

# IMPROVED OPERATIONS CAPABILITIES TO REDUCE THE RISK OF COMMAND-RELATED ERROR

---

D. Bindschadler, E. Fosse, V. Scarffe,  
K. Schimmels, C. Delp, M. McCullar

Multimission Ground Systems & Services  
JPL, California Inst. Of Technology



# Outline

- Context
- Sources of Command-related errors
- Addressing command errors
- Case Study: Mars Exploration Rover Ops
- Summary & Conclusions

# Context

- Decade-long study of Command File Errors
  - Faris and others
  - Standard institutional definition and tracking
  - Utilized to help reduce error rates
- Root-cause analysis
  - Meshkat and others
  - Bayesian Belief Network & Probabilistic Risk Assessment modeling
  - Drew conclusions about root causes

# Sources of Command File Errors<sup>1</sup>

- Important causes include
  - Flaws in process design or requirements
  - Lack of compliance with process/procedure
  - Lack of understanding of system states or overall operations context
  - Inadequate communication
  - Haste, overly stressed workforce

<sup>1</sup>L. Meshkat, “A Systems Modeling Approach for risk management of command file errors.”, Space Operations Workshop at JPL, April 2012

# Solution Space

- More resources (\$, people)
  - Should enable better design, better implementations, improved human-factor issues
  - Not realistic in current budget environment
- “Work Smarter”
  - To extent possible within constrained budgets...
- Improve tools/methods for developing and maintaining an MOS
  - Addresses many error sources
  - Can be applied to both operating missions and those in development

# Ops Revitalization Initiative

- Multi-year effort to re-architect the AMMOS
  - NASA's Advanced Multi-Mission Operations System
- Focused on improving the quality of MOS systems
  - Across lifecycle
  - Engineering for quality
  - Rigorous methods & tools (MBSE)
- Described in several published papers, available on request

# MER Case Study Capability Goals

- Use single process model for:
  - Training
  - Operations
    - Nominal activity
    - Anomalous activity
    - Logging while on console
- Flexible enough to respond to quickly needed changes
- All artifacts come from the same authoritative source
  - Operations checklists
  - Training material
  - Artifacts are configurable to Mission-Specific needs

# MER Case Study: TAP/SIE Procedure Checklist (current)

## MER-UPPERMER Sol FIRSTSOL Single-Sol Plan

### Quick-Reference TAP/SIE Procedure and Checklist

#### Window Setup

*for TAP/SIEs who like to open all windows for the day in advance, the steps are collected here -- but also appear in logical order below as well*

#### log into sunos

```
linux:xterm
ssh merLOWERMERSiel
```

#### configure linux windows

```
linux:xterm
xterm &
source /gds/mer/teamtools/ist/bin/sie_setup LOWERMER 1 FIRSTSOL
```

#### configure sunos windows

```
sunos:xterm

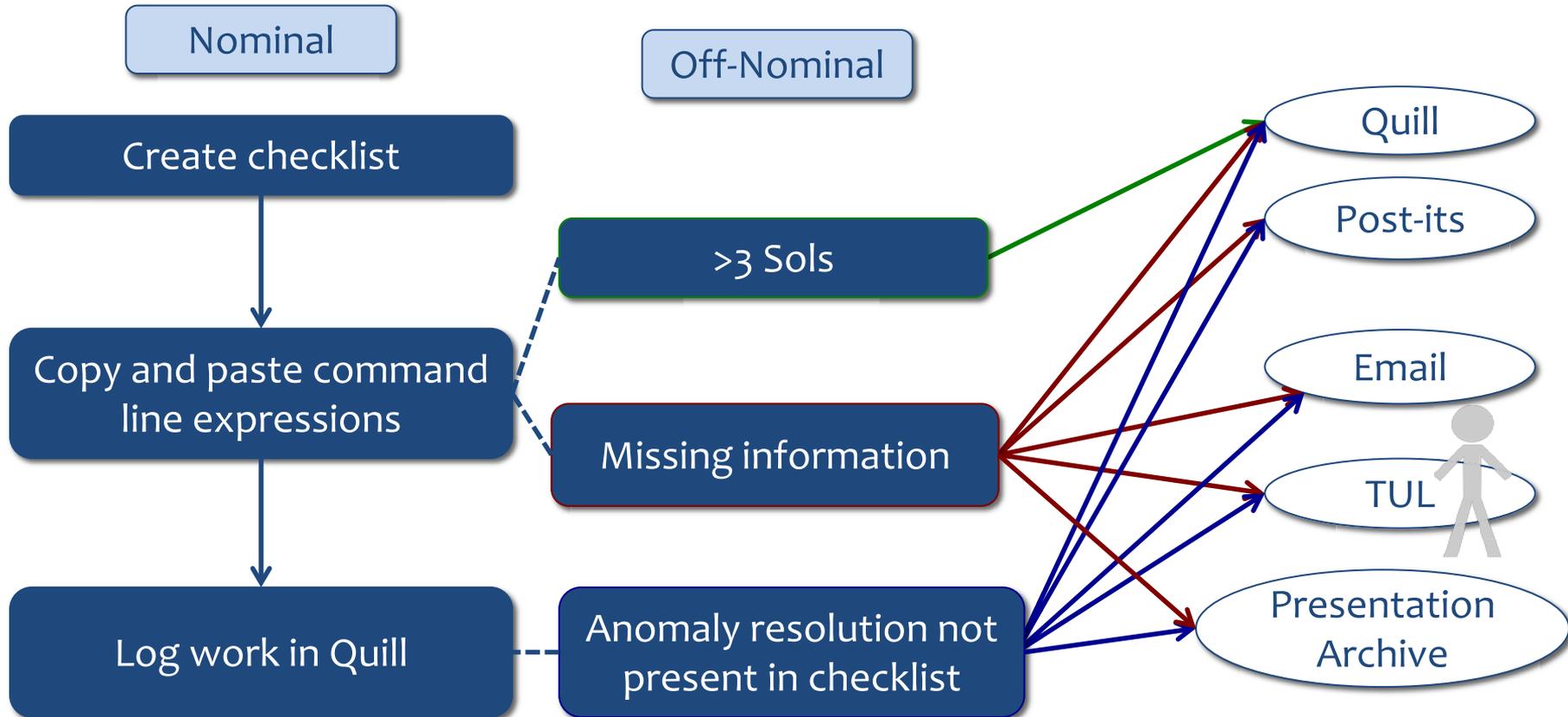
TAP

/gds/mer/teamtools/ist/bin/tap_workspace LOWERMER FIRSTSOL 1
```

- HTML Template for 1,2, or 3 Sol Sequences
- Script populates template for tactical planning
- Operators copy and paste code into appropriate console windows
- Operators fill in sequence-specific parameters prior to running SeqGen

# Current MER Process Workflow

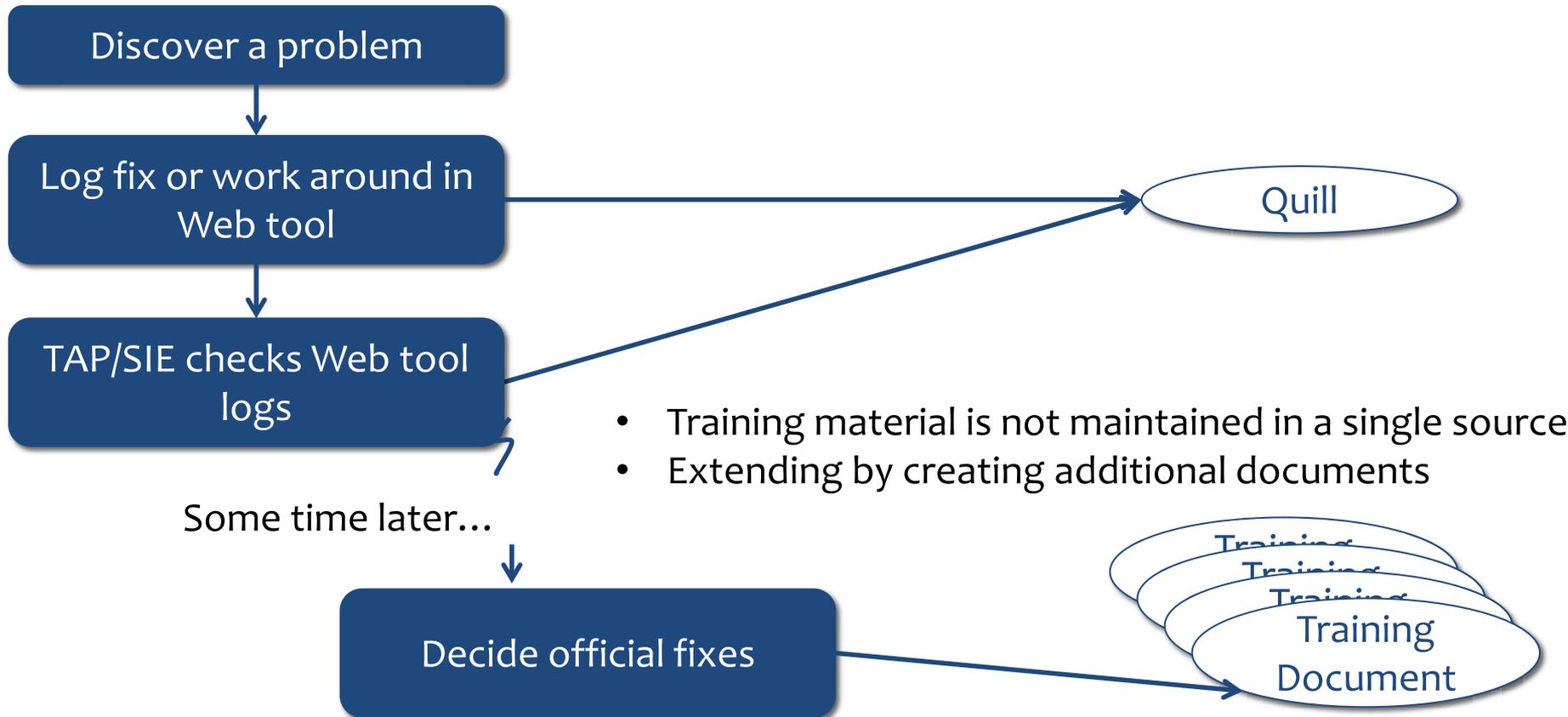
## Objective: Deliver Sequence



- Have to query multiple sources for information
- Little knowledge of information timeliness

# Current MER Process Update Workflow

## Objective: Update Checklist



# Current MER Checklist Challenges

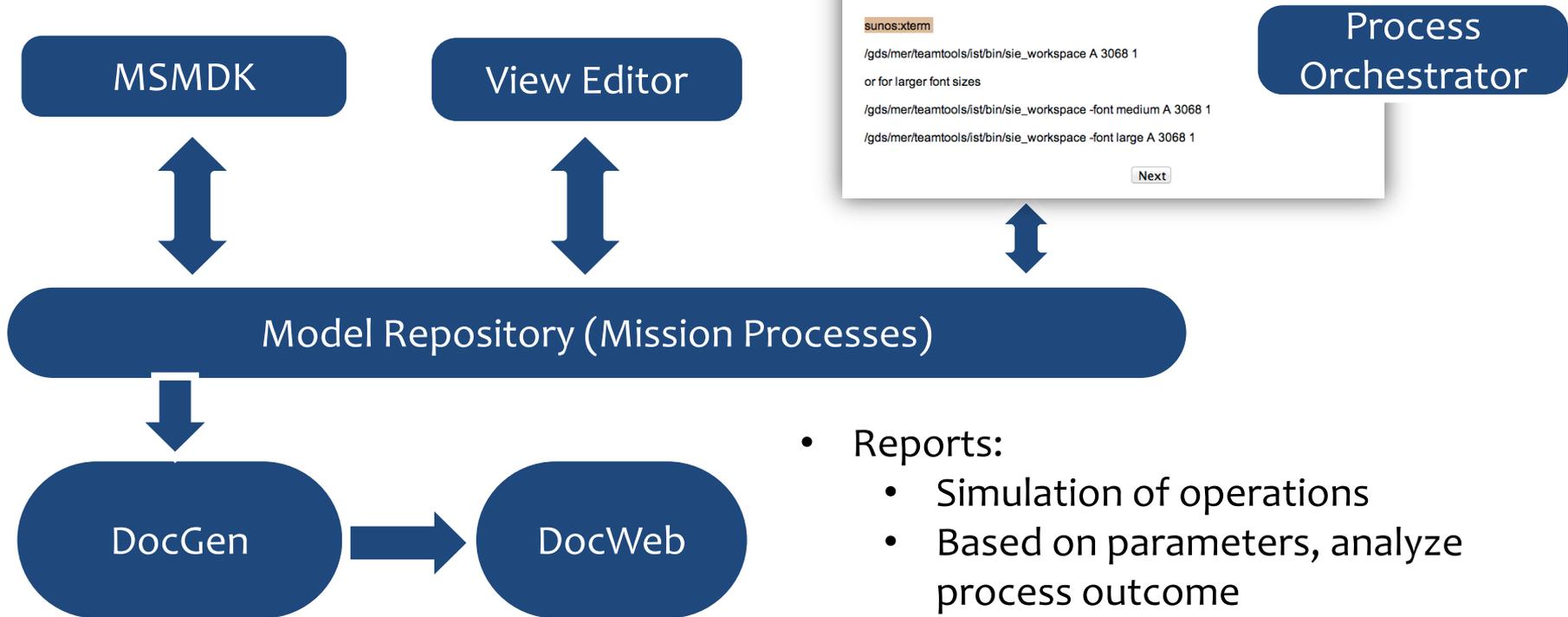
- Little to no troubleshooting capability within the process
  - No path for contingencies (even known ones)
- Changes made to the process have to be incorporated into each HTML template by hand(6+ templates).
- Templates for off-nominal situations are built by hand
  - No template support for planning >3 Sols (17 Sol conjunction in March).
- Training focused on how to do the nominal process and how to use the tools .
  - Not ops context for better understanding
  - No contingencies covered

# Case Study Objectives for MER

- Consistency
  - Authoritative source for process definition
    - No hunting for what to change where
- Productivity and efficiency
  - Flexibility to make different documents from the same model
  - Reduced overhead
    - Make updates once and have that propagate
- Training and anomaly training
  - “Why do I do it?” vs “How do I do it?”
  - A place to report and Share “lessons Learned”
    - Push notes through to the procedure
  - Efficient update of training materials
    - Authoritative source

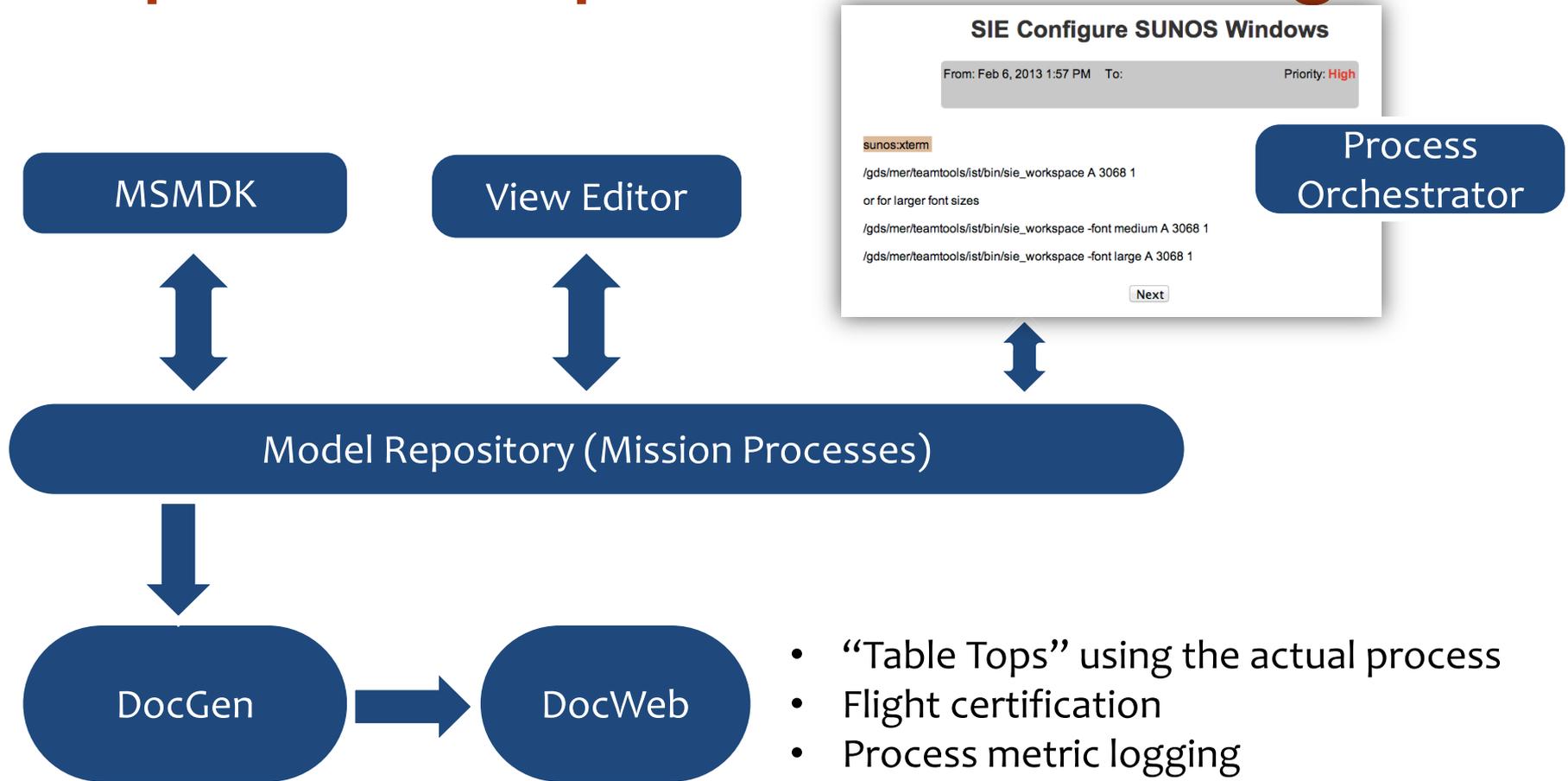
# OpsRev Capabilities: Operations

MSMDK=Mission Services Model Dev. Kit



- Reports:
  - Simulation of operations
  - Based on parameters, analyze process outcome
- Process Orchestration:
  - Process metric logging
  - Anomaly handling

# OpsRev Capabilities: Training



- “Table Tops” using the actual process
- Flight certification
- Process metric logging
- Synchronous training and processing materials

# Summary

- Demonstrate ability to create current operations process artifacts
  - Use of formal methods to develop more mature, higher quality processes
  - Facilitate representing off-nominal cases
  - Process are easier to update, improve, reuse
- Additional advantages
  - All document artifacts generated from a single, authoritative source of information
  - Closed loop logging
  - Synchronous updates of training and operational materials.
  - Real Time Process Orchestration

# Conclusions

- Improved methods and tools can reduce command-related errors in these areas:
  - Flaws in process design or requirements
    - Processes are more rigorous, more easily updated
  - Lack of compliance with process/procedure
    - Training material always kept in sync with process updates
  - Lack of understanding of system states or overall operations context
    - Ability to show procedures in tandem with broader process context
  - Inadequate communication
  - Haste, overly stressed workforce