

# Architecture Reviews @ Bosch



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Keynote  
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1

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**BOSCH**

## Architecture Reviews @ Bosch

### Abstract

#### → Automotive Software Architectures

As software is covering more and more functionality in cars, software architectures draw more attention. Software architectures represent the earliest design decisions in the development process. They have far-reaching effects on the quality attributes of the system and, thus, are extremely difficult to get right first and hard to change later on. The Architecture Trade-off Analysis Method (ATAM) developed by the SEI assesses the quality of software architecture early in the development process. ATAM is a scenario-based review method that uses business goals to evaluate the quality of software architectures.

#### → Bosch Experience

Bosch uses ATAM for five years in reviewing important software and system architectures. The improvement of the method and the knowledge transition from the SEI to Bosch will be discussed in detail.

#### → Benefits of ATAM

Benefits in using ATAM are not only the review results itself but a better documented and better understood architecture. We experienced that the most important benefit of ATAM is the rising stakeholders' awareness of architectural decisions, tradeoffs, and risks. It illuminates the software architecture better than any written documentation.

2

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### Outline

- Bosch and Software
- Automotive Software Architectures
- Architecture Tradeoff Analysis Method (ATAM)
- Bosch ATAM Experience
- Benefits of ATAM



Key Data	2002	2003
Sales	35,000	36,400
Sales outside Germany as percent of total	72	71
Average number of associates	225,900	229,400
in Germany	102,700	105,600
outside Germany	123,200	123,800
Investments in tangible fixed assets	2,000	2,000
Expenditures for research and development	2,500	2,700
Net income	650	1,100

Amounts in million euros



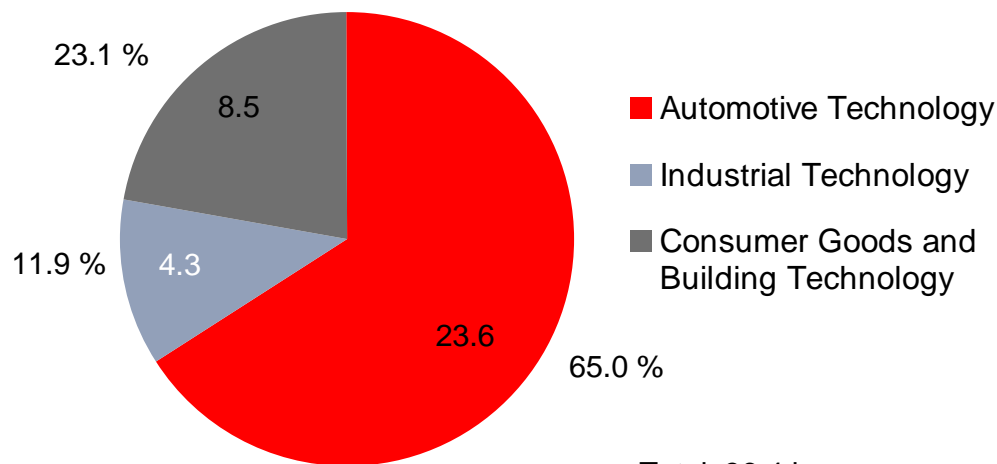
## Milestones in Automotive Technology

1897	1902	1927	1951	1967
Low-voltage magneto for vehicles	High-voltage magneto for vehicles with spark plug	Diesel fuel-injection pump	Gasoline fuel-injection pump	Electronically controlled gasoline fuel injection (Jetronic)
1976	1978	1979	1986	1991
Lambda oxygen sensor for vehicles	Antilock Braking System (ABS)	Combined digital control of gasoline injection and ignition (Motronic)	Electronic Diesel Control (EDC); Traction Control (TCS)	Controller Area Network (CAN)
1995	1997	2001	2002	2003
Electronic Stability Program (ESP); Vehicle navigation systems with voice output routing	High pressure injection system Common Rail for diesel engines	Electro-hydraulic brake (SBC)	Electronic Battery Management (EBM)	Third generation of common rail, with piezo inline injectors



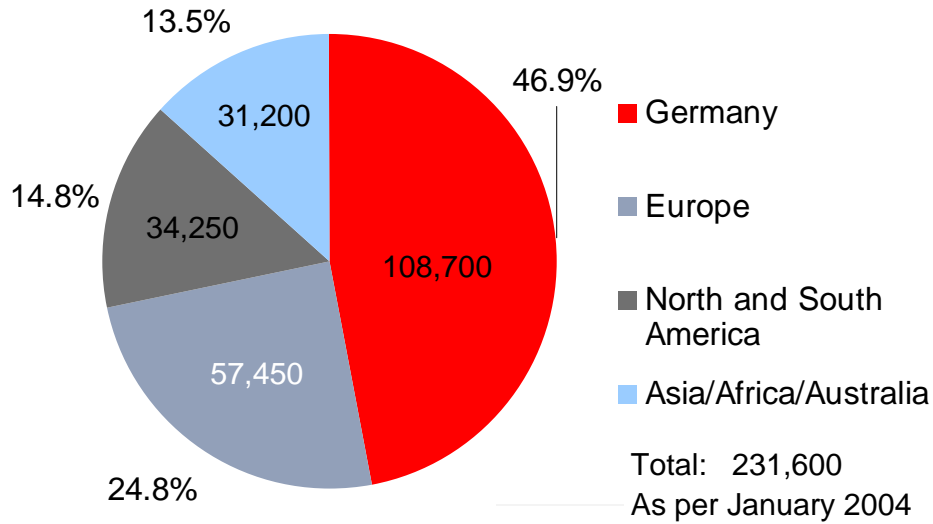
## Distribution of Sales 2003

by business sector



## Associates

by region



## New York 1906: 160 West 56th Street



### without Software



### with Software



Software has become a core technology. Many companies never envisioned that they would participate in Software Business.

### Bosch and Software?

- I can't buy Bosch Software for my PC!
- I don't buy Bosch Software in a shop!



- ... but you use it every day

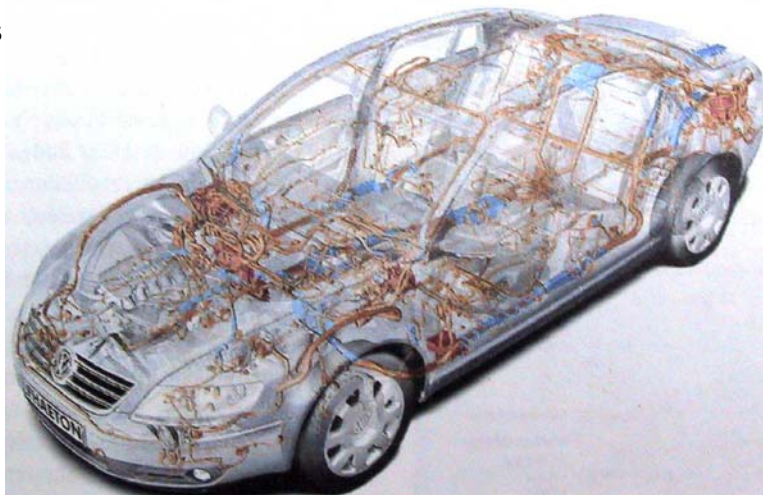
## Example: Engine Control Software



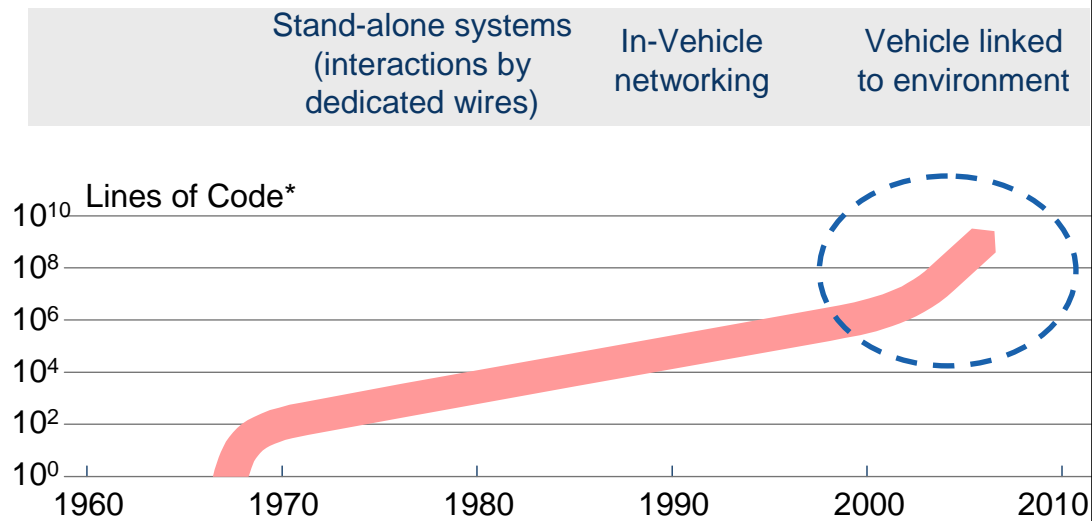
- Purpose
  - Controls air, injection, ignition, and exhaust
  - User Interface: Pedals, Cruise Control
  - Theft Control, BUS-Gateway, ...
- Size
  - 250-400 kLOC per engine
- Development Effort
  - 0.5 - 10 Man-Year per engine
  - about 1.200 engineers
- Number of Products
  - 1.000 software products per Year
  - 30.000 control units per Day

## Complexity of Today's Cars

- 61 Control Units
- 3 Bus-Systems, 1 optical Bus, Sub-Buses
- 2.500 Signals in  
250 CAN-Messages
- > 50 MB Memory
- 2.110 Connections
- 3.860 m Wire



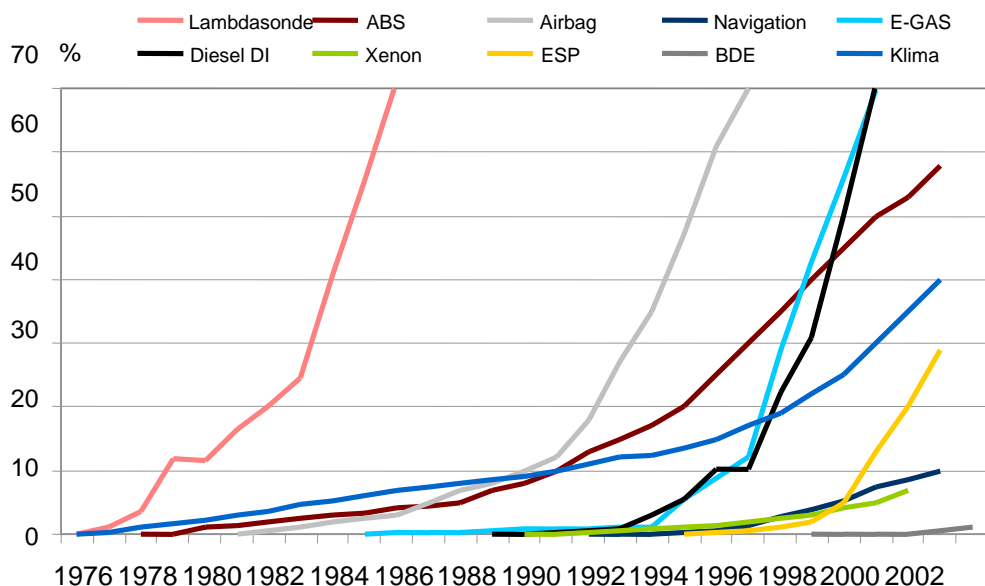
## Explosion of Functionality



\*All systems in a car (Source: DaimlerChrysler 2002)



## Prozentuale Ausstattungsverläufe (WEU)



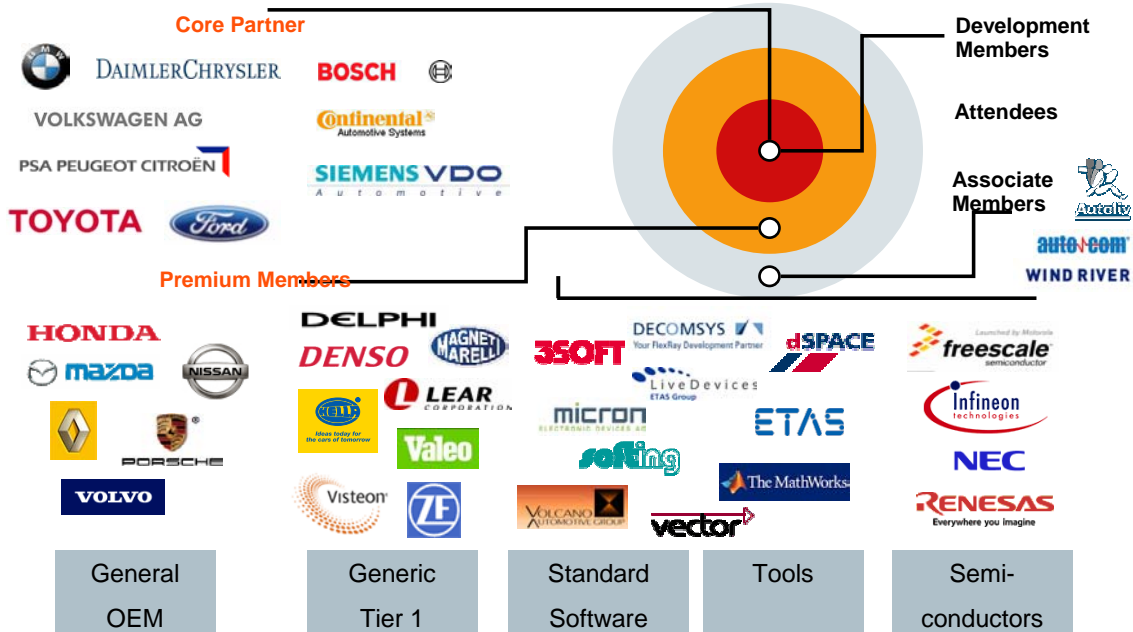


### Bosch Software Product Lines across BUs

- Platforms are an **essential** concept of RB-development
  - Platforms in production 50
  - New Platforms currently under development >7
- Strong reuse culture within Bosch
- Bosch Initiative for software-intensive Systems (BISS)
  - Change Agent for systematic software product lines
  - Support organization in corporate research
  - Combined with Process Improvement (CMMI)

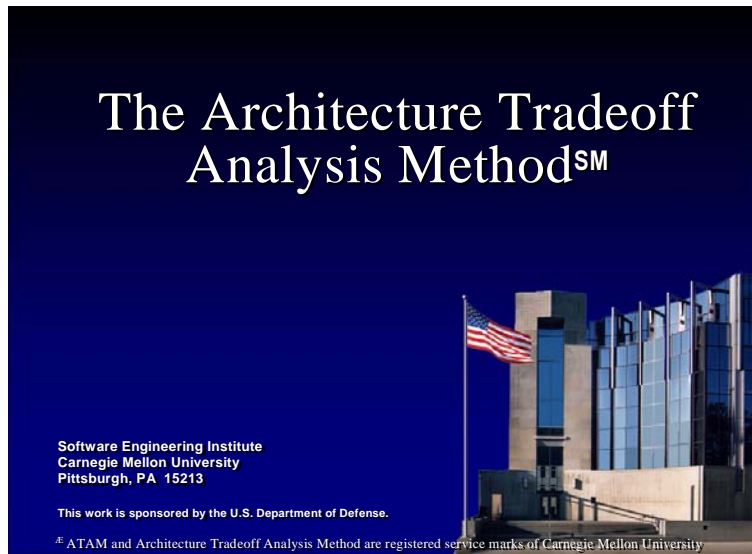


### Autosar Partners and Members





# ATAM Overview



# Why Analyze an Architecture?

- A software architecture
  - is the earliest life-cycle artifact
  - embodies significant design decisions
  - a good architecture is based upon good decisions
- All architectural decisions
  - are choices among alternatives
  - involve tradeoffs
- The purpose of the ATAM is:
- To assess the consequences of architectural decisions in light of quality attribute requirements and business goals.

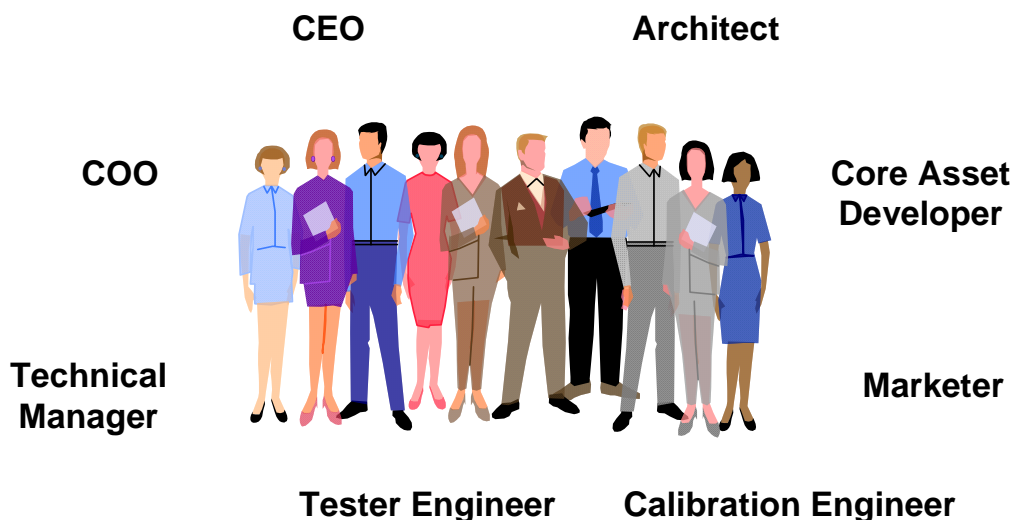


### Purpose of the ATAM

- ATAM is an early lifecycle analysis method that is designed to:
  - Discover risks ñ decisions that might create future problems in some quality attribute
  - Discover tradeoffs ñ decisions affecting more than one quality attribute
  - Discover sensitivity points ñ decisions for which a slight change makes a significant difference in some quality attribute
- The purpose of an 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.
- Discovered risks can then be made the focus of mitigation activities: e.g. further design, further analysis, prototyping.
- Surfaced tradeoffs can be explicitly identified and documented.



### Stakeholder bring their Quality Scenarios



Slide white box **reused** from Linda's Product Line Standard Presentation (SEI)



## Robert Bosch's Quality Principle

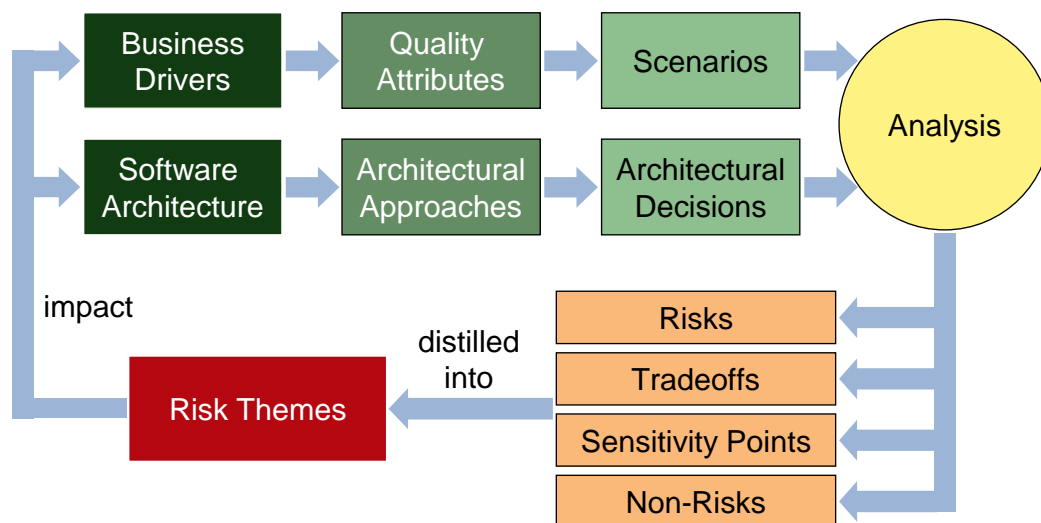


It is an unbearable thought to me that while checking one of my products, somebody could show that I in some way performed inferior work. For this reason, I have always endeavored to only deliver work which will pass any objective test, work that is, so to say, the very best of the best.

*Robert Bosch, 1918*



## Conceptual Flow of ATAM



### ATAM Steps

1. Present the ATAM
2. Present business drivers
3. Present architecture
4. Identify architectural approaches
5. Generate utility tree
6. Analyze architectural approaches
7. Brainstorm and prioritize scenarios
8. Analyze architectural approaches
9. Present results



### Defined Process: ATAM Reference Guide (ARG)

- Terms
- Roles
- Process
- Process Steps
  - participants
  - entry condition
  - inputs
  - activity
  - outputs
  - exit condition
  - next step or phase
- Templates

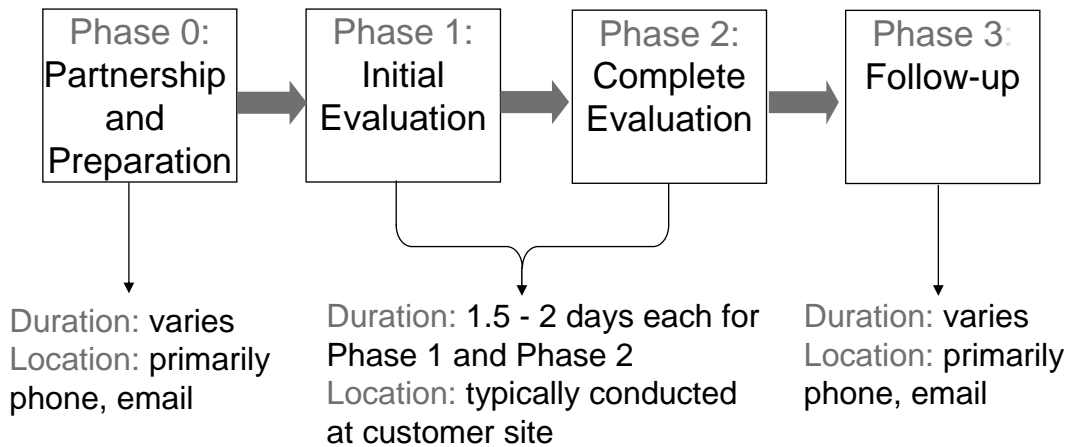
Process Model for Phase 0: Partnership and Preparation	Step 3: Make a Go/No-Go Decision	
	Description	References
Participants	<ul style="list-style-type: none"> <li>[ ] Evaluation organization members who attended the "Step 2: Describe Candidate System" step</li> <li>[ ] Others empowered to contribute to or make a go/no-go decision</li> </ul>	Table 15, "Step 2: Describe Candidate System," page 148
Entry Condition(s)	[ ] Evaluation organization representatives understand state of the architecture (as defined in the Go/No-Go criteria) well enough to make a decision.	
Input(s)	<ul style="list-style-type: none"> <li>[ ] ATAM Go/No-Go decision criteria</li> <li>[ ] Candidate system documents from "Step 2: Describe Candidate System" step</li> </ul>	ARG page (tbd) Table 15, "Step 2: Describe Candidate System," page 148
Activity	<ul style="list-style-type: none"> <li>[ ] Apply Go/No-Go decision criteria.</li> <li>[ ] If "No-Go" develop plan of action</li> </ul>	tbd
Output(s)	[ ] If "No-Go", letter sent to client explaining the reasons for declining the work and suggesting remediation steps to enable future work.	
Exit Condition(s)	[ ] Go/No-Go decision made	
Next Step or Phase	<ul style="list-style-type: none"> <li>If "Go", Step 4: Negotiate the Statement of Work.</li> <li>If "No-Go," stop.</li> </ul>	Table 17, "Step 4: Negotiate the Statement of Work," page 151

Page copy-and-paste **reused** from SEI's ARG



### ATAM Phases

→ ATAM<sup>SM</sup> evaluations are conducted in four phases.



Slide black box **reused** from Felix's Architecture Familiarization Course (SEI)



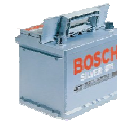
### Four Automotive Application Domains - 1



- Time-Slice Real Time System
- Several Years in a Product Line
- Architecture Development is introduced
- Reengineering of Architecture
- SW Development staff: 340
- Extensive preparation
- Big stakeholder group
- Organizational wide distribution of results
- Component Base System
- Domain Expertise: Prototypes
- Well established Architecture Development
- Exemplary Architecture Documentation
- Software Engineers: 25
- Minor preparation
- Small stakeholder group
- Results did not spread around








### Four Automotive Application Domains - 2



- Event and Periodic Time System
- Prototypes
- Architecture Development is established
- Sufficient Architecture Documentation
- SW-Engineers: 10 Research + 30 Business Unit
- small stakeholder group
- Organizational wide distribution of distilled results
- Time-Slice Real Time System
- Two Products in new Domain
- Architecture Development is introduced: first review
- Some Architecture Documentation
- SW-Engineers: 30
- adequate stakeholder group
- we don't know








### Statistical Data of ten ATAM cases

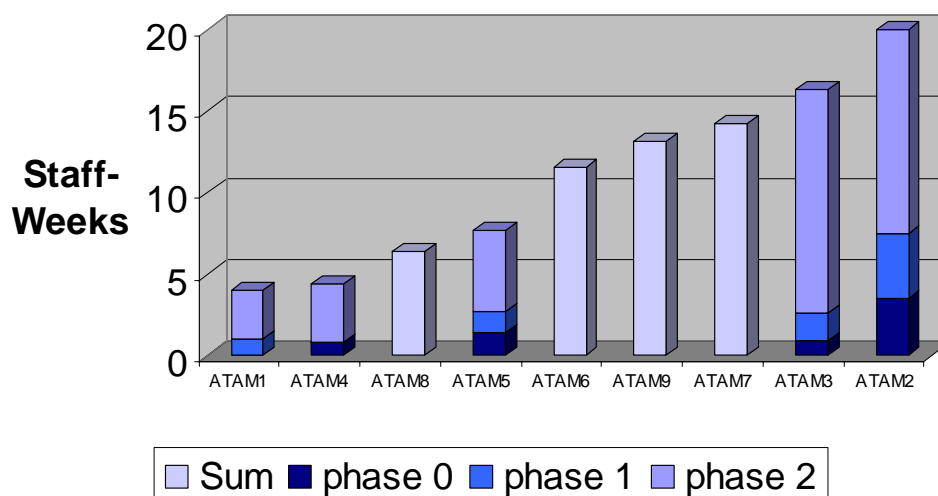
					
# attending stakeholders	3	21	35	5	12
# evaluators	7	7	10	8	6
Duration of ATAM workshop	2 days	2 days	2 days	3 days	2 days
# generated scenarios	15	52	72	34	40
# analyzed scenarios	10	5	12	8	8
# identified decisions	20	28	74	n.a.	40
# identified tradeoffs	7	6	13	3	8
# identified sensitivity points	7	3	6	3	2
# identified risks	19	35	72	13	34
# identified non-risks	2	0	8	1	8
# identified risk themes	5	5	10	3	4
# business drivers	4	5	13	7	7



## Statistical Data of ten ATAM cases

					
# attending stakeholders	16	20	21	18	8
# evaluators	7	5	6	3	5
Duration of ATAM workshop	2 days	2 days	2 days	2 days	3 days
# generated scenarios	44	71	47	66	30
# analyzed scenarios	12	11	9	12	8
# identified decisions	64	62	51	49	54
# identified tradeoffs	8	15	3	5	6
# identified sensitivity points	3	7	3	-	-
# identified risks	44	57	17	14	7
# identified non-risks	17	26	9	6	1
# identified risk themes	5	4	4	2	3
# business drivers	8	5	5	6	7

## ATAM Cost of Evaluating\*



\*does not include effort or costs for the reviewers



### ATAM Impact

- On Architecture
  - Risk avoidance
  - Better Documentation
  - Identification of non-risks
- On People
  - Disappointment
  - Consciousness and Influence of Architecture and of Business
  - More and documented insight
- Management
  - Long term adjustment of strategy (ATAM one piece in the puzzle)



### ATAM Success Factors

- Having a well documented software architecture
- or having architects that are able to communicate the architecture in the workshop.
- Presenting a realistic and the real business case
- Do not just make scenarios. Refine and rework them to make good scenarios.
- Invite all software architecture related stakeholders to the workshop.
- Make management, sales, marketing participate at least for steps 1-3 and step 9.
- Facilitate active participations of stakeholders.
- Get hold of capable evaluation leader.
- Enforce the process strictly during the ATAM workshop.
- Make sure, every participant understands how ATAM works.



## Unwritten Story of ATAM

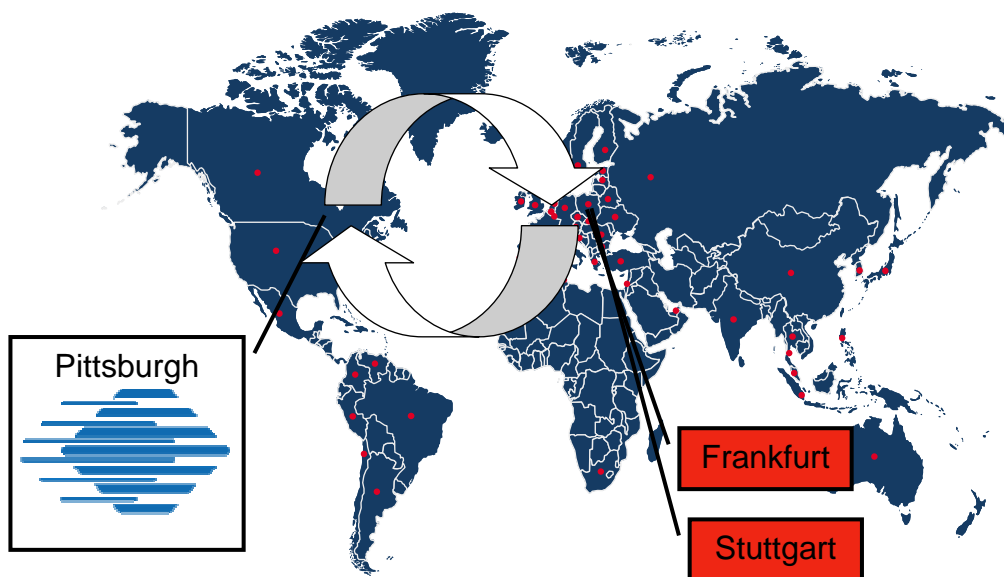
→ Social Aspect!



- Some roles meet the first time ever
- What was important? - iTalks during the break!i



## Transition ATAM to Bosch



### Transition ATAM to Bosch

#### → History

- First ATAM: Bosch Observers (2000)
- ATAM Evaluator Training in Frankfurt (2002)
- 2-4 ATAM: SEI-Bosch Teams (2001-2003)
- ATAM Evaluator and Facilitator Training (2004-2005)
- 5-x ATAM: Bosch Team (2004-)

#### → Working style

- Cultural Differences overcome by Team in Frankfurt, Business units in Stuttgart (English vs. German, \$\$\$ vs. Ä, Software vs. Bosch)
- Meetings and Phone Conference
- Partnership build on Trust



### Make ATAM Industry Standard

#### → Bosch's Interest is to make ATAM World Wide Industry Standard (like CMMI product suite)

#### → SEI ATAM Challenges:

- Extensive Course & License Requirements:  
Costs (\$40k) and Time (34d) required for companies to adopt
- ATAM is not wide spread enough wrt its maturity
- Quality Assurance unclear
- No service provider available today
- Establish in the SEI Partner network (not only Academia)



### Conclusion

- ATAM is a mature method, SEI Certification available
- ATAM has well defined process and roles
- ATAM is the right review method for product line architectures at important mile stones
- Not inexpensive, but good cost/benefit ratio
- Cost of evaluating and cost of communicating
- Bosch will continue using ATAM
- Transitioning ATAM to Bosch Corporate Research finished
- SEI needs more commitment to introduce ATAM into industry
  
- **The most important benefit of ATAM is the stakeholders' awareness of architectural decisions, tradeoffs, and risks.**

