



# Software Architecture Practices

John Klein, PhD

James Ivers

Software Engineering Institute  
Carnegie Mellon University  
Pittsburgh, PA 15213

Copyright 2021 Carnegie Mellon University.

This material is based upon work funded and supported by the Department of Defense under Contract No. FA8702-15-D-0002 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center.

The view, opinions, and/or findings contained in this material are those of the author(s) and should not be construed as an official Government position, policy, or decision, unless designated by other documentation.

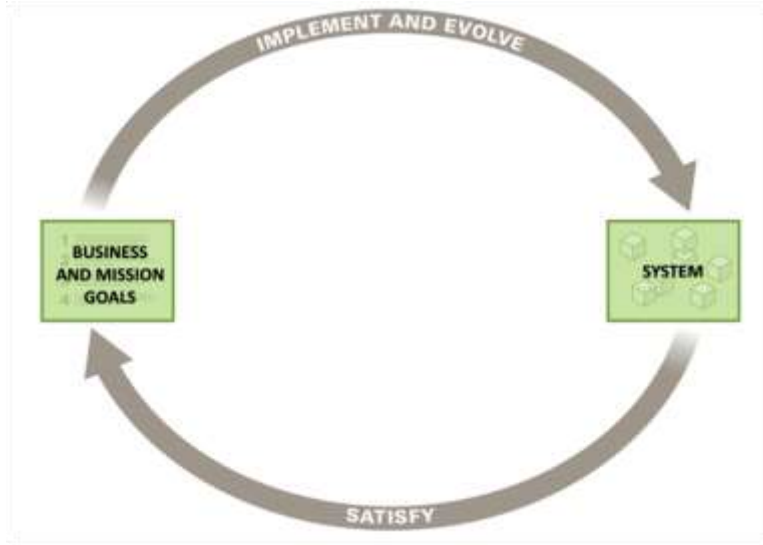
NO WARRANTY. THIS CARNEGIE MELLON UNIVERSITY AND SOFTWARE ENGINEERING INSTITUTE MATERIAL IS FURNISHED ON AN "AS-IS" BASIS. CARNEGIE MELLON UNIVERSITY MAKES NO WARRANTIES OF ANY KIND, EITHER EXPRESSED OR IMPLIED, AS TO ANY MATTER INCLUDING, BUT NOT LIMITED TO, WARRANTY OF FITNESS FOR PURPOSE OR MERCHANTABILITY, EXCLUSIVITY, OR RESULTS OBTAINED FROM USE OF THE MATERIAL. CARNEGIE MELLON UNIVERSITY DOES NOT MAKE ANY WARRANTY OF ANY KIND WITH RESPECT TO FREEDOM FROM PATENT, TRADEMARK, OR COPYRIGHT INFRINGEMENT.

[DISTRIBUTION STATEMENT A] This material has been approved for public release and unlimited distribution. Please see Copyright notice for non-US Government use and distribution.

This material may be reproduced in its entirety, without modification, and freely distributed in written or electronic form without requesting formal permission. Permission is required for any other use. Requests for permission should be directed to the Software Engineering Institute at [permission@sei.cmu.edu](mailto:permission@sei.cmu.edu).

DM21-0926

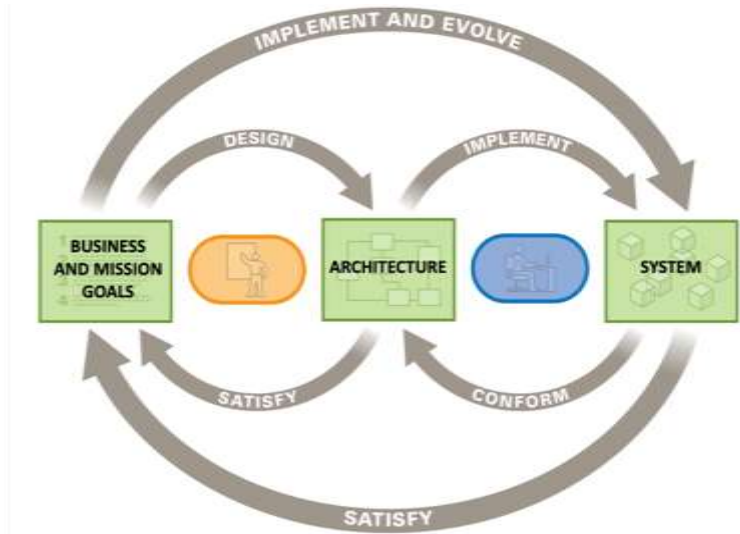
# The Engineering Challenge



Build and deliver a system that satisfies business and mission goals

- Initial operational capability goals
- Lifecycle goals for evolution and maintenance

# Architecture Can Reduce Risk



Represents **earliest** design decisions



- hardest to change
- most critical to get right
- communication vehicle among stakeholders

**First** design artifact addressing



- performance
- modifiability
- reliability
- security

Key to systematic **reuse**



- transferable, reusable abstraction

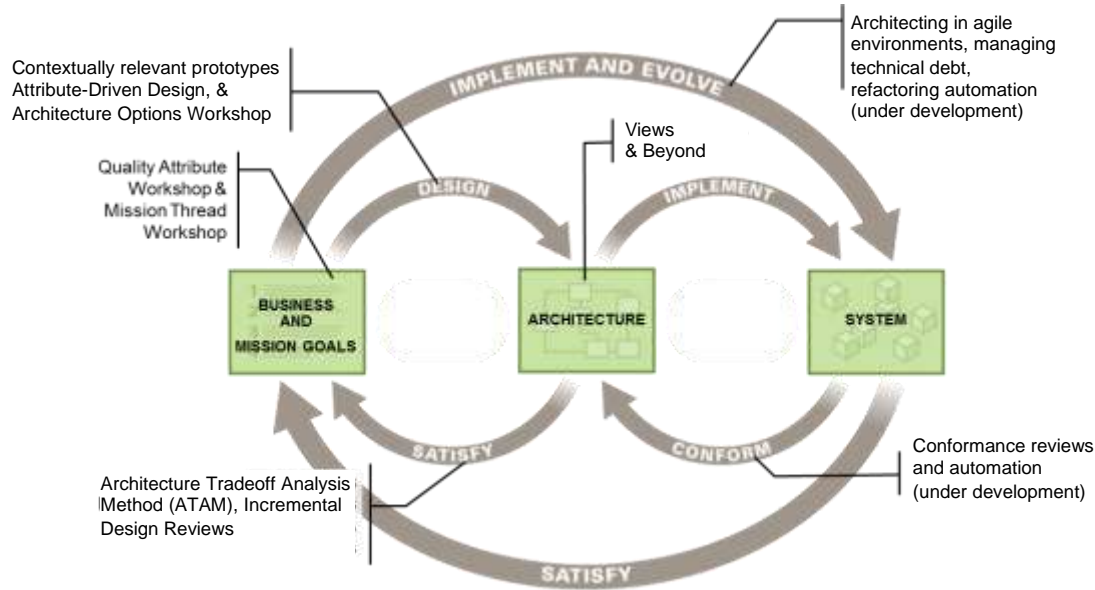
Key to system **evolution**



- manage future uncertainty
- assure cost-effective agility

The **right architecture** paves the way for system **success**.  
The **wrong architecture** usually spells some form of **disaster**.

# Establishing a Discipline of Software Architecture



Range of methods and practices applicable at different points in the development lifecycle.

- Domains of expertise include IT, C2, tactical, and health informatics
- Technology expertise includes IoT, big data, digital twin, cloud, and machine learning

10+ courses, available in a mix of public, on-site, and eLearning options.

3 professional certificates.  
A collection of books for wide dissemination.

# Architecture-related Activities

Architecture-related activities include the following:

- creating the **business case** for the system
- understanding the **requirements**
- **creating and/or selecting** the architecture
- **documenting and communicating** the architecture
- **analyzing or evaluating** the architecture
- setting up the appropriate **tests and measures** against the architecture
- **implementing** the system based on the architecture
- ensuring that the implementation **conforms** to the architecture
- **evolving** the architecture so that it **continues to meet business and mission goals**

Architecture-related activities run throughout the iterative and incremental development life-cycle.

# Selected Experience and Projects

Coaching an architecture team through iterative architecture development and evaluation (Bursatec)

Coaching team through planning and executing architecture-led iterative multi-year refactoring/modernization (FDA)

Architecture governance and identifying portfolio-level architecture debt (FDA)

Architecture-led/evidence-based/data-driven technology selection (MHS/TATRC)

Architectures for exa-scale systems (SKA)

Architectures for command and control (UC2)

Architecture practices/competence assessments (DoD platform modernization PMO, DIB contractor)

# Architecture Done Incrementally

Bolsa Mexicana de Valores (BMV) operates the Mexican Financial Markets on behalf of the Mexican government.

- Bursatec is the technology arm of the BMV

BMV desired a new stock trading engine to drive the market.

- BMV performed a build/buy analysis
- Decided that Bursatec would replace their three existing trading engines with one in-house developed system

Bursatec committed to deliver the trading engine in 8-10 quarters.

- High performing
- Reliable and with high quality
- Scalable

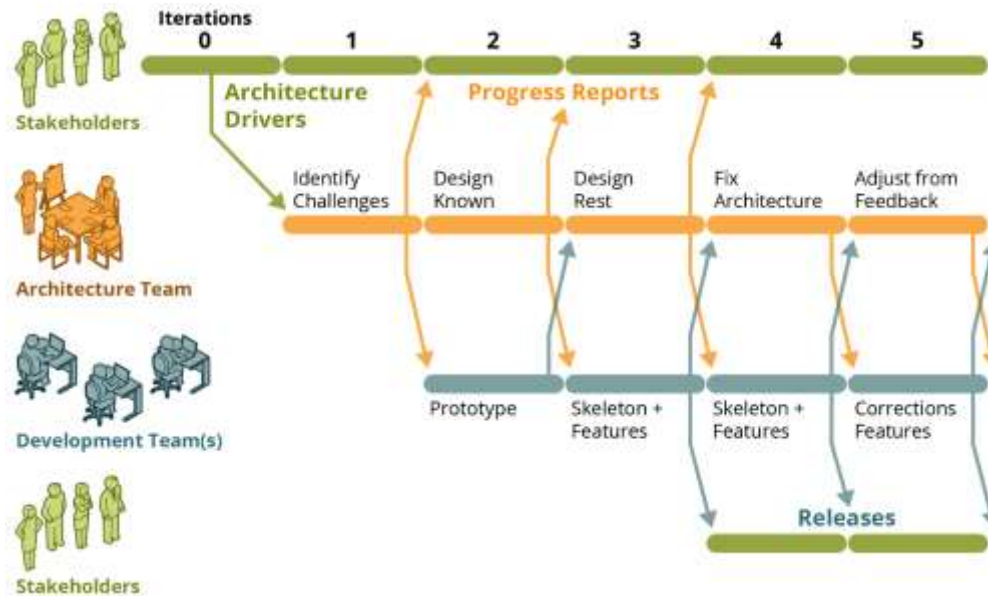


# Results

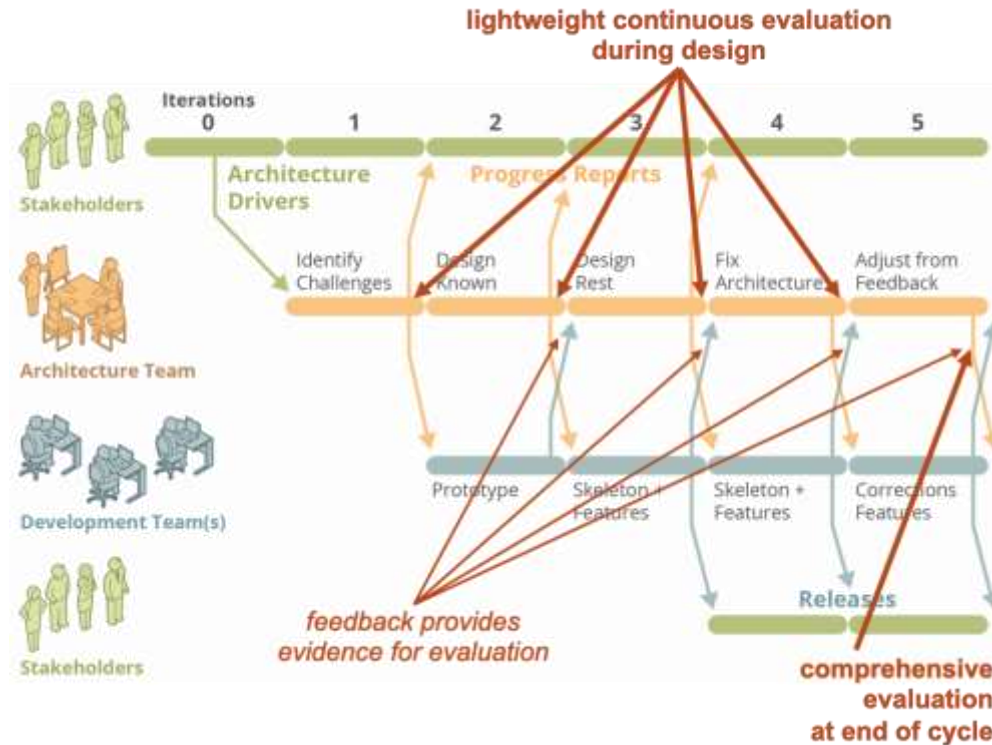
The system had significantly improved quality attribute response times developed within budget with a junior, inexperienced team.

Measure	Target	Actual
Latency	1ms	0.1ms
Throughput (transactions per second)	1,000	200,000
Schedule (months)	18	17
Quality (defects/KLOC found during validation testing)	0.25	0.1

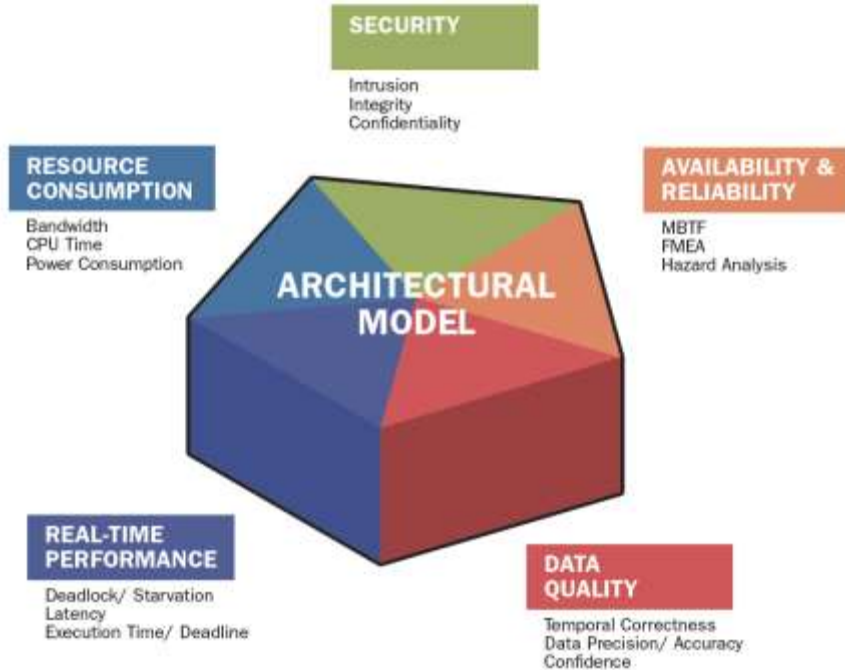
# Parallel Architecture and Development Activities



# Evaluations During Iteration Cycle Provide Visibility and Reduce Risk



# Analyzable Architecture Models Discover System Level Issues Early in Development



## Architecture Modeling Languages

- AADL – Runtime qualities
- UML/SysML
  - Structure, dependencies
  - Behavior
- Dependency Structure Matrix, Graphs
  - Dependencies

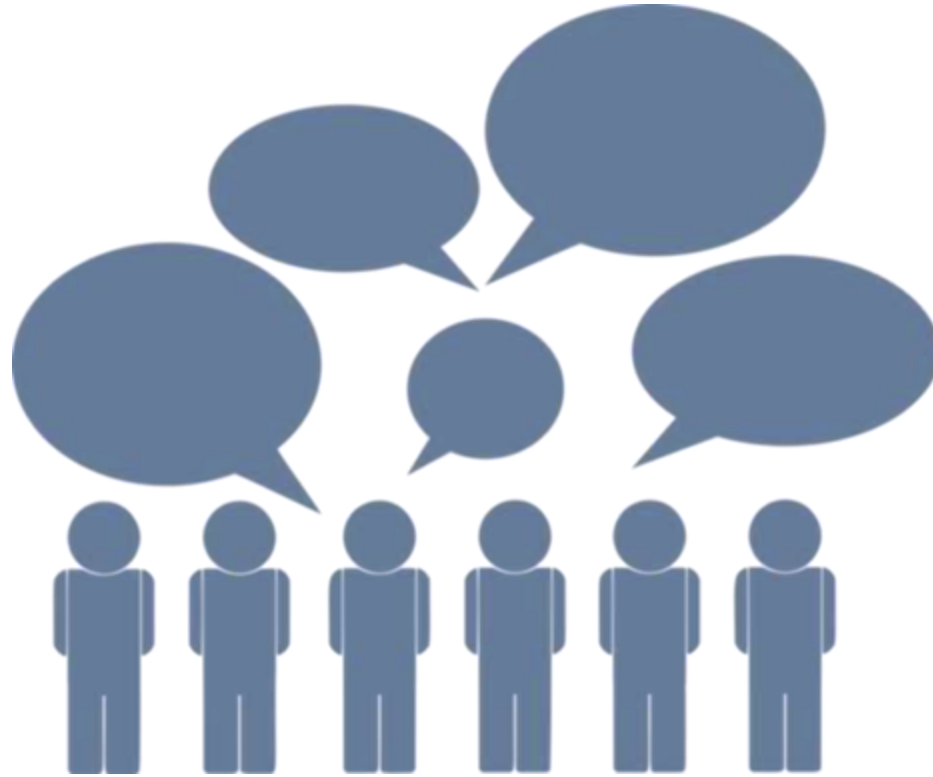
## Which models? What are your questions?

You have *questions* about architecture/system  
→ Identify the *evidence* (measures and metrics) to answer

→ Choose *analysis* to produce the evidence

→ Create *models* to facilitate the analysis

# Discussion



# For more information

John Klein, PhD  
Principal Member of the Technical Staff  
Software Engineering Institute

[jklein@sei.cmu.edu](mailto:jklein@sei.cmu.edu)

<https://resources.sei.cmu.edu/library/author.cfm?authorID=3271>

James Ivers  
Principal Engineer  
Software Engineering Institute

[jivers@sei.cmu.edu](mailto:jivers@sei.cmu.edu)

<https://resources.sei.cmu.edu/library/author.cfm?authorID=4463>