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Acquisition Program Teamwork and Performance Seen Anew: Exposing the Interplay of Architecture and Behaviors in Complex Defense Programs

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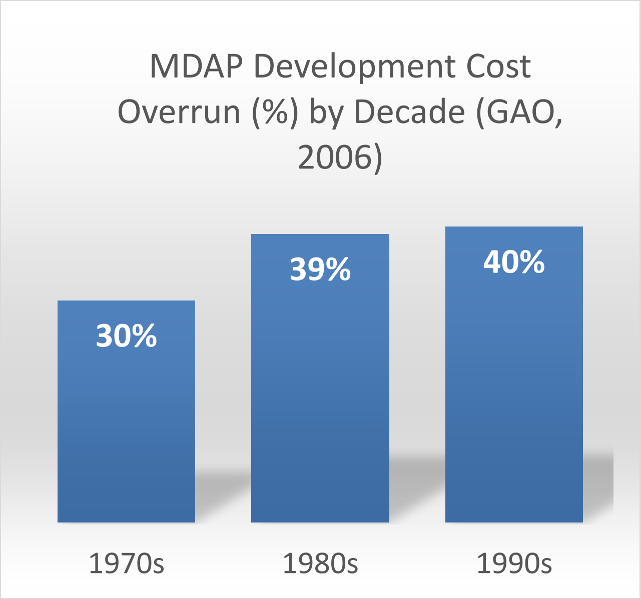
The Fundamental Challenge: Improving Development Program Performance

- Motivation
  - Performance in complex development programs (both military and civil) has not improved significantly in the last several decades, despite many new and sophisticated tools for managing these programs
    - Example: B787 development program (2004 launch)—cost from $6B to $16B; schedule from 4 years to 7 years; overall program may never be profitable.

- Research questions
  - Are current program monitoring and control systems adequate for increasingly complex sociotechnical system programs?
  - What additional measures and controls are needed to adequately understand and address the challenges posed but complex sociotechnical system programs?



Research Issue: Ineffective Control of Interactions in a Program Can Lead to Surprises

- *What we create* and *how we work* **combine as a sociotechnical system** in which products, processes, and people interact and evolve.
- When both change simultaneously the emergent performance of an engineering project becomes **difficult to anticipate**.
  - For this reason the thought leaders of scientific management a century ago promoted standard work and reduction of variation in both parts and people.
- Standardization may not always be the answer. Programs are often beset by complexity, novelty, and variability that further challenge existing connections between social and technical systems and which **lead to surprises**.

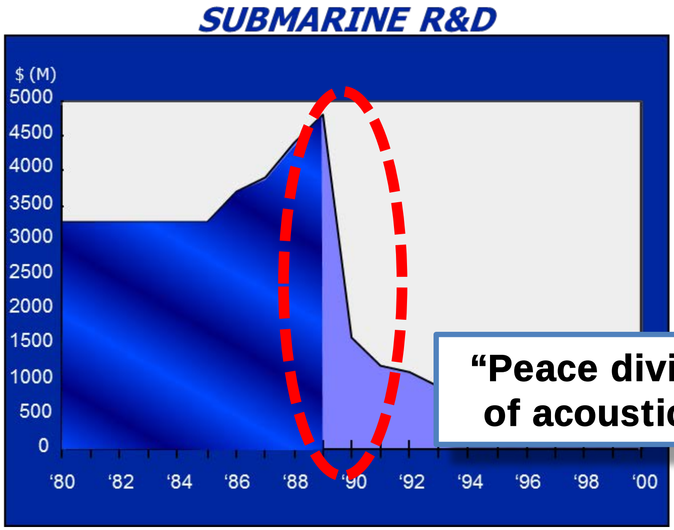
Managing interactions within/between the social and technical systems is a core program activity—the organization's ability and experience to manage these connections may be a critical differentiator for performance.

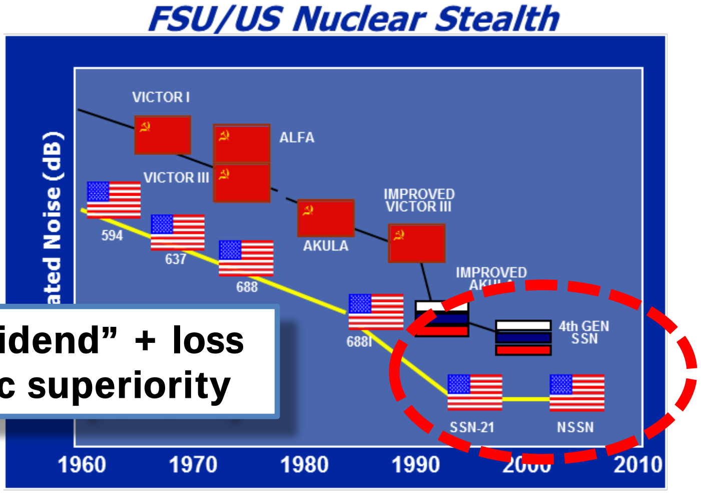
Advances in Project Control Approaches Still Largely Framed by Original Assumptions

- The starting point—the task as the “atom” of work:
  - 1903: Assumptions of fixed duration, sequence, resource neutrality are deeply embedded in early scientific management approaches (Gantt)
  - 1950s, 1960s: CPM, PERT, WBS, SEMP(499), C/SCSC
  - 1990s: DOD 5000, CMMI, PMBOK, …
  - These methods and their underlying representation of tasks and dependence drove definition of Earned Value Management (EVMS)
- Newer developments in project control (built on the same foundation assumptions):
  - Critical Chain (Goldratt 1997)
  - Earned Schedule (Lipke 2003, 2004)
  - Earned Duration (Khamooshi & Goalfshano, 2014)
  - TRLs and Technical Performance Management
  - Bottom-Up, Top-Down, and Distribution of Control Points

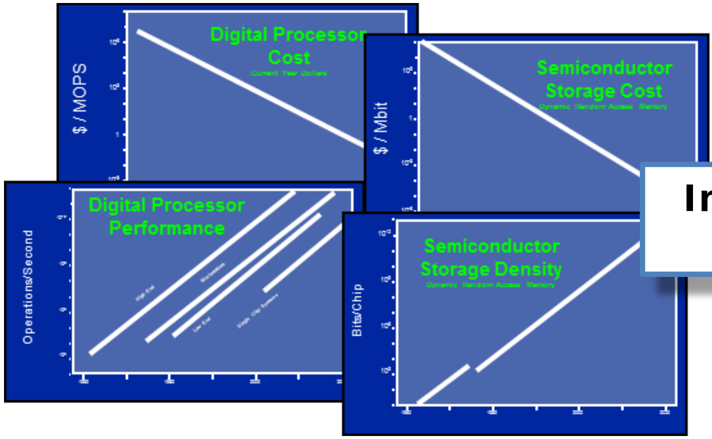
Team awareness, capacity, attention, and performance in managing the interactions (satisfying dependences) are not addressed by these program control mechanisms based on century-old assumptions

Case Study of a Complex Sociotechnical Program: Submarine Sonar System Upgrade

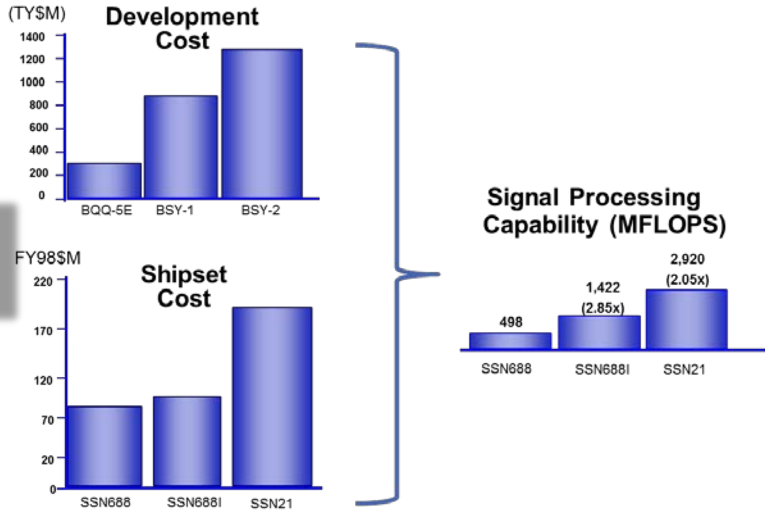




"Peace dividend" + loss of acoustic superiority



Inability to Pace Moore's Law



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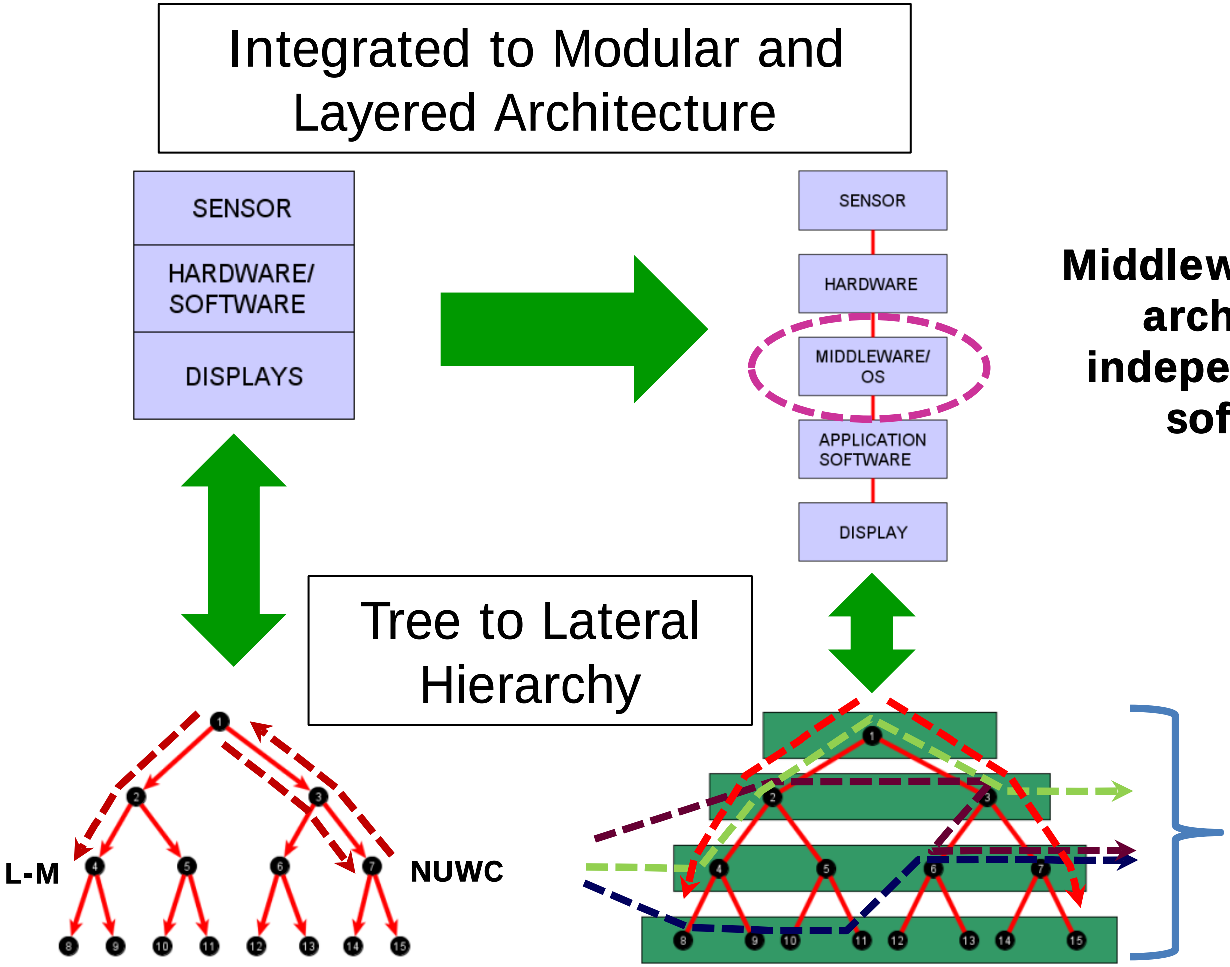
Source: NAVSEA PMS425/ASTO

Solution Required Significant Changes to the Technical System Architecture

- Action: Submarine Superiority Technology Panel
  - Reviewed technical and operational issues which determine acoustic superiority
- Diagnosis - Prescription:
  - Leverage Moore's Law: COTS hardware
  - Experiment with new algorithms
- Decision - Implementation:
  - ***Modular, "open"*** hardware, software, business architectures
  - "4 Step" build-test-build development process to experiment with new ideas using operational data

Technical System Architecture Changes Required New Interaction Patterns Among Program Stakeholders


Integrated to Modular and Layered Architecture

Tree to Lateral Hierarchy

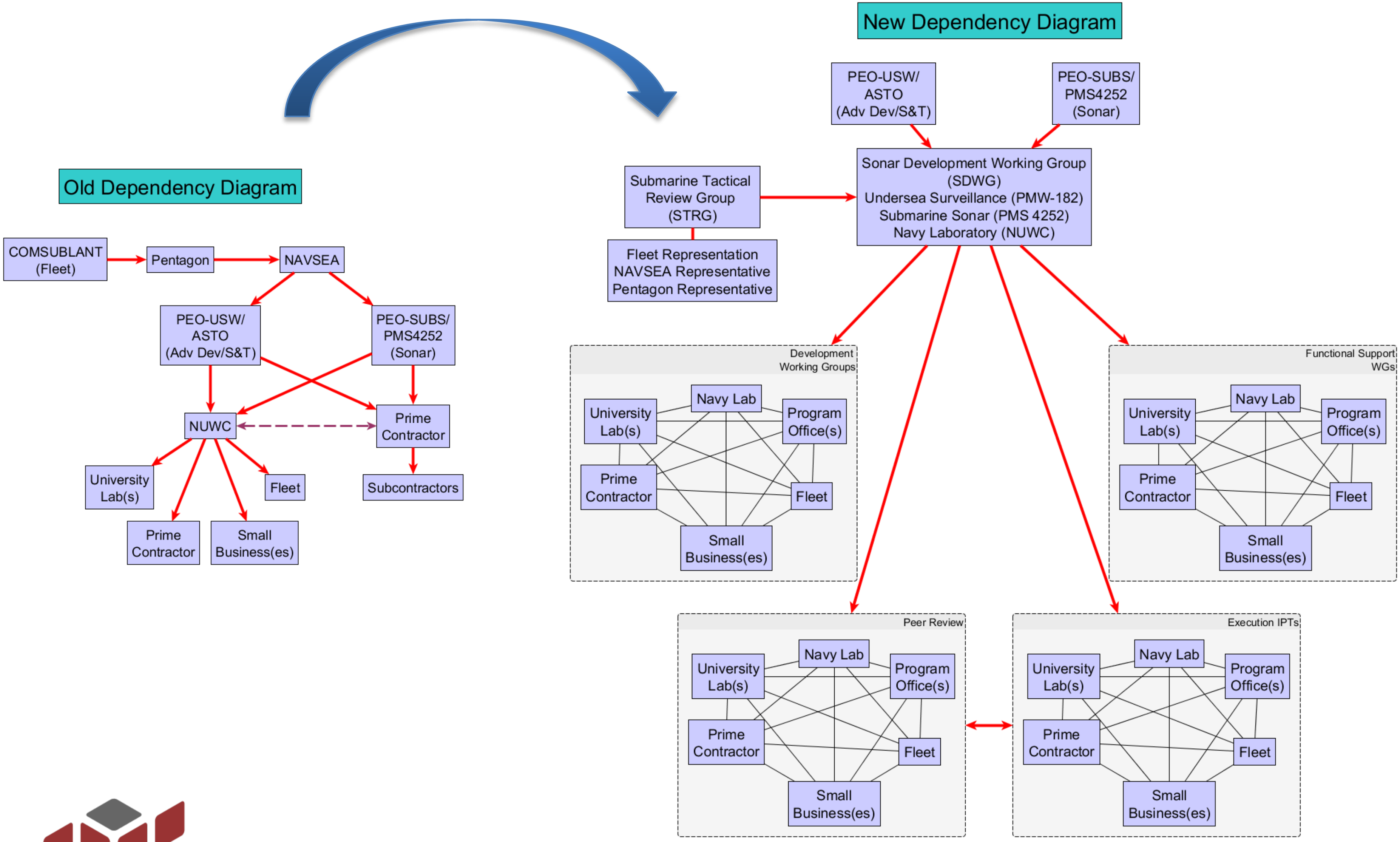
Middleware creates a layered architecture: enables independent hardware and software upgrades*

Program Office oversight + IPT structure enables:

- **Collaborative and decentralized decisions**
- **Increased flexibility**
- **Decisions on technical merit**
- **Potentially increased innovation**

*Interview data indicates that *lack* of modularity within application software block causes development/integration iterations (design churn)

A Key PM Task Was Designing New Interactions Based on the New Social and Technical System Dependencies



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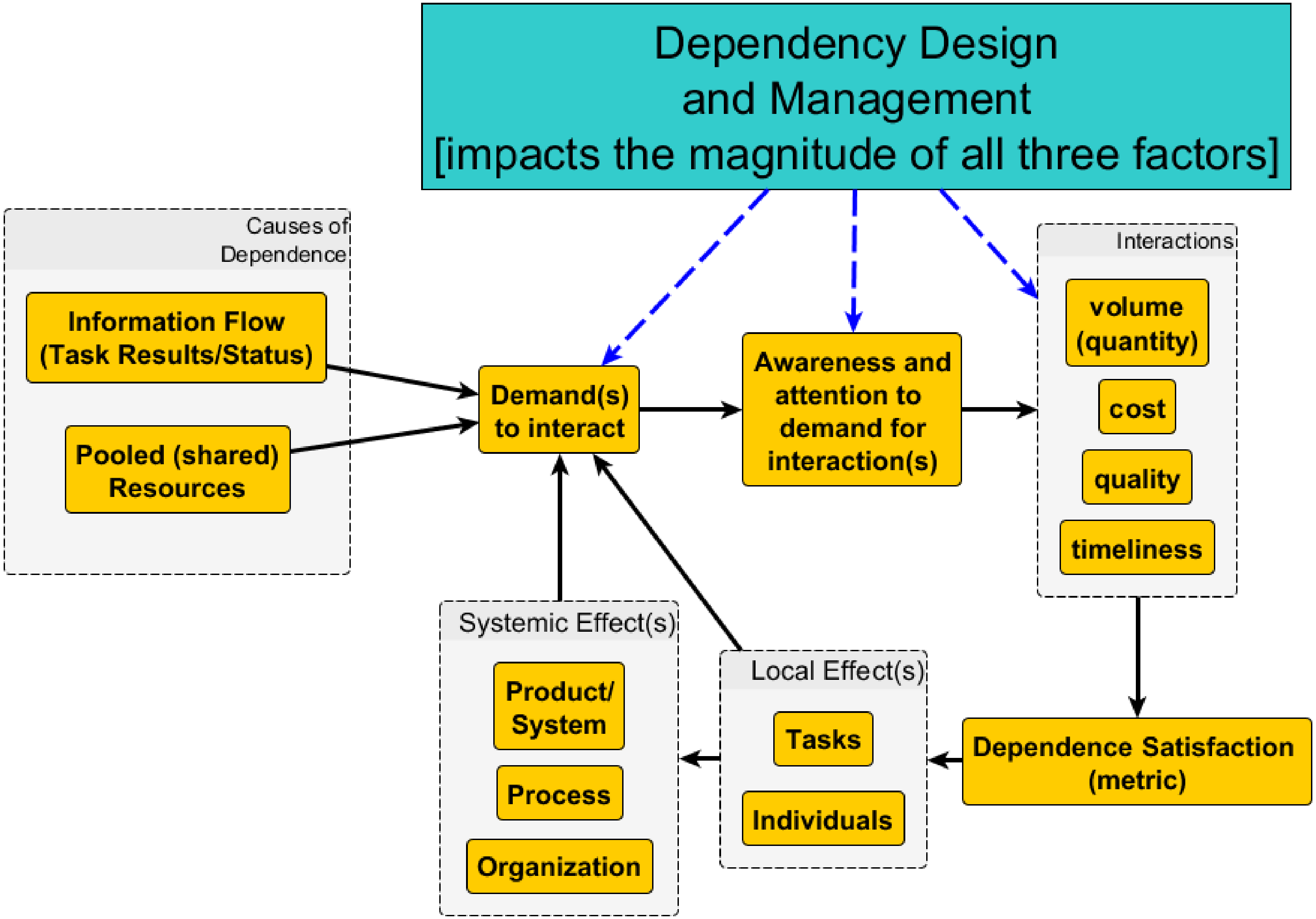
An Organic Process Evolved For Identifying and Satisfying Crucial Dependencies

- Program managers understood that the primary program challenges included the dependencies and interactions.
- They were mainly focused on implementing processes that increased the role of outside, or non-traditional, participants in the development process.
- Their focus was on outcomes and on getting the "right" participants connected to each other.
- This was a very evolutionary process, where membership was increased or decreased based on immediate need, where WGs were established and disestablished as need dictated.
  - Highlights the inherent role of change management in this kind of effort.

Proposed Framework for Understanding Dependencies and Interactions Impacts on Programs



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Potential Dependency Attributes With Measurement Challenges

Dependence Characteristic	Description
Awareness	The extent to which the interdependence is recognized within the process.
Closeness	The extent to which the actions of dependent activities have an immediate effect on each other.
Degree of mutuality	The extent to which the dependent activities have equal need for each other.
Feedback mechanism	The way feedback is passed between dependent activities.
Impact	The extent to which not fulfilling the dependence in the desired manner affects the dependent activities.
Satisfaction criteria	The criteria necessary to fulfill the dependence.
Strength	The amount of required interaction as a direct result of the dependence.
Urgency	The time-criticality for fulfilling the dependence.

- Dependence is driven by two sources of need:
  - Flow dependence results from the need for results or information from another task.
  - Pool dependence results from the need for a resource shared by another task.
- Flow dependencies are more direct and easier to measure (traditional approaches)
- Pool dependencies are more challenging to identify and measure, but also pervasive in complex networks

A New Measurement Approach to Identify Key Behaviors and Performance Drivers in Complex Sociotechnical Systems

- Key objectives of a dependence measurement system:
  - Must be able to be instrumented so as to be practically and sustainably implemented in a performance measurement system.
  - Must have a clear sampling approach, frequency, unit of analysis, etc. in order to produce reliable results.
  - Must have a clearly-defined measurement process, and ideally be indexed to current measurement and control systems in order to assess its predictive power relative to existing approaches.
- Attributes to measure (at minimum):
  - Demands to interact
  - Awareness of interaction demands
  - Performance of interactions (volume, quality, timeliness, cost, …)
  - Satisfaction of the demand to interact

This emphasis on interaction behaviors and capabilities is significantly different from, but compliments existing control systems that focus exclusively on task completion

Conclusion

- This research identified important gaps in current program control systems, primarily around dependencies and interactions within and between the social and technical systems in a program.
- The completed research will identify measures and an experimental method to empirically validate these measures of behavioral elements in programs.
- Follow-on research (just beginning) will employ these measures with teams in programs to evolve and refine the measurement process and develop corresponding control systems for design, engineering, test and evaluation, fielding and sustainment of complex engineering programs.
- By improving the awareness of, and coordination of action around critical dependencies in complex sociotechnical systems, we believe that program performance can be significantly improved.

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