Alain Bensoussan, Lama Moussawi

- Objective of Real Options
- Spiral Development
- Systems Engineering
- Flexibility Engine™

The success of Financial Risk Management

- Financial Risk Management has progressed thanks to three essential reasons:
  - Possibility of pricing risks
  - Growth of financial products and trading through financial markets
  - Predominance of external risks
- A key issue(and a two edge sword) in the progress of risk management outside finance resides in the possibility of extending these concepts to the "real" world
  - Pricing real assets, real project financing and management, real options
  - Responsibilitition due to risk intermediation
- Moreover one manipulates probabilities and not numbers
  - Non normality, Fat tails and co-dependence of risk probabilities
  - Risk predictability , and chaos," when the unlikely becomes likely"

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- Model is too simple (even for financial options)
- Totally inadequate for financial crashes or large volatile markets
- Belief that a risk-free strategy is possible.
- Cannot apply to real options
  - **Complexity much higher**
  - **Endogenous risks**
  - **Less data availability**

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APPLICABILITY OF REAL OPTION APPROACH TO PROGRAM DEVELOPMENT

- REAL OPTION IS A VALUATION TECHNIQUE.
- IT COMPARES FAVORABLY TO NPV APPROACH WHEN:
  - UNCERTAINTY IS HIGH
  - DELAYING COMMITMENTS IS POSSIBLE
- LIKE FINANCIAL OPTIONS LIMITS DOWNSIDE RISKS

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APPLICABILITY OF REAL OPTION APPROACH TO PROGRAM DEVELOPMENT

- They allow the re-design of investment strategies along two key dimensions, time and scope.
- Postponing costly investments permits one to acquire more information and thus to mitigate "downside" risk in the process.
- Possibility of Abandonment.
- The scope dimension introduces a wider array of choices for future decisions.

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APPLICABILITY OF REAL OPTION APPROACH TO PROGRAM DEVELOPMENT

- REAL OPTION APPROACH REQUIRES RELIABLE MODELS OF UNCERTAINTIES
- THE ABANDONMENT OPTION IS STRATEGIC
  - IMPOSSIBILITY OF PROVING FAILURES
  - ACTORS AT DIFFERENT LEVELS HAVE DIFFERENT PERSPECTIVES
- HOW TO INCORPORATE COMPETITION?
  - REAL OPTION AND GAME THEORY

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- Ø **Large innovative development programs in aerospace and defense are procured following spiral development principles. This concept started in software development.**
- Ø **The terminology comes from a graphic representation of all development and implementation phases of a system. The successive phases expand like a spiral, not a purely sequential process. At each phase an analysis is conducted.**
- Ø **Flexibility of choices is allowed at early stages.**
- Ø **In the spirit of real option à delay decision and utilize maximum flexibility.**

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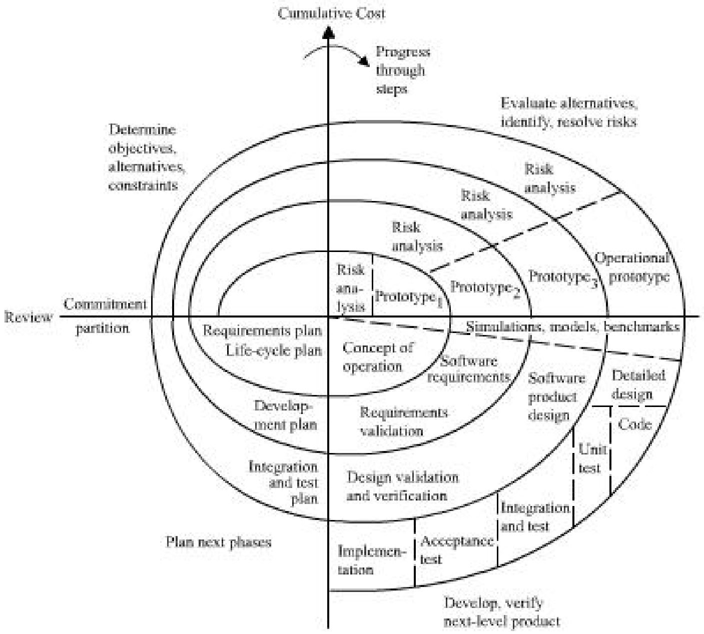
- NOT A VALUATION TECHNIQUE
- MORE AN ORGANIZATIONAL APPROACH
  - A GOOD COMPLEMENT TO REAL OPTION APPROACH
- CONTAINS THE IDEA THAT PRODUCTS ARE PUT IN THE MARKET BEFORE THE COMPLETION OF PROGRAM (Releases in Software Development)



The Spiral Model

Boehm, Barry (1988) "A Spiral Model of Software Development and Enhancement," *IEEE Computer 21*, 5, 61-72.

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WINWIN SPIRAL MODEL
A REFINED SPIRAL MODEL

- The original spiral model has difficulty determining the roots of elaborated objectives, constraints, and alternatives.
- The WinWin spiral model resolves this by adding three activities to the front of each spiral cycle:
  - Identify the system or subsystem's key stakeholders
  - Identify the stakeholders' win conditions for the system or subsystem
  - Negotiate win-win reconciliations of the stakeholders' win conditions

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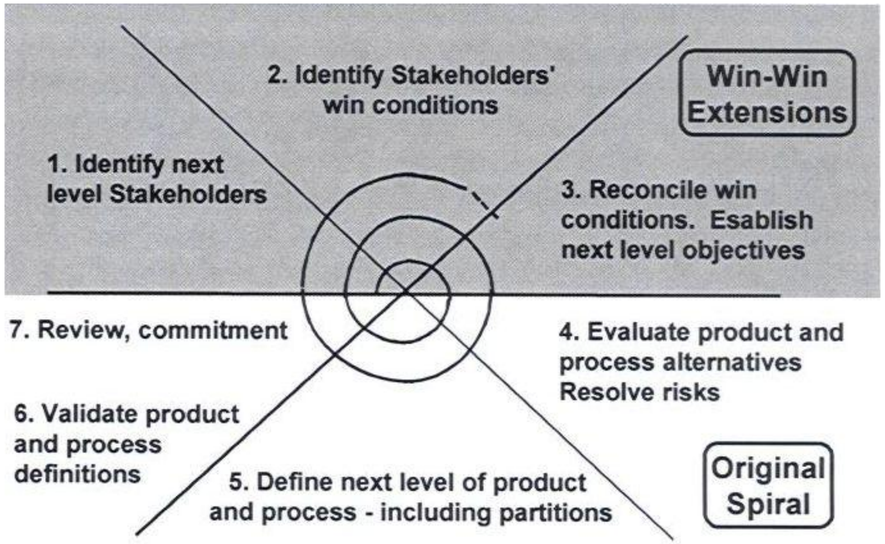

Boehm, Barry (2000) "Spiral Development: Experience, Principles, and Refinements," Carnegie Mellon University.

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WINWIN SPIRAL MODEL
KEY CONCEPTS

- Win Condition: an objective that makes a stakeholder a winner
- Issue: Conflict or constraint on a win condition
- Option: A way of overcoming an issue
- Agreement: Mutual commitment to an option or win condition
- WinWin Equilibrium State
  - All Win Conditions covered by Agreements
  - There are no outstanding Issues

From the lecture notes of Prof. Larry Bernstein at Stevens Institute of Technology

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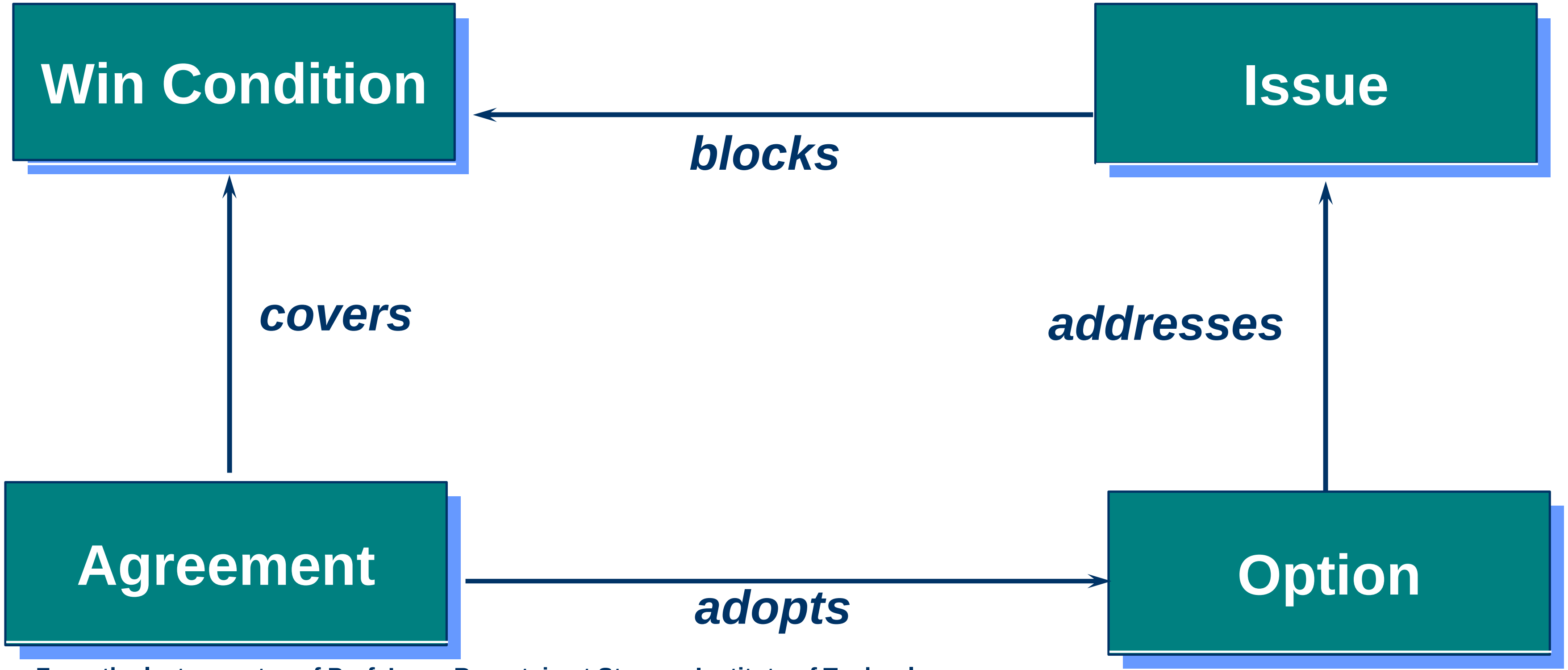
WINWIN SPIRAL MODEL
A NEGOTIATION FRAMEWORK



From the lecture notes of Prof. Larry Bernstein at Stevens Institute of Technology

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SYSTEMS ENGINEERING

- System Engineering: **is the "discipline" of designing systems properly.**

- **It is an "interdisciplinary approach" which considers the complete problem, from customer needs to design synthesis and system validation, then manufacturing and operations.**

- **The amount of system engineering depends on the amount of risk.**

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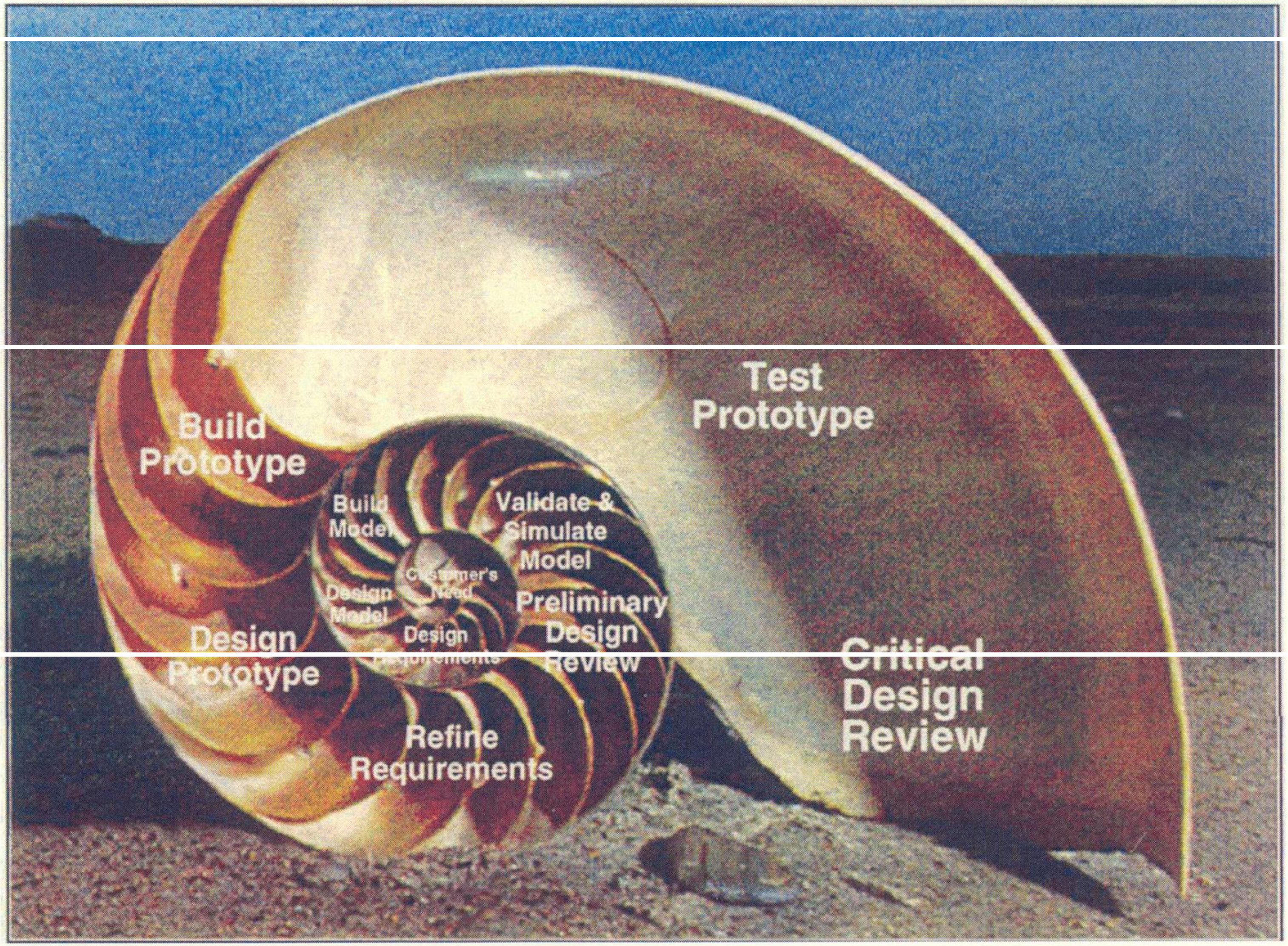
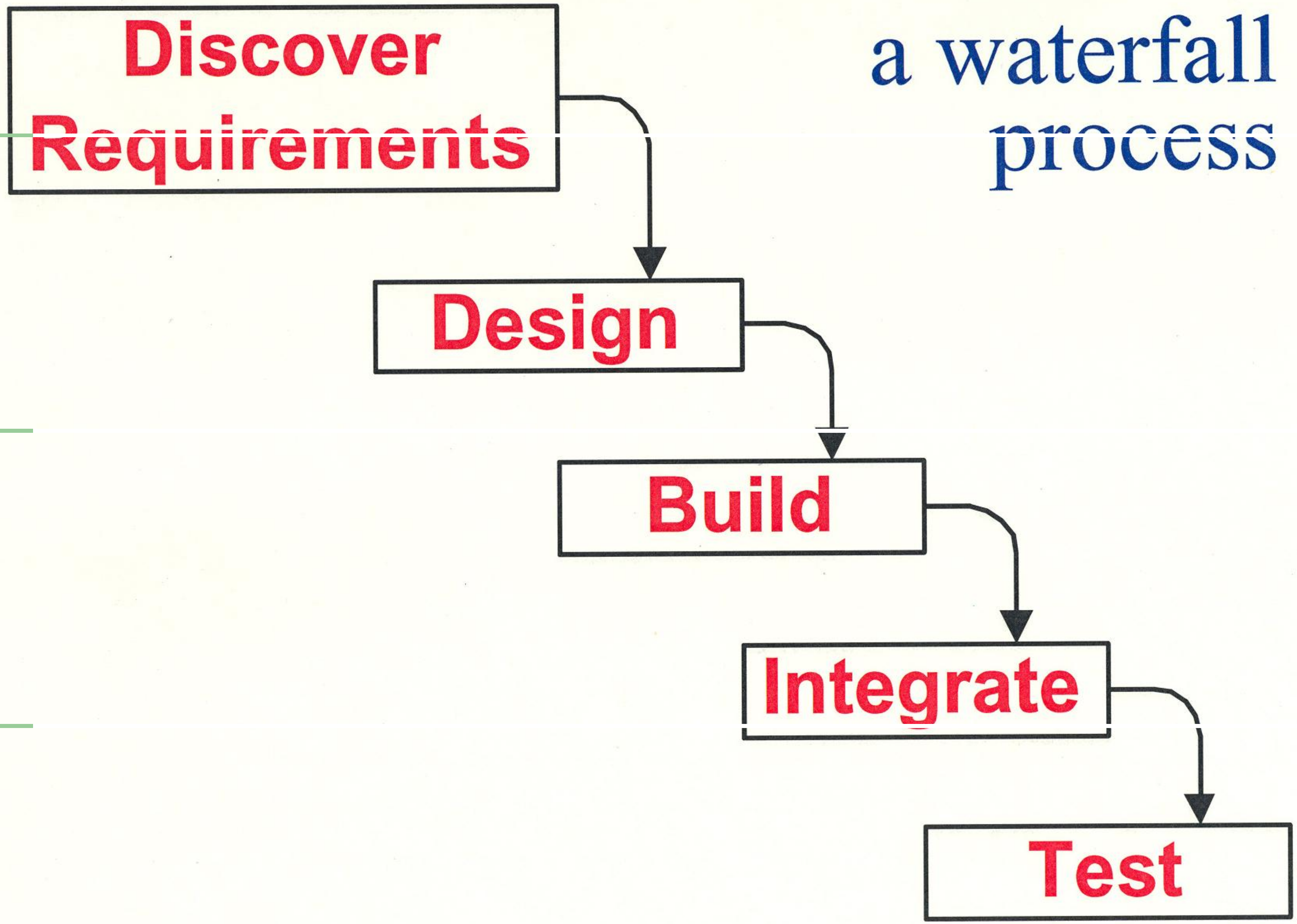
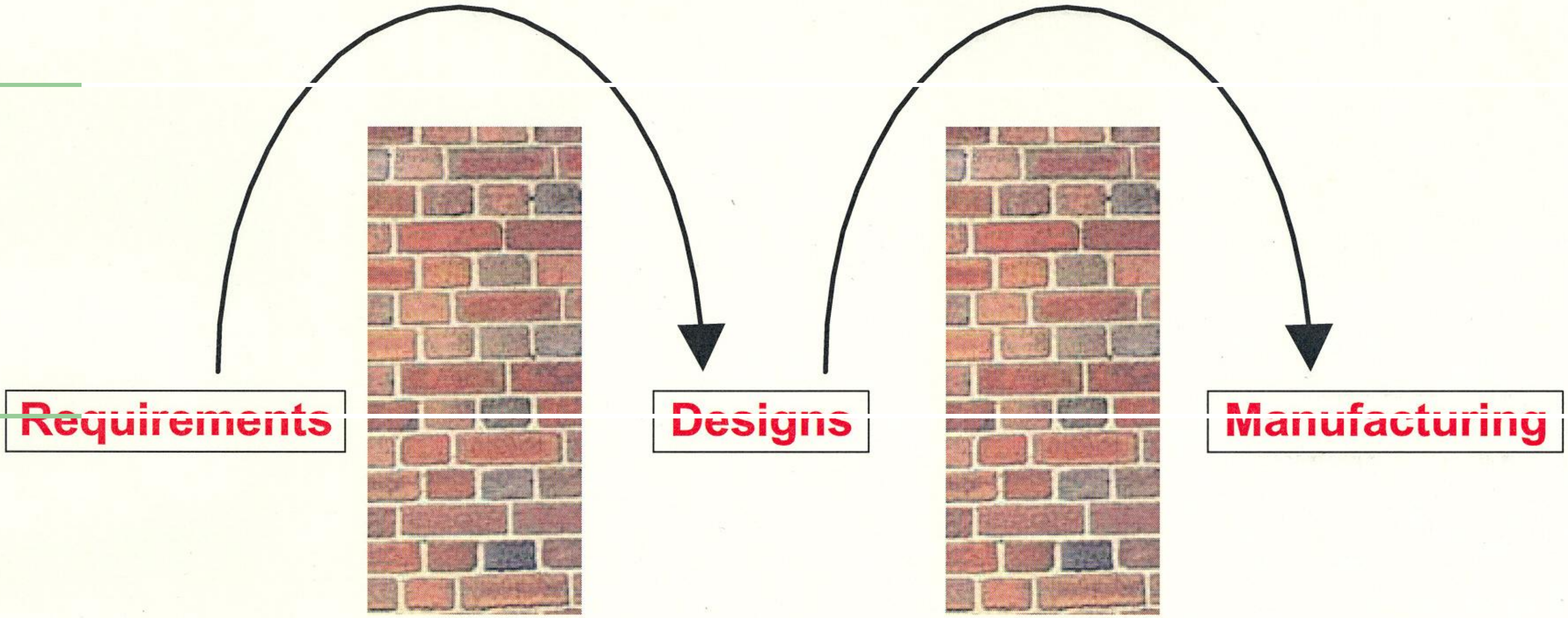
First Steps of the System Design Process



Systems engineering is not

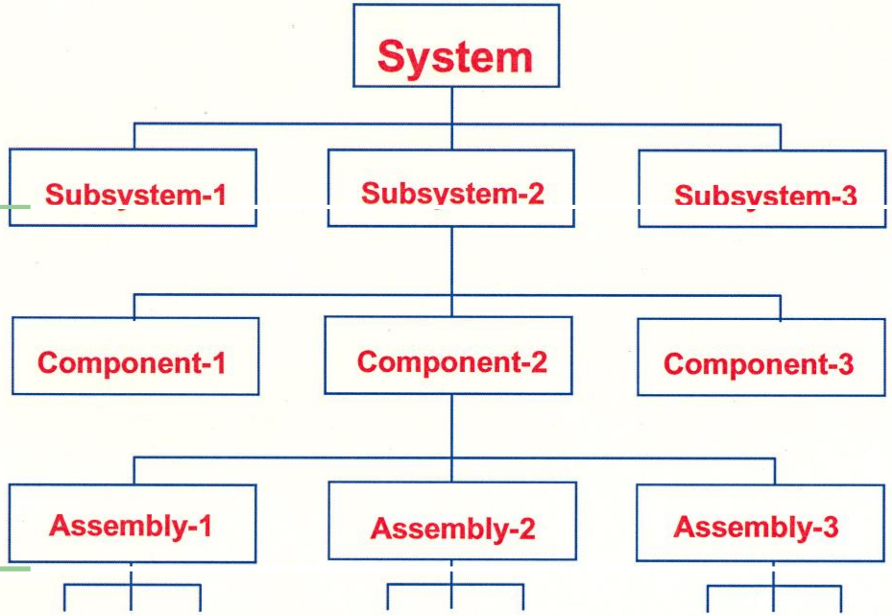


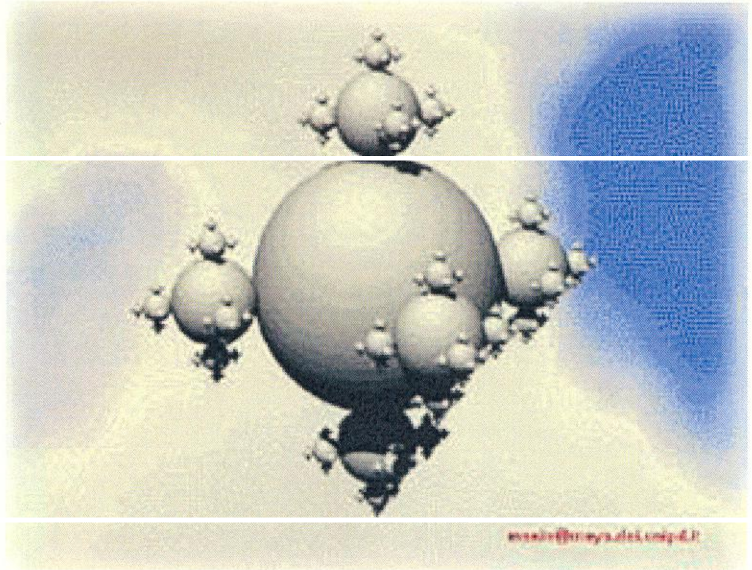
Systems engineering is not



a throw it over the wall process

Systems engineering is a fractal process





The systems engineering process is applied at levels of greater and greater detail. It is applied to the system, then to the subsystems, then to the components, etc. Similarly for the fractal pattern above, the same algorithm was applied at the large structural level, then at the medium-scale level, then at the fine-detail level, etc.

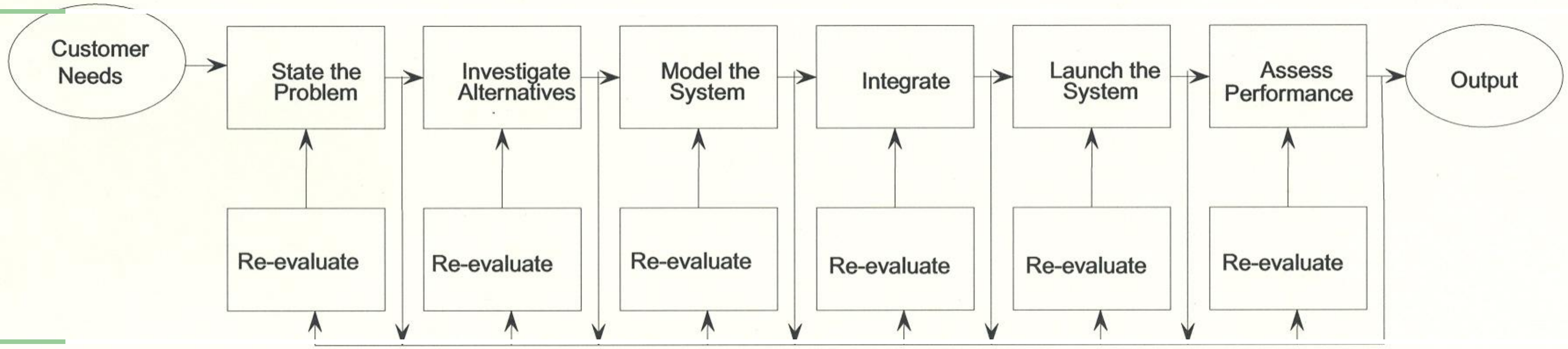
Incremental iterations

- Even the lowest level systems are developed with iterations.
- The designs get bigger with each iteration.
- This allows manufacturing to overlap design.

The Systems Engineering Process

State the problem
Investigate alternatives
Model the system
Integrate
Launch the system
Assess performance
Re-evaluate

These functions are captured in the acronym SIMILAR.



Systems Engineering Process

Iterative <u>not</u> Sequential Steps

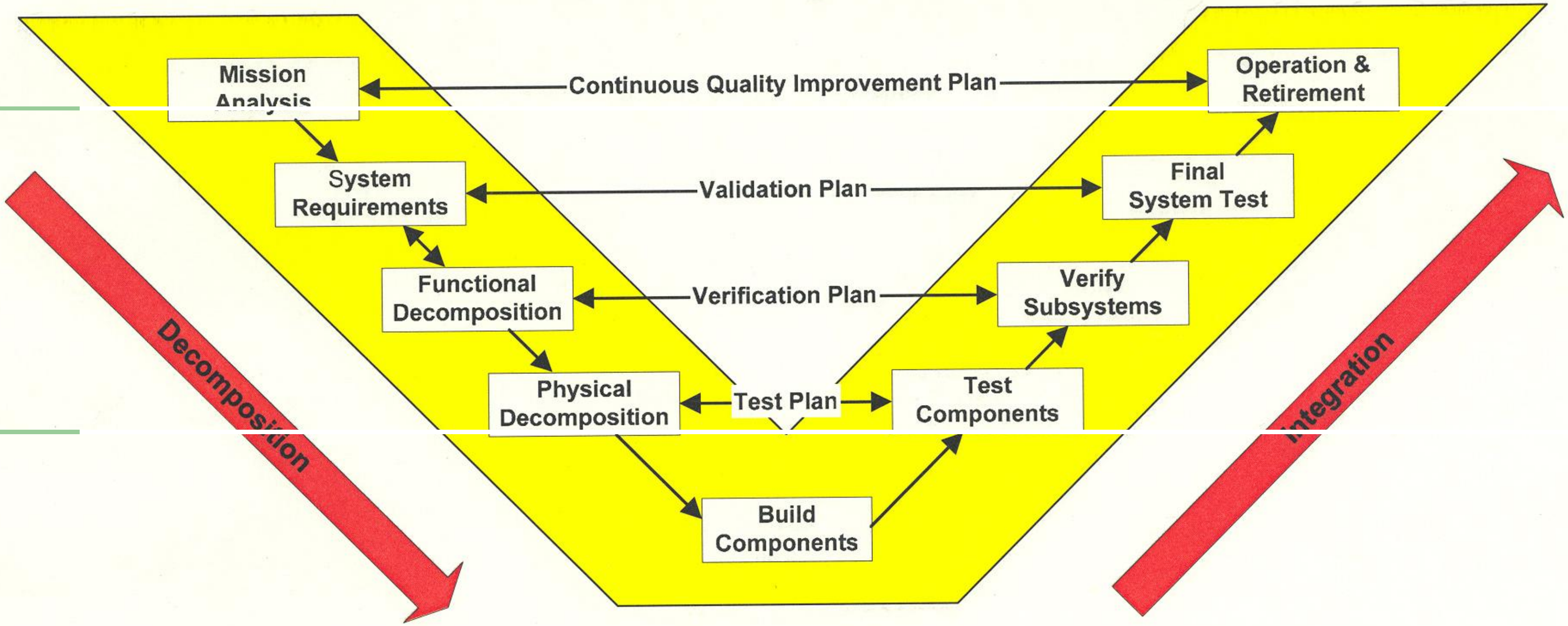
A Systems Engineering Culture will Address These Critical Areas During Program Reviews

Company Culture
Safety
Component applications
Materials
Mission profile to Detail Requirements
Manufacturing Processes and Plans
Tooling and test equipment
High Risk Technology
Reliability and Maintainability

Risk Assessments
Testability
Human Factors
Producibility and Inspectability
Subcontractor Design
Design Margin Analysis
Production Readiness
Software Design walk-through
Electro Magnetic Interference
Legal

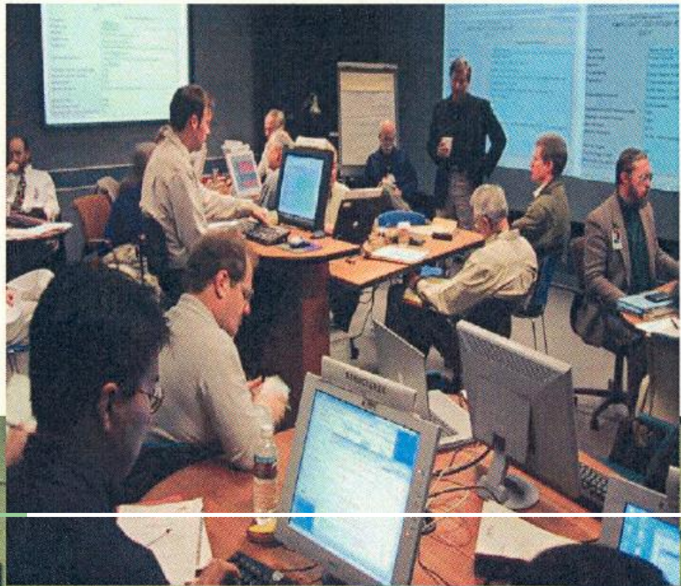
Mission Success

The vee life-cycle model



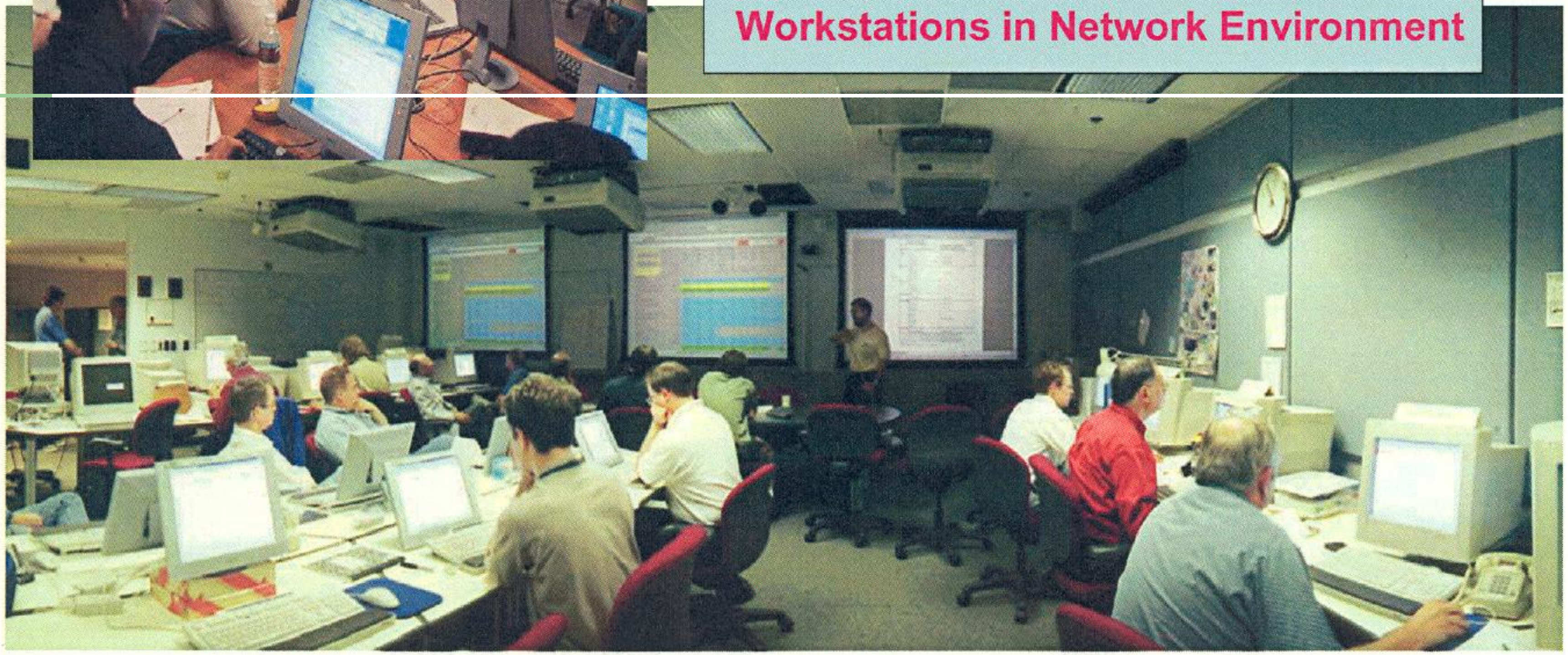
The design downstroke and the manufacturing upstroke

Mission Design Center



- Discipline-Specific Models: Trajectory Design, Information Systems Design, S/C Subsystems Design, Cost Modelling
- Integrated set of Spreadsheets for Evaluation of Design Parameters – Over 2000 Design Parameters Generated

Workstations in Network Environment



Impact of Mission Design Center Concept

- Conceptual Designs for new missions can be evaluated in less than two Days – includes cost and schedule for mission options

-Mission Design times reduced from 6 Months to 2-3 Weeks

- Mission Design Costs reduced by 20X

-Number of Mission Design Studies Increased from 5-10 per year to 100/year

- Enables Co-location of System Engineers, Designers and Customers

- Captures Lessons Learned in Design Data Bases

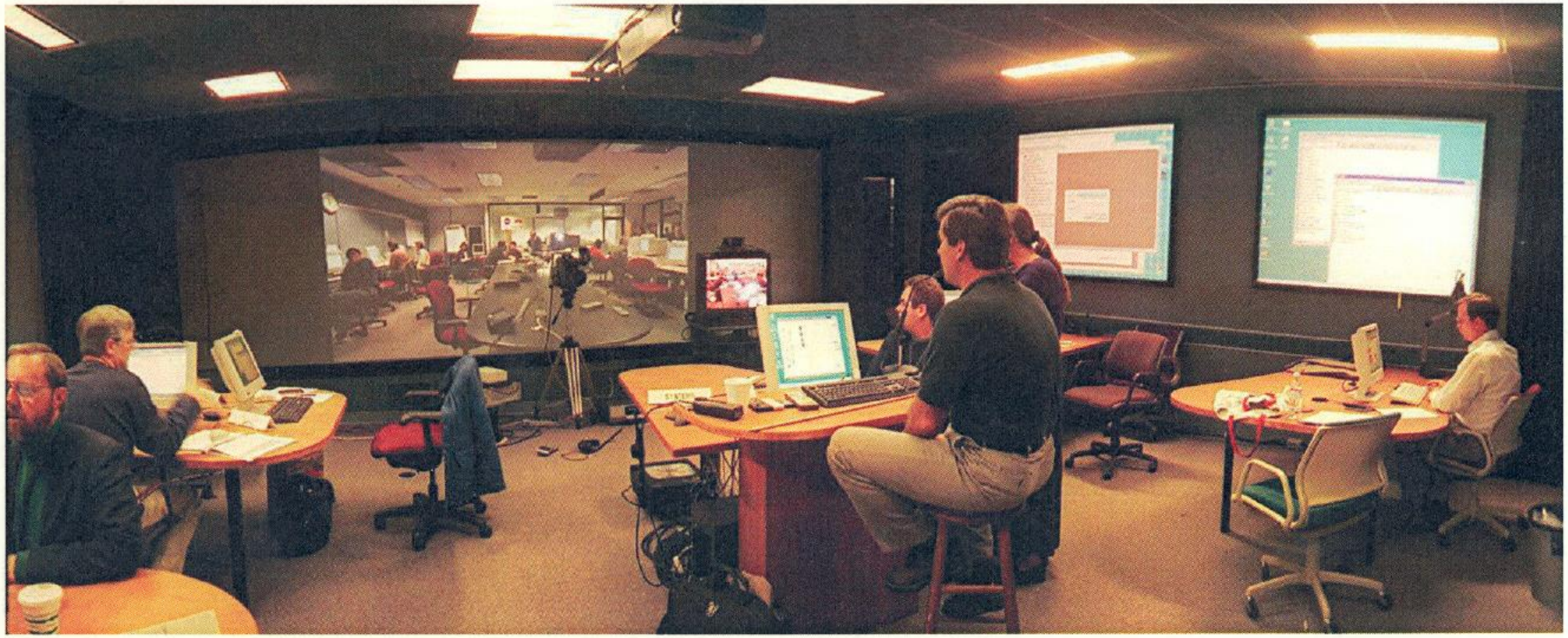
- Simulates Entire Mission in Virtual Space including Operations

Provides a Structured Environment to apply Simulation Based Design tools for Mission Concepts and Enables Systems Engineering Processes to be Applied for Assured Mission Success

<u>Future Challenge</u>: Geographically Distributed Design and Mission Planning Teams

Need To Maintain Same Efficiencies Accomplished in Single Design Center

Need to Understand the Complex Interactions between People, their Processes and Tools to Maintain Effectiveness of Distributed Teams



Systems Engineering Web Based Portal Concept for Distributed Teams

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A NEW WAY OF THINKING

- Ø <u>Framework</u> to incorporate long-term implications of current decision alternatives: how would each alternative behave over time and what kind of triggers could be needed?
- Ø <u>Process</u> to proactively capitalize on relevant, available and value-added synergies, and come up with new ones in a dynamic and complementary manner.
- Ø <u>System</u> to exploit and cope with uncertainties of the exogenous and endogenous kind explicitly.
- Ø <u>Methodology</u> to identify key elements of decision making at the executive level of the corporation, and impose performance yardsticks for sustainable growth.

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THE FLEXIBILITY ENGINE™
TYPOLOGY FOR EFFECTIVE DECISION MAKING

- Ø **Flexibility in time à American Options, Optimal Stopping**
- Ø **Flexibility in scope à Portfolio Optimization, Stochastic Control**
- Ø **Flexibility in means and ends à Spiral Development à WinWin Spiral Model**
- Ø **Flexibility in concept à Concept Maps, Causal Maps à Knowledge maps**
- Ø **Flexibility in design à Influence Diagrams, Bayesian Networks à Dynamic Decision Networks**
- Ø **Flexibility in strategy à Opportunity Development à Uncertainty Exploitation**
- Ø **Flexibility in extreme events à Disruptive Risk Management**

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THE FLEXIBILITY ENGINE™
BEYOND REAL OPTIONS ANALYSIS

- When target markets and technical agendas are flexible, that is,
  - demarcation between investment stages is blurry,
  - the scope for possible modifications in the initial stages is vast,
  - opportunities are linked to the actions of the corporation; i.e., endogenous,

  and actors at different levels of the corporation have different perspectives on the attractiveness of a given opportunity due to psychological biases, cognitive issues, and different incentive structures, the discrete logical framework of real options breaks down.

- There is a need for more generic path-dependent processes:
  - Treatment of not quantifiable risks
  - No figure is better than any figure

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