




**Measurement-based Alignment of
Software Strategies and Business Goals
IPA / SEC Tutorial**

presented by
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Fraunhofer IESE **Fraunhofer USA**

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Welcome – About the Fraunhofer Gesellschaft

- Named after
 - Joseph von Fraunhofer (1787-1826), a successful researcher, inventor and entrepreneur
- Role of the Fraunhofer Gesellschaft
 - Germany's leading organization for applied research and technology transfer
- Size
 - 58 institutes
 - Approx. 12.500 employees
- Funding Volume
 - about € 1.3 billion
 - 1/3 base funding (government)
 - 1/3 industrial projects
 - 1/3 public sector projects

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Fraunhofer Research Units in Germany

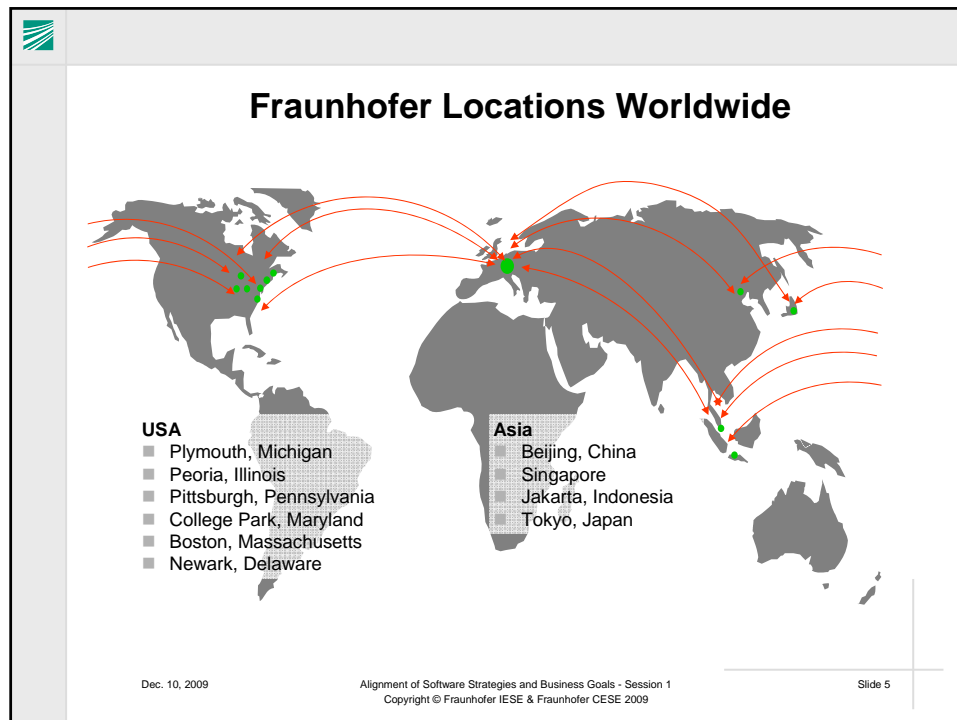
- Institutes
- Branches of Institutes, Research Institutions, Working Groups, Branch Labs, and Application Centers



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About Fraunhofer IESE

Principles	Measurement Services
■ Transferring proven technologies into practice	■ Defining and optimizing quality assurance strategies
■ Applying empirical methods to evaluate processes and products	■ Introducing and optimizing measurement systems
■ Identifying improvement areas and proposing changes	■ Establishing and improving estimation capabilities
■ Utilizing experience to guide technical and management choices	■ Assessing products and processes
	■ Introducing measurement-based software process improvement
	■ Training and coaching

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About the Presenters (1/2)

Dr. Jens Heidrich


- Head of the Processes and Measurement department (PAM) at the Fraunhofer Institute for Experimental Software Engineering (IESE), Kaiserslautern, Germany
- PAM focus on
 - Goal-oriented Measurement
 - Project Control Centers
 - Domain-specific Quality Models
 - Process Management and SPI



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About the Presenters (2/2)

Michael Kläs


- Researcher at Fraunhofer IESE, Kaiserslautern, Germany
- Department "Processes and Measurement"
- Research focus
 - Defect Prediction & Classification
 - Software Cost Estimation
 - Goal-oriented Measurement
 - Empirical Software Engineering



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Introduction of Tutorial Participants


- Name
- Role in your organization
- Prior knowledge and experience
- Expectations regarding the tutorial



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Agenda

Morning (AM)	10:00	Session I:
	-	Introduction to Software Measurement
	11:00	
	11:00	Session II:
	-	GQM+Strategies
	12:30	
Lunch		
Afternoon (PM)	13:30	Session III: Exercises Part A -
	-	GQM and GQM Abstraction Sheets
	14:30	
	14:30	Session III: Exercises Part B -
	-	GQM+Strategies
	16:00	

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Session I:
Introduction to Software Measurement

- **Motivation**
- Measurement Principles and Basics
- Goal-oriented Measurement

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Importance of IT Business Alignment

- **Focused Investment:** “A real differentiator in a company’s financial performance is not the overall IT spending but the excellence in focusing this spending by business value.”
[Accenture, 2004]
- **Alignment Gap:** In Forrester’s IT Excellence survey of 162 senior IT executives, only 15% declared themselves to be fully aligned with the business.
[Forrester, 2007]
- **Management Priority:** A 2006 survey of over 1,400 CIOs from around the world noted that linking business strategies with IT planning is the second most important strategic management priority for 2006 through 2009.
[Gartner, 2007]

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ROI of IT Investments

- Better information technology (IT) makes a quantifiable, positive difference in business performance (visibility, control, and productivity)
 - ... when properly invested in

IT Score Quartile	Average IT Score (55% average)	Comparative Revenue Growth (2002-05 CAGR)**
Top 25%	75%	3.5%
2nd 25%	63%	1.3%
3rd 25%	51%	0.9%
Bottom 25%	33%	-3.3%

*Statistically significant to the 99% level
**Compared to peer enterprises in the same industry sector.
Source: Keystone, 2006

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Critical Questions

- How can I use IT to reduce costs and sustain growth?
- How much money should I spend on IT?
- How do IT investments contribute to my business value?
- What are critical factors that affect my business goals?
- How to avoid unrealistic and contradictory goals/strategies?
- What data do I need for guiding business improvement?


In practice, these questions are hard to answer because

- there is **no explicit linkage** between business goals and IT-related strategies
- there are **limited measures** in place for evaluating whether and how applied IT solutions generate business value

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Measurement-based Alignment of Business Goals & IT Strategies





- **Problems in Practice**
 - ☐ Unrealistic goals for IT
 - ☐ Missing IT business alignment
 - ☐ IT is solely seen as cost driver
 - ☐ Major IT-related business risks
- **GQM+Strategies® Method**
 - ☐ Alignment of goals and strategies
 - ☐ Goal-oriented measurement
 - ☐ Integrating approaches such as BSC
 - ☐ Continuity across all organizational levels
- **Benefits**
 - ☐ Value-oriented IT alignment
 - ☐ Measurability of success
 - ☐ Improved communication
 - ☐ Quantitative control
 - ☐ Avoidance of goal conflicts

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Session I: Introduction to Software Measurement


- Motivation
- **Measurement Principles and Basics**
- Goal-oriented Measurement

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Why Measurement?

"What is not measurable make measurable."




Galileo Galilei

"A science is as mature as its measurement tools."



Louise Pasteur

"If you can't measure it, you can't manage it."




Peter Drucker

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Why Do Organizations Measure?

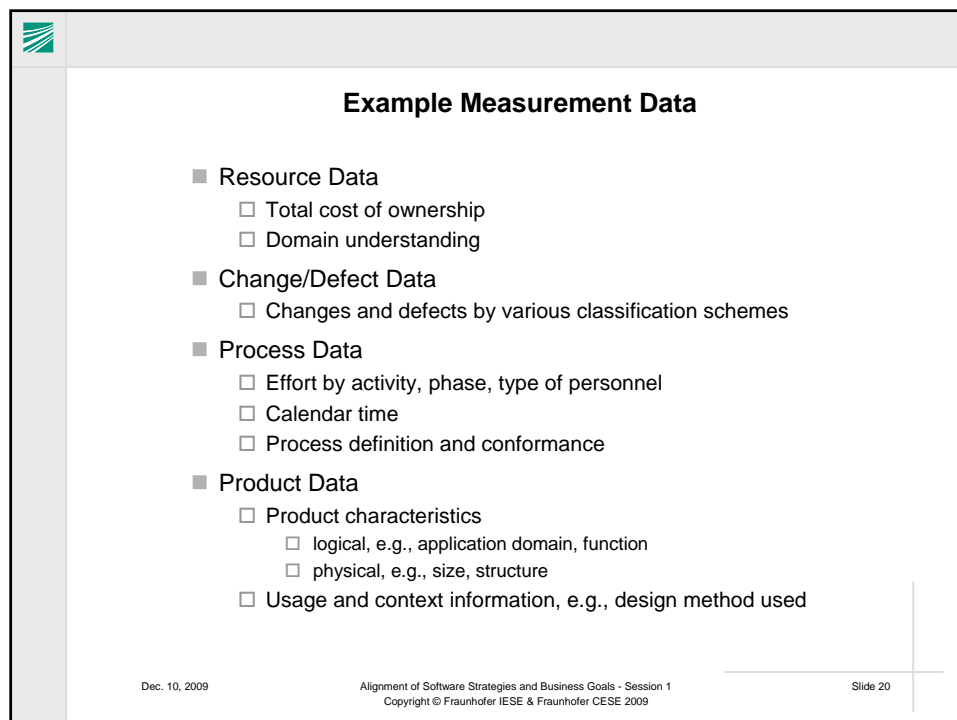
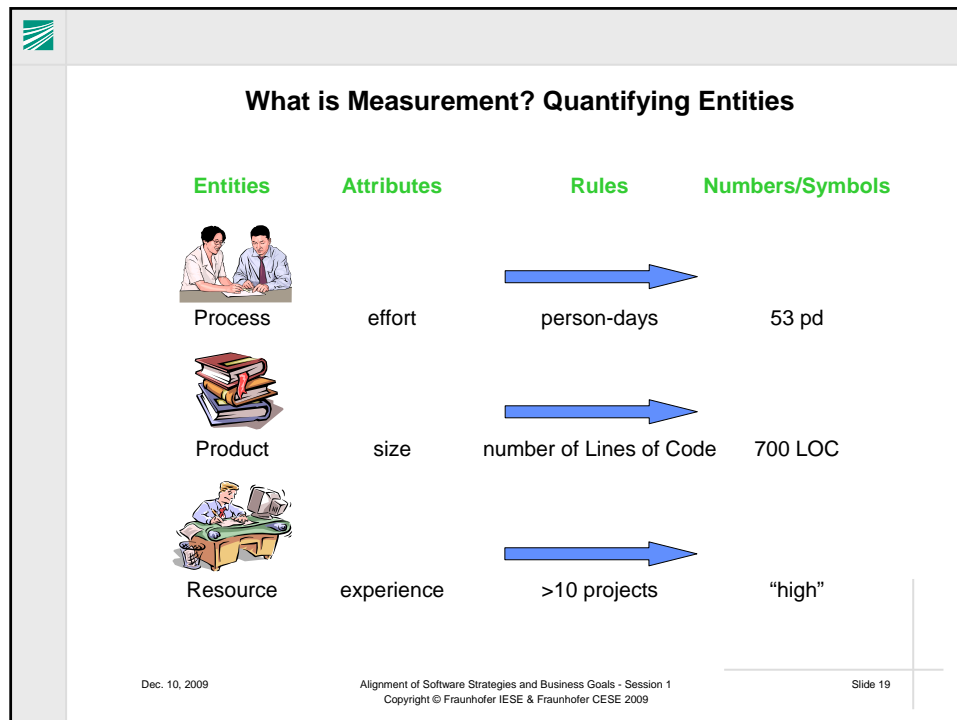
- **Understand the Business and Create Visibility**
 - ☐ Build baselines, show relationships
 - ☐ Identify critical factors
- **Manage and Control Projects Based on Quantitative Evidence**
 - ☐ Plan and estimate
 - ☐ Track- actuals versus estimates
 - ☐ Decision-making
- **Guide Improvement and Optimize the Activities**
 - ☐ Prioritize
 - ☐ Assess
 - ☐ Package Experiences

Measurement is a means to an end, not an end in itself

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Measurement Scales		
Scale Type	Basic Operations	Typical Examples
Nominal	Determination of equality	Types of defects
Ordinal	Determination of greater or less	Level of training or understanding
Interval	Determination of equality of intervals or differences	Calendar dates
Ratio	Determination of the equality of ratios	Lines of Code, number of defects, code complexity

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Objective versus Subjective Measures	
■ Objective Measures	<ul style="list-style-type: none"><input type="checkbox"/> An absolute measure taken on the product or process<input type="checkbox"/> Usually done on an interval or ratio scale<input type="checkbox"/> Examples: time for development, number of lines of code, number of errors or changes
■ Subjective Measures	<ul style="list-style-type: none"><input type="checkbox"/> An estimate of extent or degree in the application of some technique<input type="checkbox"/> A classification or qualification of problem or experience<input type="checkbox"/> Usually done on a nominal or ordinal scale<input type="checkbox"/> Examples: quality of use of a method or technique, experience of the programmers in the application or process

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Measurement Stakeholders

- There are a variety of stakeholders at multiple levels and different information needs
 - ☐ Manager
 - ☐ Customer / User
 - ☐ Developer
 - ☐ Organization
 - ☐ ...
- These points of view need to be integrated and linked and interpreted for each viewpoint based on common data

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Levels of Measurement Ability

Ability Level

Level	Description	Ability
5: Motivate / Improve	Describe what needs to be done to control and manage	<i>Build prescriptive models</i>
4: Predict	Estimate expected product quality and process resource consumption	<i>Build predictive models</i>
3: Evaluate	Assess achievement of quality goals, impact of technology on products	<i>Compare models</i>
2: Understand	Explain associations / dependencies between processes and products Discover causal relationships	<i>Analyze models</i>
1: Characterize	Describe and differentiate software processes and products	<i>Build descriptive models and baselines</i>

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Measurement is not just the collection of data...

calendar time *total lines of code*

number of failures during system test

number of open problems total effort

cyclomatic complexity

number of defects found in inspections

severity of failures *lines of code/staff month*

total number of defects

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... and cannot simply be aggregated...



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...and requires interpretation



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Problems with Measurement


- Problems
 - ☐ Too much unnecessary data is collected
 - ☐ Data is not analyzed
 - ☐ Data is not analyzed in the right environment
 - ☐ Standard measures are postulated without adaptation for the environment
 - ☐ Important aspects cannot be analyzed because data is missing
- General Consequences
 - ☐ Wrong conclusions can be drawn
 - ☐ Insufficient pay-off for the cost

➡ **Goal-oriented Measurement**

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Session I: Introduction to Software Measurement

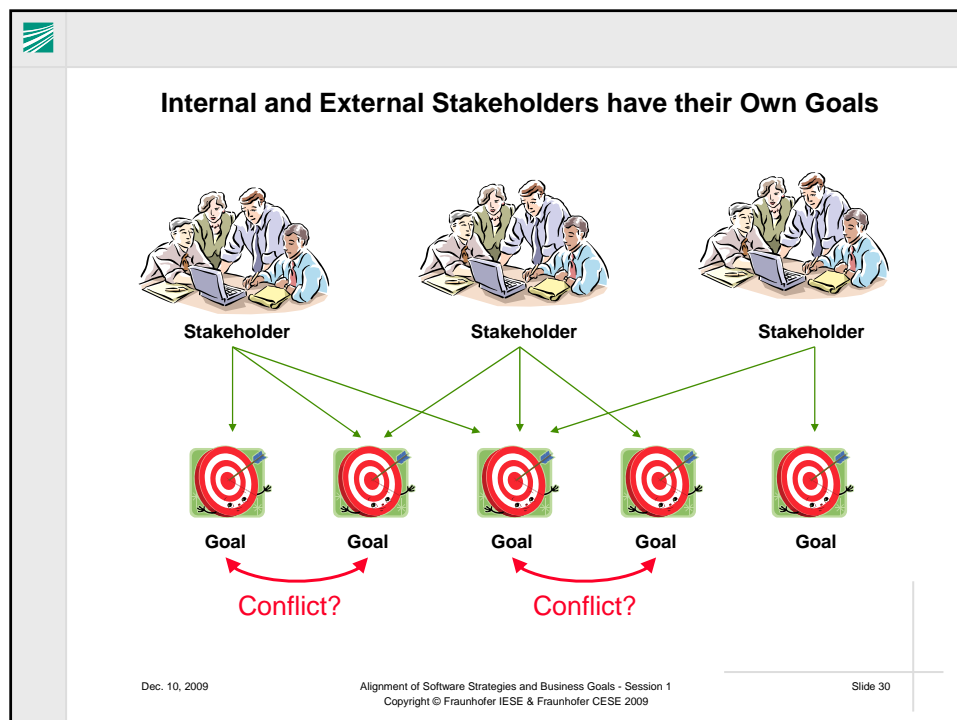
- Motivation
- Measurement Principles and Basics
- **Goal-oriented Measurement**

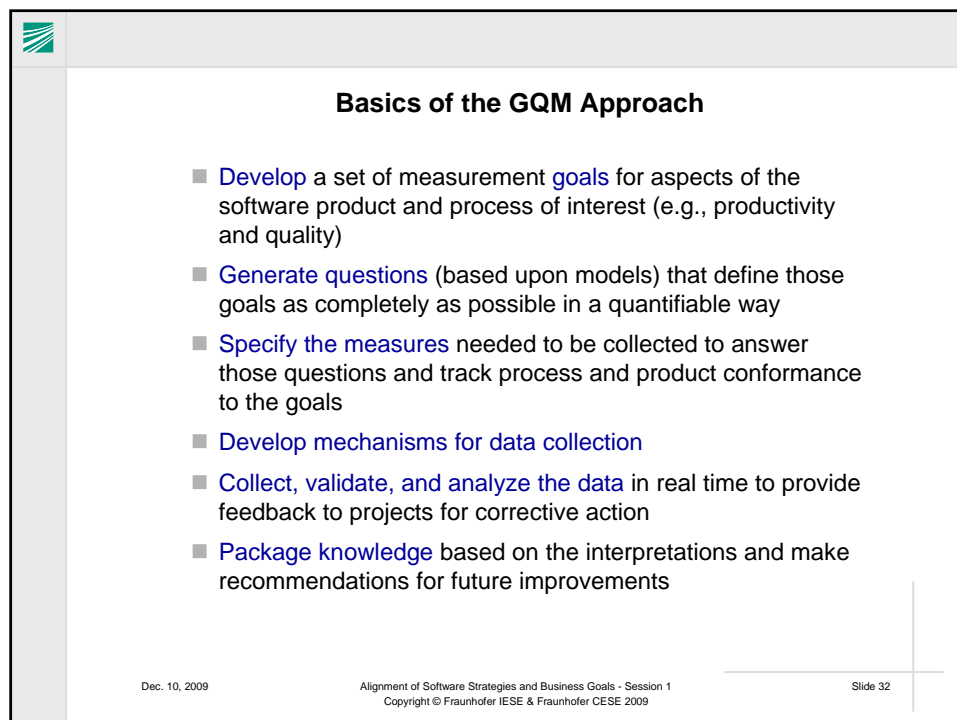
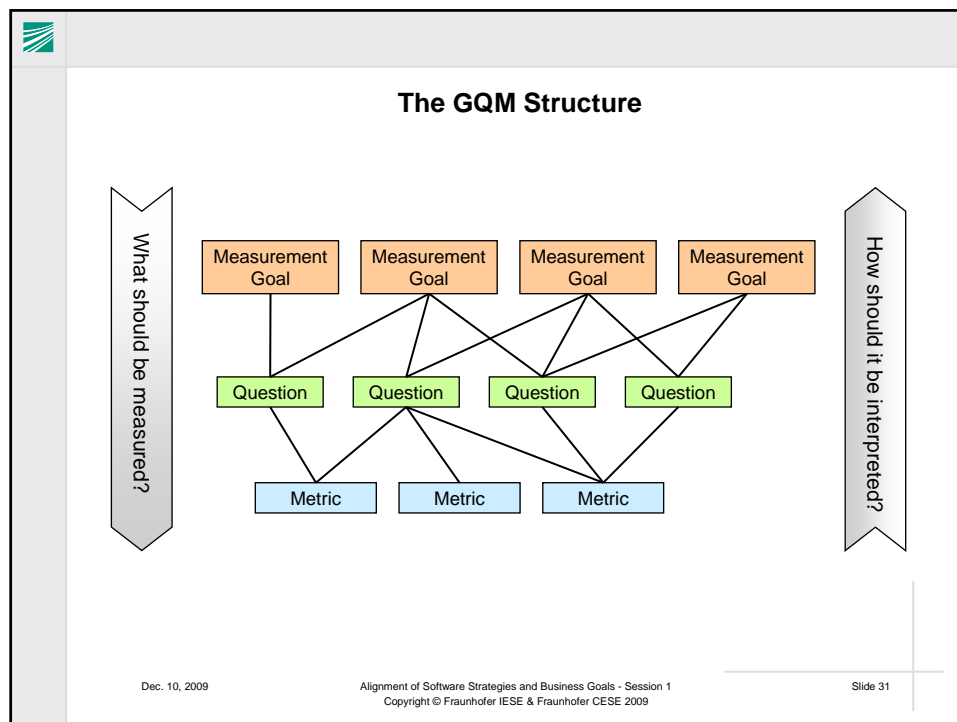
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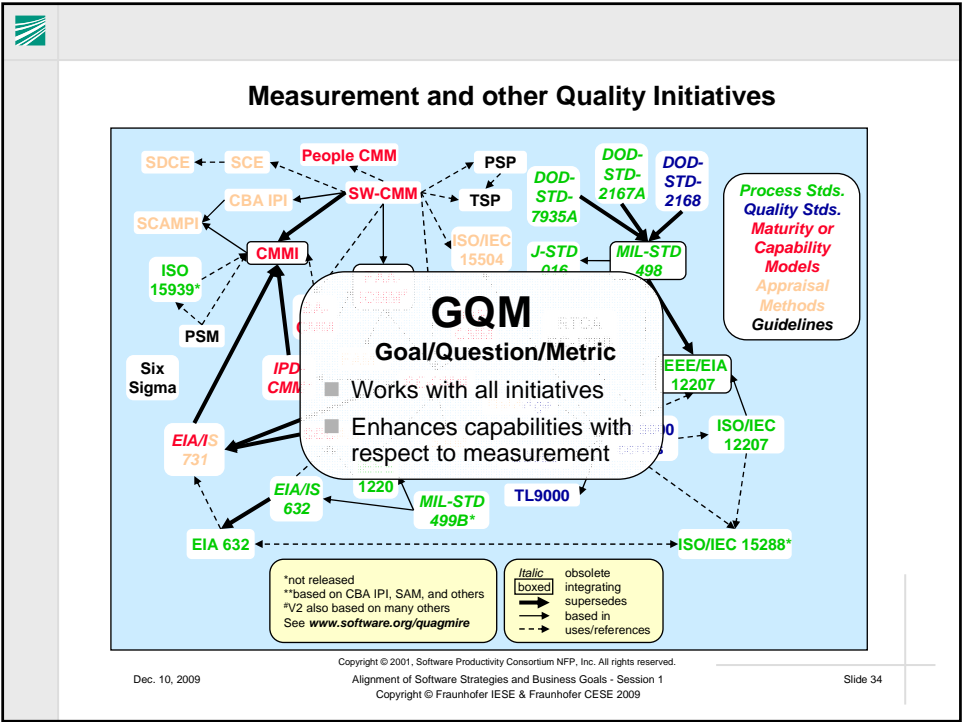
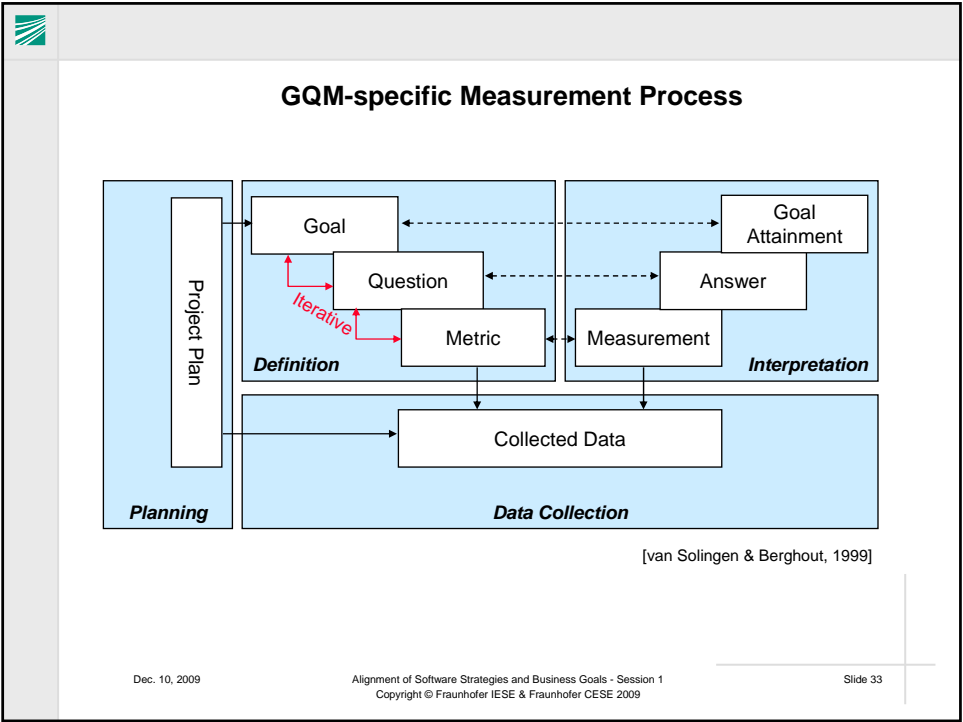
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Goal Generation Template

- Goals may be defined for any object, for a variety of reasons, with respect to various models of quality, from various points of view, relative to a particular environment.
 - **Analyze some**
 - Object of study: process, product, resource, ...
 - **for the purpose of**
 - Purpose: characterize, evaluate, predict, motivate, improve
 - **with respect to**
 - Focus: cost, correctness, defect removal, changes, reliability, user friendliness, ...
 - **from the point of view of**
 - Stakeholder: user, customer, manager, developer, corporation, ...
 - **in the following context**
 - Context: problem factors, people factors, resource factors, process factors, ...

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Example

Example 1: Generating a Measurement Goal


Consider the following situation:

- The organization needs to improve the quality of their products (**Business Goal**) because customers report too many failures, most of which should have been caught during the system test
- It is considering adopting a new system test process (a risk and expense) and wants to try the new system test process on a pilot project (**Strategy**) to determine if it is doable and more effective than what it has been doing (**Software Goal**)
- The organization has data on the number of faults identified by the system test process and the number released to the field for various products. It uses a waterfall type life cycle process, ... (**Context**)
- To make an informed decision it must define the new test process, determine if it is being followed, characterize how well the process is identifying faults, and compare it to what they were doing before (**Measurement Goal**)

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Example


Example GQM Goal 1

Object	Analyze the system test process
Purpose	for the purpose of evaluation
Focus	with respect to defect slippage
Viewpoint	from the point of view of the corporation
Context	in the context of the specific organizational environment

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Guidelines for Deriving Process-Related Questions

- Process Conformance
 - ☐ Characterize the process quantitatively and assess how well the process is performed
 - ☐ How do we quantitatively characterize the process?
- Domain Understanding
 - ☐ Characterize the object of the process and evaluate the knowledge of the object and its domain by the process performers
 - ☐ How do we quantify this knowledge?
- Focus
 - ☐ What is the aspect of the process which is of interest?
 - ☐ Analyze the output of the process according to some quality model and some viewpoint
- Feedback
 - ☐ What has been learned about the process, its application, the product domain, or any other process or product?

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Example


Example 1: Generating Questions

- **Process Conformance**
 - ☐ Q1: How many requirements are there?
 - ☐ Q2: What is the importance of testing each requirement?
 - ☐ Q3: What is the complexity of testing each requirement?
 - ☐ Q4: What is the distribution of tests over requirements?
 - ☐ Q5: Is the number of tests per requirement consistent with its complexity and importance?
- **Domain Understanding**
 - ☐ Q6: What is the experience of the team with respect to the domain?
- **Focus**
 - ☐ Q7: What is the defect slippage rate and does the new process reduce it sufficiently to invest in it?
- **Feedback**
 - ☐ Q8: Can the process be improved?
 - ☐ ...

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Example


Example 1: Measuring the Questions (1/2)


- **Q1:** How many requirements are there?
 - ☐ **M1:** Overall number of requirements
- **Q2:** What is the importance of testing each requirement?
 - ☐ **M2:** Subjective rating by marketing and testers on a scale from 0 (not important) to 5 (critical)
- **Q3:** What is the complexity of testing each requirement?
 - ☐ **M3:** Subjective rating by testers on a scale from 0 (does not need to be tested) to 5 (extremely difficult)
- **Q4:** What is the distribution of tests over requirements?
 - ☐ **M4:** Average number of tests per requirement
 - ☐ **M5:** Standard deviation from the average number
- **Q5:** Is the number of tests per requirement consistent with its complexity and importance?
 - ☐ **M6:** Subjective rating per person on a scale from 0 (no tests) to 5 (more than adequate)

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Example


Example 1: Measuring the Questions (2/2)


- **Q6:** What is the experience of the team with respect to the domain?
 - **M7:** Subjective rating per person on a scale from 0 (none) to 5 (worked in on several projects)
- **Q7:** What is the defect slippage rate and does the new process reduce it sufficiently to invest in it?
 - **M8:** Ratio of faults found in system test to the faults found after system test on this project (if at least 1 fault is found)
 - **M9:** Ratio of faults found in system test to the faults found after system test in the set of projects used as a basis for comparison (if at least 1 fault was found)
 - **DSR:** The Defect Slippage Rate (DSR) is defined as the relationship of system test on this project to faults as compared to the average of the appropriate basis set
$$DSR = M8/M9$$
- **Q8:** Can the process be improved?
 - ...

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Example

Example 1: Interpreting the Defect Slippage Rate

- If $DSR > 1$, then
 - **Method better than history for this class of project**
 - Check process conformance
 - If process conformance poor, improve process or process conformance
 - Check domain understanding
 - If domain understanding poor, improve object or domain training
- If $DSR \sim 1$, then
 - **Method equivalent to history for this class of project**
 - If cost lower than normal, method cost effective
 - Check process conformance ...
- If $DSR < 1$, then
 - Check process conformance
 - If process conformance good, check domain conformance
 - If domain understanding good
 - **Method poorer than history for this class of project**

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GQM Abstraction Sheets Overview

- A GQM abstraction sheet
 - Helps elicit and structure information during an interview
 - Assists in constructing, refining, and reviewing GQM goals, questions and metrics
 - Helps to reveal dependencies between questions
- Quadrants of a GQM abstraction sheet:
 - **Quality focus:** What are possible metrics for measuring an object of a goal, according to the project members?
 - **Baseline hypothesis:** What is the project member's current knowledge with respect to these metrics? His or her expectations are documented as 'baseline hypotheses' of the metrics.
 - **Variation factors:** Which (environmental) factors does a project member expect to be of influence on the metrics?
 - **Impact on baseline hypothesis:** How could these variation factors influence the actual measurements? What kind of dependencies between the metrics and influencing factors are assumed?

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GQM Abstraction Sheets (1/4)

Object	Purpose	Focus	Viewpoint	Context
Inspection	Understand	Effectiveness and Efficiency	Inspector	X
Quality Focus <ul style="list-style-type: none"> M1: # defects detected M2: # defects slipped M3: $M1 / (M1 + M2) \%$ M4: # hours per detection 		Variation Factors <div style="text-align: center;">  <p>Implicit Model</p> </div>		
Baseline Hypotheses <ul style="list-style-type: none"> M3: 75% M4: 3 h 		Impact of Variation Factors		

- The **focus** is defined via metrics
- Representatives of the viewpoint are interviewed (experts who know implicit model)
- Hypotheses are defined for new project (in order to allow for analyses of deviations)

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GQM Abstraction Sheets (2/4)

Object	Purpose	Focus	Viewpoint	Context
Inspection	Understand	Effectiveness and Efficiency	Inspector	X
Quality Focus <ul style="list-style-type: none"> M1: # defects detected M2: # defects slipped M3: M1 / (M1 + M2) % M4: # hours per detection 		Variation Factors <ul style="list-style-type: none"> M5: Experience of personnel (-, 0, +) M6: Size of program (-, 0, +) M7: Language (L1, L2, L3) 		
Baseline Hypotheses <ul style="list-style-type: none"> M3: 75% M4: 3 h 		Impact of Variation Factors		

- Variation factors (due to human-based inspection process) are derived from object performance and context
- Variation factors are elicited via interviews from experienced personnel
- (0, 0, L1) represents context vector for hypotheses!
- If no experienced personnel is available, then start without variation factors & include after each project

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GQM Abstraction Sheets (3/4)

Object	Purpose	Focus	Viewpoint	Context
Inspection	Understand	Effectiveness and Efficiency	Inspector	X
Quality Focus <ul style="list-style-type: none"> M1: # defects detected M2: # defects slipped M3: M1 / (M1 + M2) % M4: # hours per detection 		Variation Factors <ul style="list-style-type: none"> M5: Experience of personnel (-, 0, +) M6: Size of program (-, 0, +) M7: Language (L1, L2, L3) 		
Baseline Hypotheses <ul style="list-style-type: none"> M3: 75% M4: 3 h 		Impact of Variation Factors <ul style="list-style-type: none"> if (M5='+') then (M3='90%') & (M4='2.5 h') if (M7='L2') & (M6='+') then (M3='60%') & (M4='4 h') 		

- Any variation of current context vector may produce a varied hypothesis/model, see context vector (+,0,L1)
- A priori elicitation of variation models must be based on experience (allows focus of variation analysis)
- Collected set of models is stored in an Experience Data Base (EDB)

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GQM Abstraction Sheets (4/4)

Object	Purpose	Focus	Viewpoint	Context
Inspection	Understand	Effectiveness and Efficiency	Inspector	X
Quality Focus <ul style="list-style-type: none"> M1: # defects detected M2: # defects slipped M3: M1 / (M1 + M2) % M4: # hours per detection 		Variation Factors <ul style="list-style-type: none"> M5: Experience of personnel (-, 0, +) M6: Size of program (-, 0, +) M7: Language (L1, L2, L3) 		
Baseline Hypotheses <ul style="list-style-type: none"> M3: 75% M4: 3 h 		Impact of Variation Factors <ul style="list-style-type: none"> if (M5='+') then (M3='90%') & (M4='2.5 h') if (M7='L2') & (M6='+') then (M3='60%') & (M4='4 h') 		


- Complete intellectual control of a specific measurement goal requires coverage of all possible context factor combinations!
- Some combinations may never occur!
- Some combinations with negative effects may be avoidable (e.g. (M5='-') thru training)

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Advice and Considerations

- Measurement should not be an end in itself, but a **key factor to reach business goals**
- Measurement needs to be **deeply integrated** into organizational processes
- Measurement programs help to **make decision making more transparent**
- Goal-oriented measurement is the **basis for the success** of measurement programs
- Higher-level goals require more understanding, but **have a bigger payback**
- There is **no universal measurement** program solving all problems related to measurement
 - Metrics are context-specific
 - Metrics depend upon goal statements
 - Piloting is necessary to build up a widely accepted measurement program

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What will follow

- Session 2
 - ☐ The linkage of different [goal levels](#)
 - ☐ [Interpretation models](#) for aggregating data and decision support
 - ☐ The use of [context variables](#)
 - ☐ A comprehensive [example](#)
 - ☐ [Lessons learned](#) and [conclusions](#)
- Session 3
 - ☐ Practical exercises on [GQM](#) and [GQM Abstraction Sheets](#)
 - ☐ Practical exercises on [GQM*Strategies](#)

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