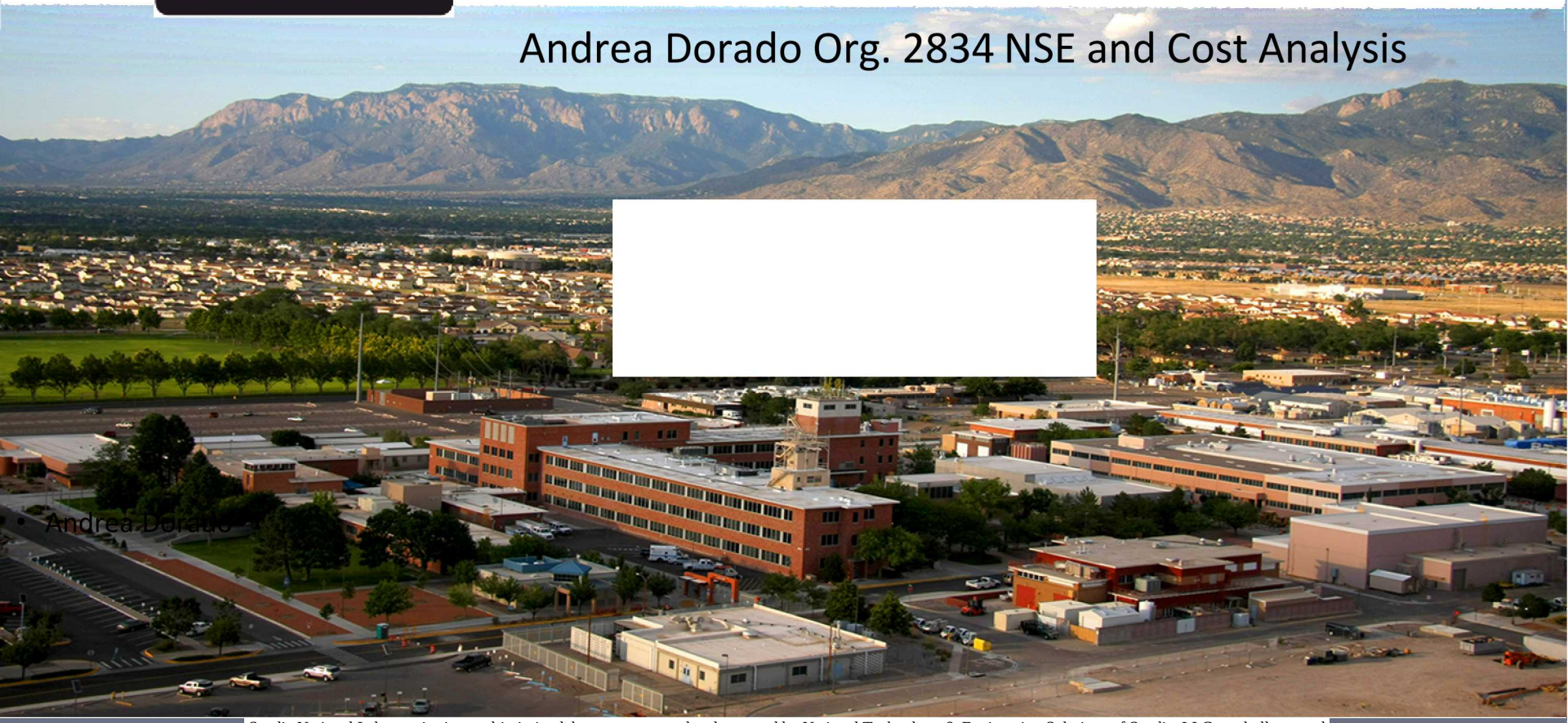
This paper describes objective technical results and analysis. Any subjective views or opinions that might be expressed in the paper do not necessarily represent the views of the U.S. Department of Energy or the United States Government.

SAND2020-7598C

Cost Estimating Informed by Design

Andrea Dorado Org. 2834 NSE and Cost Analysis



- Andrea Dorado

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Bottom Line Up Front (BLUF)

Model-Based Systems Engineering (MBSE) applies a model-based tool to support systems engineering activities.

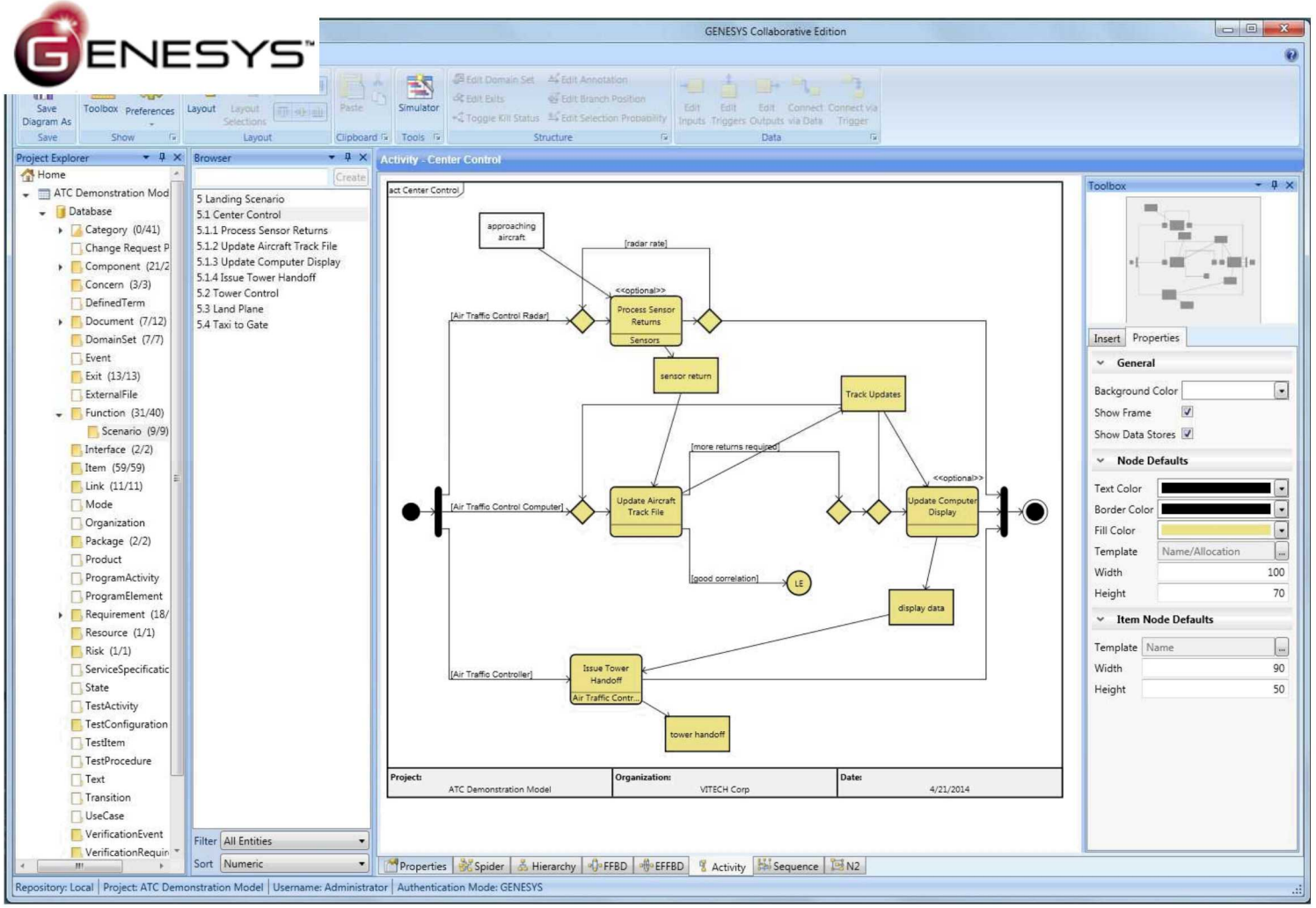
Linking cost estimating software and MBSE tool may improve our cost estimates by an:

- Increase in the amount and ease of communication/transferring of design data to inform cost estimates
- Ability to perform rapid cost estimation early in design phase which can then be used to inform design decision analysis
- As we collect and validate our cost estimates, we will enable calibration of our cost model and create cost estimates that are more consistent, credible, repeatable, and defensible.

What is MBSE? [1]

- International Council on Systems Engineering defines Model-based systems engineering (MBSE) as “the formalized application of modeling to support systems requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases.”

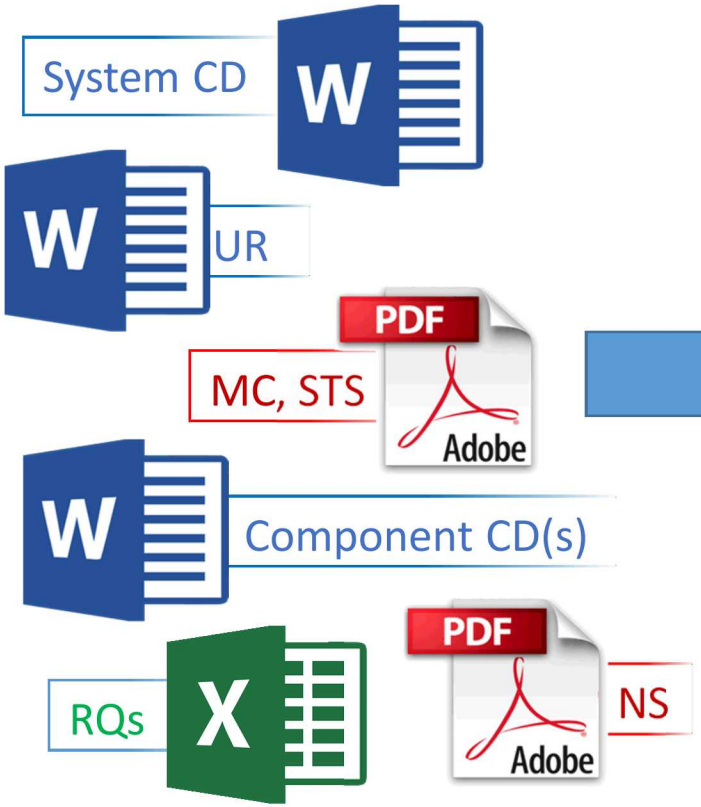
GENESYS: An MBSE Tool



http://www.vitechcorp.com/products/genesys.shtml

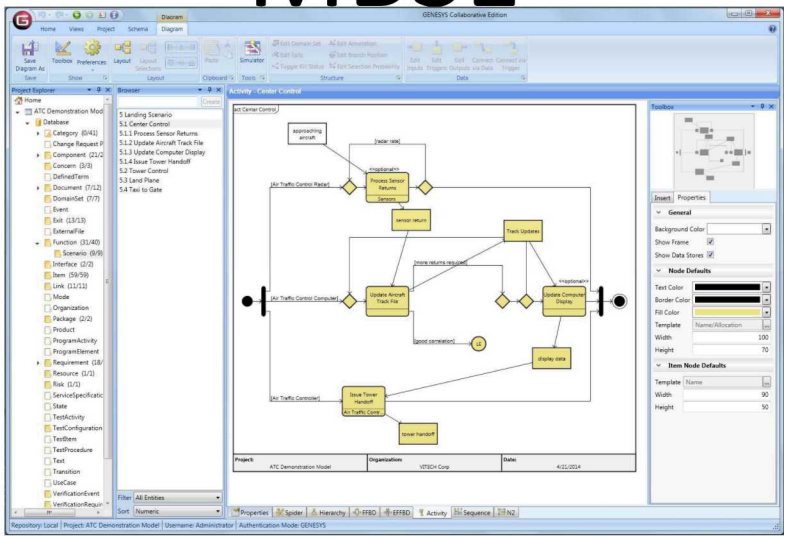
How does MBSE compare to DBSE?[1,2]

DBSE



Lots of individual documents that need to be manually updated/maintained.

MBSE



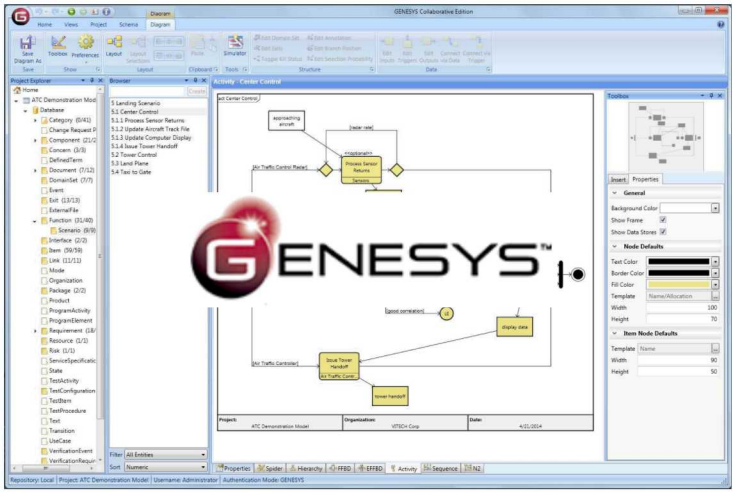
INCOSE describes the benefits of an MBSE as improving:

- communications
- ability to manage system complexity
- product quality
- knowledge capture
- ability to teach and learn SE fundamentals

What are Some Challenges Associated with Transitioning from DBSE to MBSE?[1]

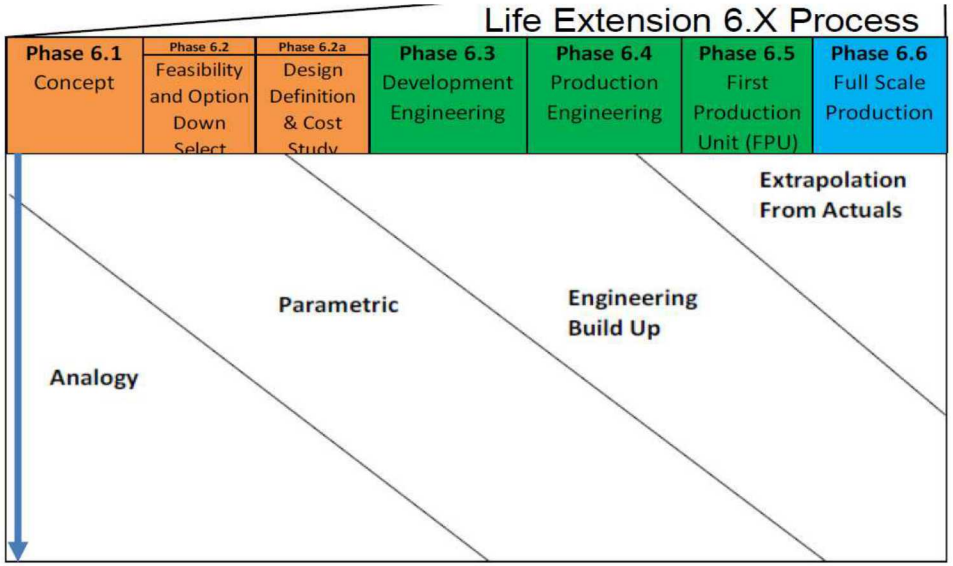
- **Broader adoption of SE modeling tools**
  - Amongst design engineers of all disciplines
  - Everyone has an understanding to utilize it's information
- **Development of model management processes**
  - Have to be able to maintain the MBSE model by managing it
    - Making sure there's configuration control
    - Continually updating it for later life cycle phases.
- **Cultural barriers across the design team and stakeholder team**
  - Need to assure stakeholders that the same information is going to be presented, but that it will look different
  - Battling the argument that "this is the way we have always done it."
  - Change in process to a "first change the model, the model is the design"

Using MBSE to Inform Cost Estimates Throughout the 6.X Process[1, 2, 3]



MBSE

Link



Cost Estimating Methodology

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2) M. Compton, M. Danik, M. Glazebrook, and J. Nistler. Applying Model Based Systems Engineering to Nuclear Weapon Development and Sustainment Programs at Sandia National Laboratories. INCOSE Enchantment Chapter Meeting. May 2020. Albuquerque, NM. SAND2020-4867 PE

3) B. Papke, S. Pavalkis, and G. Wang. Enabling Repeatable SE Cost Estimation with COSYSMO and MBSE. July 2017. 27th Annual INCOSE International Symposium. Adelaide, Australia.

4) D. Polidi. Cost Modeling as it Pertains to Systems Engineering. INCOSE LA Chapter Meeting. June 2020. Los Angeles, CA.

Terms and Acronyms

- DBSE= Document-Based Systems Engineering
- INCOSE= International Council on Systems Engineering
- MBSE= Model-Based Systems Engineering
- SE= Systems Engineering

Back Up Slides

Benefits of an Integrating System Modeling and Cost Estimating Capability [3]

- Ability to perform cost estimating and analysis early in design phase with reduction of cycle time for product decision making
- Enables designer to focus on architecture design while reducing the effort dedicated to cost estimating
- Ability to perform rapid cost-based architecture design trade studies, particularly Design-to-Cost trades
- Enforces consistency in estimating through direct traceability from sizing estimates to architecture and design artifacts
- Promoting systematic reuse in system design and development, one of the fundamental benefits of MBSE

Using Parametric Cost Tool for Design Decisions[4]

Parametric Cost Tool

To make cost informed design decisions:

1. Apply cost sensitivity algorithm & determine impactful Parameters
2. Key Size Metric to each component

Component	Parameter	Sensitivity Analysis Ranking
Part A	Size	1
Part B	Weight	2
Part C	Volume	3
Part D	Integrated Components per PCB	4
Part E	Clock Speed	5
…	…	…
Part ?	?	30

Mr. Polidi as part of his PhD, is looking to "develop algorithms for an automated tool/approach utilizing cost elements sensitivity to enable a system designer the ability to understand the relative cost impacts of various decisions/choices which affect system design early in the design cycle…"