Exploiting Decision to Requirements Traceability

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Overview

Context

- 20+ years of Systems Thinking/Engineering
- Current work at TARDEC
  - Science and Technology (S&T) programs for Army ground vehicles
  - Technology uncertainty -> decision and requirements volatility
  - Traceability has high value, long-term payoff
  - Scalable methods required

Gaps

- Observations from the tip of the spear

Key Concepts

- True and useful
- Process and tool implications

Practical Techniques

- 5 ways to get started

Gaps = Opportunities

Rationale vs. relationships

- Requirements derivation = rich relationships, not text

Batch traceability + memory loss = lost requirements + low ROI from Requirements Management

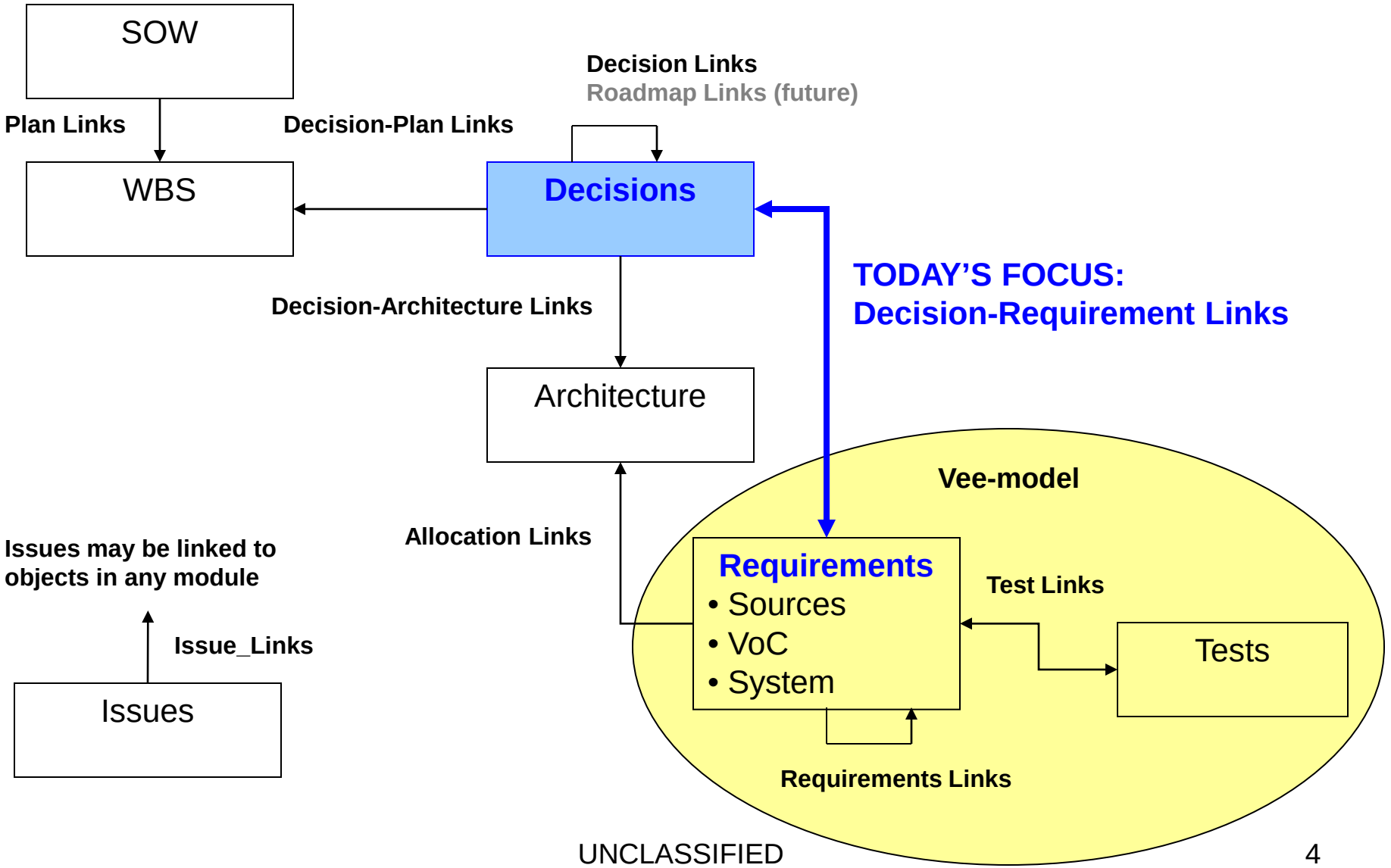
Problem domain – solution space entanglement

- Definition of a decision
  - Fundamental question/issue that demands an answer/solution
- Myth of solution-independent decomposition
- Misuse of models

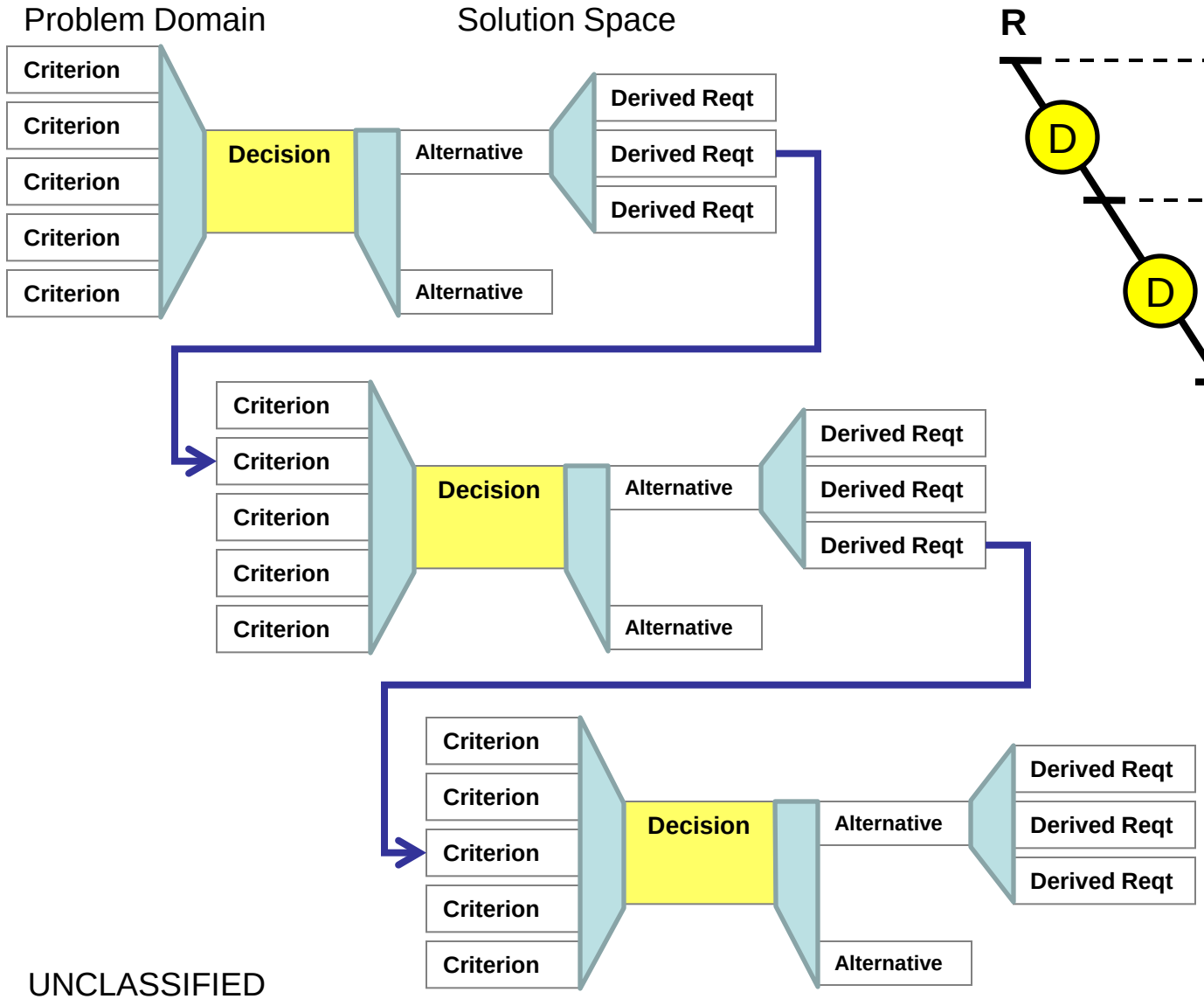
Missing relationships among SE knowledge

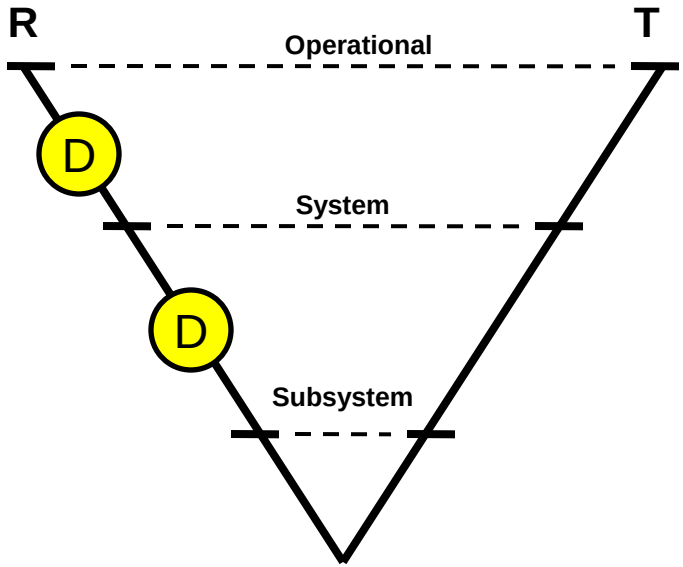
Ambiguity tolerated in the SE information model

Information Model for Science & Technology (S&T)



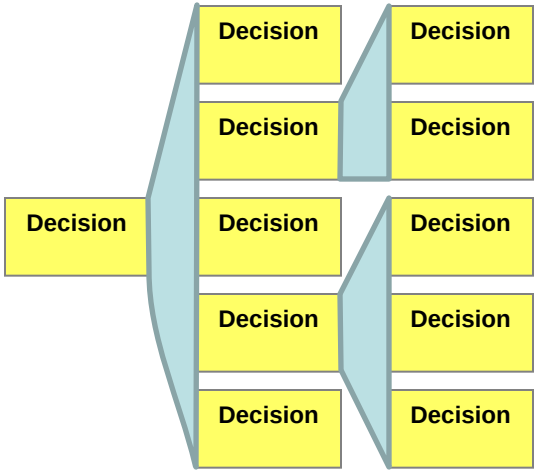
Decision to Requirements Traceability





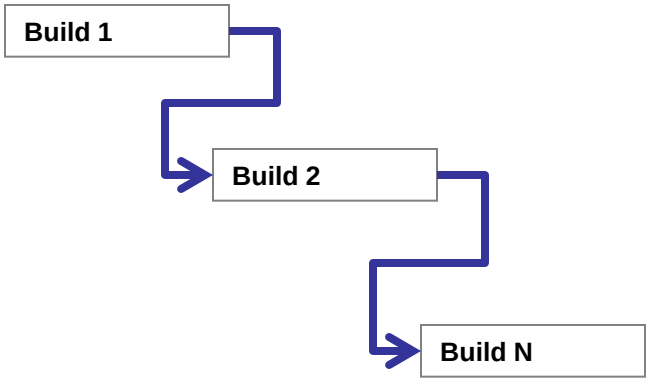
Decision to Plan Traceability

Requirements Analysis & Design



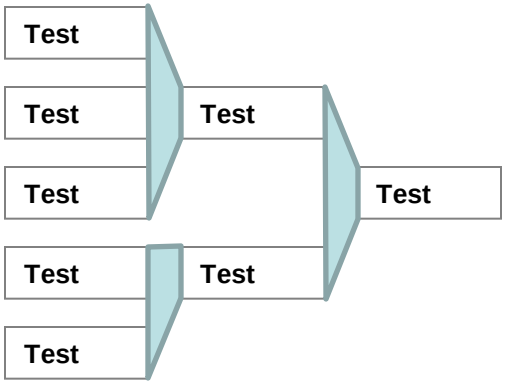
Top N decisions (Thinking Breakdown Structure) frame the WBS

Implementation

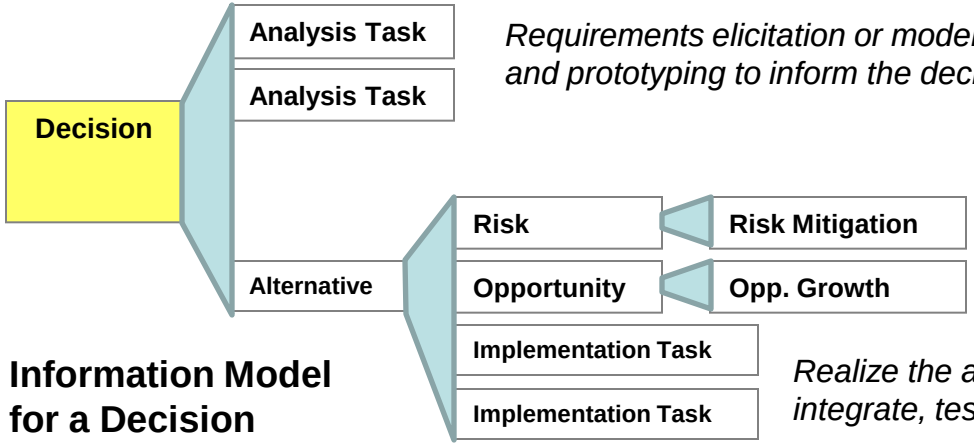


WBS = incremental realization of the solution design (alternatives)

Integration & Test



WBS = incremental verification of the solution design



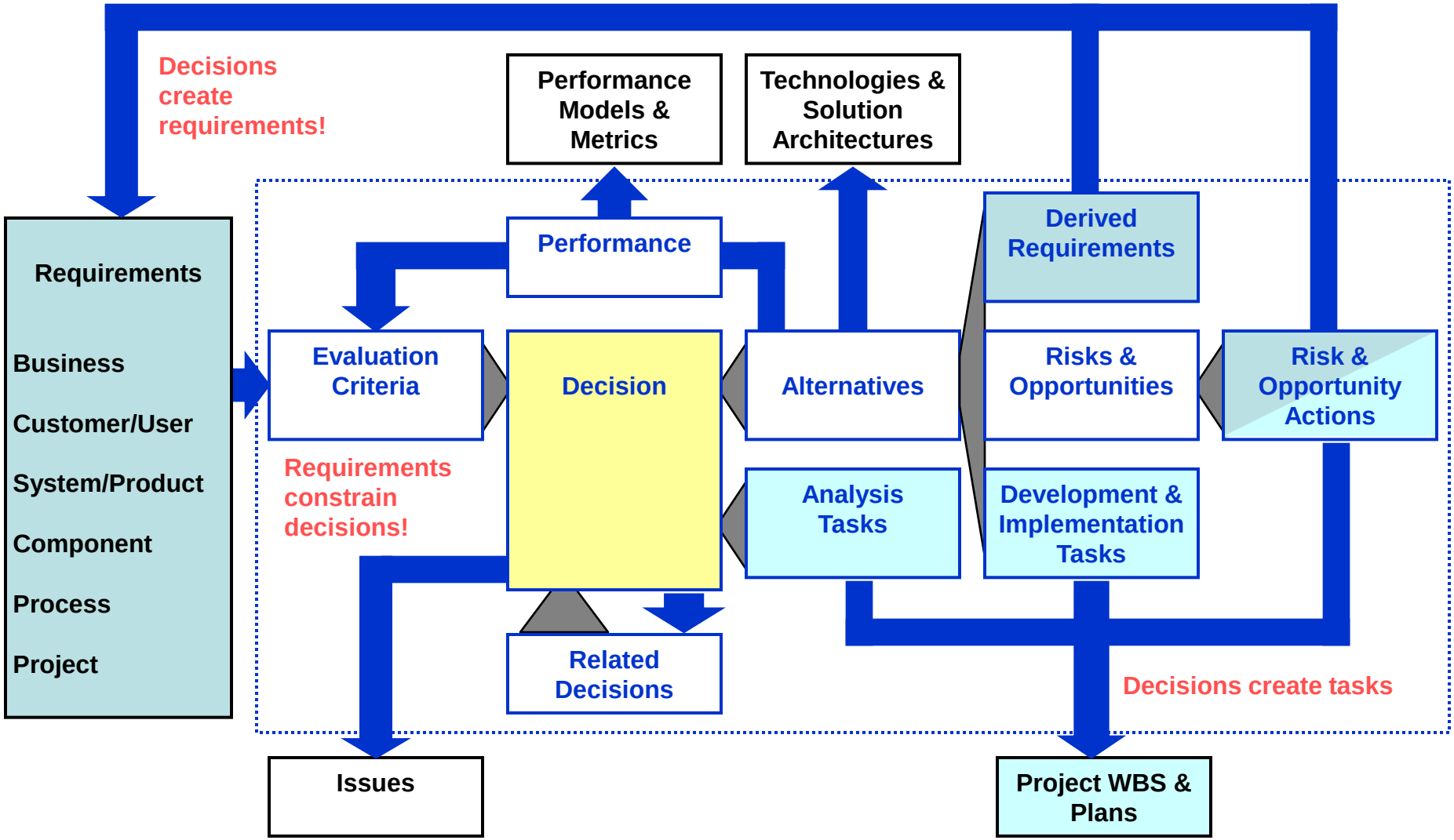
Information Model for a Decision

Requirements elicitation or modeling, simulation and prototyping to inform the decision

Changes to the plan to protect or optimize alternatives

Realize the alternative: build, integrate, test, deploy

Decision-centric Information Model



Enables continuous traceability and seamless software tools

Process and tool implications

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Stable and proven information model
- Fuzziness wrung out by 2+ software implementations
- Comprehensive, domain-independent

Focus on thinking content (linked objects)
- Not its packaging in document or view containers

High level of process and tool integration possible
- Enterprise decision model behind all knowledge-driven processes

Preserves decision context for all knowledge

Maximize use of knowledge patterns
- Decisions + related criteria/requirements, plan, models, etc.

Decisions create all dependencies/interfaces
- Need methods & tools to capture these at the point of decision

Practical Techniques for Leveraging Decision-Requirements Traceability

Requirements Derivation

Requirements Analysis – Reverse Engineering

Functional Decomposition – Requirements Allocation

Traceability Matrices

Change Management

Requirements Derivation

No decision analysis is complete until:

The inherent consequences of the “committed” alternative have been captured as derived requirements

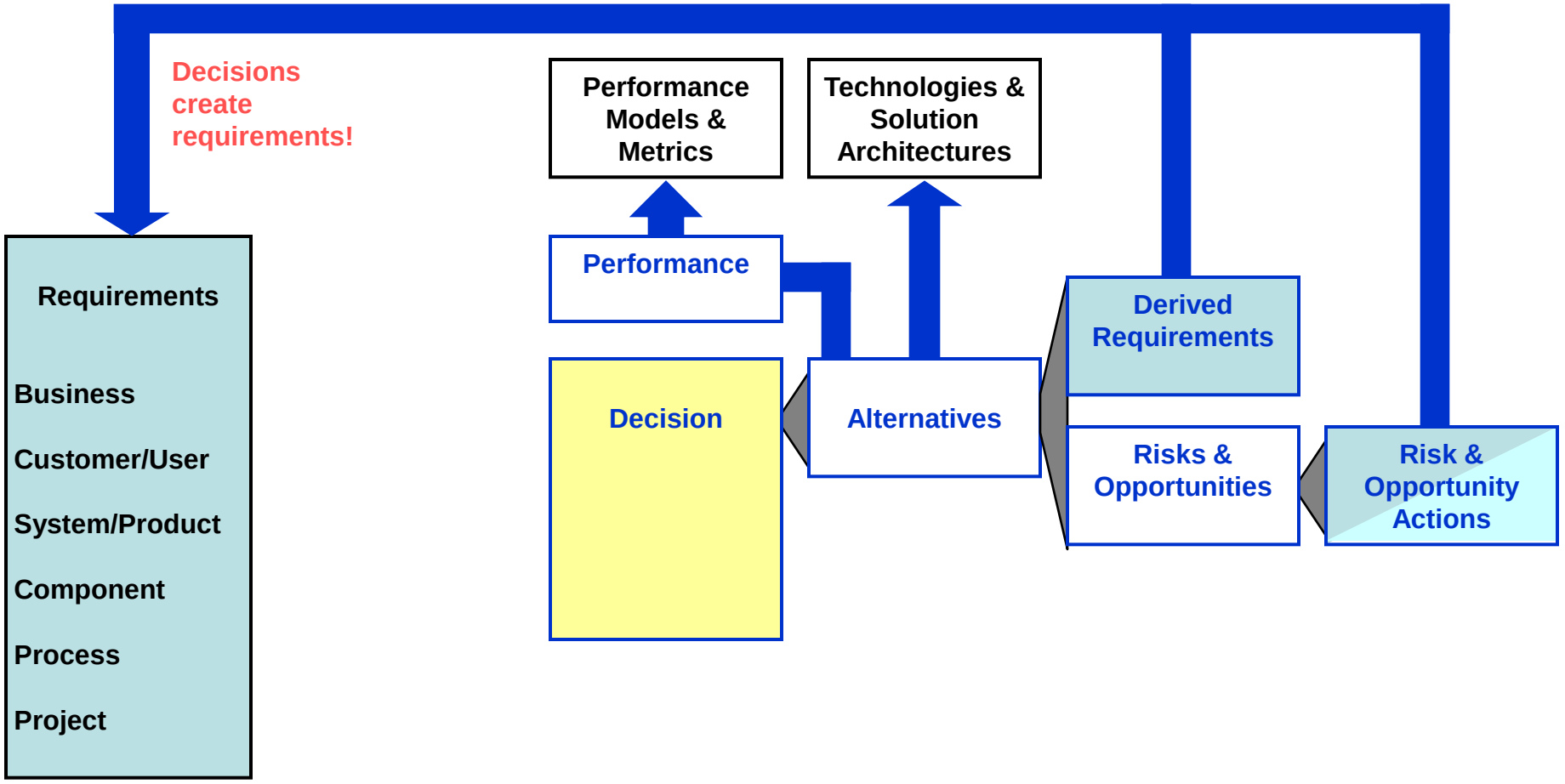
- Based on the decision-maker’s insights/perspective of the alternative’s:
  - Structure
  - Behavior
  - Footprint
  - Interfaces
  - Life Cycle

These “raw” derived requirements are captured within the formal requirements structure

- Copied/linked with explicitly traceability back to their decision source
- Refined, decomposed and accepted by the owner of the requirements “branch” in which they reside

With similar traceability maintained for risk mitigation and opportunity growth actions that are committed for implementation

Requirements Derivation



Requirements Analysis – Reverse Engineering

To improve the quality of a system requirements baseline:

- Exploit the fact that all requirements are derived requirements

Reverse engineer upstream decisions (Decision Blitz)

- Your customers', users' and System of System's decisions define your problem
- Map source documents to a proven decision pattern
  - Concept of operations, capability descriptions, use cases, DoDAF views
  - Build explicit model of the customer's problem domain (decisions) and committed alternatives
  - ASK: "If X is the answer (solution), what was the question (decision)?"
  - Very efficient, convergent knowledge acquisition process

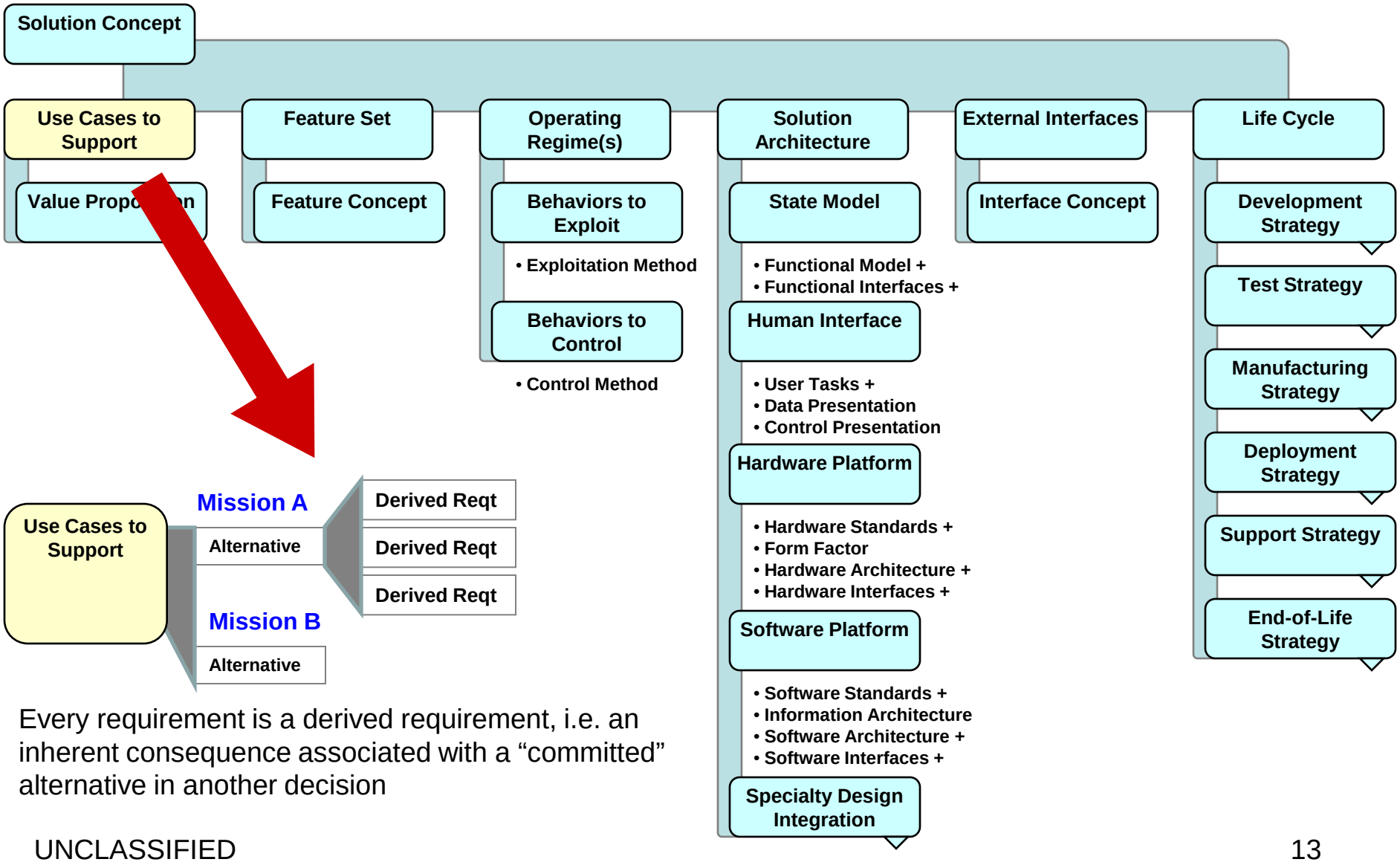
Trace system requirements to these decisions

- 100% trace possible, but not necessary (focus on toughest constraints)
- Highlights gold-plating and tunnel vision (prematurely imposed designs)
- Highlights unknowns that need to be known

Re-open upstream decisions

- Flex the trade space to give the customer what they want, not just what they asked for

Requirements Analysis – Reverse Engineering



Every requirement is a derived requirement, i.e. an inherent consequence associated with a "committed" alternative in another decision

Functional Decomposition – Requirements Allocation

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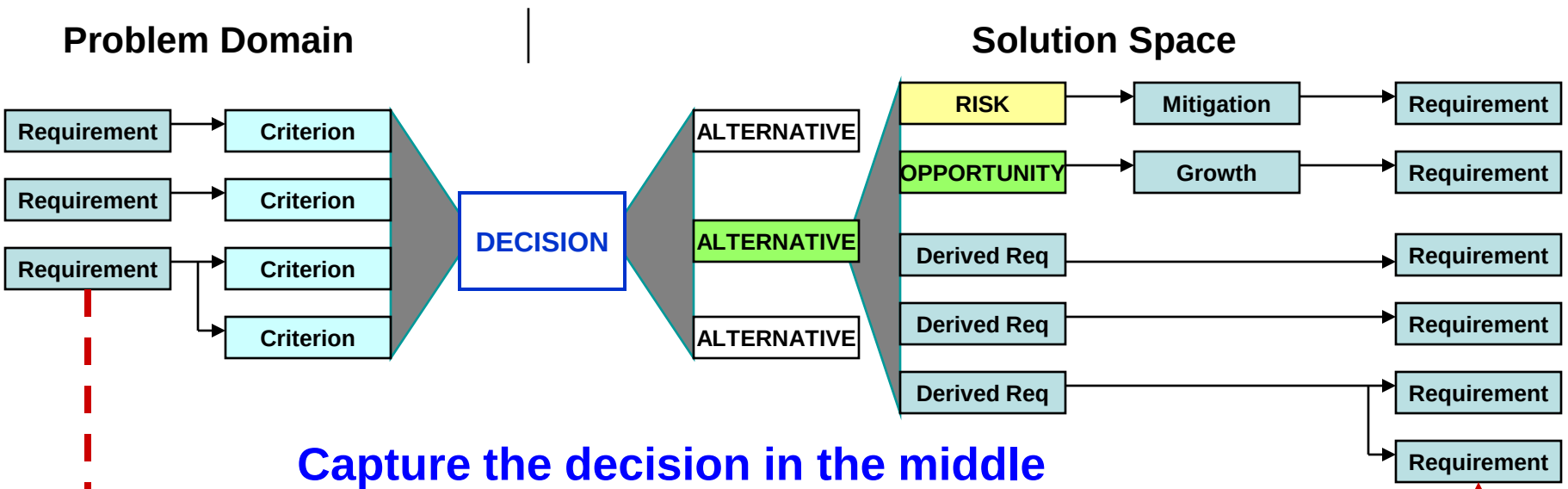
Decisions drive functional decomposition

- Choose Function X Technology/Method
- Next layer of functions created at the point of decision
- Use caution with model-based decomposition
  - Model = representation of the structure/behavior of an alternative
  - Avoid tunnel vision – first valid model is seldom the best alternative

Decisions drive requirements allocation

- Solution architecture decision “creates” components and interfaces
- Decision analysis is incomplete unless functional and performance allocation is evaluated for each design
- After decision is ratified, complete the allocation trace

Traceability Matrices

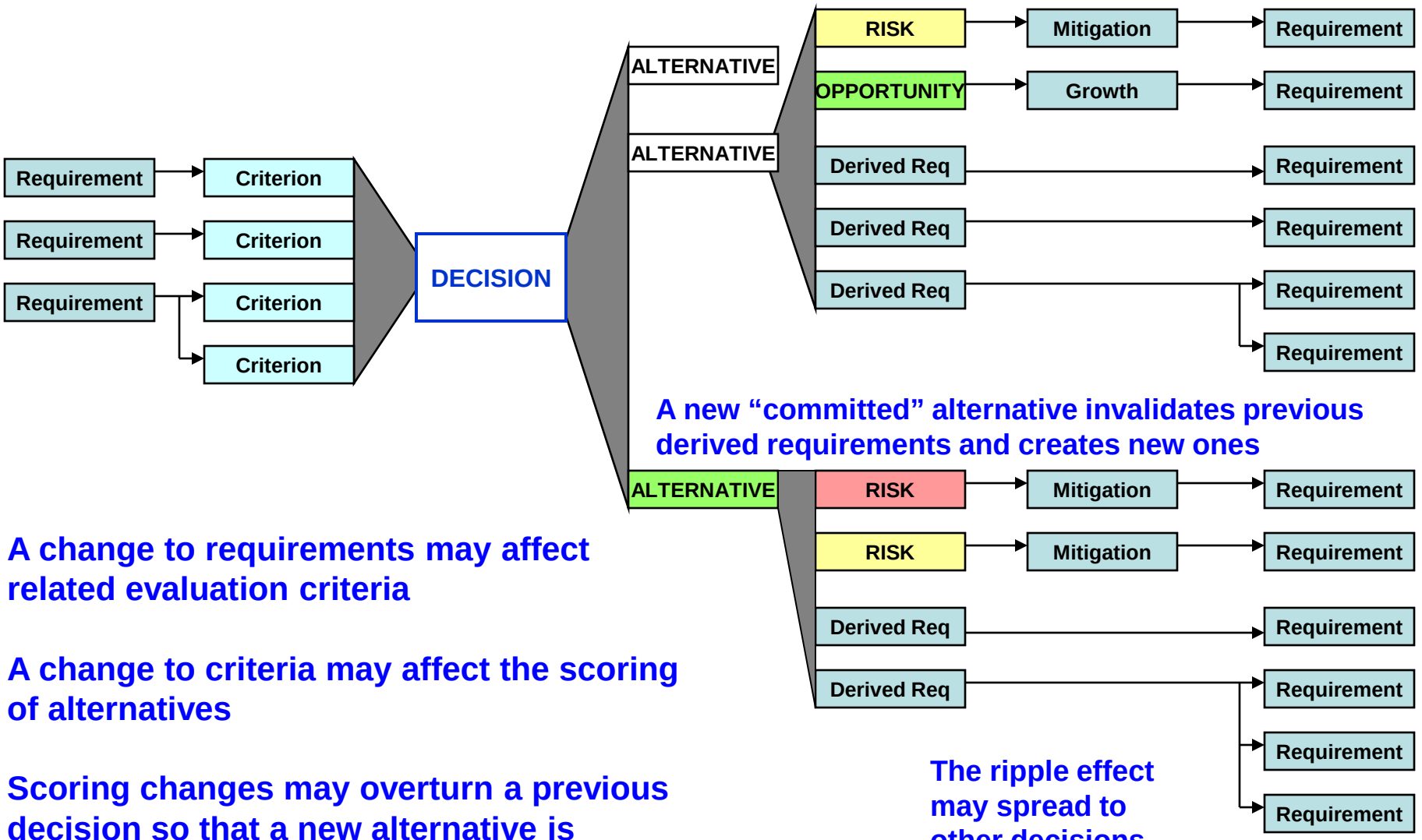


Capture the decision in the middle

Requirement	Mitigation X to Risk Y in Alternative B	Requirement
Requirement	Growth Action R to Opportunity S in Alternative B	Requirement
Requirement	Alternative B – structure, behavior, footprint, interfaces, or life cycle	Requirement

The actual derivation trace is a rich many-to-one-to-many transformation that balances multiple criteria and leads to the selection of an alternative. A one-to-one requirement trace is an approximation at best.

Change Management



A new "committed" alternative invalidates previous derived requirements and creates new ones

A change to requirements may affect related evaluation criteria

A change to criteria may affect the scoring of alternatives

Scoring changes may overturn a previous decision so that a new alternative is selected for implementation

The ripple effect may spread to other decisions

Business Case for Decision to Requirements Traceability

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Improved requirements quality
- Completeness, consistency, feasibility
- Less design rework

Continuous traceability
- Decision-makers know their constraints as early as possible

Improved understanding of customer's needs
- Opportunity to offer higher level solutions

Innovation
- Avoid tunnel vision and imposed solutions
- Optimize solution architecture, functional decomposition

Faster impact/change analysis
- Explicit trace localizes the impact of a change
- Decision logic preserved; more efficient if revisited

Scalable
- Focus traceability on the critical decisions and constraints (Pareto)