

Is an Engineer Responsible??

THIS LIGHT ALWAYS
TAKES FOREVER.

I'D LIKE TO SMACK
THE IDIOT WHO
DESIGNED THIS
INTERSECTION.



HI.

WHO THE HELL
ARE YOU?

I DESIGNED THIS
INTERSECTION.



YOU'RE RIGHT- I SHOULD HAVE JUST MADE
THE LIGHT SHORTER! NEVER MIND THE
HOURS OF SIMULATION AND TESTING I DID.
NEVER MIND THAT THIS INTERSECTION
INTERACTS WITH ITS NEIGHBORS IN A
COMPLICATED WAY AND IT TOOK ME A
WEEK TO WORK OUT
TIMING SEQUENCES THAT
AVOIDED TOTAL JAMS.



CLEARLY, I'M A CRAPPY
ENGINEER AND YOU HAVE
A BETTER SOLUTION.

GO ON, SHOW ME YOUR
PROPOSED TIMINGS.



GET THE HELL OFF
MY HOOD BEFORE I
START DRIVING AND
FLING YOU INTO TRAFFIC.

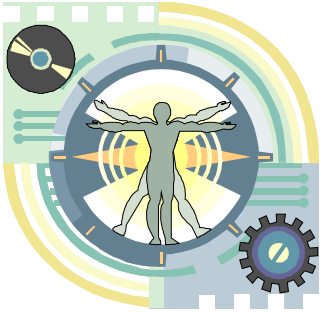


YOU CAN'T.
LIGHT'S RED.

WELL, WHEN WILL
IT CHANGE?

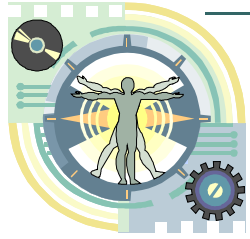
TUESDAY.





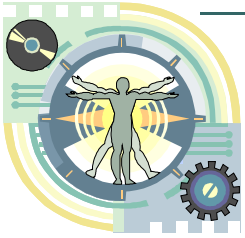
Designing Affordable System Operational ~~Effectiveness~~ ~~Benefits~~ Value Added

Mr. Paul Martin
Systems Engineer
paul.martin@incose.org



Lecture is based on . . .

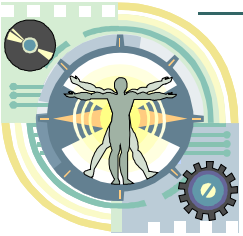
- Section 4.4 of Defense Acquisition Guidebook
 - <https://akss.dau.mil/dag/>
- Designing and Assessing Supportability in DOD Weapon Systems: A Guide to Increased Reliability and Reduced Logistics Footprint (Oct 2003)
 - http://www.dau.mil/pubs/Online_Pubs.asp#Guidebooks



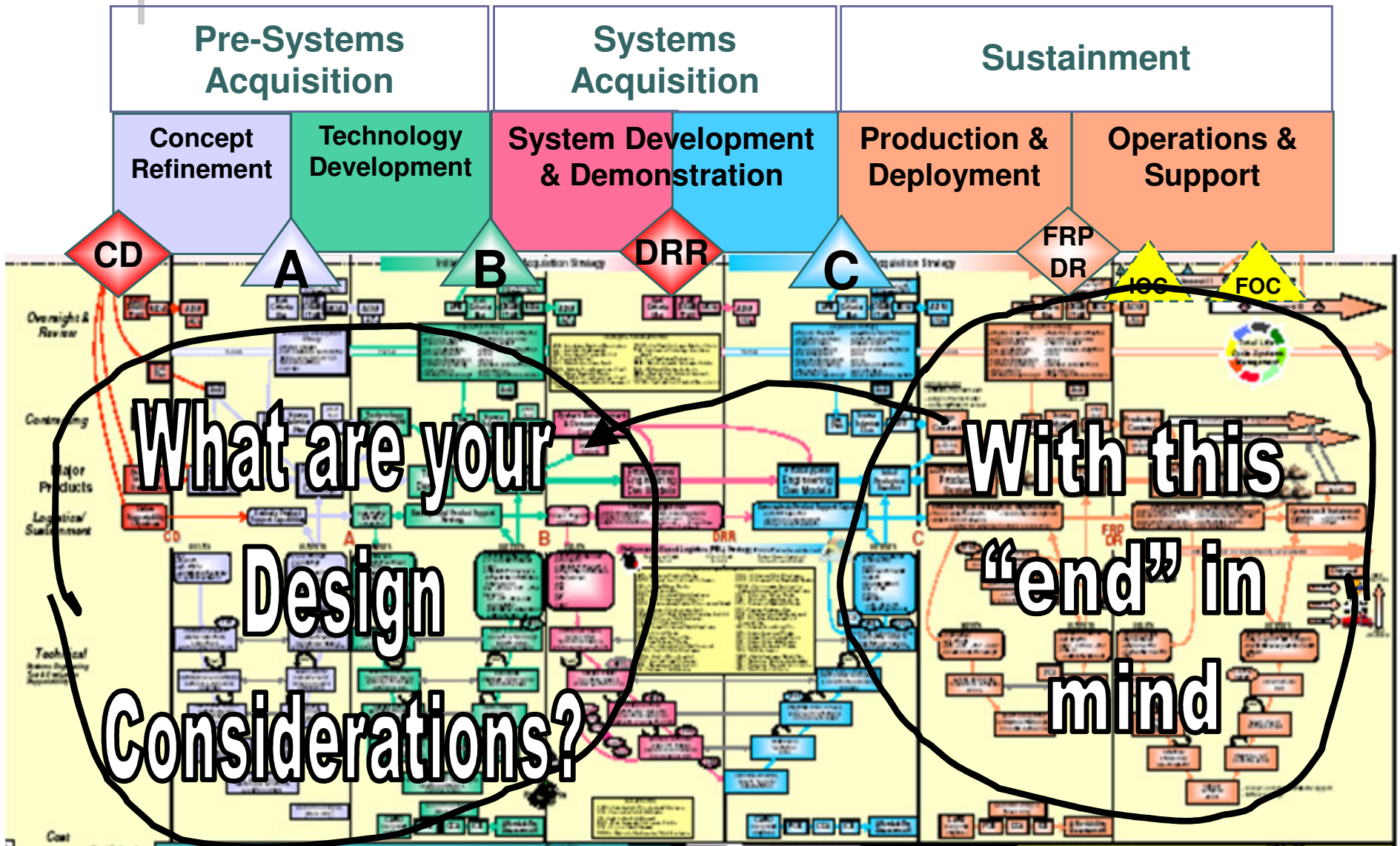
Where to start?

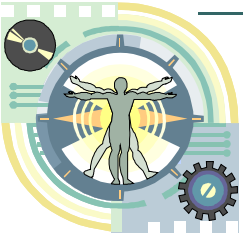
As Stephen Covey says:

Begin with the End in Mind

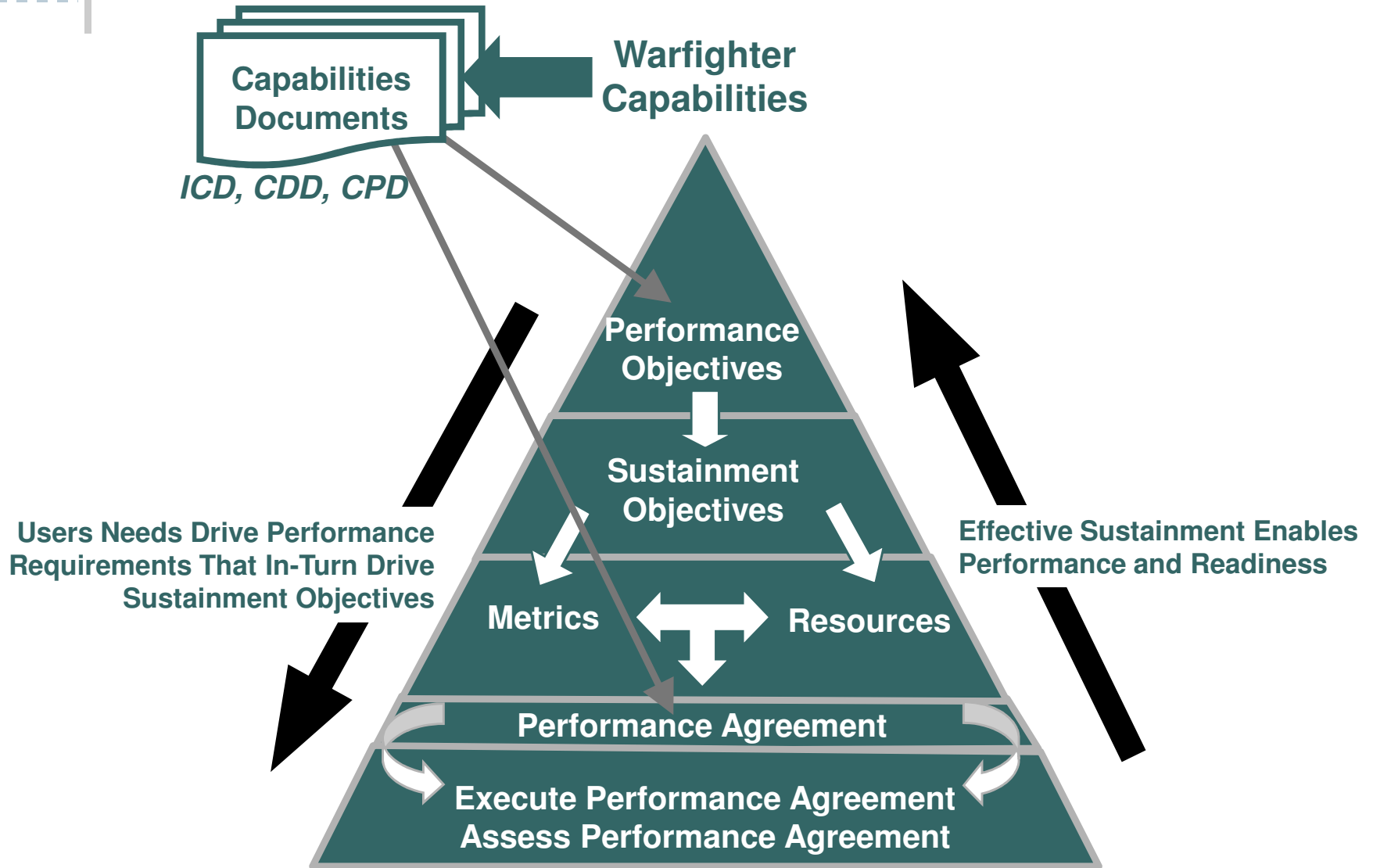


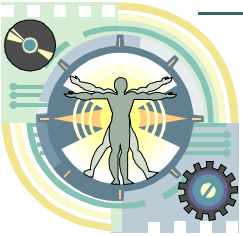
The DoD Product Life Cycle





Linkage Between Performance and Sustainment





Designing an Affordable System

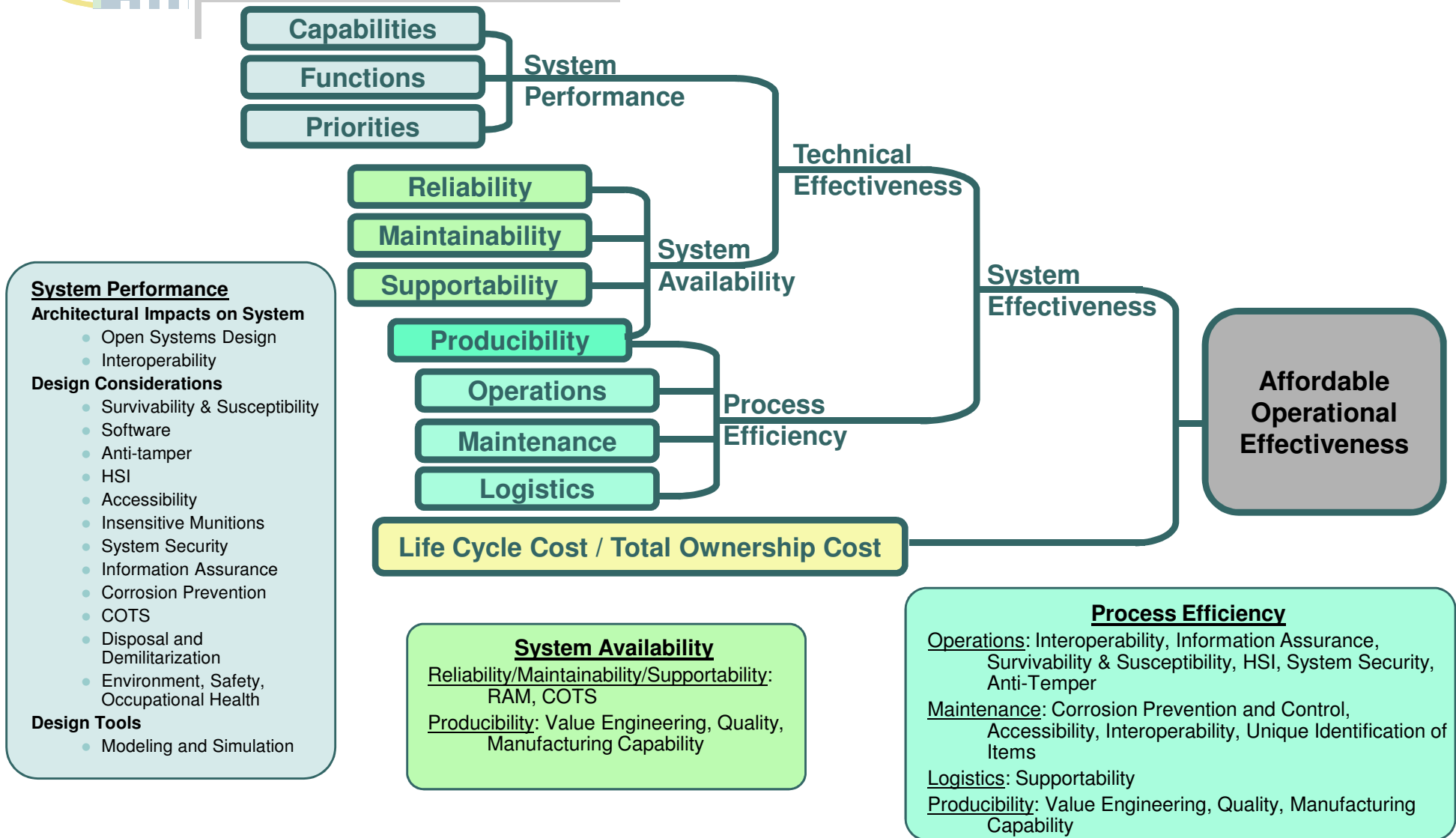
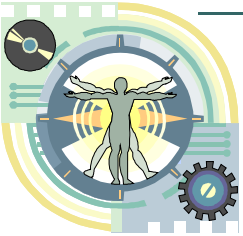


Figure 4.4.1. Affordable System Operational Effectiveness Diagram from *Defense Acquisition Guidebook*



System Performance



○ Architectural Impacts on System

- Open Systems Design
- Interoperability

○ Design Considerations

- Survivability & Susceptibility
- Software
- Anti-tamper
- Human Systems Integration
- Accessibility
- Insensitive Munitions
- System Security

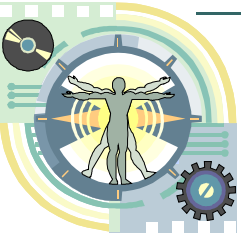
- Information Assurance
- Corrosion Prevention
- COTS
- Disposal and Demilitarization
- Environment, Safety, Occupational Health

○ Design Tools

- Modeling and Simulation

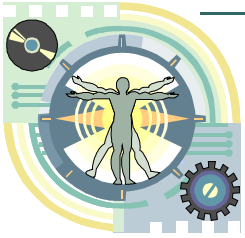
Producibility: Value Engineering, Quality, Manufacturing Capability

Figure 4.4.1. Affordable System Operational Effectiveness Diagram from *Defense Acquisition Guidebook*



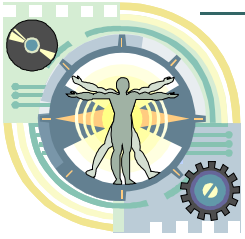
Open Systems Design

- Employs modular design tenets, uses widely supported and consensus based standards for its key interfaces, and is subject to validation and verification tests to ensure the openness of its key interfaces.
- Modular Open Systems Approach (MOSA) implementation.
 - Establish an Enabling Environment
 - Employ Modular Design
 - cohesive (contain well-focused and well-defined functionality);
 - encapsulated (hide the internal workings of a module's behavior and its data);
 - self-contained (do not constrain other modules); and
 - highly binded (use broad modular definitions to enable commonality and reuse).
 - Designate Key Interfaces
 - Use Open Standards
 - Certify Conformance



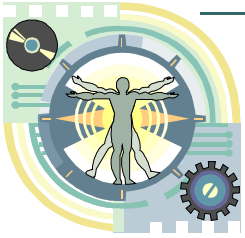
Interoperability

- All acquisition programs are required to satisfactorily address interoperability and integration.
- Requirements span the complete acquisition life cycle for all acquisition programs.
- Interoperability and supportability of information technology (IT) and National Security System (NSS) acquisition programs, are required to comply with
 - **DoD Directive 4630.5**, Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)
 - **DoD Instruction 4630.8**, Procedures for Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)
 - **CJCS Instruction 3170.01**, Joint Capabilities Integration And Development System
 - **CJCS Manual 3170.01**, Operation of the Joint Capabilities Integration and Development System
 - **CJCS Instruction 6212.01**, Interoperability And Supportability Of Information Technology And National Security Systems
 - **Public Law 104-106 (1996), and 44 U.S.C. 3506.**



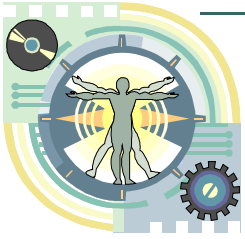
Survivability & Susceptibility

- Fully assess system and crew survivability against all anticipated threats at all levels of conflict.
- It should address cost-effective survivability techniques for:
 - Nuclear, Biological and Chemical (NBC)
 - High Altitude Electromagnetic Pulse (HEMP).
 - Electromagnetic interference (EMI)
 - Electromagnetic compatibility (EMC)
- **Improve system operational readiness and mission effectiveness**



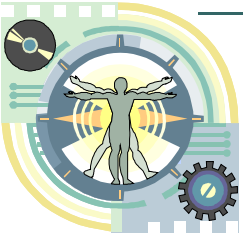
Improve System Operational Readiness And Mission Effectiveness by:

- Providing threat avoidance capabilities (**low susceptibility**);
- Incorporating hardening and threat tolerance features in system design (**low vulnerability**);
- Providing design features to reduce personnel casualties resulting from damage to or loss of the system (**casualty reduction**);
- Maximizing wartime availability and sortie rates via operationally compatible threat damage tolerance and rapid reconstitution (**reparability**) features;



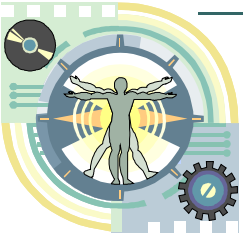
Improve System Operational Readiness And Mission Effectiveness by:

- **Minimizing** survivability program impact on overall program **cost and schedule**; and
- Ensuring **protection countermeasures** and **systems security applications** are defined for critical component's vulnerability to validated threats for systems survivability, including:
 - conventional or nuclear advanced technology weapons;
 - nuclear, biological, or chemical contamination;
 - electronic warfare threats.



Anti-tamper

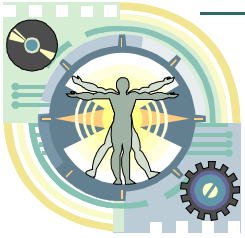
- When properly employed will add longevity to a critical technology by deterring efforts to reverse-engineer, exploit, or develop countermeasures against a system or system component.
- Should not be regarded as an option or a system capability that may later be traded off without a thorough operational and acquisition risk analysis.
 - Identify critical technologies and system vulnerabilities
 - Perform threat analyses (with assistance from counter-intelligence organizations)
 - Researches anti-tamper measures and determines which best fit the performance, cost, schedule, and risk of the program.



Human Systems Integration

Optimize total system performance and minimize total ownership cost.

- Human Factors Engineering
 - minimal manpower
 - effective training;
 - can be operated and maintained by users
 - suitable (habitable and safe with minimal environmental and occupational health hazards)
 - survivable (for both the crew and equipment).
- Habitability
 - living and working conditions that are necessary to sustain the morale, safety, health, and comfort of the user population
- Personnel Survivability
 - reduce the risk of fratricide, detection, and the probability of being attacked
- Manpower Initiatives
 - mix of military and DoD civilian manpower and contract support
- Personnel Initiatives
 - human aptitudes, knowledge, skills, abilities, and experience levels
- Training



Accessibility

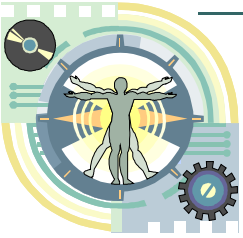
- Must comply with *Section 508 of the Rehabilitation Act of 1973*
 - Individuals with disabilities to have same access to and use of information and data as those without disabilities.

Inensitive Munitions

- Develop and field munitions that have no adverse reaction to unplanned stimuli.

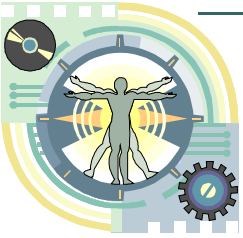
System Security

- Critical infrastructure protection
- Space control requirements,
- System hardening, redundancy, backup, and other physical protection measures.



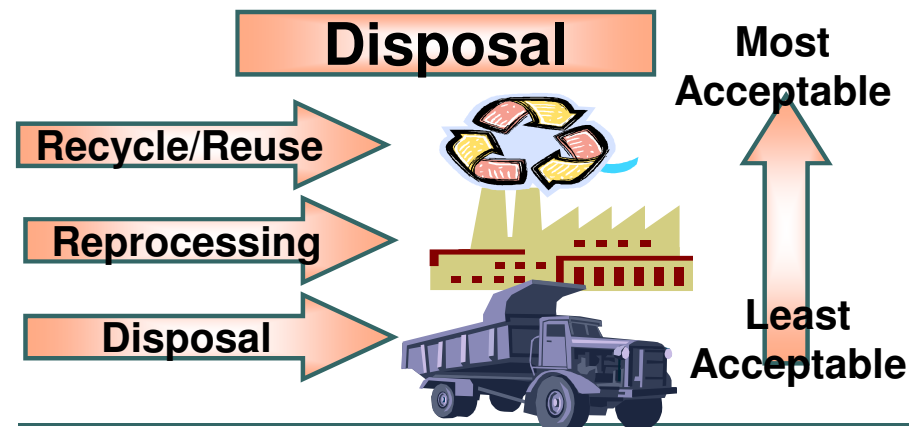
Information Assurance

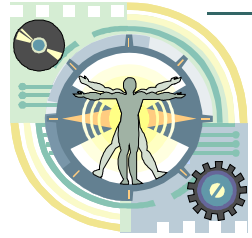
- Measures that protect and defend information and information systems by ensuring their availability, integrity, authentication, confidentiality, and non-repudiation. This includes providing for the restoration of information systems by incorporating protection, detection, and reaction capabilities.
- DoD policy for information assurance of information technology, including National Security Systems (NSS), appears in
 - DoD Directive 8500.1, *Information Assurance (IA) Implementation*,
 - DoD Instruction 8580.1, *Information Assurance in the Defense Acquisition System*,
 - DoD Instruction 8500.2, *Information Assurance (IA)*



Disposal and Demilitarization

- Coordinate with DoD Component logistics and explosive safety activities and the Defense Logistics Agency
- Identify and apply applicable demilitarization requirements necessary to eliminate the functional or military capabilities of assets
- Determine reutilization and hazardous-property disposal requirements for system equipment and by-products.

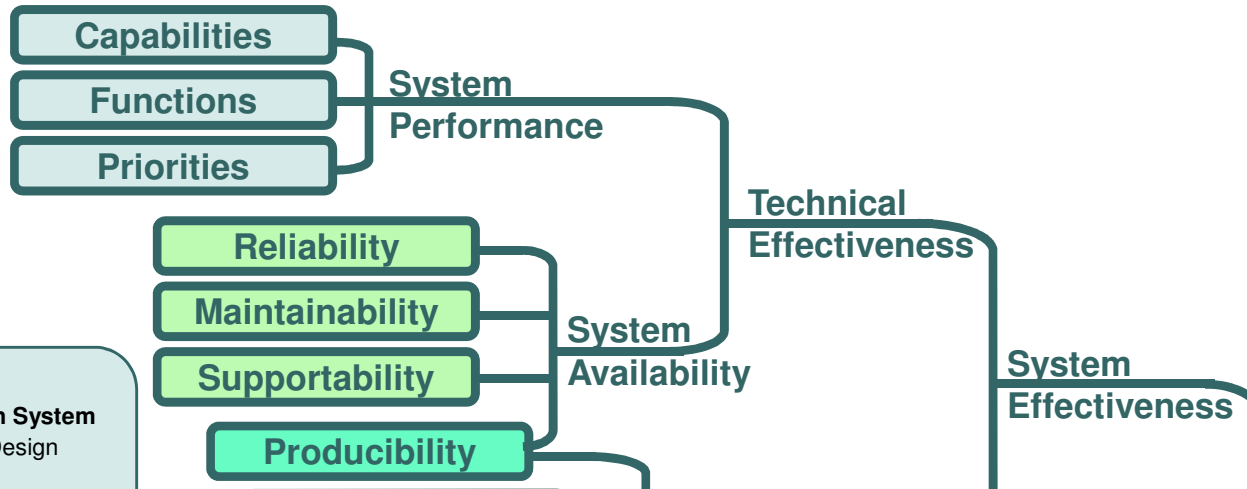
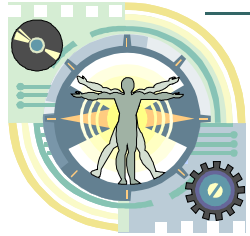




Environment, Safety, Occupational Health (ESOH)

- Perform and document a Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE)
- Establish a ESOH Risk Management Program
- Comply with the National Environmental Policy Act (NEPA)

System Availability



System Performance

Architectural Impacts on System

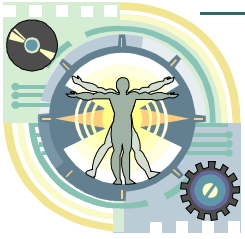
- Open Systems Design
- Interoperability

○ Reliability/ Maintainability/ Supportability

- Reliability, Availability and Maintainability (RAM)
- Commercial-off-the-Shelf Items (COTS)

○ Producibility

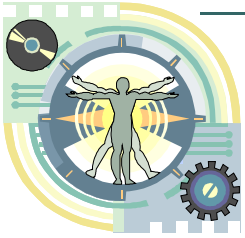
- Value Engineering
- Quality
- Manufacturing Capability



Reliability

- The ability of a system to perform as designed in an operational environment over time without failure.
 - Mission reliability addresses the probability of carrying out a mission without a mission-critical failure.
 - Logistics reliability is the ability of a system to perform as designed in an operational environment over time without any failures.
- Design Considerations for Reliability
 - Derating (defined as purposeful over-design to allow a safety margin)
 - Redundancy and Ease of reconfiguration

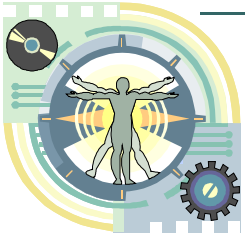
Primary objective is to minimize the risk of failure within the defined availability, cost, schedule, weight, power, and volume constraints.



Maintainability

- Address the ease and efficiency with which servicing and preventive and corrective maintenance can be conducted
- Design Considerations for Maintainability
 - Modularity: repaired via 'remove and replace' action
 - Interoperability: Standard interface protocols to facilitate rapid repair
 - Diagnostics: on-board monitoring/recording devices and software that provide enhanced capability for fault detection and isolation
 - Prognostics: on-board monitoring/recording devices and software that enable proactive maintenance optimization actions
 - Fail Safe: Ability to revert to a safe mode
 - Access: components requiring more frequent monitoring, checkout, and maintenance can be easily accessed.

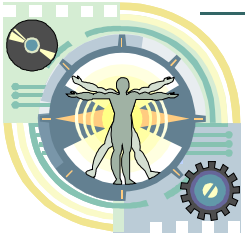
Primary objective of reducing system 'time and cost to maintain.'



Supportability

- The inherent quality of a system to facilitate detection, isolation, and timely repair/replacement of system anomalies.
 - Design, Technical Support Data, and Maintenance Procedures
- Design Considerations for Supportability
 - System training and training devices
 - System documentation/technical data
 - Supply support (including spares)
 - Sustainment planning
 - Corrosion prevention and mitigation planning
 - Test and support equipment, to include embedded system test and diagnostics
 - Facilities
 - Packaging, Handling, Storage, and Transportation (PHS&T)
 - Manpower and personnel requirements

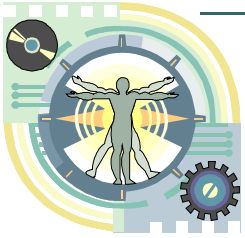
Primary objective is to positively impact and reduce the requirements for the various elements of logistics support during the system operations and maintenance phase.



System Availability

Key and Selected Tasks Associated with RMS

Reliability	Maintainability	Supportability
<ul style="list-style-type: none"> ○ Concept of Operation Definition/Mission Profile/Design ○ Reference Mission Definition ○ Reliability Requirements Analysis and Allocation ○ Reliability Modeling and Analysis ○ Reliability Prediction ○ Failure Mode, Effects, and Criticality Analysis ○ Fault Tree Analysis ○ Reliability Demonstration ○ Continual Reliability Assessment of Fielded Systems 	<ul style="list-style-type: none"> ○ System Maintenance Concept Definition ○ Failure Diagnosis/Embedded Diagnostics /BIT/Prognostics Requirements Definition ○ Maintainability Modeling and Analysis ○ High Level Maintenance and Repair Philosophy Development ○ Maintainability Requirements Analysis & Allocation ○ Maintainability Prediction ○ Reliability Centered Maintenance Analysis ○ Human Factors/Accessibility Analysis ○ Maintainability Demonstration ○ Continuous Maintainability Assessment of Fielded Systems ○ Corrosion Prevention and Mitigation Analysis 	<ul style="list-style-type: none"> ○ Support Concept of Operations Definition ○ System Analysis from Commonality Perspective ○ System Component Interchangeability Analysis ○ Compliance with Open Systems Analysis ○ Analysis of Vendors from Maturity & Stability Perspective ○ Technology Analysis from a Proprietary and Maturity Perspective ○ Application of Multi-Media Techniques, Information and Instructional Technology ○ Obsolescence Management and Technology Refreshment Analysis ○ Supportability Demonstration ○ Continuous Supportability Assessment of Fielded Systems ○ Corrosion Control



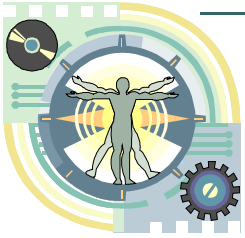
Producibility

- The degree to which the design of the system facilitates the timely, affordable, and optimum-quality manufacture, assembly, and delivery of the system to the customer and should be a development priority.

From Section 4.4.6.1 of the Defense Acquisition Guidebook

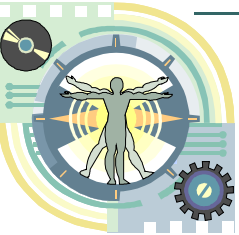
- Design Considerations for Producibility:
 - Statistical Process control
 - Six sigma approaches,
 - Taguchi Methods
 - Material characterization analysis

Design engineering efforts concurrently develop producible and testable designs, capable manufacturing processes, and the necessary process controls to satisfy requirements and minimize manufacturing costs.



Producibility (con't)

- Value Engineering: It's the Law
 - TITLE 41 U.S. Code § 432
 - (a) In general: Each executive agency shall establish and maintain cost-effective value engineering procedures and processes.
 - (b) “Value engineering” defined: As used in this section, the term “value engineering” means an analysis of the functions of a program, project, system, product, item of equipment, building, facility, service, or supply of an executive agency, performed by qualified agency or contractor personnel, directed at **improving performance, reliability, quality, safety, and life cycle costs**.
- Quality
 - Determined by the extent a product meets (or exceeds) requirements and satisfy the customer, at an affordable cost.
 - Incorporate systems engineer/design quality into the product from the beginning
 - Define the product or service quality requirements
 - Provide the development contractor maximum degree of flexibility to meet these requirements.



Process Efficiency

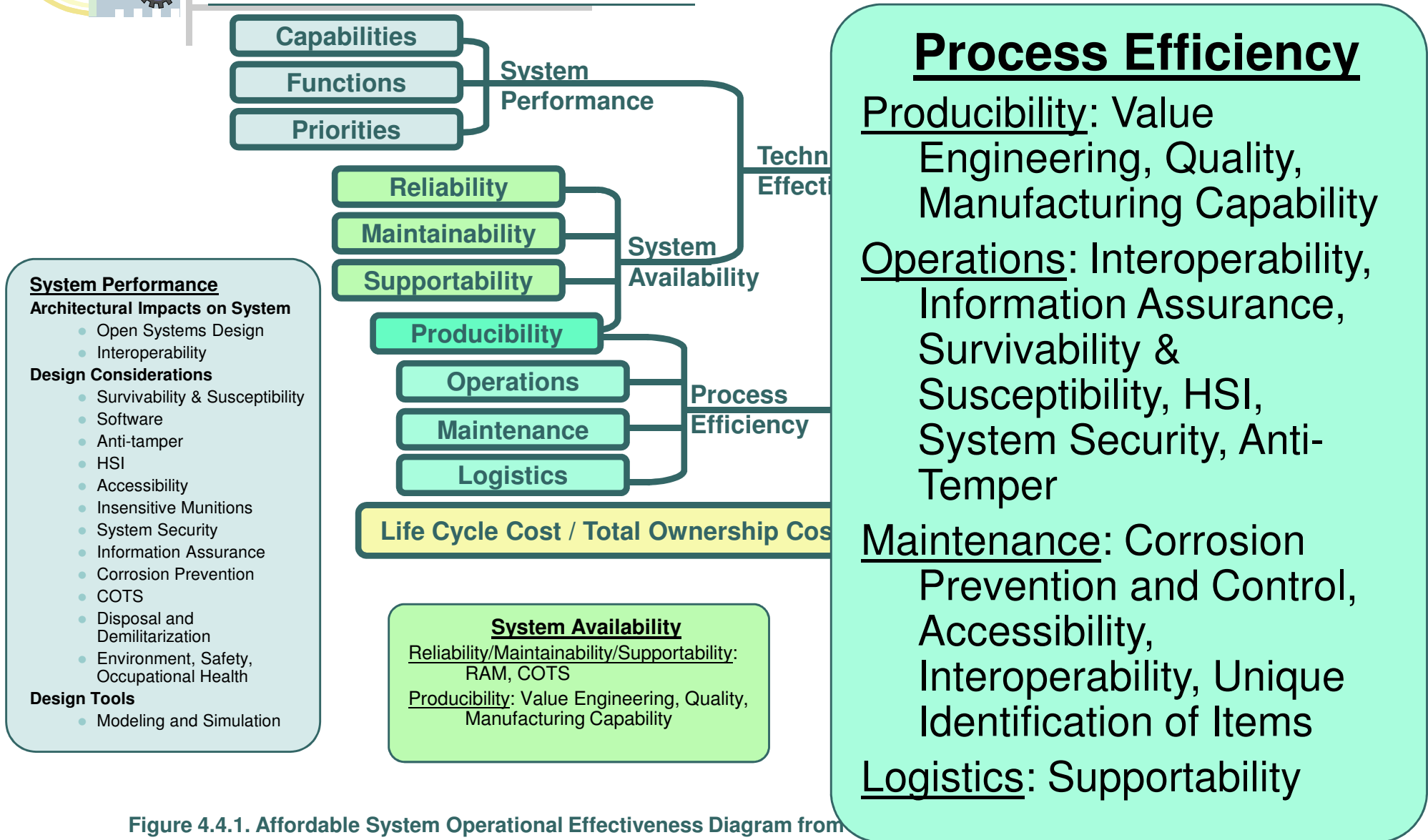
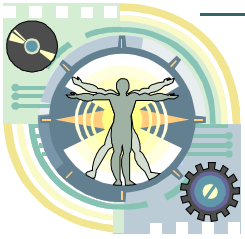
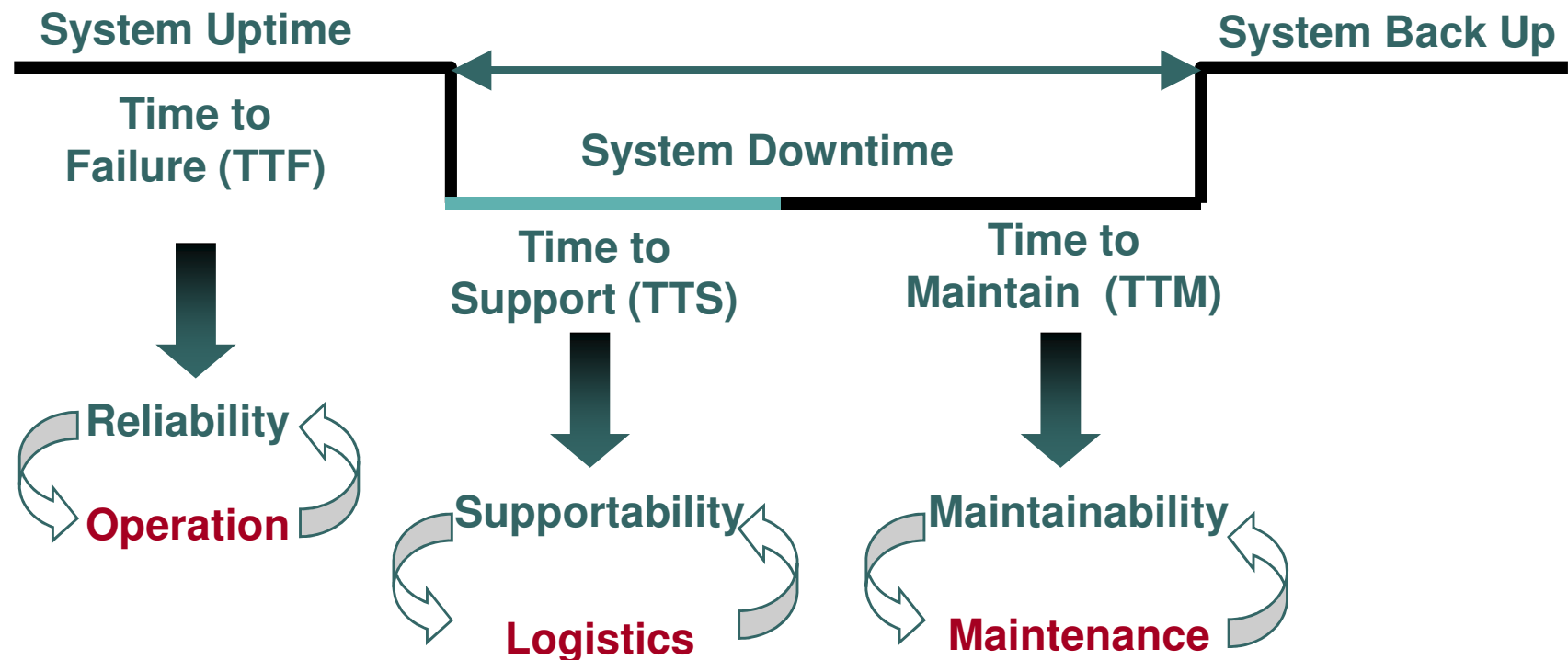
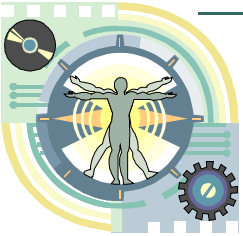


Figure 4.4.1. Affordable System Operational Effectiveness Diagram from



Cause and Effect between Design Decisions and Operational Effects





Affordable Operational Effectiveness

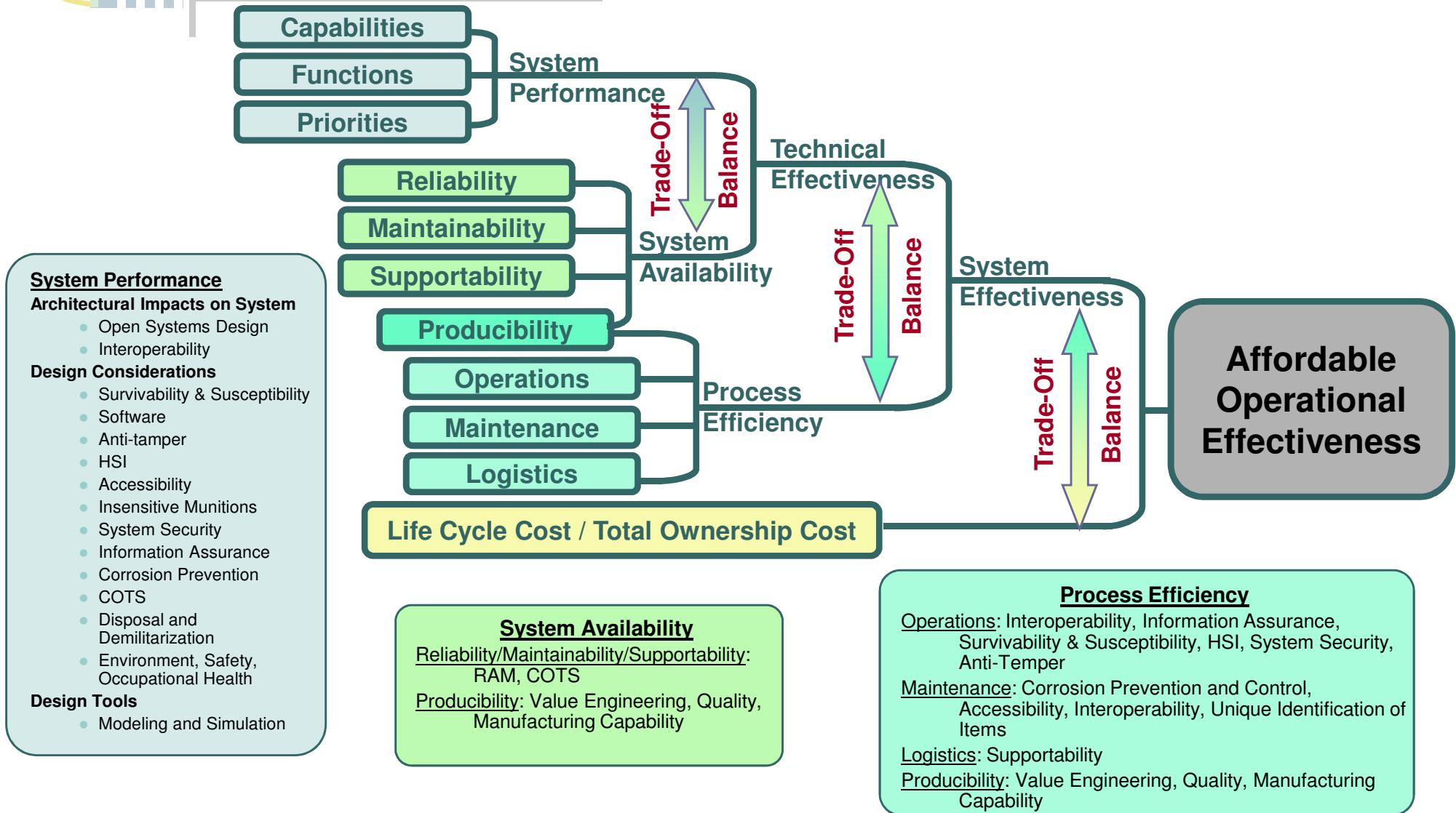


Figure 4.4.1. Affordable System Operational Effectiveness Diagram from *Defense Acquisition Guidebook*



Design for Support/Support the Design

Design for Support

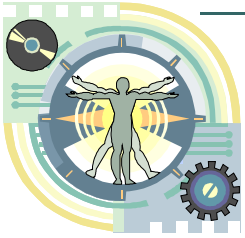
- Product Support Strategy Development
 - Develop/Implement PBL Plan
- Requirements Generation
 - R, M, S, Diagnostics, Prognostics
- Requirements Determination
- Application of the Systems Engineering Process
- TOC Assessment
- Establish Maintenance and Support Plan – Determine Maintenance and Support Requirements; RCM; MTA
- Deliver Support to Operational Sites

**System Design
for Operational
Effectiveness**

**Supply Chain
Management**

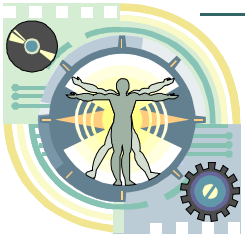
- Field Program Management
 - Implement/Maintain PBL Plan
 - Logistics Elements
 - Obsolescence/Tech. Refresh/DMS
 - Spares Re-Procurement
- Application of the SE Process
- Pulse of the Customer
 - 24/7 Contact
- Product Availability Analysis
 - Operational Effectiveness
 - Top Degraders & RCM/CBM Sustainment
- Affordability Analysis
 - O&S Cost Assessments/DLR Cost & Avail.
- Safety

Support the Design



Thank You

Any Questions



Abbreviations Used In This Lecture

ACAT	Acquisition Category
APB	Acquisition Program Baseline
BCA	Business Case Analysis
BLRIP	Beyond Low Rate Initial Production
CAIV	Cost as an Independent Variable
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CBM	Condition-Based Maintenance
CDD	Capabilities Development Document
COTS	Commercial Off the Shelf
CPD	Capabilities Production Document
CPD	Capability Production Document
CRD	Capstone Requirements Document
DLA	Defense Logistics Agency
DLR	Depot Level Repairable
DMS	Diminishing Manufacturing Sources
DRR	Design Readiness Review
ESOH	Environmental, Safety and Occupational Health
FLE	Future Logistics Enterprise
FMECA	Failure Mode Effects and Criticality Analysis
FOC	Final Operating Capability
FOT&E	Follow-on Operational Test and Evaluation
FRP	Full Rate Production
FRP DR	Full Rate Production Decision Review
FTA	Fault Tree Analysis

HIS	Human Systems Integration
HMR	Hazardous Material Report
IBR	Integrated Baseline Review
ICD	Initial Capabilities Document
ICP	Inventory Control Point
ILS	Integrated Logistics Support
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
JITC	Joint Interoperability Test Command
LCCE	Life Cycle Cost Estimate
LFTE	Live Fire Test and Evaluation
LRIP	Low Rate Initial Production
MDA	Milestone Decision Authority
MFOP	Maintenance-Free Operating Period
MOSA	Modular Open Systems Approach
MTA	Maintenance Task Analysis
MTA	Maintenance Task Analysis
O&S	Operations and Support
OEM	Original Equipment Manufacturer
OTRR	Operational Test Readiness Review
OT&E	Operational Test and Evaluation
P&D	Production and Deployment
PBA	Performance Based Agreement
PBL	Performance Based Logistics
PBL	Performance-Based Logistics
PCA	Physical Configuration Audit
PDR	Preliminary Design Review

PESHE	Programmatic Environment, Safety, and Occupational Health Evaluation
PEP	Production Engineering and Planning
PHS&T	Packaging, Handling, Storage, and Transportation
PM/FL	Performance Monitoring/Fault Localization
PPBS	Planning, Programming, and Budgeting System
PSI	Product Support Integrator
PSP	Product Support Provider
QA	Quality Assurance
QDR	Quadrennial Defense Review
RAM	Reliability, Availability and Maintainability
RCM	Reliability-Centered Maintenance
RFP	Request for Proposal
RMS	Reliability Maintainability and Supportability
SCM	Supply Chain Management
SDD	System Design and Demonstration
SDOE	System Design for Operational Effectiveness
SEP	Systems Engineering Plan
SOE	System Operational Effectiveness
SRR	System Requirements Review
TEMP	Test and Evaluation Master Plan
TLCSM	Total Life Cycle System Management
TOC	Total Ownership Costs
TTF	Time to Failure
TTM	Time and Cost to Maintain
TTS	Time and Cost to Support