COMP3029J
Software Architecture
Software Architecture Evaluation

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Outline

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Outline

Software Architecture Evaluation - Why

- **Early detection of problems with the existing architecture**
  - The earlier in the life cycle that problems are detected, the cheaper it is to fix them

- **Validation of requirements**
  - Architecture evaluations uncover the conflicts and trade-offs, and provide a forum for their negotiated resolution

- **Forced preparation for the review**
  - Many systems do not have an architecture that is understandable to all developers. The process of preparing for the evaluation will reveal many of these problems

- **Improved architectures**

Software Architecture Evaluation - Method

- **Scenario-based Architecture Analysis Method (SAAM)**
  - This was probably the first documented software architecture analysis method and was originally developed to analyze an architecture for modifiability. However, it is useful for analyzing any nonfunctional aspect of an architecture. It is founded on the use of stakeholder-generated scenarios to assess an architecture.

Software Architecture Evaluation - Method

- **Architecture Trade-off Analysis Method (ATAM)**
  - This is a successor of SAAM and is also gaining widespread use.
  - This method incorporates quality attribute utility trees and quality attribute categories in the analysis of an architecture.
  - Whereas SAAM does not explicitly address the interactions between quality attributes, ATAM does. Thus, the trade-offs are with respect to competing quality attributes.
  - ATAM is a specialization of SAAM, specifically focusing on modifiability, performance, availability, and security.

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Software Architecture Evaluation - Method

- **SAAM Founded on Complex Scenarios (SAAMCS)**
  - This method considers the complexity of evaluation scenarios as the most important risk assessment factor

- **Extending SAAM by Integration in the Domain (ESAAMI)**
  - This method integrates SAAM with domain-specific and reuse-based software development processes

- **Software Architecture Analysis Method for Evolution and Reusability (SAAMER)**
  - This method focuses specifically on the quality attributes of evolution（演化） and reusability

Software Architecture Evaluation - Method

- **Scenario-Based Architecture Reengineering (SBAR)**
  - This method utilizes scenarios, simulation（仿真）, mathematical modeling, and experience-based reasoning（基于经验的推理） for assessing quality attributes. This method also incorporates an architecture design method.

- **Architecture Level Prediction of Software Maintenance（ALPSM）**
  - This is another method for analyzing maintainability using scenarios, called change scenarios, which represent maintenance tasks.（体系结构级别上的软件维护预测）

- **Software Architecture Evaluation Model (SAEM）**
  - This method is based on formal and rigorous（严格精确的） quality requirements.

Outline

ATAM - Introduction

- **The ATAM is a method that helps stakeholders ask the right questions to discover potentially problematic architectural decisions.**

- **Tradeoffs（折衷） can be explicitly identified and documented.**

- **Discovered risks can then be made the focus of mitigation（减轻） activities: e.g. further design, further analysis, prototyping.**

ATAM - Target

- The purpose of the ATAM is NOT to provide precise analyses . . . the purpose IS to discover risks created by architectural decisions.

- We want to find trends: correlation between architectural decisions and predictions of system properties.

ATAM - Benefits

- **There are a number of benefits from performing ATAM evaluations**
  - identified risks
  - clarified quality attribute requirements
  - improved architecture documentation
  - documented basis for architectural decisions
  - increased communication among stakeholders

- **The results are improved architectures.**

ATAM – Evaluation Teams

- **Evaluation teams**
  - Each evaluation team consists of a leader and at least three other team members.
  - ATAM team members must be experienced architects.
  - ATAM leaders must have excellent communication and facilitation skills.

- **Project decision maker**
  - A person who can control the program development process and authorize changes
  - Usually includes project managers, users who pay for development, and architect developers

ATAM – Evaluation Teams

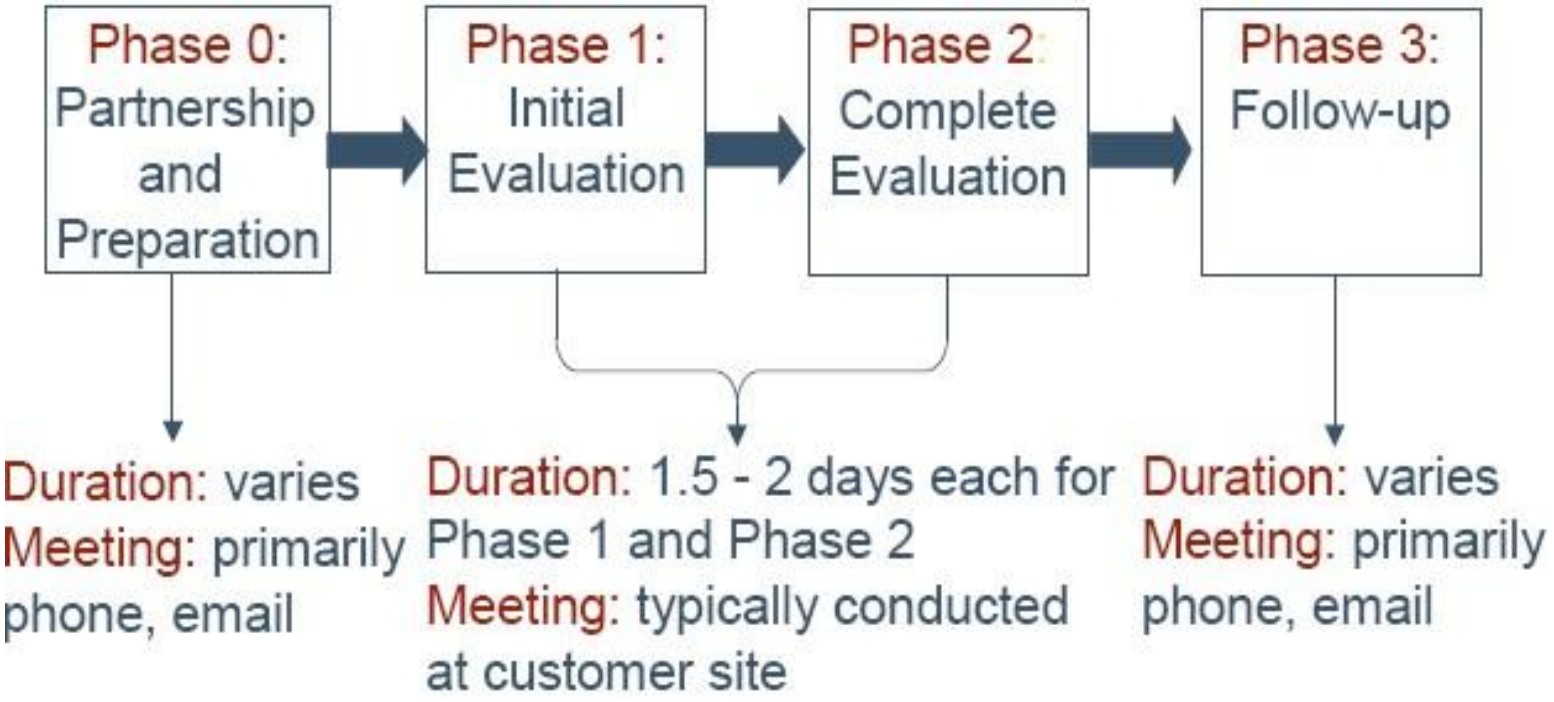
- **Architecture Stakeholders**
  - Stakeholders are everything and everyone related to the system to be developed.
  - The degree to which the architecture supports quality attributes such as modifiability and security will directly affect the normal work of stakeholders.
  - Stakeholders are not equal to users. Users in the usual sense refer to users of the system, which are only part of the stakeholders.
  - Stakeholders typically include developers, testers, integrators, system maintainers, performance engineers, users, and more.

ATAM – Evaluation Teams

角色	职责	理想的人员素质
评估小组负责人	准备评估…	善于协调…
评估负责人	负责评估工作…	能在众人面前表现自如…
场景书记员	将场景写到活动挂图上…	未搞清楚某个问题之前坚持要求继续进行讨论…
进展书记员	记录评估进展情况…	对构架理解透彻，能融会贯通快速理解技术问题
计时员	帮助评估负责人保证评估工作按时进行；…	勇于不顾情面中断讨论，宣布时间已到
过程观察员	记录如何改进评估过程或评估如何偏离了原计划…	善于观察和发现问题；熟悉评估过程…
过程监督者	帮助评估负责人记住并执行评估方法的各个步骤	对评估方法的各个步骤非常熟悉；….
提问者	提出涉众或许未曾想到的关于构架的问题	对构架有出色的见解；对涉众需要有敏锐的洞察力…

ATAM – Evaluation Phases

- **ATAM evaluations are conducted in four phases**

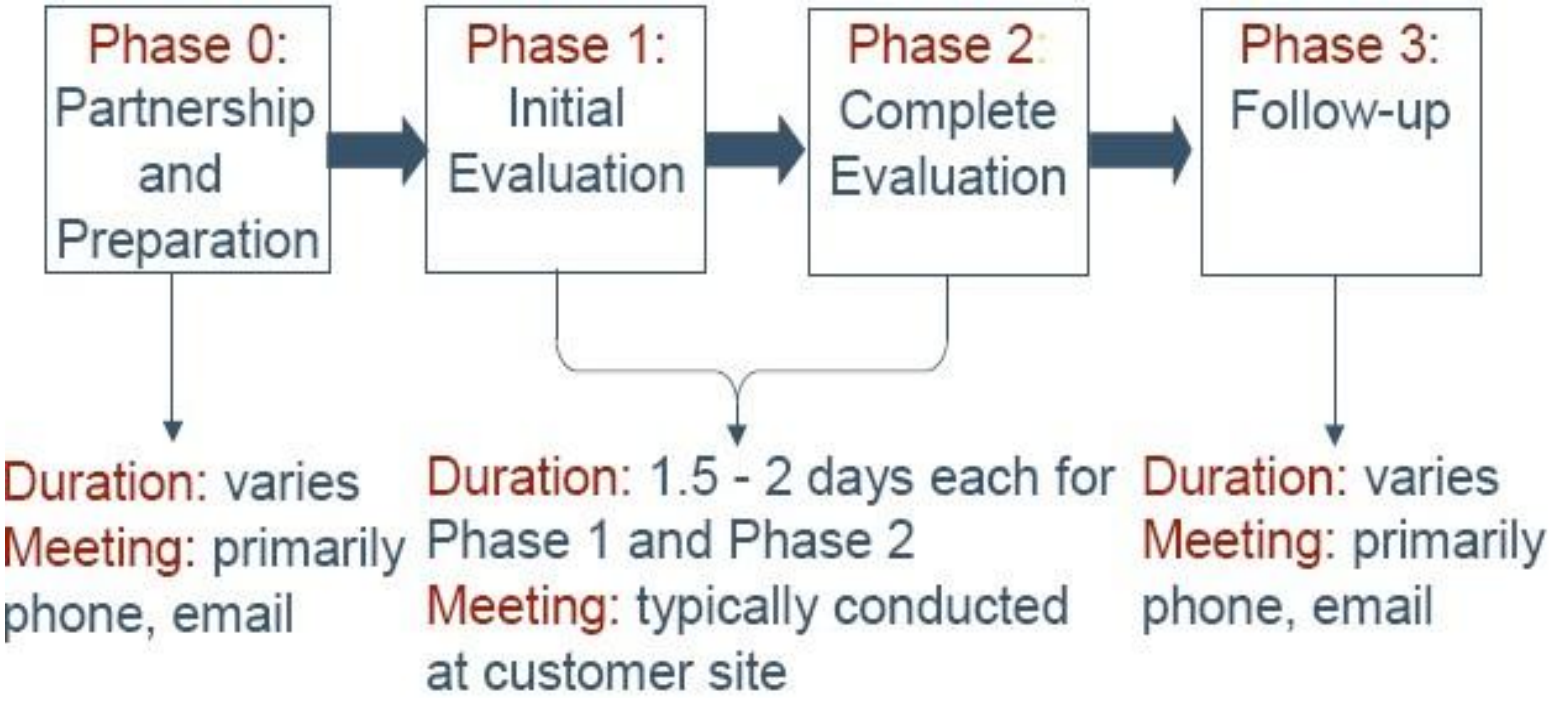


ATAM – Evaluation Phase 0

- **Phase 0: this phase precedes the technical evaluation**
  - The customer and a subset of the evaluation team exchange understanding about the method and the system whose architecture is to be evaluated.
  - An agreement to perform the evaluation is worked out.
  - A core evaluation team is fielded（登场）.

ATAM – Evaluation Phases

- **ATAM evaluations are conducted in four phases**



ATAM – Evaluation Phase 1

- **Phase 1: focused on eliciting detailed architectural information and analyzing it**

  - involves a small group of predominantly technically-oriented stakeholders

  - architecture centric

  - top down analysis

ATAM – Evaluation Phase 1

1. Present the ATAM
2. Present business drivers
3. Present architecture
4. Identify architectural approaches
5. Generate quality attribute utility tree
6. Analyze architectural approaches

Phase 1

7. Brainstorm and prioritize scenarios
8. Analyze architectural approaches
9. Present results

ATAM – Evaluation Phase 1

1. The evaluation team presents an overview of the ATAM

- **ATAM steps in brief**
- **Techniques**
  - utility tree（效用树） generation
  - architecture elicitation and analysis
  - scenario brainstorming/mapping
- **Outputs**
  - architectural approaches
  - utility tree and scenarios
  - risks, non-risks, sensitivity points, and trade-offs

ATAM – Evaluation Phase 1

2. The customer describes business drivers of the system.

- **business context for the system**
- **high-level functional requirements**
- **high-level quality attribute requirements**
  - architectural drivers: quality attributes that “shape” the architecture
  - critical requirements: quality attributes most central to the system’s success

ATAM – Evaluation Phase 1

3. Designer presents an overview of the architecture design.

- **technical constraints such as an OS, hardware, or middleware prescribed for use**
- **other systems with which the system must interact**
- **architectural approaches used to address quality attribute requirements**

ATAM – Evaluation Phase 1

4. Identify core architectural approaches.

- client-server
- 3-tier
- Event dispatcher mechanism
- publish-subscribe
- redundant hardware

The evaluators begin to identify places in the architecture that are key to realizing quality attribute goals.

ATAM – Evaluation Phase 1

5. Identify, prioritize, and refine the most important quality attribute goals by building a utility tree.

Utility Tree

A utility tree is a top-down vehicle for characterizing and prioritizing the "driving" attribute-specific requirements.

（效用树是一个自顶向下的工具，用来刻画重要的需求）

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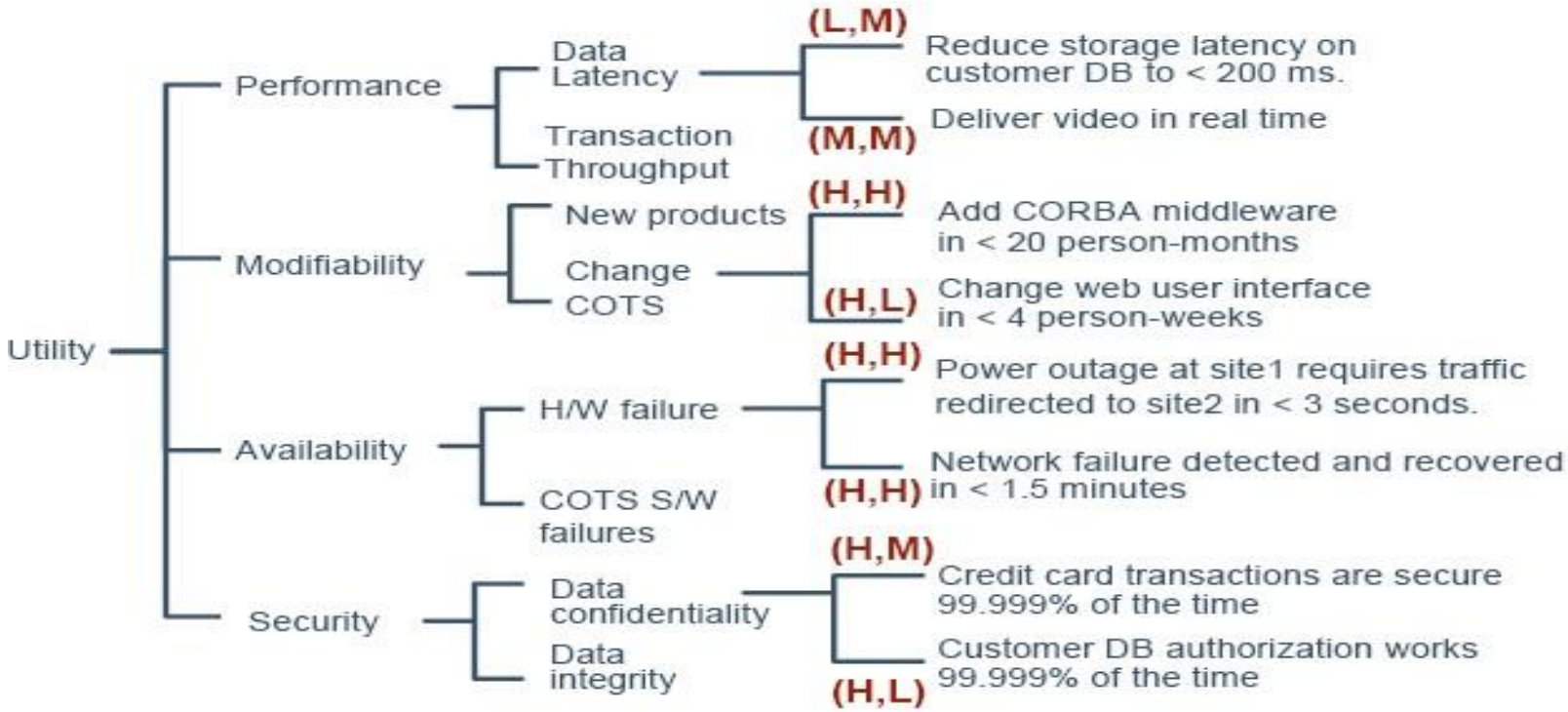
ATAM – Evaluation Phase 1 - Utility Tree

- **The driving quality attributes are the high-level nodes (typically performance, modifiability, security, and availability).**
- **Scenarios are the leaves of the utility tree.**



Output：a characterization and a prioritization of specific quality attribute

ATAM – Evaluation Phase 1

Stimulus, Environment, Responses

- **Use Case Scenario**
  - Remote user requests a database report via the Web during peak period and receives it within 5 seconds.
- **Growth Scenario**
  - Add a new data server to reduce latency in scenario 1 to 2.5 seconds within 1 person-week.
- **Exploratory Scenario**
  - Half of the servers go down during normal operation without affecting overall system availability.

ATAM – Evaluation Phase 1

6. Evaluation team probes architectural approaches from the point of view of specific quality attributes to identify risks.

- **identify the architectural approaches**
- **ask quality attribute specific questions for highest priority scenarios**
- **identify and record risks and non-risks, sensitivity points and tradeoffs**

ATAM – Sensitivity Point

Risks, Tradeoffs, Sensitivities, Non-Risks

- **A sensitivity point is a property of one or more components (and/or component relationships) that is critical for achieving a particular quality attribute response.**

  - "The level of confidentiality in a virtual private network might be sensitive to the number of bits of encryption. "

ATAM – Tradeoff Point

Risks, Tradeoffs, Sensitivities, Non-Risks

- **A tradeoff point is a property that affects more than one attribute and is a sensitivity point for more than one attribute.**

  - "Changing the level of encryption could have a significant impact on both security and performance."

ATAM – Risks

Risks, Tradeoffs, Sensitivities, Non-Risks

- **A risk is a potentially problematic architectural decision.**
  - "The level of confidentiality in a virtual private network might be sensitive to the number of bits of encryption. "

ATAM – Non-Risks

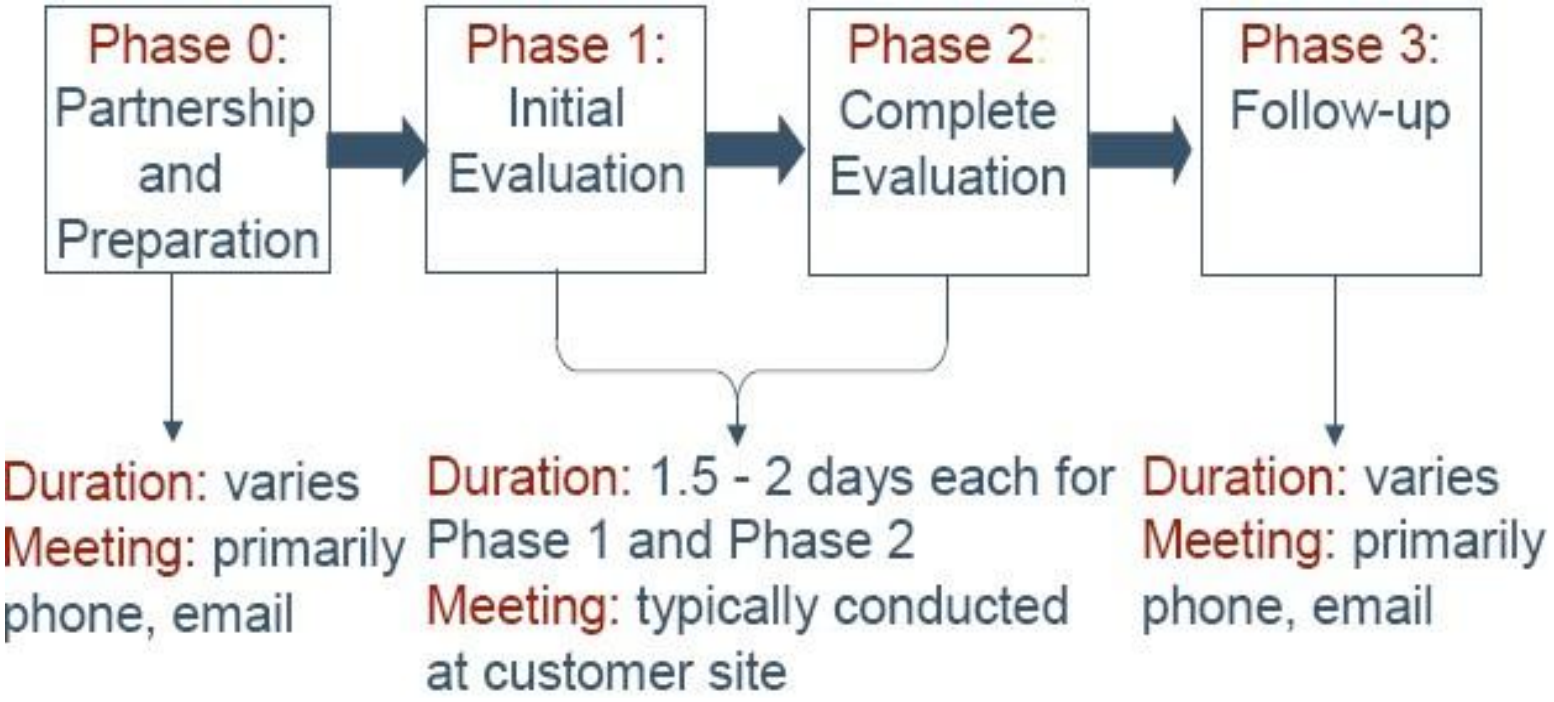
Risks, Tradeoffs, Sensitivities, Non-Risks

- **Non-risks are good architectural decisions that are deemed safe upon analysis.**

  - "Assuming message arrival rates of once per second, a processing time of less than 30 ms, and the existence of one higher priority process, a 1 second soft deadline seems reasonable."

ATAM – Evaluation Phases

- **ATAM evaluations are conducted in four phases**



ATAM – Evaluation Phase 2

1. Present the ATAM
2. Present business drivers
3. Present architecture
4. Identify architectural approaches
5. Generate quality attribute utility tree
6. Analyze architectural approaches

Recap Phase 1

Phase 2

7. Brainstorm and prioritize scenarios
8. Analyze architectural approaches
9. Present results

Do this

ATAM – Evaluation Phase 2

- **Phase 2: involves a larger group of stakeholders**
- **Phase 2 is**
  - stakeholder centric
  - focused on eliciting diverse stakeholder points of view and on verification of the Phase 1 results.
- **How?**
  - Stakeholders generate scenarios using a facilitated brainstorming process. Scenarios at the leaves of the utility tree serve as examples to facilitate the step.

ATAM – Evaluation Phase 2

7. Stakeholders generate scenarios using a facilitated brainstorming process.

- **Scenarios at the leaves of the utility tree serve as examples to facilitate the step.**

Phase 2: Brainstormed Scenarios		
Scenario Number	**Scenario Text**	**Number of Votes**
2	Changes to the CAAS are reflected in the simulation and training system concurrently with the airframe changes, without coding it twice (simulation and training stakeholder).	5
3	No single point of failure in the system will affect the system's safety or performance (system architect stakeholder).	10
5	Multiple versions of the system must be fielded at the same time. Those versions should be distinguishable and should not have a negative impact on the rest of the system (system implementer stakeholder).	1
9	75% of the CAAS is built from reused components increasing new business opportunities (from Phase 1, program manager stakeholder).	9
13	Given maximum "knob twiddling" to the level that the system's performance is degraded, the system can prioritize its flight-critical functions, so they are NOT degraded (safety stakeholder).	6
15	Given the need for a second ARC231, the radio can be incorporated into the existing system by reusing existing software at minimal or no cost (requirements stakeholder).	2
20	An application doesn't crash, but starts producing bad data. The system can detect the errant data and when applications crash (reliability stakeholder).	3

ATAM – Evaluation Phase 2

8. Identify the architectural approaches impacted by the scenarios generated in the previous step.

- **This step continues the analysis started in step 6 using the new scenarios.**
- **Continue identifying risks and non-risks.**
- **Continue annotating architectural information.**

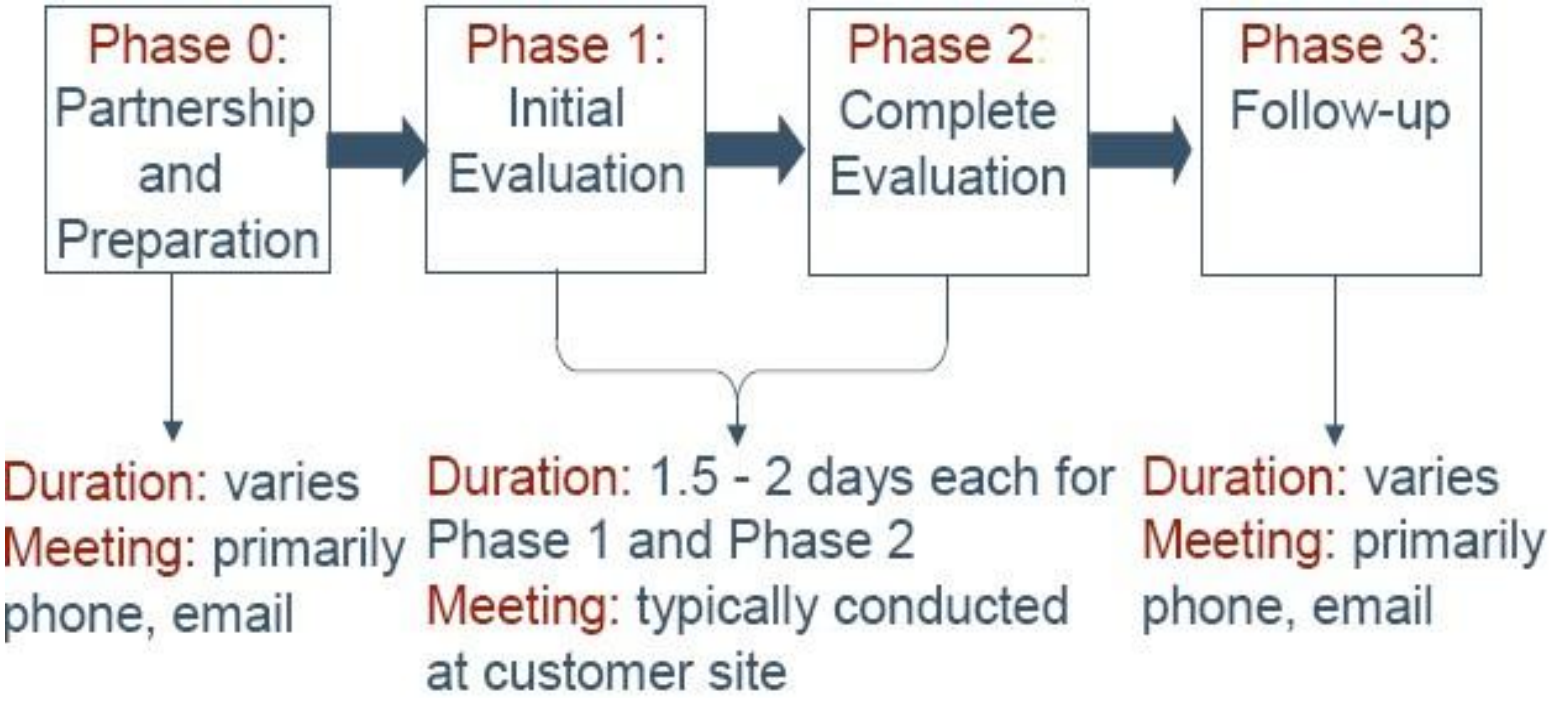
ATAM – Evaluation Phase 2

9. Recapitulate（概括） all the steps of the ATAM and present the ATAM outputs.

- **architectural approaches**
- **utility tree**
- **Scenarios**
- **risks and non-risks**
- **sensitivity points and tradeoffs**
- **risk themes**

ATAM – Evaluation Phases

- **ATAM evaluations are conducted in four phases**



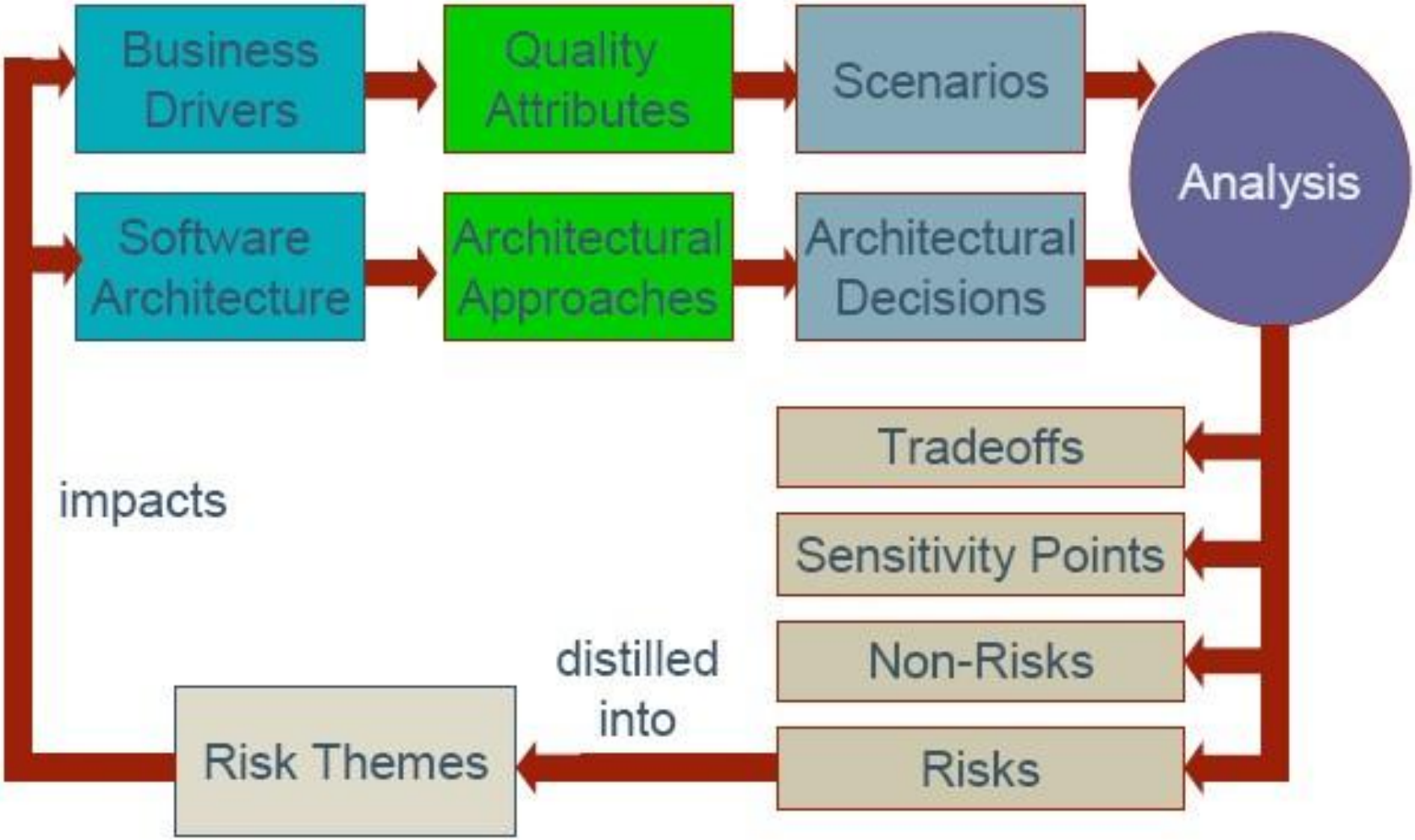
ATAM – Evaluation Phase 3

- **Phase 3: primarily involves producing a final report for the customer as well as reflecting upon the quality of the evaluation and the ATAM materials.**

Final Report

- Executive summary
- Description of ATAM
- Description of business drivers and architecture
- List of phase 1 and phase 2 scenarios and utility tree
- Phase 1 and phase 2 analysis: architectural approaches, decisions, risks, sensitivities, tradeoffs, and non- risks
- Risk themes
- Next steps

ATAM


Business Drivers
Quality Attributes
Scenarios
Analysis
Software Architecture
Architectural Approaches
Architectural Decisions
Tradeoffs
impacts
Sensitivity Points
Non-Risks
distilled into
Risk Themes
Risks

ATAM - Summary

- **The ATAM is**

  - a method for evaluating an architecture with respect to multiple quality attributes

  - an effective strategy for discovering the consequences of architectural decisions

  - a method for identifying trends, not for performing precise analyses

Thank you!