



***Panel:***  
***Input uncertainty &  
experimental robustness***

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**Workshop on deterministic & stochastic simulation  
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# Input uncertainty

Workshop theme: *Deterministic & stochastic* simulators

Interpretations of 'stochastic':

1. *Deterministic* simulation with *numerical noise*
2. *Deterministic* simulation with *random input* PDF  
'Uncertainty propagation'  
*Epistemic* uncertainty (analyst, subjective)
3. *Discrete-Event Dynamic Systems* (DEDS) using  
Pseudo-Random Numbers  
*Aleatory* uncertainty (system, objective)  
Example: Queuing at supermarket, IT-network, etc.

# Input uncertainty: Questions

See Jon Helton (Sandia) publications (e.g. RESS)

How to

1. Obtain *experts' judgment*? Delphi, etc.
2. *Quantify & represent*? PDF, fuzzy sets, evidence theory
3. *Propagate*? Space-filling (LHS), size ( $n = 100, 300$ )
4. *Analyze*: Risk (uncertainty) & sensitivity analysis
5. *Represent*? CDF, Complementary CDF

# Robust optimization

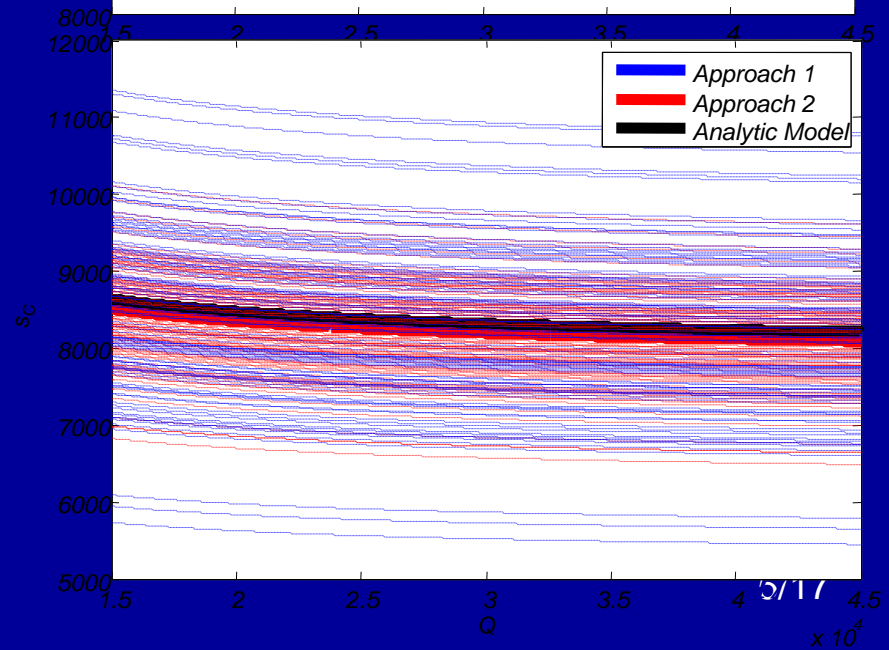
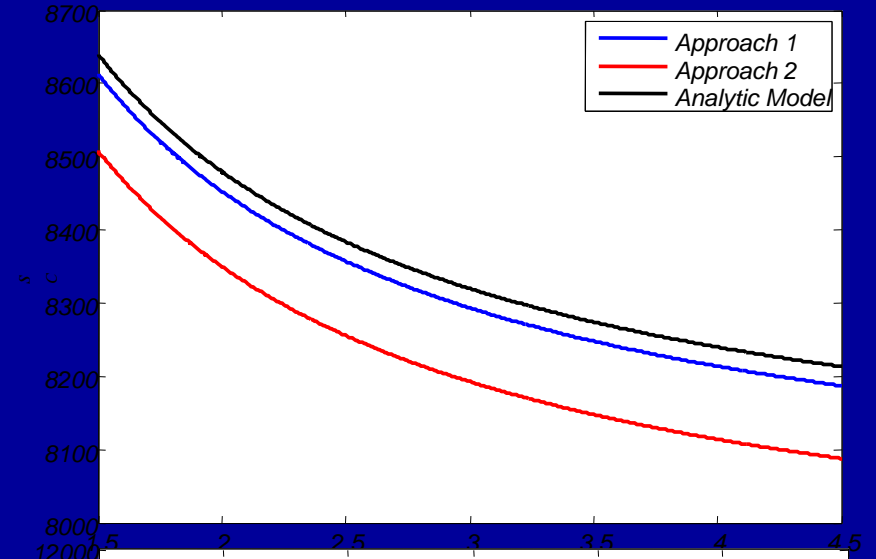
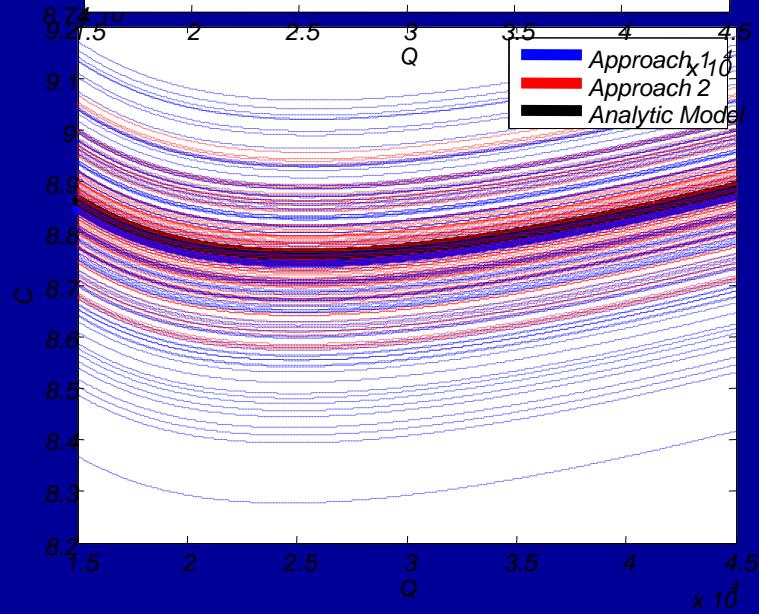
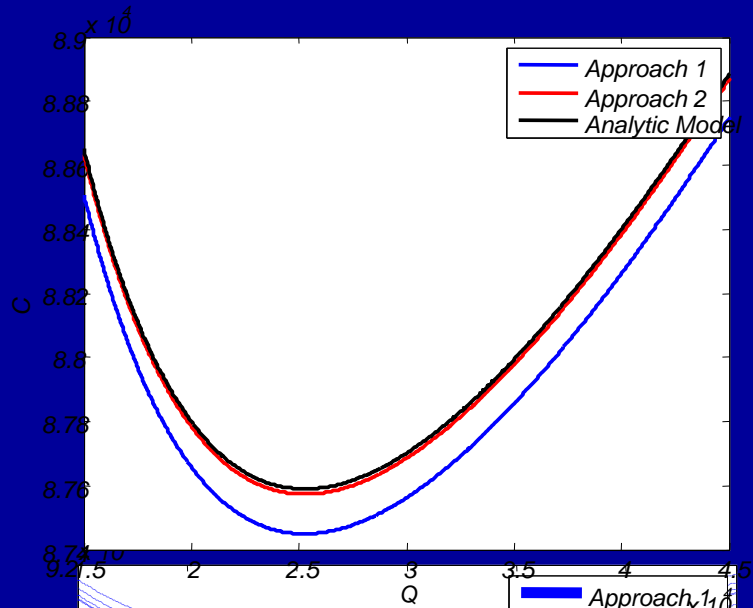
Worldview of *Taguchi* in 'robust design' (not Ben-Tal, et al.):

- *Decision* inputs  $d$  (order quantity; wing span)
- *Uncertain environmental* inputs  $e$  (demand, wind)

Taguchi's *methodology* adapted:

1. *Kriging* replaces low-order polynomial regression
2. *Design: Crossed* space-filling design for  $d$  & LHS for  $e$  replaces orthogonal arrays
3. *NLP* solver replaces maximize signal/noise
4. *Pareto* frontier by changing NLP-constraint values
5. *Distribution-free bootstrap* quantifies Kriging / Pareto variability

# Robust optimization: EOQ example



# Robust opt.: *Future* research

- Replace 'Min.  $\mu$  s.t.  $\sigma \leq T$ ' by quantile or CVaR
- Random ( $s, S$ ): Aleatory & epistemic uncertainty
- Multiple constrained random outputs (e.g. Service > 95%)