



Use of Design of Experiments to Determine the Critical Technical Parameters and Evaluation Framework in the T&E strategy

Developmental Test & Evaluation

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March 2, 2010



Agenda



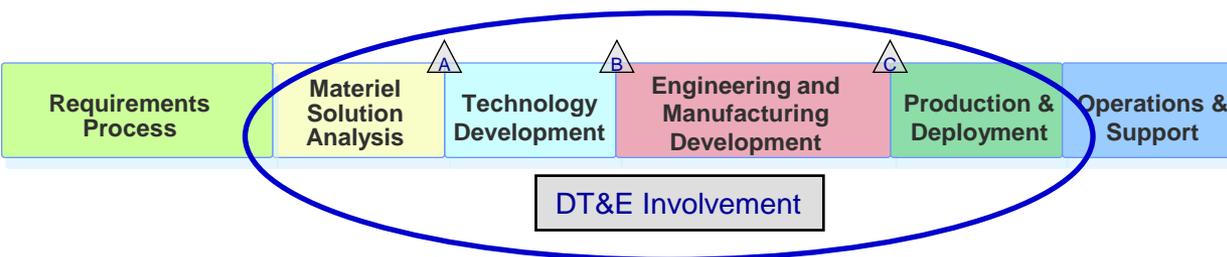
- **Mission**
- **Topic Shortfall**
- **High Level Design of Experiments (DOE) Discussion**
- **“Classical” DOE Limitations**
- **Implication to the Department of Defense Acquisition Lifecycle**
- **Conclusion**



OSD/DT&E Mission



As an advocate for the DT&E community, we provide **Policy** and **Oversight** across the **lifecycle** for Acquisition Programs and the Department



The right information, to the right decision maker, at the right time, for **better** decisions



Topic Shortfall

- Objective of the DT&E DOE investigation was to develop guidance on implementing DOE into Test and Evaluation Strategies (TES) and Test and Evaluation Master Plans (TEMPs)
- **That objective was not met.** Literature has a difficult time discussing DOE application to development approaches for complex systems or increments building to full functionality and capability.
- Case studies mainly focus on fully functioning systems or discrete subsystems
- Therefore, this discussion focuses on investigative findings and perceived shortfalls in implementing DOE within DT&E strategies for complex systems



High Level DOE Discussion



- **DOE is a systematic approach for investigation of a system or process.**
- **...is an application of statistics to analyze both main effects of input variables and interactions of those effects on response (output) variables.**
- **...increases both effectiveness and efficiency of testing – reduces overall quantity of test points**
- **...depends on strict control of inputs to a process in order to understand effects on the outputs, often in a laboratory environment**

Partial DOE Lexicon: Fisher, Taguchi, Orthogonality, Full Factorial, Fractional Factorial, Randomization, Replication, Blocking, Plackett-Burnam, D-Optimal, Box-Behnken



High Level DOE Discussion

- **DOE is widely used in R&D, where large proportions of resources go toward solving optimization problems**
- **...is used for optimizing design over many variables**
 - **Evaluating just one combination of design parameters would take a considerable amount of time because of analyses complexities. DOE quickly zeroes in on the area of the design space containing the optimum solution. It also provides expected values as well as confidence intervals for the responses with the factors optimized.**

Current OSD Project: Generate OSD T&E guidance, which explains acceptable and possible use of designed experimentation (DOE).



High Level DOE Discussion



- **DOE addresses interactions between input variables in a process – an effect often missed with traditional “one factor at a time” test design**
 - Thomas Edison, applied trial and error OFAT to invent the light bulb “1% inspiration and 99% perspiration.”
- **...provides a measure of the experiments’ ability to determine the probability that the observed system response is representative of the true behavior—statistical confidence.**
- **...gives the probability that a certain sample size was adequate to detect defined changes in the level of the response under test—statistical power.**

HOWEVER.....



“Classical” DOE Limitations



- **DOE does not handle large numbers of variables well and requires screening to reduce variables for control**
- **...is used in research and development, determination of design robustness, design optimization and resolving problems**
- **...is best suited where interactions and effects among a handful of strictly controlled variables are of interest. Systems with higher complexity, the number of variables must be reduced, which can result in omission of possible combinations of interactions.**



“Classical” DOE Limitations



“What it does for you - DOE is about option selection. It works the best when you already have a working design (product, process, system, plan, etc.) and you want wish to put the finishing touches.

If you are after developing a new product or process, it is probably not the right time for DOE. (Emphasis added)

You need to look for other means to determine the working parameters. It is only after you reached a workable condition that satisfy your objectives, and know your process/system well, you would benefit from DOE. You will apply DOE to determine the best among many good conditions. In other words, it is something that will help you hone-in the process to perfection or help you select something that will consistently produce what you want, all the time.” (NUTEK, Inc.)

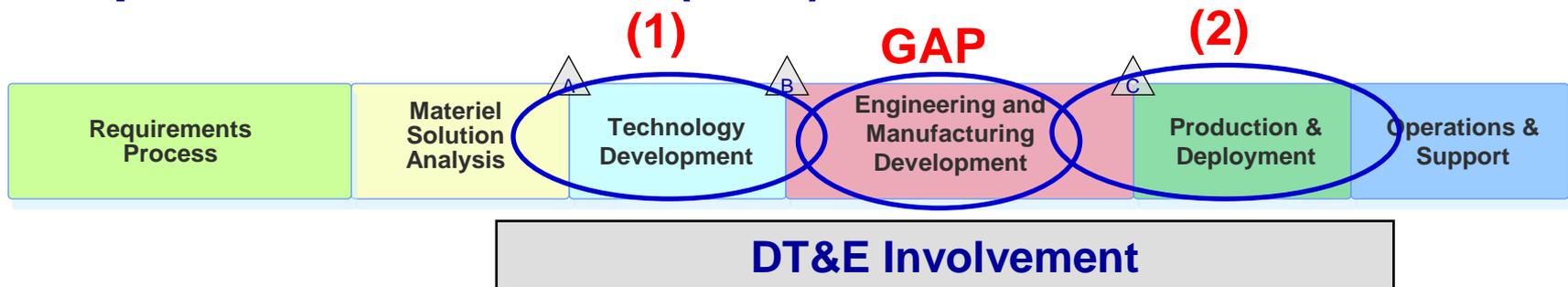
Applying DOE across DoD Acquisition Lifecycle is Not Clear Cut



Implication to the Department of Defense Acquisition Lifecycle



- **OSD/DT&E Investigation of DOE implementation:**
 - DOE maybe best suited for a T&E strategy in the technology development phase and for testing prototypes **(1)**
 - DOE may be a better approach for technology evaluations and operational T&E **(2)**
- However, the investigation of the literature and case studies found a **gap** for the concurrent system development approach used in acquiring complex systems in the Department of Defense (DoD)





DOE Summary

- ...used to interrogate a process, improve knowledge, optimize deficiency resolution and identify factors and interactions affecting variability of performance
- ...technique to determine the minimum number of trials necessary to measure all interactions and combinations among factors
- ...saves time and considers interactions better than traditional one-factor-at-a-time (OFAT)
- ...strictly controls inputs in order to understand the effects on the outputs. Strict control in testing alternative components or subsystems is used to determine the optimal combinations.

Ensure the right information, gets to the right decision maker, at the right time, for *better* decisions



Conclusion

- **Some experts contend that if you are developing a new product or process, it is not the right time for DOE.**
- **Best suited for where interactions and effects among a handful of strictly controlled variables are of interest. In experiments with higher complexity, the number of variables must be reduced, which can result in omission of many of the possible combinations of interactions.**

Bottom line: DT&E needs to investigate further, prior to issuing OSD TES and TEMP guidance on implementing DOE across the Acquisition Lifecycle



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