Practical Software Measurement: History and Origins

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Agenda

- History
- Technical Background
- Measurement Framework
- Process Model
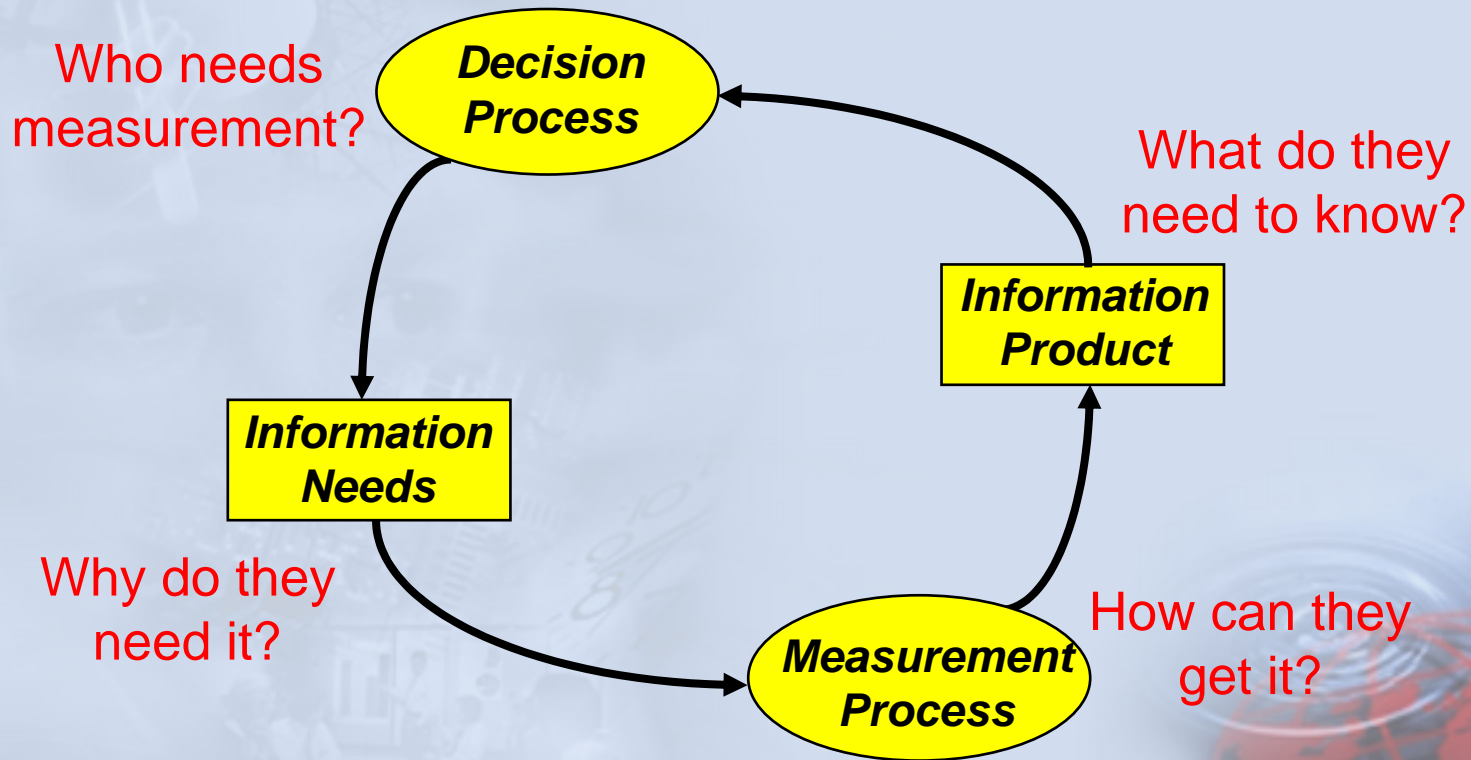- Information Model
- Measurement and the CMMI
- Summary

History

- Initiated in 1994 by the U.S. Department of Defense

- Developed by a team of authors

- Advised by a Technical Working Group of industry, government, and academia

- Continuing project to evolve and transition concepts

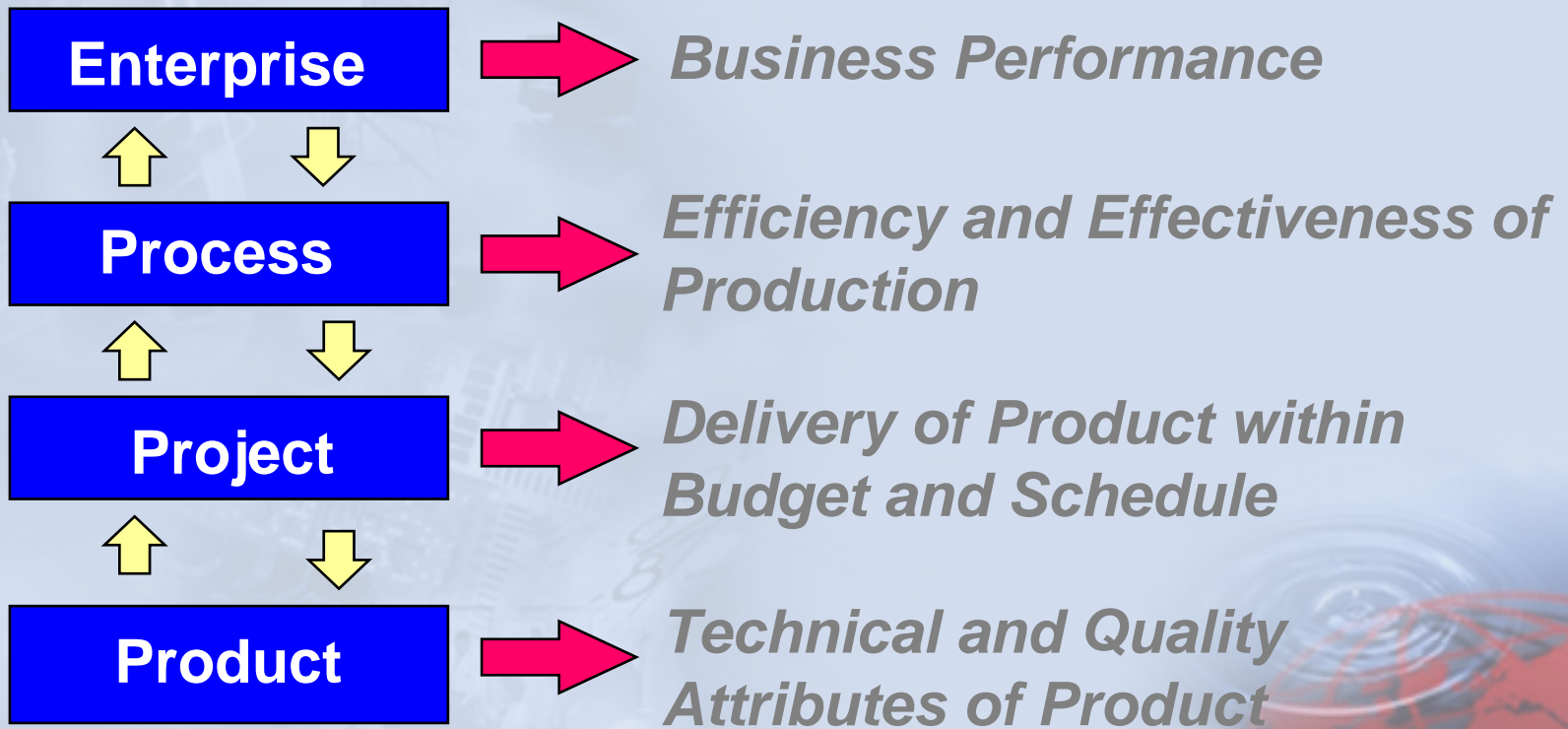- Designated transition organizations and qualified instructors

Technical Background

- ISO/IEC Standard 15939 is the basis for the Measurement and Analysis (M&A) Process Area of the CMMI^{sm}

- ISO/IEC Standard 15939 is based on earlier ISO guidance such as the International Vocabulary and Glossary of Terms in Metrology

- PSM is an implementation guide for ISO/IEC Standard 15939 and M&A at CMMI Level 2/3

- Measurement framework incorporates these concepts but addresses a broader range of decision-making

Framework Elements

Who needs measurement?

Decision Process

What do they need to know?

Information Product

Information Needs

Why do they need it?

Measurement Process

How can they get it?

D.N. Card, A Practical Framework for Software Measurement and Analysis, Auerbach *Systems Management Strategies***, October 2000.**

Hierarchy of Decision Making

Enterprise ➡️ *Business Performance*

Process ➡️ *Efficiency and Effectiveness of Production*

Project ➡️ *Delivery of Product within Budget and Schedule*

Product ➡️ *Technical and Quality Attributes of Product*
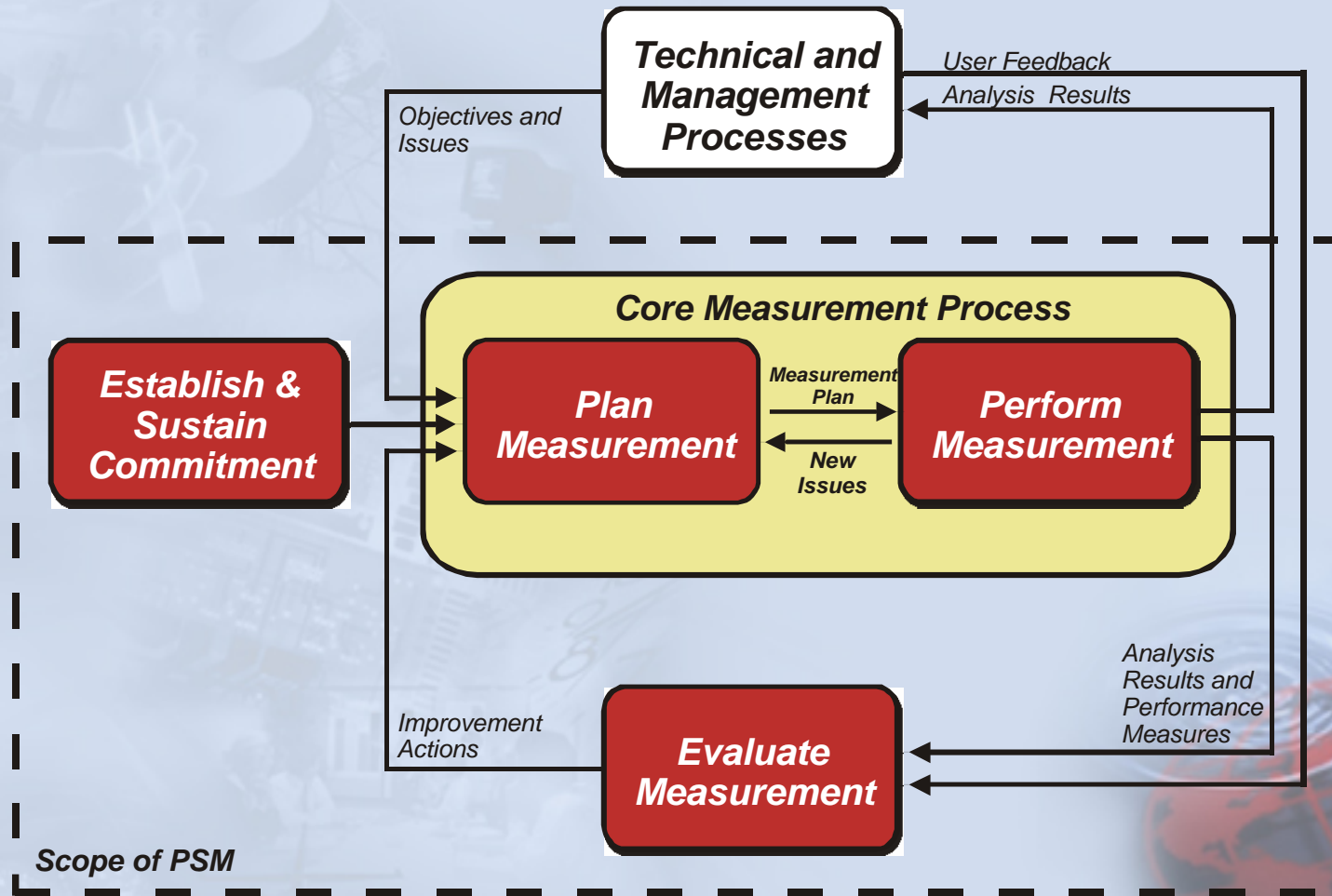
Information Needs

- Objectives
  - Business goals
  - Customer requirements
  - Intermediate targets
- Obstacles to Achieving Objectives
  - Risks
  - Problems/Constraints
  - Lack of Information

Process Model

- Describes the basic activities in processing measurement data

- Applicable to all types of measurement data (per the CMMI)

- Addresses both "collection" and "analysis" of data

- Involves the development and execution of a measurement "plan"

Measurement Activities

Adapted from K. El Emam and D. Card (eds.), *ISO/IEC Standard 15939, Software Measurement Process*, 2000

Information Model Overview

- Provides Rigorous Definitions of Basic Measurement Concepts

- Links Information Needs to Measurable Entities

- Avoids Use of "Metric" (a term not used in CMM or CMMI)

- Explains Prevalence of Three-Level Measurement Models (e.g., GQM, ICM, FCM)

- Provides a Template for Fully and Unambiguously Defining Measures and Analysis

High-Level View

Information Need

Information Product

Measurable Concept → **Measurement Construct**
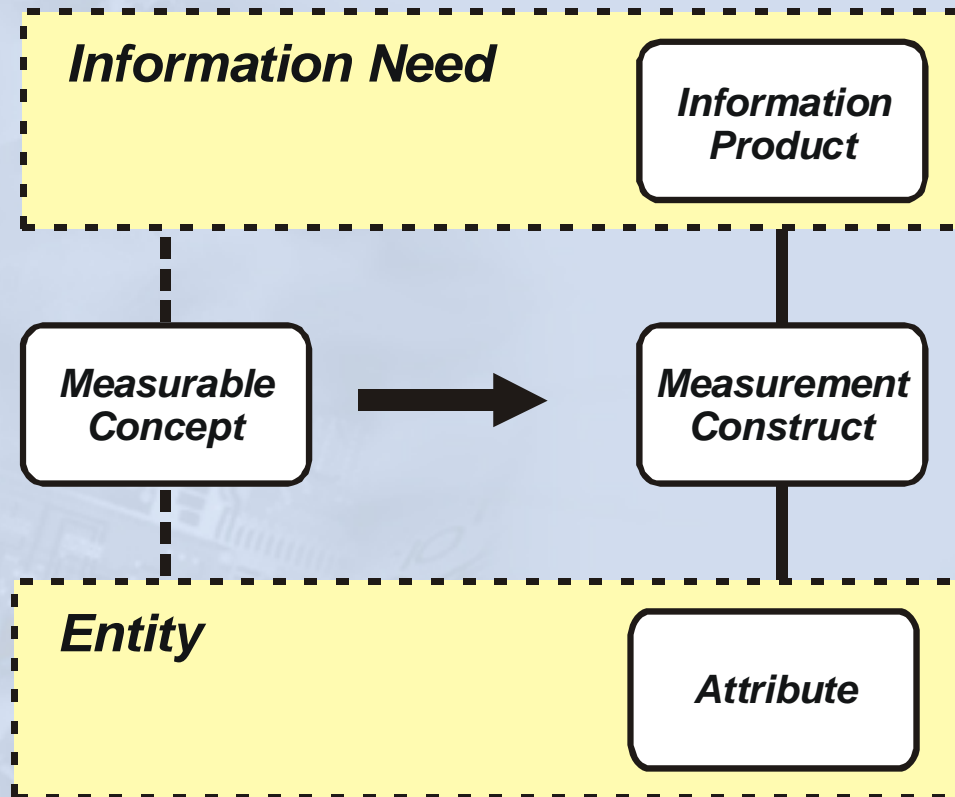
Entity

Attribute

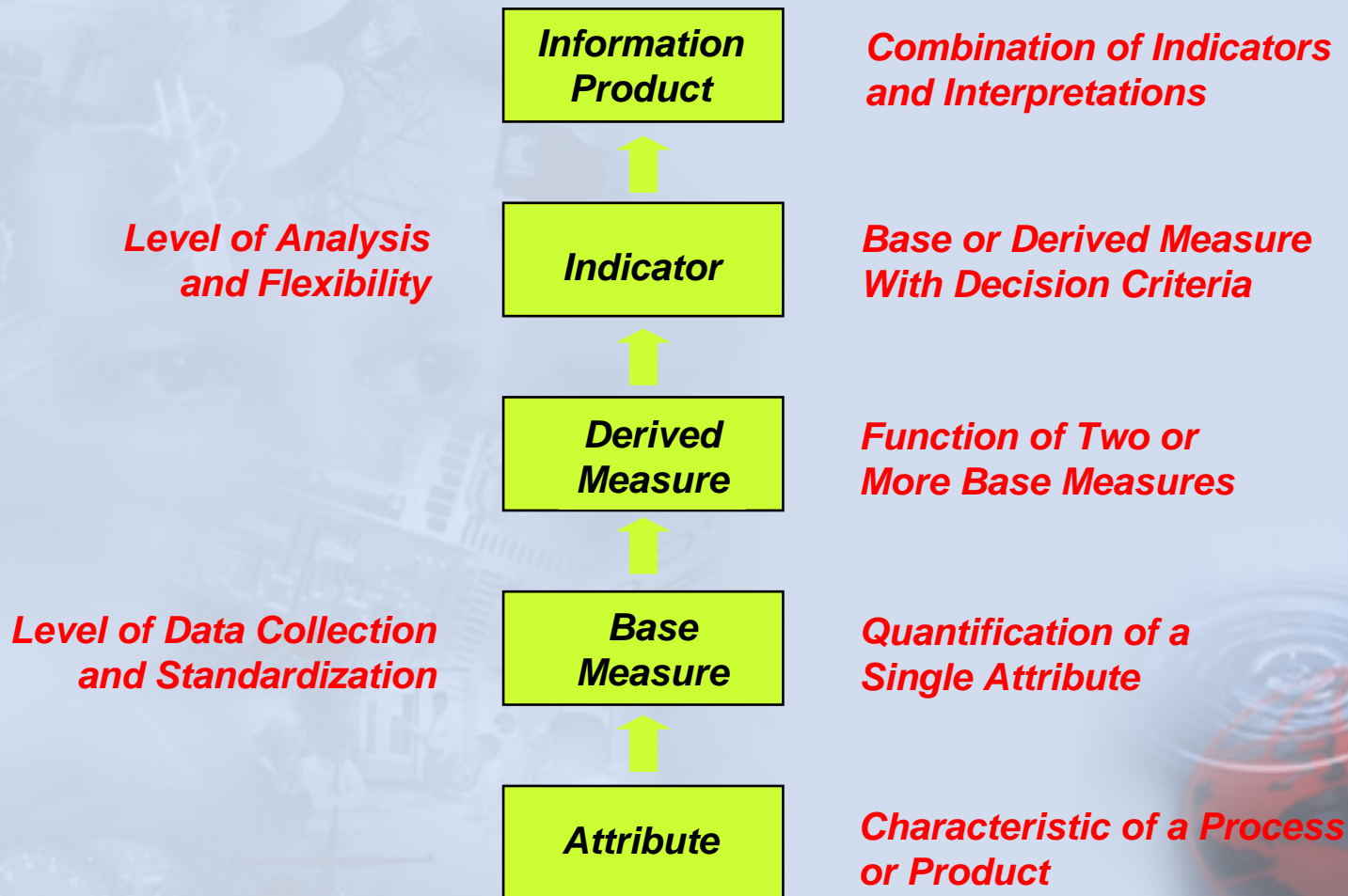*Adapted from ISO/IEC 15939 - Software Measurement Process*

Measurable Concept

- An "Idea" About How an Information Need Can Be Satisfied
  - Possible entities and attributes to be measured
  - Potential use of results in decision making
- May Be Implemented with Many Different Measurement Constructs
- Each Measurable Concept Responds to a Different Question

Measurement Construct

- A Specific Method for Implementing a Measurable Concept
  - Specific entities and attributes
  - Pre-planned analysis

- Consists of Base Measures, Derived Measures, and Indicators

- An Information Product Is Comprised of a Collection of Measurement Constructs with Interpretations

Measurement Construct

Information Product — *Combination of Indicators and Interpretations*

↑

Level of Analysis and Flexibility — **Indicator** — *Base or Derived Measure With Decision Criteria*

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Derived Measure — *Function of Two or More Base Measures*

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Level of Data Collection and Standardization — **Base Measure** — *Quantification of a Single Attribute*

↑

Attribute — *Characteristic of a Process or Product*

Base Measure Definition

- A Measure of a Single Attribute

- A Base Measure Includes:
  - A measurable attribute of an entity
  - A method for quantifying the attribute
  - A value resulting from applying the method

- Related Concepts Include:
  - Measurement scale (used by method)
  - Unit of measure (used by scale)
  - Observation (act of assigning a value)
  - Unit of observation (i.e., type of entity)

Derived Measure Definition

- A Measure that Incorporates Information About Two or More Attributes or Multiple Observations of the Same Attribute

- A Derived Measure Includes:
  - Two or more values of base and/or derived measures
  - A mathematical function combining the values
  - A value resulting from applying the function

Indicator Definition

- A Measure that Provides an Estimate or Evaluation of Specified Attributes with Respect to an Information Need

- A Indicator Includes:
  - One or more values of base and/or derived measures
  - An analysis model combining the values
  - A value resulting from applying the model
  - Decision criteria used to assess the indicator value

Measurement Procedures

- Define the Specific Operations, Tools, and Responsibilities for Measurement Activities
- Address Both:
  - Data collection and storage
  - Data analysis and reporting
- Integrate Measurement into Engineering and Management Processes

Data Collection

- Base Measures to Collect
- Sources of Data
- Data Collection Tools
- Databases and Retrieval Tools
- Base and Derived Measures to Store
- Verification Activities
- Collection Frequency
- Applicable Phases and Activities
- Responsibility

Data Analysis

- Base and Derived Measures to Analyze
- Databases to Access
- Data Analysis Tools
- Indicators to Produce
- Activities to Review Results
- Analysis and Reporting Frequencies
- Applicable Phases and Activities
- Responsibility

M&A in the CMMI

- Supporting process area
- Assigned to Level 2 in the staged representation
- Not a process area in the CMM
- Two specific goals and supporting practices
  - Plan
  - Perform
- Generic goals and practices address "Establish" and "Improve" activities in ISO/IEC Standard 15939
- Uses terminology of Information Model

Measurement & Analysis - 1

SG 1   Align Measurement and Analysis Activities

Measurement objectives and activities are aligned with identified information needs and objectives.

SP 1.1 Establish Measurement Objectives **Establish and maintain measurement objectives that are derived from identified information needs and objectives.**	**Completely new**
SP 1.2 Specify Measures **Specify measures to address the measurement objectives.**	**Although the use of measurements (as required in CMM) implies specifications of measurements, this GP requires much more rigor.**
SP 1.3 Specify Data Collection and Storage Procedures **Specify how measurement data will be obtained and stored.**	**Completely new**
SP 1.4 Specify Analysis Procedures **Specify how measurement data will be analyzed and reported.**	**Completely new**

Measurement & Analysis - 2

SG 2	Provide Measurement Results

> *Measurement results that address identified information needs and objectives are provided.*

SP 2.1 Collect Measurement Data Obtain specified measurement data.	Completely new
SP 2.2 Analyze Measurement Data Analyze and interpret measurement data.	Completely new
SP 2.3 Store Data and Results Manage and store measurement data, measurement specifications, and analysis results.	Completely new
SP 2.4 Communicate Results Report results of measurement and analysis activities to all relevant stakeholders.	Completely new

Information Needs in the CMMI

- Project Planning

- Project Monitoring and Control

- Quantitative Project Management

- Organizational Process Performance

- GP 2.8 in all Process Areas

- Requirements of Specific Practices

Many different indicators can be produced from the same base measures to satisfy multiple information needs.

Summary

- Measurements may/should be made for many purposes (per the Measurement Framework)
- Effective implementation of the Measurement and Analysis Process Area ensures that information needs are satisfied systematically
  - ✓ Information model
  - ✓ Process model

PSM Transition Organizations

- Liveware (Argentina)
- ti Metricas (Brasil)
- Centro de Investigaciones Matematicas (Mexico)
- Q-Labs (USA)
- others

About Q-Labs

- Consulting and Appraisals in Software Measurement, CMM/CMMI, ISO 9000, SPICE, etc.

- International Company
  - France
  - Germany
  - Sweden
  - UK
  - USA

- 120 employees

- ISO 9001 Certified

- A broad international client base, e.g.
  - Alcatel, Bouygues Telecom, France Telecom, Orange
  - AXA, BNP Paribas, Banques Populaires
  - ABB, R. Bosch, EDF, IBM, Siemens, Schneider Electric, Thomson Detexis, Volvo, Sony
  - Atomic Energy Board of Canada, FAA, Norwegian Ministry of Justice, Swedish Civil Aviation Administration
  - Thales, Thomson, FMV, US Army TACOM