

## Systems Engineering Cost Estimation Across BAE Systems: Trans-Atlantic Collaboration and Identification of Future Opportunities

### Introduction

As organizations develop more complex systems, increased emphasis is being placed on Systems Engineering (SE) to ensure that cost, schedule, and performance targets are met. Correspondingly, the failure to adequately plan and fund the systems engineering effort appears to have contributed to a number of cost overruns and schedule slips, especially in the development of complex aerospace systems. This has resulted in a recent increased emphasis on revitalizing systems engineering in government and commercial organizations.

COSYSMO, the Constructive Systems Engineering Cost Model, is an “open” model that can help people reason about their decisions related to systems engineering through a structured approach for estimating systems engineering effort. BAE Systems, in close collaboration with University of Southern California (USC) Center for Systems and Software Engineering (CSSE) and the MIT/Lean Aerospace Initiative (LAI), has been intimately involved in the development and validation of the model since its inception and continues to collaborate on the refinement of the model.

### Description

As systems become larger and more complex, system engineering assumes a greater role throughout the lifecycle. This trend drives the need to be able to estimate and re-estimate the system engineering tasks and efforts more effectively and systematically.

COSYSMO is a parametric estimating tool developed by Ricardo Valerdi as part of his PhD work at the University of Southern California (Valerdi 2005). Once calibrated for a business, COSYSMO can provide an improved estimating capability. Part of the COCOMO Suite, a set of influential estimating tools, COSYSMO is the only parametric model available that is dedicated to Systems Engineering estimation. Its size drivers and effort multipliers are illustrated in Figure 1. Parametric cost estimates use Cost Estimating Relationships (CERs) and associated mathematical algorithms to establish cost estimates based on historic information, providing more timely estimates without increasing risk. With ever increasing systems engineering and integration activities in today’s development and acquisition programs, engineering managers are actively seeking more effective and systematic methods and tools that are tailored to their organization and that can estimate end-to-end SE efforts

with high level of confidence.

## 4 Size Drivers and 14 Cost Drivers

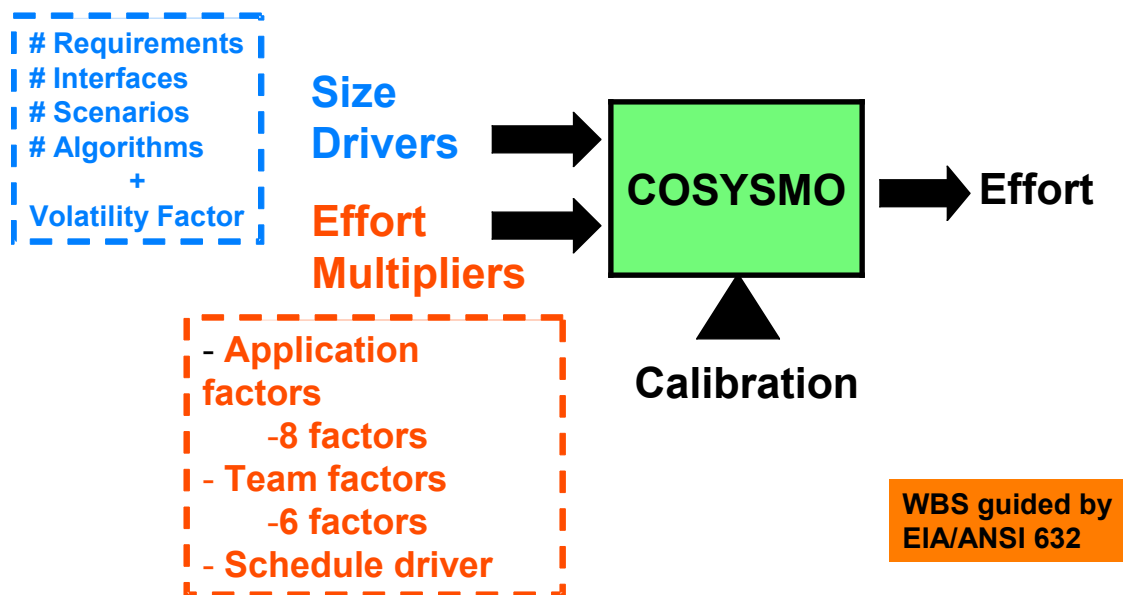


Figure 1 - COSYSMO Operational Concept

Whilst a number of North American business units at BAE Systems, Inc. sites have already engaged COSYSMO, current and planned interaction with BAE Systems plc's Insyte business unit in the UK is breaking ground as the first international involvement with the COSYSMO industry model.

### BAE Systems, Inc. COSYSMO involvement

As Corporate Affiliates of the Center for Software Engineering at USC and Consortium Members of the Lean Aerospace Initiative at MIT, BAE Systems, Inc. (BAE Systems' North American corporate entity) has leveraged the expertise from both research groups to develop a tailored version of COSYSMO. Such tailoring involves:

- the synchronization of COSYSMO life cycle scope (inspired by ISO 15288 and EIA 632) with the life cycle phases used at BAE Systems; and
- the mapping of the systems engineering Work Breakdown Structure activities (derived from EIA 632) to the systems engineering activities considered to be systems engineering at BAE Systems

Three BAE Systems, Inc. Lines of Business within the Electronics and Integrated Solutions Operating Group (E&IS OG) in Nashua, NH, San Diego, CA, and Reston, VA have been involved in the early development, as well as the current validation of the model. In total, BAE Systems has contributed 10 data points towards the industry calibration of the model which is representative of about 20% of the industry data repository.

### **Identifying trans-Atlantic collaboration opportunity**

At the end of 2005, BAE Systems plc's Insyte business unit in the UK identified that they needed to find a way in which they could improve Systems Engineering. While parametric software estimating models had been in use for a number of years, the development of such models to support Systems Engineering was not realized until very recently, as the need to engineer more complex systems increased the emphasis on Systems Engineering to meet cost, time and performance targets. In support of this aim, Insyte has funded a team of five engineers to calibrate and evaluate the COSYSMO tool across its twelve operating sites. As part of this activity they are working closely with the University of Southern California and their colleagues in North America, working towards creating their own calibration of COSYSMO tailored to their specific lifecycle phases and systems engineering activities. Concurrently, an E&IS OG team in North America, led by Dr. Gan Wang, is currently developing local calibrations of COSYSMO while working in parallel with Insyte to continuously contribute to the validation and enhancement of the industry model. It is expected that these organizations will increase the influence of BAE Systems on the COSYSMO industry calibration. Both groups are collaborating through common involvement with CSSE and LAI, via Dr. Ricardo Valerdi, with teleconferences, email, and symposia. In July 2006, BAE Systems US and UK units plan to continue collaboration with each other and CSSE & MIT by holding a COSYSMO Symposium in Loughborough, UK which has already generated much interest, including international interest from systems organizations in Australia. The Symposium is being supported by Galorath International and PRICE Systems, two of the leading vendors of parametric estimating tools, who each have direct relationships with the COSYSMO team and are working towards integration of COSYSMO into their product offering.

### **BAE Systems Impact on the cost estimation and systems engineering communities**

Through its involvement with COSYSMO, BAE Systems plans to feed back results of internal validation efforts to CSSE and LAI in order to help the application and adoption of the "global" industry model within the International Council On Systems Engineering (INCOSE). Additional improvements driven by BAE Systems such as the expansion of COSYSMO to cover the Operate, Maintain, or Enhance phases (see Figure 2) is planned and will continue to contribute materially to the COSYSMO community.



Figure 2 - COSYSMO Life Cycle Scope

Furthermore, as member of the MIT Industrial Liaison Program (ILP), BAE Systems, is planning further collaborative research exchange with MIT that will address additional systems engineering initiatives across the lifecycle beyond cost estimation. In the UK, the Insyte business unit is actively engaging with commercial tool vendors to understand their future plans and how future improvements might be integrated into their existing toolset. Insyte is also actively engaging with the Systems Engineering Innovation Centre at Loughborough with the aim for the SEIC to become the focal point of UK calibration.

### Conclusion

The COSYSMO effort has involved all the major players of the U.S. aerospace industry and BAE Systems has been on the leading edge from the beginning. The COSYSMO development effort is not only an indication of effective collaboration between BAE Systems and academic institutions, but it also demonstrates healthy industry collaboration with Raytheon, General Dynamics, Northrop Grumman, SAIC, and Lockheed Martin to develop a model that addresses the needs of multiple stakeholders (Valerdi, Miller & Thomas 2004). In the end, INCOSE and the systems engineering community benefit from an industry-validated model based on historical data and corresponding lessons learned (Valerdi, Rieff, Roedler, et al 2004) that can help advance the understanding and consequently the management of systems engineering.

### References

- Valerdi, R., "The Constructive Systems Engineering Cost Model (COSYSMO)", USC PhD Dissertation, 2005.
- Valerdi, R., Miller, C., Thomas, G., "Systems Engineering Cost Estimation by Consensus," 17th International Conference on Systems Engineering, Las Vegas, NV, 2004.
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