Extending the System Engineering “V” to Measure Transformational Results

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Abstract

The “V” diagram is commonly used in system engineering to depict the relationship between design and test, different measures, and to emphasize different levels of detail and abstraction. The “V” diagram can be extended upwards to depict commonly used measures, relationships and levels of abstraction from enterprise architecture to provide a more complete model of enterprise transformation measurement. This brief paper describes the technique.

Extending the System Engineering “V” to Measure Transformational Results.

The “V” diagram is commonly used to depict systems engineering concepts and process. Figure 1 illustrates the “V” diagram used in Department of Defense system engineering training,

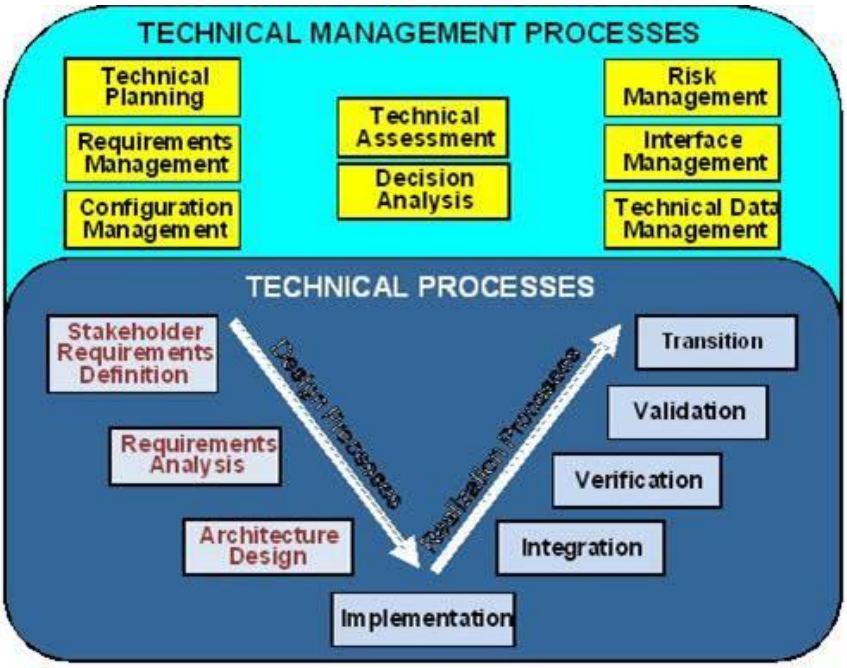

Figure 1 System Engineering "V" from Defense Acquisition University course numbered "SYS 101"

and Figure 2 shows the “V” diagram used by the standards body for commercial systems engineering, the International Council on System Engineering (INCOSE). In these diagrams design activities are shown on the left, and the level of detail of design increases toward the bottom of the figure. Test and evaluation activity is shown on the right, with tests at greater level of operational abstraction shown nearer the top of the diagram. Different types of measures to be used in testing occur at different levels of abstraction. Other various organizations have similar diagrams describing the system engineering process.

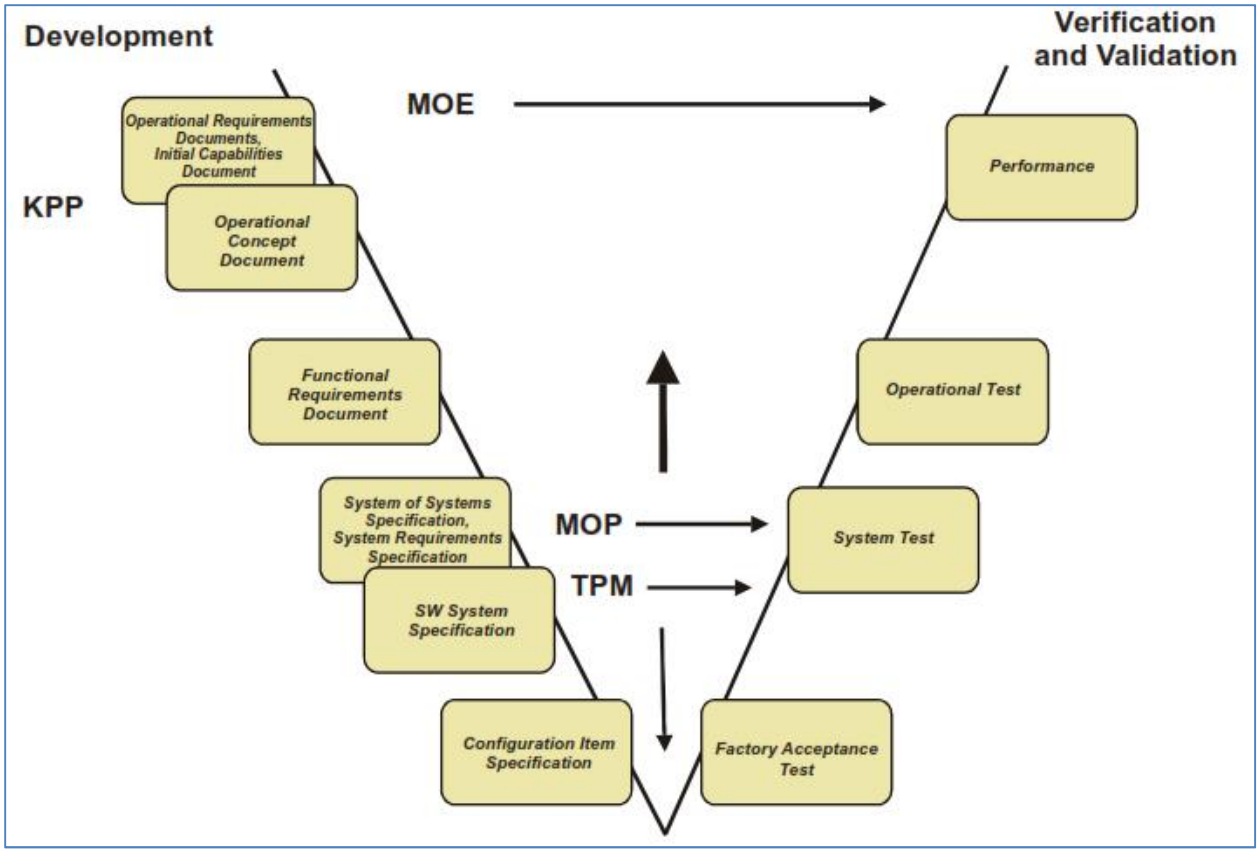

Figure 2 "MOEs, MOPs, TPMs and the "V" Model of System Development" form the INCOSE Technical Measurement Guide

Enterprise transformation is a topic often addressed by enterprise architecture. Enterprise architecture seeks to improve the function of the organization, by changing or “transforming” that organization.

In the US Federal Government (as an example) the effectiveness such transformation to be guided by the goals and objectives of the organization’s strategic plan. A primary measure of the effectiveness of such transformation is the organizational performance improvement. Figure 3 depicts the structure of the US Federal Government’s performance reference model, which provides guidance on the types of performance measures to be used. In this paper we term these Operational Performance Measures (OPMs).

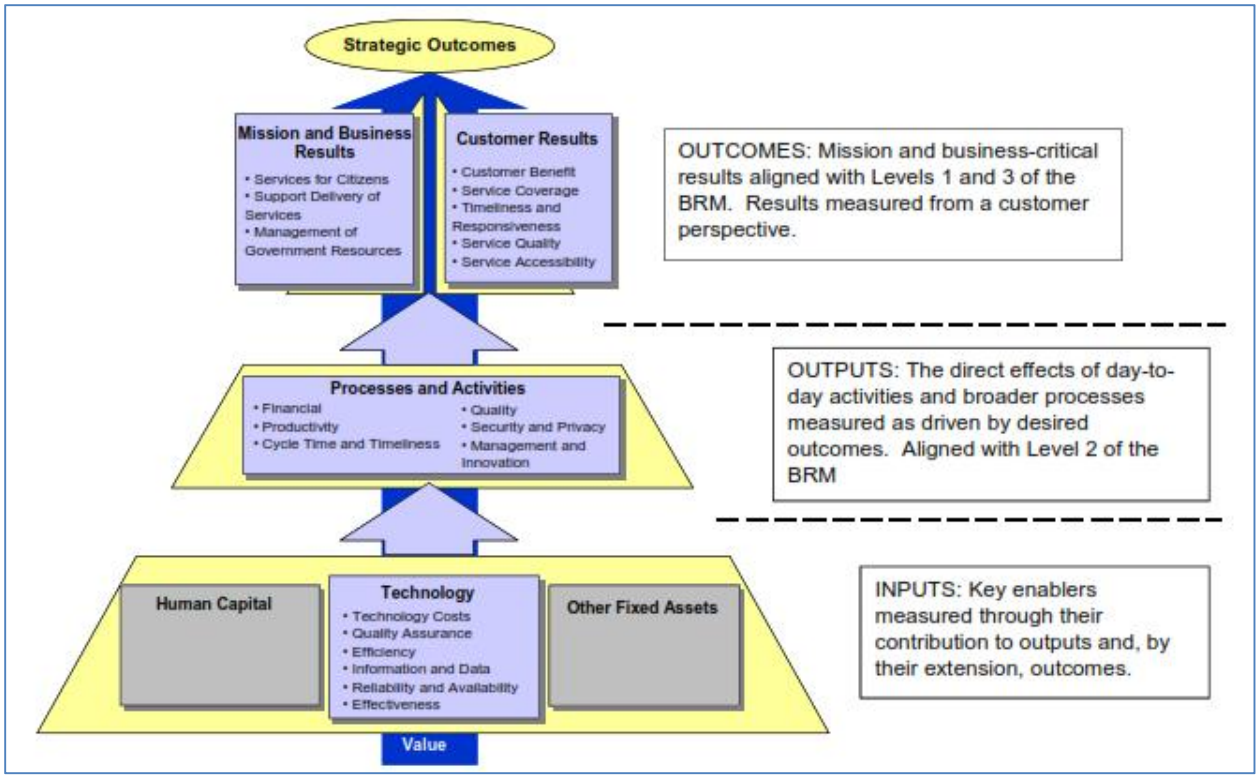

Figure 3 Performance Reference Model (PRM) Framework from United States Federal Enterprise Architecture Consolidated Reference Model

Discussion

It is possible to extend the "V" diagram of systems engineering to embrace the organizational transformation goals of enterprise architecture. In enterprise architecture there is a concept called "alignment" which is used to describe the extent to which an implemented change supports the strategic goals and objectives and/or improves operational performance. By combining the measures and levels of structure in system engineering and enterprise architecture a hybrid model may be created to depict this alignment. The system engineering V diagram may be extended upwards by two levels as shown in figure 4.

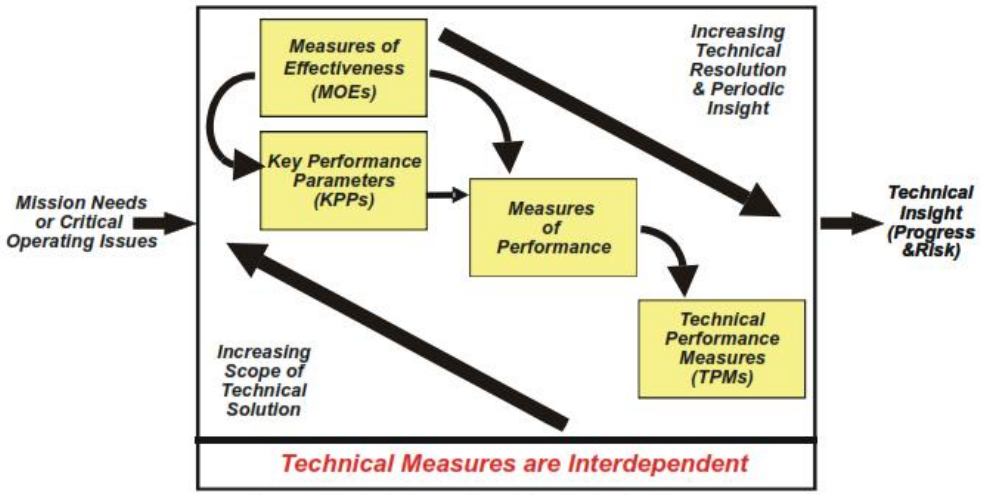

Figure 4 "Relationship of the Technical Measures” " from the INCOE Technical Measurement Guide

In system engineering various more detailed measures are to be partially derived from and partially guided by higher level measures as shown in Figure 5. This also applies to the extended model in the extended “V” diagram. In enterprise architecture today organizational performance measures are chosen to support strategic goals and objectives. A new linkage from organizational performance measures and system engineering measures is now required to complete the model. For INCOSE, that would be a derivation of Measures of Effectiveness from Organizational Performance Measures.

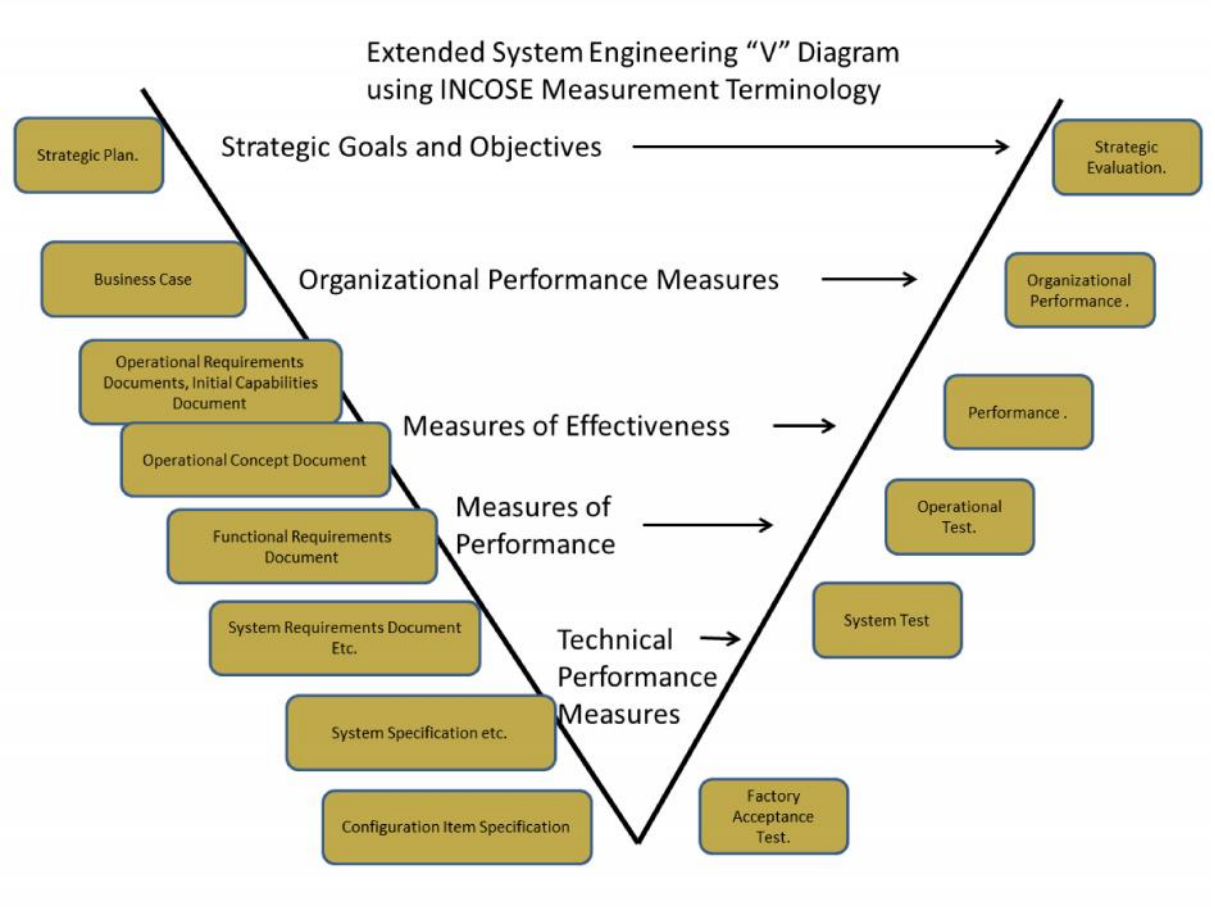

Figure 5 Combining Enterprise Architecture and INCOSE System Engineering Measures in a Single Hierarchy

The approach is not limited to INCOSE system engineering concepts. The approach is intended to be interpreted as quite flexible. For example the United States Department of Defense often uses mission needs in lieu of strategic goals, and mission goals could be substituted. In addition to using INCOSE measurement terminology, the United States Department of Homeland Security describes system engineering in terms of 1) Operational Requirements, 2) Functional Requirements and 3) System Requirements. A diagram depicting this approach extended to transformational measurement is shown in Figure 6.

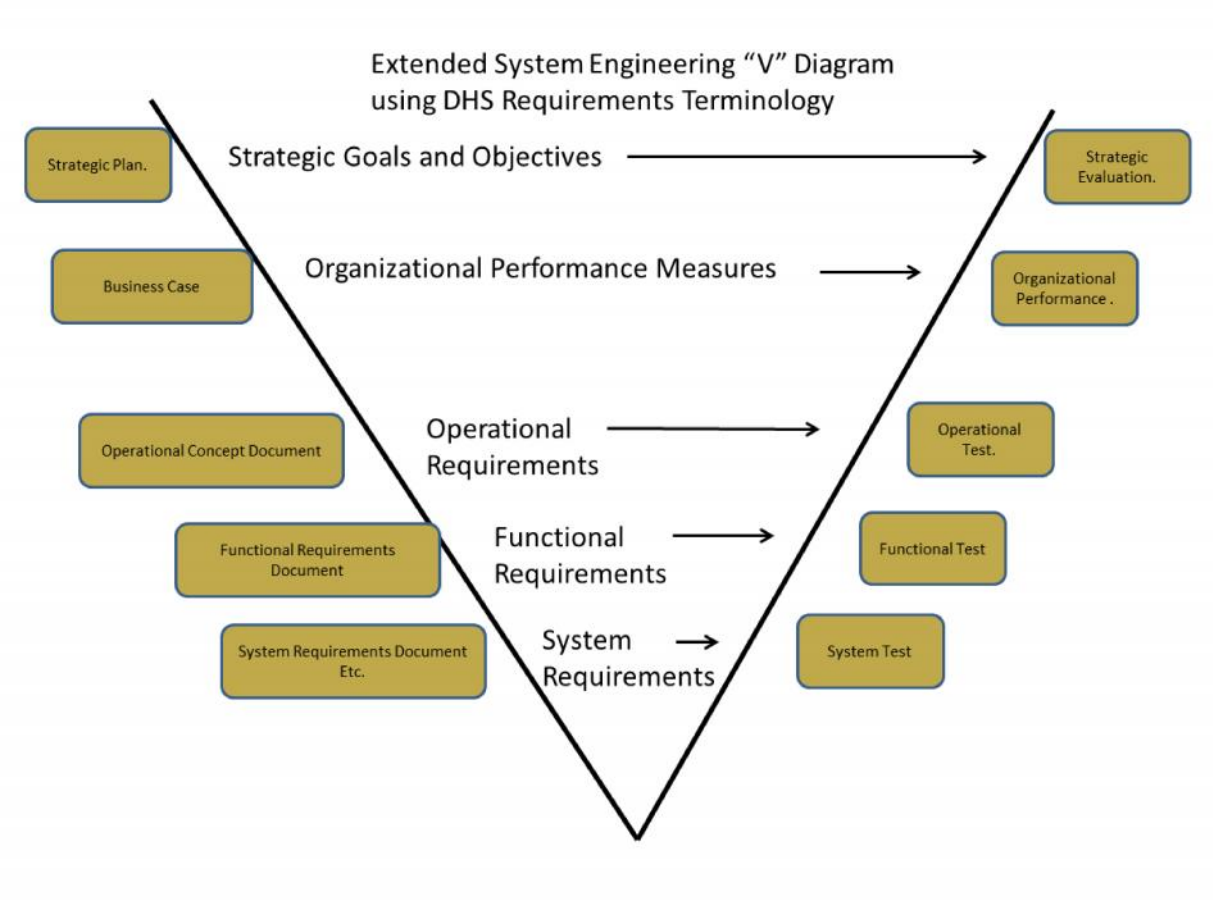

Figure 6 The System Engineering "V" Extended for Transformational Measures with DHS Requirements Terminology Shown

In enterprise architecture an “alignment diagram” is an artifact that depicts the linkage of a system or other transformation through various levels of justification back to strategic goals. The combined model described here allows a new sort of alignment (line of sight) diagram as shown in figure 7. This can be used to show how each measure is derived from the level above, providing a visual kind of proof of alignment. It can also provide insight into missing measures. In the example in Figure 7 no MOEs and MOPs support the number of products in a production line or the time to market, indicating possible improvements in metrics to achieve the strategic goal of agility. Alignment shown in the example can be improved significantly.

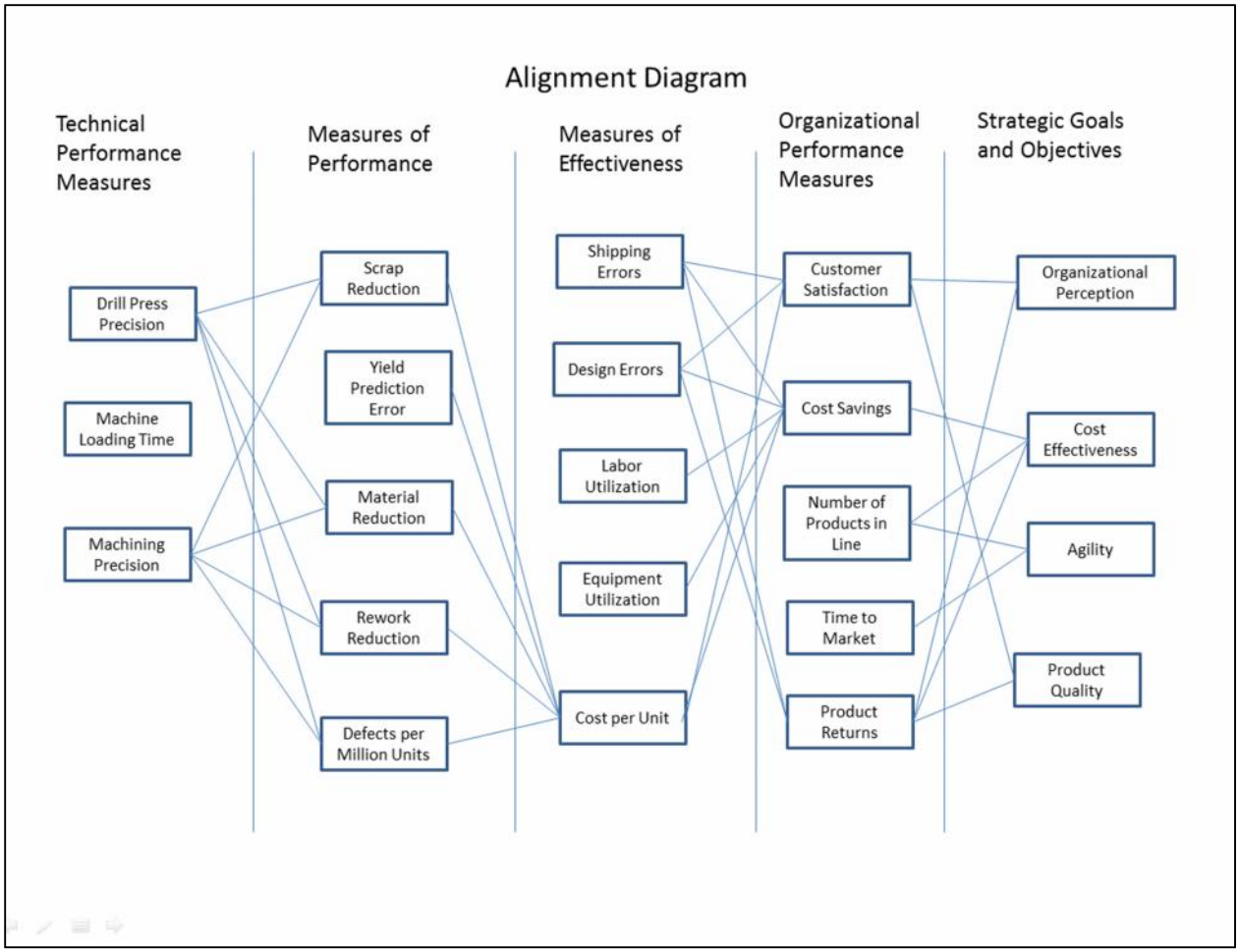

Figure 4 Partial Alignment Diagram showing how Measures and Improvements Support Strategy

Caveats and Notes

Discussion above on the flexibility of the approach presented should not be construed as advocating conflicting or redundant documents with overlapping purpose. Use of both a strategic plan and also several independent Mission Need Statements (MNS) is not implied. Nor is use of both a CONcept of OPerationS document (CONOPS) and a business case being advocated. The simultaneous use of INCOSE measures, a requirements chain of operational, functional and system requirements and also use cases is not implied. The approach presented is more meant to help unify a single authoritative derivation of requirements and is flexible in supporting whichever approach is selected.

Flexibility in the presented approach is also not meant to promote non-compliance with law or policy influencing the choices of which documents are used. If law prescribes that a strategic plan must be used the discussion here should not be taken as using another document instead, and so forth down the line of document choices. The presented approach is flexible in allowing the required documentation to be used in compliance with laws or policies.

While the discussion of derivation of operational performance measures from the goals and objectives of the strategic plan is well covered in the cited documents, as it’s the derivation from MOE to MOP and TPM in the INCOSE approach, there is a gap in description of the analysis of deriving a MOE (Measure of Effectiveness) from an OPM (Organizational Performance Measure). There are several approaches. First, the set of MOEs may be taken as identical to the OPMs, collapsing the hierarchy by one level. Second, the MOEs may be a subset of OPMs applicable to the particular system being analyzed. In this case OPMs are taken as having enterprise wide applicability. Third, the MOEs may be taken as more specific than the more general OPMs relevant to the system; Applying for example to specific operational process steps rather than the performance of the organization as a whole.

The approach is flexible in which supporting analysis might support identification of MOEs from OPMs. Improvement or reengineering of business processes may be used, as is common in information systems. Alternately simulation may be used, as is common in weapon systems. The approach is not then, for example, limited to information systems.

Systems engineering supports test and measurement while enterprise architecture supports transformation The measurement of operational performance changes in transformation are best conducted on real operational implementations, outcomes, rather than potential operational outcomes or capabilities when possible.

Conclusion

This paper has described a technique for depicting a linkage from enterprise architecture to system engineering. The method is flexible and can be applied to different system engineering methodologies and measurement regimes.

The combined model described may be used to illustrate "alignment". Measures of transformational effectiveness can be combined with system engineering measures to create a more complete measurement regime. Alignment may be improved by deriving measures from top to bottom, extending current practice in system engineering and enterprise architecture. Improved alignment may be depicted in a new type of alignment diagram based on the extended model. Improving alignment can demonstrate that systems support strategic goals by improving organizational performance and effectiveness.

The approach also supports improved measurement of organizational transformation by relating system requirements to improvements in organizational performance.

References

International Council on Systems Engineering and Practical Software and Systems Measurement. Technical Measurement. Roedler, Gary J. and Jones Cheryl. 27 December 2005. INCOSE-TP-2003-020-01. Note from original: "Permission to reproduce, use this document or parts thereof, and to prepare derivative works from this document is granted, with attribution to PSM, INCOE and the original author(s), provided this copyright notice is included with all reproductions."

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