Modeling Project Complexity

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Agenda

• Review of Problem
• Relevance to Today’s System Engineers
• State of Literature
• Defining System Complexity
• A Potential Approach for Describing System Complexity
The Problem

- Despite 40+ years of systems engineering there is:
  - No accepted definition of a “Complex System” [1]
  - As a result of the above, no acceptable way to model that complexity

- Some baseline literature found describing problem
  - Limited work in area, so ripe for exploitation
  - Increasing interest as general project complexity increases
Relevance

- Systems continue to grow in complexity
  - Success rates of new projects are not encouraging [2]
  - It may be impossible to fully specify a system
  - Corporations, Governments and Academia need to balance resources

- The ability to directly compare project complexity will improve:
  - Resource allocation
  - Evaluation of project risk
  - Ability to apply quantitative methods to compare projects from many sources, domains
• Complexity of Systems Increasing [1,2,3,4]

• Many qualitative descriptions of complex systems

• Few quantitative approaches to a taxonomy or ontology to describe Complex Systems - COSYSMO is one exception

• Evolution of complex projects have driven new methods of requirements management, and newer methods may be necessary [5,6]
Many methods of Controlling or Mitigating Complexity via Requirements Engineering have been attempted:

- Structured Analysis and Design Technique [7]
- Partitioning [3,8]
- Separation of Concerns [9]
- Expert systems with formal syntaxes [10,11]

None of these actually define system complexity

Some of these actually start a practitioner down the path of design before fully understanding the system
Potential Approach

- Create and define a generic model of systems complexity
- Describe factors based upon:
  - External Interfaces
  - Internal Interfaces
  - Maturity
  - Documentation Requirements
- Define numeric exponents of critical factors in complexity
  - Quantifiable
  - Similar in concept to O Notation from Computer Science
  - Provide an order of magnitude measure – Point Estimator
Possible Method

- Develop baseline approach as 4-tuple
  \[ e^w \int x m^y \, dz \]
- Use case studies to examine projects of varying (known) complexities
- Confirm that these are the right factors
- Begin to develop proper weighting
  - Real option analysis may be of assistance
  - Utility analysis for non-quantitative data

System Complexity and Project Complexity are not the same thing
Defining System Complexity

External Interfaces:
- Number of interfaces
- Maturity of Interfaces
- Team Experience with relevant Interfaces

Internal Interfaces:
- Number of interfaces
- Maturity of Interfaces
- Team Experience with relevant Interfaces

Maturity:
- Legacy System – no Documentation
- Legacy System – limited Documentation
- Legacy System – full Documentation
- New Development – architecture understood
- New Development – limited architecture
- New Development – R&D

Documentation Requirements:
- Agile
- Defined, but open (SRS, SDS, etc)
- Formal (Hatley Pirbhai, CORE)
- Full Architecture (DoDAF, etc)
- Legal
- Safety

Other affecters (perceived or real)

Point Estimation of Complexity
\[ E^I F^J M^K D^L \]
Tools for Defining Factors and Weightings

- Multidisciplinary Approach Required
  - Computer Science probably leads field in this area
    - Metrics including Cyclomatic Complexity, Efferent Couplings, Lack of Cohesion of Methods, etc

- Systems Engineering approaches include those discussed as well as work from Hatley/Pirbhai, various architectural methodologies, etc
Potential Advantages of Approach

- Ability to directly compare resources across projects of differing types
  - Do projects with similar exponents have similar resources?
  - Predicting required resources from model
  - Have projects of a given complexity historically succeeded?

- Ability to graph visually the measures of complexity and compare graphs to look at indicators that may impact success/failure
Path Ahead

• Develop a generic model similar to O-Notation that can be used to quickly describe complexity of a project
  • Desired goal is a point estimator vice “the answer”
  • Useful tool for scoping project level of effort
  • Significant future refinement/growth required

• Continue to refine scope and focus of effort

• In the absence of any tools, a simple tool may be sufficient
Questions and Discussion
Backup Slides
About the Co-Authors

- **Dr. Thomas Mazzuchi** received a B.A. (1978) in Mathematics from Gettysburg College, Gettysburg, PA, a M.S. (1979) and a D.Sc. (1982), both in Operations Research from the George Washington University (GWU), Washington DC. Currently, he is a Professor of Engineering Management and Systems Engineering in the School of Engineering and Applied Science at GWU. He is also GWU's Chair of the Department of Engineering Management and Systems Engineering where he has served as the Chair of the Operations Research Department and as Interim Dean of the School of Engineering and Applied Science. He has been engaged in consulting and research in the area of reliability, risk analysis, and quality control for over twenty years.

- **Shahram Sarkani, Ph.D., P.E.** is Professor of Engineering Management and Systems Engineering at The George Washington University (GWU), and he has been a member of the faculty since 1986. His administrative appointments at GWU include chair of the Civil, Mechanical, and Environmental Engineering Department (1994-1997); Interim Associate Dean for Research and Development for the School of Engineering and Applied Science (1997-2001); and Faculty Adviser and Academic Director of EMSE Off-Campus Programs (since 2001). In his current role, he designs and administers world-wide off-campus programs in 20 locations with over 1,000 graduate students pursuing Master of Science and Doctor of Philosophy degrees in several areas within the fields of systems engineering and engineering management.


