Strategic Analytics for NATO Supply Chain Operations

14th NATO OR&A Conference

Colonel Greg H. Parlier, USA ret

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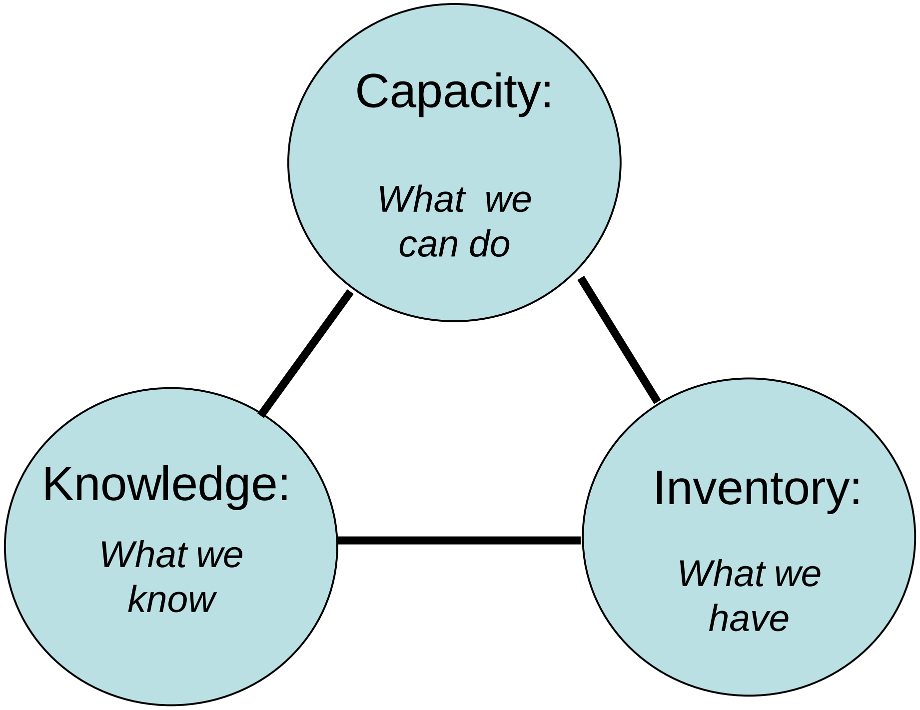
gparlier@knology.net
256.457.9782

Public Releasable

Capacity, Inventory, and Knowledge

Substitutable Ingredients of
Enterprise System Performance



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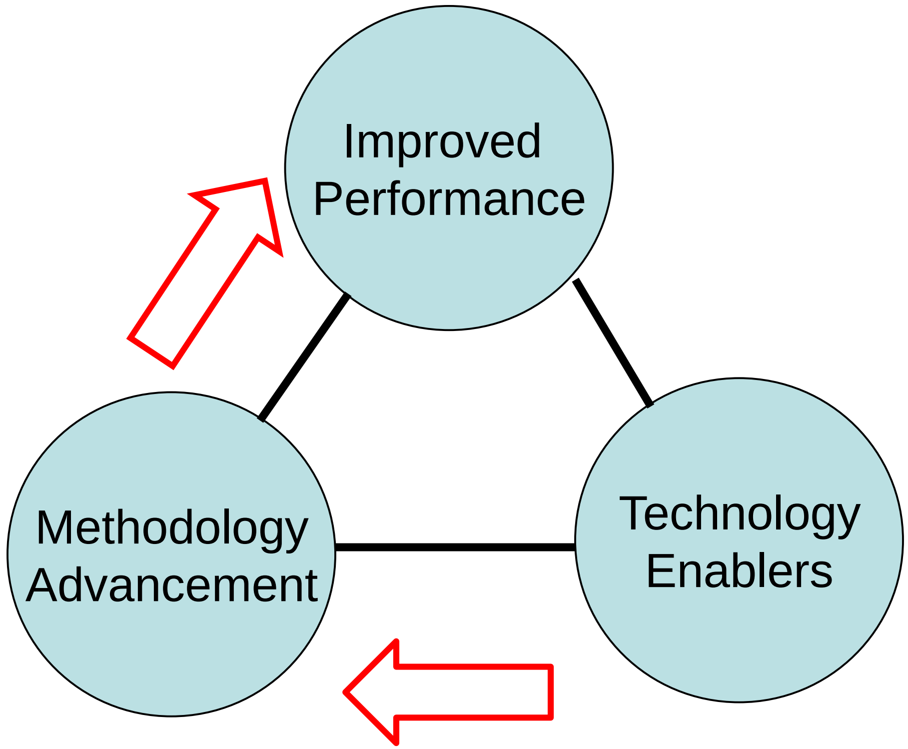
Strategic Analytics: Foundational Building Blocks

Information Technologies
Decision Support Systems
The Internet of Things
Engineering Systems
Dynamic Strategic Planning
Engines for Innovation
Analytical Architectures

Information Technologies vs. Decision Support Systems

Management <u>Innovation:</u>

- MERBS
- MBF
- R3
- DSLP
- SEWS



Technology <u>Innovation:</u>

- CBM
- RFID
- TAV
- ERP

Multi Echelon Readiness Based Sparing

Mission Based Forecasting

Readiness Responsive Retrograde

Dynamic Strategic Logistics Planning

Sustainment Early Warning System

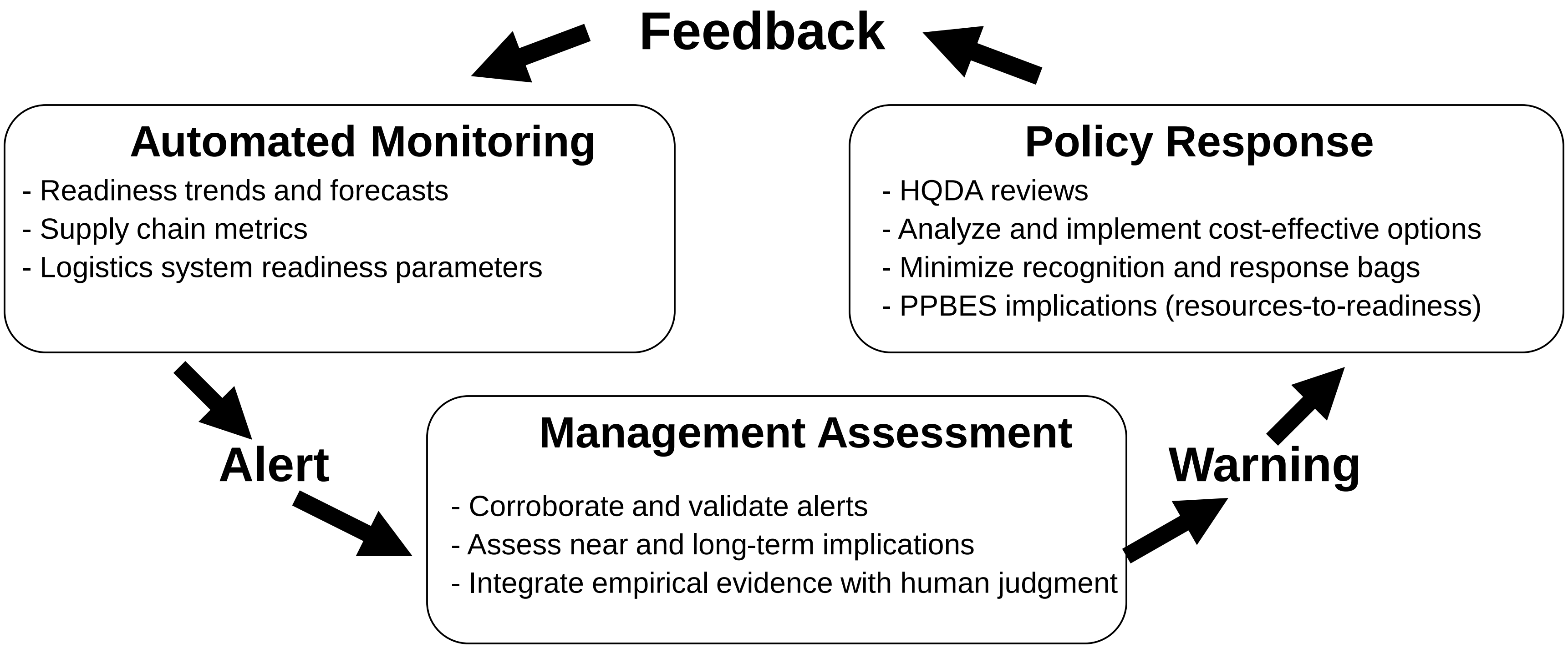
Condition Based Maintenance

Radio Frequency Identification

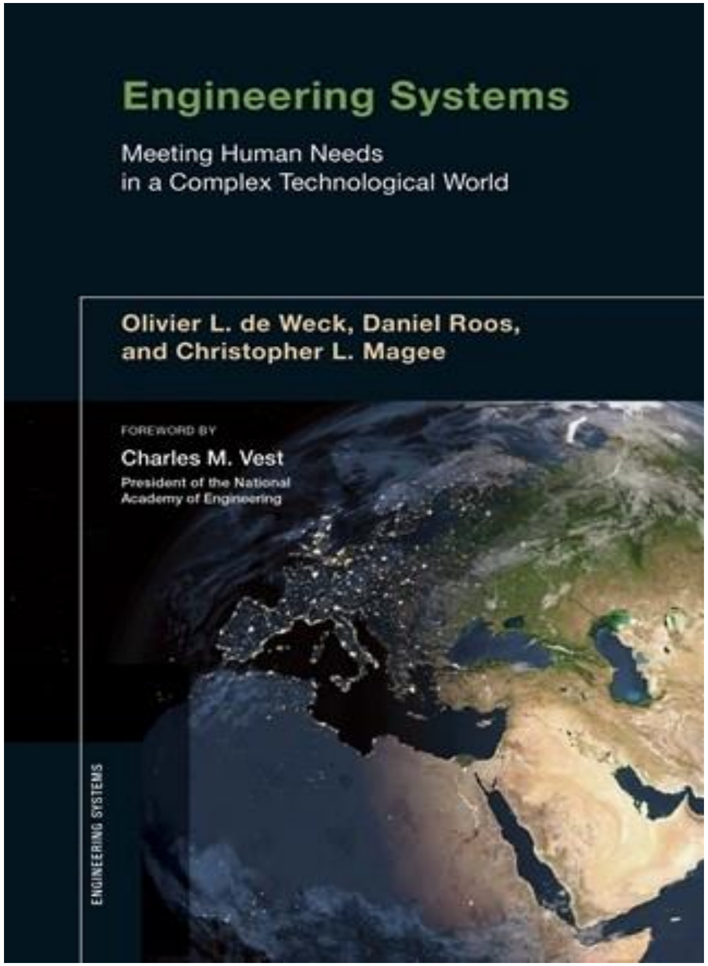
Total Asset Visibility

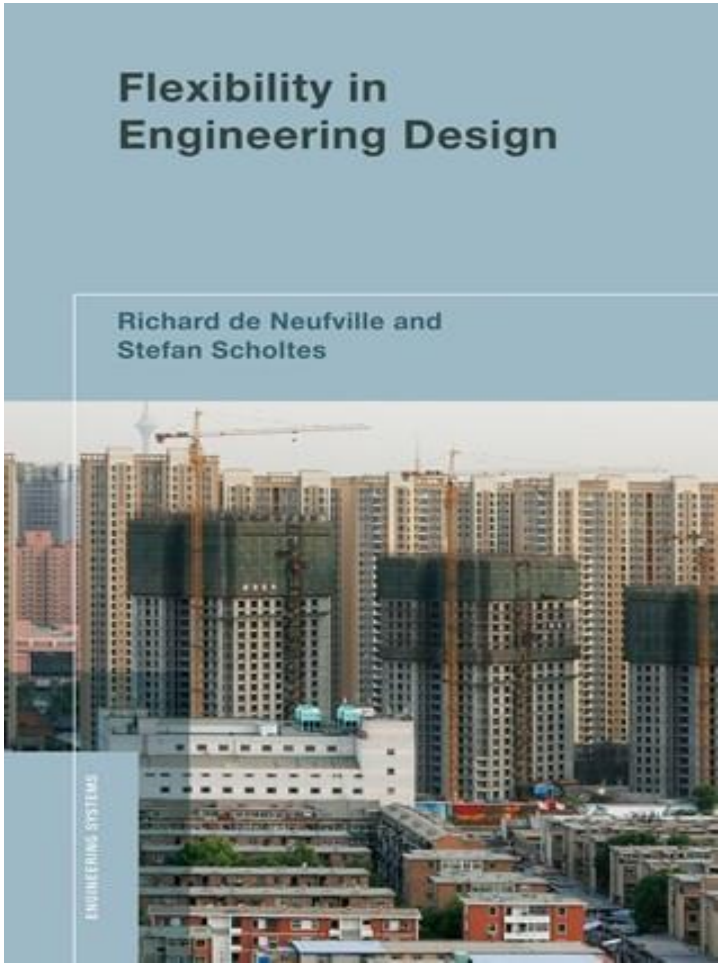
Enterprise Resource Planning

Internet of Things (IoT): Early Warning Systems



MIT Engineering Systems Division (ESD)





Enterprise (Engineering) Systems

Some Definitions:

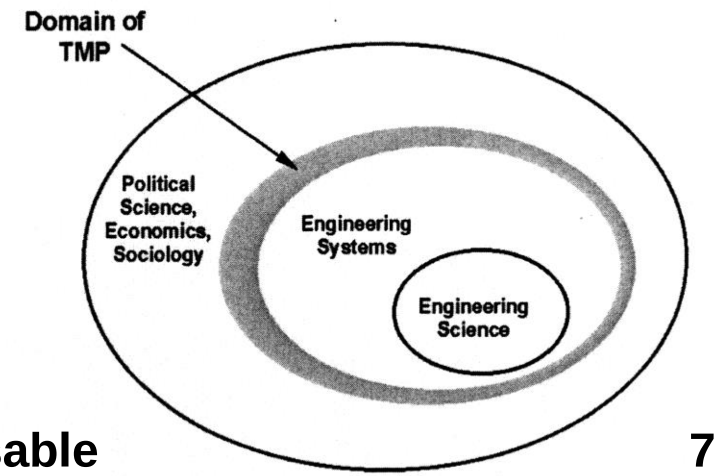
An emerging way to think about how to model, analyze, and design large-scale, complex, socio-technical systems.

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.

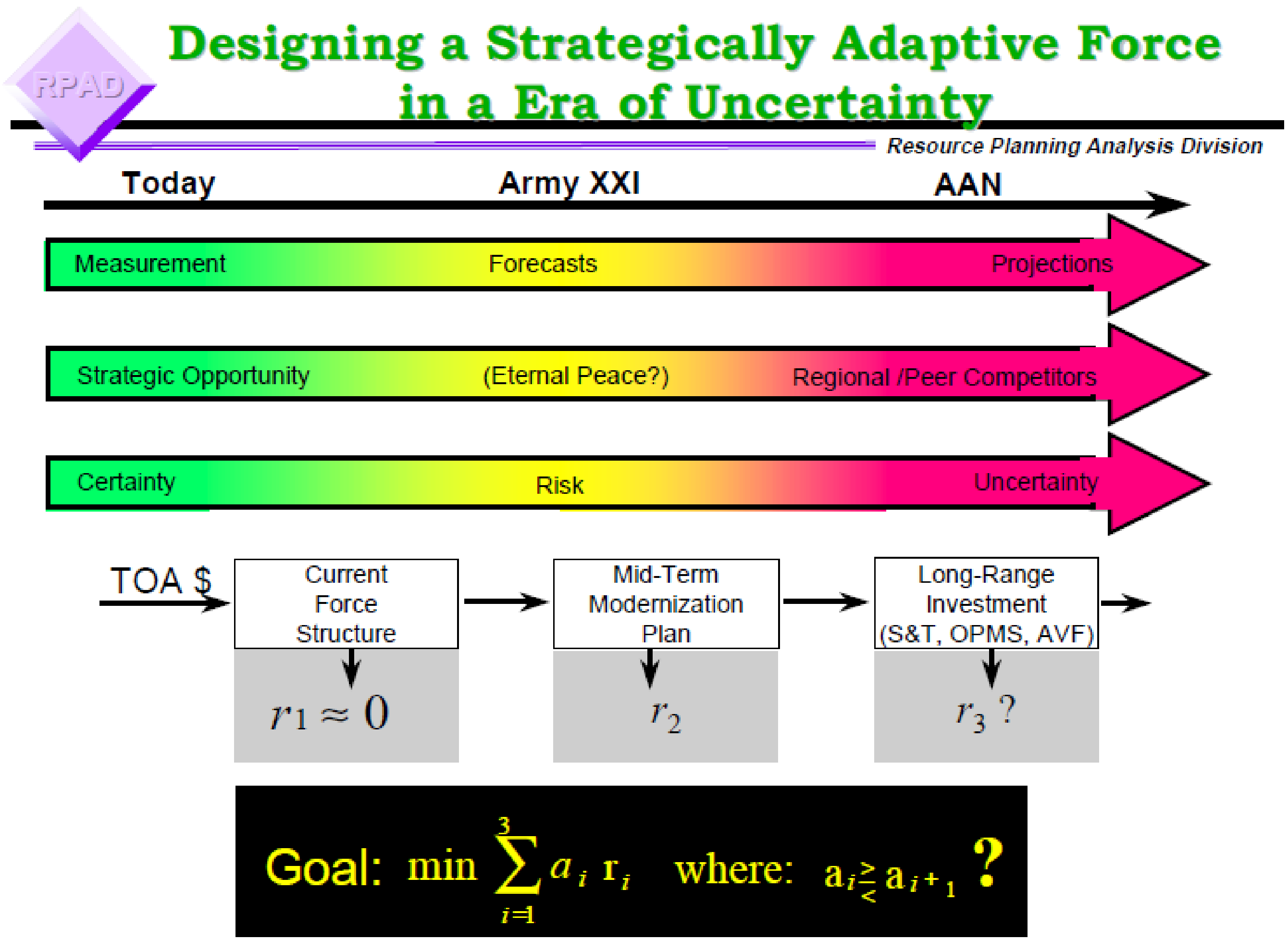
Enterprise engineering is the body of knowledge, principles, and practices to design an enterprise.

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.

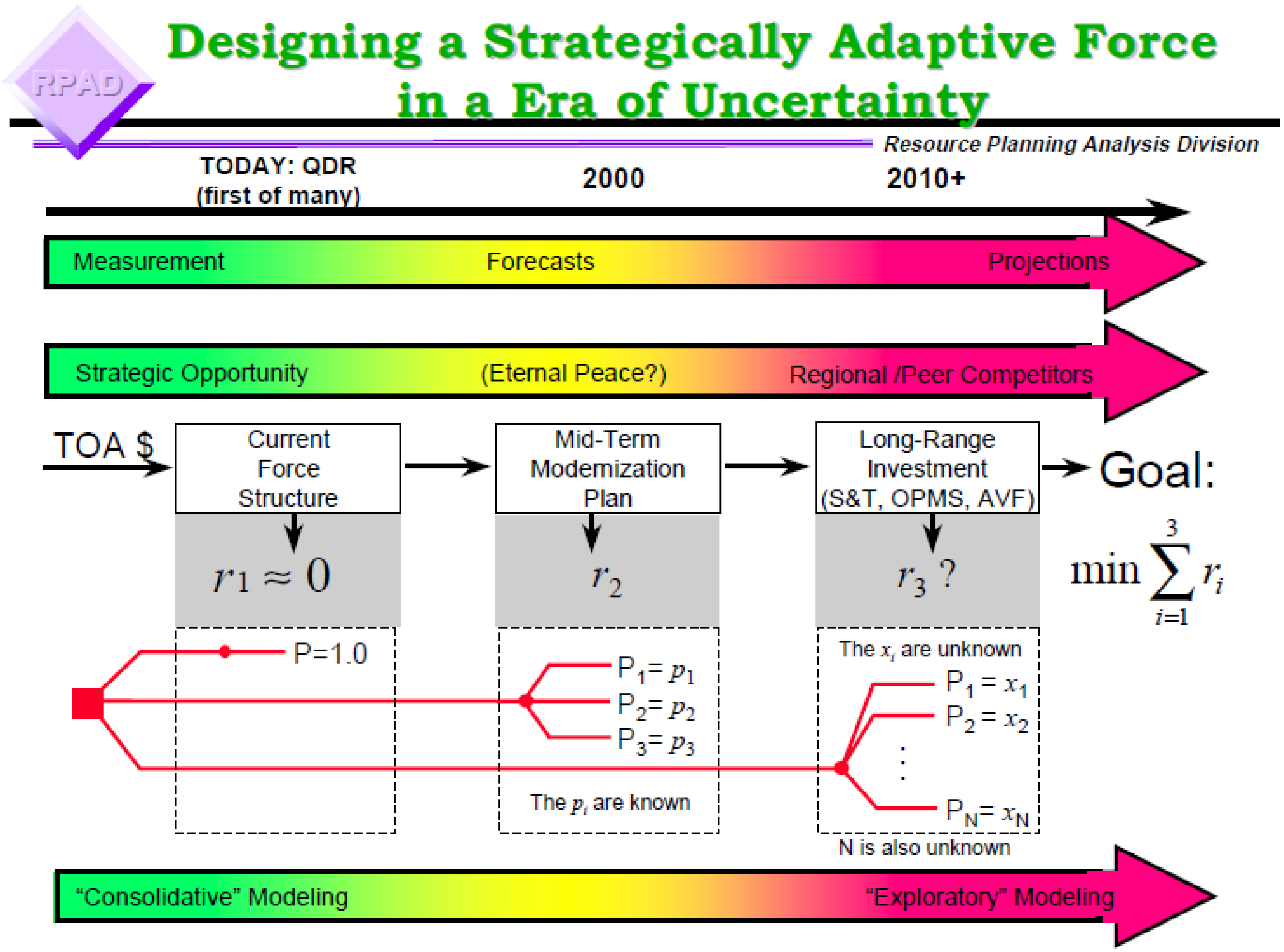


An emerging field at the intersection of engineering, management, and the social sciences.

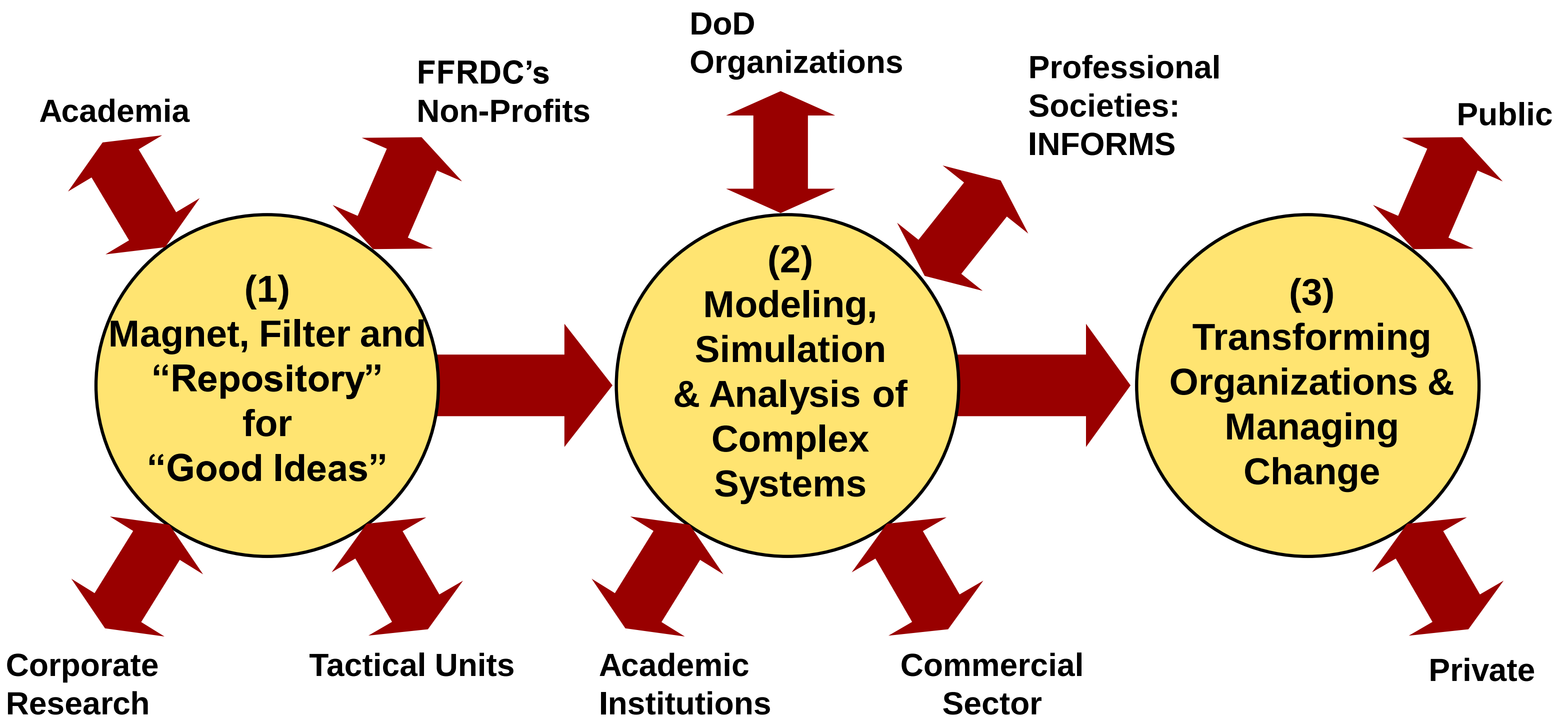
Traditional Strategic Planning



Dynamic Strategic Planning



Engines for Innovation (EfI)



- Organizational Design
- Supply/Value Chain
- Workforce Development
- Technology Implications
- Productivity Gain

- System Dynamics Modeling
- Large Scale System Design, Analysis, and Evaluation
- Systems Simulation, Modeling and Analysis

- Cost Benefit Analyses
- Risk Reduction & Mitigation
- Education & Training
- Technical Support
- Change Management

Analytical Architectures

Goal: Improve Logistics Chain Efficiency and Effectiveness to Enable a Strategically Responsive, Transforming Army

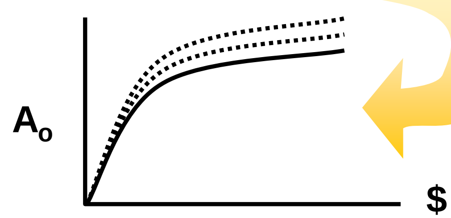
Objectives:

- Reduce Lead Time Demand & System Variability
- Improve Strategic Mobility; Reduce Force Closure Timelines
- Reduce Sustainment ‘Footprint’
- Reduce Costs While Maintaining Readiness

Performance Measures: (MOEs, ‘Metrics’)

Reduce Lead Time Demand & System Variability	Improve Strategic Mobility; Reduce Force Closure Timelines	Reduce Sustainment ‘Footprint’	Reduce Costs While Maintaining Readiness
▪	▪	▪	▪
▪	▪	▪	▪
▪	▪	▪	▪
▪ A_O	▪ A_O	▪ A_O	▪ A_O

Readiness Outcome:



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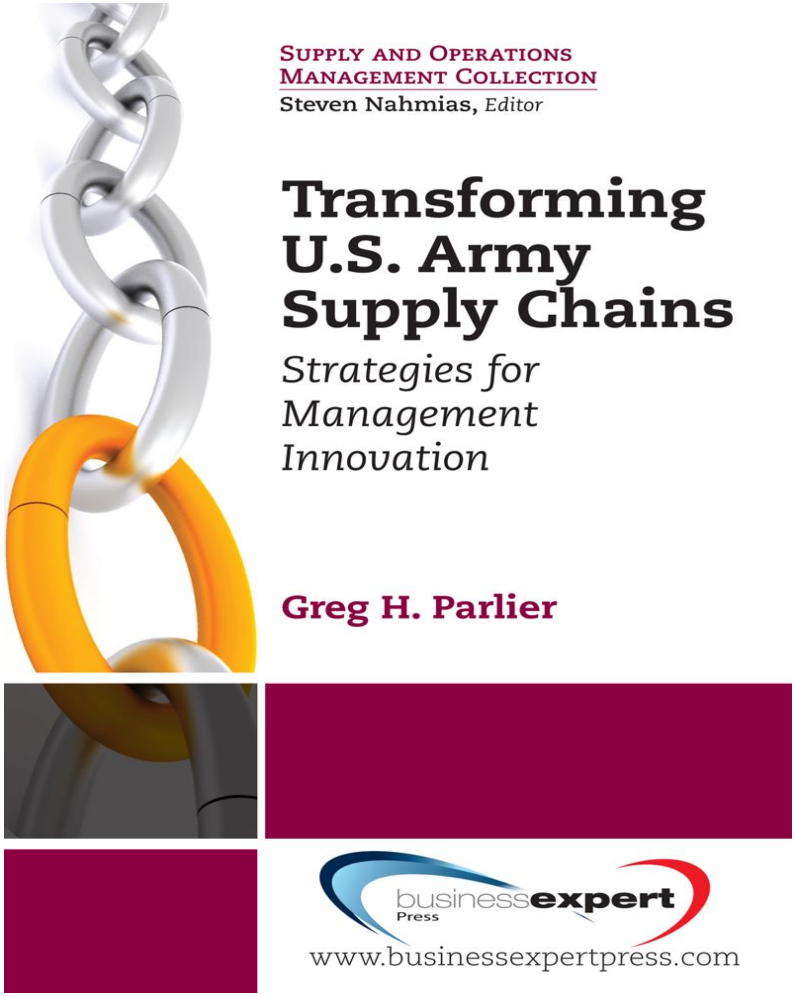
Linking Strategy to Measurable Results



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

"Strategic Analytics" = Descriptive + Predictive + Prescriptive Analytics

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

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?

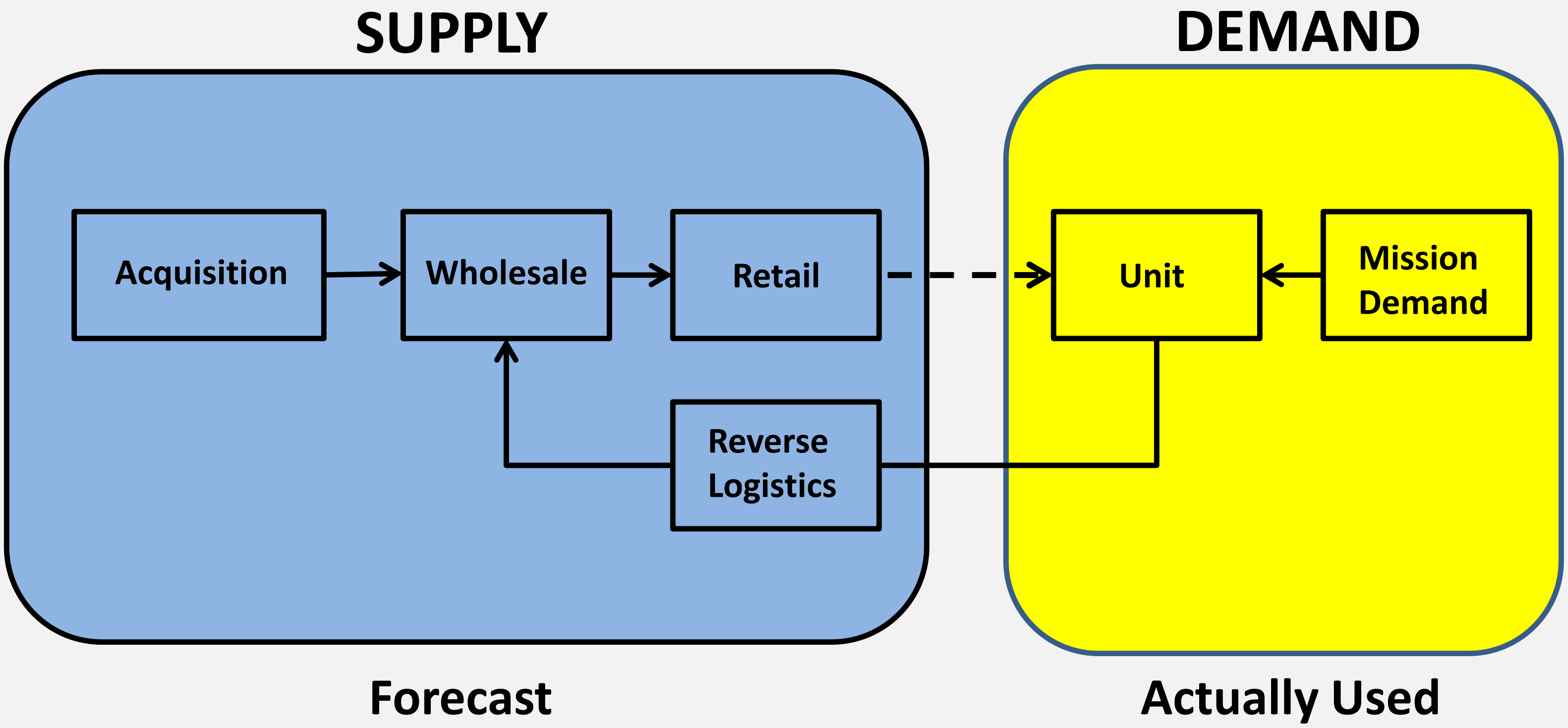
IV. Design and Evaluation: An "Analytical Architecture" to Guide Logistics Transformation
- 15. Multi-Stage Supply Chain Optimization
- 16. System Dynamics Modeling and Dynamic Strategic Planning
- 17. Operational and Organizational Risk Evaluation
- 18. Logistics System Readiness and Program Development
- 19. Accelerating Transformation: An "Engine for Innovation"

Predictive Analytics: How can we get there?

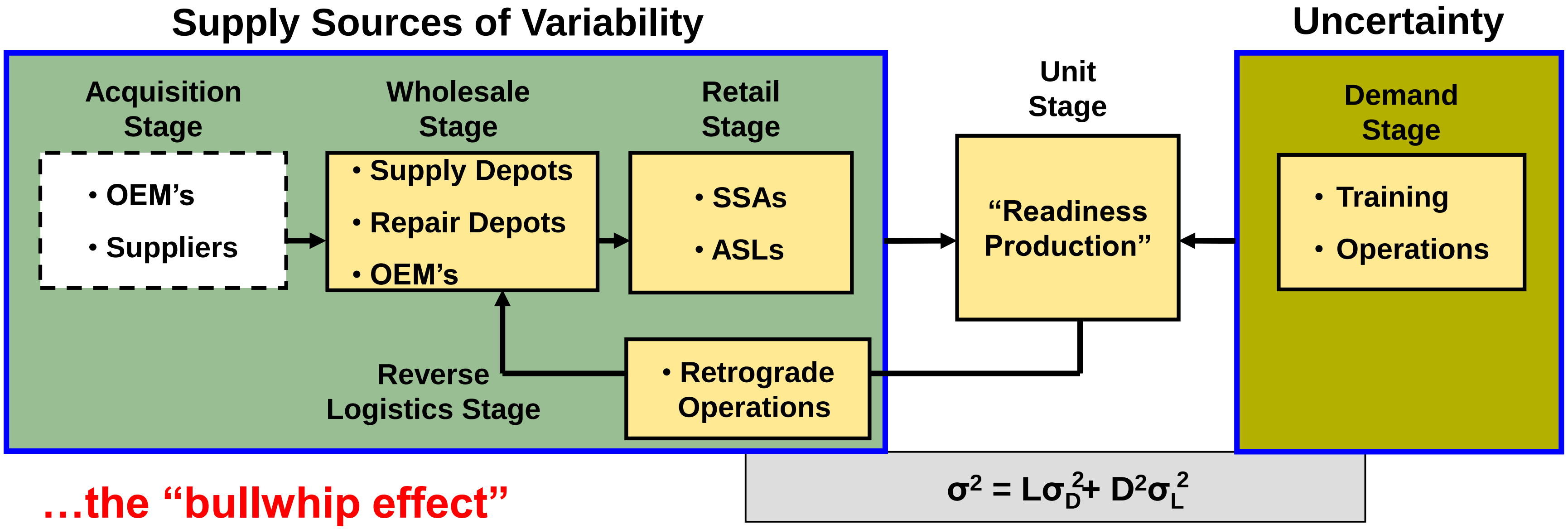
V. Management Concepts for Transformation
- 20. Organizational Redesign for Army Force Generation
- 21. Contributions of Information Systems Technology and Operations Research
- 22. Strategic Management Concepts for a Learning Organization
- 23. PBL and Capabilities Based Planning for an Expeditionary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

Managing Enterprise Transformation: What will it take?

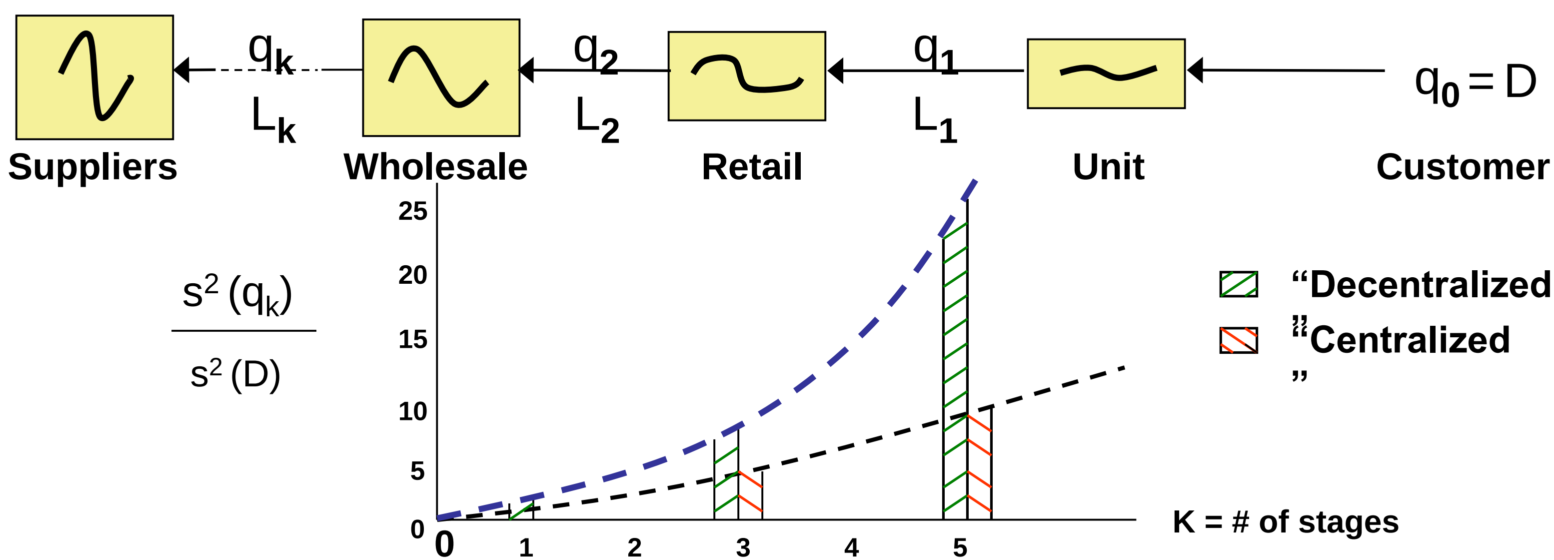
Aligning Supply to Readiness-Driven Demand in the Materiel Sustainment Enterprise



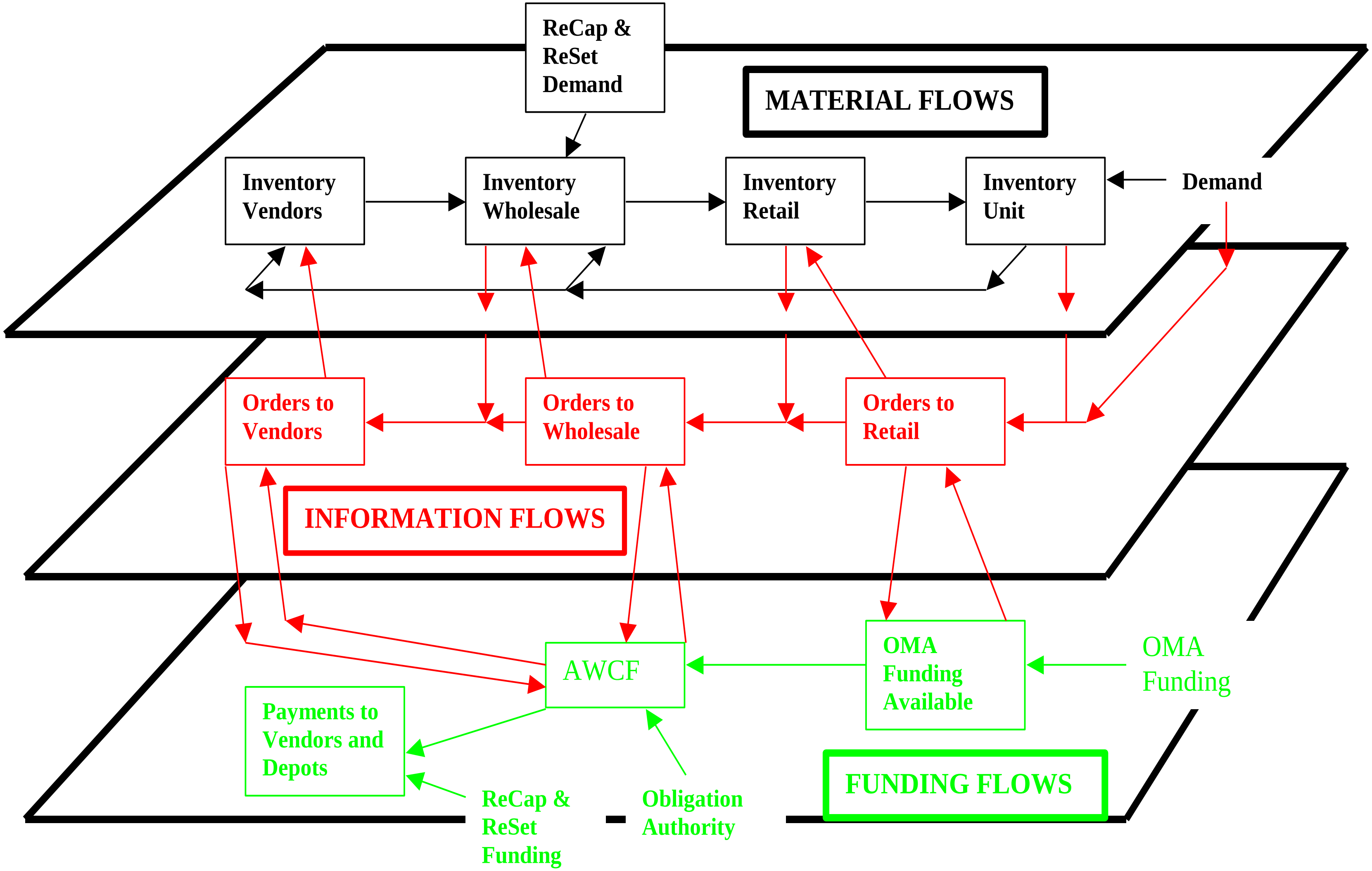
Supply Variability and Demand Uncertainty: Army Supply Chain Model



…the "bullwhip effect"



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

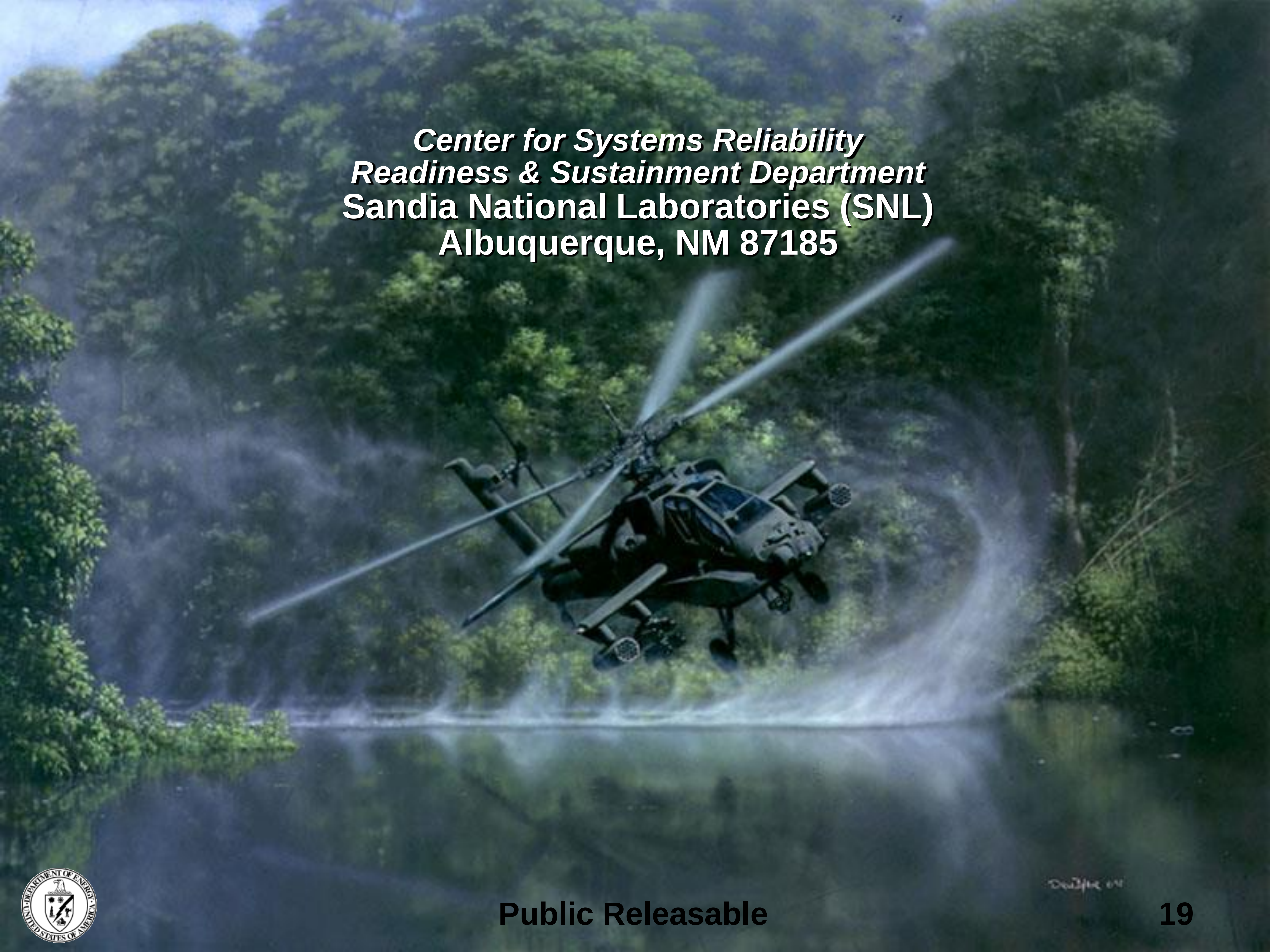


Mission Demand

Operation Type/Duration

Environmental Conditions

Force Size/Composition

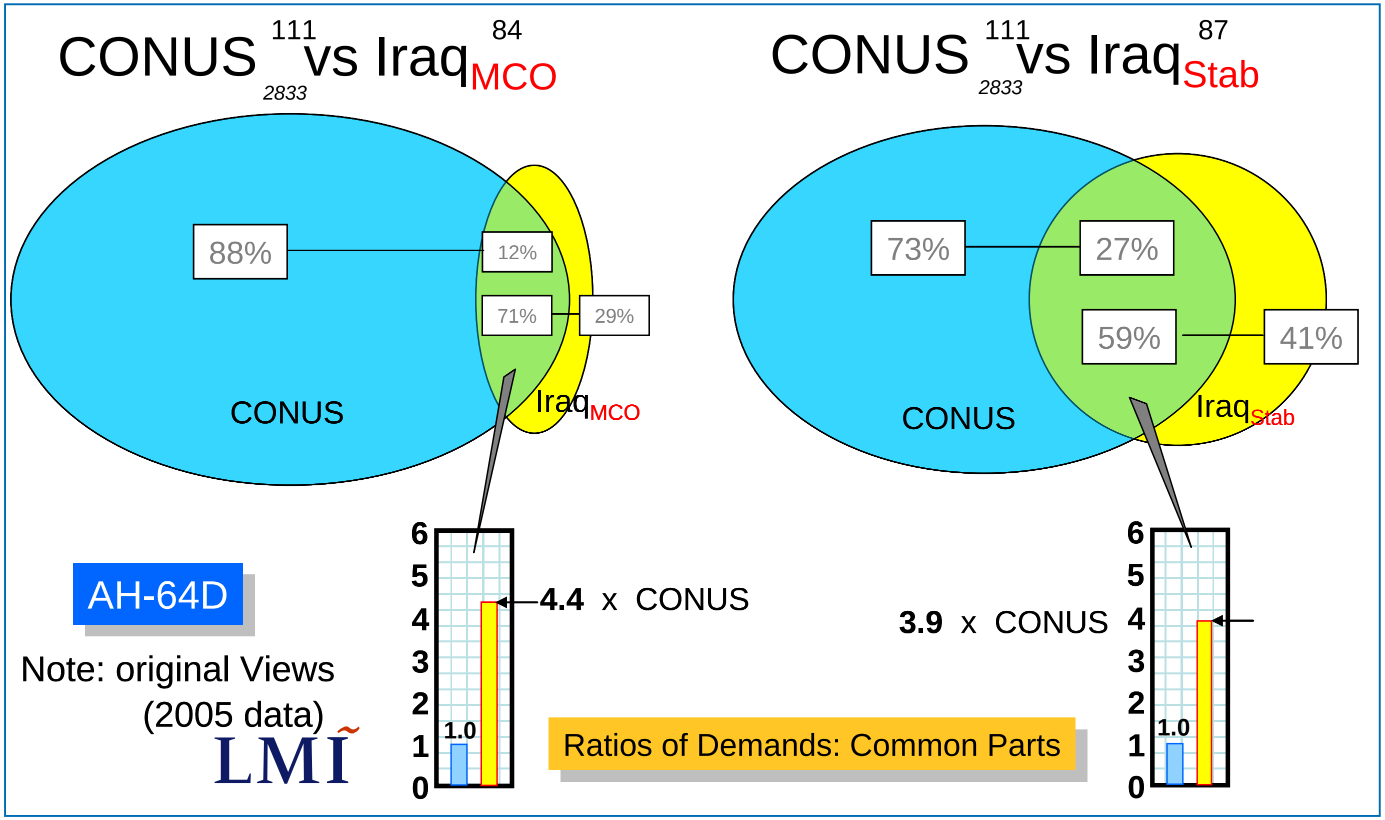


Center for Systems Reliability
Readiness & Sustainment Department
Sandia National Laboratories (SNL)
Albuquerque, NM 87185

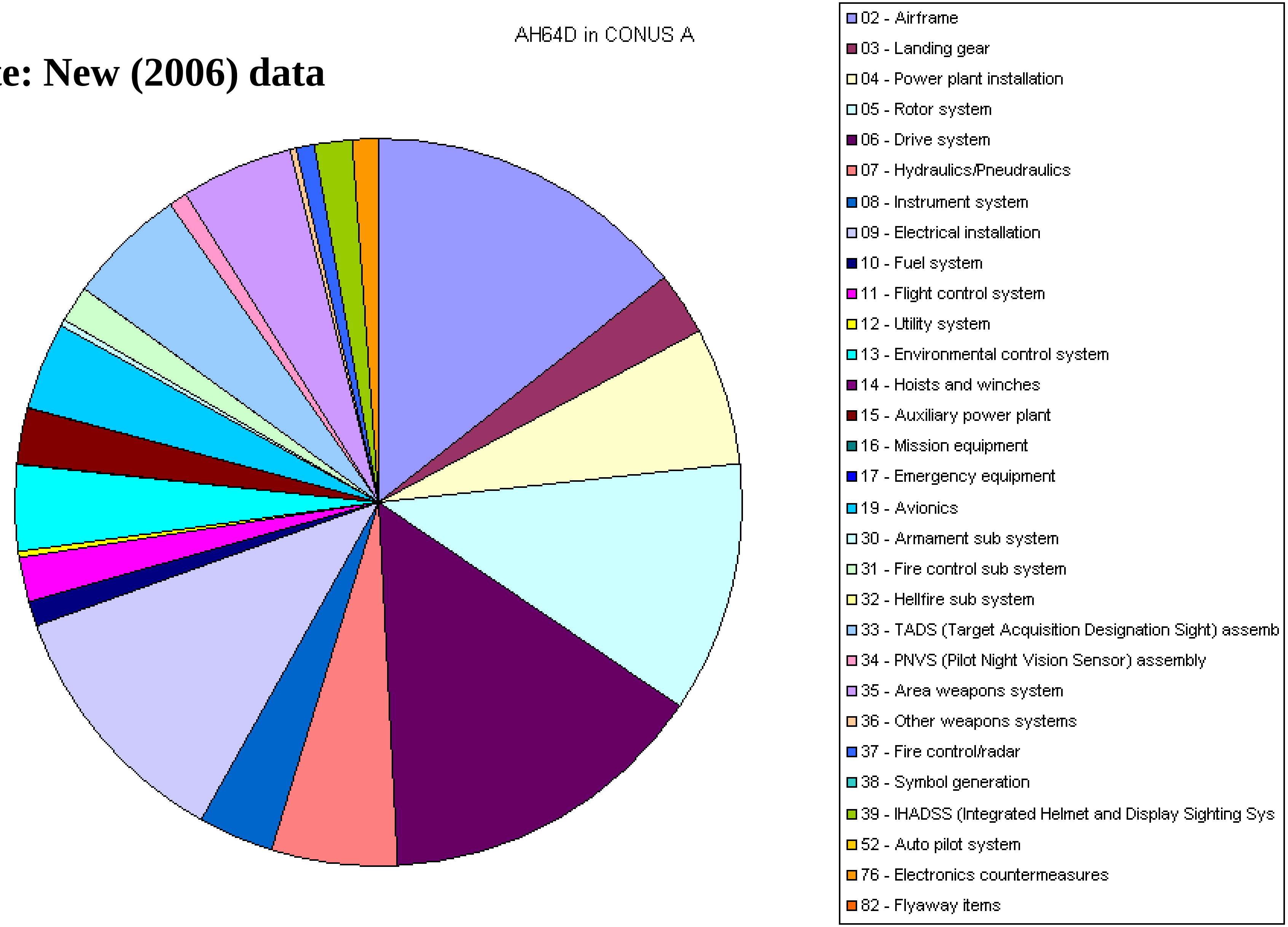
Innovation Catalyst: Mission-Based Forecasting (MBF)

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



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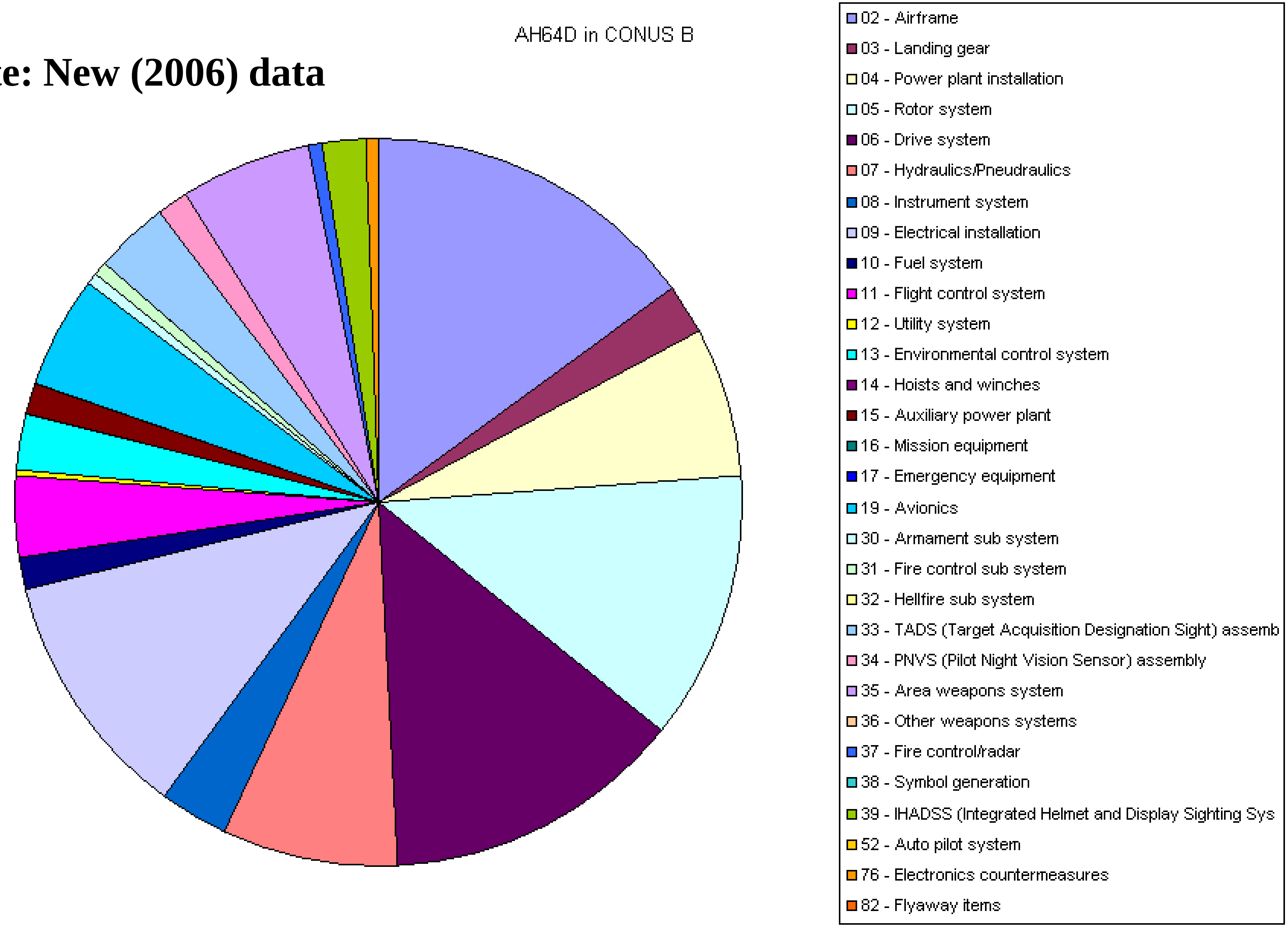

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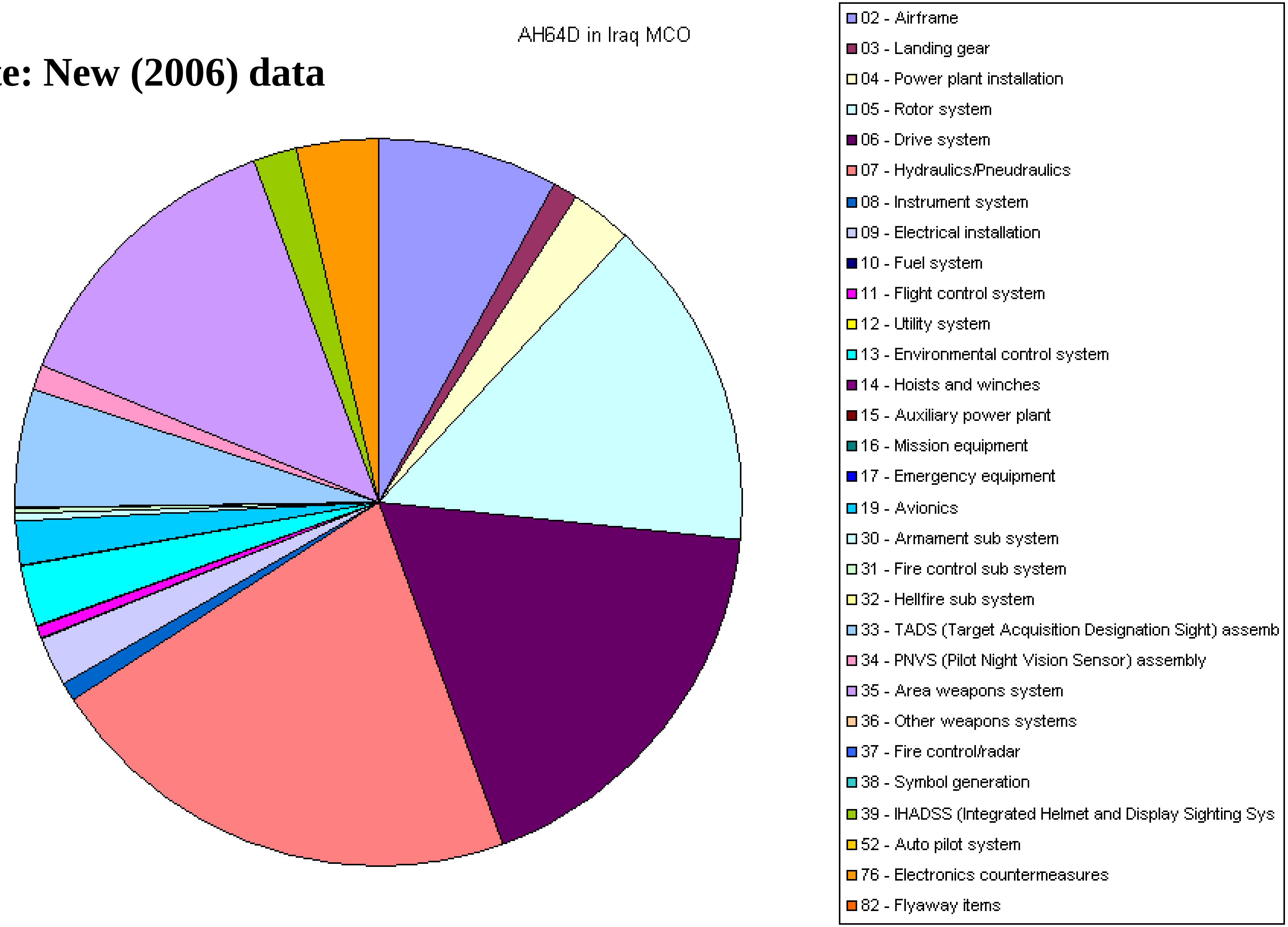
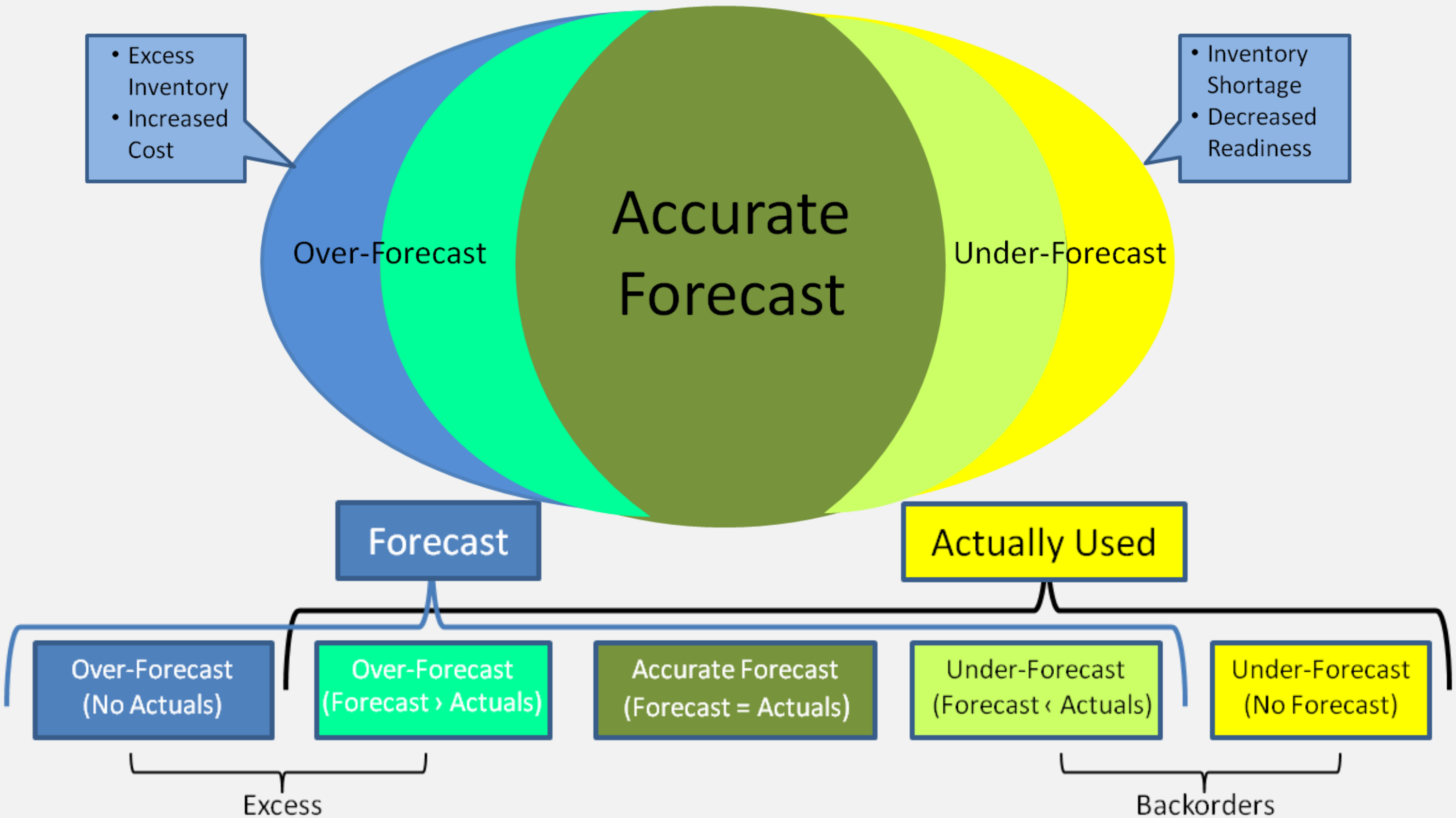


Measuring Forecast Accuracy: Reducing Error Sources



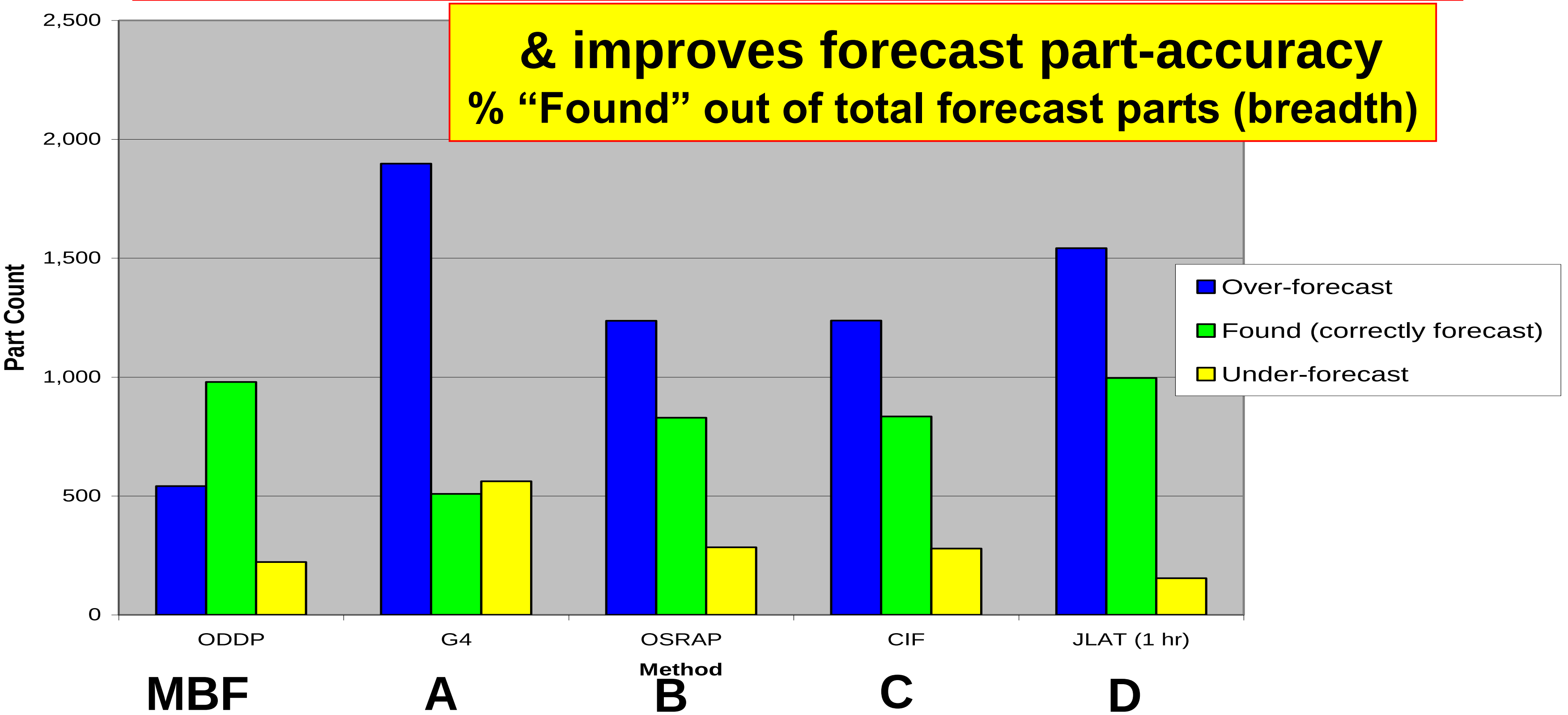
Improving Forecast Accuracy: Reduces Forecast Errors, Increases Readiness, Reduces Excess, and Minimizes Burden

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

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

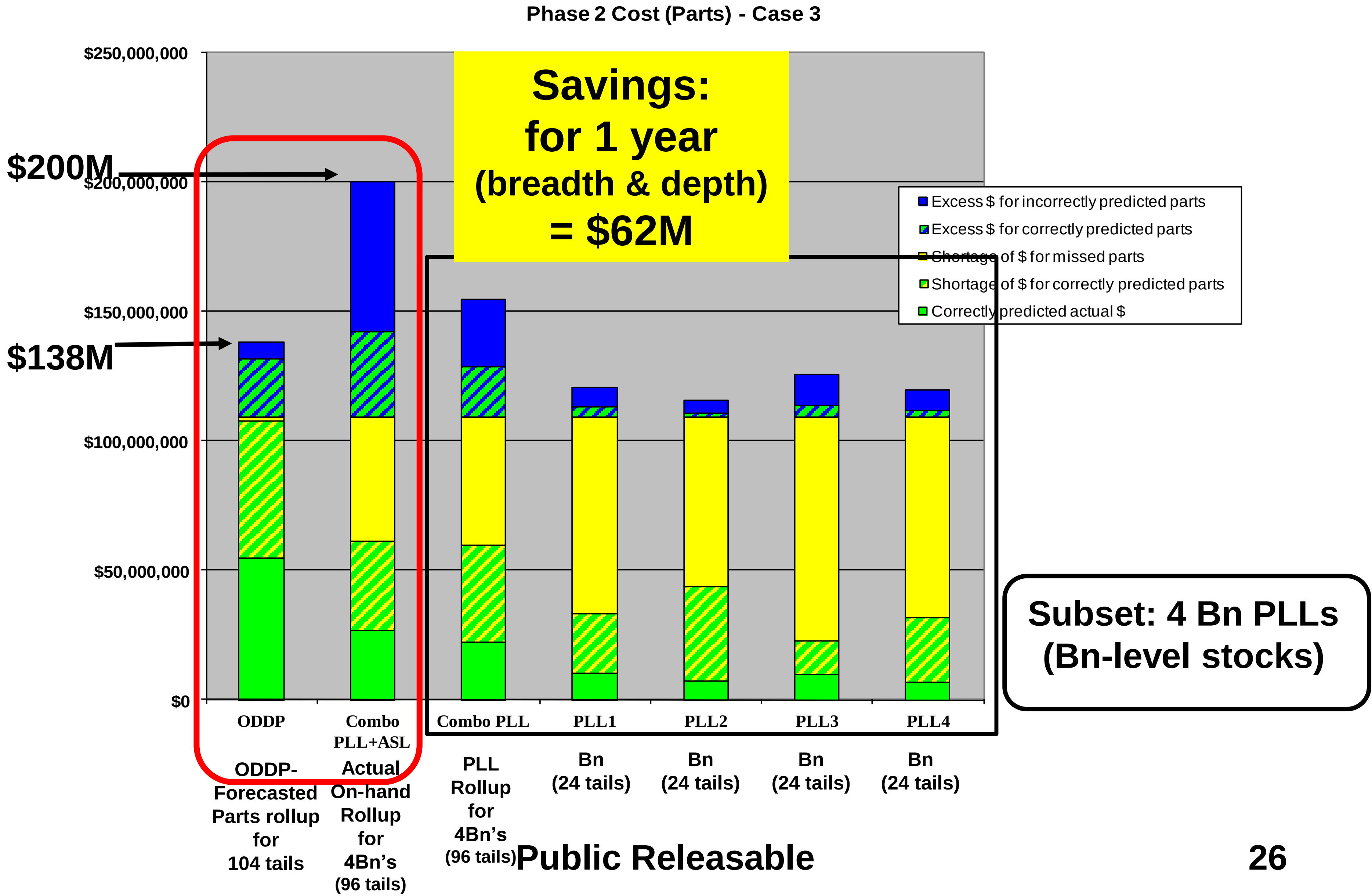
MBF reduces part over-forecast, and under-forecast

& improves forecast part-accuracy
% "Found" out of total forecast parts (breadth)



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



Intermittent Demand

Professional Judgment

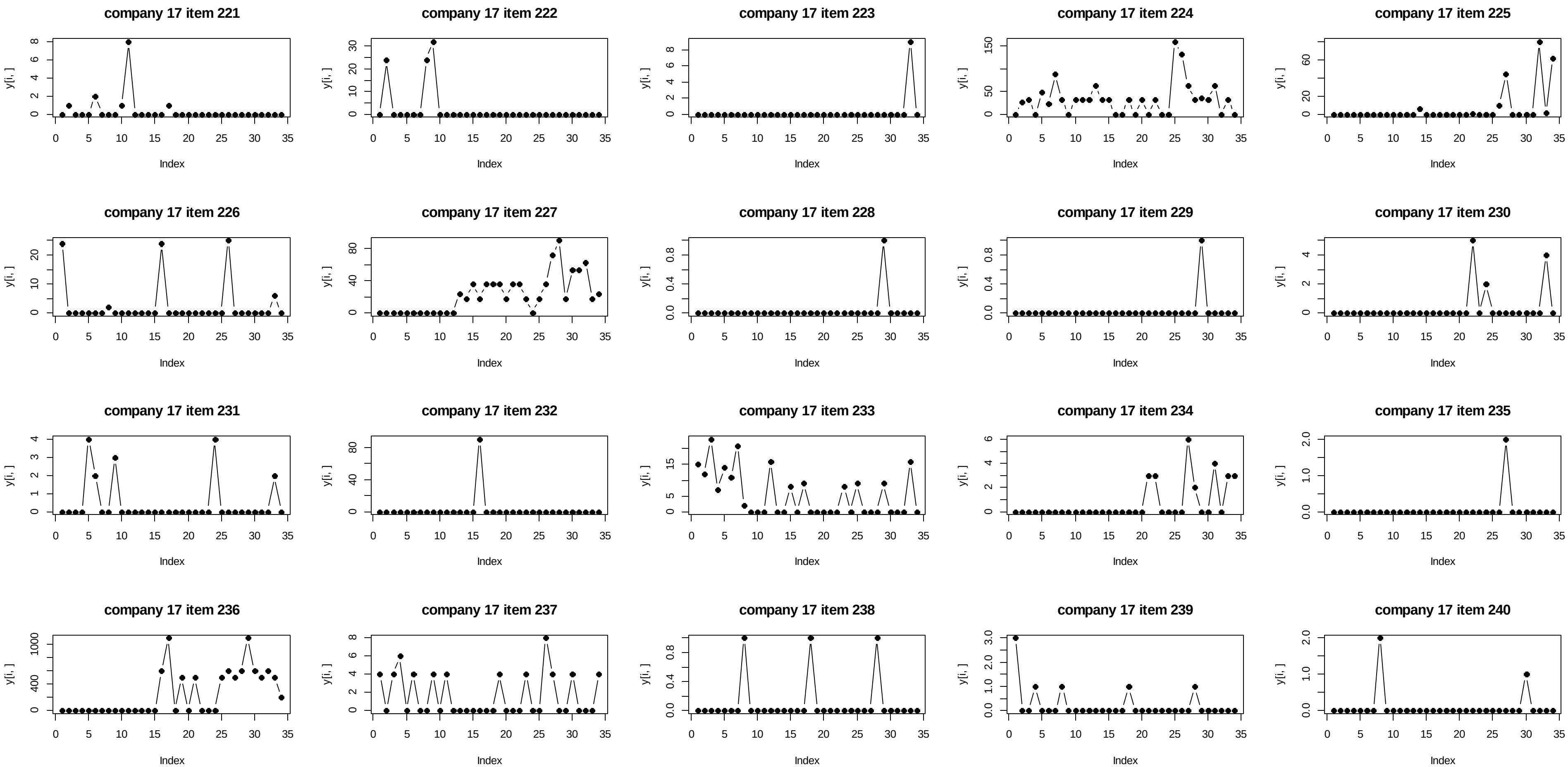
Moving Avg/Exponential Smoothing

Poisson Methods (Croston)

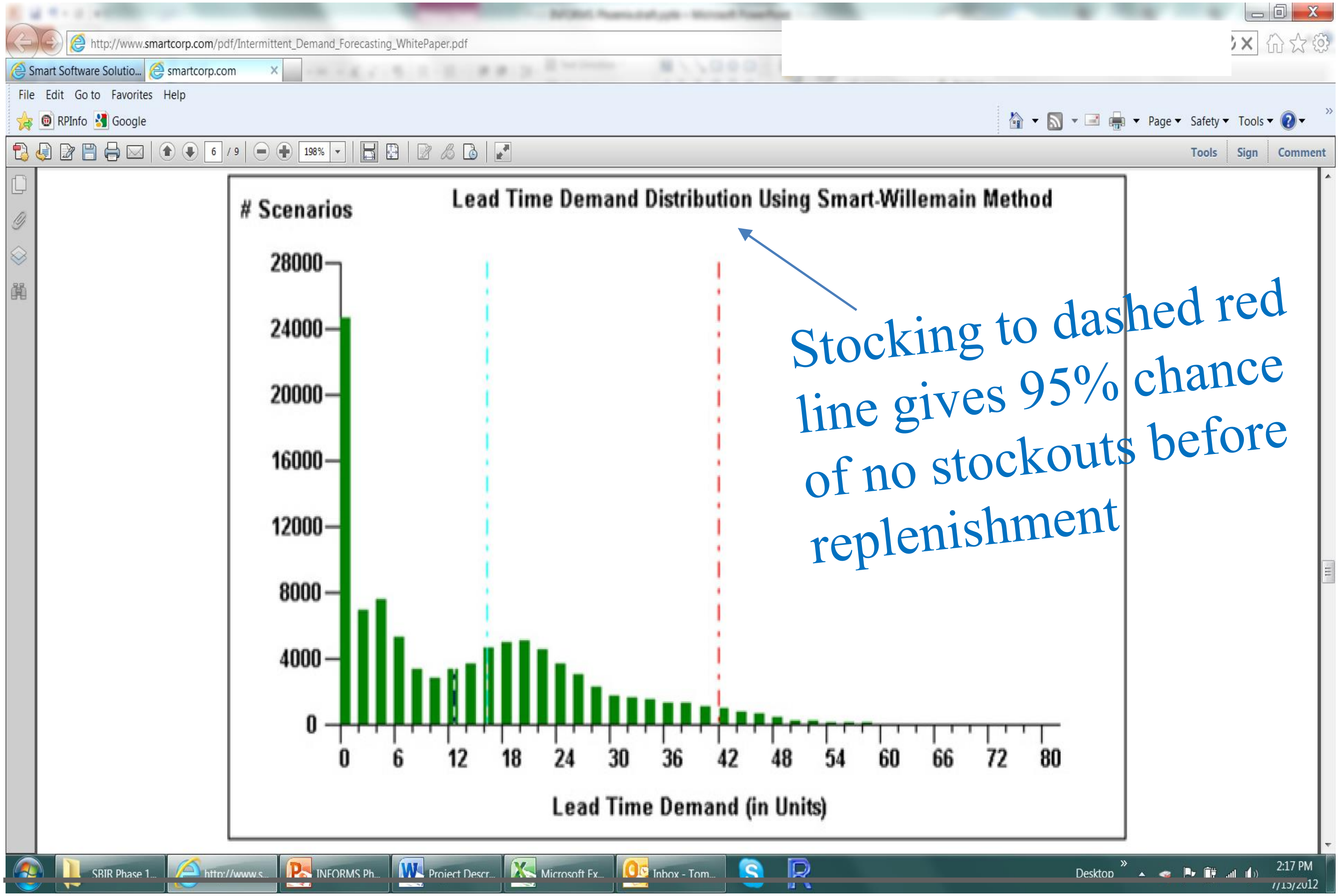
ID Specific: Smart-Willemain

Ongoing Research

Varieties of Intermittent Demand



Output of Markov Bootstrap



Prognostic Demand

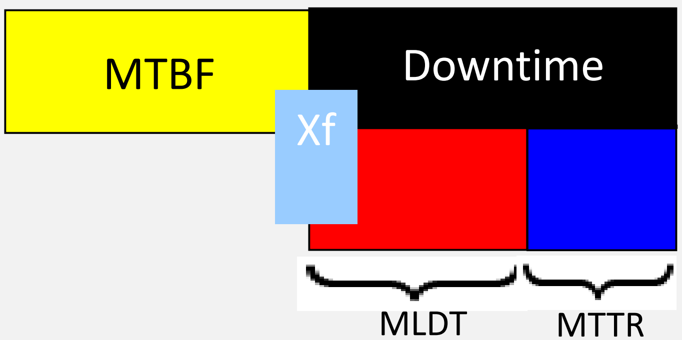
Condition Based Maintenance (CBM)

“Connecting” CBM to the Supply Chain

Remaining Useful Life (RUL)

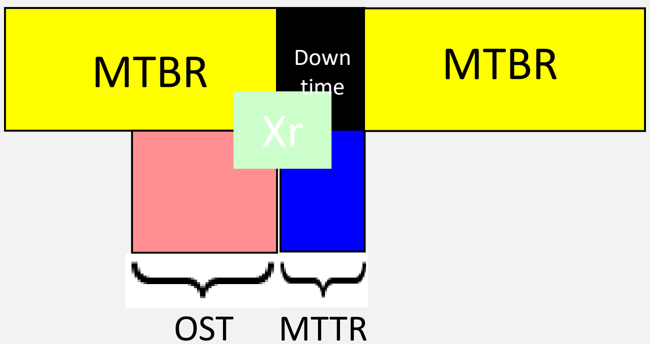
"Connecting" CBM to the Supply Chain: A Mathematical View

Reactive Repair vs. Proactive Replacement



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

$$\textbf{MLDT} = \sum_{\forall_i} ost_i$$



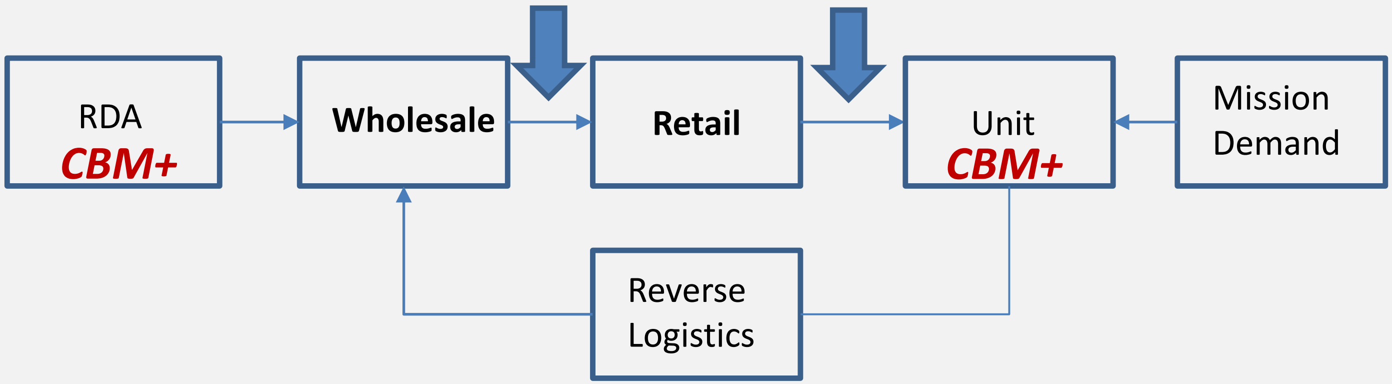
$$A_o = \frac{\textbf{MTBR}}{\textbf{MTBR} + \text{MLDT} + \text{MTTR}}$$

$$MLDT \simeq 0$$

Benefits of “Connecting” CBM to Forward Supply Chain

CBM+ = Early Warning

- Anticipatory requisitioning for proactive maintenance
- Supply Forecasting - Readiness Based Sparing (RBS)
- Reduced Enterprise Requirement Objective (RO) for Cost-Wise Readiness



Contributes to Achieving Cost-Wise Readiness

CBM Prognostics Simulation Model – Initial Results

Expected Results Based on Improved Predictive Ordering

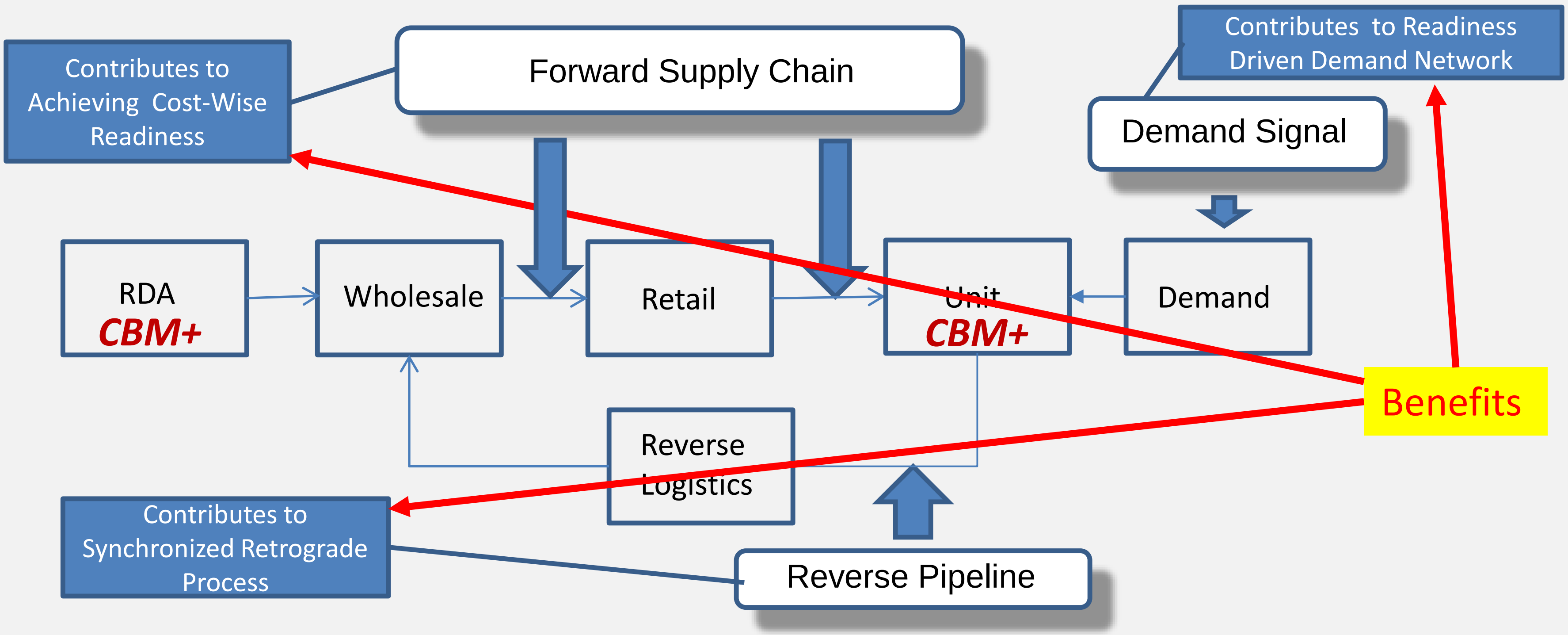
# of Times an Aircraft was Down for More Than One Day

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

Sustainment Enterprise IoT: Connecting CBM+ to the Supply Chain



Logistics Readiness Early Warning System

Feedback

Automated Monitoring

- Readiness trends and forecasts
- Supply chain metrics
- Logistics system readiness parameters

Policy Response

- HQDA reviews
- Analyze and implement cost-effective options
- Minimize recognition and response lags
- PPBES implications (resources-to-readiness)

Alert

Management Assessment

- Corroborate and validate alerts
- Assess near and long-term implications
- Integrate empirical evidence with human judgment

Warning

The regression relating Mission Capable rates (MC) to backorder average age lagged 5 months, shown in the equation below, indicates that a one-month increase in 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)

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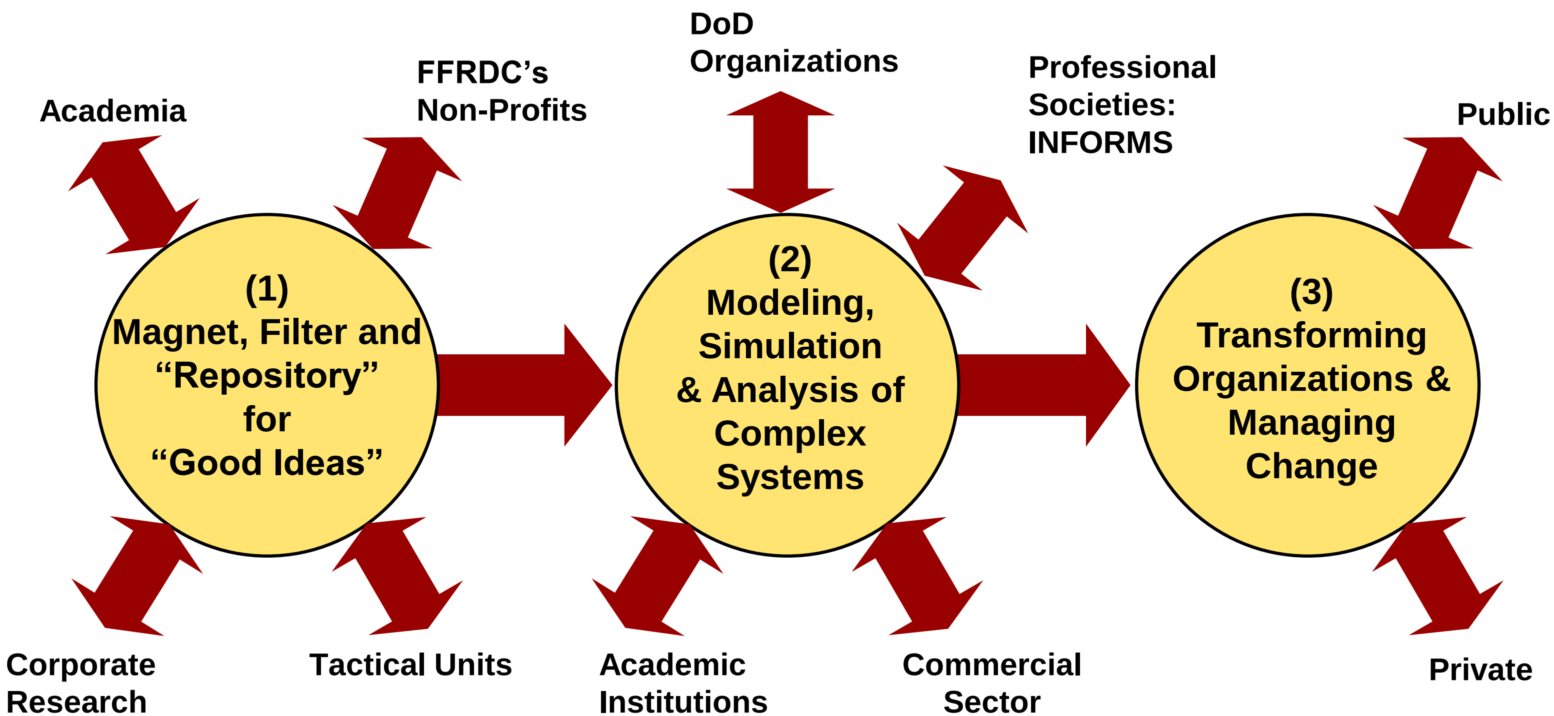
An "Engine for Innovation":
The Center for Innovation in Logistics Systems (CILS)

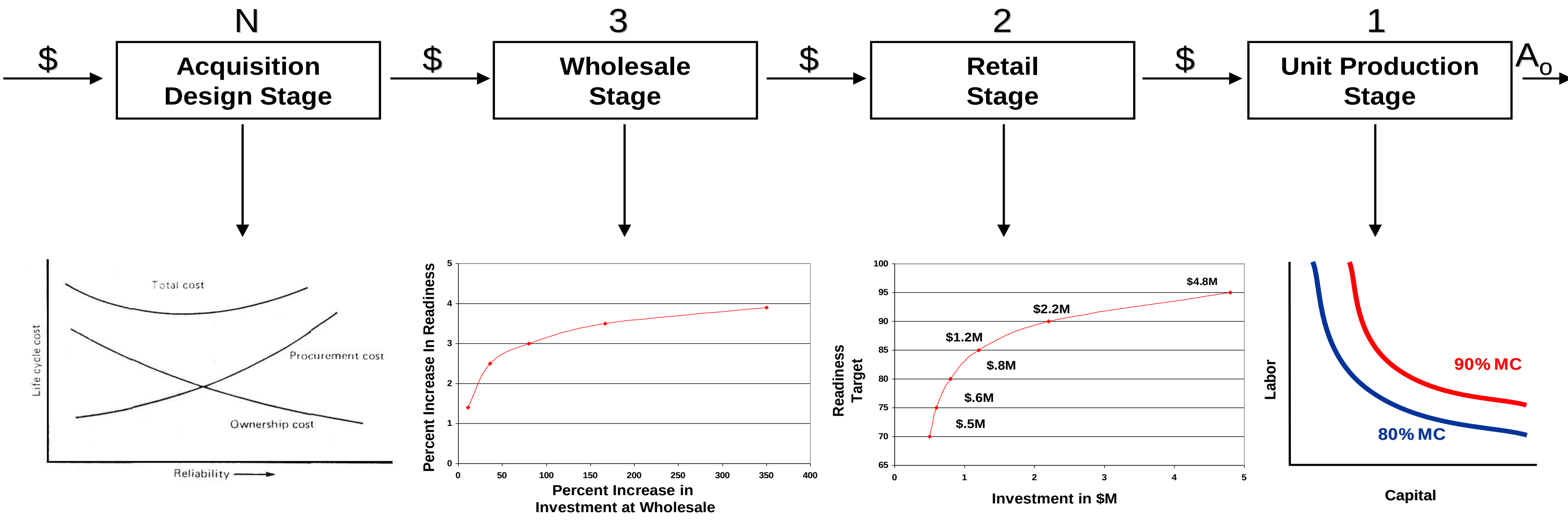


- Organizational Design
- Supply/Value Chain
- Workforce Development
- Technology Implications
- Innovation & Productivity Gain
- R & D

- 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

"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:

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

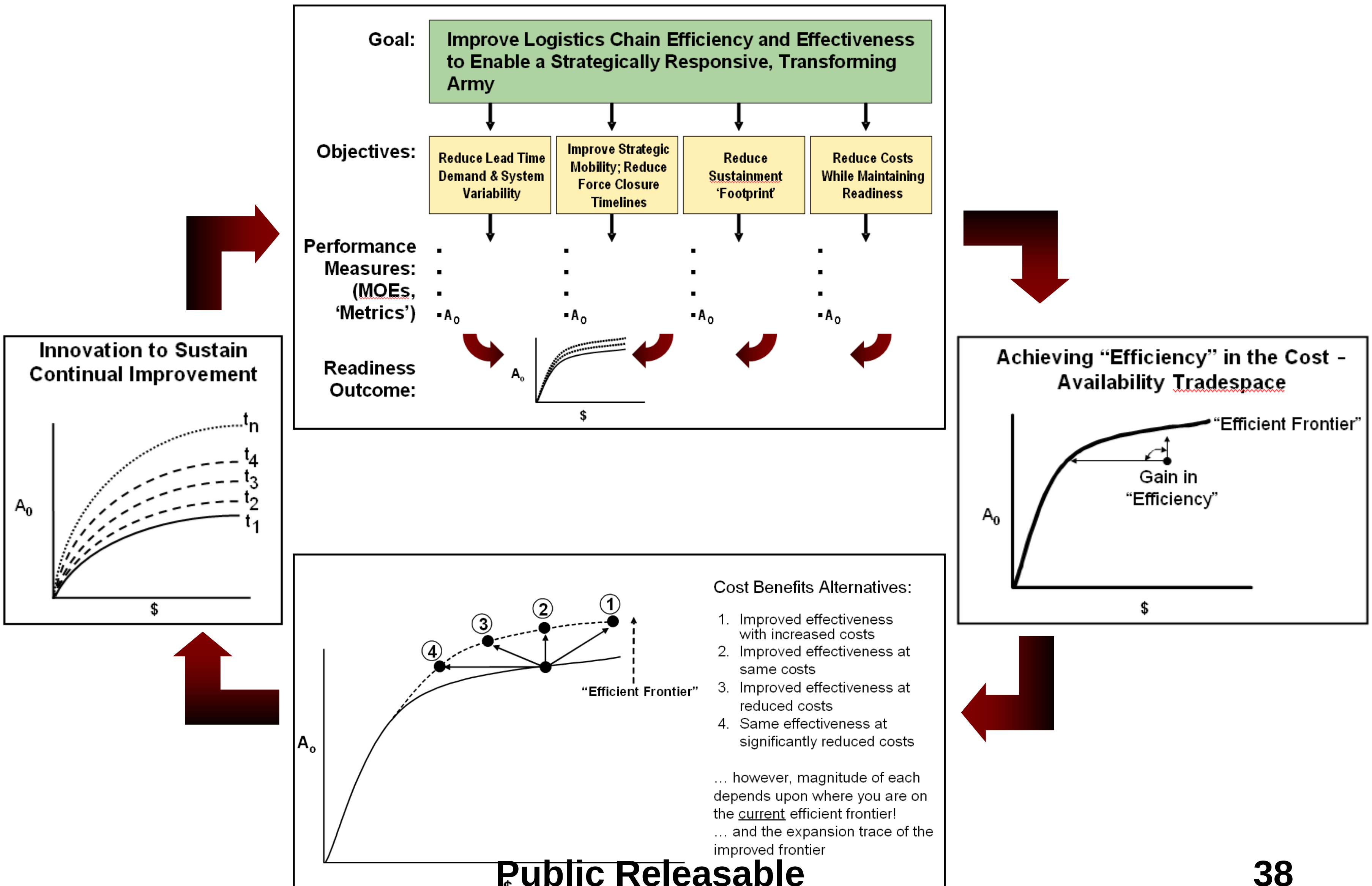
where: $S_{n-1} = S_n - d_n L_n$

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

$f_n(S_n, d_n) = r_n d_n$

$n = 1, 2, 3, 4$

Sustaining Innovation While Linking Execution to Strategy



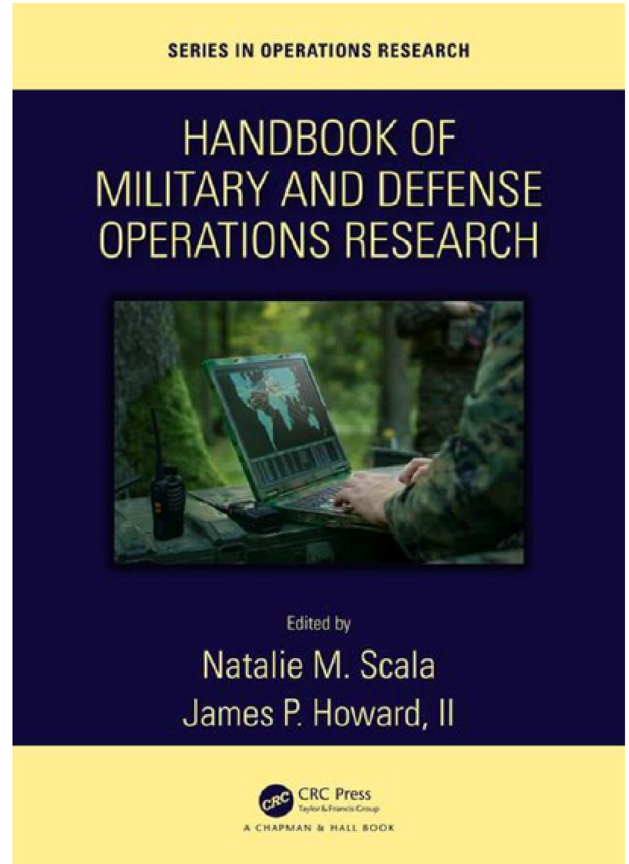
Chapter 20: Strategic Analytics & the Future of Military OR

Applications to Present Challenges:

Resource Planning for National Security

Transforming Defense Supply Chains

Human Capital Enterprise



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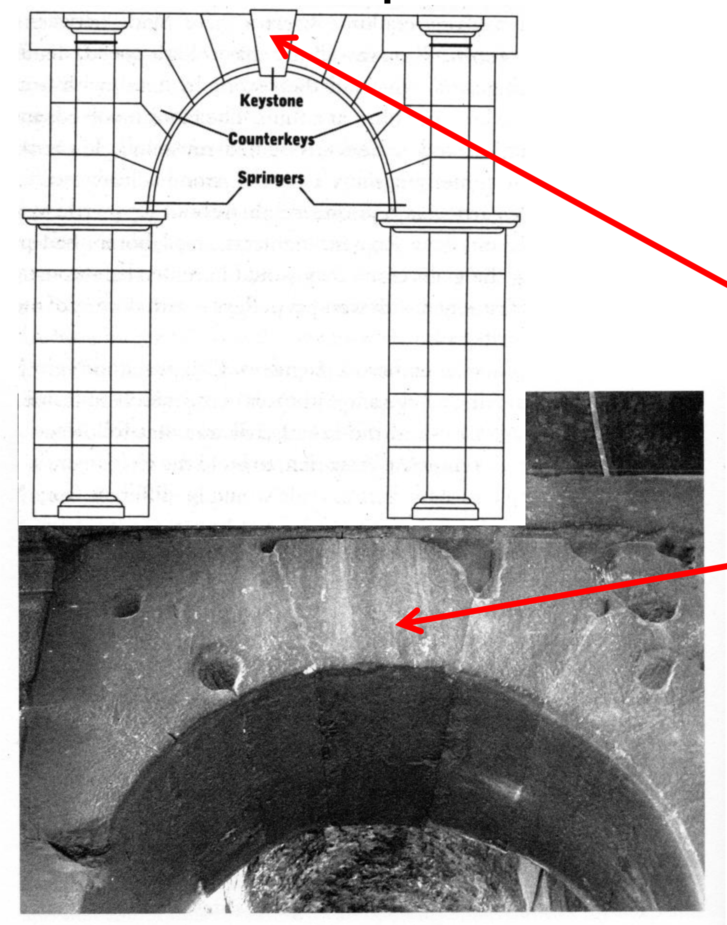
A Keystone in Time: The voussoir arch in the Roman Empire



A.D. 2020

Confronting the "Ingenuity Gap":
- **Technological Ingenuity**
- **Social Ingenuity**
- **Enterprise Systems**

- **Operations Research**
- **Strategic Analytics**
- **Management Innovation**

" . . .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."

Strategic Analytics for NATO Supply Chain Operations

14th NATO OR&A Conference

Colonel Greg H. Parlier, USA ret

5-6 October 2020

gparlier@knology.net
256.457.9782

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