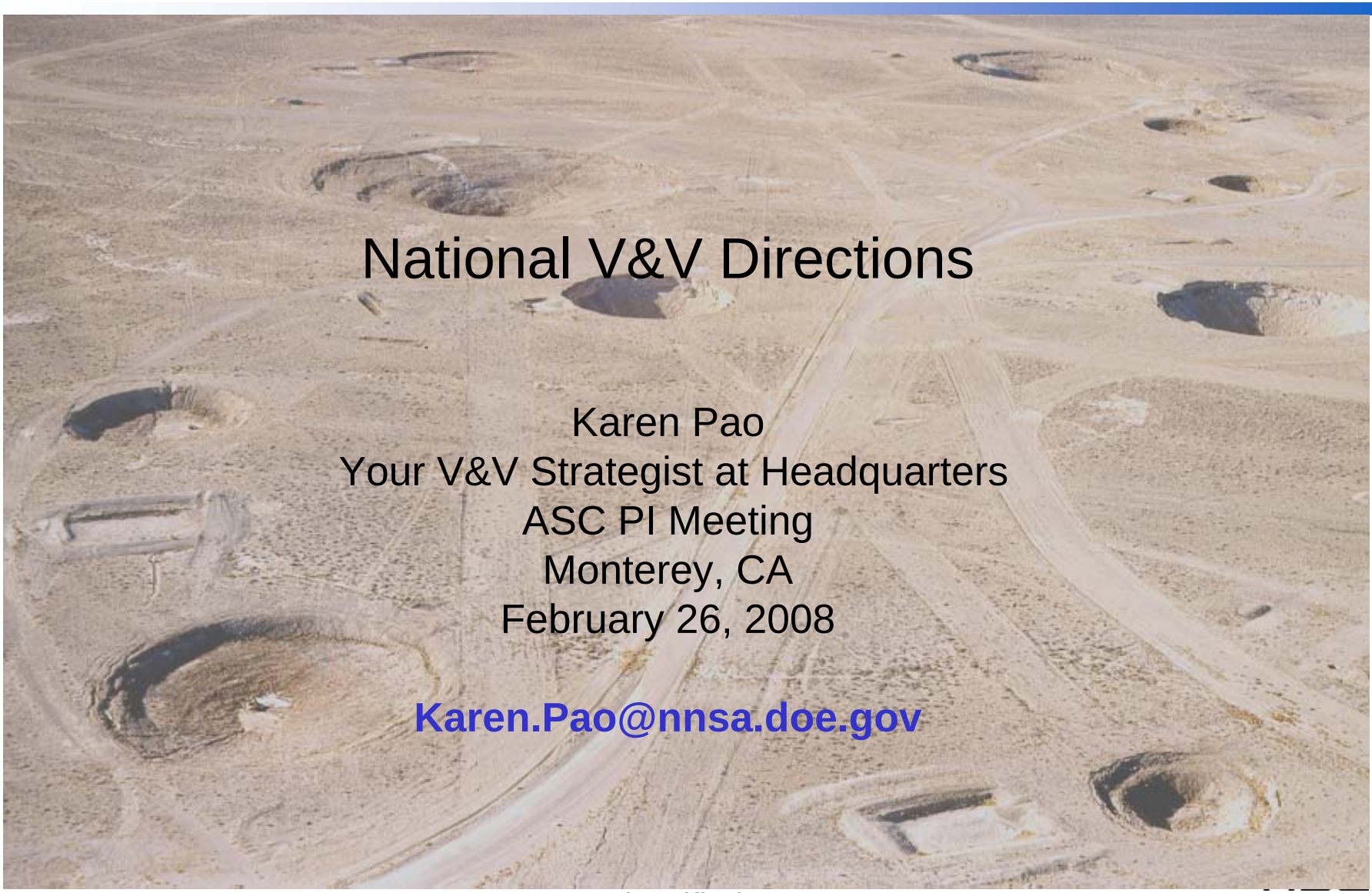

National V&V Directions

Karen Pao
Your V&V Strategist at Headquarters
ASC PI Meeting
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What is Verification and Validation?

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- Verification: solving the equations right
- Validation: solving the right equations
- Uncertainty Quantification is recognized as an integral component of V&V

When the answer matters, V&V matters!

Verification and Validation: Mission Objectives

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Focus Area	Current State	Future State
Credibility	• Annual assessment of current stockpile based on NTS data, hydro test data, and engineering tests	• Assessment and certification -- with confidence -- of stockpile in states different from those tested (LEP, SFI, aged, modified design, etc)
Science-based Predictive Capability	• Sensitivity studies for knob settings • Knobs used to compensate for incomplete knowledge	• Physical processes understood and correctly modeled with uncertainties • Be able to predict observables of future experiments
Broadened national security mission	• Great software and hardware tools for NW simulations	• Great tools for national security simulations, leveraging our NW knowledge and capability

V&V focuses on credible predictive capability for today's and tomorrow's national security mission

V&V Overall Vision

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V&V assures defensible, quantifiable, and discovery-enabling simulations

The Vision in short

- **Defensible:** simulation with a *provenance*
- **Quantifiable:** interpretation of simulation results
- **Discovery-enabling:** looking to what's next

*The scientific community at large is already using simulations for discovery – it's now just a matter of time before someone demands **credibility**!*

The "Steady State" V&V Program

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The long-term V&V program consists of these elements:

- Day-to-day assessment and analysis, plus documentation and quality assurance;
- Research and development of tools to facilitate continuous improvement to our understanding of the complex system under the hood;
- A "test bed" for numerical methods, physics models, and UQ methodologies – comprehensive assessment of new technology for use in production.

V&V should not be about giving the impression that our codes are right…
V&V should be about "asking the hard questions!"

Where are we today?

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Consider some indicators of our current state:

- "Numerical error" remains largely ignored by analysts and designers – thus, for example, we can't really say we can estimate uncertainties due to meshing
- V&V activities are centered around certification/assessment; codes that are not "design codes", such as post-processing, support software, links, etc., have gone under the radar
- We've identified a lot of parameters and done a lot of sensitivity studies; we've learned a lot about knob settings but haven't been able to do without most of these knobs.

Have the last 15 years of simulation been a happy conspiracy of compensating errors?!

Where others think we are today

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- Consider the JASON RRW report:
  - *"…A concern remains, however, that even though codes can reproduce the performance of previously tested weapons, it is not yet possible to quantify how well excursions from a tested design can be modeled and predicted…"*
- This and other concerns led to a new Congressional direction to establish the "Advanced Certification" Campaign to address:
  - *improvement of the weapons certification process through expanded, independent peer review mechanisms and refinement of computational tools and methods;*
  - *advancement of the physical understanding of surety mechanisms;*
  - *further exploration of failure modes;*
  - *manufacturing process assessments; and*
  - *the study of strategic system-level requirements.*

IMHO, *"Advanced Certification" is about realizing the "defensible, quantifiable, and discovery-enabling" vision of verification and validation!*

Strategy to reach steady state

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We will take the next few years to realign the V&V program with our vision. The steps are

1. **Evaluate today's state of simulation**
2. **Address today's deficiencies**
3. **Start quantification**
4. **Re-evaluate at the end of five years**

In addition, we will need to **change our mode of operation**.

Step 1: Evaluate Current State

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- **Process qualification**: figure out -- and document -- the physical models and numerical algorithms currently in our performance and engineering codes
- **Uncertainty Quantification**: "just how bad are we?" What if we are to *turn off key knobs*?
- **Data Evaluation**: what kind of experimental data do we have on hand, and how useful are they?
- …

Step 2: Address Deficiencies

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- Identify major physics and numerical uncertainties; devise plans for quantification
- Quality control in data analyses – documentation of experimental conditions, validation of analysis processes, etc.; determine scientifically sound use of data
- Software quality and assessment of key feeder codes and links
- Software quality improvement of performance and engineering codes
- …

Step 3: Results Quantification

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- **Banish the picture norm!**
- Identify appropriate ways to report uncertainties
- Identify and use appropriate metrics; explore different metrics
- Validate sensitivity studies: when can “sensitivity studies” be considered “uncertainty quantification?”
- Continue R&D for UQ methodologies
- …

Step 4: Reassessment

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- Where have steps 1-3 taken us? Are we ready to:
  - Inform the design of experiments and predict observables, possibly with prediction error bars?
  - Simulate, with confidence, national security problems that are not “tuned” to existing above-ground or underground data?
- If yes, we’ve arrived!
- If not, go back to Step 1.

Changing our mode of operation

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- "Coordination" and "Interdependence": Three Labs work together toward *national solutions*
  - We encourage *scientific independence*, but not *local* solution!
  - Codes will change, and V&V tools need to be "code agnostic"
  - Demonstration of work through negotiated Tri-Lab/Bi-Lab milestones
- Start thinking V&V as the "Jiminy Cricket for NW programs"
  - Customers requirements need to be met, but we have an opportunity to meet these requirements in a broader context!
  - V&V activities for customers should have an emphasis on *V&V methodology development and application* (for example, a demonstration of how multiple metrics may work to help understand an uncertainty, instead of baseline model matches to PINEX data in the eyeball norm) .

A modest proposal: new V&V work breakdown structure (wbs)

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Current

- V&V Methods
- Primary V&V
- Secondary V&V
- Engineering V&V
- Specialized V&V
- Data Validation and Archiving

Proposed

- Verification applications
- Validation, UQ, and Metrics applications
- Support Codes V&V
- Experimental Data Quality Assurance
- SQE/SQA
- Foundational Research & Application

Karen's (V&V-Centric) View of the ASC Program

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Not to Scale