Cost and Risk Model Development for Testing Unmanned and Autonomous Systems of Systems

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Expected Completion: December 2010
Massachusetts Institute of Technology

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This material is based upon work supported by the Department of Defense, United States Army, White Sands Missile Range, NM under Contract No. W9124Q-09-P-0230. The authors would like to thank the Test Resource Management Center (TRMC) Test and Evaluation/Science and Technology (T&E/S&T) Program for their support. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the Department of Defense, United States Army, White Sands Missile Range, NM.

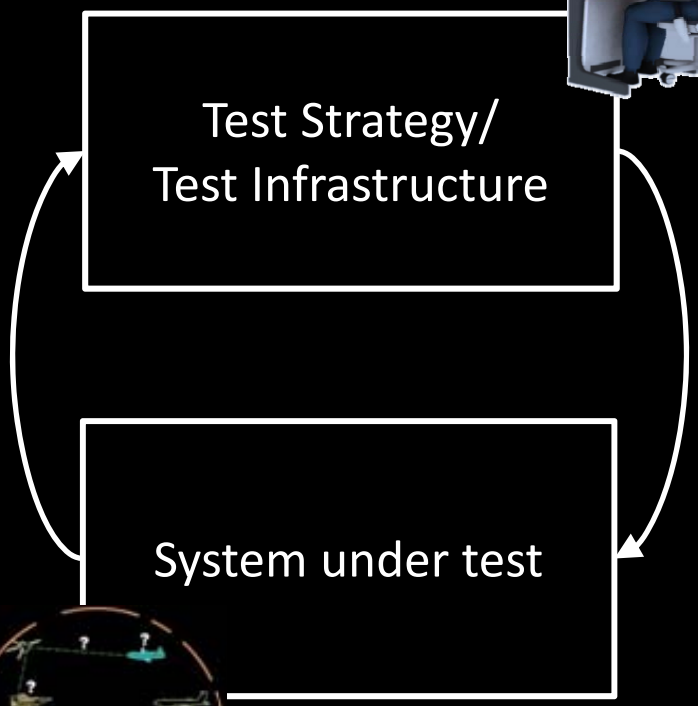
The Challenge

What is a UAS? Why UAS? Why UASoS?

The evolutionary nature of Unmanned and Autonomous Systems of Systems (UASoS) acquisition needs to be matched by evolutionary test capabilities yet to be developed.

Singer, P. W., *Wired For War: The Robotics Revolution and Conflict in the 21st Century* (Penguin, 2009)

The Prescriptive and Adaptive Testing Framework (PATFrame)



http://mit.edu/patframe

Why focus on testing?

- Need for T&E processes to recognize levels of effectiveness
- Need to focus on the interactions between components and emergent behaviors
- Need to move away from boundaries between DT and OT
- Need ability to make effective contingency plans as requirements change

The need for effort estimation of UASoS testing

- Trade off between effort required and risk mitigation
- Emergent properties drive up costs
- Using past projects as basis for current project costs
- Strategic options to improve confidence and ability to prioritize
- Avoid unreliable estimates and unfavorable system performance
- Cheaper to fix now than later

Hypothesis

A cost model can be developed to predict the effort required for testing unmanned and autonomous systems of systems using existing cost modeling techniques and historical project data.

Risk and Cost Considerations

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Merging qualitative results with historical project data for parametric cost model

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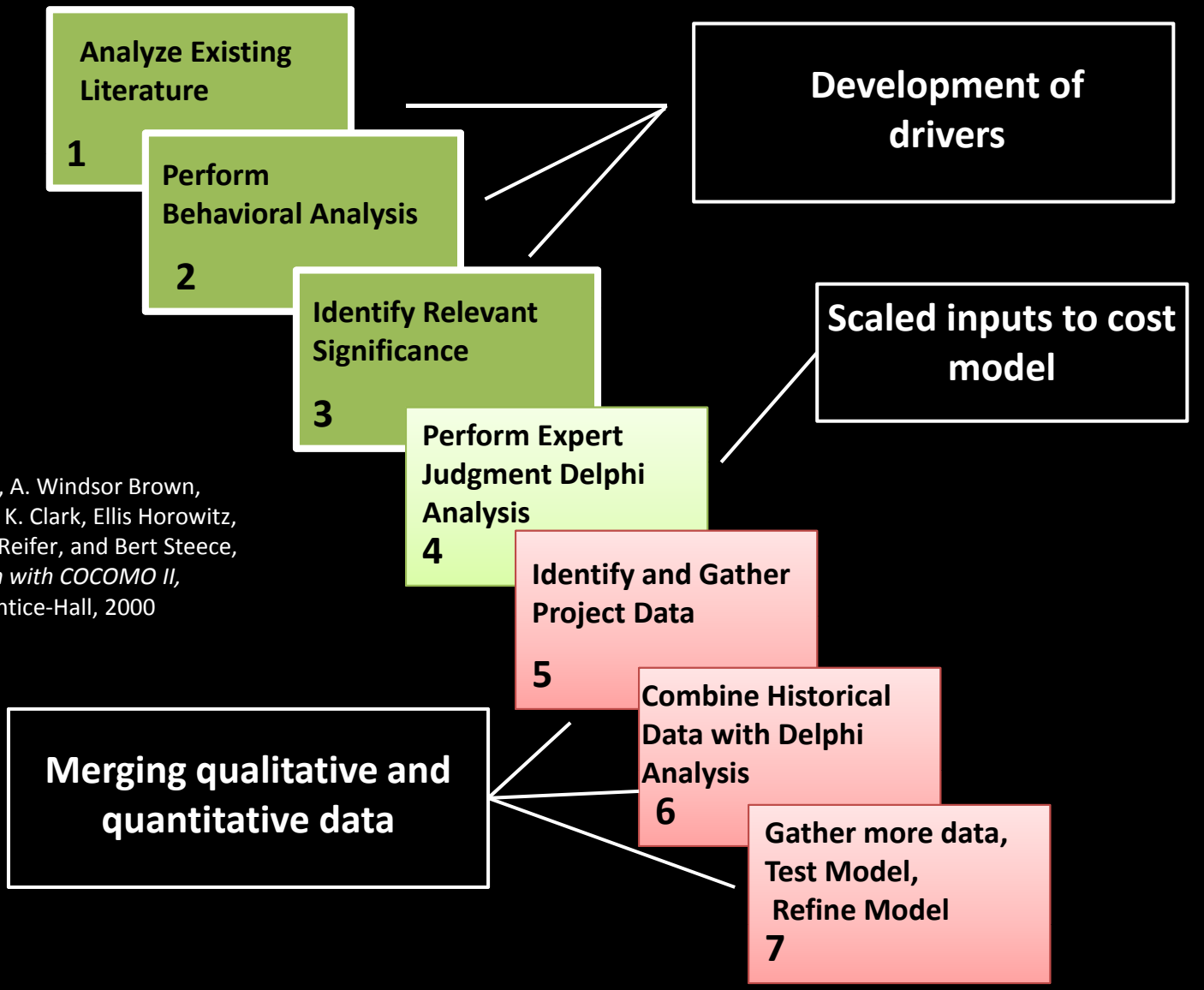
Demonstration of application

Cost Estimation Tools

Tool	Focus	Limitation
COSYSMO (Valerdi, 2008)	Estimate system engineering effort	Only applicable at the single system level
COSOSIMO (Lane, 2009)	Estimate system engineering effort for development and integration SoS components into the SoS framework	Does not account for flexibility and emergent behaviors of complex UASoS testing
"Bridge the gap between software test processes and business value" (Li et al, 2009)	Value based testing to better align investments with project objectives and business value	More applicable to business critical projects rather than safety critical domains
"Managing your way through the integration and test black hole" (George, 2004)	Integration effort is function of time defects, time to fix defects, test cases and time to implement them	Assumes only issue with integration testing is defects which are easy to find

The Boehm Seven Step Modeling Methodology



Barry Boehm, Chris Abts, A. Windsor Brown, Sunita Chulani, Bradford K. Clark, Ellis Horowitz, Ray Madachy, Donald J. Reifer, and Bert Steece, *Software cost estimation with COCOMO II, Englewood Cliffs,* NJ:Prentice-Hall, 2000

Ranking of Technical Cost Drivers | n=10

Number of systems

Integration complexity

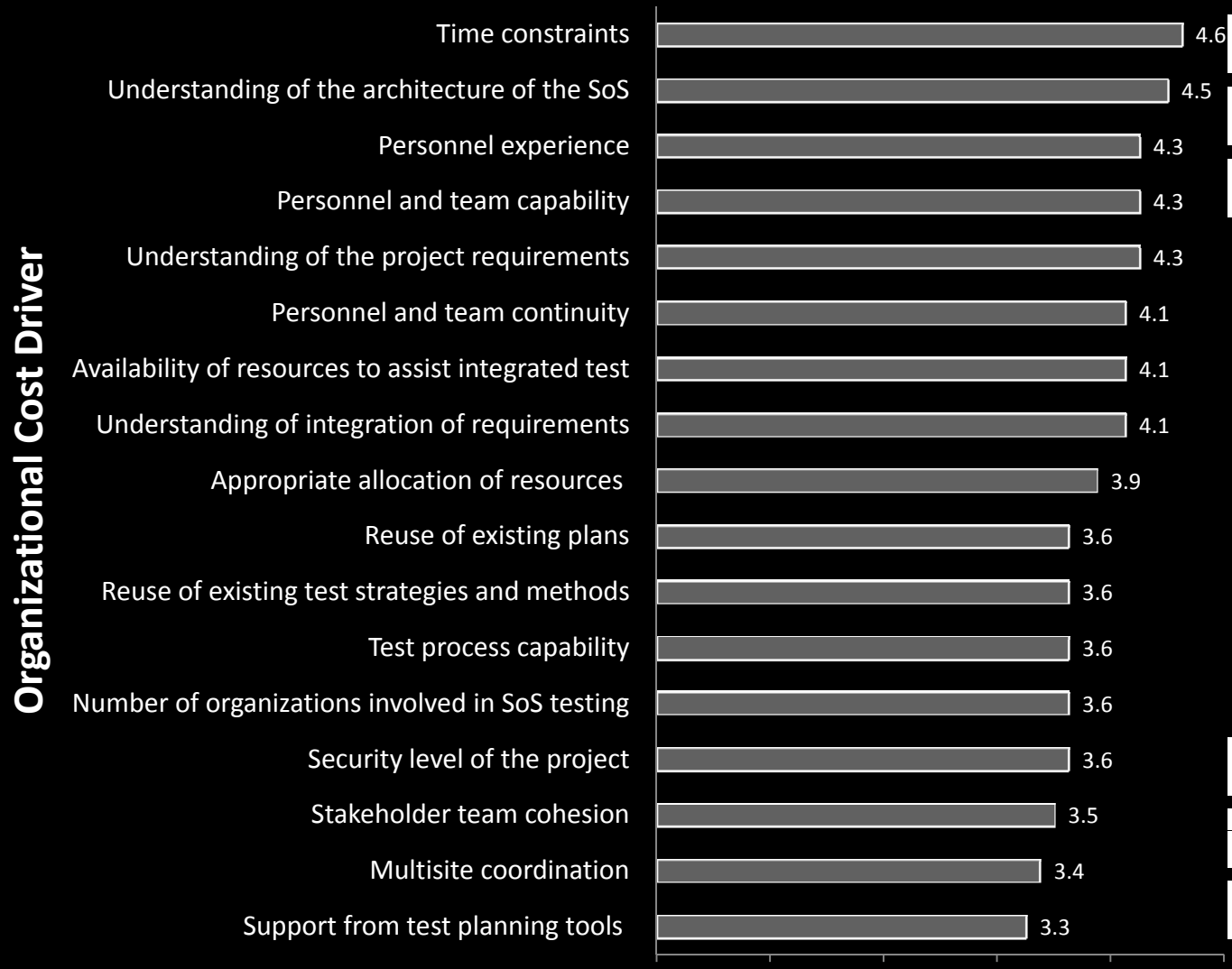
Complexity of test

Data collection rates

Maturity level of test

Power availability

Ranking of Organizational Cost Drivers | n=10



Impact

- **Test and Evaluation Planners**
  - provide tradeoff analyses between costs and risk mitigation
  - provide support in day to day testing procedures
  - helps with more efficient use of time and resources
- **Program Managers**
  - better allocation of resources (time and money) based on cost estimates
  - better coordination of multiple programs
- **DoD Policy Makers**
  - give evidence of budgeting requirements for testing projects
  - ensure adequate testing of UASoS to be used

Summary

1. **There is need for optimized testing strategies for UASoS**
   - UASoS are in more demand in the DoD
   - The advances in the technology need to be matched by advances in testing capabilities

2. **Provide program managers, test conductors, and policy makers**
   - An integrated decision support system for testing UASoS
   - A means to predict how much effort is required to conduct a test of UASoS while minimizing risk
   - A basis to perform cost and risk tradeoffs and prescribe how tests can adapt depending on resource or schedule constraints

Questions?

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