Overview of an Emerging Standard on Architecture Evaluation – ISO/IEC 42030

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The Aerospace Corporation

19 July 2017
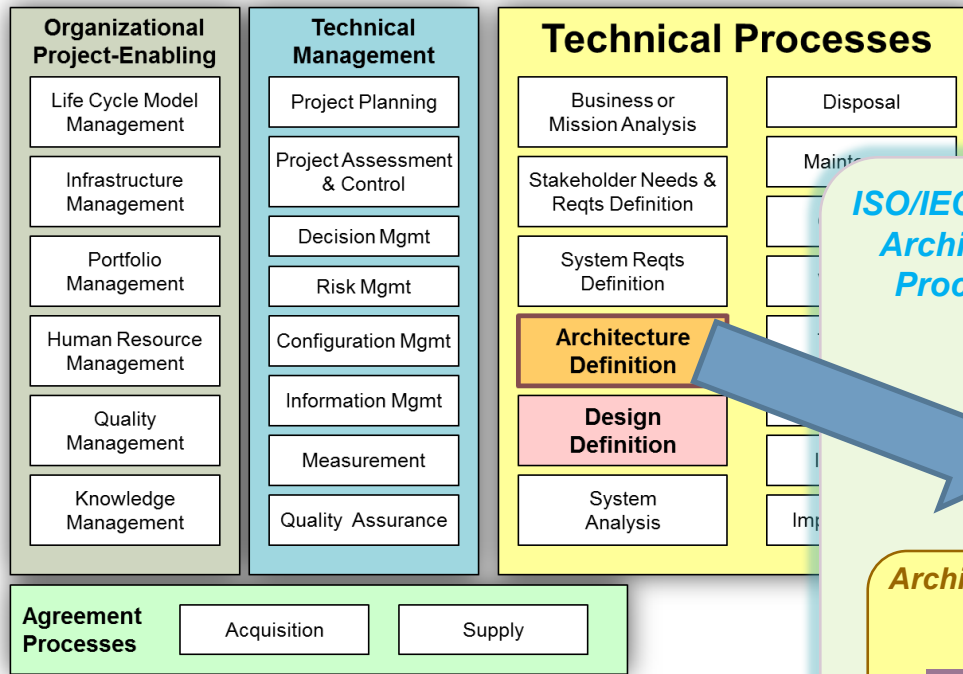*INCOSE International Symposium*
Adelaide, Australia

Architecting is really about…

Tools

42030

Methods

42010

42020

Process

Perspective

Principles

Outcome

Creativity

Discovery

Art

Science

www.incose.org/symp2017

Source: Essentials of Architecting, David Long

ISO/IEC/IEEE 15288 Systems Engineering

Organizational Project-Enabling
- Life Cycle Model Management
- Infrastructure Management
- Portfolio Management
- Human Resource Management
- Quality Management
- Knowledge Management

Technical Management
- Project Planning
- Project Assessment & Control
- Decision Mgmt
- Risk Mgmt
- Configuration Mgmt
- Information Mgmt
- Measurement
- Quality Assurance

Technical Processes
- Business or Mission Analysis
- Stakeholder Needs & Reqts Definition
- System Reqts Definition
- Architecture Definition
- Design Definition
- System Analysis
- Disposal
- Maintenance
- Implementation

Agreement Processes
- Acquisition
- Supply

ISO/IEC 42020 – Architecture Processes

- Architecture Governance
- Architecture Management
- Governance Directives & Guidance
- Management Plans & Status
- Management Instructions & Guidance
- Execution Plans & Status

Architecting
- Architecture Conceptualization
- Architecture Evaluation
- Architecture Elaboration

- Architecture Process Enablers
- Enablement Requests & Feedback
- Architecture Enablement

ISO/IEC 42030 – Architecture Evaluation Framework

Architecture

evaluates

- Architecture Evaluation Objectives
- Value Assessment Objectives
- Architectural Analysis Objectives

drive / drive

guide

- Architecture Evaluation Approach
- Value Assessment Method
- Architectural Analysis Method

employs / employs

- Evaluation Results
- Assessment Results
- Analysis Results

inform / inform

3

Architecture Standards
Current & Future

- 42010 – Architecture Description
  - *Published in 2011*

- **42020 – Architecture Processes**
  - ***Started 2015 (expected release by 2017)***

- **42030 – Architecture Evaluation Framework**
  - ***Updated Draft now in review***
  - ***To be published in 2018***

- 42040 – Architecture Methods
  - *Future*

- 42050 – Architecture Tools
  - *Future*

- Review Apr-Aug 2017
- Release Dec 2017

- Review Jul-Dec 2017
- Release June 2018

ISO/IEC 42020 – Architecture Processes

Architecture Governance

Management Plans & Status

Governance Directives & Guidance

Architecture Management

Execution Plans & Status

Management Instructions & Guidance

Architecting

Architecture Conceptualization

Architecture Evaluation

Architecture Elaboration

Architecture Process Enablers

Enablement Requests & Feedback

Architecture Enablement

Purpose of the 42030 Standard

> **Architecture Evaluation**
> – *The act of making a judgment or determination about the value of one or more architectures*

- **Answers these kinds of questions**
  - *What is the Quality of an architecture?*
  - *How well does an architecture address Stakeholder Concerns?*

- **Reasons for doing Architecture Evaluation?**
  - *Determine capability gaps*
  - *Selection of best solution among alternatives*
  - *Identification of best enterprise portfolio*
  - *Development of feasible requirements*
  - *Etc…*

➢ *This Standard specifies a Framework of "Elements" to be used in an evaluation, not the Process to be followed*

Basis of the Architecture Evaluation Standard
Building upon Industry Best Practices & Lessons Learned
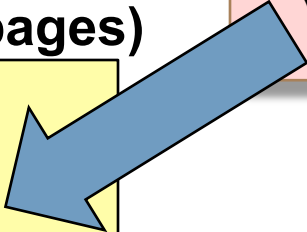
- **Architecture Tradeoff Analysis Method (ATAM)**
  - *Developed by the Software Engineering Institute (SEI)*
  - *Uses "Quality Attributes" and QA Workshop approach*

- **Quality Assessment of System Architectures & their Requirements (QUASAR)**
  - *Also published by SEI*
  - *Uses a "Quality Case" based on claims, arguments and evidence*

- **Analysis of Alternatives (AOA) Process**
  - *Office of Aerospace Studies, Air Force Materiel Command, Kirtland AFB (2013)*

- **Value-Focused Thinking**
  - *Ralph Keeney (1996) book*

Document Structure
Table of Contents

- **Front Matter (4 pages)**
  - *Scope & Conformance Criteria*
  - *References*
  - *Terms & Definitions*
- **Conceptual Foundation (13 pages)**
  - *Ontology & Structure*
  - *Key Concepts*
- **Architecture Evaluation (14 pages)**
  - *Evaluation Synthesis*
  - *Value Assessment*
  - *Architectural Analysis*
  - *Architecture Evaluation Frameworks*
  - *Evaluation Plans & Reports*
- **Annexes** (value & quality concepts, examples) (12 pages)

Requirements & Recommendations

- ✓ **38 "shall" statements**
- ✓ **54 "should" statements**

Architecture Evaluation Ontology
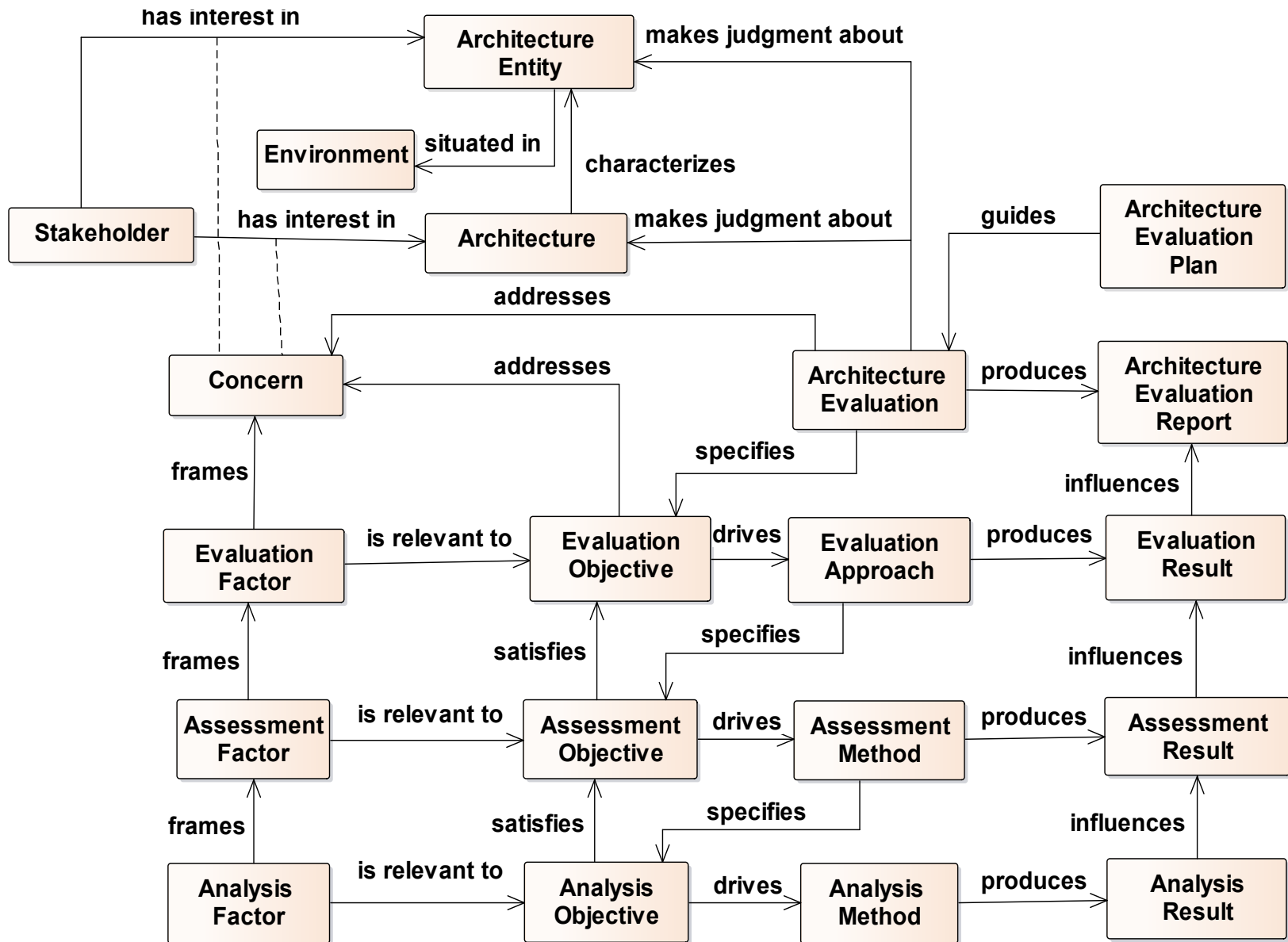
Generalized Architecture Evaluation Framework with Three Tiers of Evaluation Elements

Architecture Evaluation Work Products

| Evaluation Plan | | | Evaluation Report |

Architecture Evaluation Elements

	Evaluation Objectives	Evaluation Factors	Evaluation Approach	Evaluation Results
Evaluation Synthesis Tier	Evaluation Objectives	Evaluation Factors	Evaluation Approach	Evaluation Results
Value Assessment Tier	Assessment Objectives	Assessment Factors	Assessment Methods	Assessment Results
Architectural Analysis Tier	Analysis Objectives	Analysis Factors	Analysis Methods	Analysis Results

The 42030 Standard provides a Generalized Framework that can be adapted for your Organizational Practices and for particular Evaluation Efforts

Customized Architecture Evaluation Framework
Reusable, Off-the-shelf Document (based on this standard)

- **Purpose**
  - *Supports repeatable evaluations*
  - *Basis for employee training in evaluation practices*
  - *Enables more efficient & effective architecture studies*

- **Example:** Standardized Value Assessment Method for Company X, plus corresponding
  - *Value Assessment Objectives & Factors*
  - *Architectural Analysis Methods & Factors*
  - *Analysis Tools & Techniques*

- May also include Architecture Evaluation templates, checklists, assessment criteria, key references, guidelines, etc

Architecture Evaluation Context
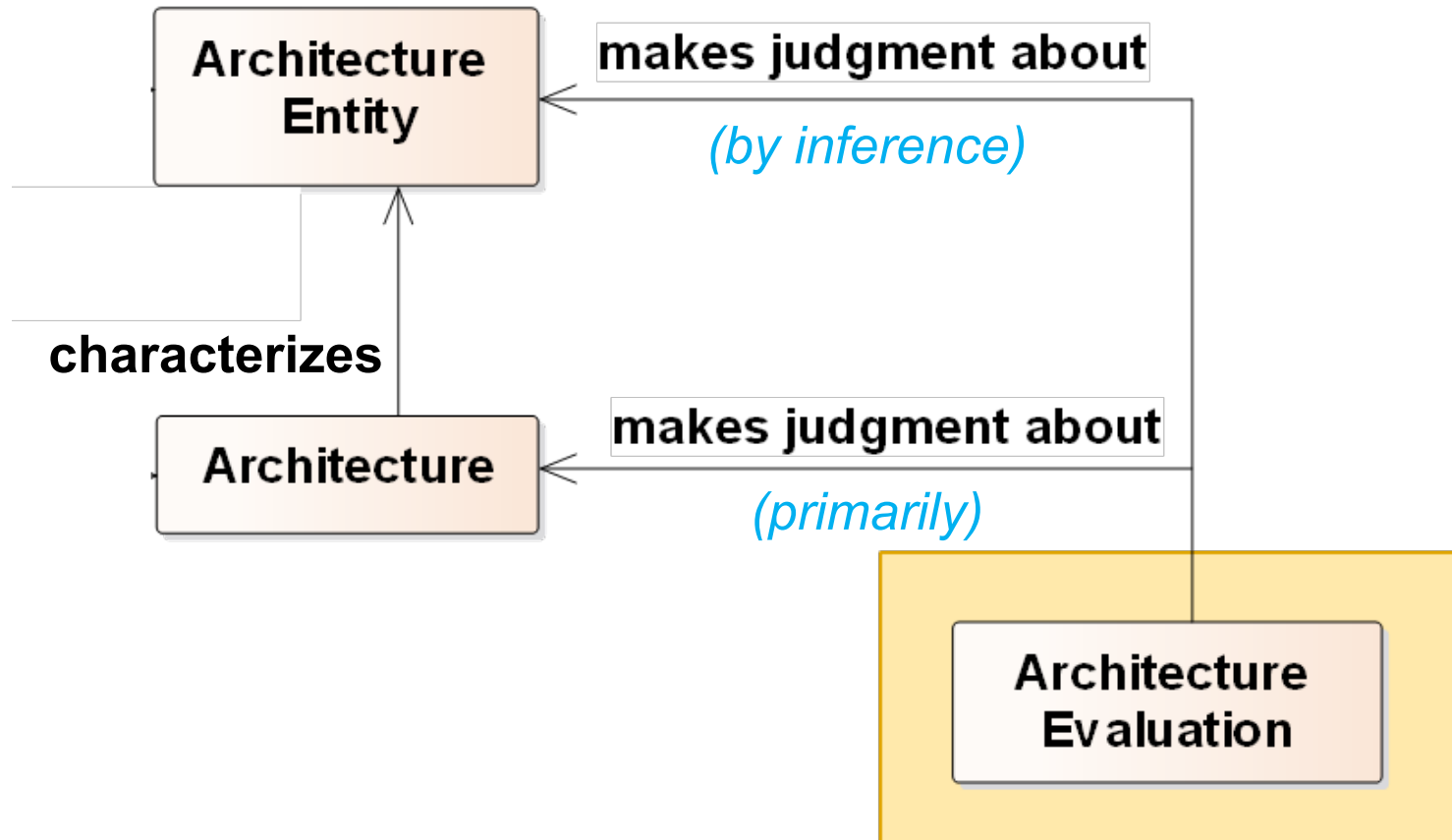
Not Just Systems to be Architected…

1. Enterprise
2. System of systems
3. Collection of systems
4. Class of systems
5. Family of systems
6. Individual system
7. Portion of a system
8. Product line

9. Product
10. Service
11. Individual hardware or software item
12. Any other entity that is amenable to architectural definition *(eg, data, doctrine, organization, process, method, technique, policy, facilities, etc)*
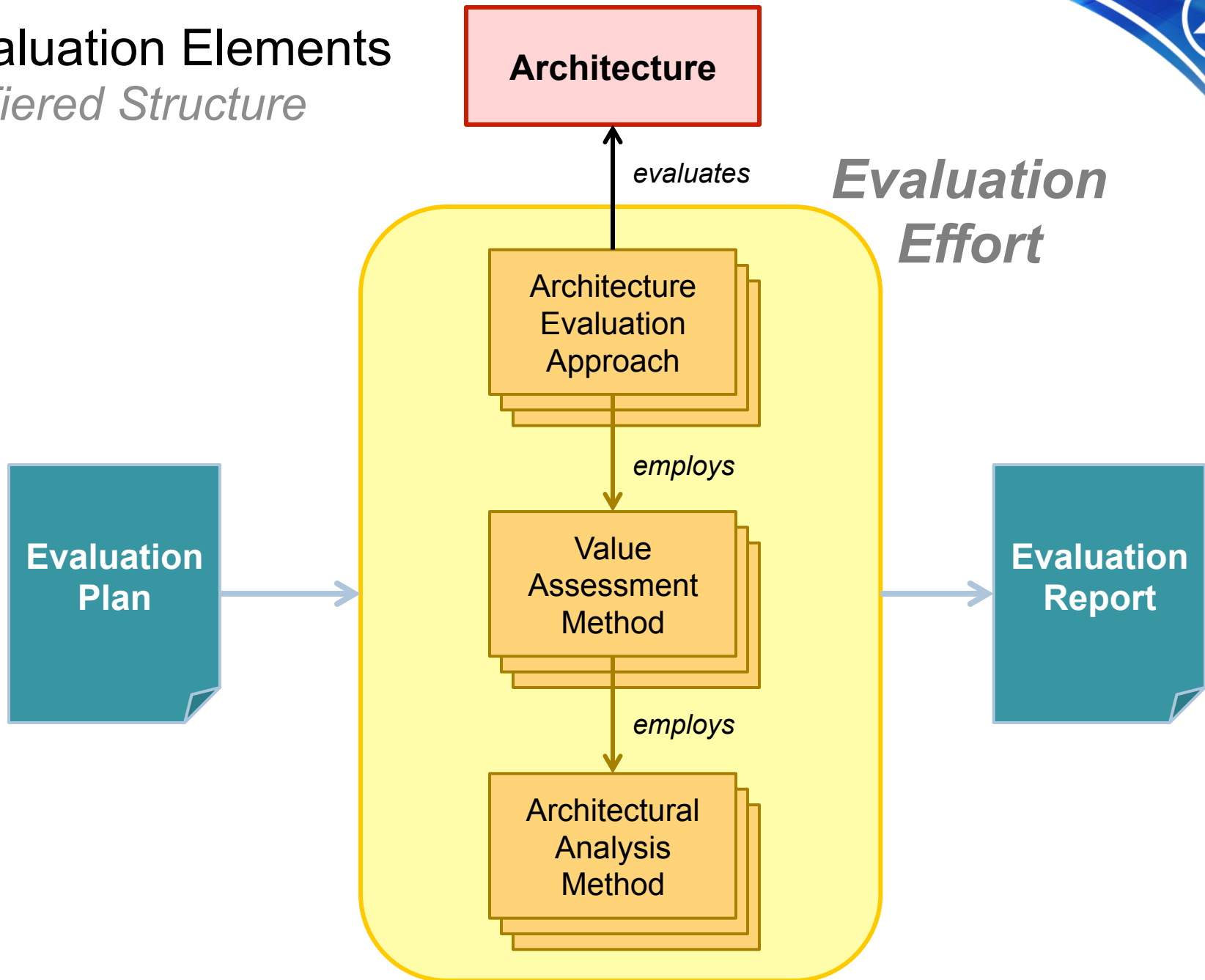
Architecture —characterizes→ **Architecture Entity**
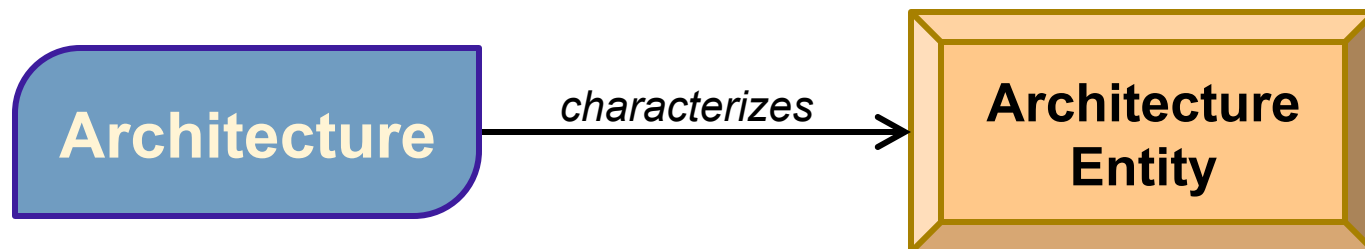
Use of Stakeholder Concerns as the Foundation for Architecture Evaluation

Stakeholder —has interest in→ **Architecture Entity**

Architecture Entity ←makes judgment about— **Architecture Evaluation**

Environment —situated in→ **Architecture Entity**

Stakeholder —has interest in→ **Architecture**

Architecture —characterizes→ **Architecture Entity**

Architecture ←makes judgment about— **Architecture Evaluation**
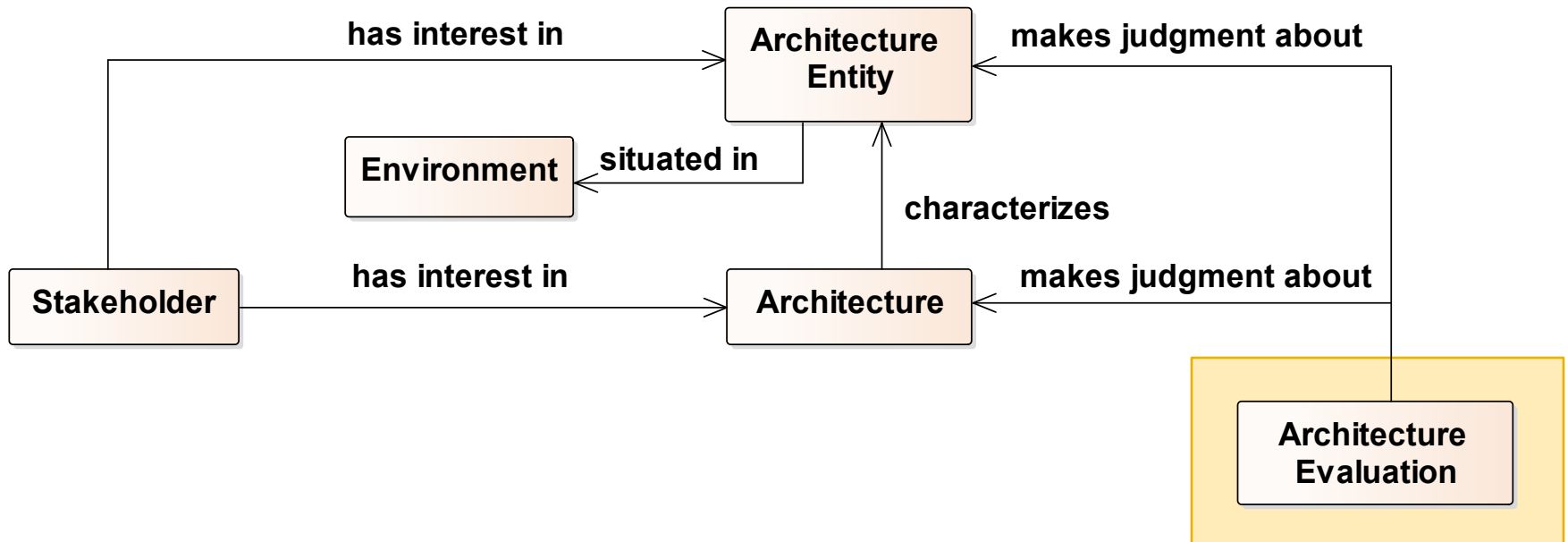
Evaluation Elements
3-Tiered Structure

Evaluation Management
Plan the effort → Report the results

Evaluation Plan

- Purpose & scope

- Evaluation objectives, constraints, criteria, priorities

- Schedule & required resources

- Evaluation framework(s) to be used

- Evaluation approach(es) & method(s) to be used

- Roles & responsibilities of evaluators

- Required inputs & reference materials

- Expected outputs & deliverables

Evaluation Report

- Purpose, scope & objectives

- Participants in the effort (either directly or indirectly)

- Inputs used

- Frameworks used

- Approaches and methods used (and possibly tailored)

- Method results & rationale

- Observations & findings

- Risks & opportunities identified

- Recommendations & regrets

Evaluation Drivers

Ensures Well-Scoped Evaluation Effort
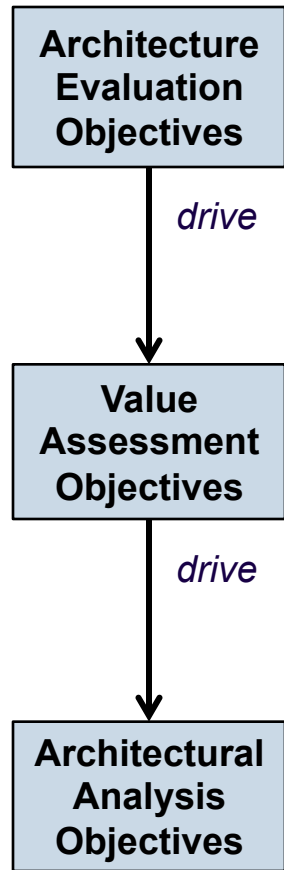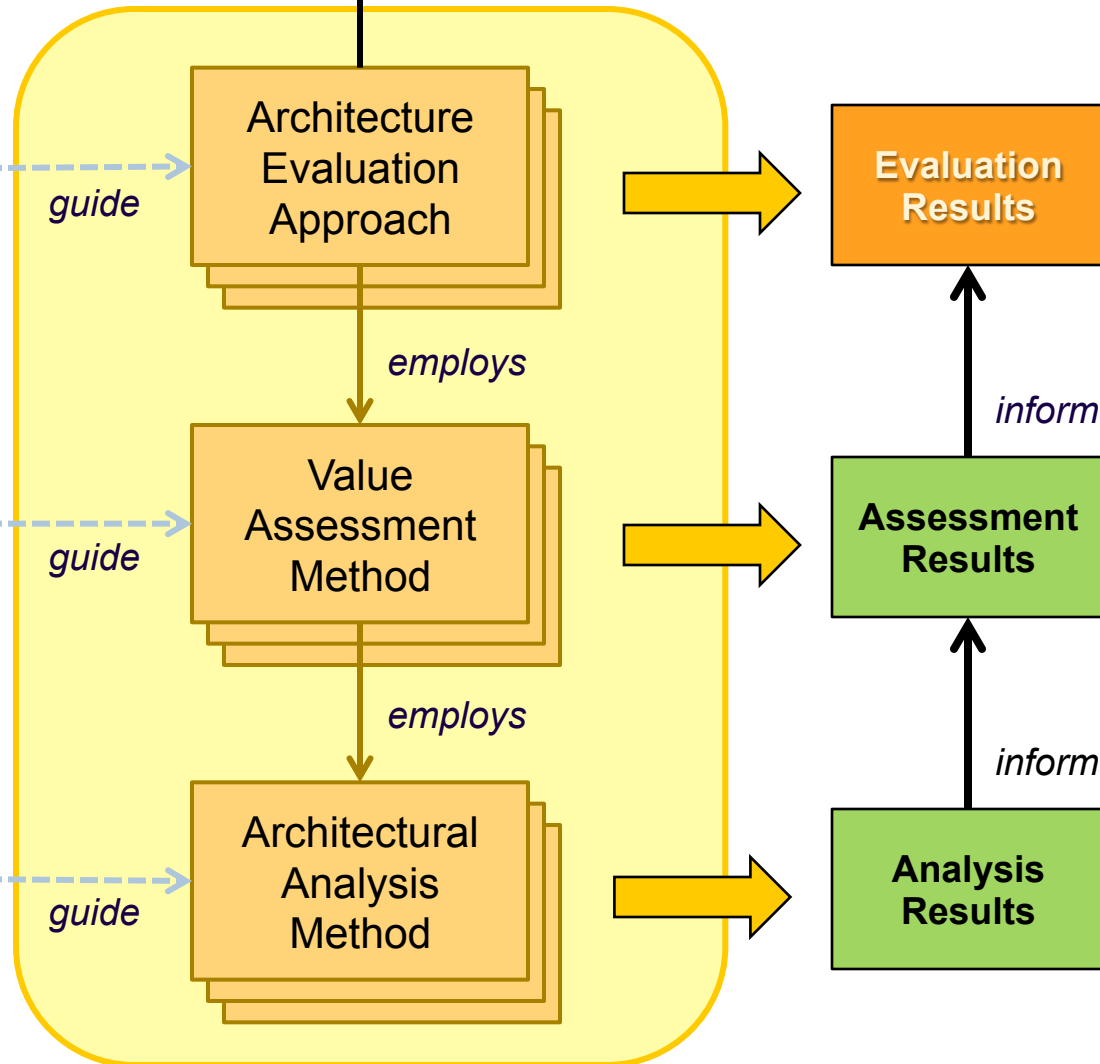
Evaluation Approach
The "Line of Attack"

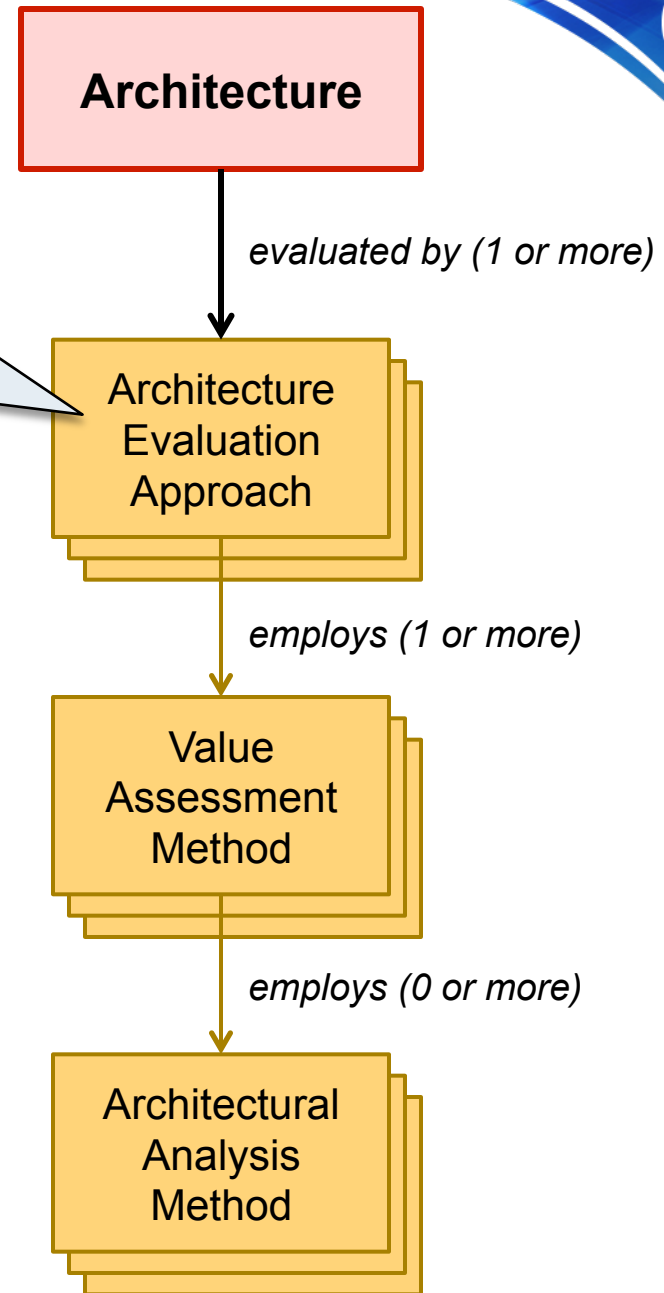**Architecture**

evaluated by (1 or more)

Architecture
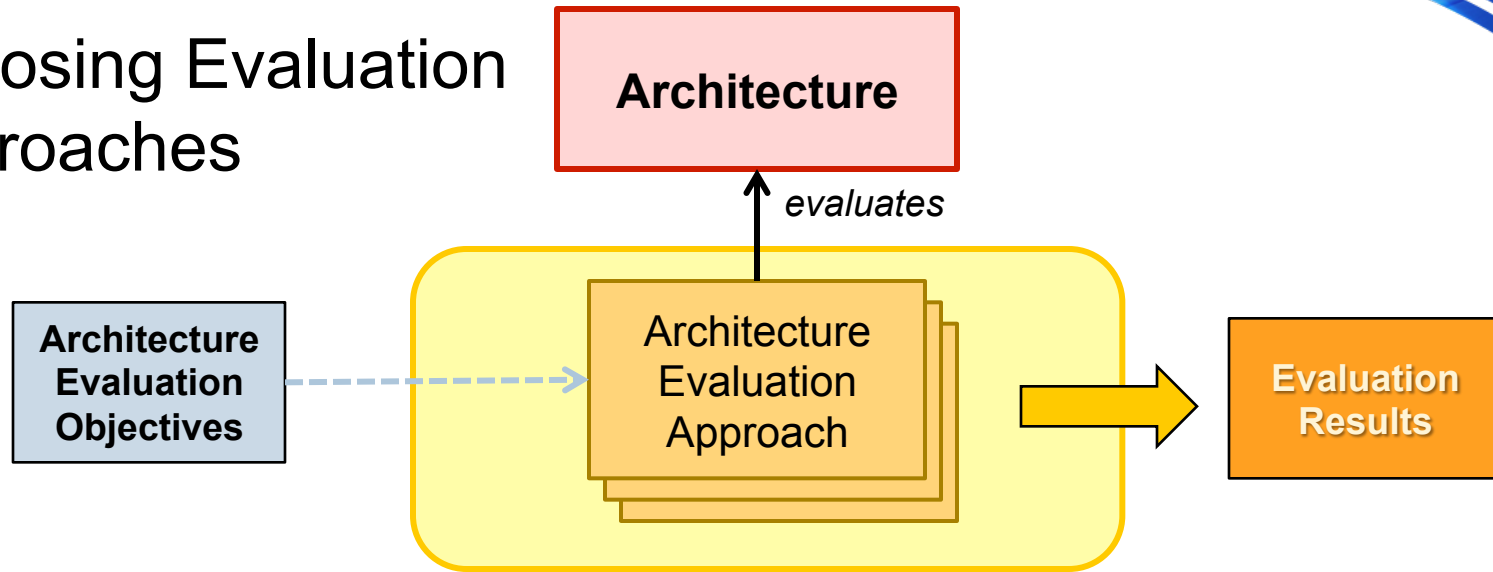Evaluation
Approach

Ways to deal with the architecture to:

➢ determine key characteristics, properties, knowledge or skills

➢ of future, current, or past systems related to that architecture

employs (1 or more)

Value
Assessment
Method

Example approaches:

a) Modeling & Simulation
b) Prototype Demonstration
c) Wargaming Scenarios
d) System Experiment
e) Model Walkthrough
f) Technical Analysis
g) Quality Workshop
h) Compliance Audit
i) Gray Beard Panel
j) Concept Review

employs (0 or more)

Architectural
Analysis
Method

Choosing Evaluation Approaches

- **Evaluation Objectives (example)**

  A. Recommend changes to portfolio of systems and technologies

  B. Recommend architecture studies to be conducted
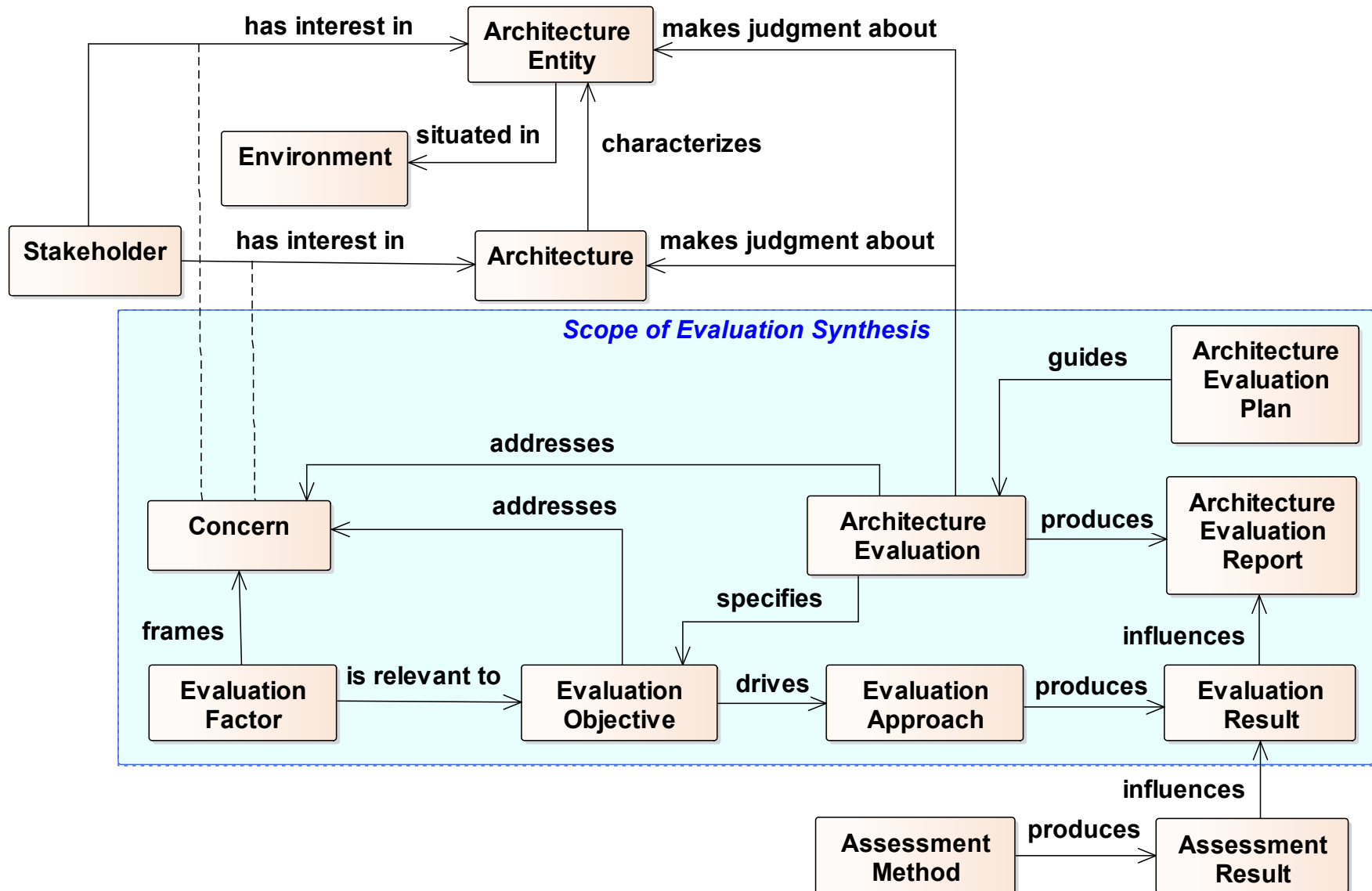
- **Evaluation Approaches (example)**

  1) Modeling & Simulation (performance of current systems)

  2) Prototype Demonstration (benefits of promising technologies)

  3) System Experiment (impact of changing CONOPS)

  4) Concept Review (feedback from key stakeholders after looking at future architecture alternatives and changing conditions & scenarios)

Evaluation Synthesis (Conceptual Model)

Value Assessment
Addressing Stakeholder Concerns

Architecture

evaluates

Architecture Evaluation Approach

employs (1 or more)

Value Assessment Method

employs (0 or more)

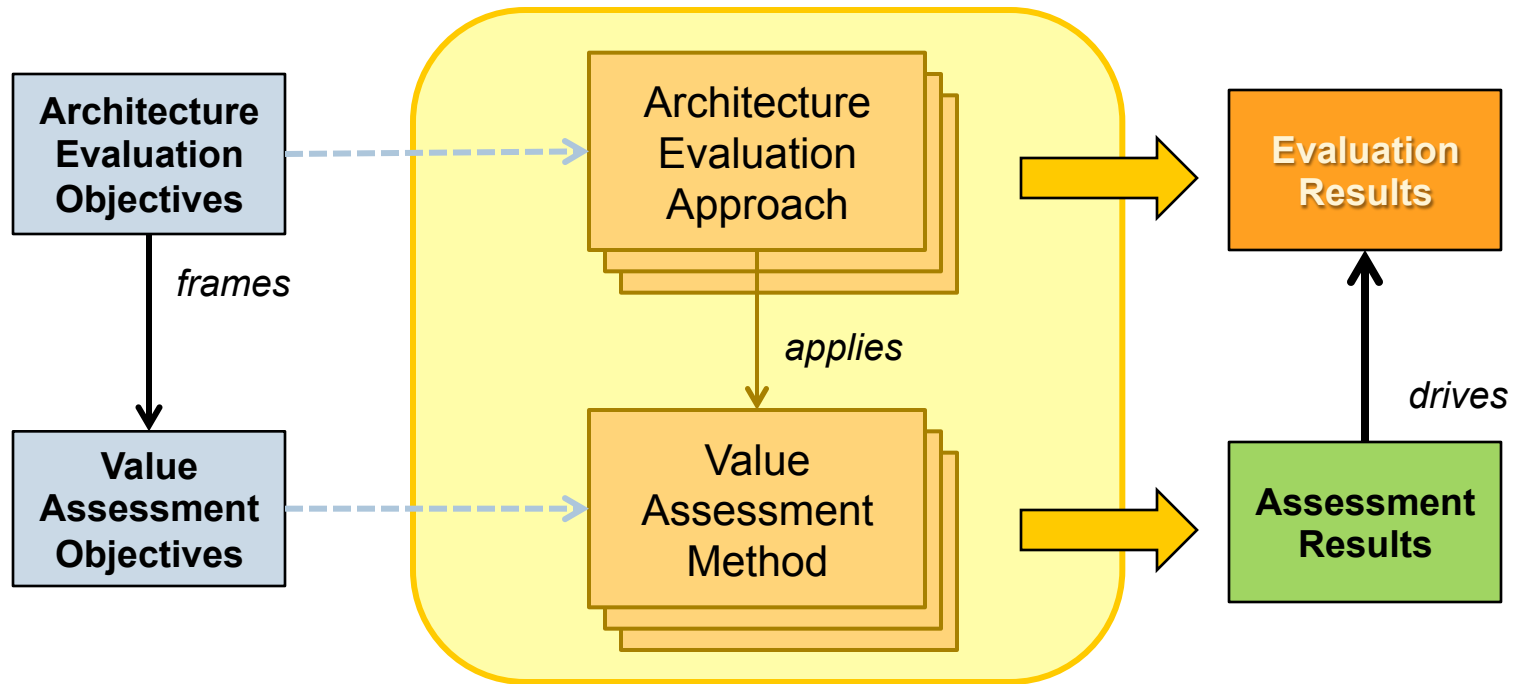Architectural Analysis Method

A systematic way of :

➢ Answering evaluation questions

➢ Determining if key criteria are met & stakeholder concerns are addressed

Example VA Methods:

a) Multi-Attribute Utility Analysis

b) Mission Impact Assessment

c) Environmental Impact Assessment

d) Business Case Analysis

e) Socio-Economic Analysis

f) Strategy-to-Task Analysis

g) User Focus Group Study

h) Customer Survey
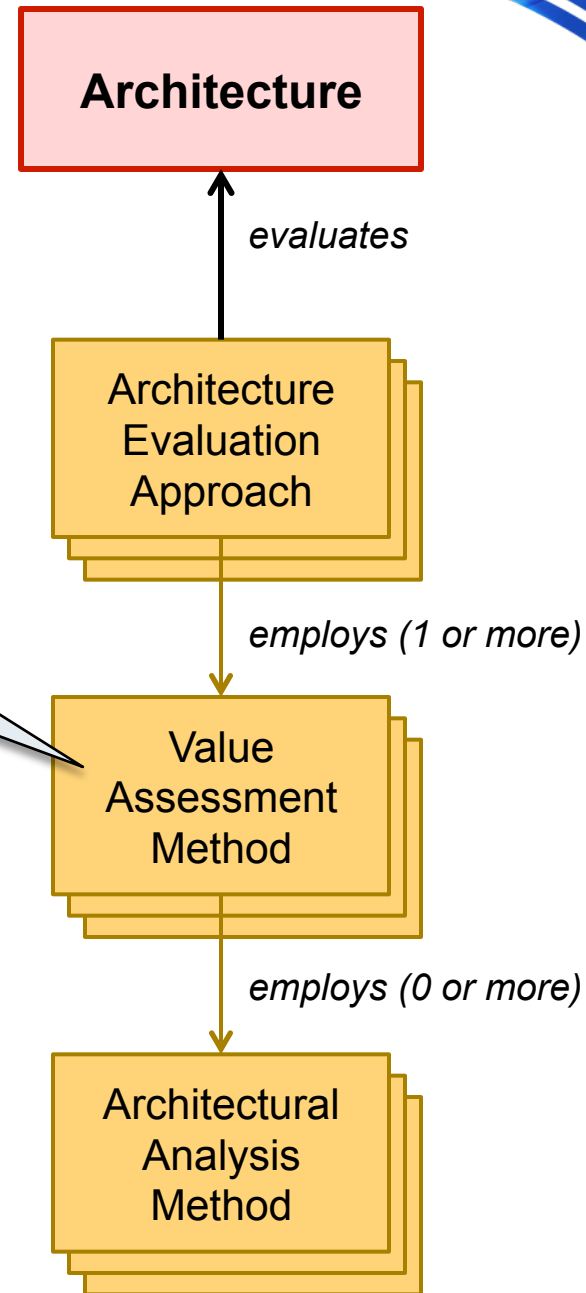
Choosing Value Assessment Methods

- **Evaluation Objectives (example)**

  A. Recommend changes to portfolio of systems and technologies
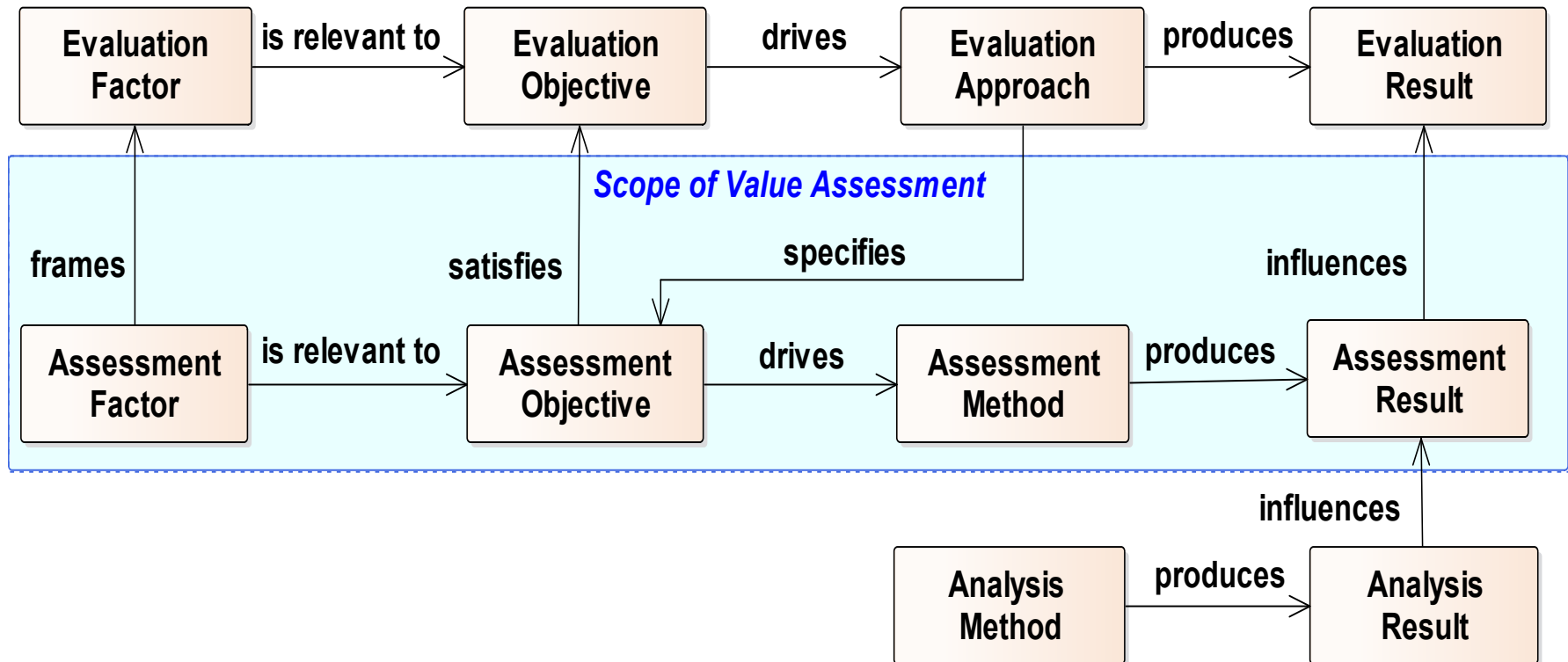
  B. Recommend architecture studies to be conducted

- **Value Assessment Methods (example)**

  A. Mission Impact Assessment

  B. Business Case Analysis

  C. User Focus Group

Evaluation Questions
- Which systems to add, modify, drop?
- Which technologies to adopt?

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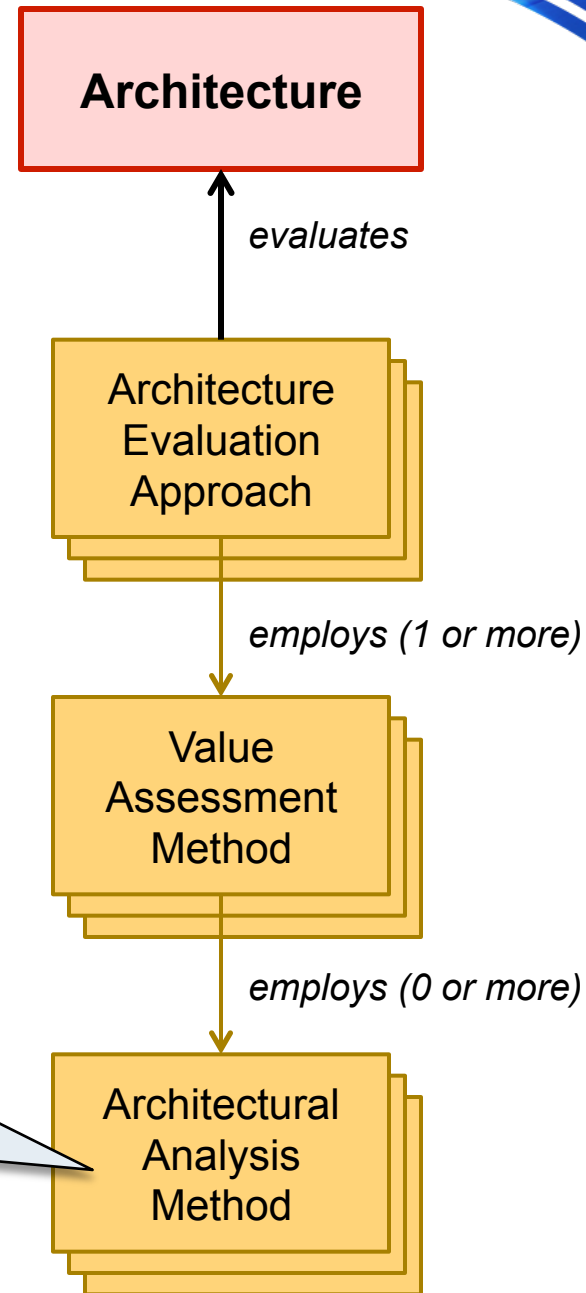# Value Assessment (Conceptual Model)

Architectural Analysis
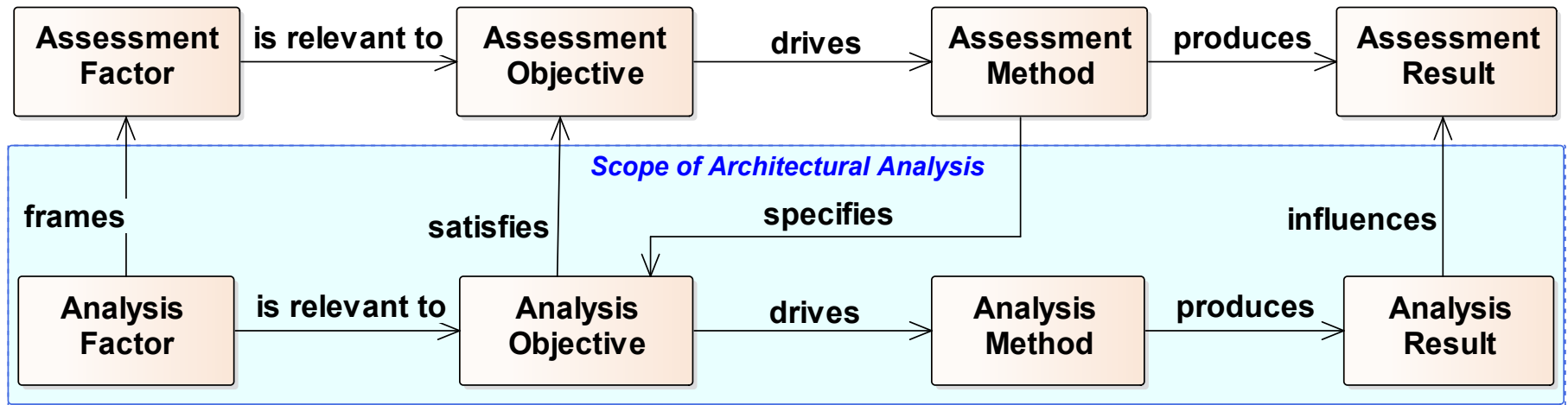## *Measuring architecture features*

Example AA Methods:

a) Functional & Object-oriented Analysis

b) Behavioral & Performance Analysis

c) Cost & Schedule Analysis

d) Risk & Opportunity Analysis

e) Failure Modes, Effects & Criticality Analysis (FMECA)

f) Focus Group Survey

g) Delphi Method

A systematic way of :

➤ Measuring the magnitude of key parameters (eg, along a scale)

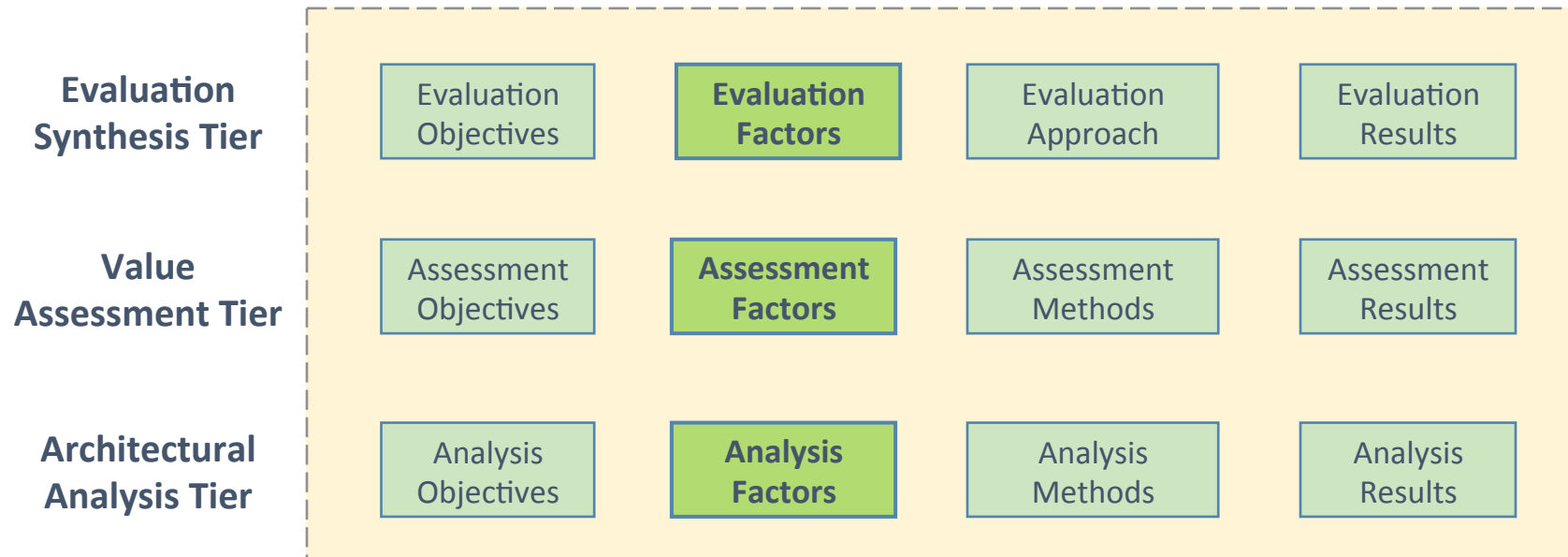➤ Measuring how well key analysis criteria are met

Architecture

evaluates

Architecture Evaluation Approach

employs (1 or more)

Value Assessment Method

employs (0 or more)

Architectural Analysis Method

Architectural Analysis (Conceptual Model)

Evaluation, Assessment & Analysis Factors
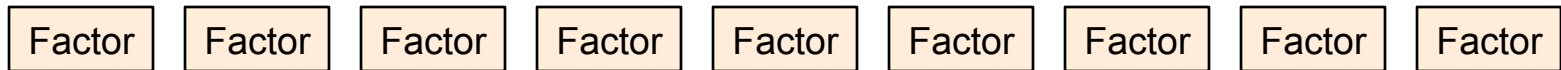
- ***Factor:*** Thing that contributes causally to a Result; A circumstance, fact, or influence that contributes to a Result or an Outcome

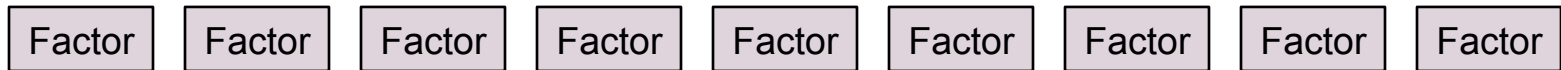|				
Evaluation Synthesis Tier	Evaluation Objectives	**Evaluation Factors**	Evaluation Approach	Evaluation Results
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Factors in each Tier can Help to Systematically Characterize the Problem Space

Evaluation Factors

| Factor | Factor | Factor | Factor | Factor | Factor | Factor | Factor | Factor |

Value Assessment Factors

| Factor | Factor | Factor | Factor | Factor | Factor | Factor | Factor | Factor |

Architectural Analysis Factors

| Factor | Factor | Factor | Factor | Factor | Factor | Factor | Factor | Factor |
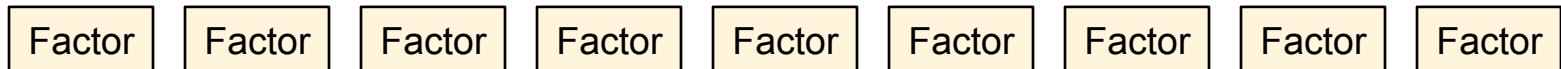
Factors are the things that help discriminate between alternatives or determine what things are important in the evaluation
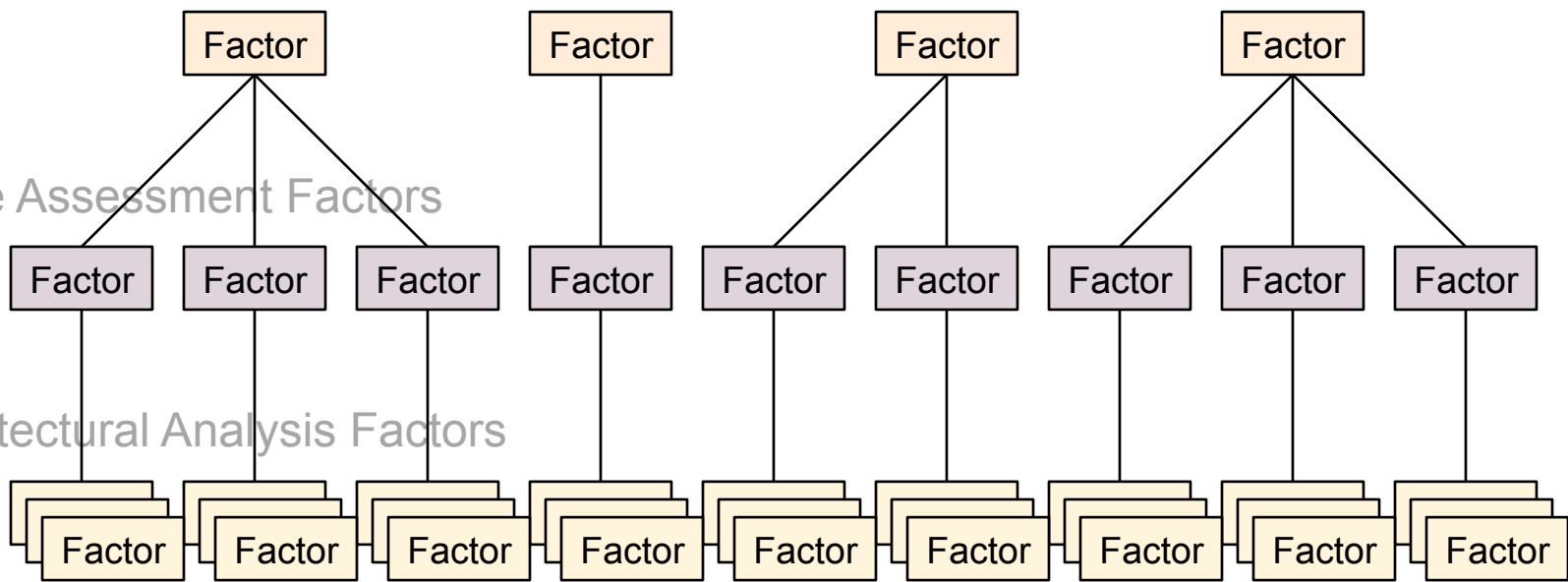
Factors Decomposition (Simple Case)

Evaluation Factors

Value Assessment Factors

Architectural Analysis Factors

These can be found through straight-forward decomposition to build a "Factors Tree" or Hierarchy
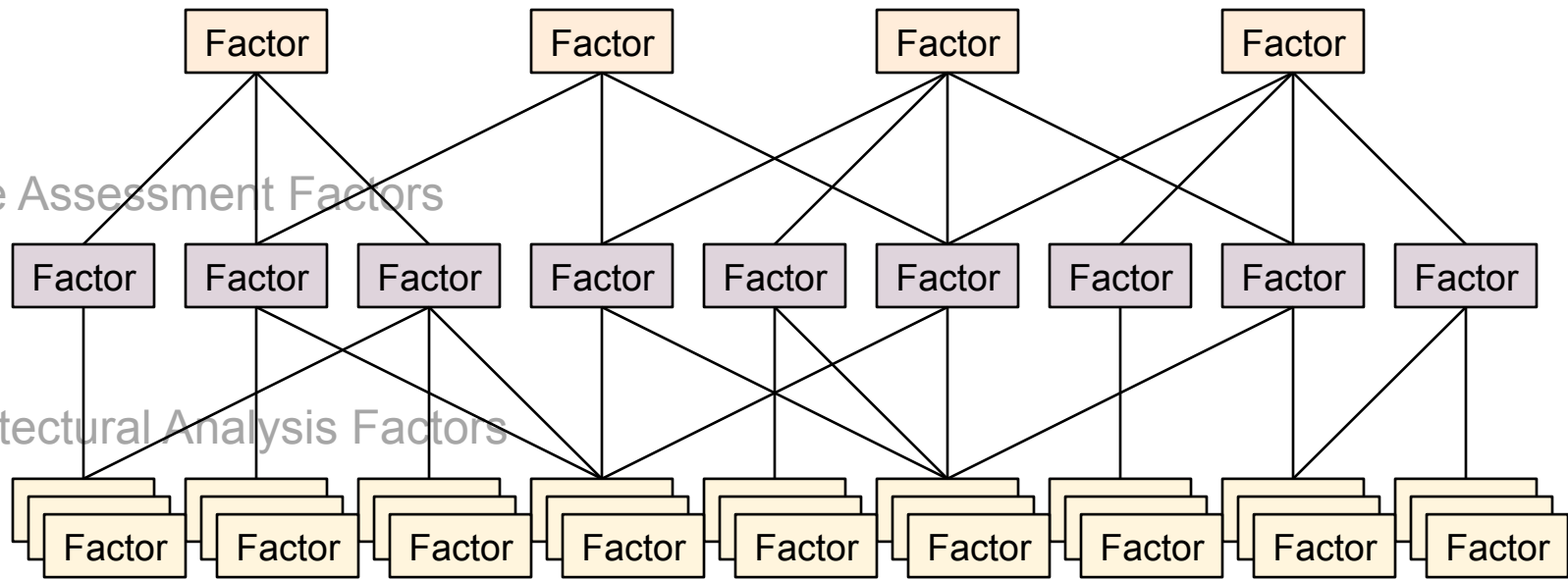
Factors Decomposition (Complex Case)

Evaluation Factors

Value Assessment Factors

Architectural Analysis Factors

A factor can be used by more than one upper tier factor (in a more complex manner) to inform higher tier evaluation results

Factors Decomposition (Multi-Level)
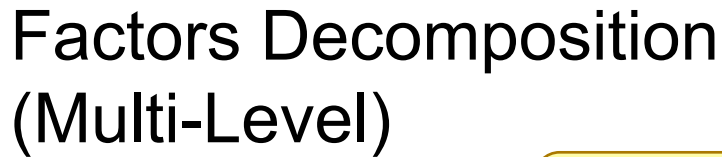
Evaluation Synthesis Factors

Value Assessment Factors

Architectural Analysis Factors

No Analysis Factors needed for this factor. Eg, Value Assessment results directly from subject matter experts.

No Value Assessment needed for this factor. Only used as comparison between other Factors. Or reserved for Decision Maker judgment (eg, "fudge" factor).

Often need to decompose factors into sub-factors to facilitate the analysis or assessment.

Value Assessment vs. Architectural Analysis
What's the difference?

- **Analysis** deals with "what" the system does, how well, how often, when, where, under what conditions,…

  - ➢ But does not deal with Value w.r.t. Stakeholder Concerns
    (where "value" signifies its worth, importance, significance, or quality)

  - ➢ Does not answer the "So What?" question

- **Assessment** deals with the "goodness" of the architecture

  - – *Goodness defined in terms of Stakeholder Concerns*

  - – *Not all concerns are "technical" in nature*

  - – *Can sometimes be "socio-political" factors*

Assessment vs. Analysis

Characteristics	Value Assessment Method	Architectural Analysis Method
Goal Orientation		
Results		
Breadth		
Basis of Work		
Scope		
Focus		
Typical Figures of Merit		
Key Items of Interest		
Primary Questions		

Assessment Characteristics

| Characteristics	Value Assessment Method	Architectural Analysis Method
Goal Orientation	Ends Objectives (often multi-level)	
Results	Passes "judgment"	
Breadth	Single, Unified Activity	
Basis of Work	Synthesis of analysis results	
Scope	Utility, Value, Worth, Priorities, Ranking, Tradeoffs	
Focus	Effectiveness, Efficiencies, Equities	
Typical Figures of Merit	MOE's, ROI, Breakeven Point, Key Success Factors (KSF's)	
Key Items of Interest	Competing Concerns, performing tradeoffs, achieving balance & robustness	
Primary Questions	So what?, Who cares?, What impacts?, Why?, Why not?	

Analysis Characteristics

Characteristics	Value Assessment Method	Architectural Analysis Method
Goal Orientation	Ends Objectives (often multi-level)	Means Objectives (often multi-level)
Results	Passes "judgment"	Matters of Fact
Breadth	Single, Unified Activity	Multiple, Separate Activities
Basis of Work	Synthesis of analysis results	Technical and other analyses
Scope	Utility, Value, Worth, Priorities, Ranking, Tradeoffs	Ways & Means
Focus	Effectiveness, Efficiencies, Equities	Performance determination, Limits identification (bounds)
Typical Figures of Merit	MOE's, ROI, Breakeven Point, Key Success Factors (KSF's)	MOP's, KPP's, TPM's, Quality Metrics
Key Items of Interest	Competing Concerns, performing tradeoffs, achieving balance & robustness	Individual Concerns, determining system properties & characteristics
Primary Questions	So what?, Who cares?, What impacts?, Why?, Why not?	What, where, when, how, how much, how often?

Assessment vs. Analysis

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Basis of Work	Synthesis of analysis results	Technical and other analyses
Scope	Utility, Value, Worth, Priorities, Ranking, Tradeoffs	Ways & Means
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Primary Questions	So what?, Who cares?, What impacts?, Why?, Why not?	What, where, when, how, how much, how often?

Generalized Architecture Evaluation Framework
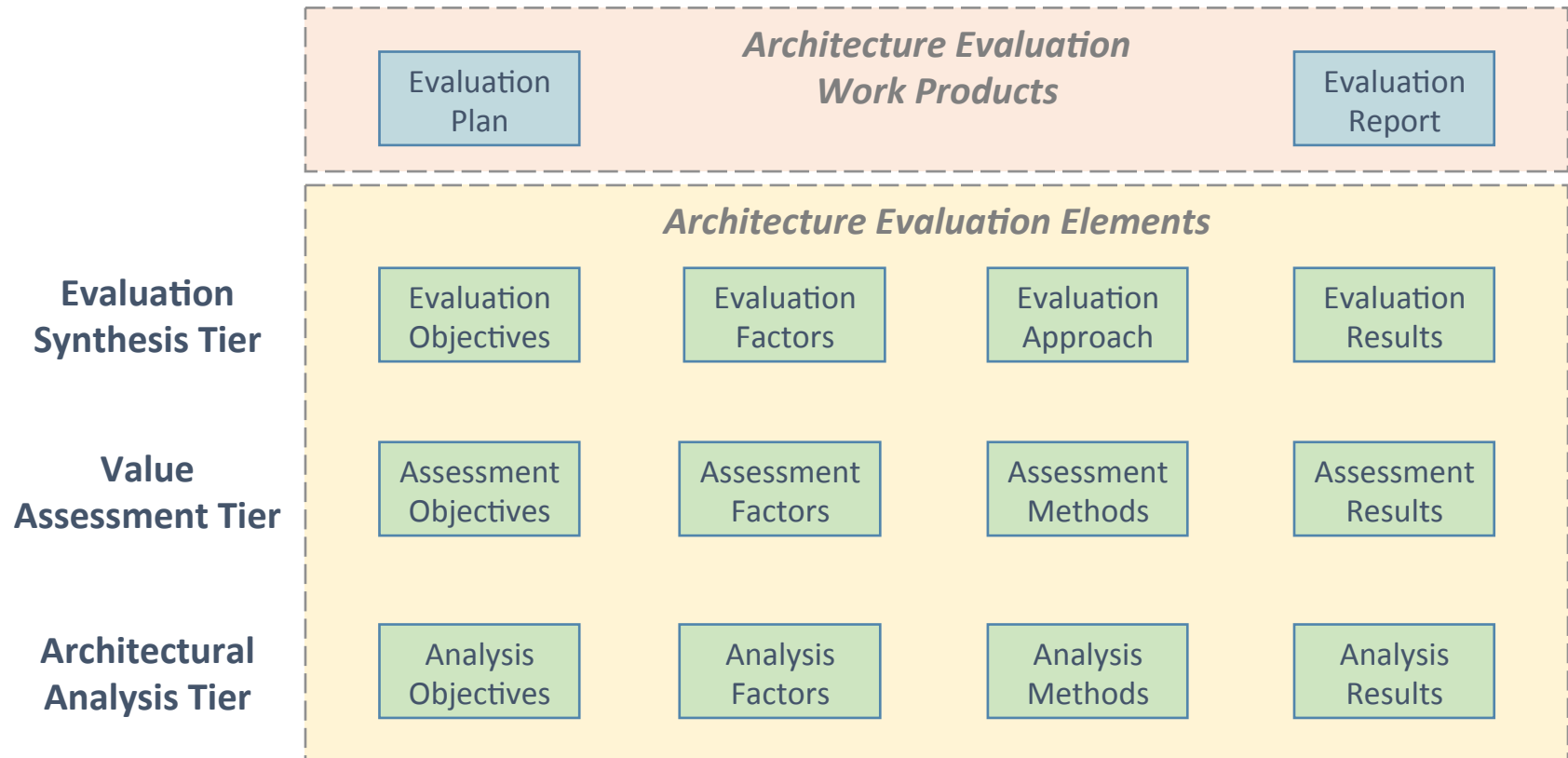
Basis for development of customized frameworks for local adaptation of this standard to enable repeatable evaluation efforts
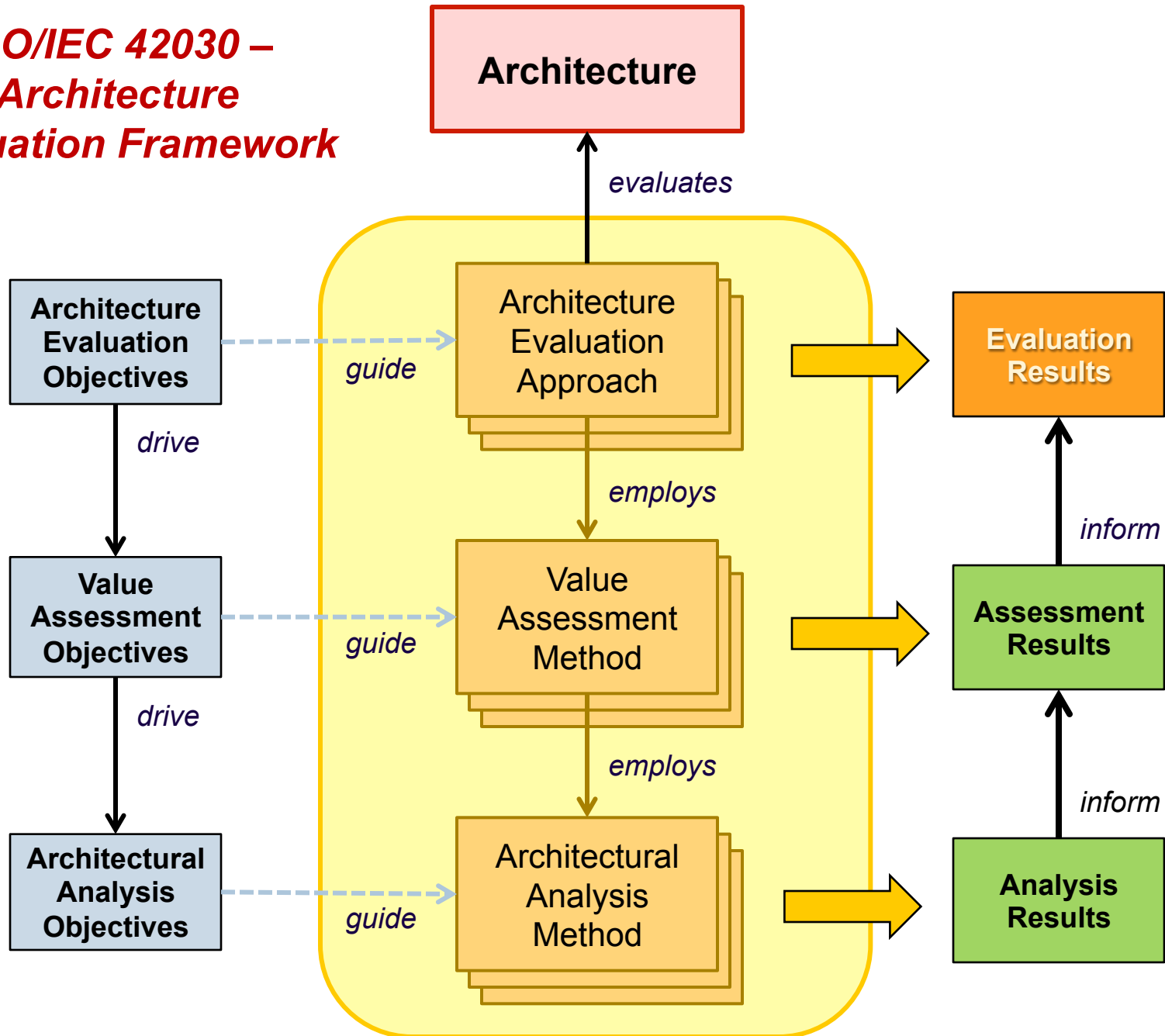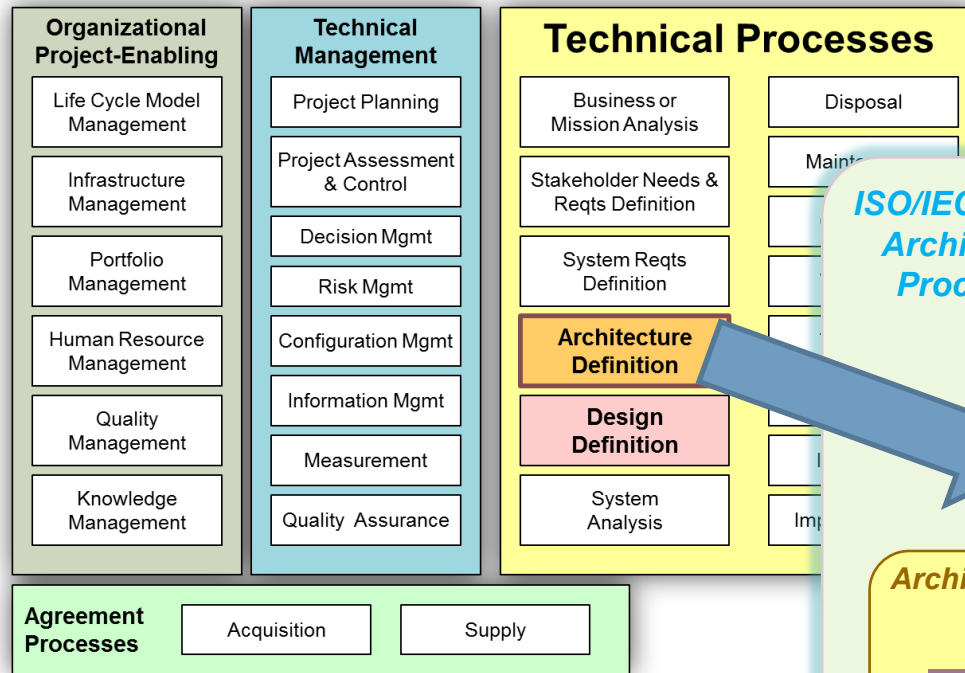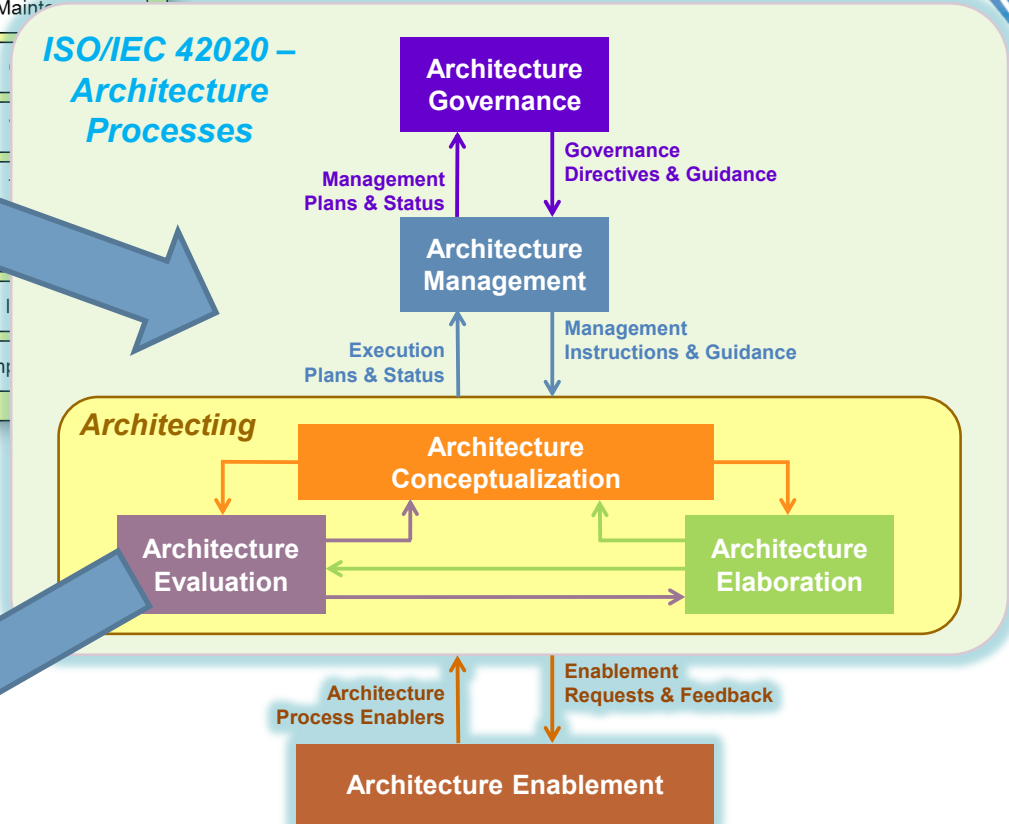
ISO/IEC 42030 – Architecture Evaluation Framework
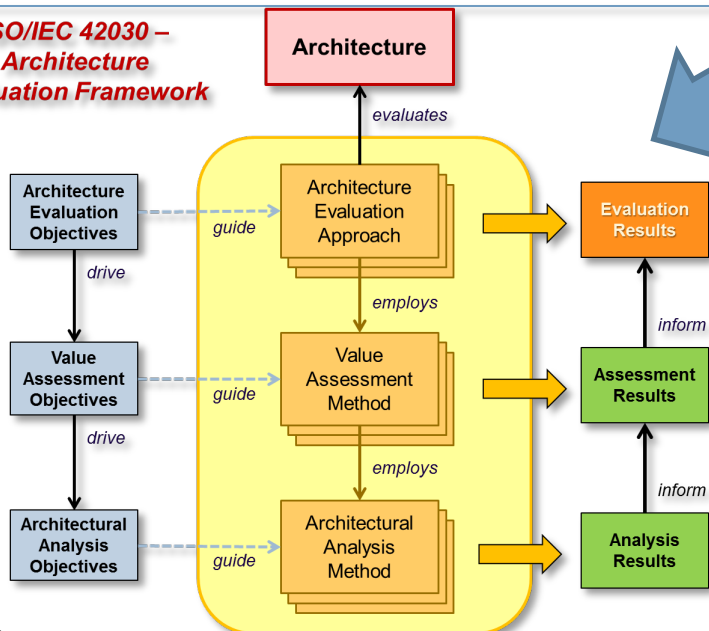
Summary & Conclusions

- Specifies key elements of Architecture Evaluation
  - *But does <u>not specify the process </u>for doing it*
  - *Compatible with the process in ISO 42020 standard*

- Can improve the effectiveness & efficiency of Architecture Evaluation efforts

- Standard can be a useful benchmark for assessing quality of your own Architecture Evaluation practices

Stakeholders & their Concerns should Drive the Architecture

```
Stakeholders --have--> Concerns --correspond to--> Viewpoints
Concerns --about--> System
System --support--> Missions
Viewpoints --specify--> Views (or Models)
System --characterized by--> Architecture
Views (or Models) --depict--> Architecture
Architecture --provides capabilities for--> Missions
```
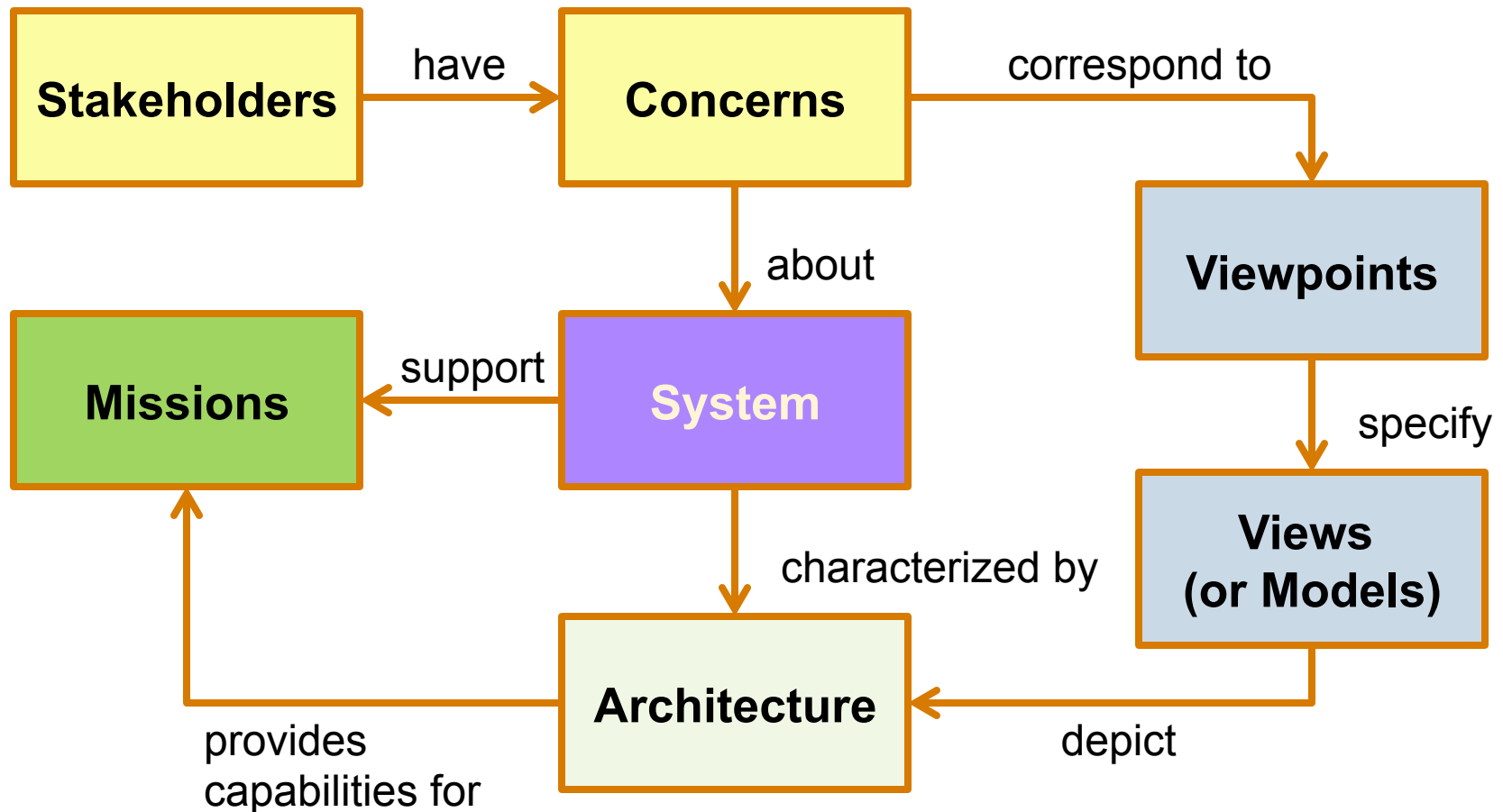
Stakeholders & Concerns

- **Example Stakeholders:** users, operators, maintainers, owners, sponsors, acquirers, developers, builders, integrators, suppliers, industrial base, labor force, third parties (eg, environmental impacts), evaluators, policy makers, certification authorities, auditors, etc.

- **Example Concerns:** affordability, agility, alignment with business goals and strategies, assurance, autonomy, availability, behaviour, business impact, capability, complexity, compliance to regulation, concurrency, control, cost, customer experience, data accessibility, deadlock, disposability, evolvability, feasibility, flexibility, functionality, information assurance, interoperability, inter-process communication, known limitations, maintainability, mission impact, misuse, modifiability, modularity, openness, performance, privacy, quality of service, reliability, resilience, resource utilization, schedule, security, shortcomings, state change, structure, subsystem integration, system features, system properties, system purposes, usability, usage, viability, etc.

Evaluation Taxonomy
Evaluation Approaches & Methods

Evaluation
Objectives

Evaluation
Plan

defines

identifies

Evaluation
Approach

Evaluation
Approach

Evaluation
Approach

applies

Value
Assessment
Method

Value
Assessment
Method

Value
Assessment
Method

invokes

Architectural
Analysis
Method

Architectural
Analysis
Method

Architectural
Analysis
Method
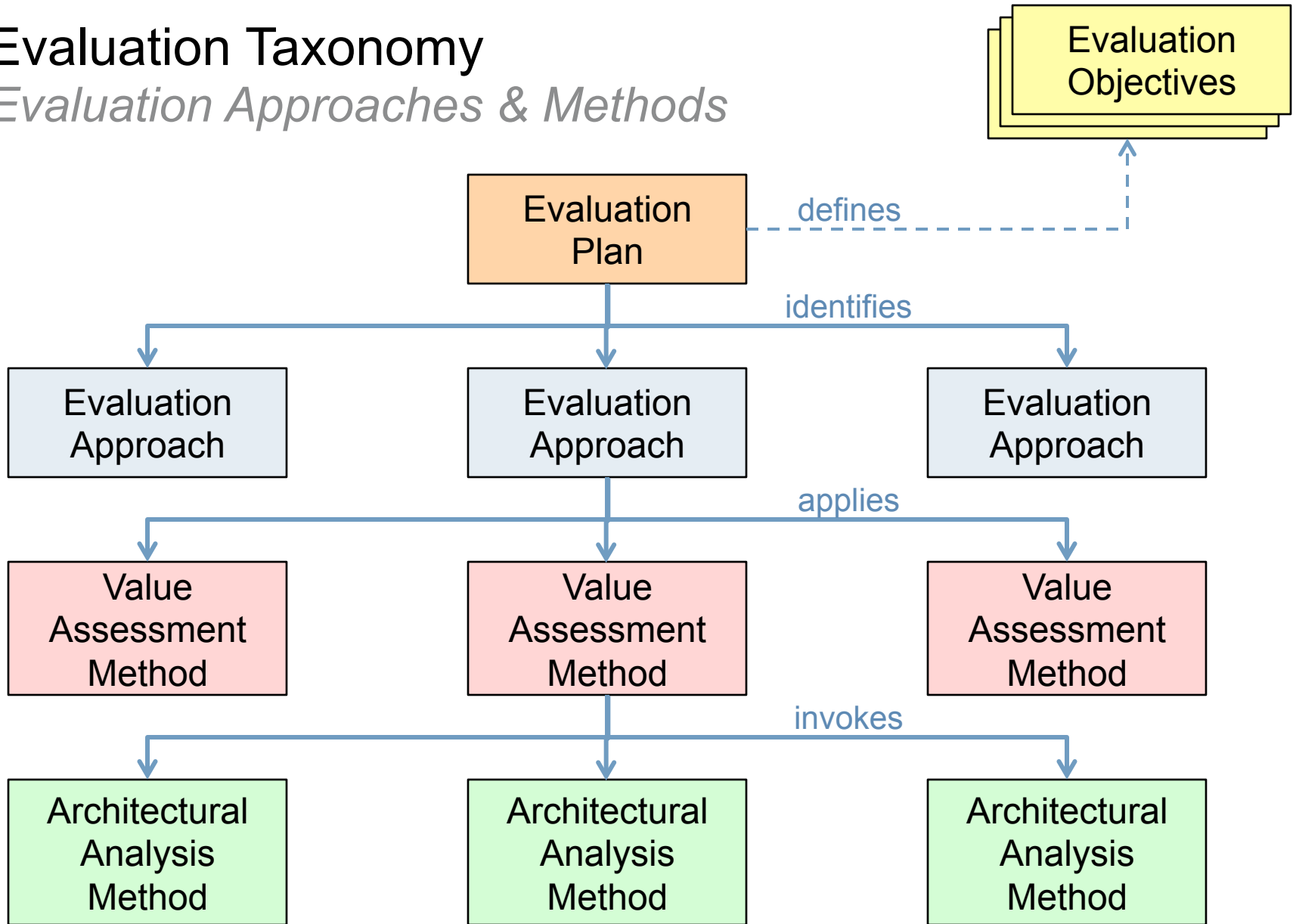
Evaluation Taxonomy (Example)
Business Impact Methods

Evaluation Objectives

Evaluation Plan

- **Mission Impact-Cost Ratio (max)**
- **Business Impact-Cost Ratio (max)**
- **Environmental Impact (min)**

Evaluation Approach — System Experiment

Evaluation Approach — Modeling & Simulation

Evaluation Approach — Prototype Demonstration

Value Assessment Method — Environmental Impact

Value Assessment Method — Mission Impact

Value Assessment Method — *Business Impact*

Architectural Analysis Method — Cost & Schedule

Architectural Analysis Method — Risk & Opportunity

Architectural Analysis Method — Return on Investment

Evaluation Taxonomy (Example)
Mission Impact Methods

Evaluation Objectives

Evaluation Plan

- **Mission Impact-Cost Ratio (max)**
- **Business Impact-Cost Ratio (max)**
- **Environmental Impact (min)**

Evaluation Approach — **System Experiment**

Evaluation Approach — **Modeling & Simulation**

Evaluation Approach — **Prototype Demonstration**

Value Assessment Method — **Environmental Impact**

Value Assessment Method — *Mission Impact*

Value Assessment Method — **Business Impact**

Architectural Analysis Method — **Performance Analysis**

Architectural Analysis Method — **Failure Analysis**

Architectural Analysis Method — **User Satisfaction**

Architecture Features (Examples)

```
                    ┌──────────────┐         ╔═══════════╗
                    │    Value     │  ───▶   ║  Mission  ║
                    │ Assessment   │         ║  Impact   ║
                    │   Method     │         ╚═══════════╝
                    └──────┬───────┘
         ┌─────────────────┼─────────────────┐
         ▼                 ▼                 ▼
```

Architectural Analysis Method	Architectural Analysis Method	Architectural Analysis Method
Performance Analysis	**Failure Analysis**	**User Satisfaction**

• Speed	• Reliability (MTBF)	• Timeliness
• Accuracy	• Repairability (MLDT)	• Relevance
• Resolution	• Maintainability (MTTR)	• Integrity
• Duty cycle	• Operational Availability	• Accessibility
• Quantity per Day	• Failure Recovery Rate	• Dependability
• Probability of Detection		

Architecting & Engineering –
Two Sides of the Same Problem

Collective vision, goals, constraints, conditions, challenges & other concerns of stakeholders

Architecting
Synthesis of Form

Iteratively compose separate elements to form a coherent whole

Architectural Objectives

Critical Point

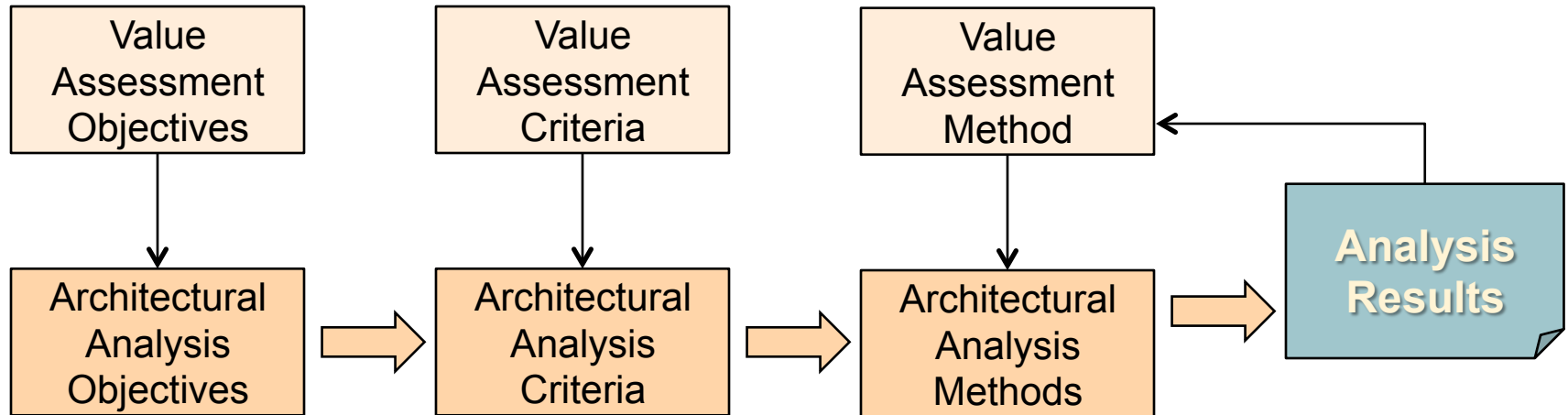**Engineering Requirements**

Analysis of Function
Engineering

Iteratively decompose and separate a primarily functional representation of a whole

Representations of economically producible components that can be assembled to construct the functional whole
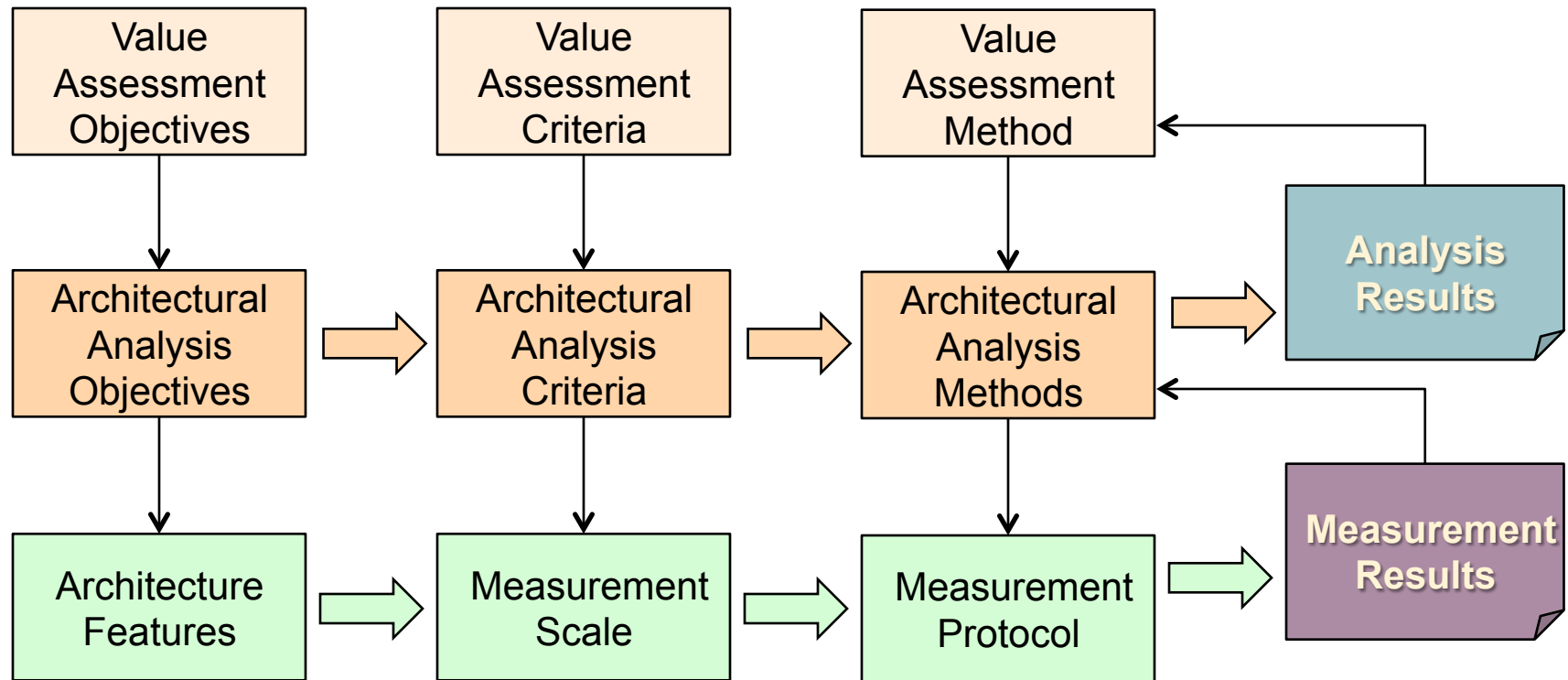
Architectural Analysis Methods
Providing information that feeds Value Assessment

Measurement Scales & Protocols
Determining the magnitude of architectural attributes

Summary & Conclusions

- Specifies key elements of Architecture Evaluation
  - *But does <u>not specify the process </u>for doing it*
  - *Compatible with the process in ISO 42020 standard*

- Can improve the effectiveness & efficiency of Architecture Evaluation efforts

- Standard can be a useful benchmark for assessing quality of your own Architecture Evaluation practices