

Extending CMMI Level 4/5 Organizational Metrics Beyond Software Development

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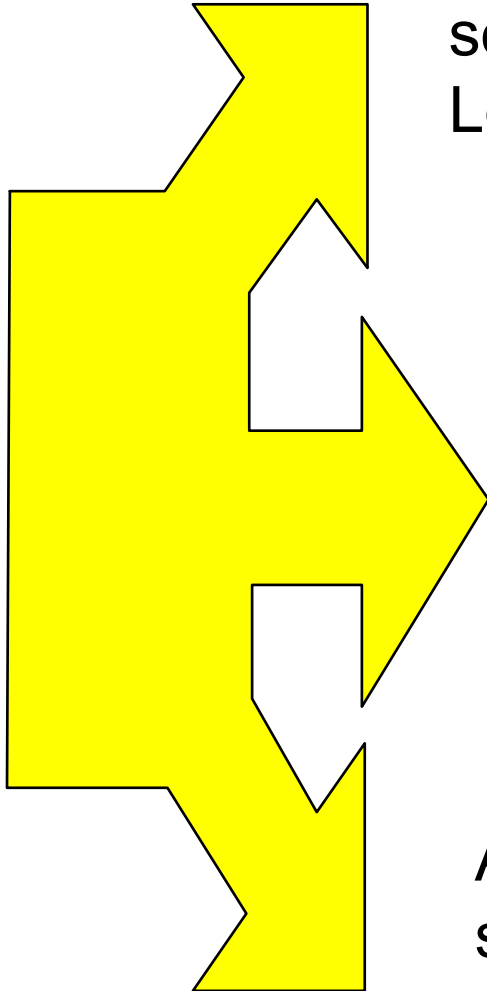
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Topics

- The Challenge
- The Pitfalls
- Background
- Proposed Approach
- Northrop Grumman Mission Systems Case Studies
- Summary

The Challenge

Extending organizational metrics beyond software development to achieve CMMI Levels 4/5 requires breaking new ground.



Few examples exist for project types such as systems engineering (SE), operations and maintenance (O&M), services, hardware development.

A repeatable process for developing such metrics that avoids typical pitfalls is needed.

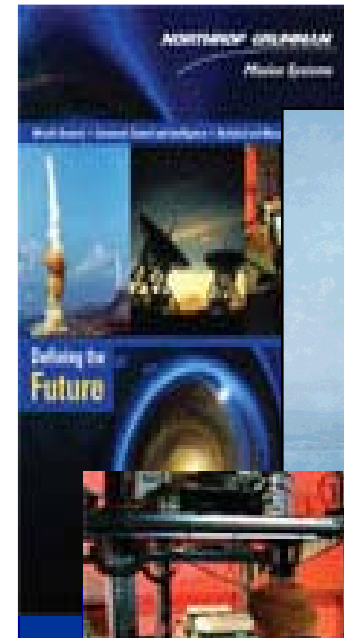
5 Major Pitfalls

- 1. Getting the cart before the horse - business needs not driving metrics definition**
- 2. Not taking advantage of in-house and/or industry experience**
- 3. Industry or in-house examples implemented organization wide without evaluating needs and/or impact**
- 4. Insufficient stakeholder buy-in**
- 5. Cost of collecting the metrics greater than the benefits to be derived**

Northrop Grumman Mission Systems

- **A leading global integrator of complex systems**
 - Based on information technology and systems engineering expertise
 - Integrated solutions: architecture, development and sustainment
- **Over \$5B 2004 Revenue**
- **18,000+ Employees**
- **Diverse business base**
 - 300 locations in 20 countries, 50 states
 - 2,000 active contracts and task orders

Command,
Control &
Intelligence



Missile Systems



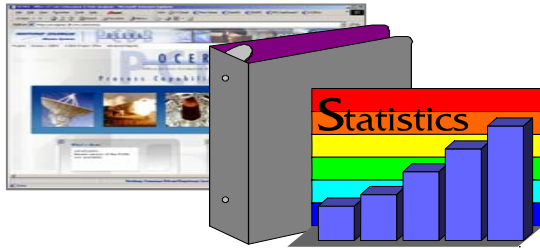
Technical & Management
Services

CMMI Organizational Metrics Support Meeting Business Needs

- ✓ **Leverage organization historical data to ensure accurate estimates for new work**
 - Level 3: Historical data is the foundation for cost credibility and accuracy
- ✓ **Understand process performance to enable more effective management**
 - Level 4: Statistical process control – a means for understanding performance
- ✓ **Improve process performance to increase competitive edge**
 - Level 5: Improvement activities based on accurate measures

Level	Process Areas
5 Optimizing	Causal Analysis and Resolution Organizational Innovation and Deployment
4 Quantitatively Managed	Quantitative Project Management Organizational Process Performance
3 Defined	Requirements Development Technical Solution Product Integration Verification Validation Organizational Process Focus Organizational Process Definition Organizational Training Risk Management Integrated Project Management (for IPPD*) Integrated Teaming* Integrated Supplier Management** Decision Analysis and Resolution Organizational Environment for Integration*
2 Managed	Requirements Management Project Planning Project Monitoring and Control Supplier Agreement Management Measurement and Analysis Process and Product Quality Assurance Configuration Management
1 Performed	

Supporting Infrastructure



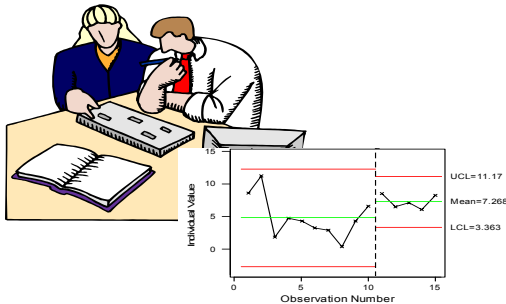
Mature metrics collection

- Metrics repository
- Organization Metrics Manual
- Established organization baselines & models
- Established collection process



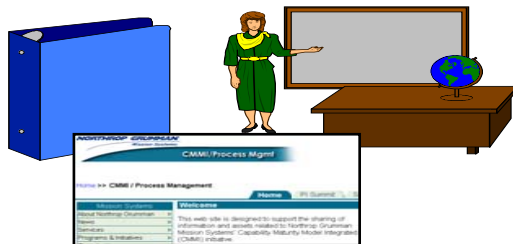
Engineering Process Group

- Provides stakeholder input
- Metrics/QM working group



Six Sigma/Lean

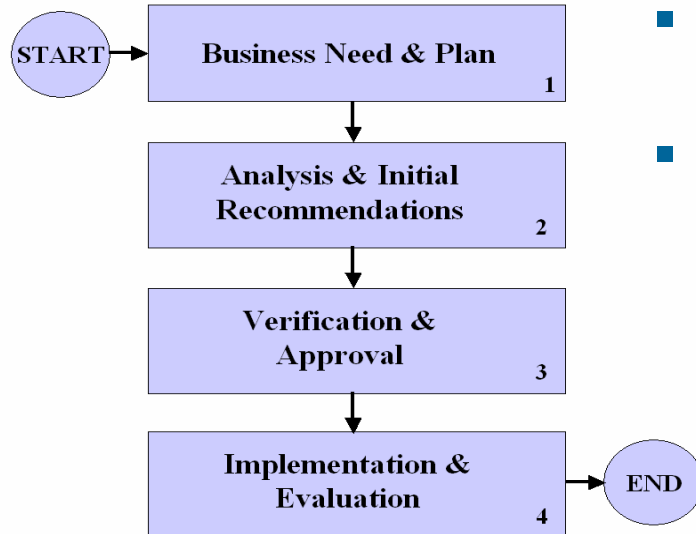
- Structure for improvement
- Tools & methods



CMMI Level 5

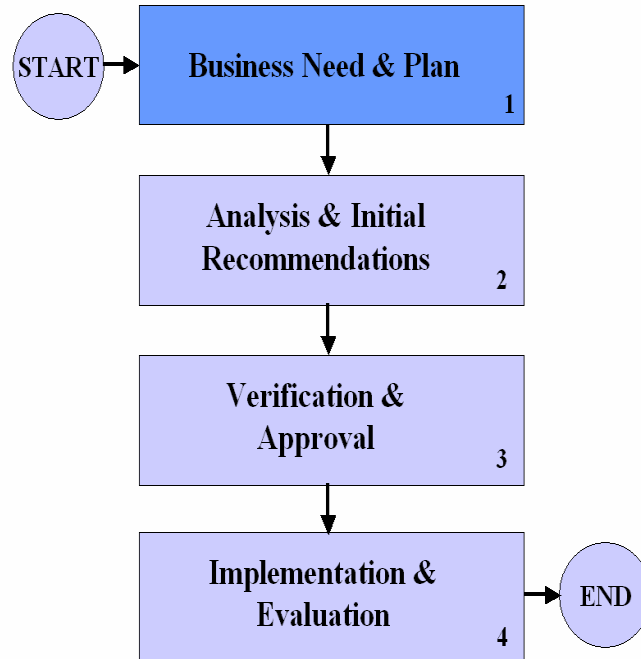
- Mature processes
- Structure for sharing best practices

Standard Metric Development Process Overview



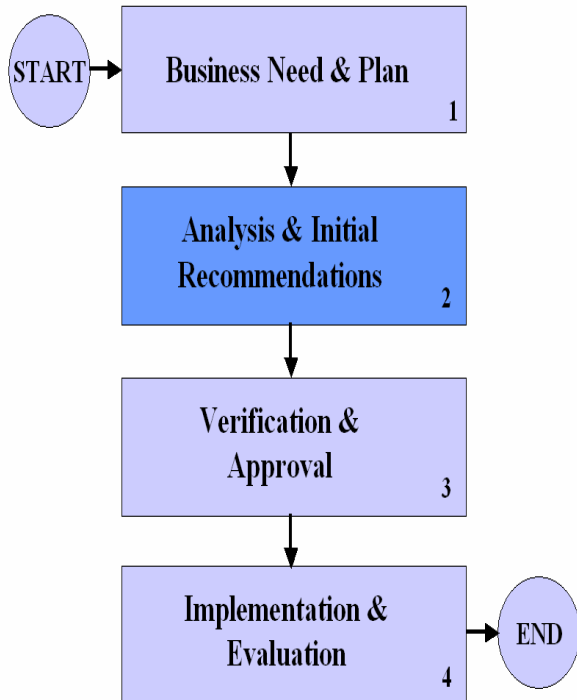
- Starts when the metric sponsor identifies a business need
- A Metric Development Project Lead is appointed to lead the process
- The standard process ensures:
 - Metric development is integrated into the annual overall organizational metrics planning;
 - The relationship and effect on the organizational standard processes is considered;
 - All stakeholders are kept informed and can provide inputs;
 - Results are documented and appropriate approvals are obtained.

Step 1 – Business Need & Plan



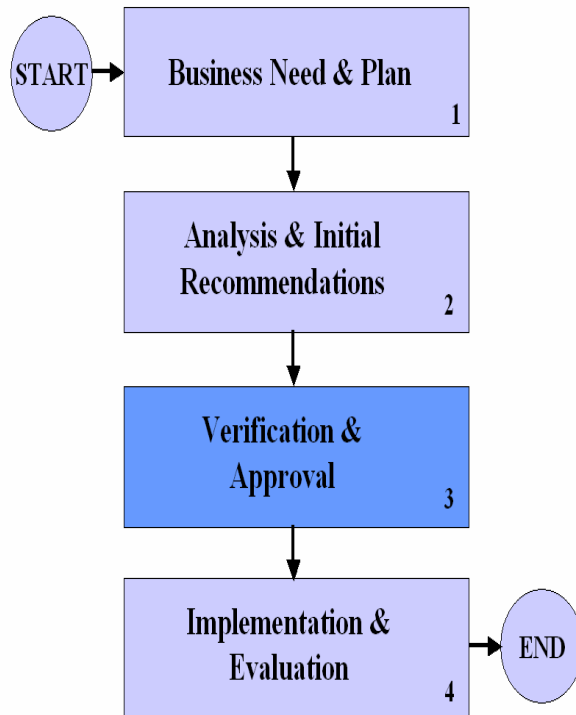
- Develop business need description
- Identify Metric Sponsor, Metric Development Project Lead, affected process owners, other stakeholders
- Establish initial schedule for each process step and identify resources
- Coordinate with the organization stakeholders for integration with organization priorities and plans
- Document results

Step 2 – Analysis & Initial Recommendations



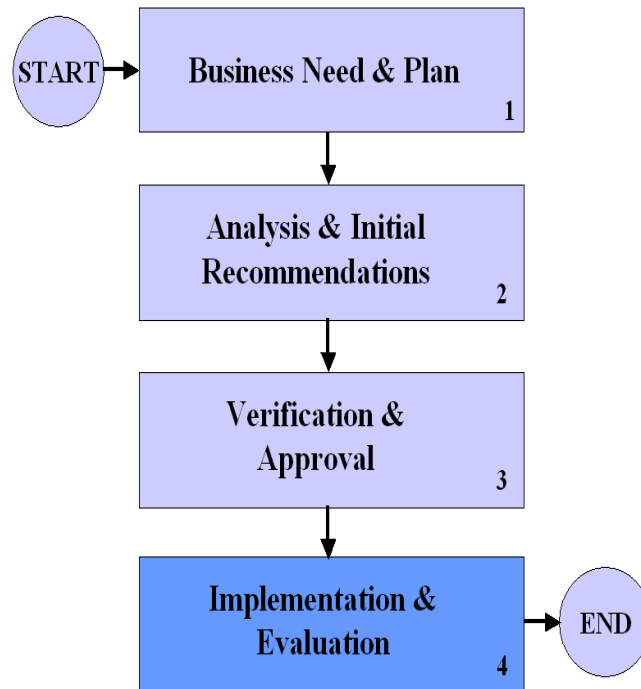
- Assess and evaluate related in-house metrics use
- Assess and evaluate related industry metrics use
- Analyze fit related to meeting business needs
- Evaluate potential impact on policy/processes/projects
- Specify proposed metrics
- Evaluate cost vs. benefit
- Document results

Step 3 – Verification & Approval



- Obtain stakeholder input and verification of satisfaction of business needs
- Update plans and metrics definition as needed
- Prepare draft Change Request and supporting documentation
- Document results
- Obtain required organization/CCB approvals (provide documented process results to approval authorities)

Step 4 – Implementation & Evaluation



- Implement metrics collection
- Analyze results
- Prepare results for use
- Prepare recommendations for changes or needed actions

Metric Development Documentation Outline

Business Need and Plan (documents results of process step 1)

- ✓ Business need description
- ✓ Metric Sponsor, Metric Dev Project Lead, stakeholder identification
- ✓ Target/actual completion date and status for each process step

Analysis and Initial Recommendation (documents results of process step 2)

- ✓ In-house metrics assessment
- ✓ Industry metrics assessment
- ✓ Other analysis results
- ✓ Impact evaluation
- ✓ Definition of proposed metric(s)

Verification and Approval (documents results of process step 3)

- ✓ Record of stakeholder input and review
- ✓ Mapping to business needs
- ✓ Change Request to related documentation
- ✓ Record of required org/CCB approvals

Post Collection Analysis and Recommendations (documents results of process step 4)

- ✓ Summary of analysis results and recommendations



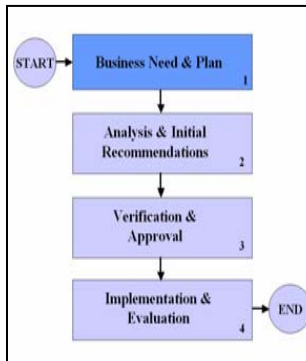
Northrop Grumman Mission Systems Case Studies

- **O&M Metrics Example**
- **Systems Engineering Metrics Example**



O&M Metrics Development Example

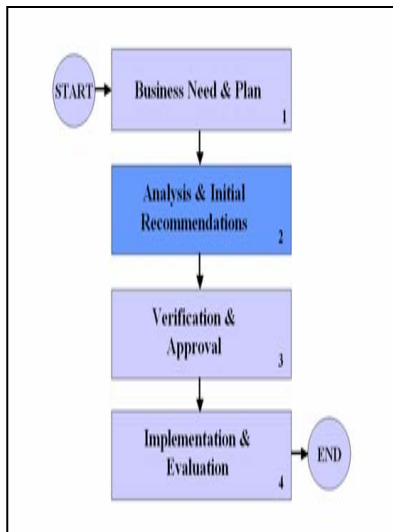
Step 1 Highlight – Business Needs



- **Prediction of effort for new work requires productivity values for key O&M processes**
 - Defect Correction
 - Small Enhancements
 - Help Desk Support
 - Operations Support
- **Additional needs to provide the organization with more useful process performance baselines and/or models**

Background goal to limit impact on projects and the organization collection system

Step 2 Highlight – Analysis: Sources & Eval



➤ In-house metric sources

❑ Projects A, B and C

- Projects used defect related metrics similar to development projects for project specific baselines/models
- Recommend expanding defect metrics to O&M project activities

❑ Metrics currently collected as part of the organization data collection

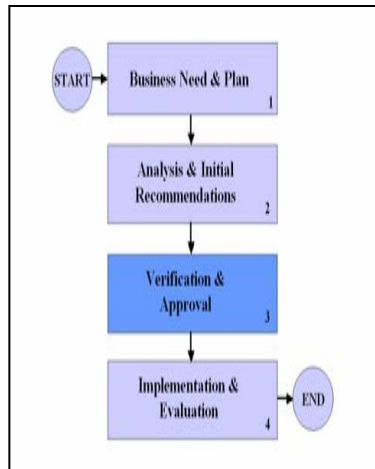
- Potentially useful productivity measures could be computed from metrics already being collected
- Need more data points

➤ Industry metric sources considered

❑ SEER-SEM and COCOMO cost models

- Use to validate productivity values

Step 3 Highlight – Verification Against Business Needs

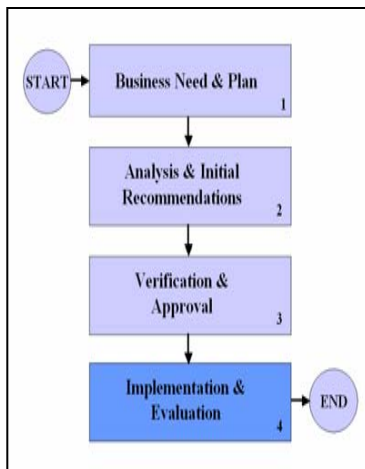


- Prediction of effort for new work
 - ❑ Currently collect potentially useful metrics to enable computation of needed productivity measures
- Providing more useful organization process performance baselines/models
 - ❑ Potentially this need will be met by the currently collected data and the addition of selected defect data
 - ❑ Analysis against productivities derived from existing data shows promise

Productivity = Size/Effort

Process	Potential Size Metric(s)	Effort Metric From Related Standard WBS Line Item(s)
Software Defect Correction	# base code SLOC,	12.1.3 Software Defect Correction
Small SW Enhancements	# base code SLOC, # base code SLOC affected, # SLOC added, # SLOC changed # SLOC deleted	12.1.6 Software Enhancements
Help Desk Support	# sites supported, # users supported, # calls per week, # hours per week	12.1.9 Help Desk Support

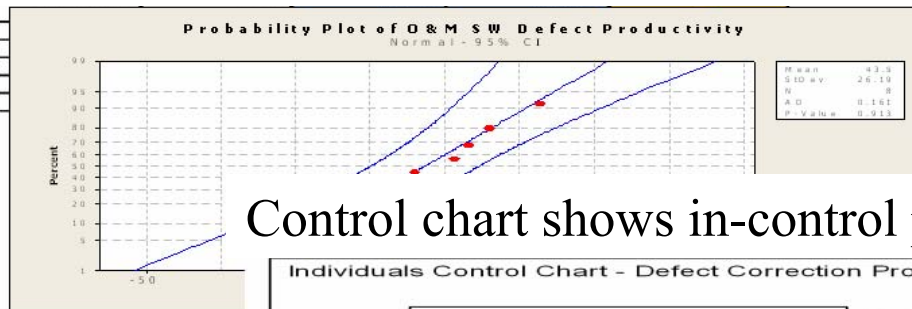
Step 4 Highlight – Eval of Collected Data



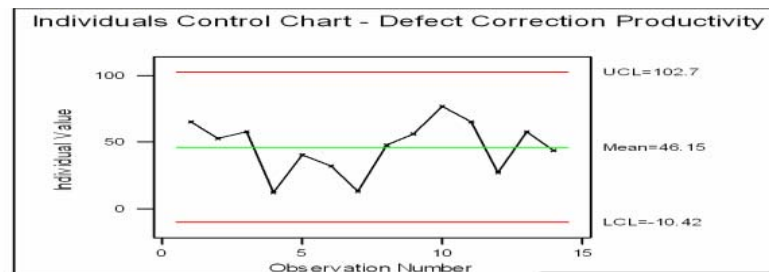
Notional raw defect correction productivity data

Proj	Duration in Months	Completion Date	Software Defect Correction Hrs	Software Defect Correction Hrs Annualized	Defect Correction SLOC Maintained	SW Maintenance Productivity (Base SLOC/Hrs Annualized)
1	12	3/15/2002	11139	11139	722000	65
2	12	3/31/2002	60063	60063	3199663	53
3	19	6/1/2002	44813	28303	1640825	58
4	19	11/2/2002	20048	12662	150481	12
5	12					
6	12					
7	5					
8	6					
9	12					
10	18					
11	12					
12	12					
13	12					
14	18					


Check shows data to be normally distributed



Control chart shows in-control process

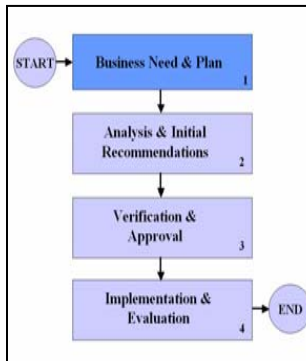


Productivity useful for estimating and as organization baseline data



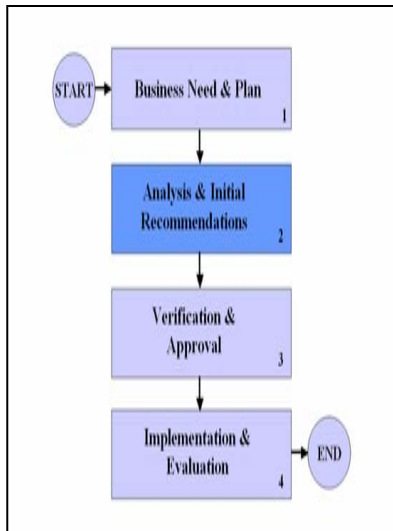
Systems Engineering (SE) Metrics Development Example

Step 1 Highlight – Business Needs



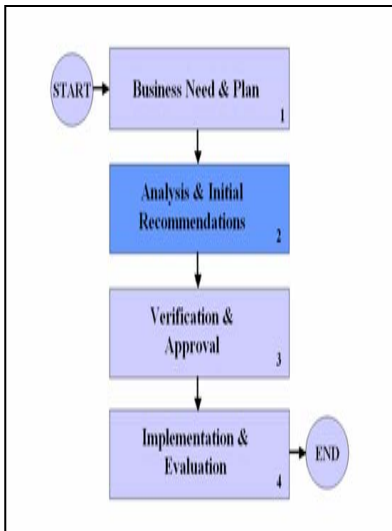
- **Prediction of effort for new work requires productivity values for key systems engineering processes**
 - Architecture definition, Concept of Operations Development (including scenario and use case development)
 - Requirements Analysis (including system, software, and hardware)
 - Major Interface Definition
 - Performance Modeling
- **Additional needs to provide the organization with useful process performance baselines and/or models**
- **Provide ability to support development and use of COSYSMO estimating model**

Step 2 Highlight – Analysis: Sources & Eval



- **In-house metric sources considered & eval**
 - ❑ Division Six Sigma Project on System Sizing Cost Estimating Relationships
 - COSYSMO size measures fit primary needs for division and organization use
 - ❑ Projects A, B use of cycle-time and other metrics for key processes
 - Metrics too specific for organization use
 - ❑ Currently collected SE metrics
 - Need a few additions to support desired productivity calculations
 - ❑ SE metrics discussion with stakeholders
- **Industry metric sources considered**
 - ❑ USC/Industry COSYSMO SE cost model
 - ❑ INCOSE Systems Engineering Measurement Primer
 - ❑ Papers and Presentations

Step 2 Highlight – Analysis: Candidate Process Performance Metrics



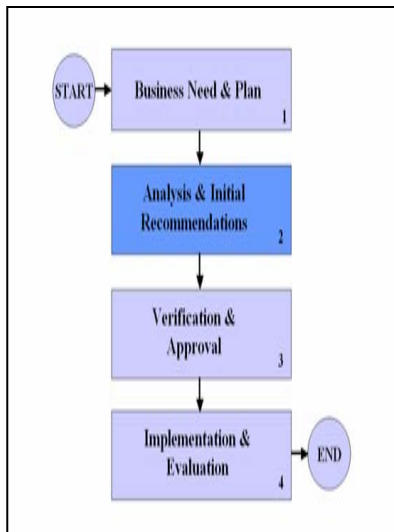
$$Productivity = Size / Effort$$

Size

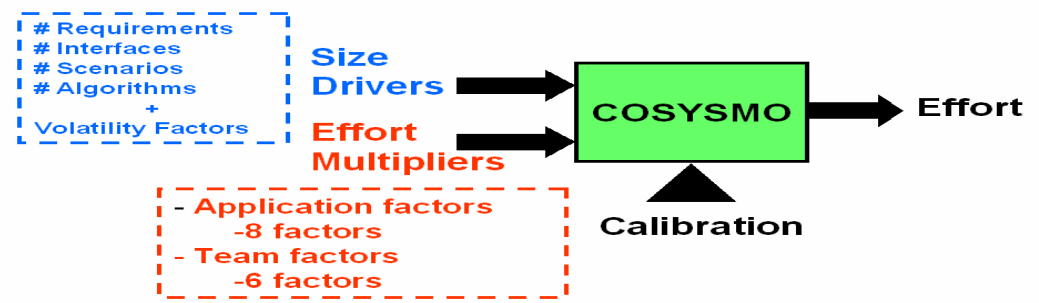
Effort

Process	Potential Size Metric(s)	Effort Metric From Related Standard WBS Line Item(s)
Requirements Analysis	# system reqs, # SW reqs, # HW reqs, # scenarios	2.3 System Requirements, 2.5 SW Requirements Analysis, 2.4 HW Requirements Analysis,
Architecture/Concept of Operations	# system reqs, # SW reqs, # HW reqs, # scenarios	2.6 Architecture Analysis/System Design, 2.8 Operations Concept Definition
Major Interface Definition	# interfaces	2.7 Interface Definition

Step 2 Highlight – Analysis: Constructive Systems Engineering Cost Model (COSYSMO)



COSYSMO Operational Concept*

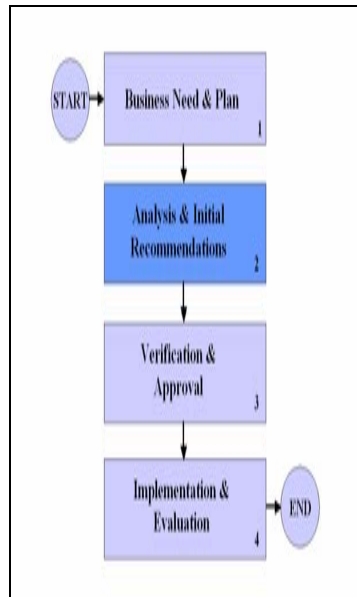


COSYSMO Background

- ❑ Part of COCOMO Suite of models being developed under the guidance of Dr. Barry Boehm, the Director of the Center for Software Engineering at USC
- ❑ Goal to more accurately estimate the time and effort associated with performing the system engineering tasks defined by ISO/IEC 15288
- ❑ Development started in 2002, with industry (USC affiliates) and INCOSE involvement
- ❑ 42 historical data points from 6 companies; 15 business units
- ❑ Northrop Grumman participating in the development and submittal of history data

* Used with permission of Dr. Barry Boehm

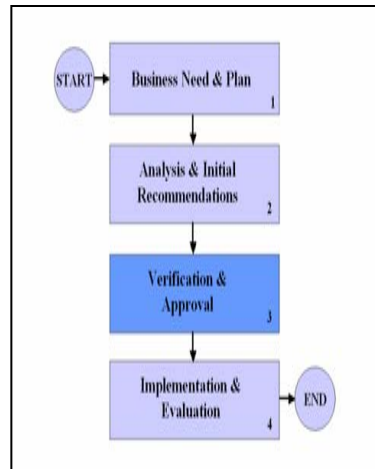
Step 2 Highlight – Initial Recommendations



- Include the four COSYSMO size parameters, with difficulty level
- Add hardware requirements metrics
- Add collection of defect data for system requirements, hardware requirements and scenario/use case reviews
- Proposed Mods to the organization Standard WBS
 - Separate architecture, SW COTS assessment, HW COTS assessment
 - Separate performance modeling and life cycle cost analysis

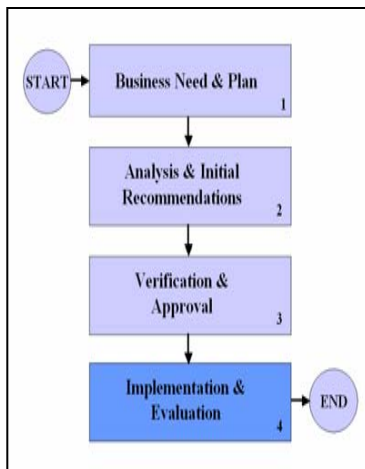
Modifications to the organization data collection, Metrics Manual and related documents

Step 3 Highlight – Verification Against Business Needs



- **Prediction of effort for new work**
 - ❑ Size and accounting data already collected or identified for addition can potentially meet this need
 - ❑ COSYSMO should be of use as well
- **Development of organization process performance baselines/models**
 - ❑ Potentially this need will be met by the recommended data
 - ❑ Analysis against productivities derived from existing data shows promise
- **Support of COSYSMO development & use**
 - ❑ Existing plus new metrics support this

Step 4 Highlight – Eval of Collected Data

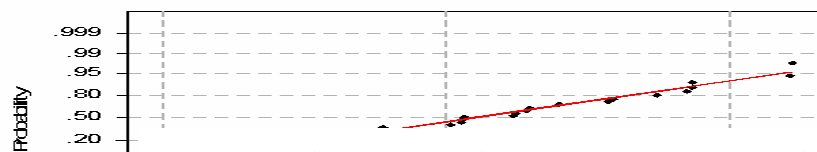


Notional raw system requirements productivity data

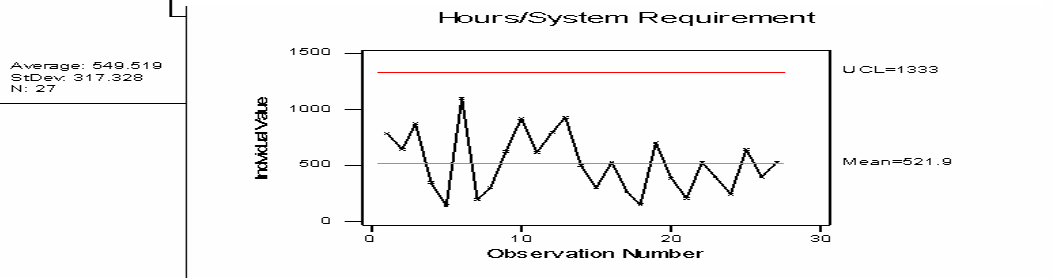
Project	# Sys Reqs	Hours	Hrs/Sys Requirement
1	464	365149	787
2	55	35663	648
3	164	113450	692
4			
5			
6			
7			
9			
10			
11			
12			
13			
14			
15			
16			
17			

Check shows data to be normally distributed

Probability Plot of System Reqs Productivity



Control chart shows in-control process



Productivity useful for estimating and organization baseline data

Summary

A metrics development process should:

- **Ensure business needs drive the process**
- **Take advantage of in-house and industry experience and best practices**
- **Include obtaining stakeholder input and buy-in**
- **Ensure benefits are worth the cost**
- **Include documentation and post-implementation evaluation**