

Elizabeth Kielczewski, Qingfeng He, **Karen Smiley** - ABB Corporate Research, Industrial Software Systems **SATURN 2009**

# Leveraging ADD for Objective Technology Evaluation and Decision Analysis AHEAD method and case study

# Leveraging ADD for Objective Technology Evaluation and Decision Analysis

## AHEAD method and case study

Topics in this presentation:

1. Software technology evaluation challenges
2. Initial approach using ADD with prototyping
3. Requirements: scope, criteria, alternatives
4. Architecture and design of technology prototypes
5. Adjustment of approach (AHP) / emergence of AHEAD
6. Evaluation results and decision analysis
7. Lessons learned
8. Conclusions

# Why Use ADD for Software Technology Evaluations?

## Key Principle

*Meaningful evaluations of  
software technologies  
require that  
**technology alternatives**  
must be assessed  
within the context of  
corresponding  
**software system architectures.***

# Technology Evaluation Goals in This Case Study

Customer's goal:

To improve architectural aspects (*maintainability, performance, scalability, usability, and configurability*) of a component of a well-established product suite

Evaluation project goals:

- Objectively evaluate candidate software technologies
- Recommend software system architecture for implementing the preferred technology

# Technology Evaluation Challenges – 1

## Architectural Design

- Scope: What (part of the) system are we designing?
  - Client application interacting with other parts of the system, and other systems in the product family
  - Long-term strategic technology plans
  - Organizational constraints and stakeholder selection
- Which non-functional qualities of this system are most critical to its design?
- What technologies are available?
- Which design options are relevant to these technologies?
- Is a technology-agnostic architecture possible?

# Technology Evaluation Challenges – 2

## Evaluation Method

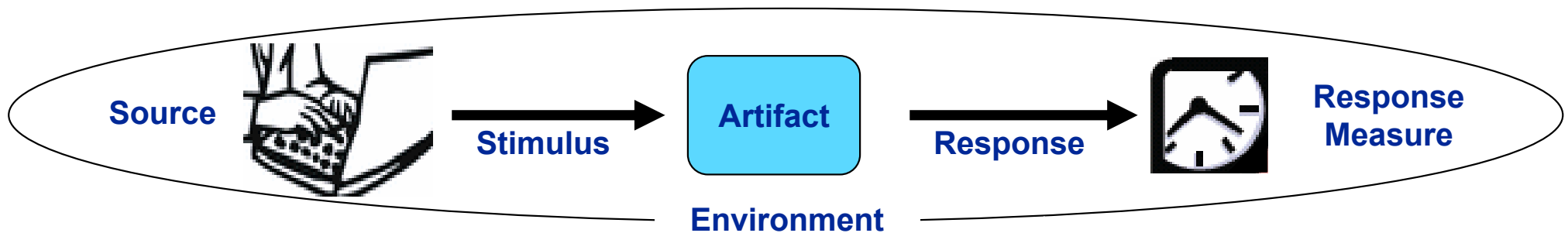
- How can we \*efficiently\* evaluate technologies?
  - Balancing cost and schedule vs. the risk of a ‘bad’ decision
- How to \*objectively\* compare the technology alternatives?
  - “Apples vs. oranges”
  - Minimizing impact of acknowledged or latent biases



# Technology Evaluation – Leveraging ADD

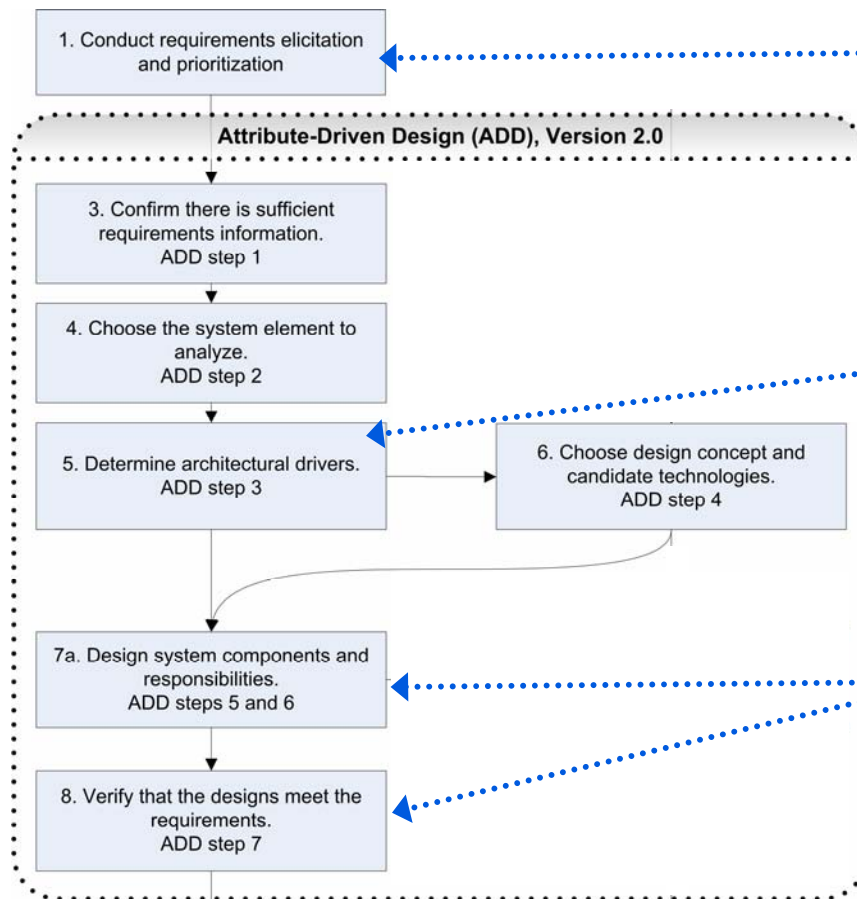
## Initial approach

- Identify and prioritize business goals and technical criteria
- Survey software technologies and frameworks
- Design candidate solutions using SEI Attribute-Driven Design (ADD) method
- Prototype and evaluate candidate solutions
- Recommend the best (technology + architecture) to meet the requirements



# Technology Evaluation – Leveraging ADD

## Adapting ADD for Evaluating A Software Technology



▪ Elicitation precedes ADD; technology evaluations require both functional and non-functional criteria.

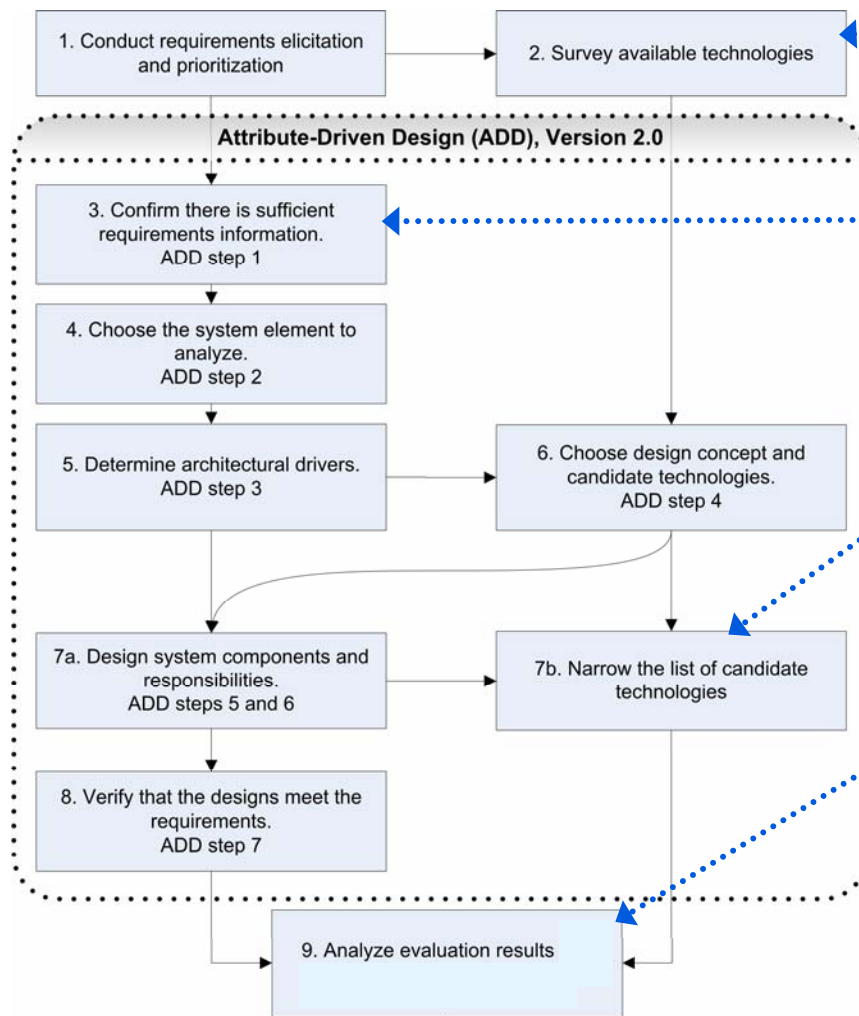
▪ Tradeoff analyses can focus on the top N criteria; an **evaluation** typically requires more exhaustive consideration.

▪ Prototyping can provide insight.



# Technology Evaluation – Leveraging ADD

## Adapting ADD for Comparing Software Technologies



Comparative evaluations require a list of alternatives.

With many evaluation criteria, H-M-L or H-HM-M-ML-L priority scales may not suffice.

Eliminate technology options when it is determined that they cannot satisfy the criteria.

Choosing the best technology alternative requires careful weighting and assessment of prioritized criteria and how well the candidates satisfy them.

# Technology Evaluation – Leveraging ADD

## Identification of criteria and technology alternatives

Requirements elicitation and prioritization were performed in parallel with surveying the current market of technologies and frameworks relevant for development of complex, data-intensive applications.

This yielded 50 criteria and 11 technology alternatives for further evaluation.

These 50 criteria were ranked for **importance**:

- by 3 stakeholders
- with a 5-level nominal scale (H, HM, M, ML, L)

Later, they were also ranked for **architectural impact**:

- with a similar 5-level scale (H, HM, M, ML, L)
- by 4 researchers



# Technology Evaluation – Leveraging ADD

## Using ADD steps 2, 3 & 4

In ADD, the criteria are stratified using dual rankings of importance and architectural impact. Rather than limit our evaluation to the top 5-6, we chose all criteria ranked:

- **H** in importance, **Any** architectural impact
- **HM** in importance, **H, HM, or M** architectural impact

This yielded 25 key criteria (candidate architectural drivers).

- Measurable quality scenarios were defined for the 25 criteria, and combined into use cases to form the basis for prototyping
- We agreed with stakeholders to focus on one functional area
- The design concept of implementing our exploratory prototypes as browser-based applications (RIA) was chosen
- 3 technologies were selected from the 11 candidates, for further investigation.

# Technology Evaluation – Leveraging ADD

## Why and how the AHEAD method emerged

### ***Identified Concerns:***

- Desire for better objectivity
  - Stakeholders can have very different priorities
  - Researchers can have varying technology biases
- Measurable, comparable, traceable results
- Need to handle 25 important criteria
  - *Nominal scale does not ‘prioritize’ among the 25*
  - *Significant prototyping effort foreseen to examine them all*

# Technology Evaluation – Leveraging ADD

## Adjustment of approach / how AHEAD emerged

### ***Identified solutions:***

- Use **AHP** (**A**nalytic **H**ierarchy **P**rocess) for:
  - rigorous prioritization of criteria
  - quantitatively evaluating (‘scoring’) candidate solutions vs. the criteria
  - calculating overall evaluation result from priorities and scores

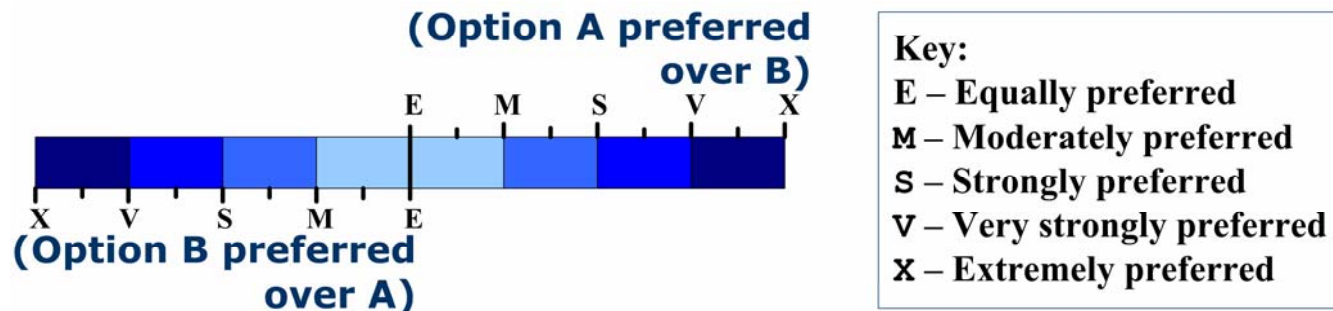
### *But not yet ... first:*

- Eliminate ‘equivalent’ criteria from further evaluation (identify “discerning criteria”)
  - Perform additional prototyping and evaluation for specific scenarios to assess “discerning criteria”
- **AHEAD** method – “Attribute Hierarchy-based Evaluation of Architectural Designs”

# Technology Evaluation – Leveraging ADD Using AHP – Why?

**AHP (Analytic Hierarchy Process)** is a well-established **multi-criteria decision making (MCDM)** technique which:

- Leverages hierarchies to manage complexity
- Uses pair-wise comparisons to bring mathematical rigor and greater accuracy to human judgments
- Enables easy aggregation of conflicting opinions of multiple stakeholders and evaluators
- Provides an “inconsistency ratio” calculation to assess whether the ratings make sense overall.

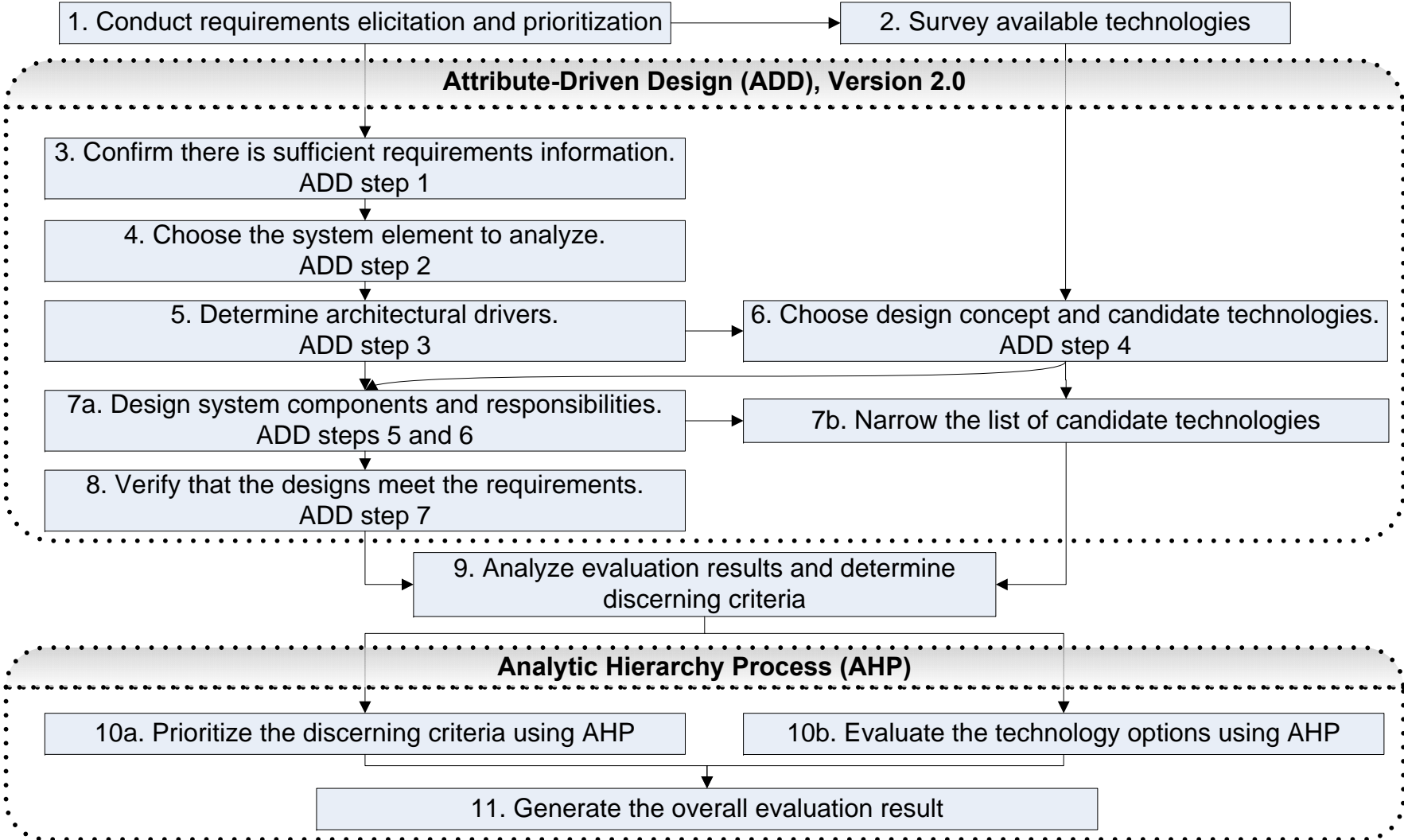


# Technology Evaluation – Leveraging ADD Using AHP – Why ‘not yet’?

- + AHP delivers an accurate, robust set of judgment ratings which are mathematically valid ratio-scale numbers.
- AHP scalability is a concern:
  - 7 criteria require 21 comparisons ( $6+5+4+3+2+1$ )
  - 25 criteria would require ( $24+23+22+\dots$ ) = 300 comparisons, if not structured into a hierarchy
  - Creating an AHP hierarchy (using KJ Method, or affinity process) reduces the comparisons, but the effort can still be significant.

# Technology Evaluation – Leveraging ADD

## Steps of the AHEAD method





# Technology Evaluation – Leveraging ADD

## Prototyping + preliminary evaluation

As we created 3 proposed architectures and prototypes, by following ADD steps 5 & 6:

- 1 technology alternative was disqualified
- Prototypes and further research were completed for the top 2 technologies

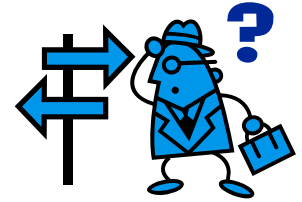
Per ADD step 7, we verified the two designs/prototypes:

- 10 criteria could not be judged effectively within the constraints of the evaluation;
- the candidate technologies were considered equally preferred for 33 criteria;
- distinct differences were noted on 7 ‘discerning criteria’, but without team consensus on which technology was better

*Additional evaluation effort was needed to assess the options.*

# Technology Evaluation – Leveraging ADD

## Quantitative evaluation of alternatives



After **additional prototyping and research** to better examine satisfaction of the 7 discerning criteria, numerical priorities and technical scores were obtained with AHP:

- 21 pair-wise comparisons of importance priorities were collected from the 3 stakeholders, and their ratings aggregated.
- 4 researchers pair-wise-compared the 2 final prototypes, and their technical judgments were combined.

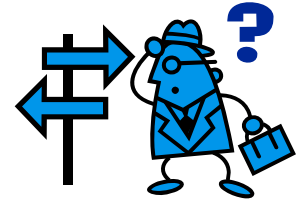
Inconsistency ratios were low, confirming validity of judgments.

The AHP-derived priority and judgment vectors were aggregated to yield overall scores for both final technology alternatives.

Sensitivity analyses examined robustness.

# Technology Evaluation – Leveraging ADD

## Results and decision analysis



- Both final technologies could meet the needs for improving the identified architectural qualities of this product.
- Based on the sensitivity analyses and scores, technology (A) would better satisfy the prioritized evaluation criteria.
- ✓ The team uniformly accepted the overall evaluation result.
- ✓ Stakeholders understood the basis for the recommendation.

Discerning Criteria		BU Priority	Technical Evaluation		Weighted Result	
			A	B	A	B
<b>C1</b>	Dialog response time	<b>12.4%</b>	0.50	0.50	0.062	0.062
<b>C2</b>	Integration with product portfolio	<b>5.1%</b>	0.13	0.87	0.007	0.044
<b>C3</b>	Ease of migration to new development env.	<b>23.0%</b>	0.79	0.21	0.181	0.049
<b>C4</b>	Maximum reuse of existing code	<b>17.9%</b>	0.75	0.25	0.134	0.045
<b>C5</b>	Minimum thin client installation effort	<b>9.9%</b>	0.88	0.12	0.087	0.012
<b>C6</b>	UI widget features	<b>15.0%</b>	0.77	0.23	0.116	0.034
<b>C7</b>	Minimum overall deployment cost	<b>16.8%</b>	0.57	0.43	0.095	0.072
<b>OVERALL</b>		<b>100%</b>			<b>0.68</b>	<b>0.32</b>

# Technology Evaluation – Leveraging ADD

## Lessons Learned

### 1. Analysis of evaluation scope is critical

- Interdependence of components in product suite
- Strategies for surrounding sub-systems
- Choice of stakeholders and weight attributed to each

### 2. Practice makes perfect

- Hands-on experience in methodology to conduct evaluation
- Detailed design of prototypes to provide results which can be meaningfully compared
- Unambiguous and measurable criteria to minimize subjectivity

### 3. Evaluation result $\neq$ automatic decision

- Technical aspects vs. other decision factors
- Both priorities and technologies evolve, over time

# Technology Evaluation – Leveraging ADD

## Conclusions

**Combining ADD with incremental prototyping and AHP delivered an overall evaluation result accurately reflecting the stakeholders' stated priorities.**

### **Benefits of using ADD and the AHEAD method:**

- Guidance for all phases of the comparative evaluation project
- **Technologies evaluated in software system architecture context**
- Balance efficiency, accuracy, completeness, cost, schedule
- Mitigation of subjective decision factors
- Traceable evaluation which delivers quantitative results
- Ease of performing sensitivity analysis

### **Future work:**

- Improved elicitation of architectural requirements
- Examination of the full set of requirements
- Applicability towards functional requirements
- Reusability of evaluations

# Technology Evaluation – Leveraging ADD

## Contact Information

Authors: Elizabeth Kielczewski  
Qingfeng He  
**Karen Smiley**

ABB Corporate Research  
Industrial Software Systems Program  
940 Main Campus Drive  
Raleigh, NC 27606 USA

Email: <first name>.<last name>@us.abb.com  
or AHEAD@agileteams.com

## QUESTIONS, COMMENTS...



# Technology Evaluation – Leveraging ADD

## References

- Attribute-Driven Design, Version 2.0 : CMU/SEI-2006-TR-023, SEI, <http://www.sei.cmu.edu/publications/documents/06.reports/06tr023/06tr023.html>
- *“Architectural Requirements Prioritization and Analysis Applied to Software Technology Evaluation”*, by Karen Smiley, Qingfeng He, Elizabeth Kielczewski, Aldo Dagnino. *Symposium on Applied Computing, SAC’09, March 8-12, 2009, Honolulu, Hawaii, U.S.A.*
- *Fundamentals of Decision Making and Priority Theory with The Analytic Hierarchy Process*, 2nd Ed. Thomas L. Saaty, RWS Publications, Pittsburgh, PA. ISBN 0-9620317-6-3, 2001.
- *Design For Six Sigma*, C. M. Creveling, J. L. Slutsky, and D. Antis Jr., Prentice Hall PTR, Upper Saddle River, NJ, 2003.
- *“Replacing Pugh Concept Selection with the Analytic Hierarchy Process”*, Richard Zultner, pp. 1-38, *Transactions from the International Symposium on Quality Function Deployment, Sept. 7-8, 2007, Williamsburg, VA, ISBN 1-889477-19-2.*

See: [www.agileteams.com/AHEAD.html](http://www.agileteams.com/AHEAD.html) for further information.

**Power and productivity  
for a better world™**

