addresses two perspectives



AH-64D Parts Count Forecast (Breadth of NSNs): MBF Compared to Current Methods

Case 3, Stability Ops (mid-level threat), 12 months, 104 tails

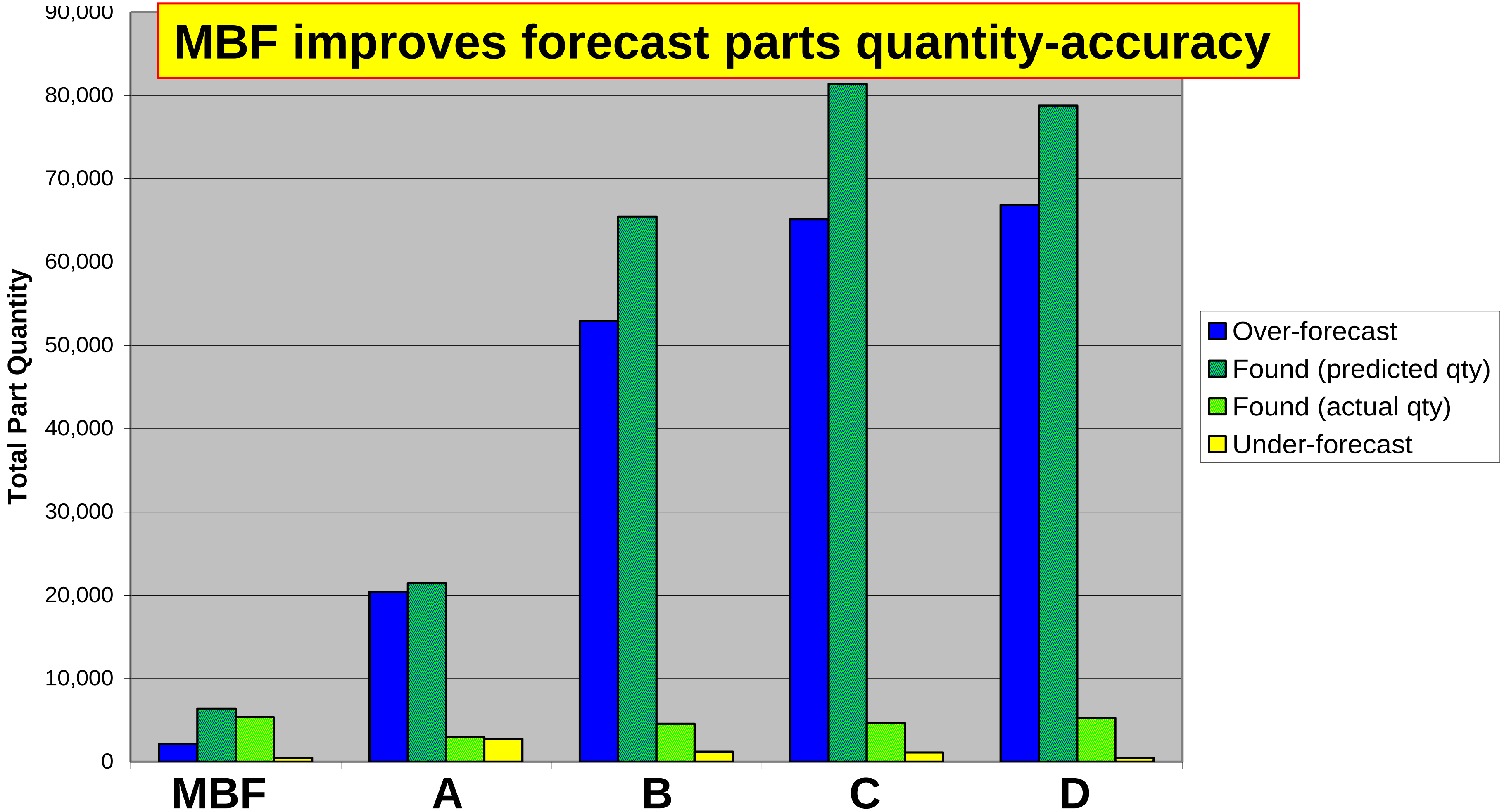


These current methods (A, B, C, D) use supply requisitions data

AH-64D Parts Quantity Forecast (Depth of NSNs): MBF Compared to Current Methods

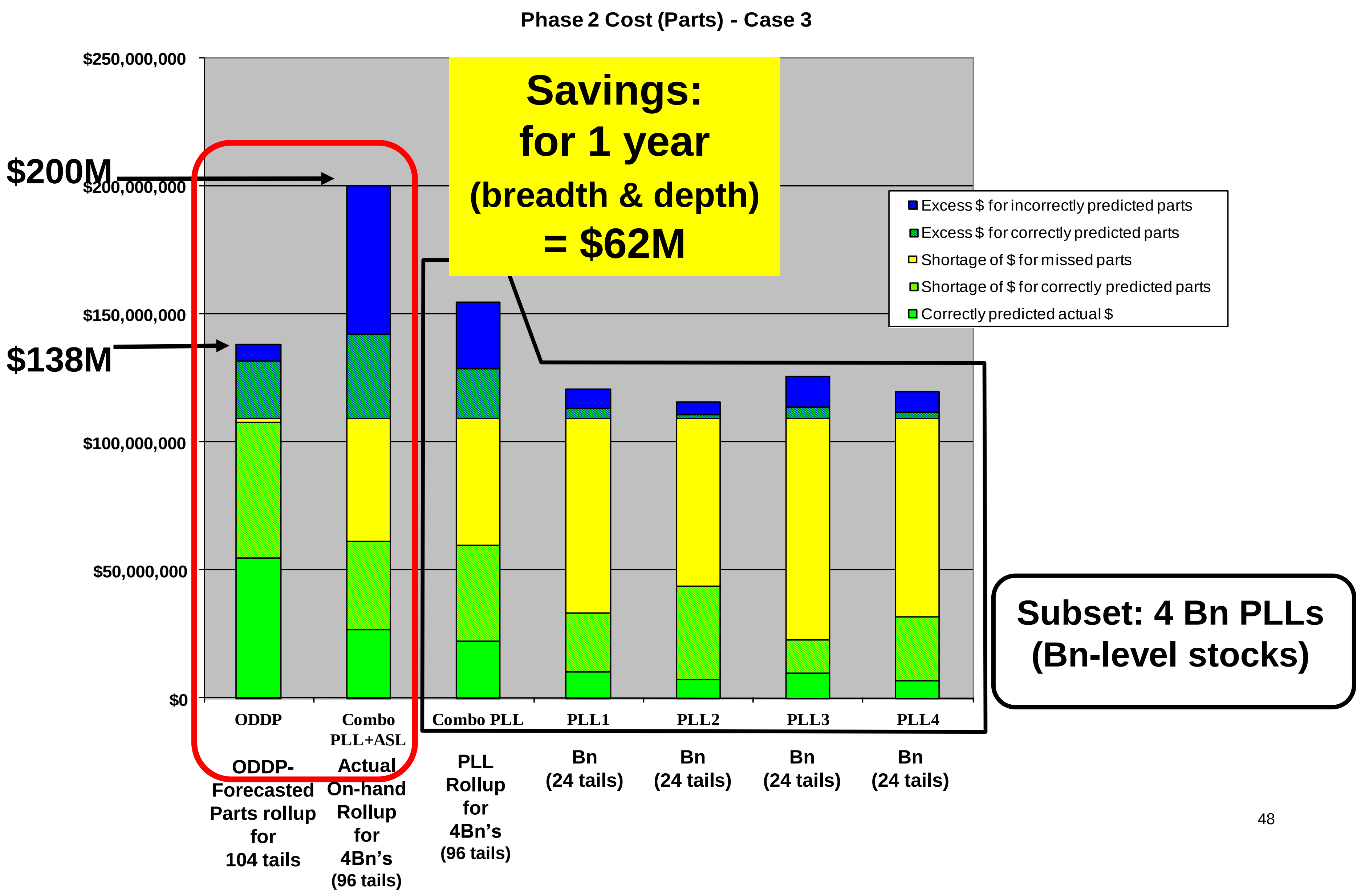
Case 3, Stability Ops (mid-level threat), 12 months, 104 tails

MBF improves forecast parts quantity-accuracy

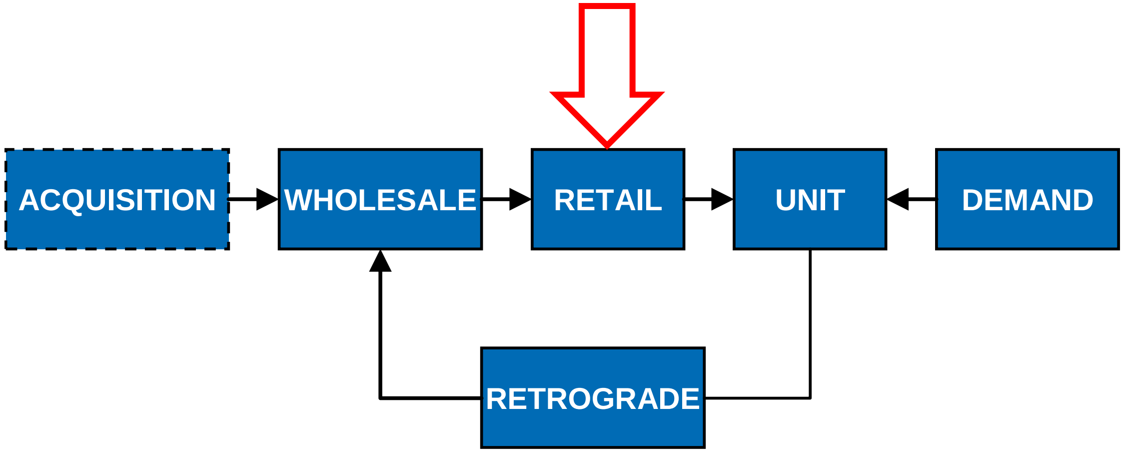


These current methods (A, B, C, D) use supply requisitions data

AH-64D Parts Quantity Forecast (Depth of NSNs): MBF Compared to Actual On-Hand Stocks



Analyzing Root Causes and Prescribing Innovation Catalysts Across the Supply Chain

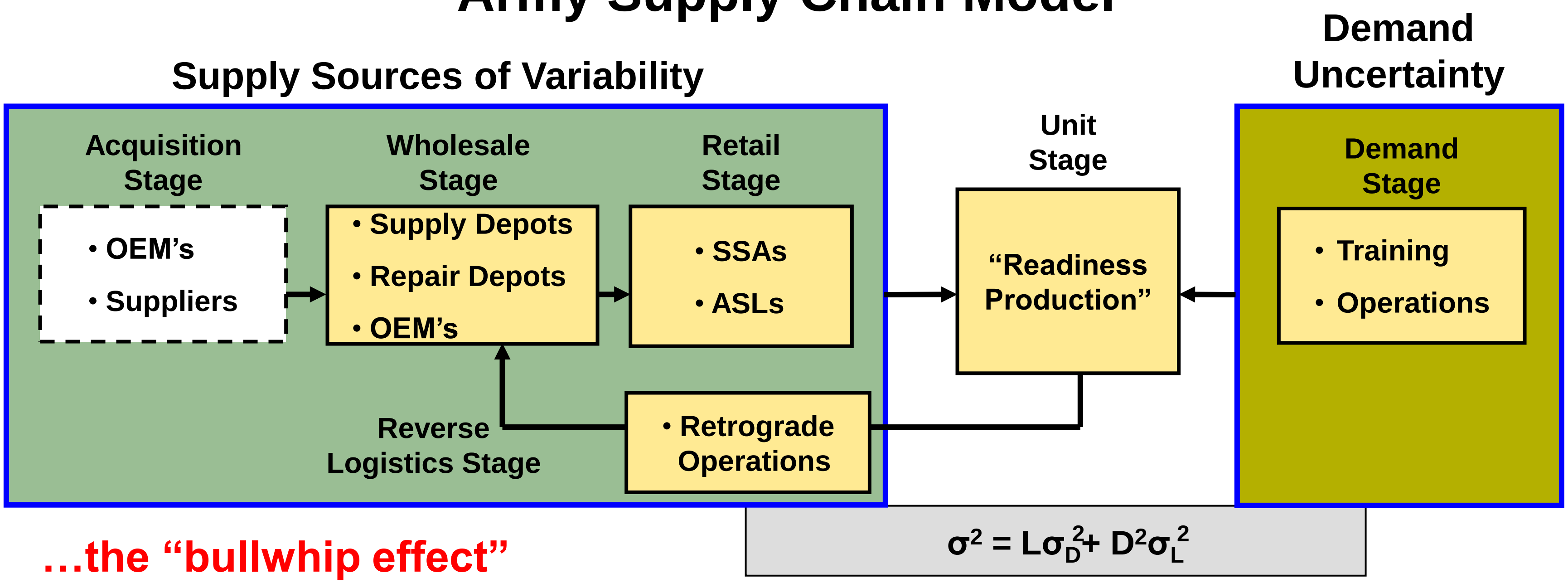


(3) failure to optimize retail stock policy to achieve cost-efficient readiness (customer) objectives which results in inefficient procurement and reduced readiness;

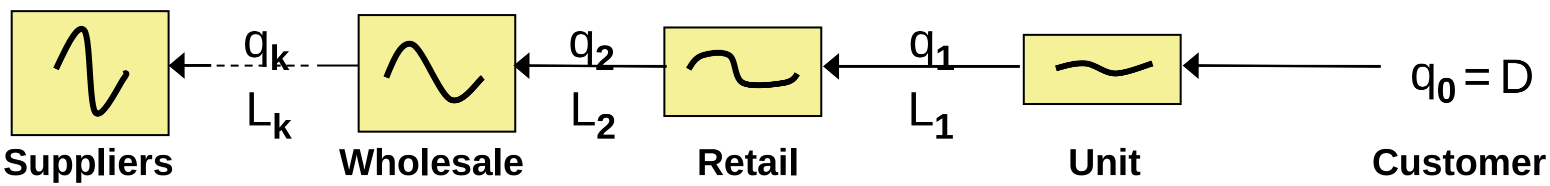
Innovation Catalysts:

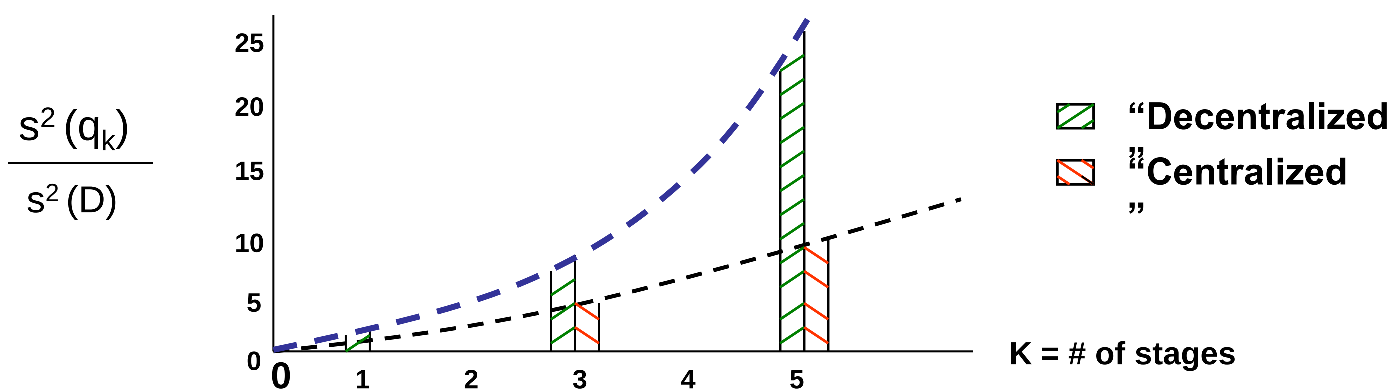
- Defining the Readiness Equation
- Connect CBM to the Supply Chain
- Mission Based Forecasting
- Readiness Based Sparing
- Readiness Responsive Retrograde
- Leveraging Lessons Learned & Best Practices

Supply Variability and Demand Uncertainty: Army Supply Chain Model



…the "bullwhip effect"

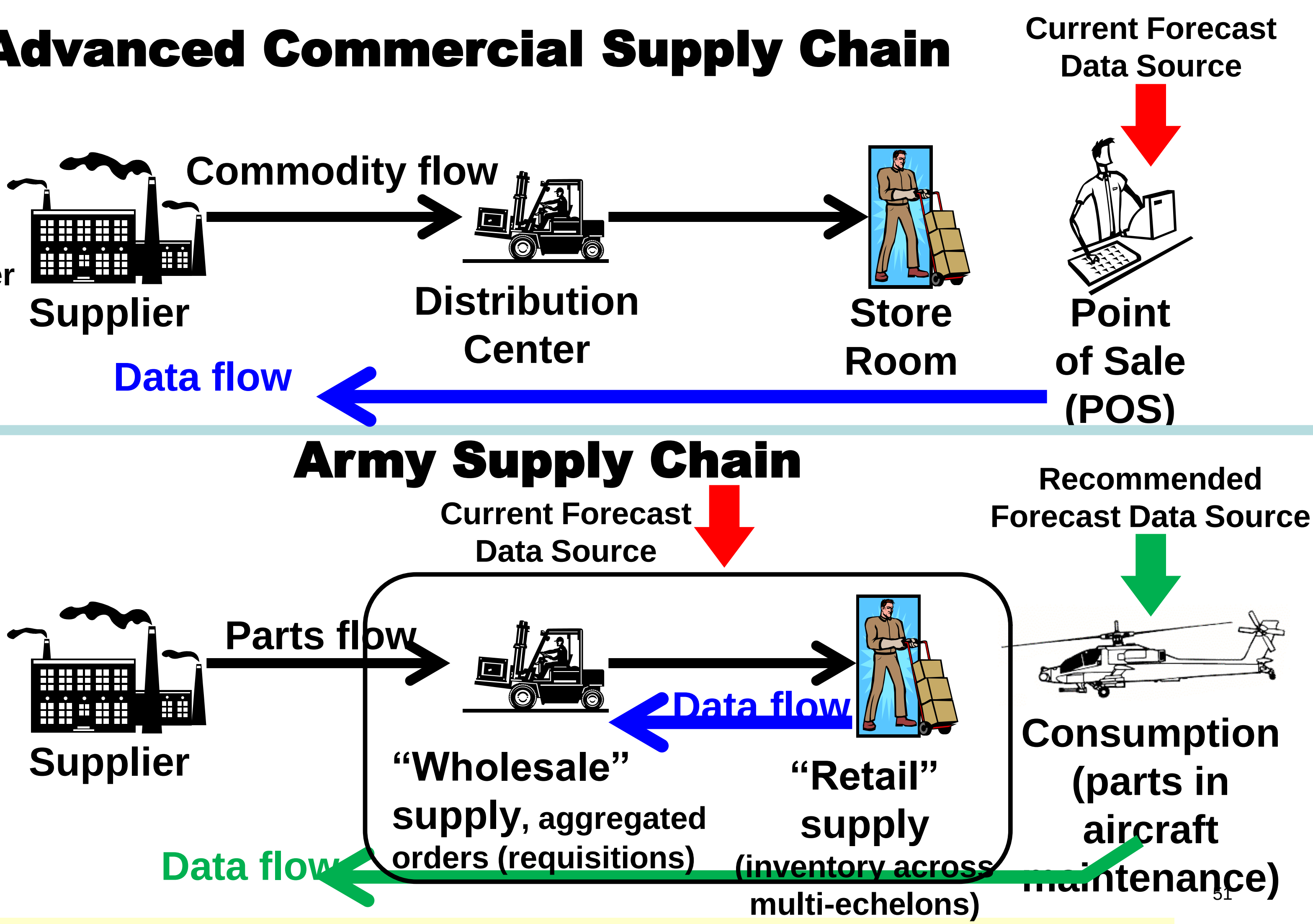




Adopting Mission Based Forecasting (MBF): Key enabler for a "readiness-driven" supply network (RDSN)

Focus: Bottom-up, POS based approach geared toward meeting customer demands

Focus: Top-down approach geared toward meeting inventory level targets



Army Consumption Data=Commercial POS Data

Guiding Principles for Readiness-Driven Demand

1. **The purpose of the materiel enterprise is to sustain current readiness and generate future capability.**

2. **Since readiness is "produced" by tactical (and training) units, these tactical "consumers" represent the ultimate "customer".**

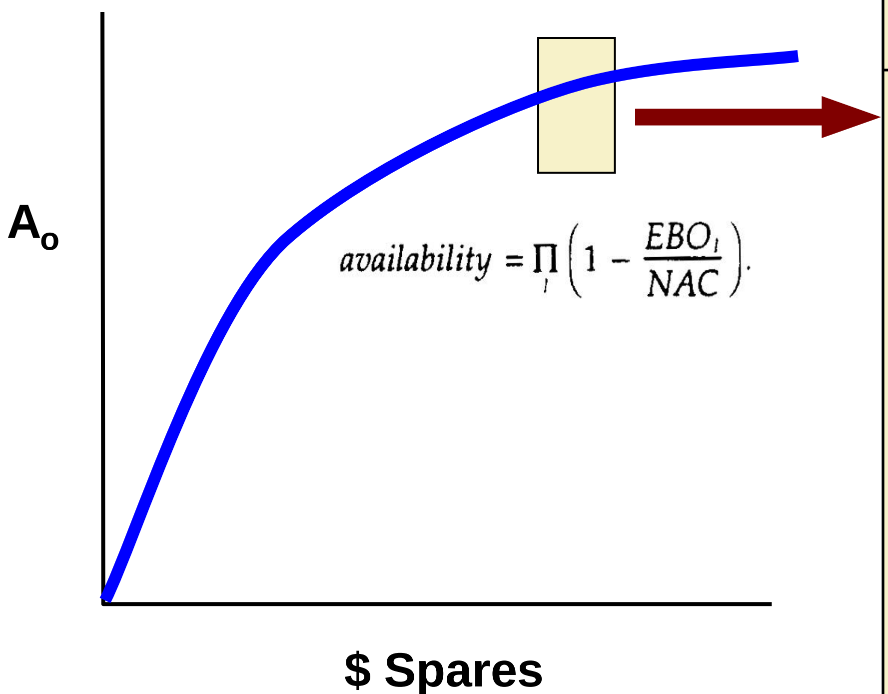
3. **Actual consumer demand needed to produce "readiness" for training and operational missions should drive the materiel enterprise - these are customer "requirements" .**

4. **These requirements must be systematically measured and accurately forecasted at the "point of sale" where readiness is produced by the consumer.**

5. **Demand planning across the enterprise must focus on meeting these requirements (for *effective* performance) while reducing forecast error (*efficient* performance).**

**Align the Class IX supply chain to "real" customer demand,
then pursue Continuous Performance Improvement efforts and initiatives
focusing on "Cost-Wise Readiness" for Army Materiel Transformation**

Readiness Based Sparing (RBS)



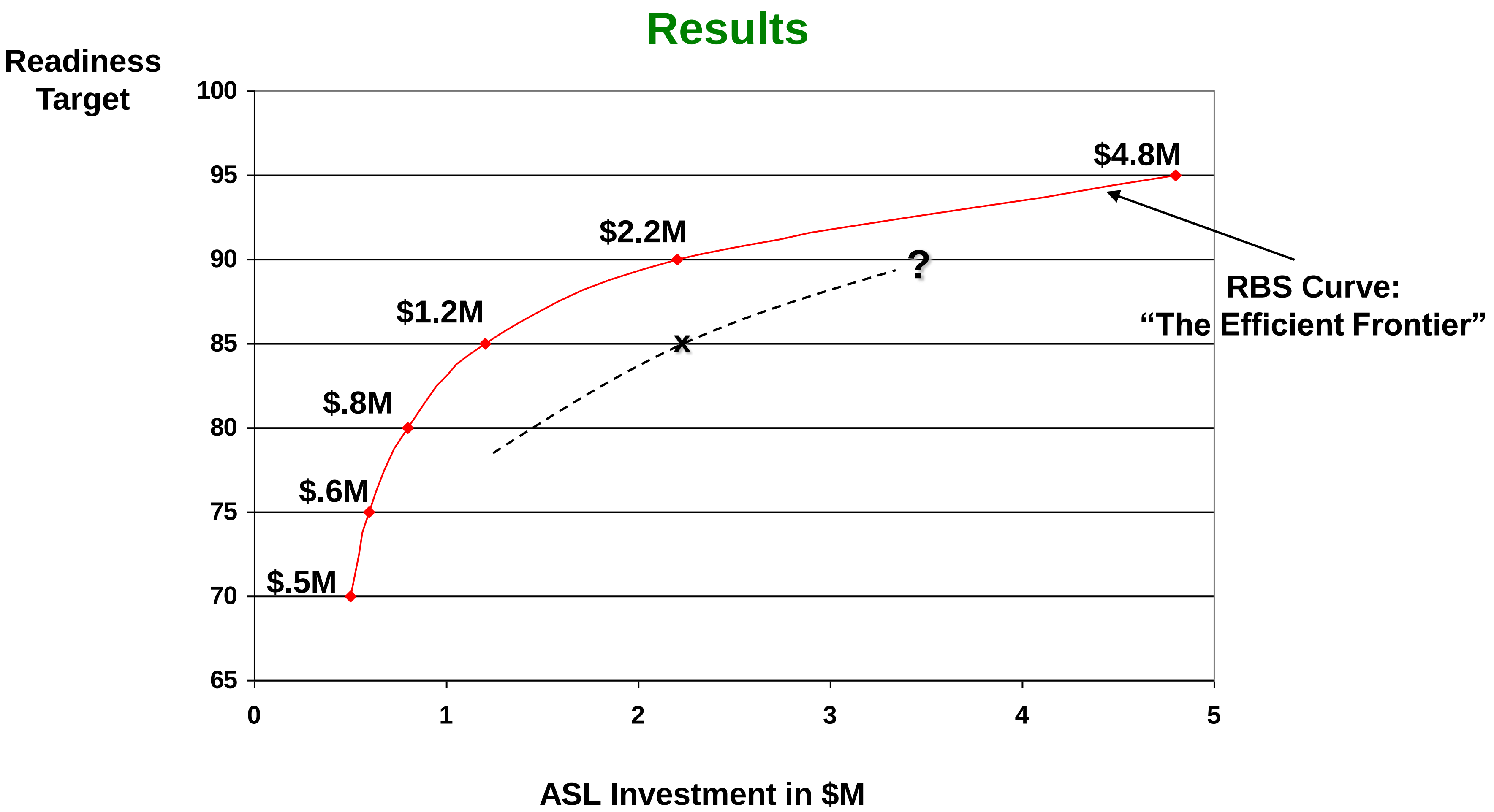
$$availability = \prod_i \left(1 - \frac{EBO_i}{NAC}\right).$$

Shopping List

Item	Unit Cost ($)	Added Aircraft/ $10K	Total Cost ($)	Availability Rate (%)
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
6th A	1,600	0.388	101.600	66.67
11th B	2,300	0.352	103.900	66.69
2nd C	10, 400	0.312	114.300	66.74
12th B	2,300	0.283	116.600	66.76
1st D	13,800	0.154	130.400	66.78
7th A	1,600	0.144	132.000	66.79
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-

Marginal Analysis Includes:
- Cost of Parts
- Frequency of Use/Need
- Part Impact on Readiness

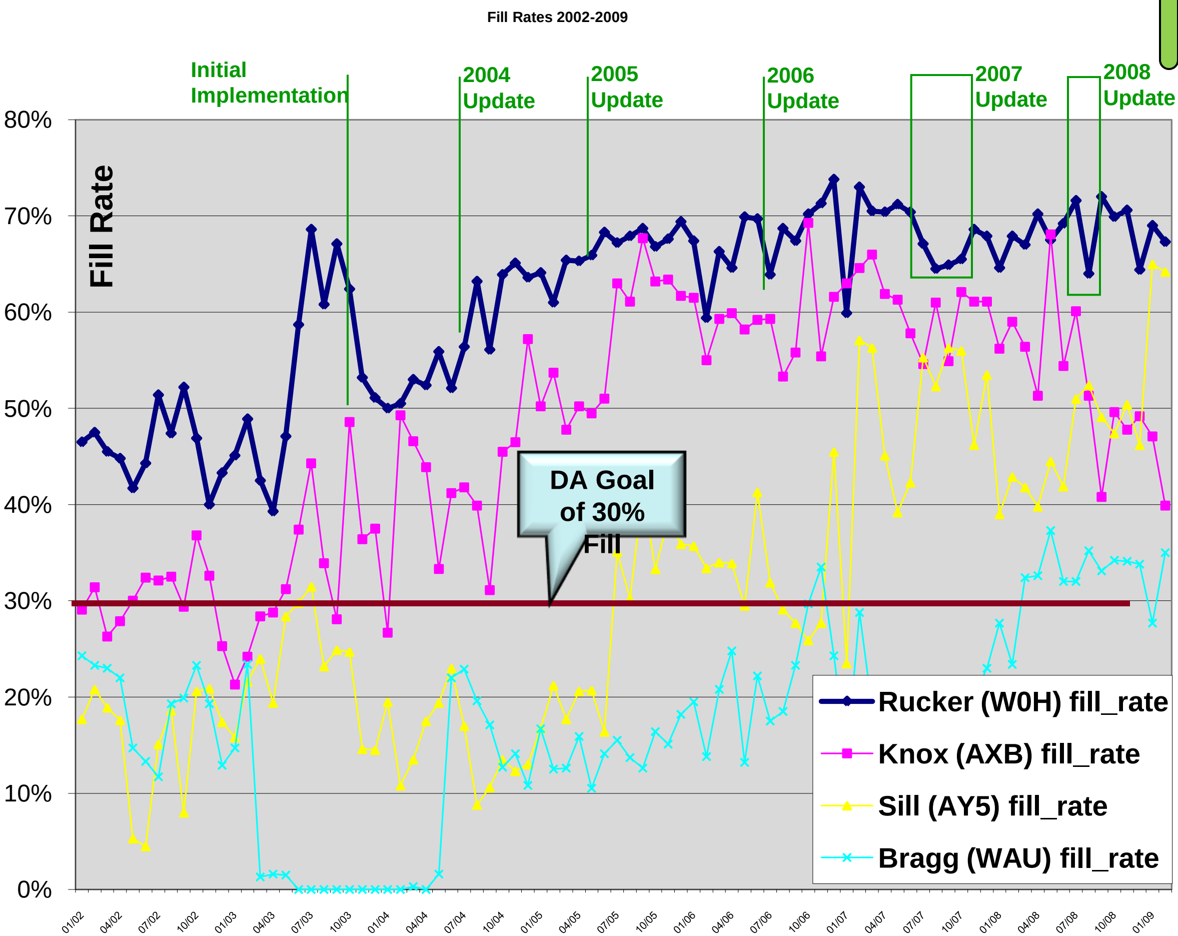
Analytical Demonstration:
Readiness Based Sparing: 101st ABN DIV UH-60



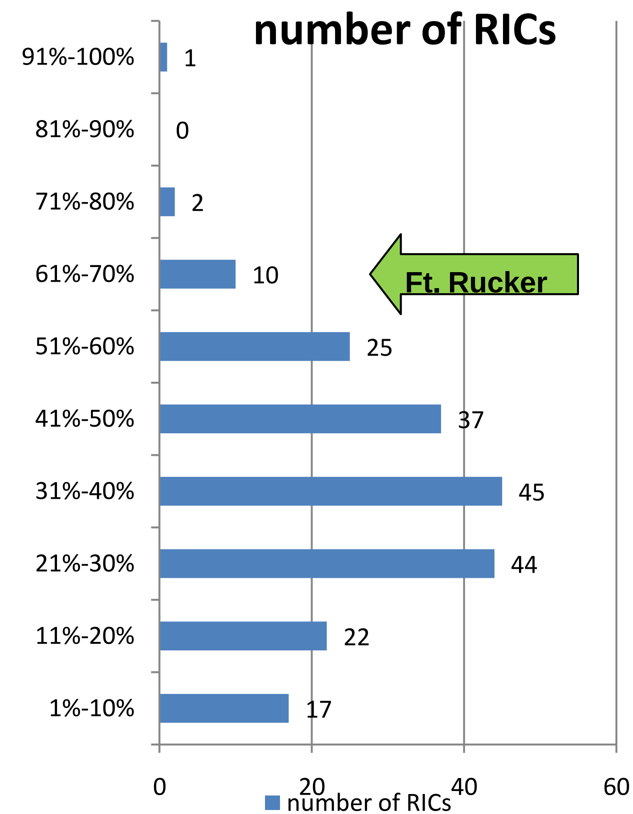
Source: AMSAA

- **Provided first RBS ASL in 2003 (MG Dodgen) and continue to provide yearly updates**
- **Ft. Rucker winner of 2006 and 2009 Supply Excellence Award for CAT IV (Large Group) SSA**

Ft. Rucker consistently has the highest fill rates in the Army

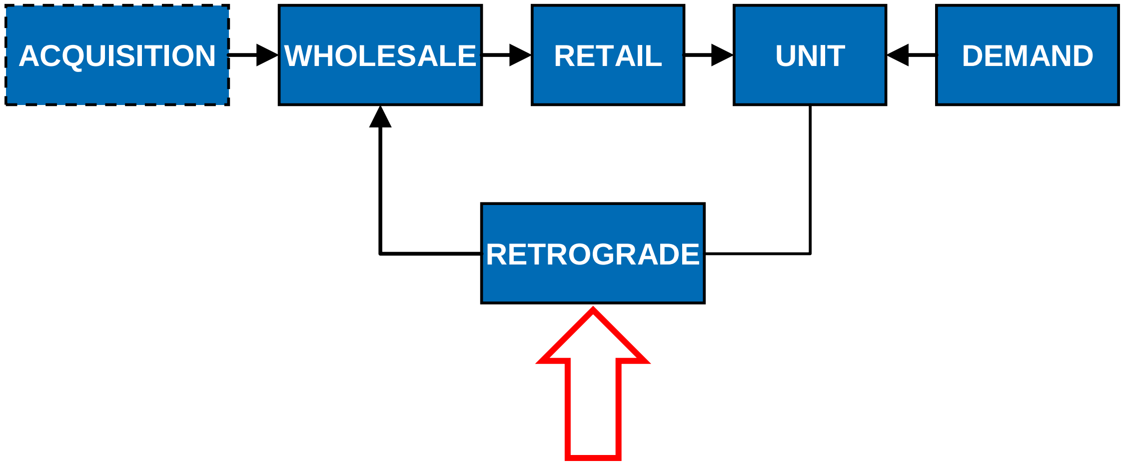


ILAP performance rates as of March 20, 2009



ILAP performance for June 2009

Analyzing Root Causes and Prescribing Innovation Catalysts Across the Supply Chain



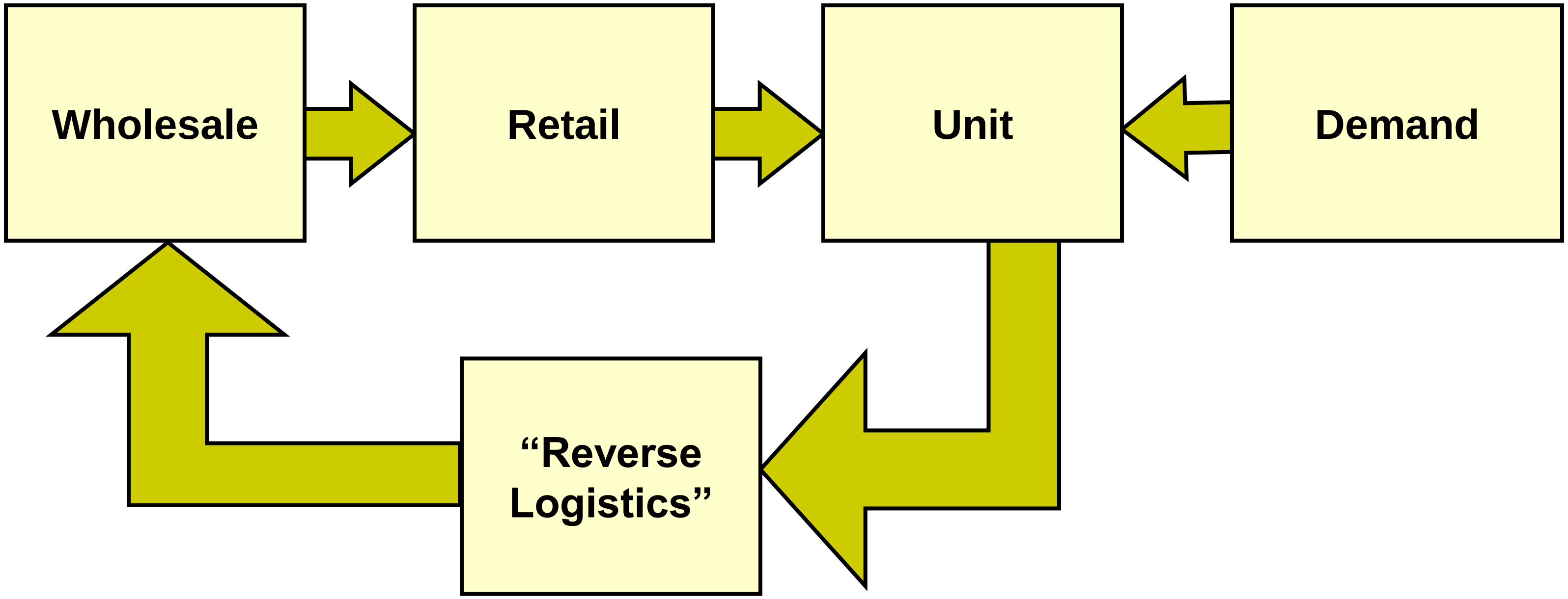
(4) failure to proactively synchronize and manage reverse logistics which contributes significantly to increased DLR RO, excess inventory, increased delay times (order fulfillment), and reduced readiness while simultaneously precluding the enormous potential benefits of a synchronized, closed-loop supply chain for DLRs;

Innovation Catalysts:

- **Defining the Readiness Equation**
- **Connect CBM to the Supply Chain**
- **Mission Based Forecasting**
- **Readiness Based Sparing**
- **Readiness Responsive Retrograde**
- **Leveraging Lessons Learned & Best Practices**

The Retrograde Challenge: Depot Level Reparables (DLRs)

- Represents the Army's "Value Recovery Effort" – the "Feedback Loop"
- Accounts for 13% of customer orders, but 88% of Sales Value



- The FY00 average reverse pipeline delay was 80 Days
- AMCOM shortfall for DLR maintenance was $1.4B in 02
- Increasing obsolescence challenges will further stress RL and illuminate RCT inefficiencies, e.g. PATRIOT TWTs during OIF

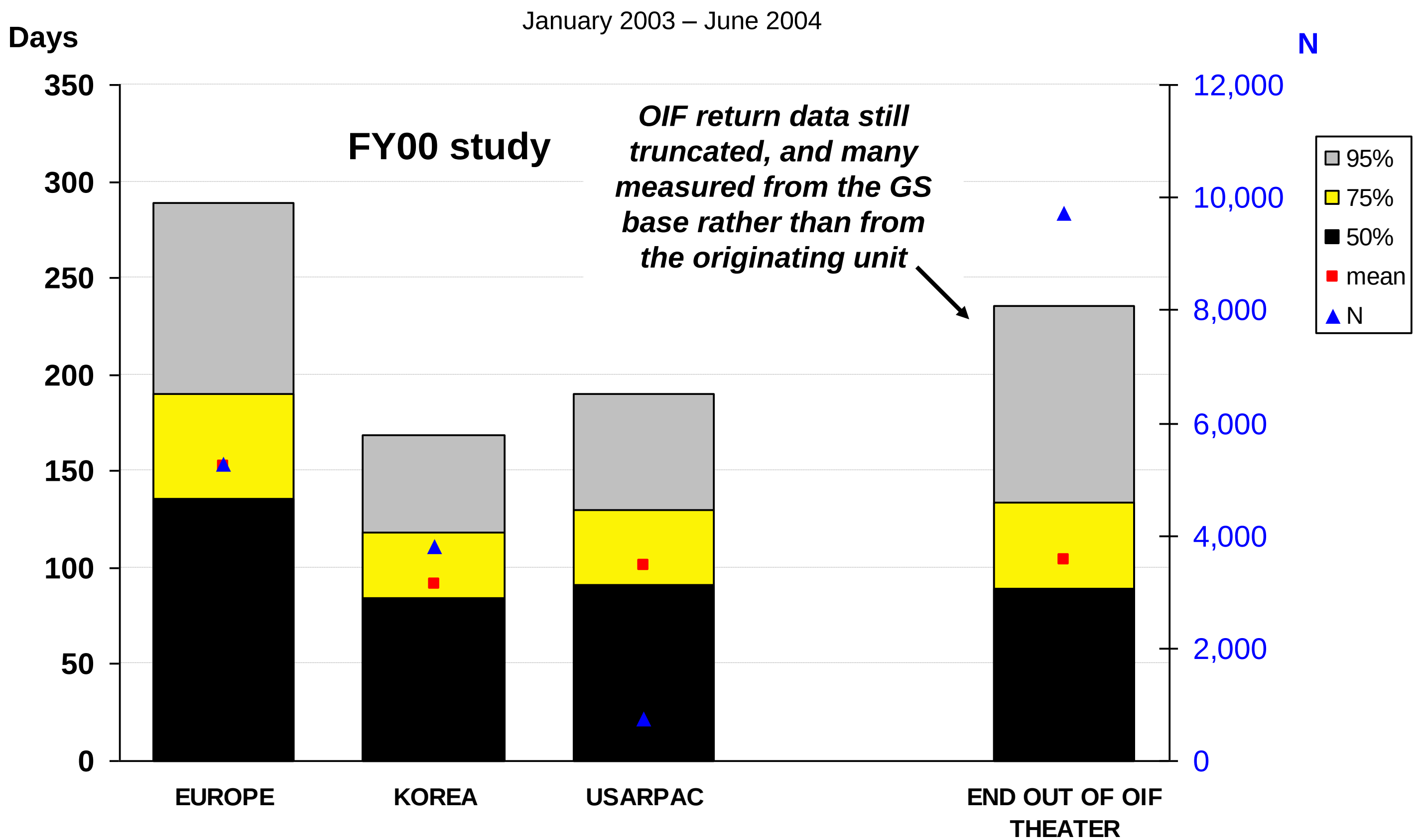
Innovation Catalyst: Readiness Responsive Retrograde

Conditions:

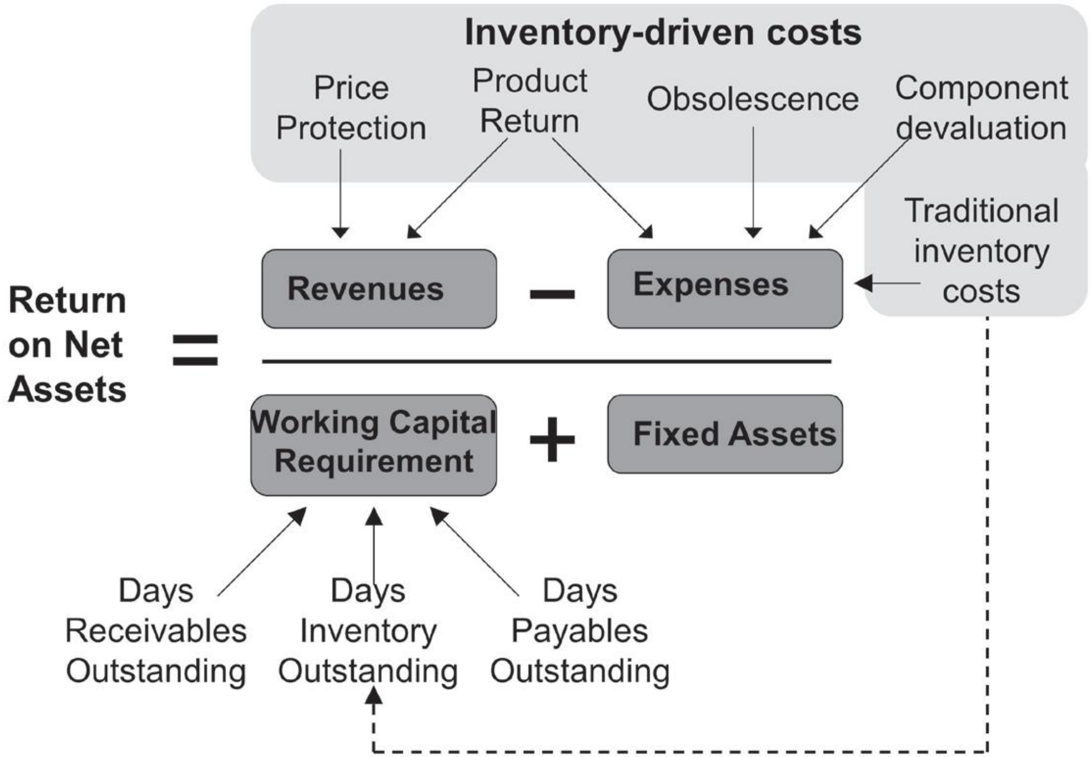
Represents "Value Recovery Effort" – the "Feedback Loop". Accounts for 13% of customer orders, but 88% of sales value.

Research Results:

Tremendous potential for reducing retrograde delay: DLR RO can then be reduced, or used for other purposes, *and* readiness improved. However, TRANSCOM metrics focus on transportations costs, not readiness outcomes.

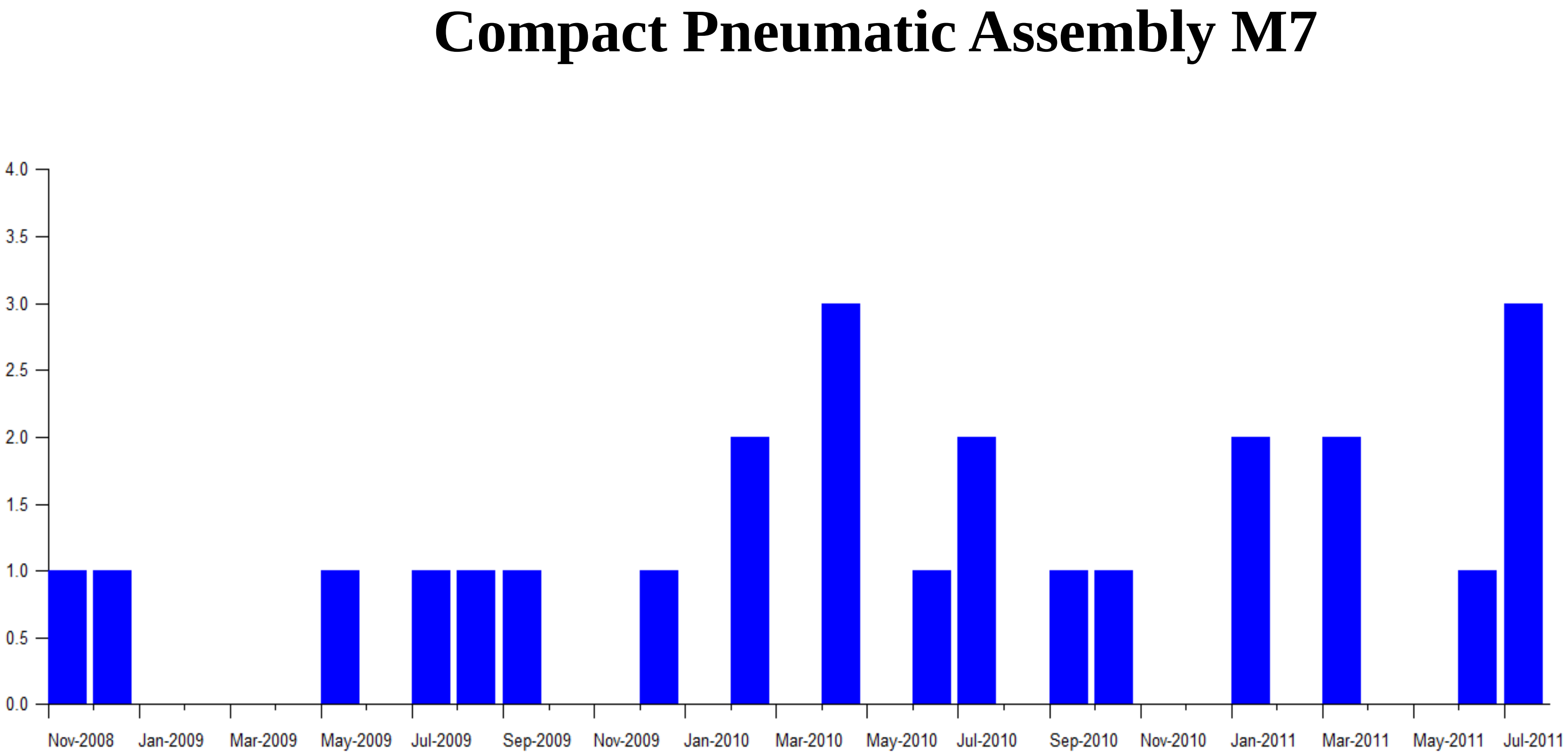


Evaluating Retrograde Efficiency: Readiness Return on Net Assets



Retrograde Efficiency Measures for management focus:
Minimize: transportation costs? DLR inventory cost per aircraft?
Maximize: materiel availability? DLR turnover ratio?

Example of Intermittently-Demanded Service Part



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Evolution of Intermittent Demand (ID) Forecasting Methods

- **1st Generation: Subjective (still most used)**
- **2nd Generation: ID-ignorant stat methods (USAF D200)**
  - Exponential smoothing, Moving average
- **3rd Generation: ID-aware stat methods (USA LMP)**
  - Croston's method, Poisson and extensions
- **4th Generation: State of the art ID-aware stat methods**
  - Markov bootstrap
- **5th Generation (future): Advanced ID statistical methods**
  - Mining large sets of stochastic process data

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4th Gen – ID State of the Art: Markov Bootstrap

- **US Patent 6205431 B1 to Smart Software, Inc.**
- **Positives**
  - Highly accurate on real-world data
  - Explicitly accounts for key data features
    - Integer nature of demand
    - Large % of zero values
    - High variability in nonzero demand values
    - Autocorrelation of successive demands
- **Negatives**
  - Assumes no trend or seasonality
  - … but an even better version is coming (patent pending)

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Markov Bootstrap Methodology

Observation	1	2	3	4	5	6	7	8	9	10	11	12
Demand	4	0	0	9	3	2	0	0	8	3	0	5
Binary demand	X	0	0	X	X	X	0	0	X	X	0	X
Non-zero demands	4	9	3	2	8	3	5					

Markov model		Next	demand		Markov model		Next	demand	
transition counts		0	X		transition probabilities		0	X	
Current	0	2	3	5	Current	0	0.40	0.60	1.00
demand	X	3	3	6	demand	X	0.50	0.50	1.00
				11					

Lead time scenarios

Future observation	13	14	15		Future observation	13	14	15	LTD
Replication #1	0	0	X		Replication #1	0	0	3	3
Replication #2	0	X	X		Replication #2	0	9	8	17
Replication #3	X	X	0		Replication #3	3	4	0	7
Replication #4	0	0	0		Replication #4	0	0	0	0

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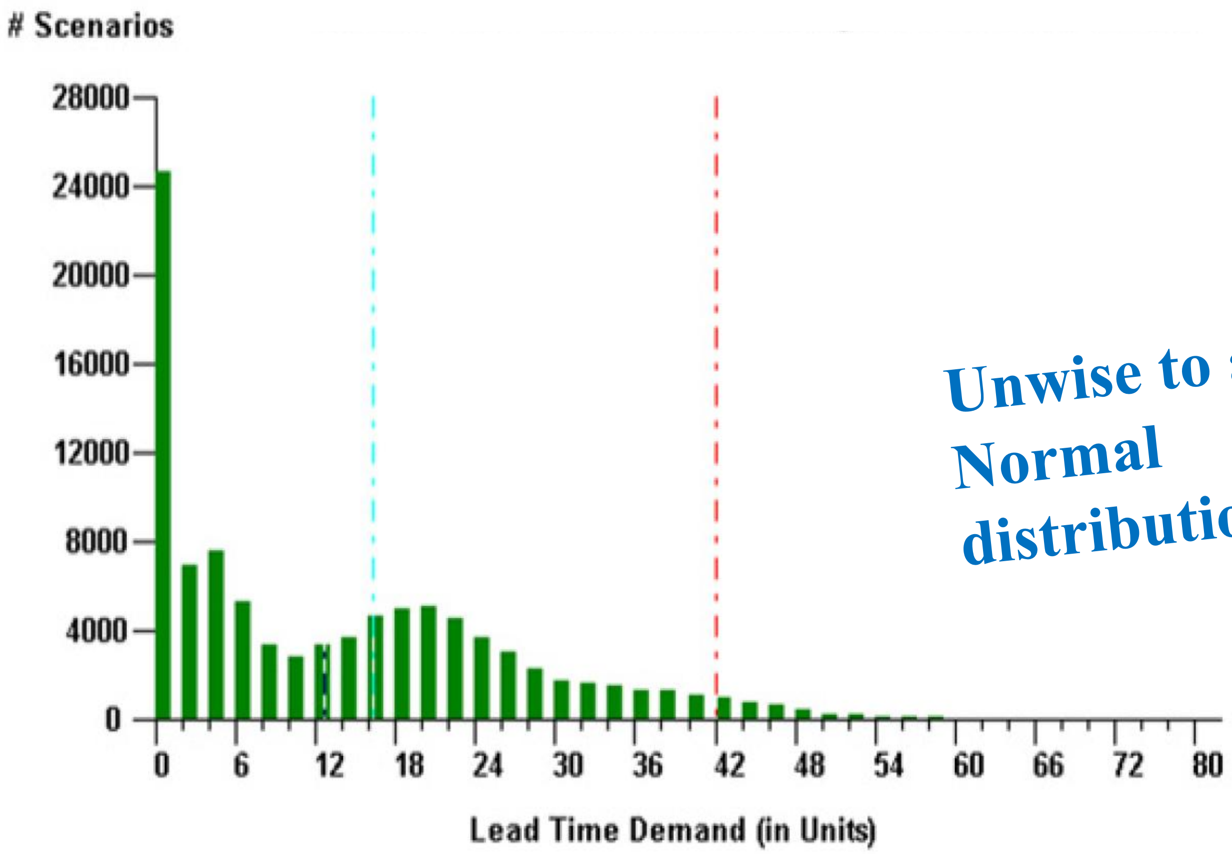
ID Demand Forecast Over Lead Time



Unwise to assume a Normal distribution

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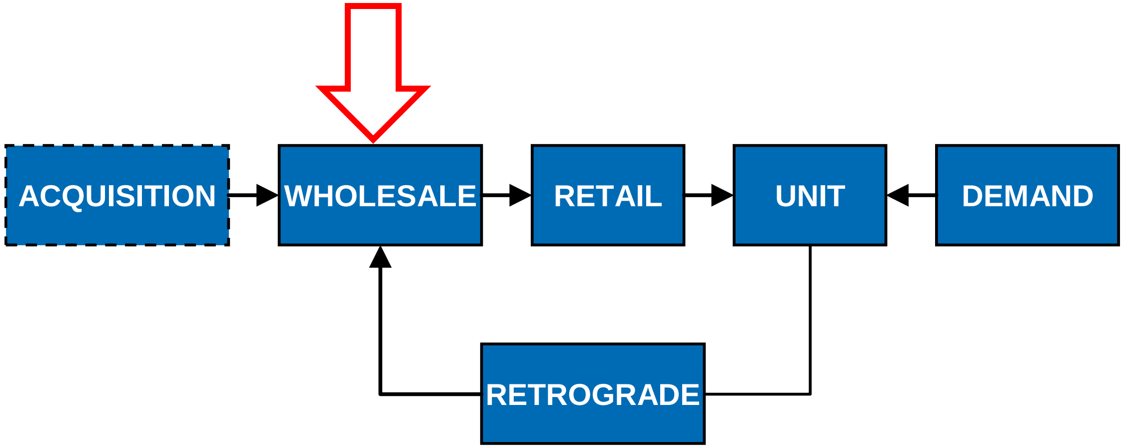
Analyzing Root Causes and Prescribing Innovation Catalysts Across the Supply Chain

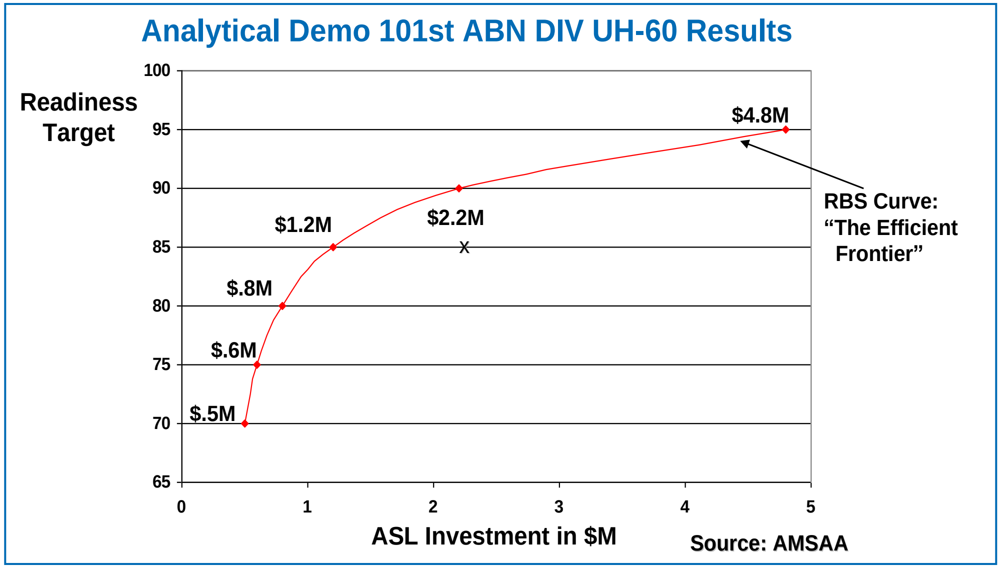


(5) inability to "see" – and to adapt to and anticipate changes in – actual customer demand, causing inefficient procurement actions within an unresponsive wholesale stage characterized by abysmal demand plan forecast accuracy thereby precluding enterprise-wide "cost-wise readiness";

Innovation Catalysts:

- **Defining the Readiness Equation**
- **Connect CBM to the Supply Chain**
- **Mission Based Forecasting**
- **Readiness Based Sparing**
- **Readiness Responsive Retrograde**
- **Leveraging Lessons Learned & Best Practices**

Innovation Catalyst: Multi-Echelon Readiness Based Sparing

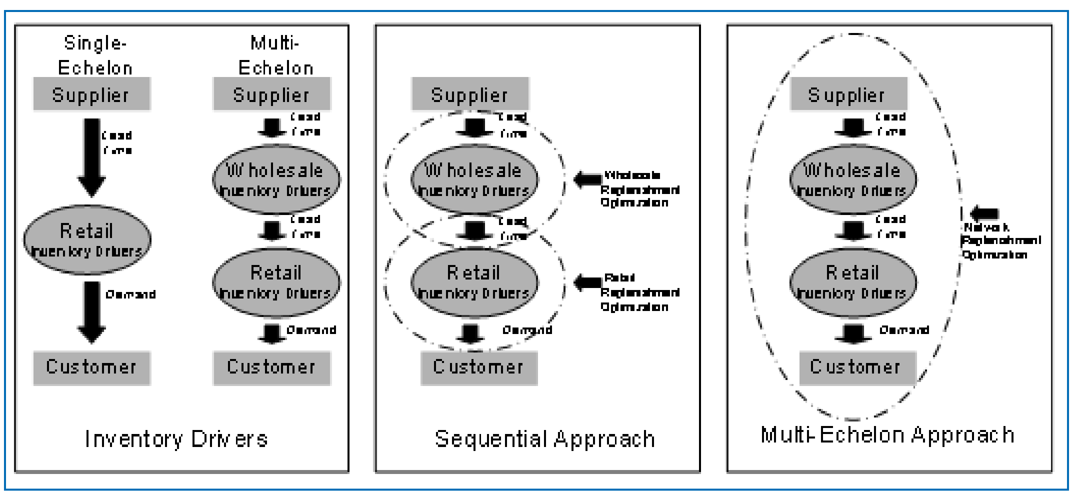


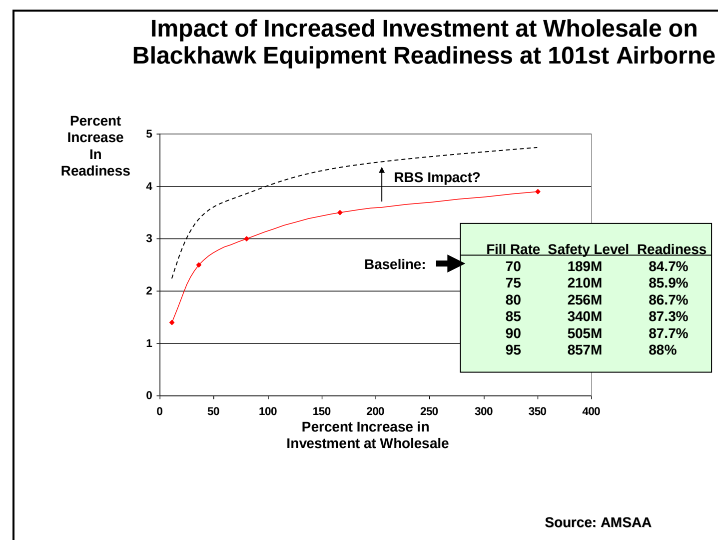
Conditions:

- Low $ parts were causing Army weapon systems NMC
- "Readiness Based Sparing" (RBS), developed at RAND and LMI, had not been tested for Army Aviation

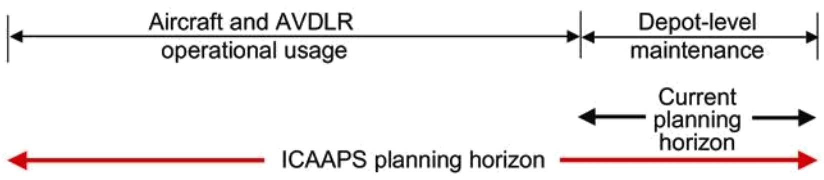
Research Results:

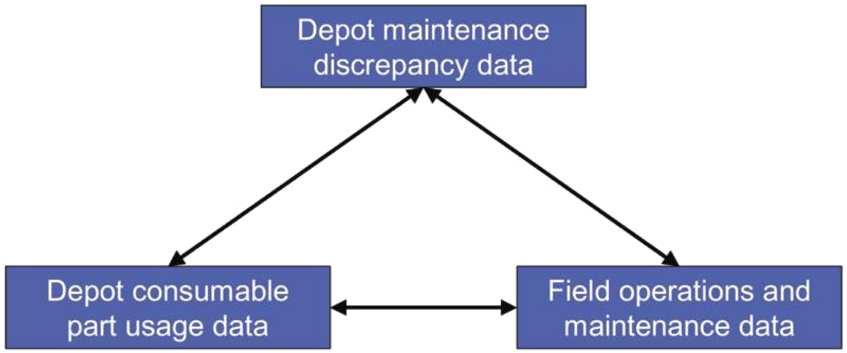
- Analytical Demo revealed significant potential to reduce costs *and* relate investment levels to Ao. . . RBS later adopted at Fort Rucker.
- Multi-Echelon RBS exhibits tremendous potential for cost savings *and* relating resources to Ao fleetwide.

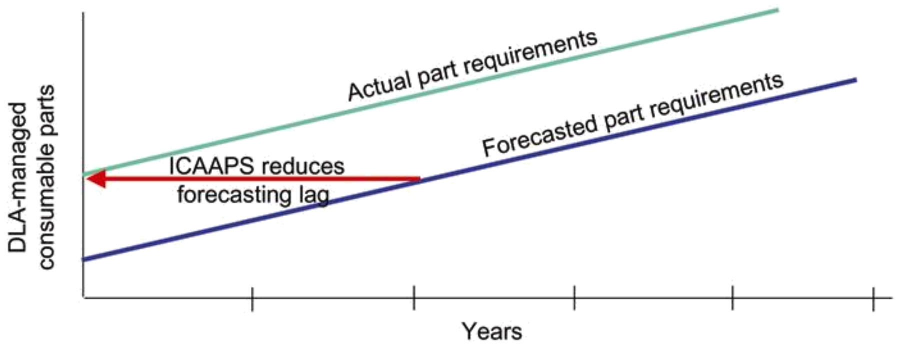


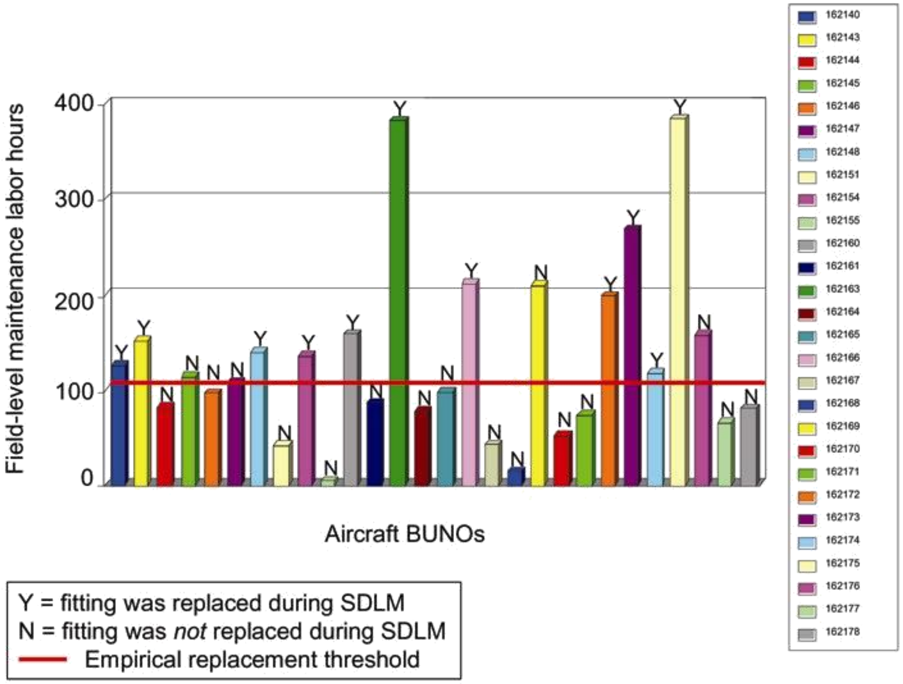


ICAAPS: Intelligent Collaborative Aging Aircraft Parts Support (LMI)



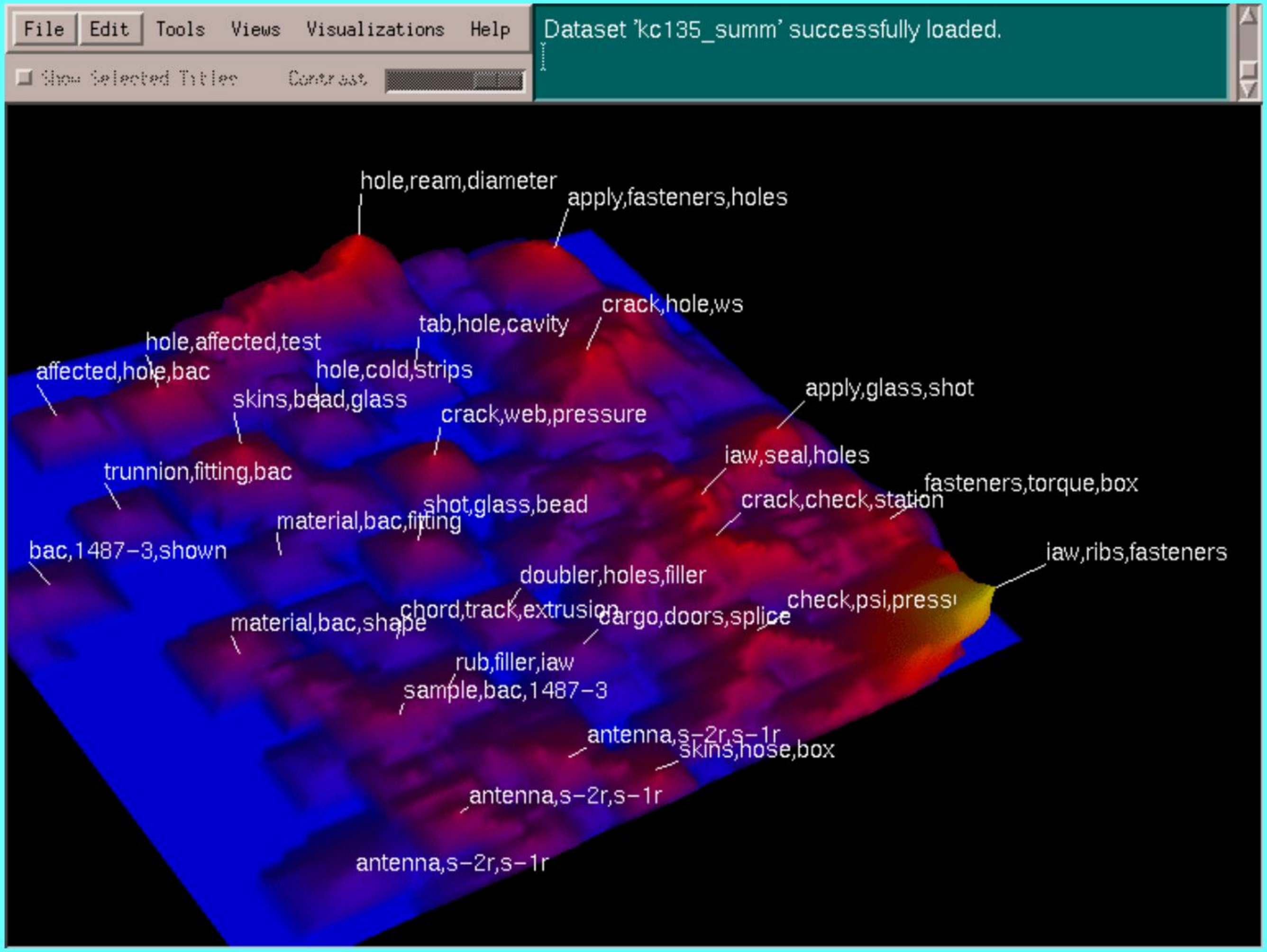






SPIRE 'Themescape' view of KC135 Maintenance Data

Partnering for the Future
IS&E
Information Sciences and Engineering



Battelle

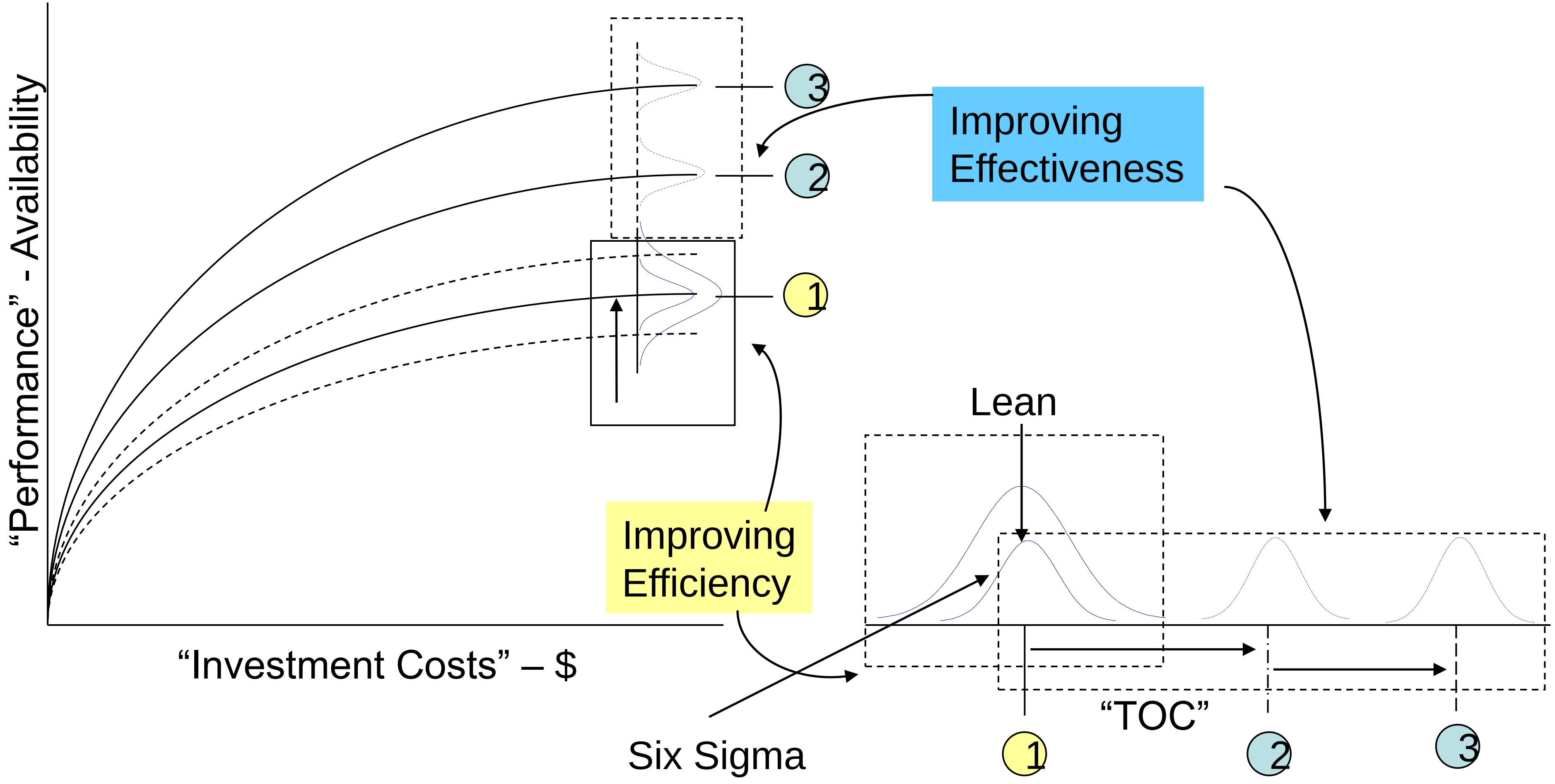
U.S. Department of Energy
Pacific Northwest National Laboratory

SIX SIGMA, LEAN, AND THEORY OF CONSTRAINTS: CONTRIBUTIONS IN THE COST-PERFORMANCE TRADESPACE

Six Sigma – improving product quality (fewer defects) by reducing process variation (variation reduction)

Lean – synchronizing process flow ("takt" time) by removing excess WIP (inventory reduction)

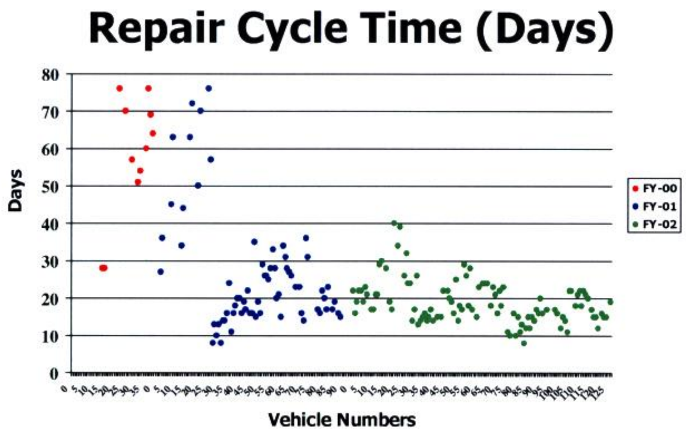
Theory of Constraints – improving cost effectiveness by strengthening weak links (constraint reduction)



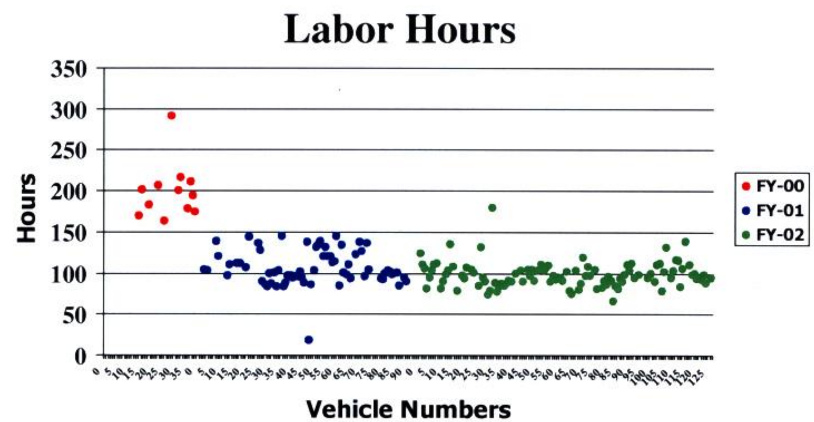
MATCOM

USMC Maintenance Depot, Albany, GA

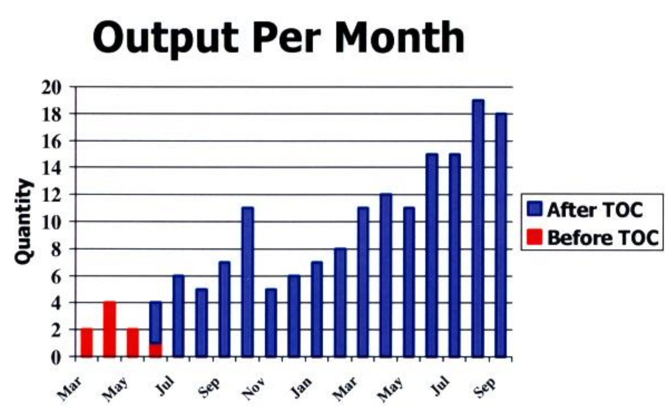
MK-48 Engine



Data Source: Concerto Activity By Project Records

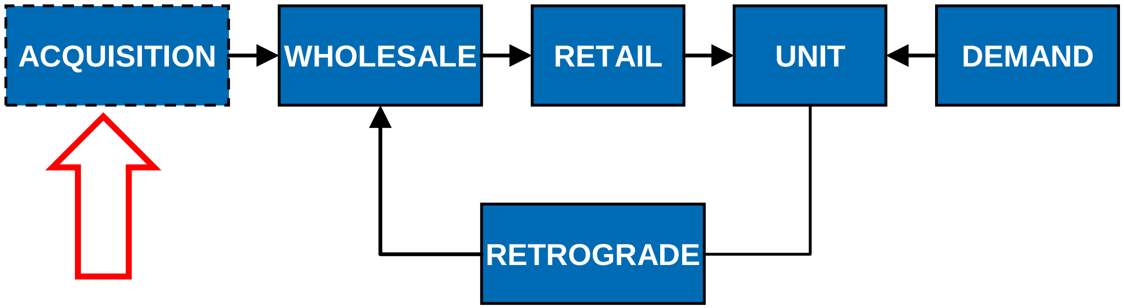


Data Source: Essex Replacement Program (ERP)



Data Source: Concerto Activity By Project Records

Analyzing Root Causes and Prescribing Innovation Catalysts Across the Supply Chain

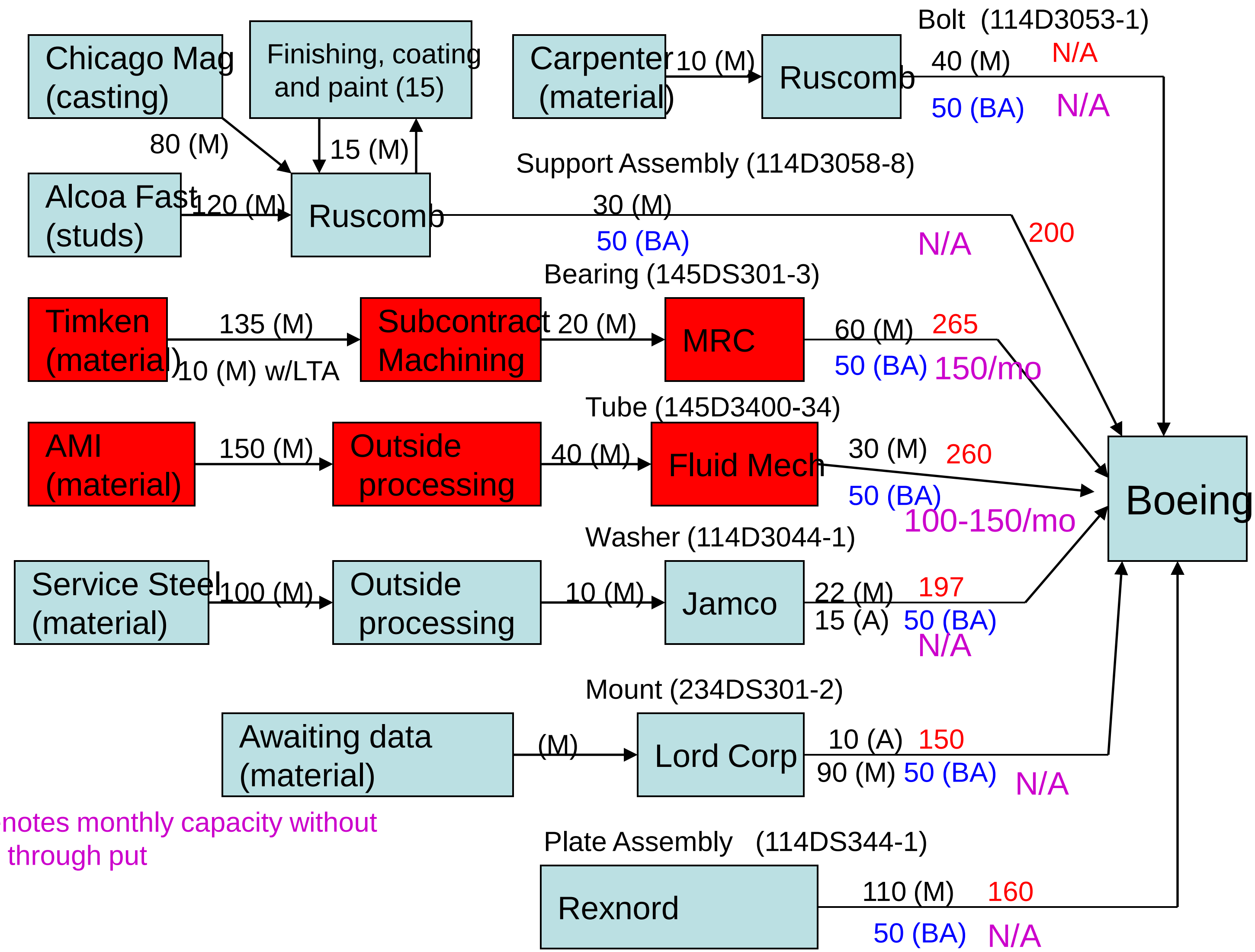


(6) limited visibility into and management control over disjointed and disconnected OEM and key supplier procurement programs which are vulnerable to boom and bust cycles with extremely long lead times, high price volatility for aerospace steels and alloys, and increasing business risk to crucial, unique vendors in the industrial base resulting in diminishing manufacturing sources of materiel supplies, and growing obsolescence challenges for aging aircraft fleets;

Innovation Catalysts:

- **Defining the Readiness Equation**
- **Connect CBM to the Supply Chain**
- **Mission Based Forecasting**
- **Readiness Based Sparing**
- **Readiness Responsive Retrograde**
- **Leveraging Lessons Learned & Best Practices**

CH-47 Sync Shaft Assembly Monthly Capacity



Notes: Purple denotes monthly capacity without impact to normal through put

Findings and Concerns

- **Supply chain plagued by extremely long and growing lead times**
- **Companies in the supply chain are averse to risk and investment resulting in little or no inventories**
- **There are very few long term contracts**
- **Essentially no visibility of downstream demand in supply chain**
- **Suppliers are very concerned about demand uncertainties and financial viability over the next 5 years.**
- **Continuous improvement programs are limited to localized manufacturing processes**
- **Specific vulnerabilities:**
  - raw material price escalation
  - union contract negotiations
  - sole suppliers for many parts and required specialty steels
- **Common issues across multiple aviation platforms**

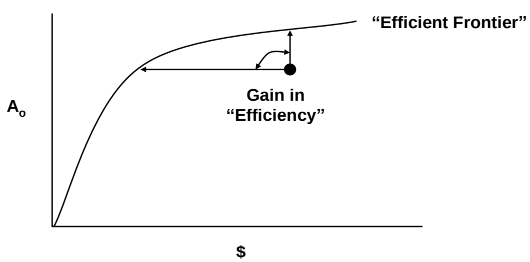
"Instead of protecting the 20th Century defense industrial base , government and industry need to transform it into a 21st Century industrial base that can justify its existence by providing needed military equipment at an affordable price. This requires an across-the-board transformation – including infrastructure, equipment, workforce, and the defense industry at large."

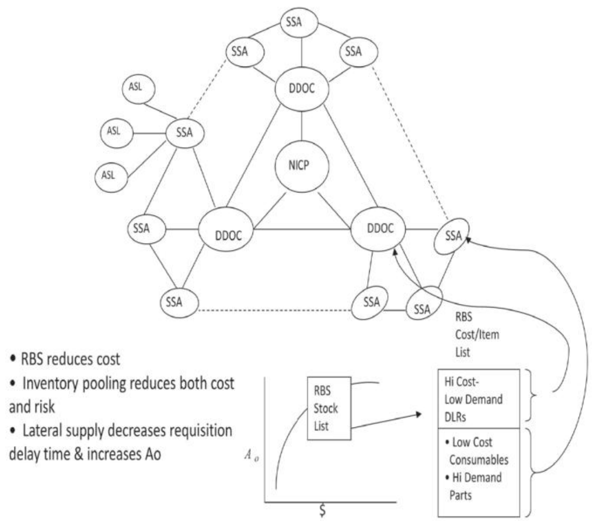
From Democracy's Arsenal: Creating a 21st Century Defense Industry, by Jacques S. Gansler, former Under Secretary of Defense for Acquisition, Technology, and Logistics 1997-2001

Part III. Enterprise Integration: Prescriptive Analytics for Efficiency, Resilience, and Effectiveness

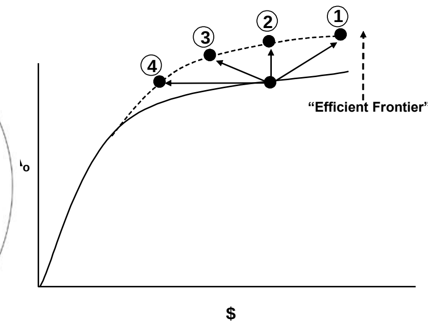
12. Achieving Efficiency: An Integrated Multi-Echelon Inventory Solution
13. Designing for Resilience: Adaptive Logistics Network Concepts
14. Improving Effectiveness: Pushing the Logistics Performance Envelope

Achieving “Efficiency” in the Cost - Availability Trade Space





Increasing “Effectiveness” in the Cost -Availability Tradespace



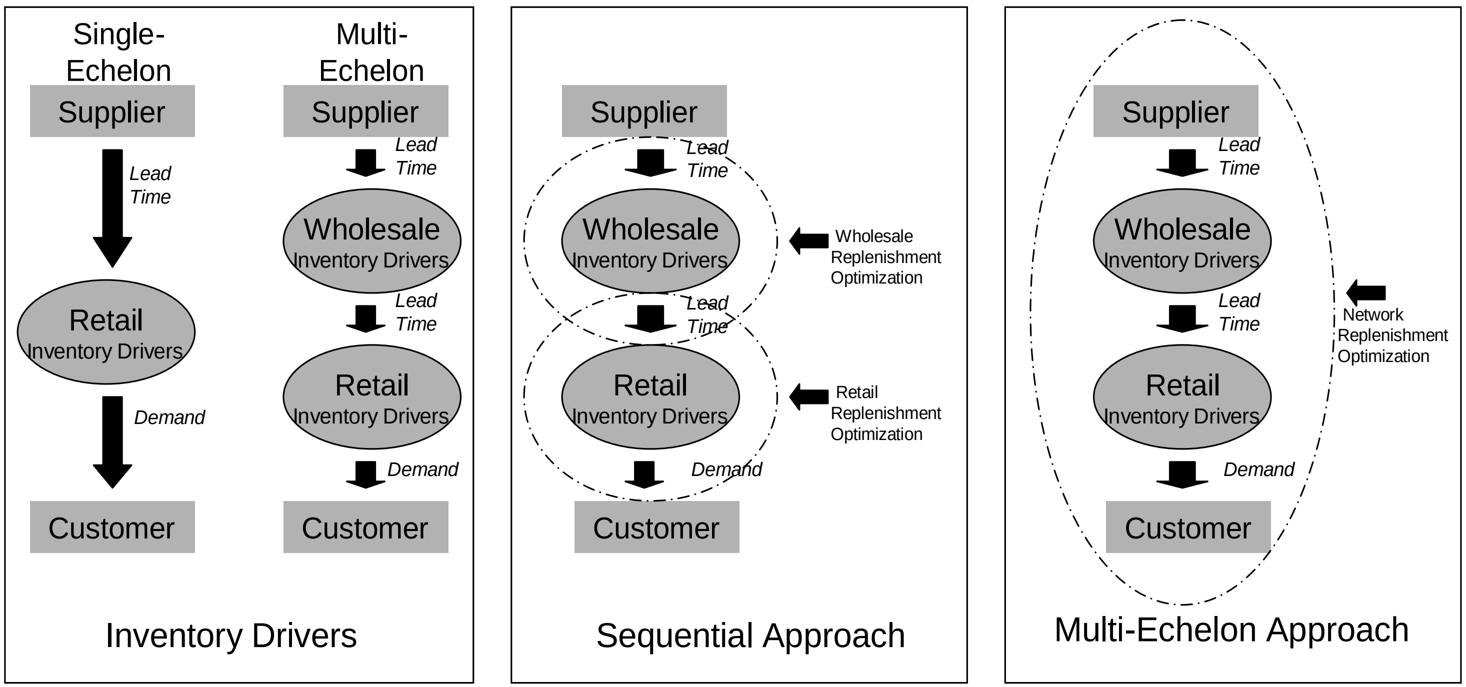
Cost Benefits Alternatives:

1. Improved effectiveness with increased costs
2. Improved effectiveness at same costs
3. Improved effectiveness at reduced costs
4. Same effectiveness at significantly reduced costs

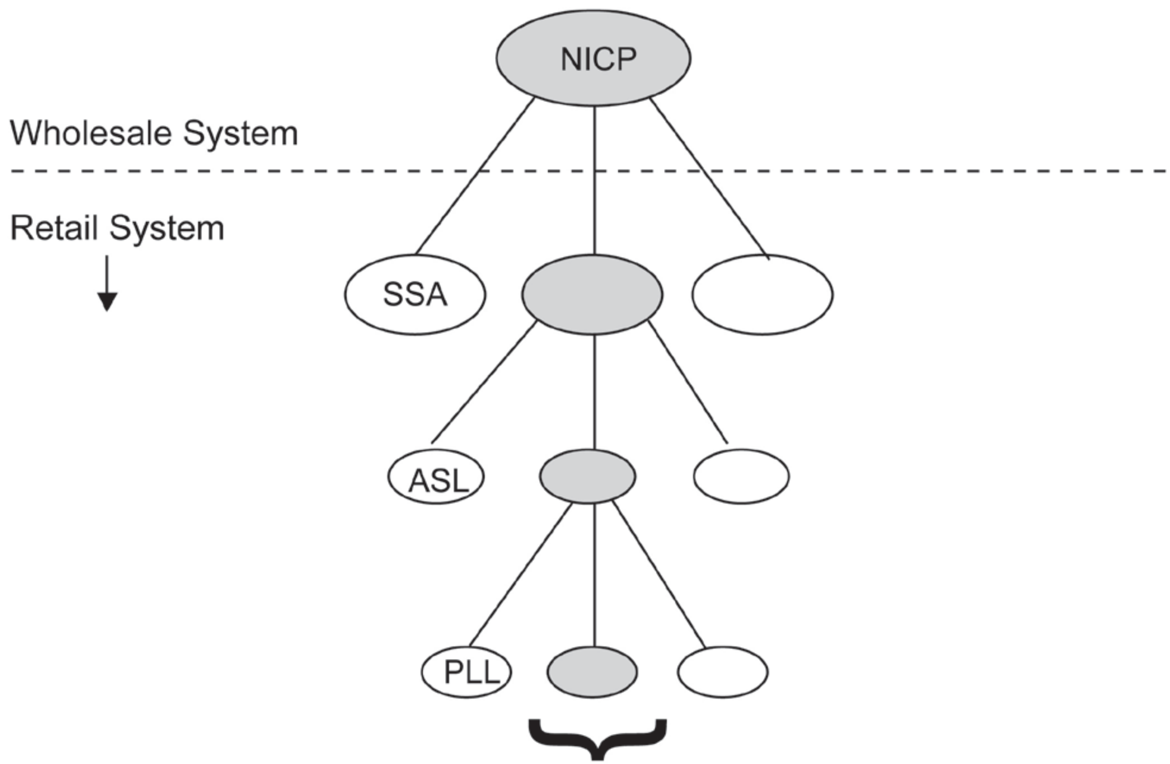
… however, magnitude of each depends upon where you are on the current efficient frontier!
… and the expansion trace of the improved frontier

(7) independently operating, uncoordinated and unsynchronized stages within the supply chain creating pernicious “bullwhip” effects including large RO, long lead times, and declining readiness;
(8) fragmented data processes and inappropriate supply chain MOEs focusing on interface metrics which mask the effects of efficient and effective alternatives, and further preclude an ability to determine “readiness return on net assets” or to relate resource investment levels to readiness outcomes;

Achieving Materiel Enterprise Efficiency: Multi-echelon Integration

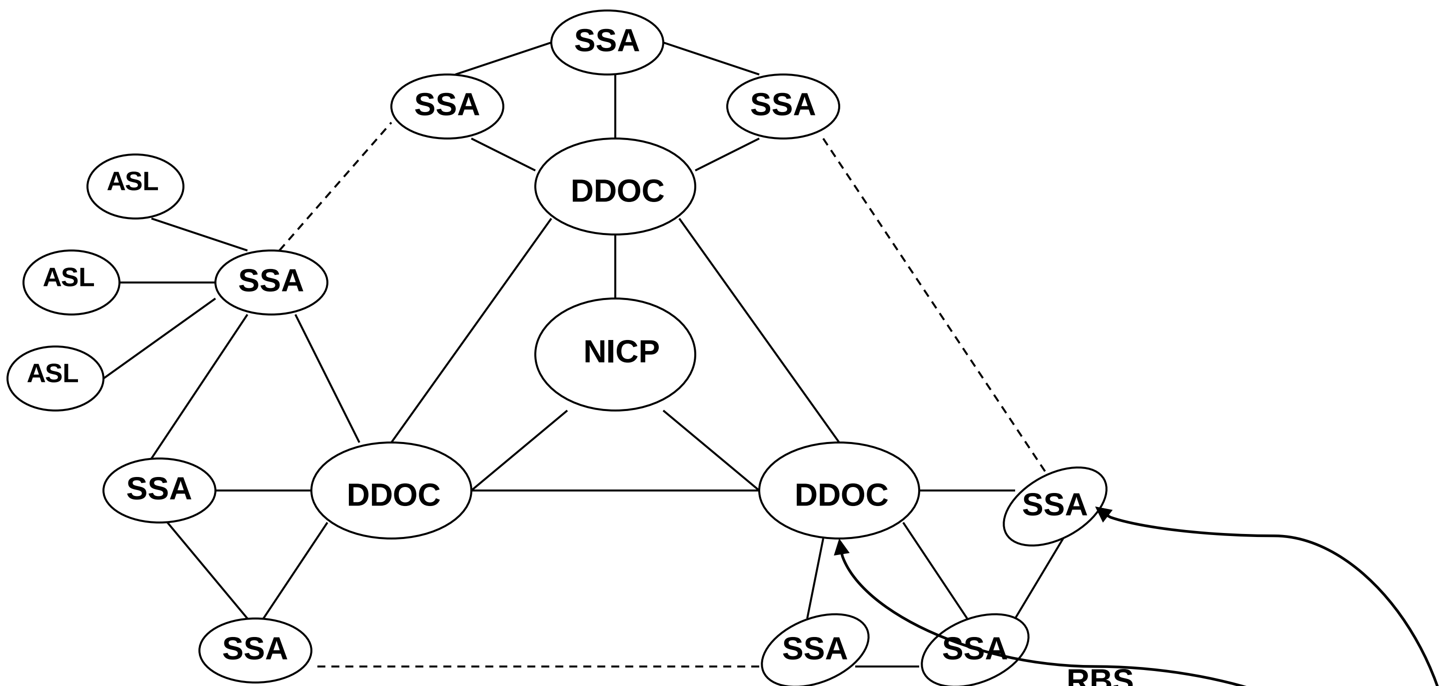


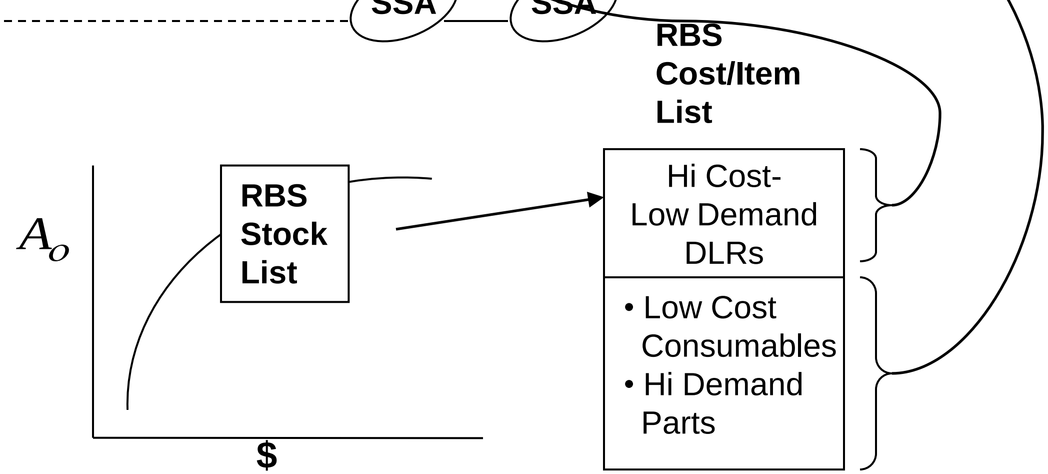
Current Vertical Supply "Chain" Structure



- Vertical "serial chains" create vulnerable supply channels
- Increased buffer stock is required to reduce risk
- Results in increased inventory investment costs

Design for Structural Resilience: Readiness Driven Supply Network

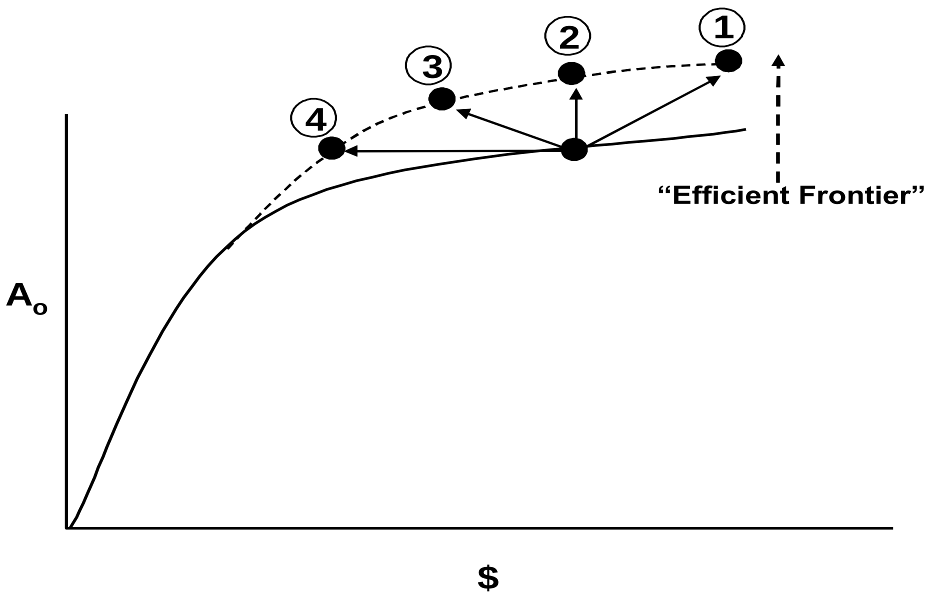




- RBS reduces cost
- Inventory pooling reduces both cost and risk
- Lateral supply decreases requisition delay time & increases Ao

Pursuing Cost-Effective Readiness: Pushing the Performance Envelope

Increasing "Effectiveness" in the Cost -Availability Tradespace



Cost Benefits Alternatives:

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… however, magnitude of each depends upon where you are on the current efficient frontier!
… and the expansion trace of the improved frontier

Part IV. Predictive Analytics for Design and Evaluation: An "Analytical Architecture" to Guide Materiel Enterprise Transformation

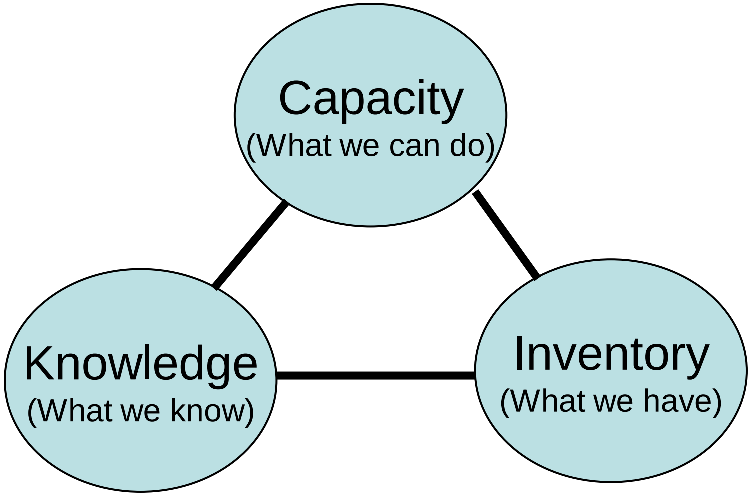
15. Multi-Stage Supply Chain Optimization

16. System Dynamics Modeling and Dynamic Strategic Planning

17. Operational and Organizational Risk Evaluation

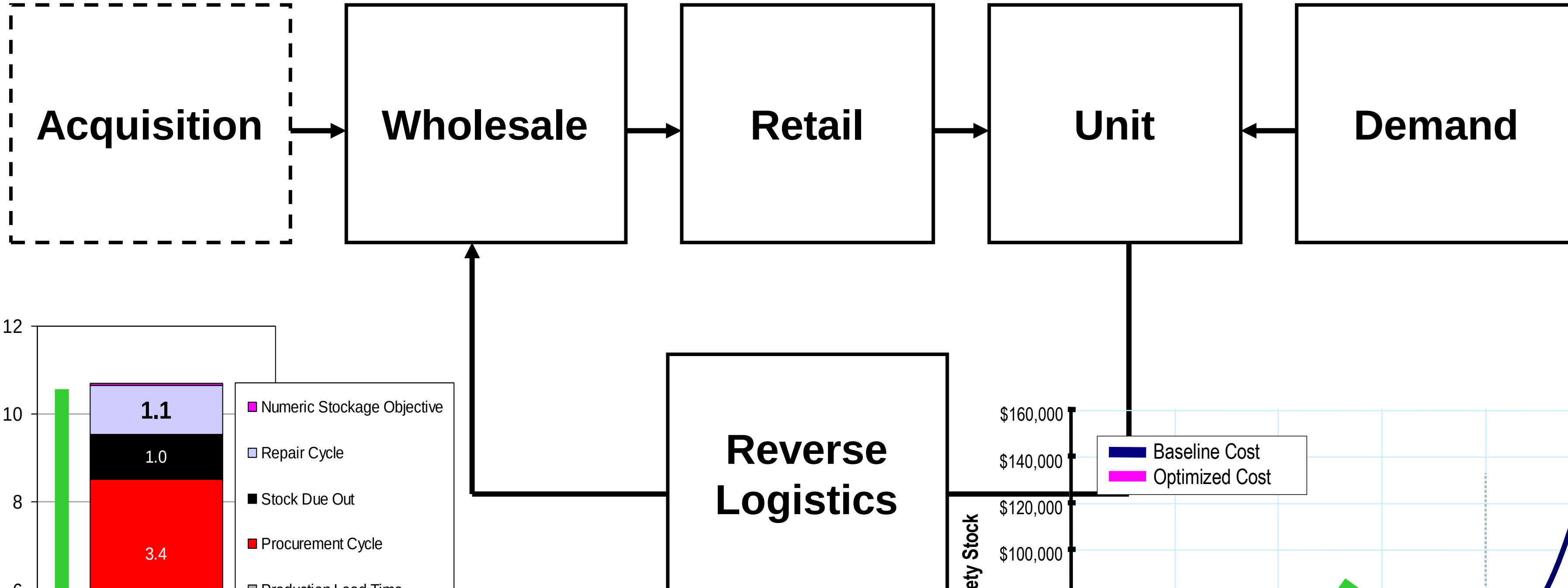
18. Logistics System Readiness and Program Development

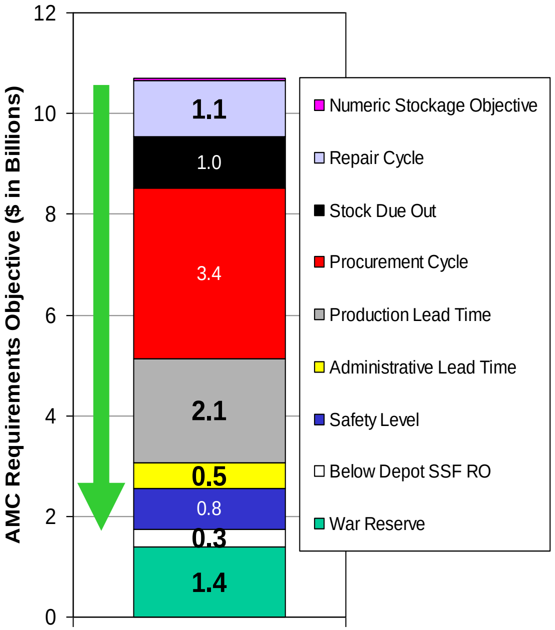
19. Accelerating Transformation: An "Engine for Innovation"



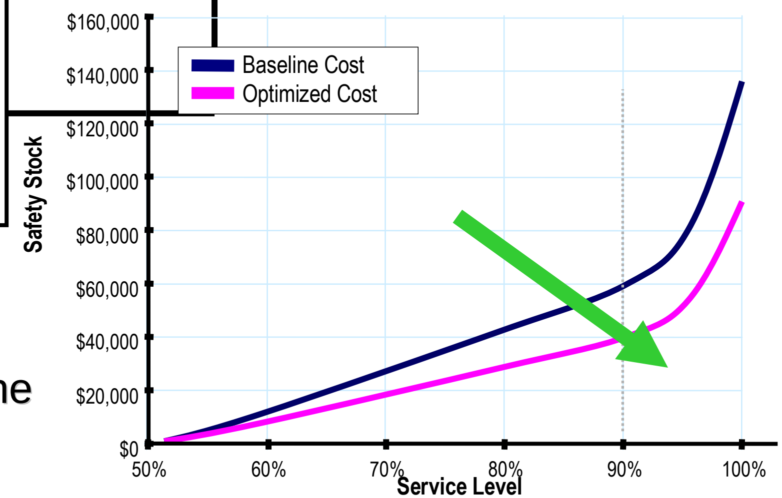
(9) lack of central supply chain management and supporting analytical capacity results in multi-agency, consensus-driven, bureaucratic workarounds hindered by lack of an Army supply chain management science and an enabling "analytical architecture" to guide Logistics Transformation;
(10) lack of an "engine for innovation" to accelerate then sustain continual improvement for a learning organization.

Improving System Efficiency: Across the System of Stages and within each Stage

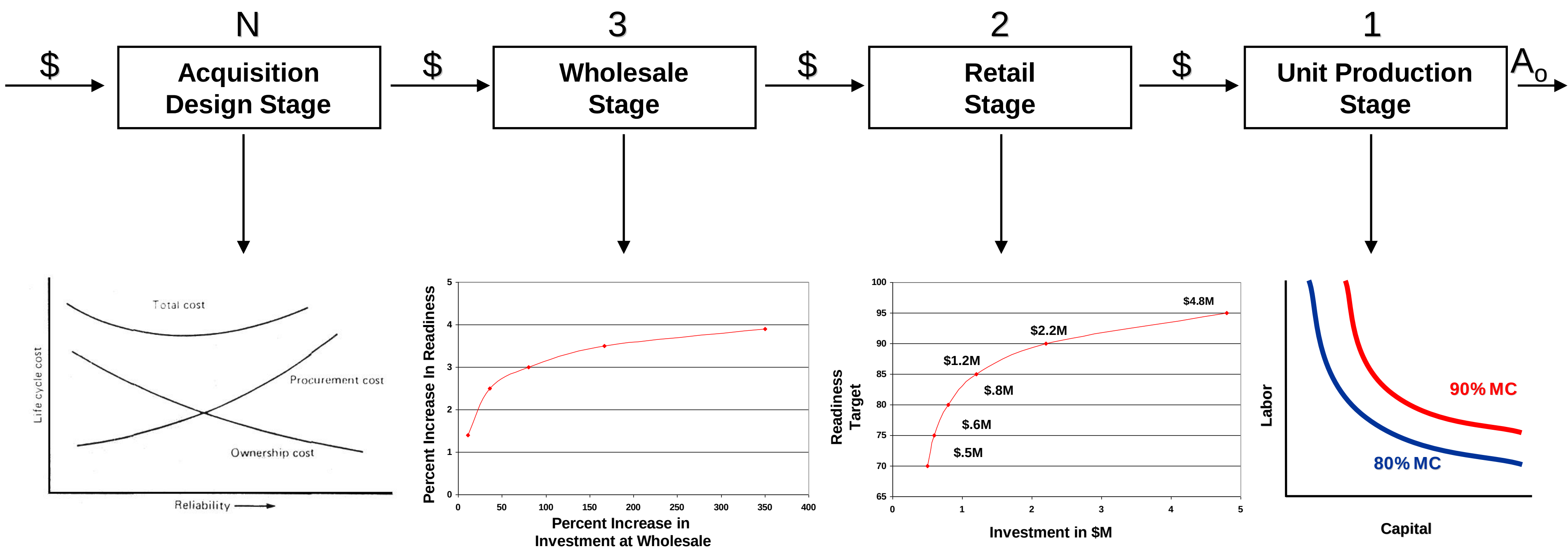




Because inventories are managed to the computed RO, reducing the value of the RO calculated by AMC's models is a critical first step to reducing inventories.



“Optimizing” the System: Applying a Dynamic (Multi-Stage) Programming Model



10.4 DEVELOPING AN OPTIMAL DECISION POLICY

If our multistage system actually looks like the one just illustrated, then we can notice some interesting characteristics; namely,

1. There are exactly N points at which a decision must be made.
2. If we *start* at stage 1, then nothing affects an optimal decision except the knowledge of the *state* of the system at stage 1 and the choice of our *decision variable.*
3. Stage 2 only affects the decision at stage 1; the choice we make at stage 2 is governed only by the *state* of the system at stage 2 and the restrictions on our decision variable.
4. And so on to stage N.

The dynamic programming problem is therefore given by the following expression at the nth stage:

$$f_n^*(S_n) = \max_{0 \le d_n \le [S_n/L_n]} \{r_n(S_n, d_n) + f_{n-1}^*(S_{n-1})\}$$

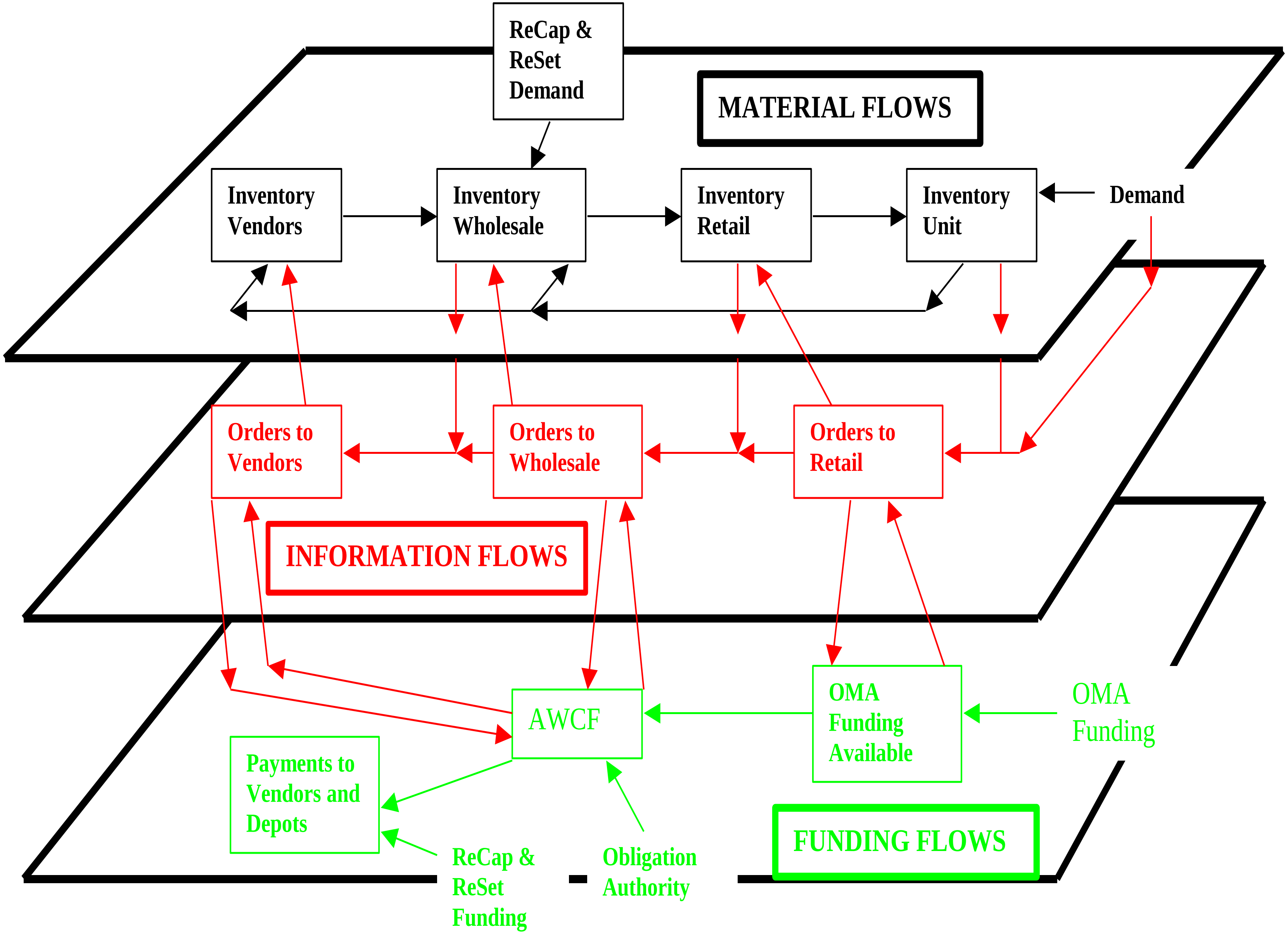
where: $S_{n-1} = S_n - d_n L_n$

and $f_0^*(S_0) \equiv 0$

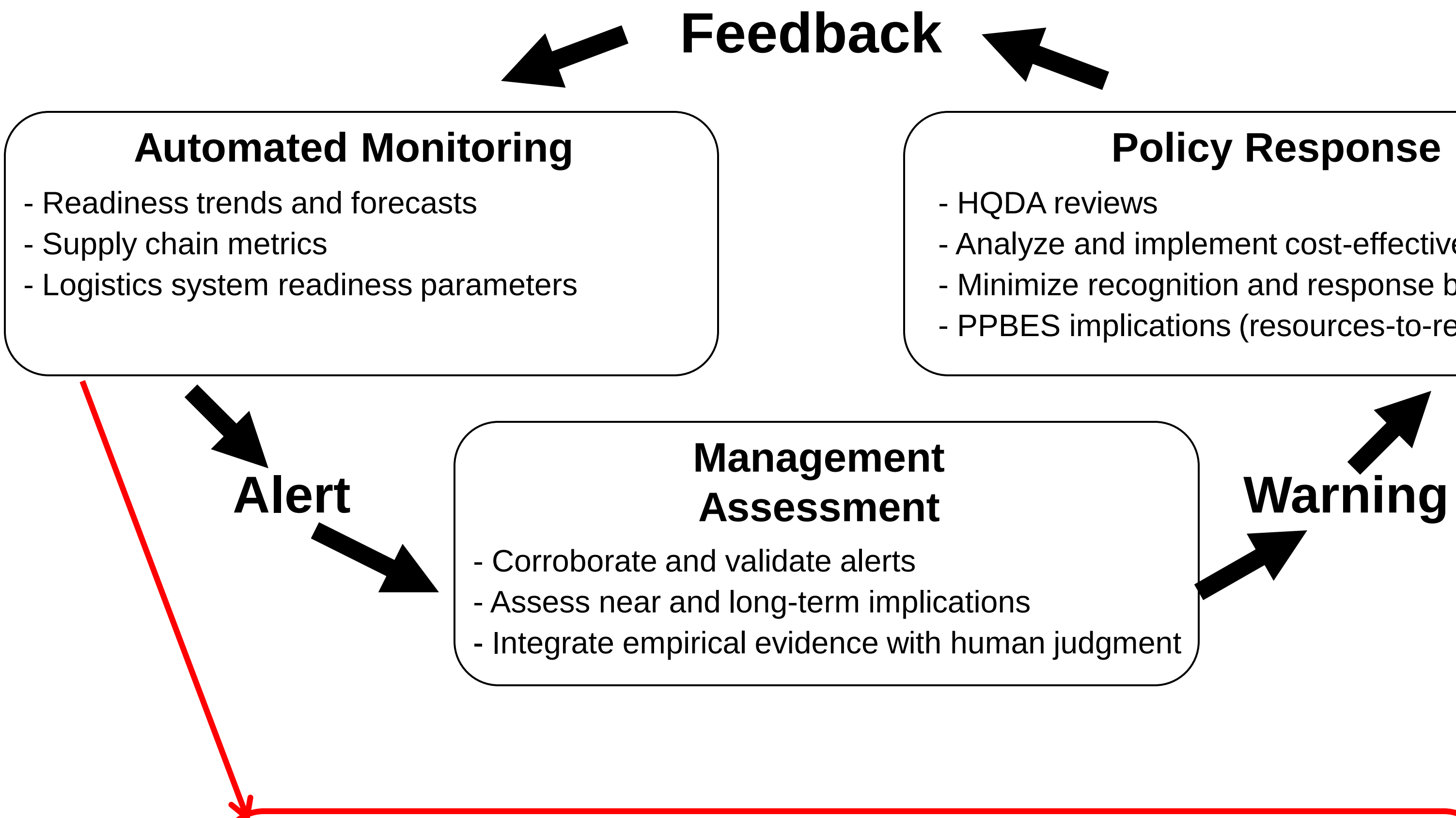
$f_n(S_n, d_n) = r_n d_n$

$n = 1, 2, 3, 4$

Supply Chain Framework



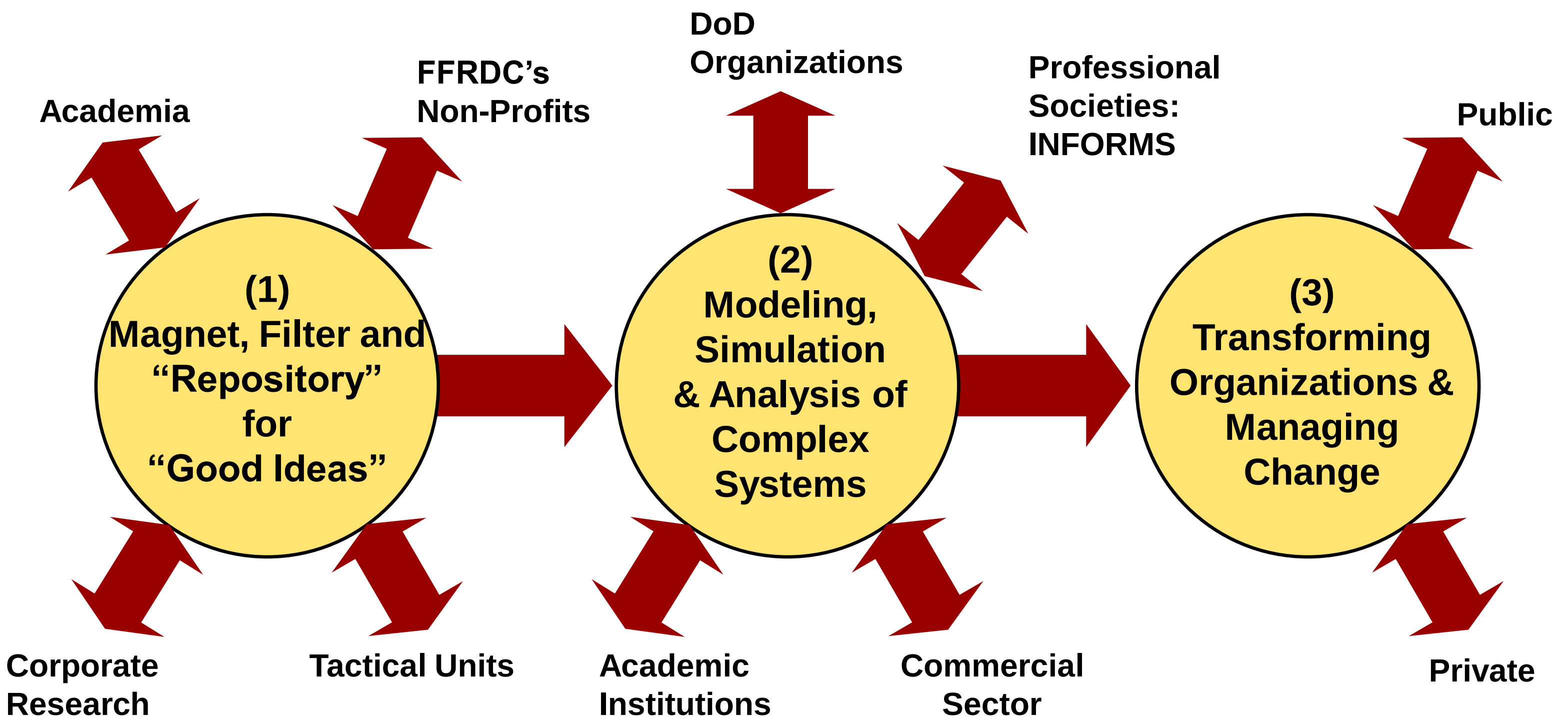
Logistics Readiness Early Warning System



The regression relating Mission Capable rates (MC) to age lagged 5 months, shown in the equation below, indicates that a one-month increase in backorder average age leads to a reduction of 2.8 percentage points in MC rate 5-months hence. The coefficient is highly significant (at the one percent level), and the R2 is 63 percent.

MC = 0.97 – 0.028 (Age lagged 5 months)

An "Engine for Innovation":
The Center for Innovation in Logistics Systems (CILS)



- Organizational Design
- Supply/Value Chain
- Workforce Development
- Technology Implications
- Innovation & Productivity Gain
- R & D

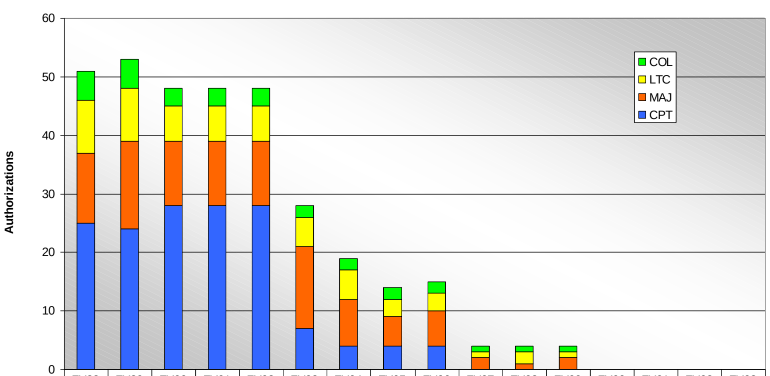
- System Dynamics Modeling
- Large Scale System Design, Analysis, and Evaluation
- Systems Simulation, Modeling and Analysis
- Repository for validated models & analytical tools

- Cost Benefit Analyses
- Risk Reduction & Mitigation
- Research, Studies, and Analysis
- Education & Training
- Technical Support
- Change Management

Part V. Management Concepts for Materiel Enterprise Transformation

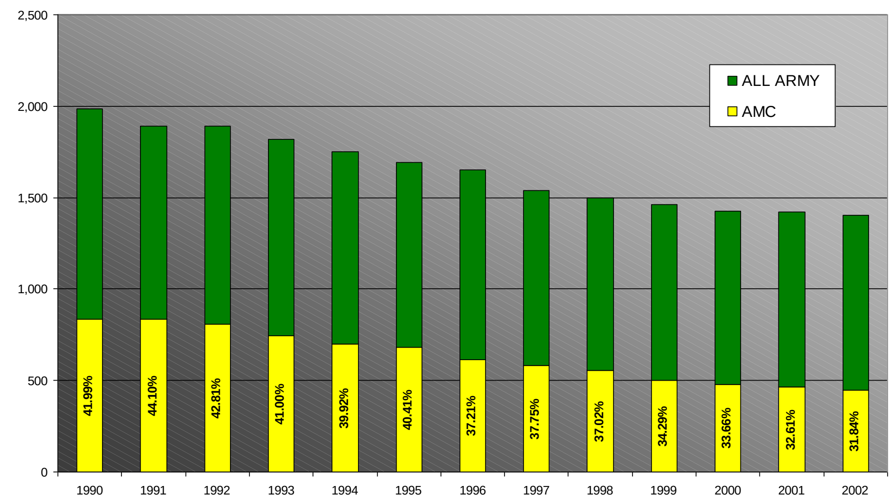
20. Organizational Redesign for Army Force Generation
21. Contributions of Information Systems Technology and Operations Research
22. PBL and Capabilities Based Planning for an Expeditionary Army
23. Financial Management Challenges to "Business Modernization"
24. Human Capital Investment for a Collaborative Organization
25. Strategic Management Concepts for a Learning Organization
26. Final Thoughts

Officer ORSA (FA49) Strength in AMC

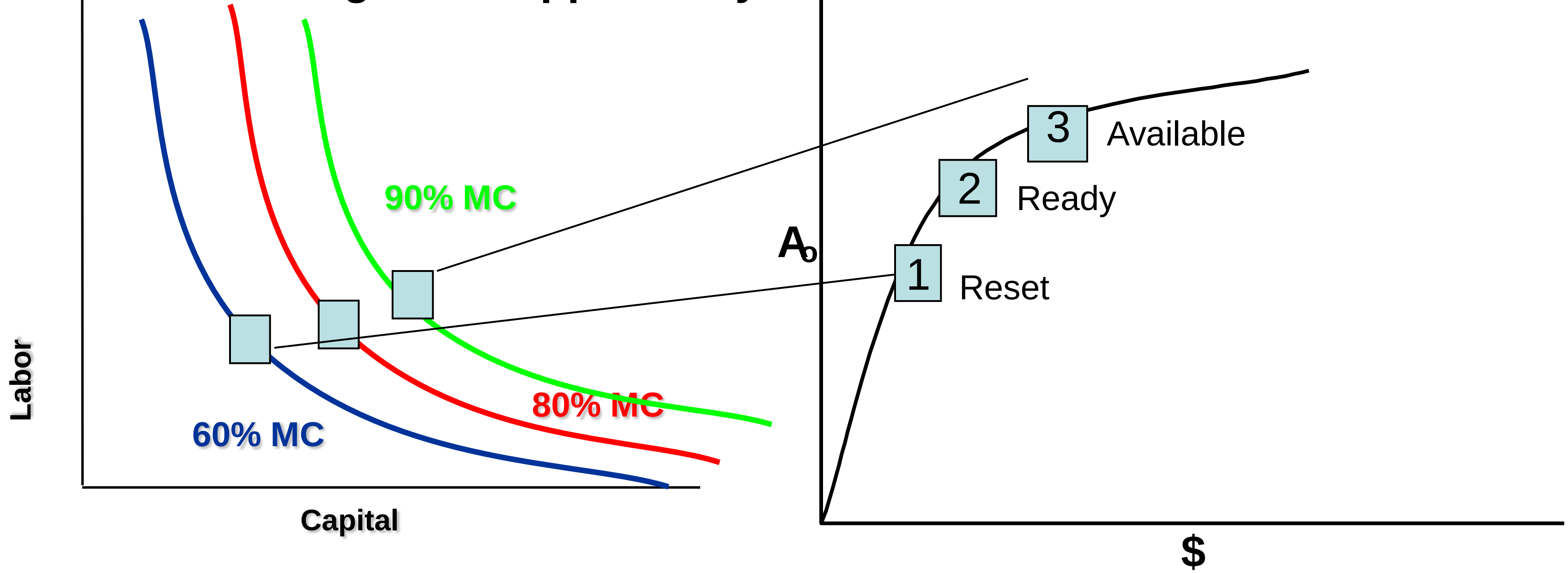


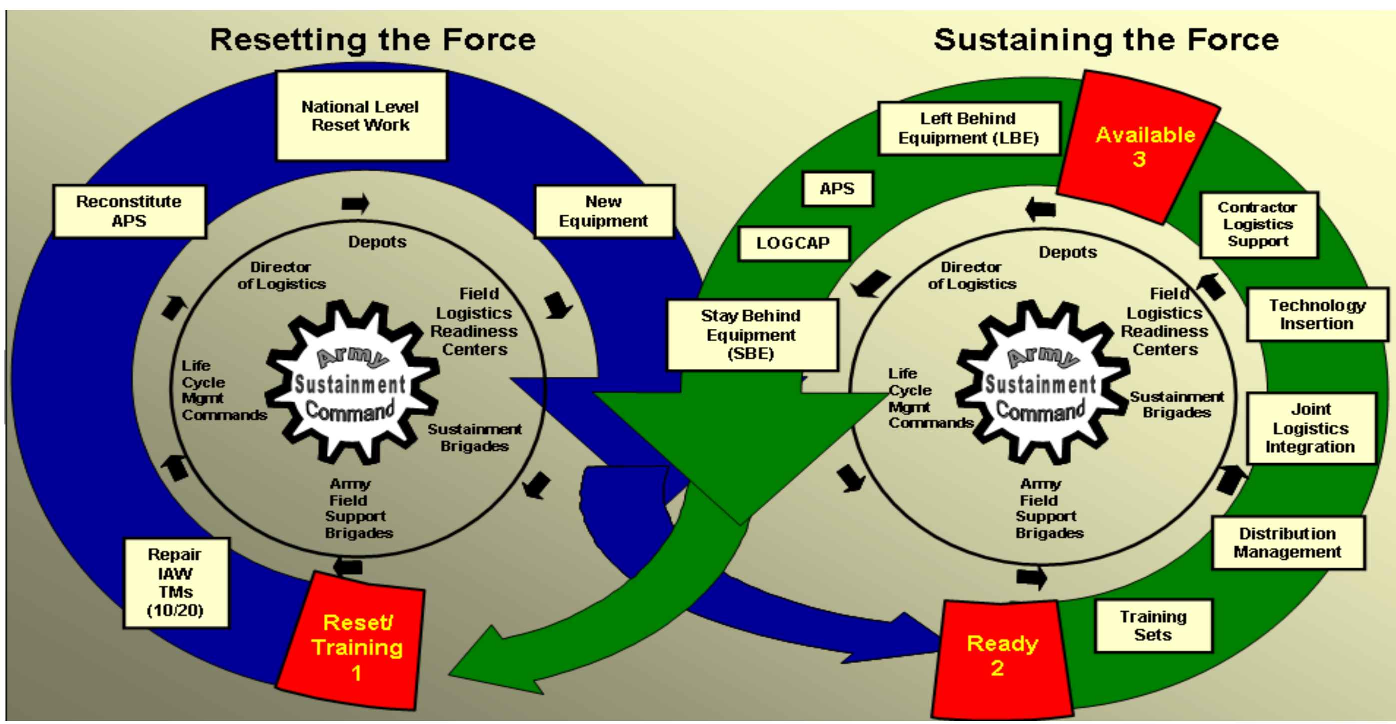
	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03
COL	5	5	3	3	3	2	2	2	2	1	1	1	0	0	0	0
LTC	9	9	6	6	6	5	5	3	3	1	2	1	0	0	0	0
MAJ	12	15	11	11	11	14	8	5	6	2	1	2	0	0	0	0
CPT	25	24	28	28	28	7	4	4	4	0	0	0	0	0	0	0

Civilian "ORSA" (1515) Strength in AMC

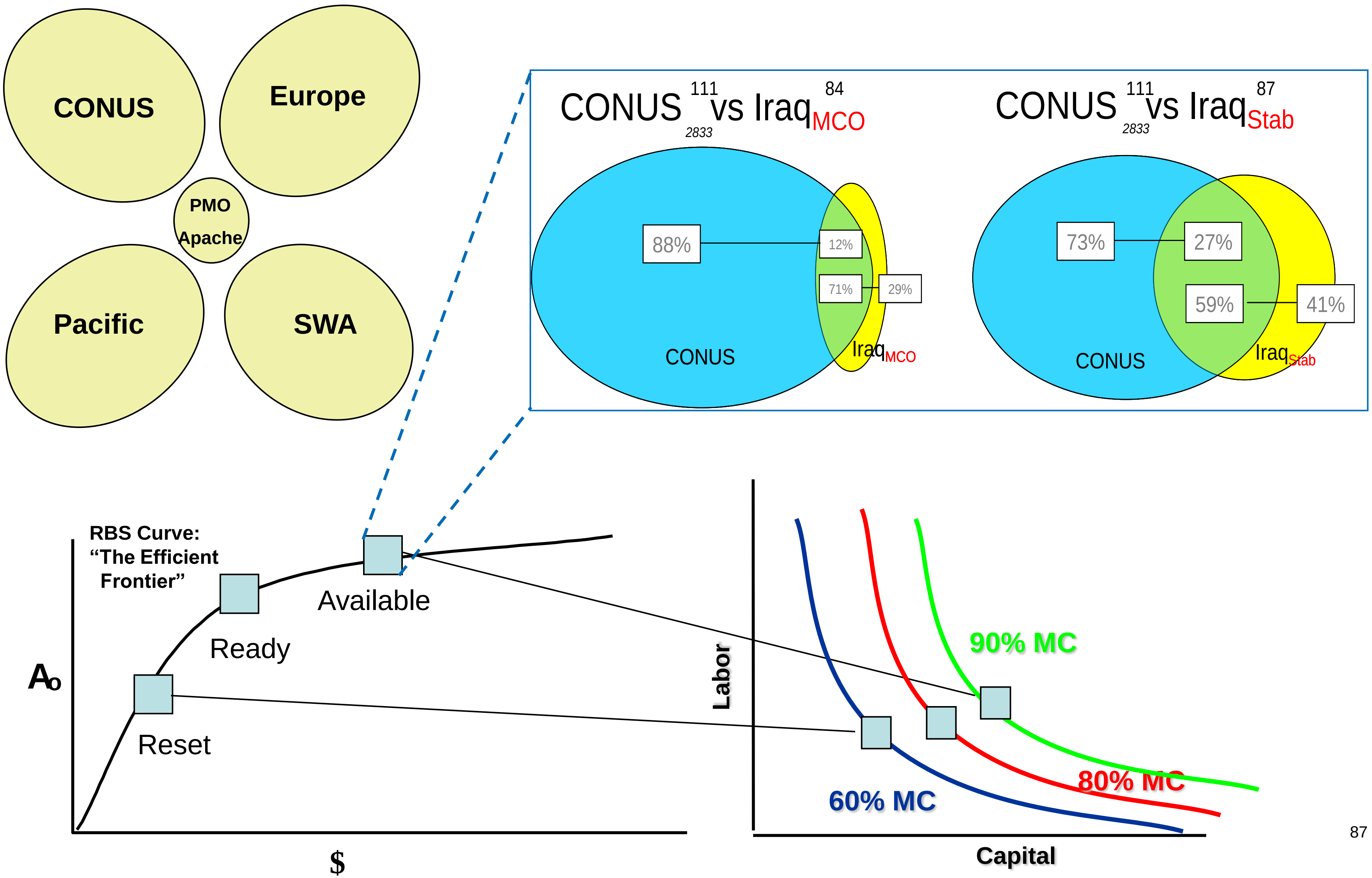


Integration Opportunity – RBS for ARFORGEN

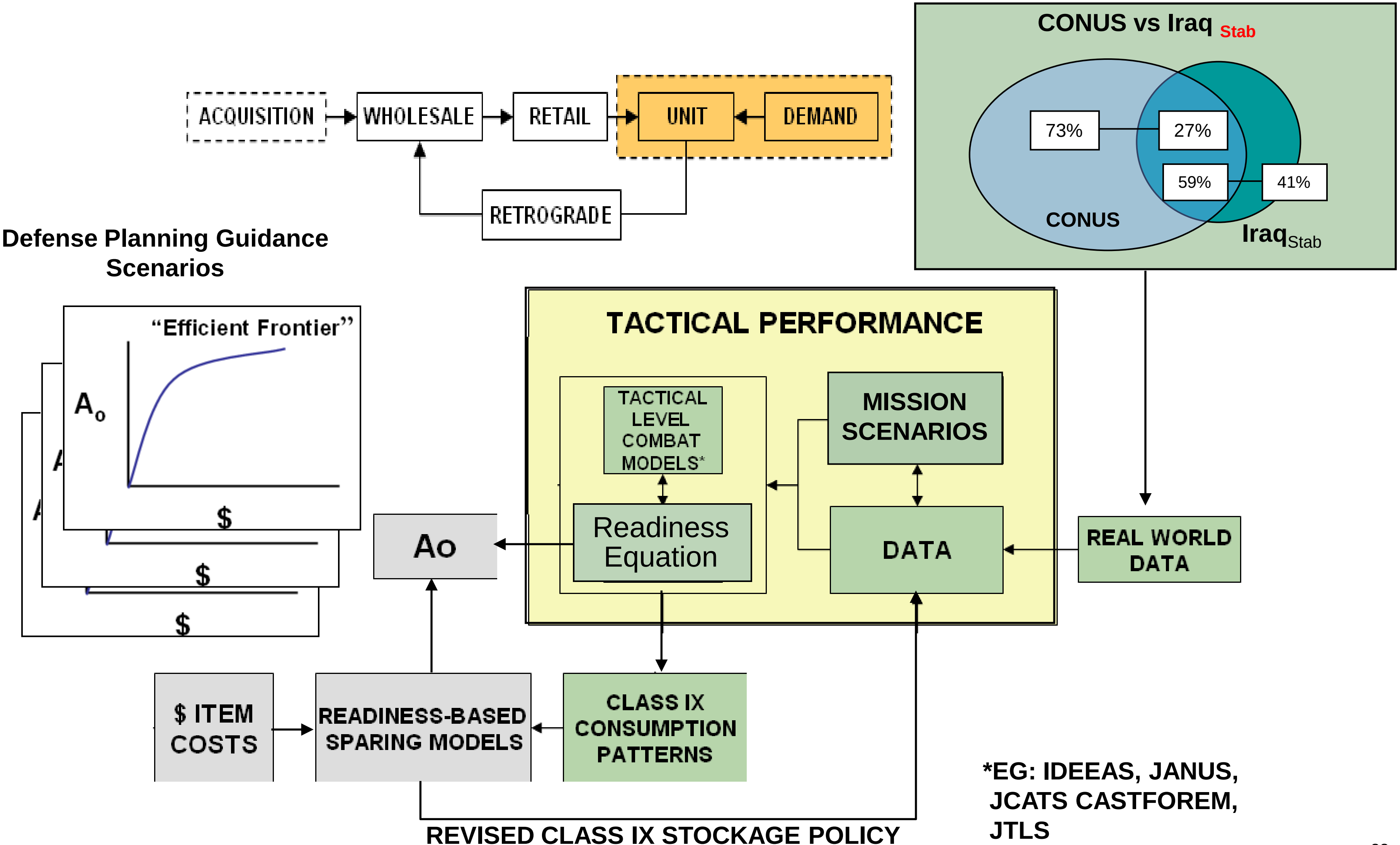




Integration Opportunity: RBS and MBF for the Army's new Regionally Aligned Force Concept

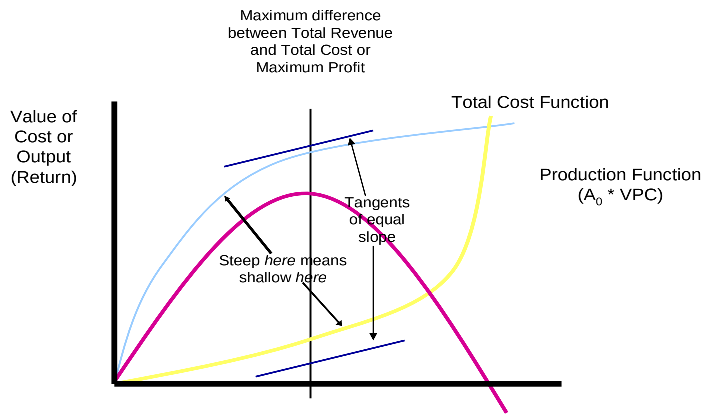


Integration Opportunity: "Advanced Analytics" for a Capabilities Based Force

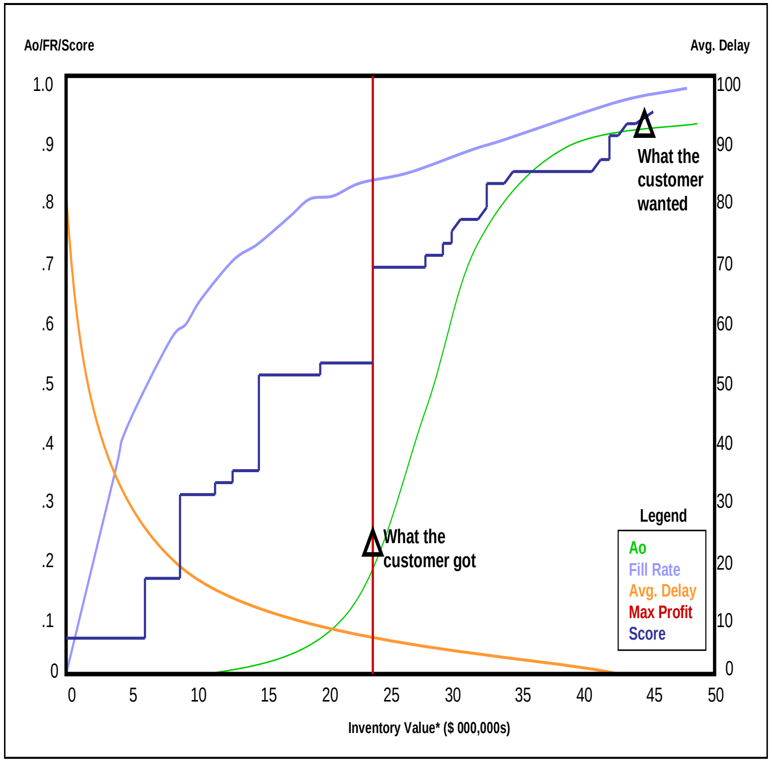


Integration Opportunity: Product Support Integration for Performance Based Logistics (PBL)

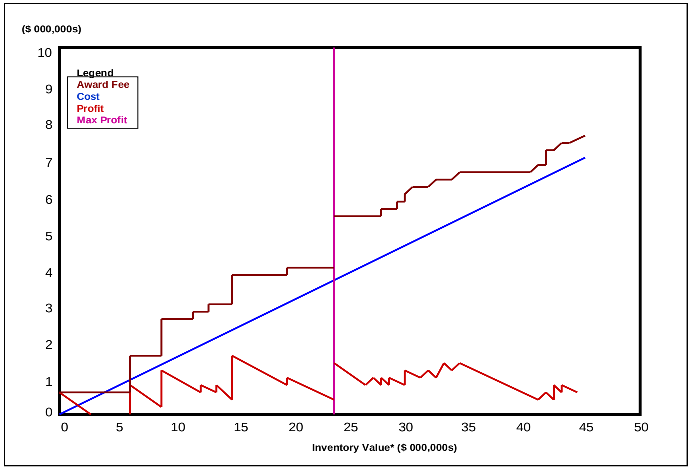
Aligning PBL Incentives to Readiness Outcomes



The Fallacy of 'Fill Rate' as an Incentive for SC Performance



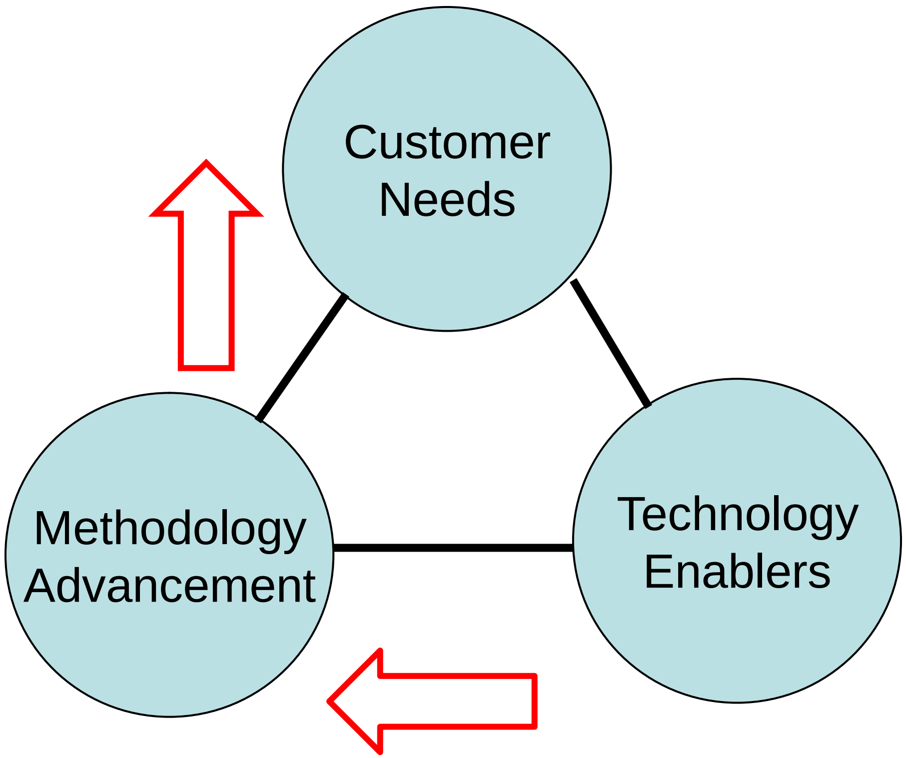
PBL Contract Scoring Regime Results



Management Innovation as a Strategic Technology

Management Innovation:

- MERBS[1]
- MBF[2]
- R3[3]
- DSLP[4]
- LREWS[5]



Technology Innovation:

- CBM[6]
- RFID[7]
- TAV[8]
- ERP[9]

[1]Multi Echelon Readiness Based Sparing

[2]Mission Based Forecasting

[3]Readiness Responsive Retrograde

[4]Dynamic Strategic Logistics Planning

[5]Logistics Readiness and Early Warning System

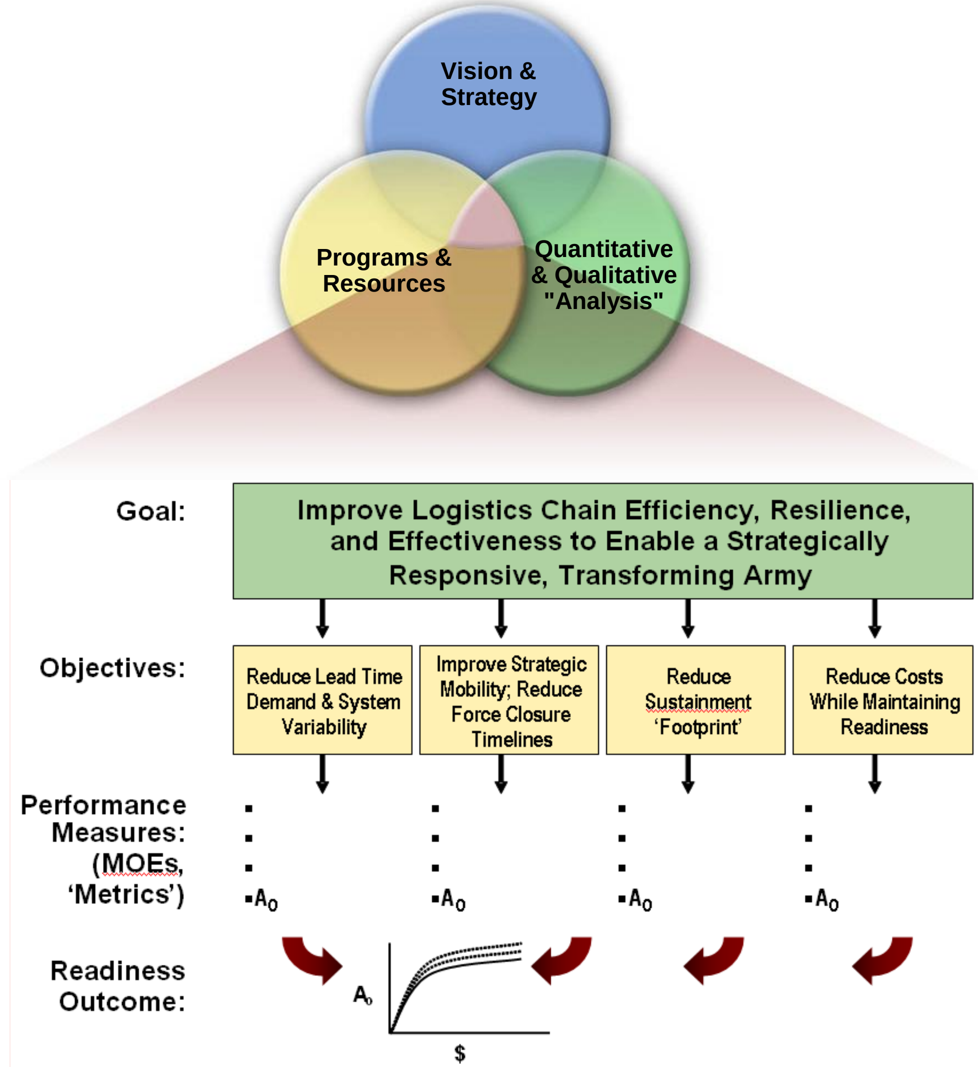
[6]Condition Based Maintenance

[7]Radio Frequency Identification

[8]Total Asset Visibility

[9]Enterprise Resource Planning

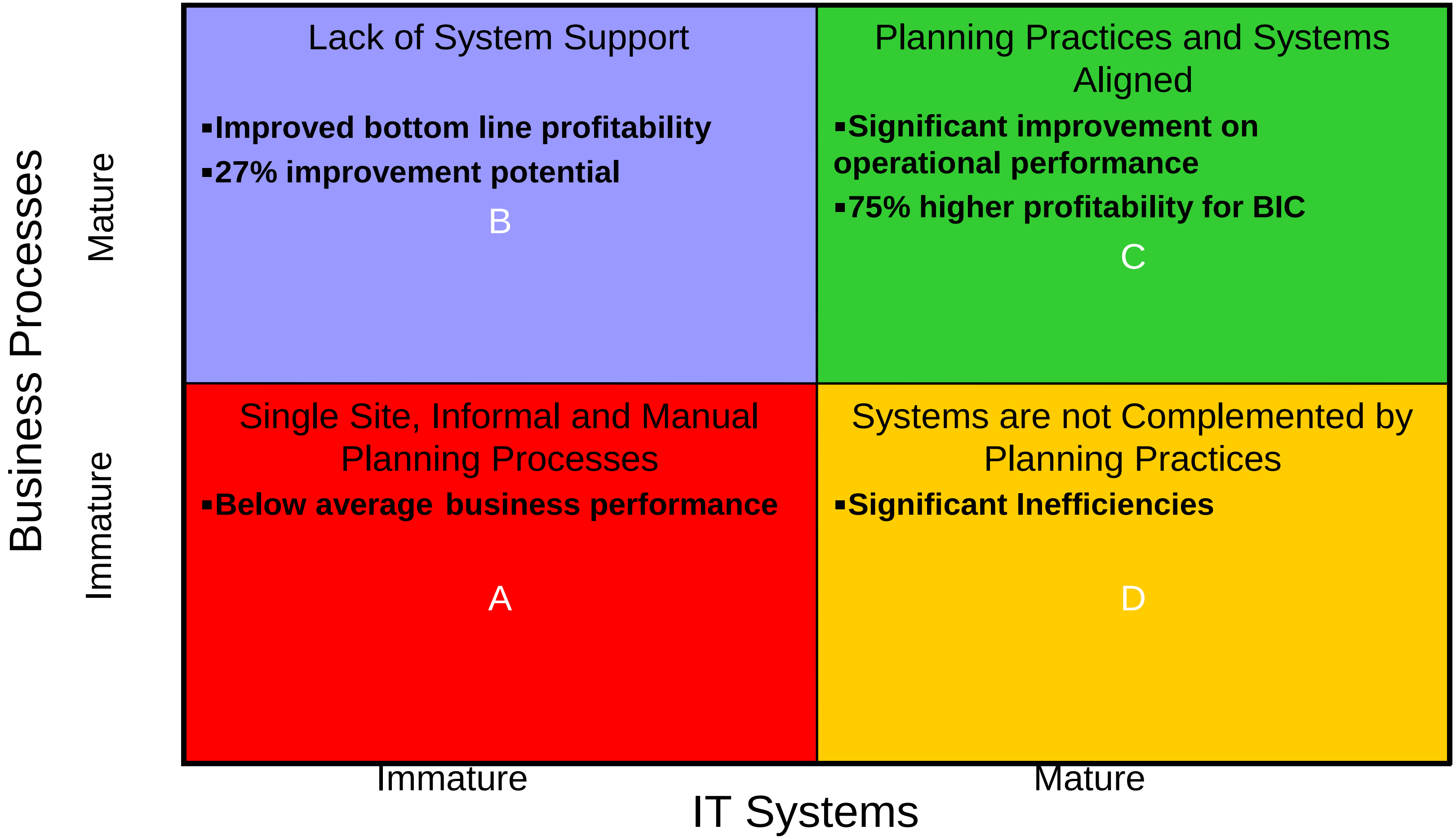
Contributions of Information Systems Technology and Operations Research: “Advanced Analytics” for Enterprise Strategy and Integration



"Readiness"

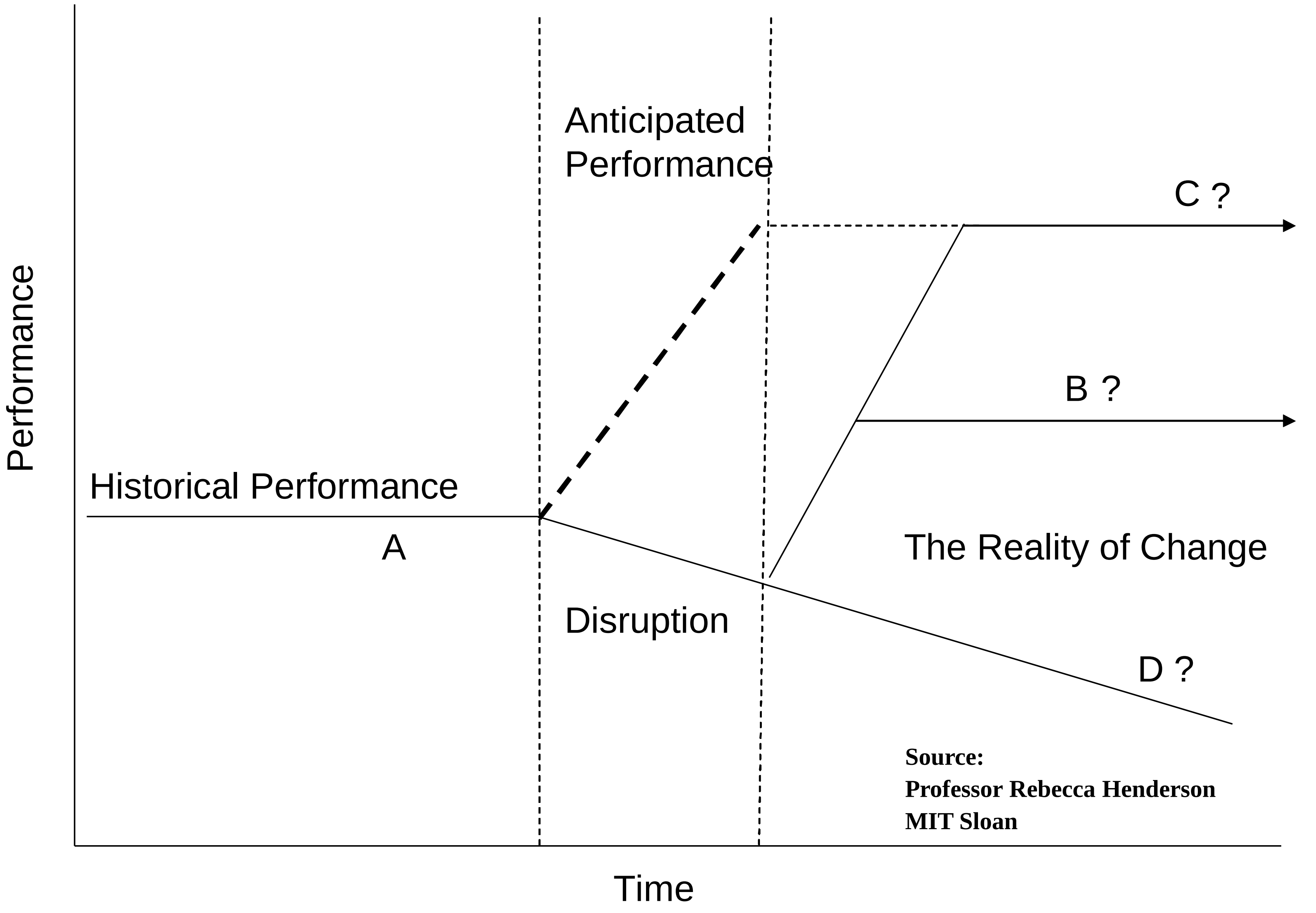
- Traditional Weapon System "A_0"
- Program Sustainment
- Capability to Meet Operational Needs

Linking Processes and Systems with Operational and Financial Performance

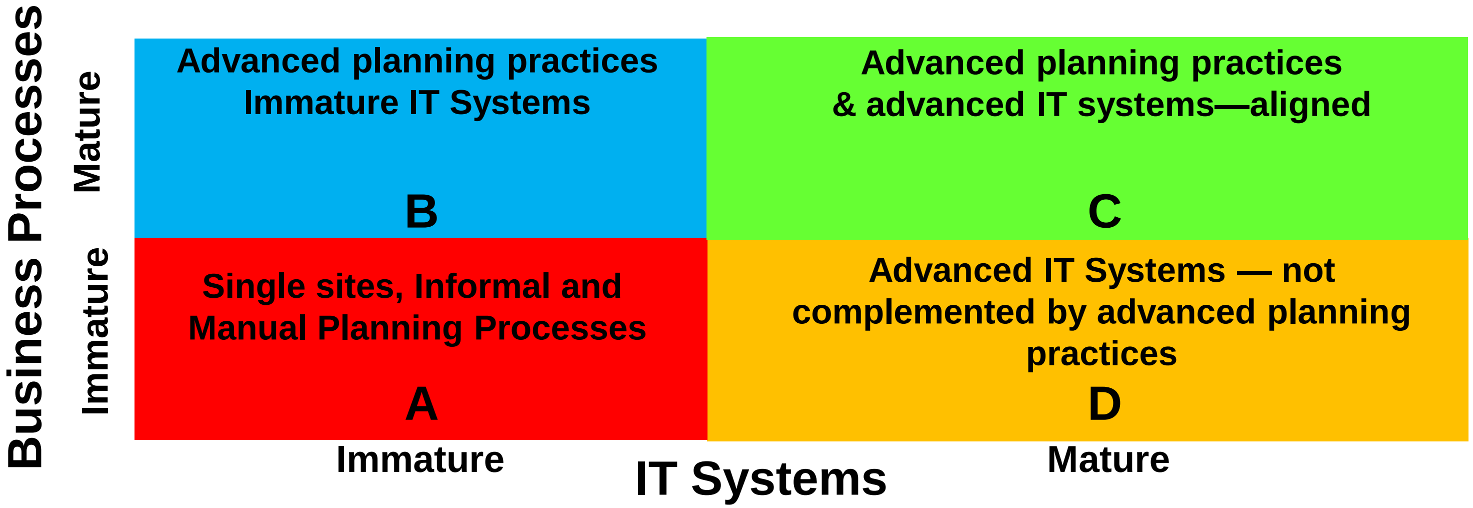


As of FY 2011: GAO found DoD ERP implementation delays ranging from 2-12 years with cost increases of nearly $7 billion; for the Army, LMP reported more than $10.6 billion in "abnormal balances" within the Procure-to-Pay general ledger accounts.

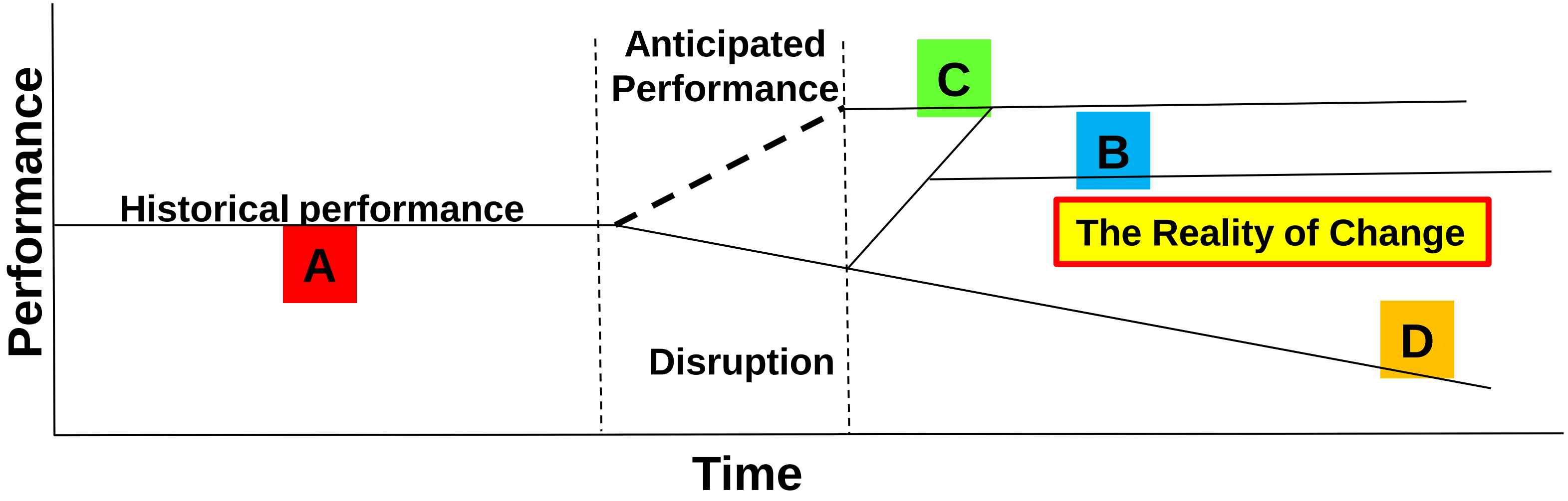
Common Expectations and the Reality of Change



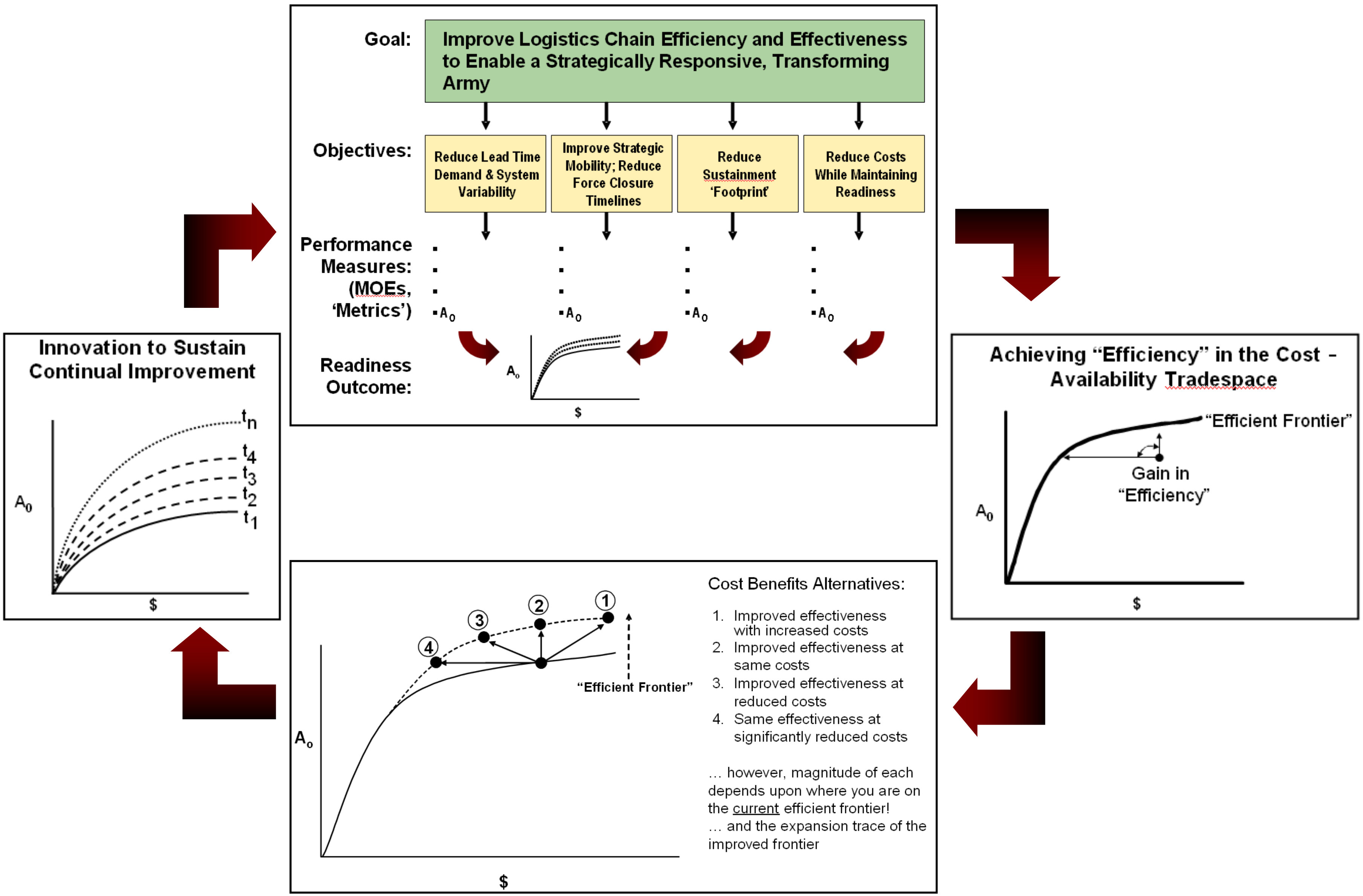
Linking Business Processes and IT Systems with Operational and Financial Performance



Common expectations and the reality of change

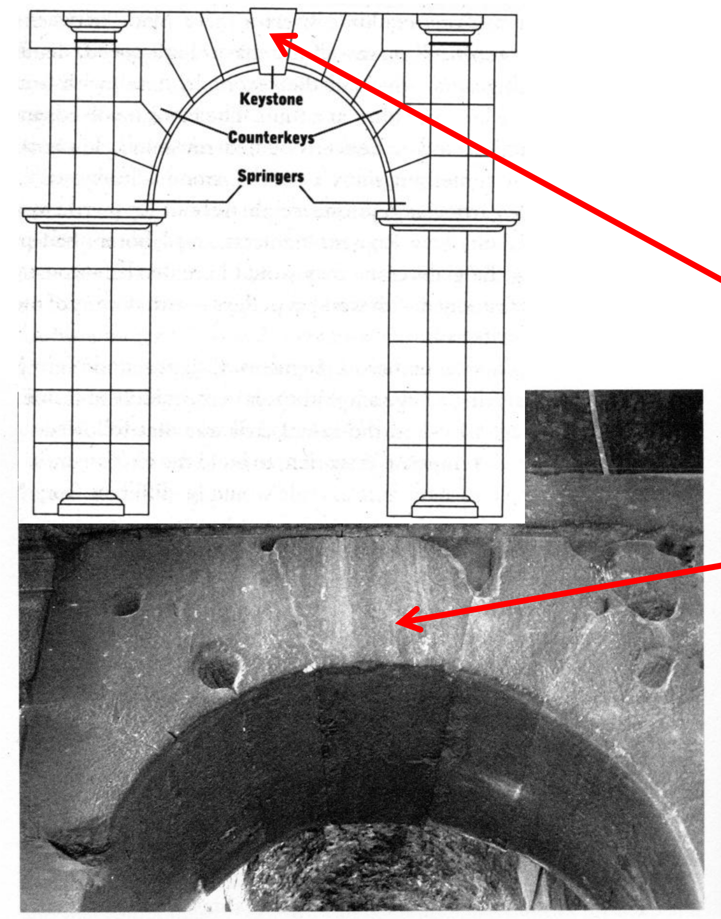


Sustaining Innovation While Linking Execution to Strategy



A.D. 80

A Keystone in Time: The voussoir arch in the Roman Empire



A.D. 2012

Current Global "Tectonic Stresses" & "Grand Challenges" for Engineering Systems:

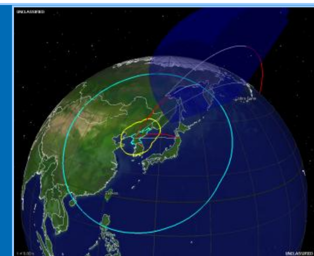
Population
Energy
Environmental
Climate
Economic

- **Operations Research**
- **"Advanced Analytics"**
- **MIST**

" . . .the organizational 'glue' needed to coordinate, orchestrate, and pull the enterprise together to keep it focused and continuously learning, precluding chaos during a period of transformational change."

Confronting the "Engenuity Gap": Operations Research and Management Innovation for Enterprise Systems

2nd International Conference on Operations Research and Enterprise Systems (ICORES) 2013
Barcelona, Spain

“Transforming a Complex, Global Organization: Operations Research and Management Innovation for the US Army’s Materiel Enterprise”

Greg H. Parlier, PhD, PE
Colonel, US Army, Ret
gparlier@knology.net

18 February 2013

“Formulas”

1. “Advanced Analytics” = Descriptive + Predictive + Prescriptive Analytics

2. Management Innovation as a Strategic Technology (MIST):

   MIST = OR[MIS + DSS] + TSP[EfI + STAAMP] + IMS where:

   (see handout)

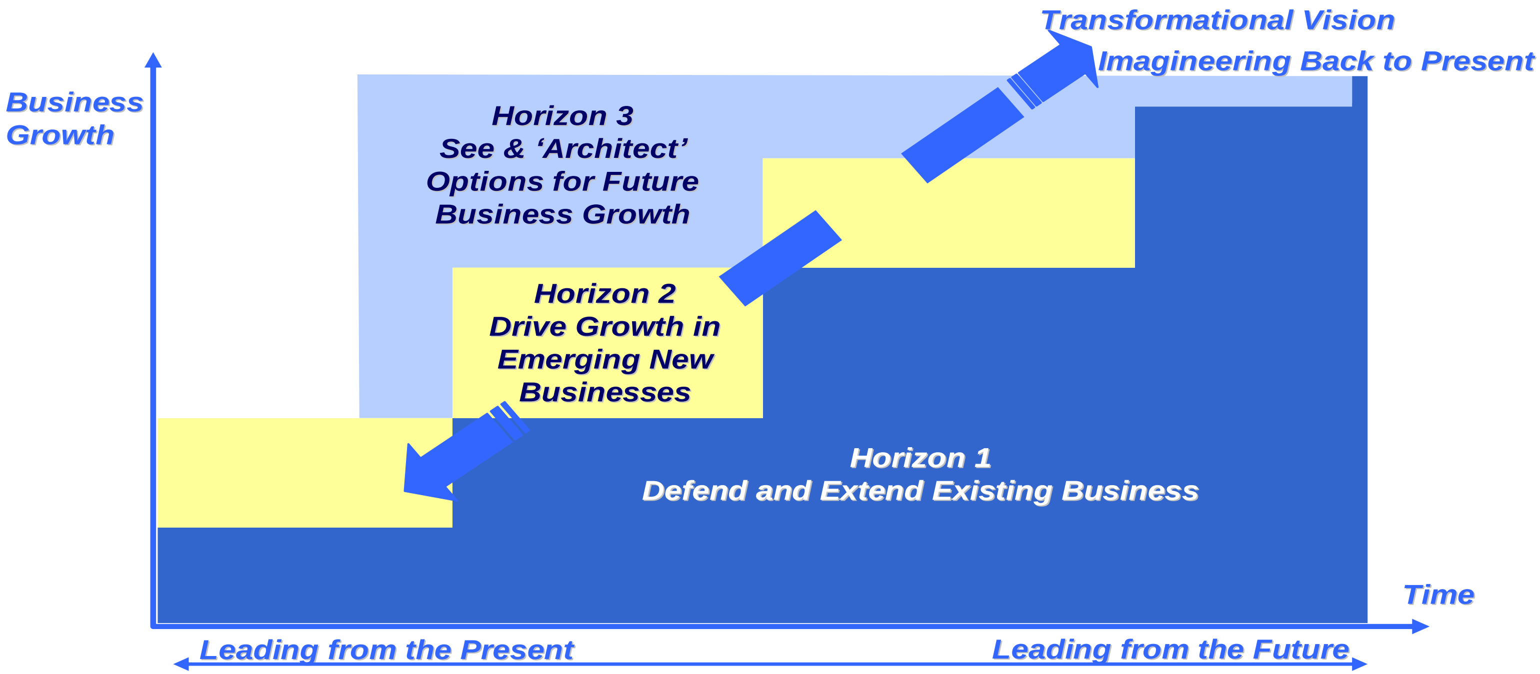
3. f(D x VL x F) > R   where:

   f = “forcing” function (for organizational change)
   D = dissatisfaction
   VL = visionary leadership
   F = first steps -- the compelling analytical argument for change
   R = resistance -- bureaucratic and/or organizational

“Literature Search” – A Few Suggestions

- MIT Series on Engineering Systems:
  - **Engineering Systems: Meeting Human Needs in a Complex Technological World**; deWeck, Roos, and Magee
  - **Flexibility in Engineering Design**; deNeufville and Scholtes
  - **Design Structure Matrix Methodology and Applications**; Eppinger and Browning
- **Design of Enterprise Systems: Theory, Architecture, and Methods;** Giachetti
- **Transforming US Army Supply Chains;** Parlier
- **The Engenuity Gap: How can we solve the problems of the future?** Homer-Dixon
- **Consilience: The Unity of Knowledge;** EO Wilson
- **Operational Research in the RAF;** Her Majesty’s Stationery Office, 1963
- **Democracy’s Arsenal: Creating a 21st Century Defense Industry;** Gansler

Traditional (Incremental) vs. Transformational Strategic Planning



The Aggregate Impact of Both Uncertain Demand and Variable Supply

Impact of
<u>Variable Supply Lead Times</u>

Impact of
<u>Variable Demand Rates</u>