A Practical Systems Engineering Measurement Model

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Agenda

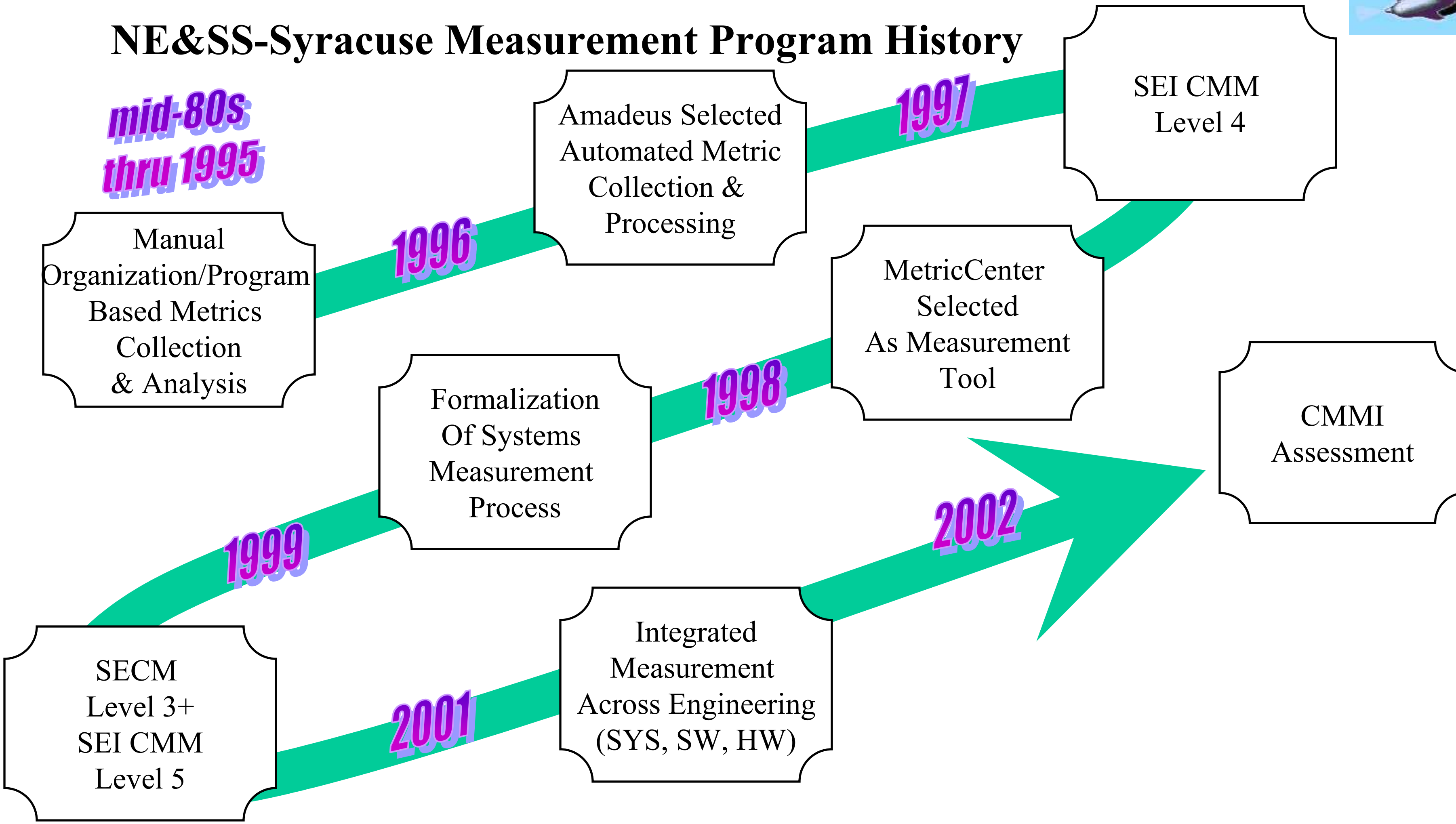
- **Our History**
- **Introduction**
- **The Modeling Process**
- **Measures**
  - **Base**
    - **Categorizing**
    - **Measured**
  - **Derived**
- **Data Collection**
- **Implementation**
- **Mock Results**
- **Future Efforts**
- **Summary**

NE&SS-Syracuse Engineering Excellence

- Over 12 years of formal continuous engineering process improvement
  - First SEI CMM credentials established in 1993
  - SECM Level 3+ achieved 1999
  - SEI CMM Level 5 achieved in1999
  - Currently performing a CMMI Assessment
- Over 10 years of active participation in LM Engineering Process Improvement Center (EPI Program)
- Embraced philosophy of LM-Integrated Engineering Process
- LM-21 best practices
  - Booz-Allen Hamilton "Best in Class" benchmark and best practices transfer (Requirements Generation, Verification & Management, Design Re-Use, …)
  - Six Sigma/SPC, Lean, EXCEL teams
- Management commitment and support
  - Management is convinced that improved processes result in significant and quantifiable cost savings and product quality
  - Significant investment is made each year to maintain and improve processes

Demonstrated Commitment to Engineering Process Improvement.

NE&SS-Syracuse Measurement Program History



Measurement is a journey, not a destination

Introduction

- **Dilemma**
  - Proposal costing and quoting of System Engineering (SE) relied too heavily on individual experience and hence suffered from inherent subjectivity

- **Vision**
  - To establish a model based on historical performance supporting objective proposal costing and quoting.
  - The model should be able to answer questions such as
    - How much labor is required to produce a System Requirement Specification (SRS)?
    - How much labor is required per requirement to produce a SRS?
    - What trends exist regarding the development of SE products?

The Modeling Process

- Identify the products (e.g. SRSs, etc) to model
- Define base measures to collect
  - Categorize data (e.g. business, program)
  - Measure data (e.g. number of requirements, number of pages)
- Define derived measures to produce
- Collect historical program data
- Implementation
- Use

Remember to use PSM/GQM etc to select measures

Base Measures: Categorizing Data

Category	Description
Product	SRS, Operational Concept, Interface Control Document, etc.
Product Type	A second level of product description (e.g. Display, Signal Processing)
Business Area	The line of businss (e.g. Ocean, Radar)
Program	The specific program
Discipline	Systems, Software, Hardware, Integration & Test
Cost Account ID	A unique cost tracking identifier

Strongly typed category fields support dynamic ad hoc queries

Base Measures: Measured Data

Field	Definition
Person Days	The amount of labor required to produce a product
Complexity	1 (low) to 5 (high) - Assigned by product owner
# of Reqts.	The total number of requirements for this product (as applicable)
% New Reqts.	Of the total requirements, what % are brand new (vs.reused)
# of Pages	The total number of pages in document products

Measures obtained from source tools and product owners

Derived Measures

- **Primary**
  - **Labor required to create SE product(s)**
    - **SRSs by type**
    - **Operational Concepts**
    - **Etc.**
  - **Labor required to develop a requirement per SE product type**
- **Auxiliary**
  - **Distribution of labor between disciplines**
    - **In person-days**
    - **As a percentage**
  - **Distribution of labor between SE products**
    - **In person-days and as percentages**
  - **SE product size measures**
  - **Etc.**

The model provides useful product performance measures

Data Collection

- **Data initially collected from**
  - **2 lines of business**
  - **14 programs**
  - **7 “disciplines”**
  - **14 product types**
  - **Many product subtypes**
- **Base measures obtained from**
  - **Cost accounting system**
  - **Requirements tracking systems**
  - **Configuration Management systems**
  - **Product owners**
- **Obtaining historical data was challenging since some cost structures were not established with product level measures in mind**
  - **Cost accounts should be created for each individual product**

Ensure infrastructures support collection of the natural measures

Implementation

- MS-Excel was selected for the initial model
  - It provides easy interrogation and ad hoc querying
  - It allows for easy migration to a relational DB in the future
- Architecture
  - A spreadsheet database
  - Strongly typed fields
  - Additional text description fields
- How the model works...
  - Filters are used on the category fields to query appropriate products
    - Program
    - Product type
    - Discipline, etc
  - This allows users to view measures for a program, set of products, individual products or any combination.
  - Once filtered, the complete set of derived measures (including standard deviations) are automatically provided

Historical performance measures enabled with fast, intuitive and dynamic searches

Mock Results

- Possible results for Control SRSs from the Ocean business
  - All Numbers, Descriptions, and Program Names have been changed to protect proprietary information

SRS Filtered

Control Filtered

Bus.	Prog.	Discip.	Prod.	Type	Description	S	Cmplxty	Base MD	EReqts.	% New	# Pages	# Reqts.
Ocean	A	SE	SRS	Control	SW Spec SR	C	5	250.0	500.0	100%	220	500
Ocean	B	SE	SRS	Control	SW Spec S/L	C	3	170.0	300.0	100%	150	300
Ocean	C	SE	SRS	Control	SW Spec CS	C	3	170.0	200.0	100%	50	200
Ocean	D	SE	SRS	Control	SW Spec CP	C	3	200.0	230.0	100%	125	230

Business Filtered

Key Measures

		Base MD	EReq		# Pages
Averages:	3.5	197.5	307.5	1.0	136.3
Standard Deviation:	1.0	37.7	135.0	0.0	70.2

MD/EReq
0.64

Empirical data has demonstrated the model to be very accurate

Future Efforts

- Continue to populate the database
  - A larger database population will reduce the effects of statistical outliers, and increase the overall accuracy of the model
  - Complete data update for active programs and add new programs as necessary.
- Formalize Database
  - Evaluate available databases which provide best migration from existing DB structure
- Further statistical analysis of current data
  - Perform regression analysis to determine how much variance is described by model
  - Improve query and analysis techniques
- Increase the number of descriptive fields which allows for greater accuracy when estimating products
  - Leverage parameters from COSYSMO
  - Examples:
    - Number of Interfaces
    - Duration
    - Experience
    - Specific Product Experience
    - Team Size

Summary

- **The model provides a historical database to satisfy measurement needs**
  - **Provides framework for improving accuracy of quotes**
  - **Quantitative data available as an alternate "Check & Balance"**
  - **Provides means to add new programs and update active programs**
  - **Provides a future path consistent with the System Engineering vision**

Even in the development stage, the model is very useful