Leveraging Statistical Engineering for Emerging Challenges

Laura J. Freeman, Virginia Tech

Peter A. Parker, NASA

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Solving Large Complex Problems

• Solving complex challenges in defense, aerospace, and national security requires sustainable solutions based on data driven methods combined with domain knowledge
  – The interactions between these domains are accelerating

Sustainable Solutions
Requires – Education, Training and Tools to Implement New Methods

Data Driven
Tangible Data Collection Efforts of High Value Data Points, Synthesizes Data and Engineering

Domain Knowledge
Leverages Computer Models and Engineering Knowledge to Inform Testing and System Assessments
Technology is Changing

- The first cyberspace environment?
  - Semi-Automatic Ground Environment (SAGE) was deployed to automate air defense of North America (1957)
  - Data in motion and data at rest
The Rapid Evolution of Computer Network Technology

Images, left to right: IBM 1401 from Computer History Museum, Microsoft Surface
Our Systems are Changing

Airborne Software

SLOC in thousands

- 135  236  1,000  1,700  6,800  8,000  9,200

Airborne + Support Software
Emerging Challenges

- Hypersonics
- Space Exploration
- Directed Energy
- Quantum Computing
- Microelectronics
- Big Data Analytics
- Machine Learning
- Artificial Intelligence
- Urban Mobility

Need Interdisciplinary Approaches

• DATAWorks is a unique, cross-cutting community
  – Many Disciplines
  – Senior Leadership
  – Application Focused

• Interdisciplinary collaboration is required for emerging challenges
  – Tool mastery is necessary, but not sufficient to solve challenges

Effective interdisciplinary collaboration between statisticians and other subject matter experts

Christine M. Anderson-Cook\textsuperscript{a}, Lu Lu\textsuperscript{b}, and Peter A. Parker\textsuperscript{c}

with 6 Discussants: DeHart and White, Hoerl, Jensen, Litano, Slade, Typhina and Wilson
A Timeline of Collaboration

2011 NASA Statistical Engineering Symposium

2011 Test Science Steering Group DOE Meeting

2014 Statistical Engineering Inter-Agency Agreement

Today! DATAWorks

Rigorous Test and Evaluation for Defense, Aerospace, and National Security
April 11-13, 2016
Crystal City Marriott/Reagan National Airport
DoD and NASA develop, acquire, evaluate, and operate some of the world's most advanced and sophisticated systems.

To advance and broaden statistical engineering practice, a partnership was developed to share knowledge and experience to generate better solution strategies to solve high-impact challenges.

Partnership is a catalyst to engage the broader statistical engineering community in industry, academia, and other government agencies.

Key Elements

- Leadership webinars and Tactical practitioner collaboration
- Statistical engineering workshop - DATAWorks
- Research collaboration and joint technical publications
A Different Lens on Professional Development

• Why are you all at DATAWorks?
• To learn about,
  – Verification, Validation, Uncertainty Quantification
  – Data Integration & Sequential Testing
  – Autonomy, Artificial Intelligence, Machine Learning
  – Data Curation and Engineering
  – System Cybersecurity
  – Human System Integration

Shameless Plug – the IDA Handbook on Statistical Design and Analysis Techniques for Modeling and Simulation Validation is now available on testscience.org

Learn & Bring Resources Back
Statistical Engineering Overview

• Engineering discipline
• Application focused, rather than data and/or tools centric

Solution Characteristics
• Interdisciplinary collaboration
• Synergistic combination and extension of tools and methods
• Embedded into standard work processes

Motivation to Apply
• Efficiently Gain Knowledge
• Ensure Strategic Resource Investment
• Support Risk-Informed Decisions
Engineering Discipline

Engineering is the practical application of pure sciences (physical, biological, mathematical)

Engineering statistical sciences to generate strategic, innovative solution approaches

Application Focused,
Starting with Fundamental Questions

• Heilmeier questions for successfully launching a research project
  “to curb and clarify both the enthusiasm of the researchers and to evaluate the resource demands of the project managers”

• What are we seeking to learn, discover, or confirm?
  – How will we know when we’ve learned it?
    • Are the objectives quantifiable, detectable, measurable?
      – What is the impact if we are successful?

• How well do we need to know the answers?
  – How much risk are we willing to accept in being wrong?
  – What are the consequences if we are wrong?

• Does our approach rigorously link to the stated objectives and risk?
  – Are the resource demands justifiable and defendable?

Solid Rocket Motor Heritage System
Leveraged for New Architecture

Shuttle
Ares I
Flight Test

Full-Scale Static Firing

Contributors: Gentz, Roberts, Parker, Rhew, Jones, McLennan, Nester, Freeman, Vining
Mission

To be the voice for statistical engineering, serving as a catalyst to drive sustainable results and impact by integrating multiple disciplines through the scientific method.

Activities

• Raising discipline awareness and connecting across societies
• Theory development and practitioner guidance
• Curriculum building for professional and academic training

“We predict that in the coming decades, Statistical Engineering will revolutionize the practice of statistics in business, industry and government, and change how statistics is taught and perceived.”

Anderson-Cook & Parker, 2012

We encourage you to join our fast-growing society.
Our Challenge to You

• Keep coming to DATAWorks
  – Invite others - organizations, application areas, disciplines
  – Engage your leadership to raise their awareness
  – Share your experiences and case studies

• Take what you learn back to your own organizations
  – Not just the tools, but also the stories
  – Invite a guest speaker to your organization

• Join the International Statistical Engineering Association (ISEA)
  – Look for meetings, webinars, and publications
  – Attend the ISEA Summit 2019 at NIST, Sept. 23-24

Our leadership and potential contributions in emerging system technologies are clear and unlimited.