Raytheon

Customer Success Is Our Mission

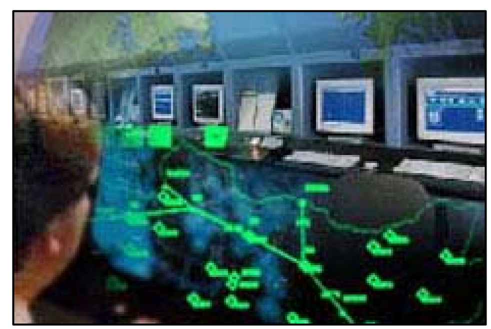
Measurement Journey to Successful Multi-site and Multi-discipline CMMI Level 5

Outline

- Introduction to Raytheon
- Process Improvement Journey to CMMI Level 5
- Best Practices
- Future Opportunities
- Results
- Q & A

Introduction to Raytheon and NCS

- Raytheon is an industry leader in defense and government electronics, space, information technology, and technical services
- Network Centric Systems (NCS) develops and produces mission solutions for networking, command and control, battle space awareness, homeland security and air traffic management



Major NCS Sites and Overall Goal

- NCS Engineering Organization = Over 5,000 individuals
- Number of programs to appraise = 33 (CA 8, TX 4, IN 9 , FL 4, MA 8)
- Various levels of CMMI maturity at the project onset

NCS Process Improvement Journey: Measurement-Related Goals

- Establishing a Common Measurement Program
  - All major NCS sites and engineering disciplines
  - Common plans and work instructions that support CMMI Level 5
  - Common process and tooling

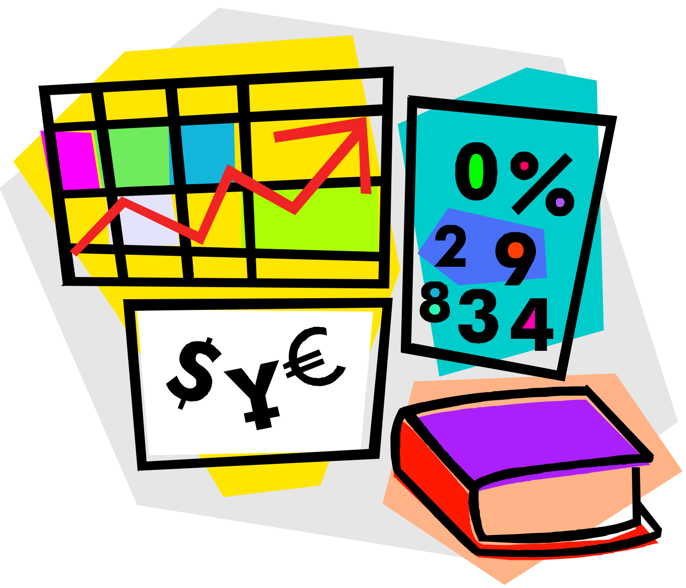
- Consistent Approach
  - Define core set of engineering measures
  - Define analysis that should occur at various levels
  - Define measures roll-up as related to NCS goals
  - Define a set of CMMI Level 4 Sub-process approaches

- Have a "one company" look to our customers
  - Accurate historical data and consistent estimates across sites
  - Support Mission System Integrator (MSI) role
  - Support multi-site bids and work transfers between sites

Best Practice – Planning:
Define Core Engineering Measures

- Cost and Schedule Measures
- Defect Containment
- Staffing Profile
- Measurement Compliance
- Change Management
- Peer Review
- Requirements Volatility
- Design Margin Index (DMI)
- Size
- Productivity

There were many more measures, but Engineering started with a list of core measures



Best Practice – Planning:
Use Common Cost Collection Scheme

ACTIVITY TITLE	PE	SE	SW	HW: General Hardware	HW: Analog	HW: Digital	HW: FPGA	HW: Mechanical
PROJECT PLANNING & MANAGEMENT								
Planning and Management								
Quality Engineering								
Configuration Management								
REQUIREMENTS DEVELOPMENT								
System Requirements Definition								
System Design & Architecture								
Product Requirements Definition								
Product Design & Architecture								
Component Requirements Definition								
PRODUCT DESIGN & DEVELOPMENT								
Requirements Management								
Simulation and Modeling								
Preliminary Design								
Detailed Design								
Implementation								
Integration								
SYSTEM INTEGRATION & VALIDATION								
Product Verification & Validation								
System Integration								
System Acceptance Test								
System Field Test								

- Aligns disciplines and activities
- Used to identify and collect costs for Work Breakdown Structure (WBS) elements
- Scheme is aligned with Cost Estimation
- Facilitates collection of consistent historical data
- Defect data can be collected in these bins

Sets the foundation for CMMI Level 5 by aligning cost, schedule, and quality data

Best Practice – Definition: All Size Measures have Consistent Elements

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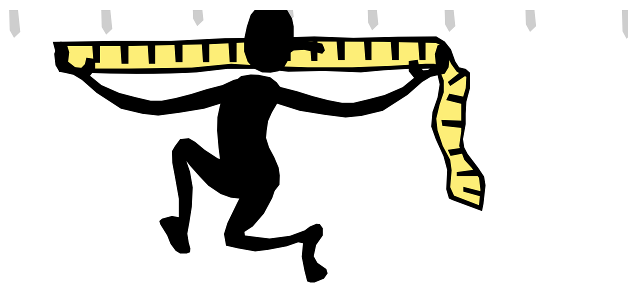
- Size measures were defined for Systems Engineering (SE), Software (SW), Hardware (HW)-Analog, HW-Digital, HW-FPGA (Field-Programmable Gate Array), and HW-Mechanical disciplines
- Sizes for each discipline were defined to have the capability to be converted to equivalent size units, where equivalent means equivalent to requiring the same amount of effort as developing it from scratch
- Each discipline's size data includes these elements
  - **Reused**
  - **Modified**
  - **New**
  - **Reuse Factor (F_R)**
  - **Modified Factor (F_M)**

$$\textbf{Equivalent} = \textbf{New} + (\textbf{Modified} * F_M) + (\textbf{Reused} * F_R)$$

Best Practice – Definition: Align SE Size Measures with CO SYS MO

- Raytheon created the SECOST tool, which aids deployment and company calibration with the Constructive Systems Engineering Cost Model (COSYSMO)
- NCS System Engineering sizes are aligned with COSYSMO sizes
- For each system of interest these are collected to compute equivalent requirements (EREQ):
  - System requirements
  - System interfaces
  - System algorithms
  - System scenarios



- For a complete SE size set of requirements data, additional NCS SE size measures include:
  - Software product requirements
  - Hardware product requirements
  - Hardware component requirements

Best Practice – Definition:
Specify SE Productivity Activities

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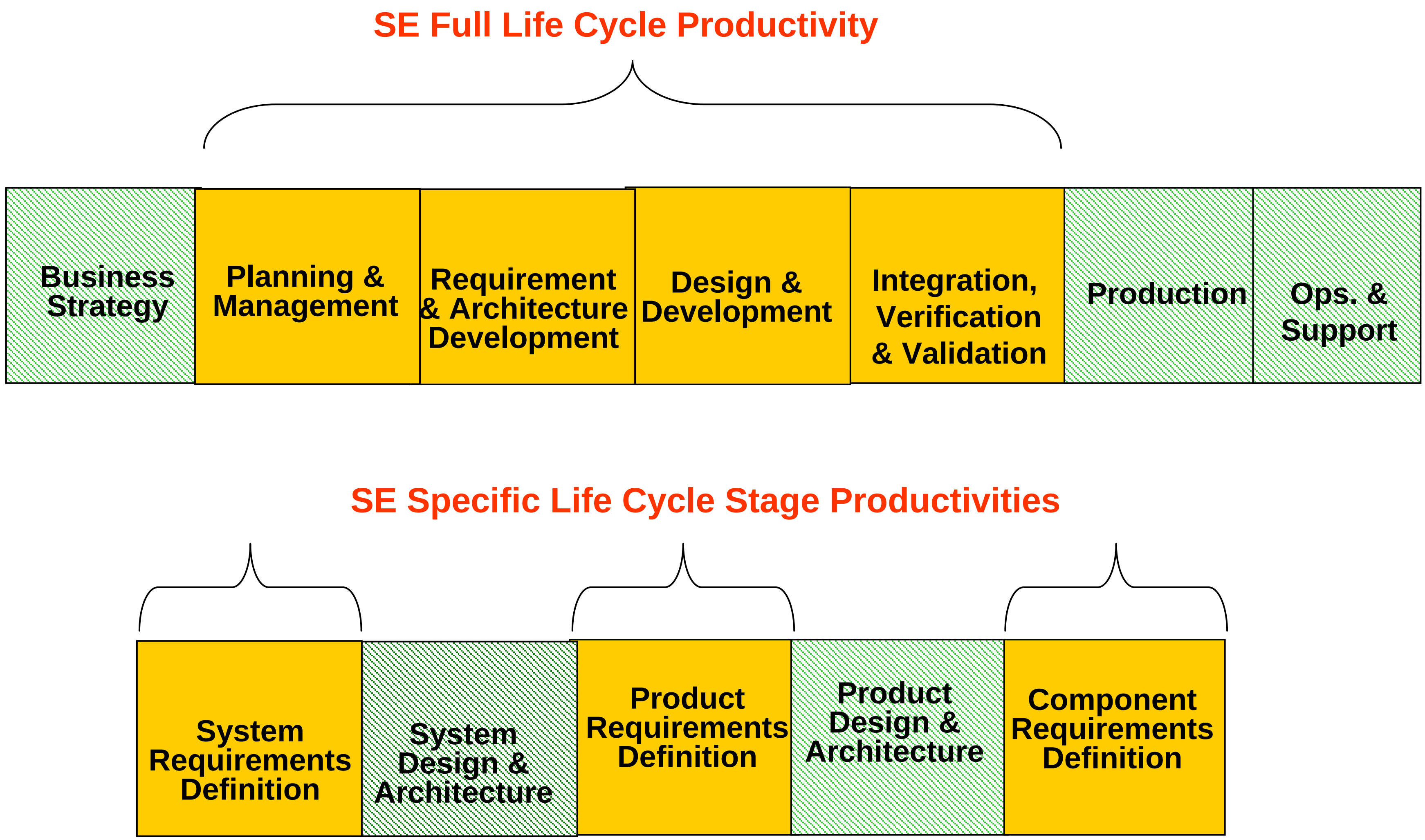
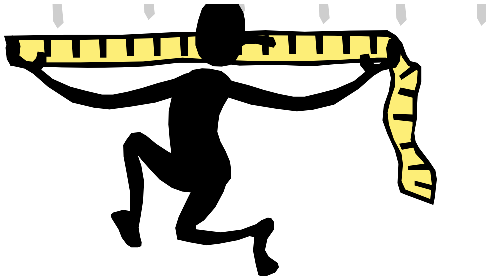


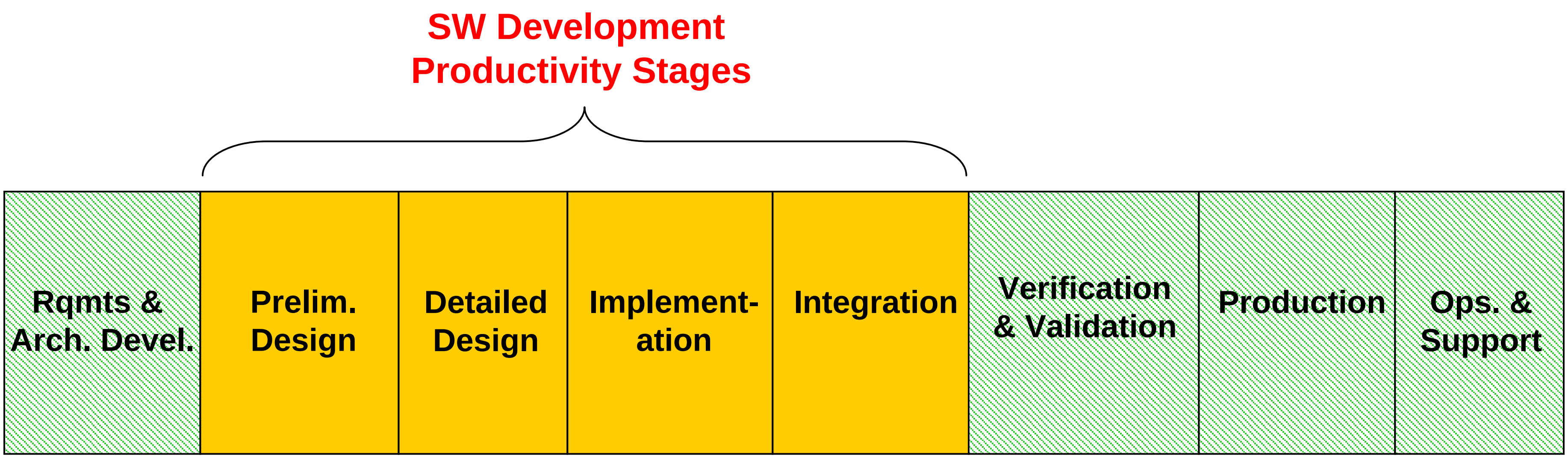
Specific cost collection codes are used to capture hours for Productivity measures

Best Practice – Definition: Align SW Size Measures with Cost Models

- Raytheon has used parametric SW models such as COCOMO, COCOMO II, REVIC, Price-S, and SEER-SEM for many years
- Specific alignment was made to the SEER-SEM SW Application types to allow stratification of data such as productivity
- NCS SW Size measures support these models with parameters of Source Lines of Code (SLOC) categorized by Reused, Modified, and New, with Reuse and Modified Factors
- A standard NCS software line counting tool was deployed across all sites so that sizes are measured consistently and with automation



Best Practice – Definition:
Specify SW Productivity Activities



Specific cost collection codes are used to capture hours for Productivity measures

Best Practice – Definition: Determine HW Size Measures

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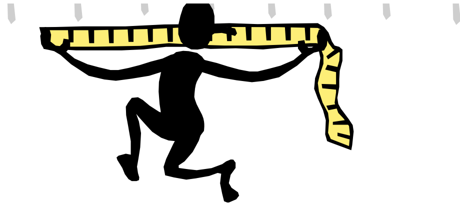
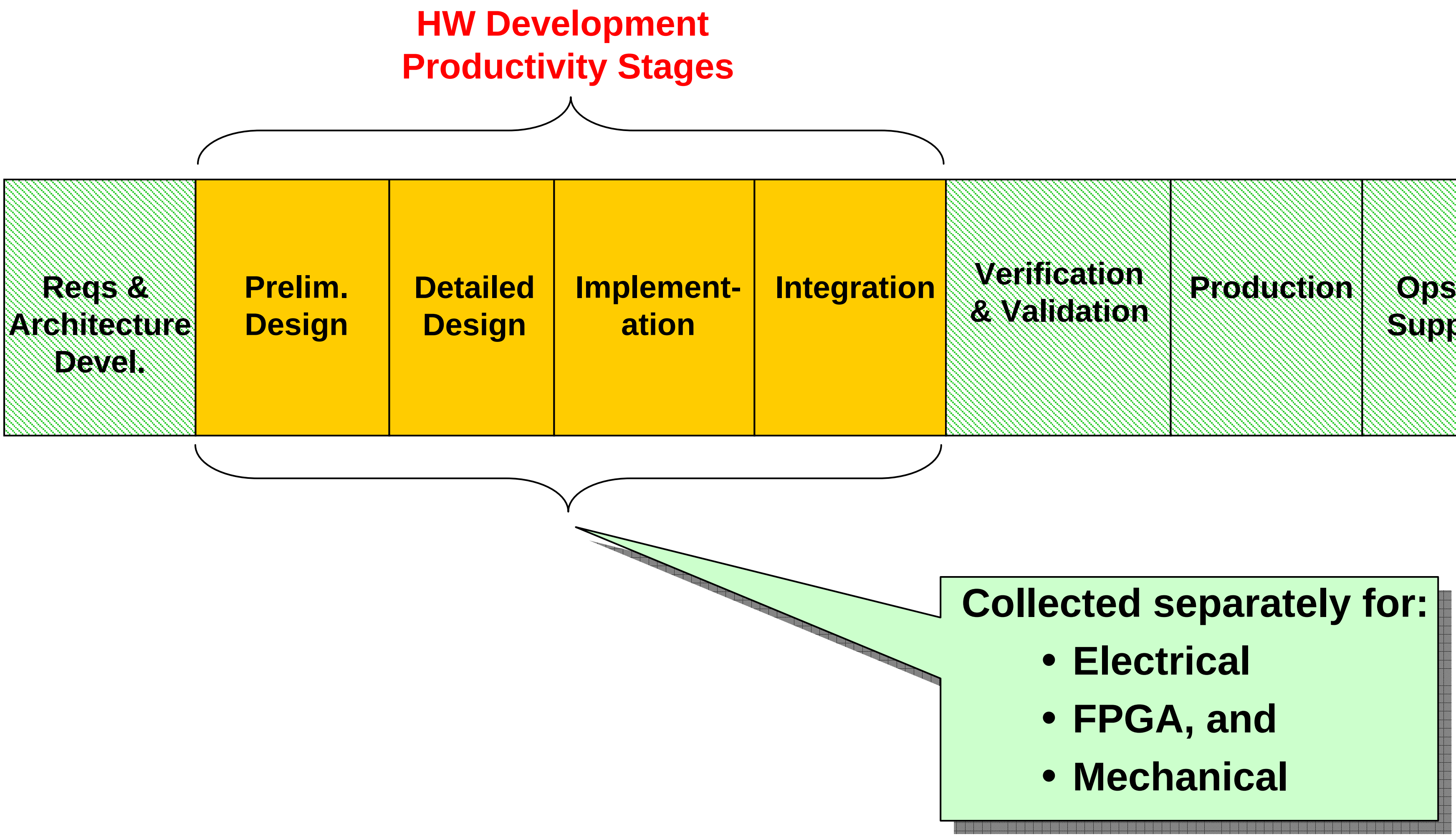
HW Sub-Discipline	Size Unit	Definition of Size Unit
Electrical	Terminations	Termination count is the sum of all external physical leads
FPGA	FPGA Lines of Code	Lines of Code - like software engineering
Mechanical	Square Feet of Drawing	The square feet of drawings required to document the design



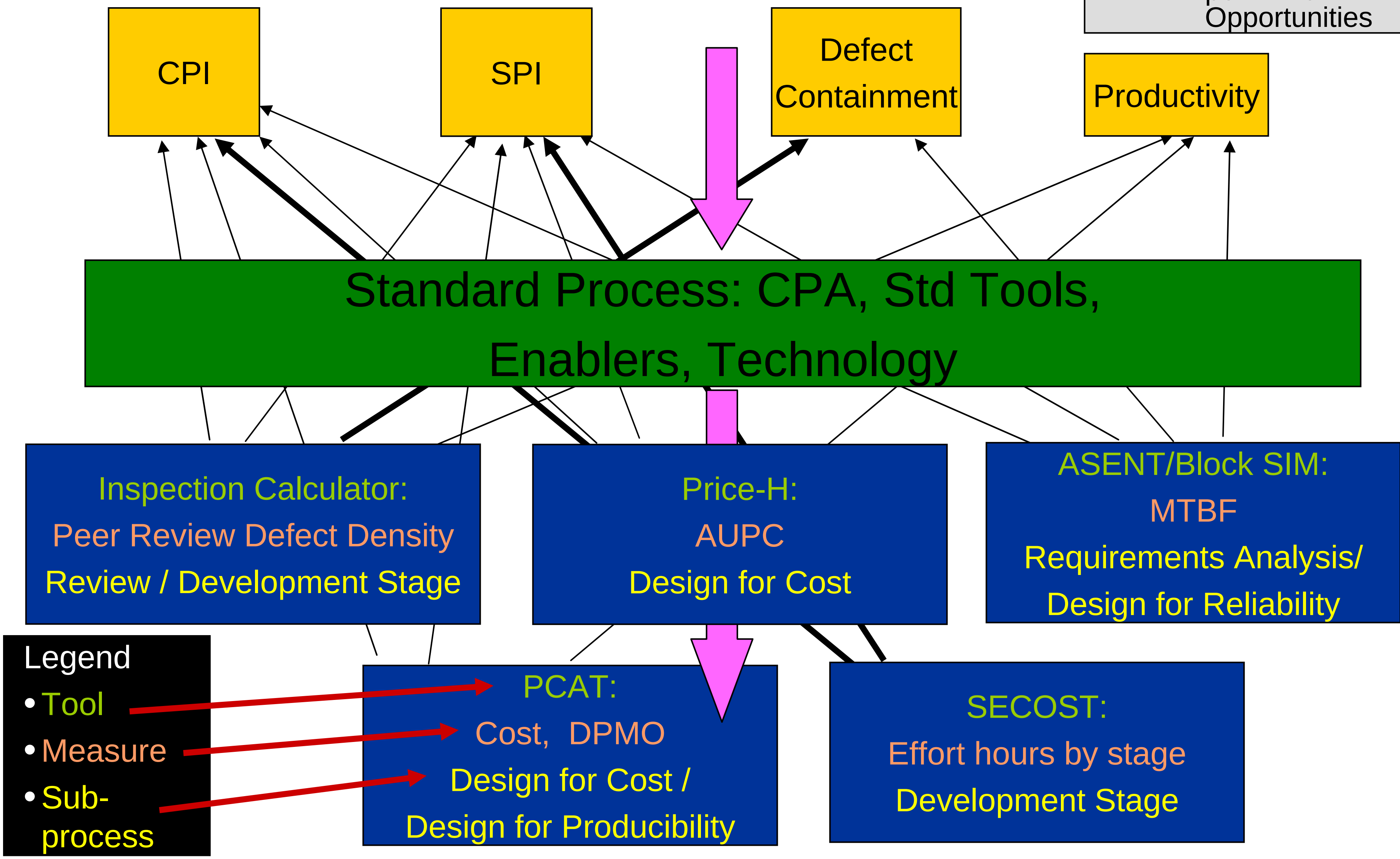
Hardware Size Units are an indication of which hardware sub-discipline is producing this data

Best Practice – Definition: Specify HW Productivity Activities



Best Practice – Quantitative Mgmt: Integrate Org & Program Activities

MTBF – Mean Time Between Failures
AUPC – Average Unit Production Cost
DPMO – Defective Parts per Million Opportunities



Programs have a variety of tools and models to use for statistical control

Best Practice – Quantitative Mgmt: Establish Org Baselines - Peer Review Example

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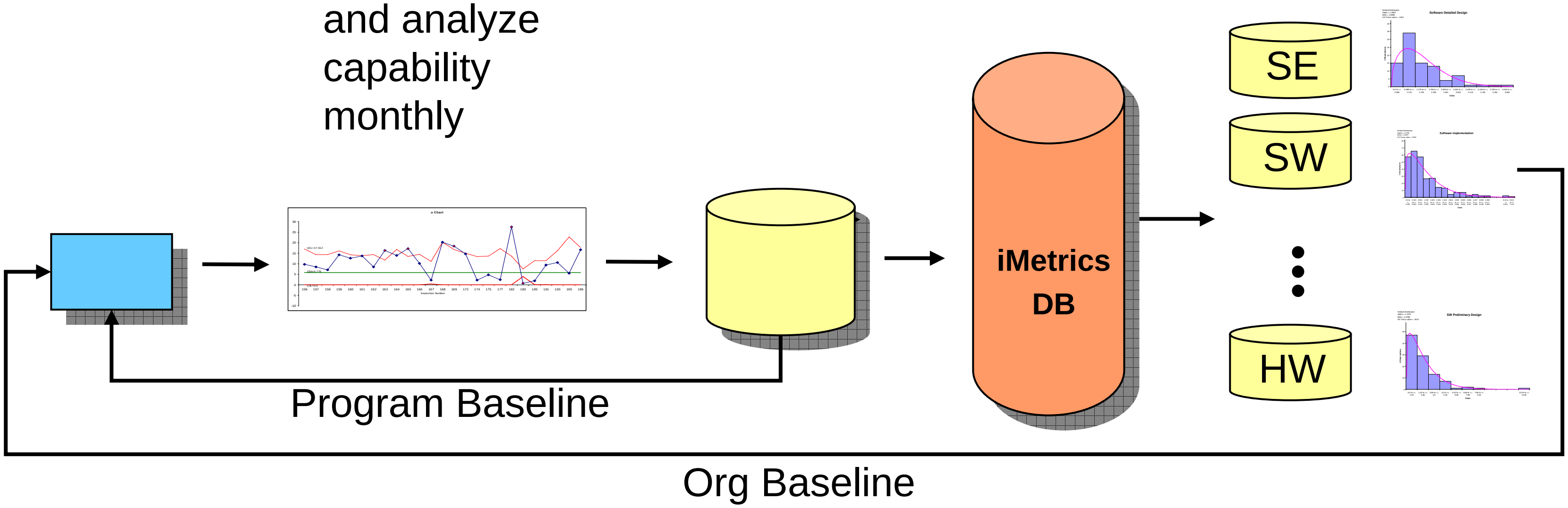
Program Execute Peer Reviews

Programs select baselines, use control charts, and analyze capability monthly

Programs record Peer Review data in review tools

Measurement Repository

Establish Org Baselines



- Programs use latest org baselines and program/product line baselines
- Baselines are recalculated periodically and then fed back to programs
- Peer review tools are updated to include new org norms

Best Practice – Quantitative Mgmt: Allocate TPMs to Architecture

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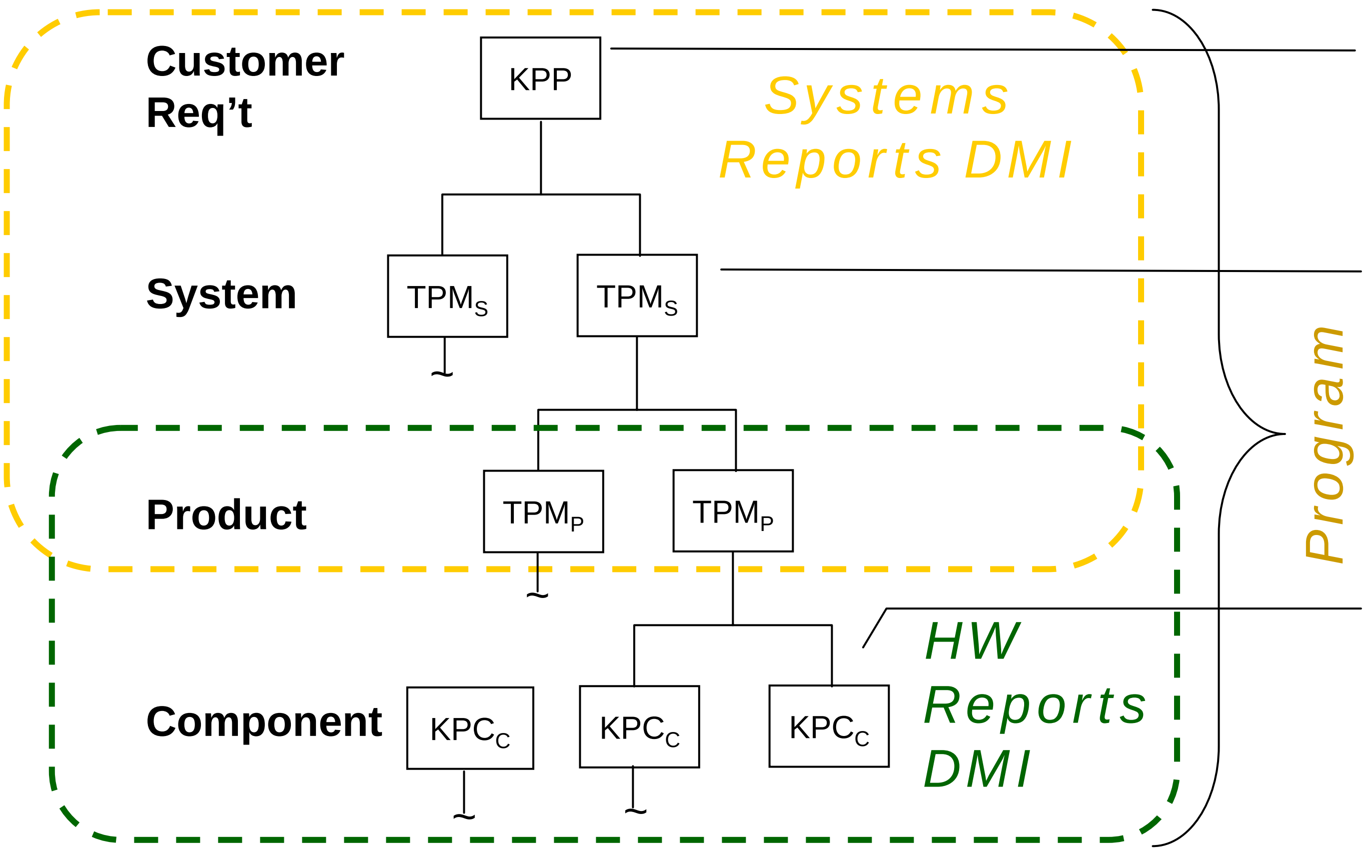


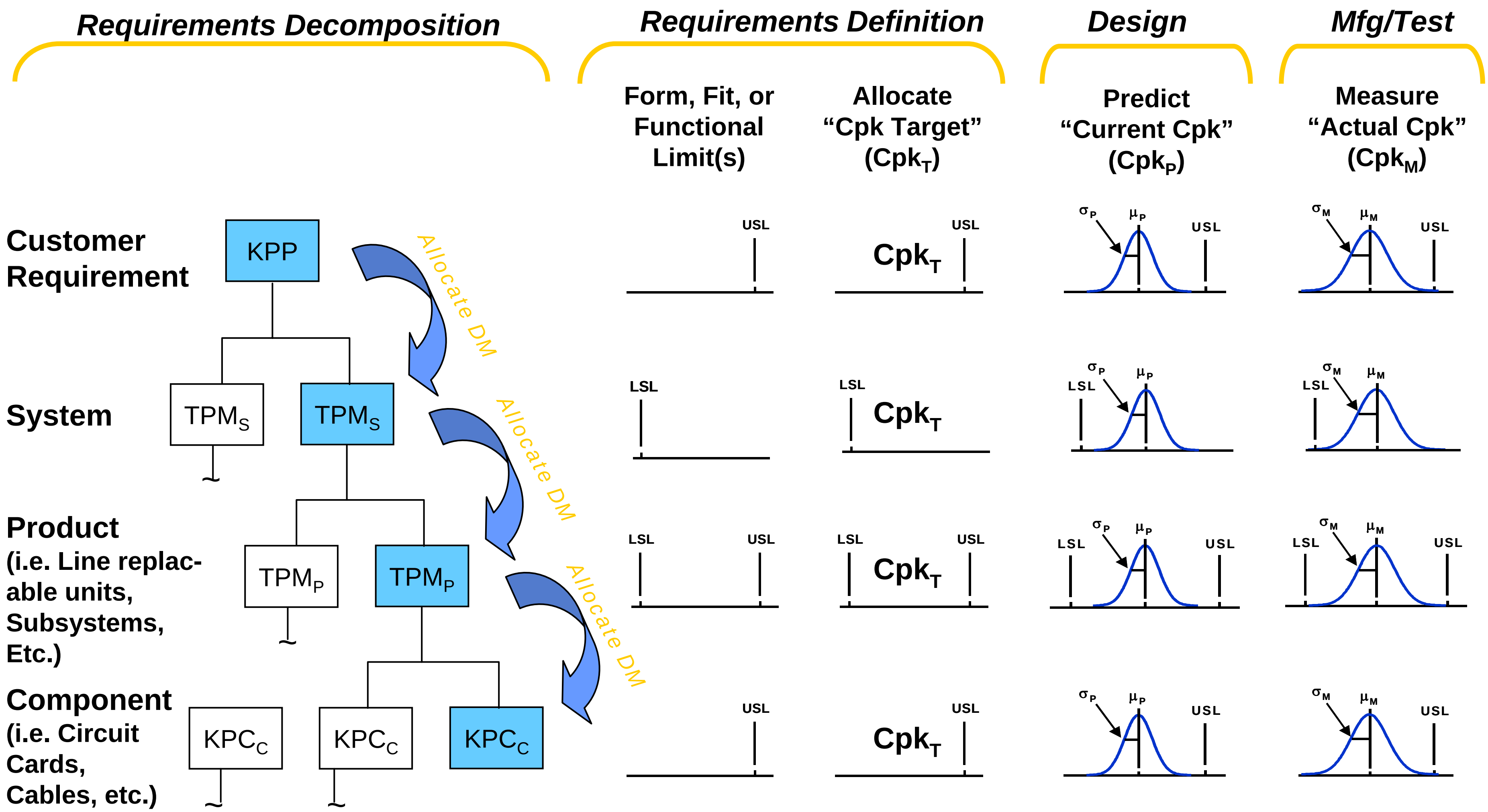
KPP - Key Performance Parameters are system level attributes

TPM - Technical Performance Measures are functions of Key Product Characteristics

KPC – Key Product Characteristics can significantly affect a TPM or KPP

- **KPPs are decomposed into objectives and managed at lower levels to ensure program success**
- **DMI is an <u>index</u> used to measure the <u>design margin</u>**
- **DMI is a useful measure for assessing "over" design and "under" design**

Best Practice – Quantitative Mgmt: Manage KPPs over Program Life Cycle



- TPMs are used for quantitative management and statistical control
- This gives the programs added value and can help significantly reduce program costs

Best Practice – Analysis & Review: Involve Quantitative Management Stakeholders

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Program Engineer and Discipline Teams

NCS Engineering Process Steering Team

Engineering Councils

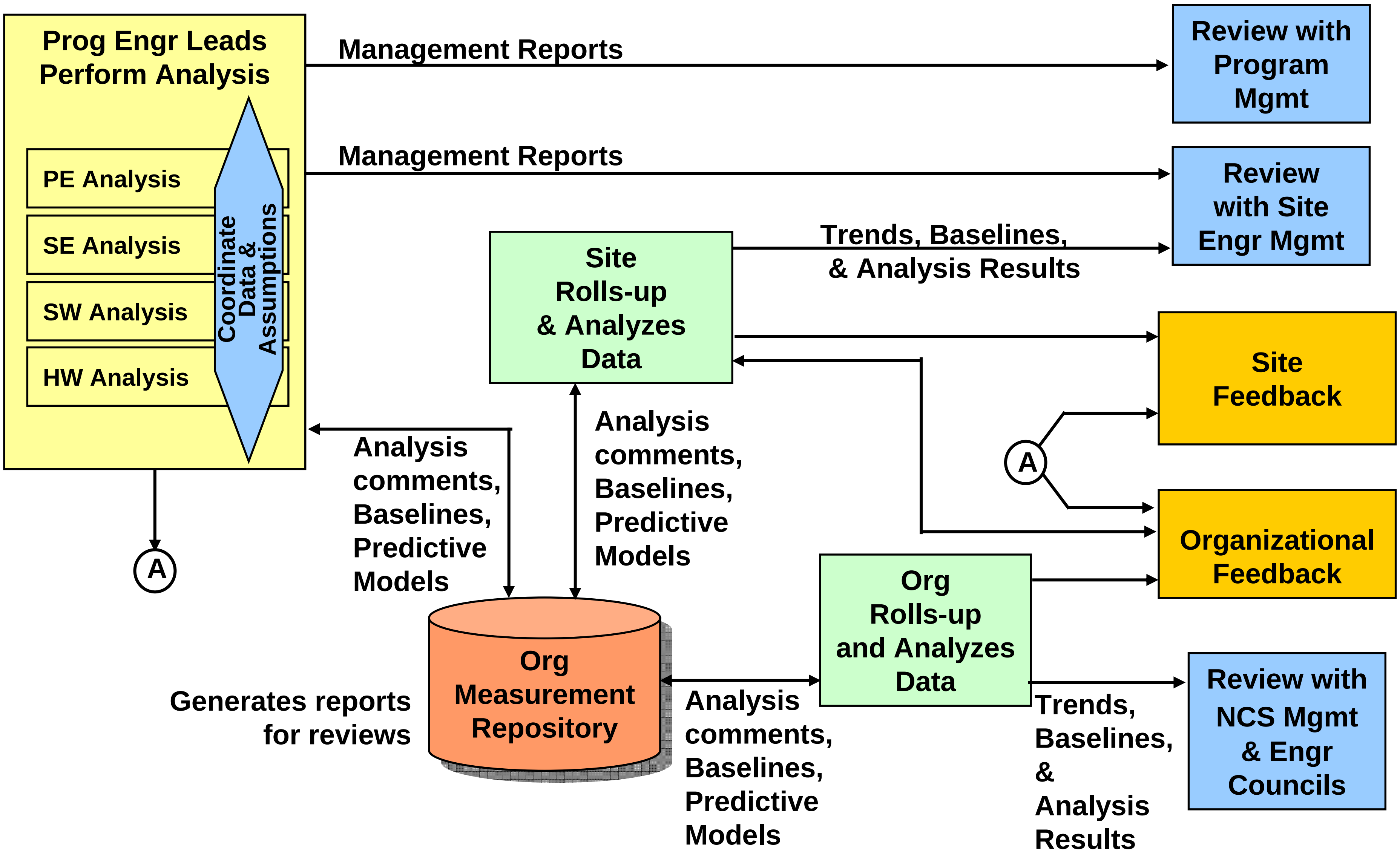
NCS Measurement Council

Site Measurement Teams

Engineering Management

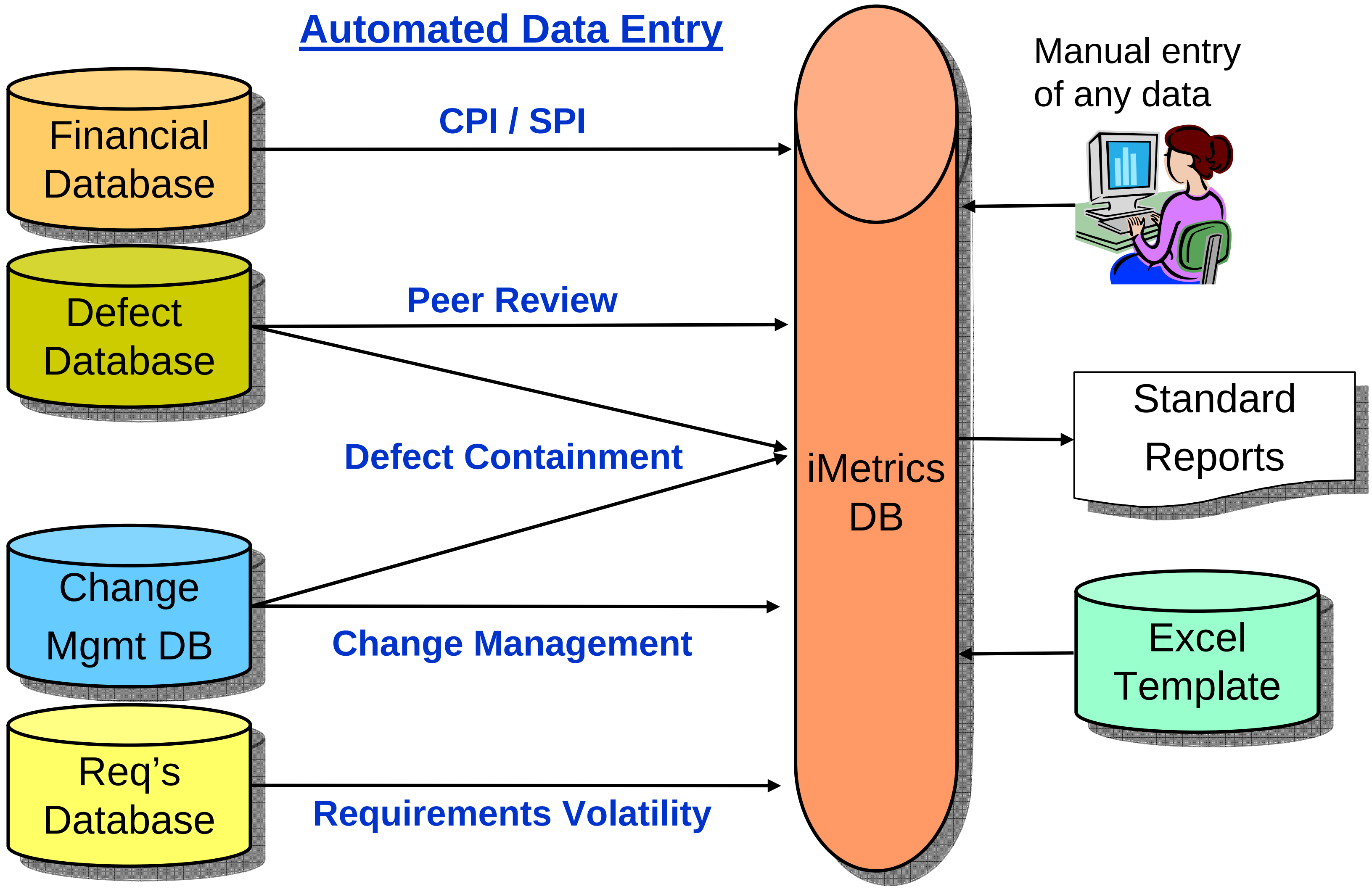
- **High level teams and managers were very interested is analyzing and reviewing measurement data**
- **This created a positive “pull” for information across NCS**

Best Practice – Analysis & Review: Define Analysis and Review Flow



Consistent flow across NCS sites and disciplines

Best Practice – Tooling: Integrate & Automate Databases and Tools



Automation allows repeatable quick entry of data tools to supply measurement data!

Future Opportunities

- Increase the coverage and use of common cost collection codes to more disciplines and activities
- Extend use of measurement database to other roll-up management measures such as Oregon Productivity Matrixes (OPMs)
- Incorporate statistical and textual analysis capability into the measurement reporting automation
- Improve alignment of financial processes and tooling with the common cost collection codes
- Define collection scheme for the Incremental Development life cycle model
- Continue to broaden the scope of automation that supports collection and reporting or measures

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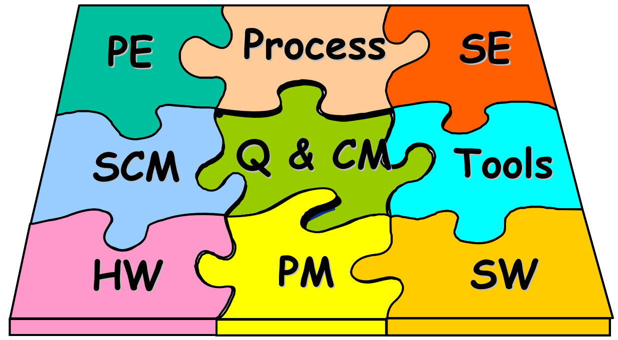
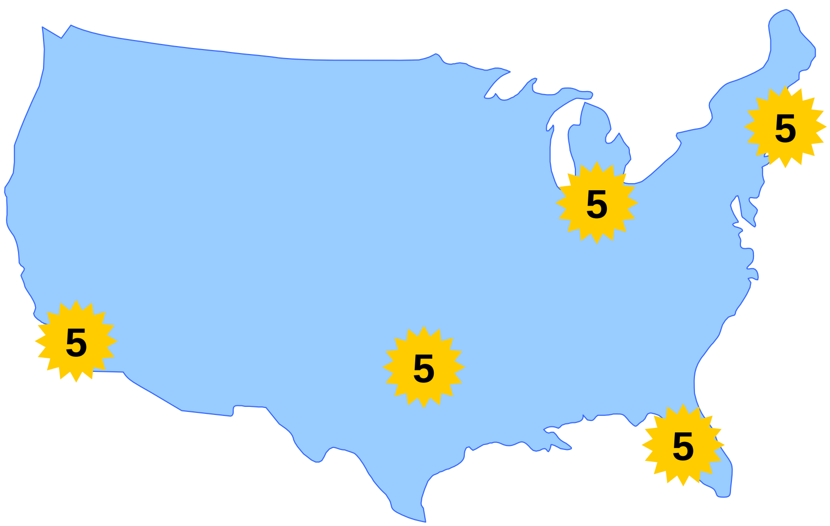
Results

Raytheon NCS deploys integrated processes with measures across multiple disciplines and sites to an engineering org of over 5,000 !!!





Raytheon NCS Achieves CMMI Level 5 on 1 June 2007 for Systems, Software, and Hardware Engineering !

QUESTIONS ?

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