



# QUALITY

LEADERSHIP FORUM

— VIRTUAL SERIES —

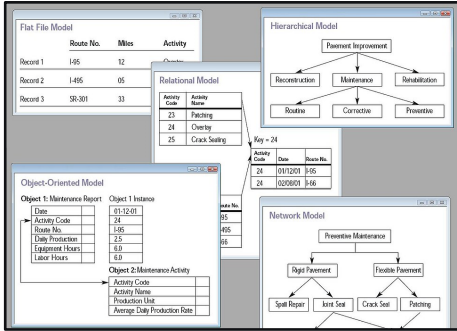
## A Digital Engineering Toolchain Concept for Quality

*Thursday, April 16, 2026 | 1:00 – 2:00 p.m. Eastern*

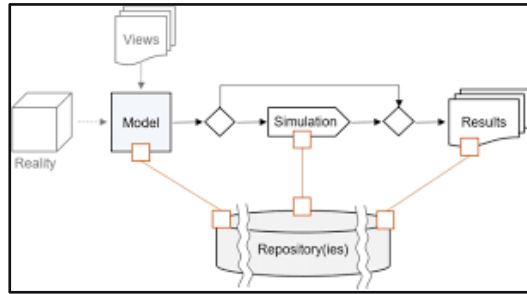
*Presenter*

*Ronnie Knight* – Quality Engineer Subject Matter Expert, Bastion Technologies,  
Marshall Space Flight Center

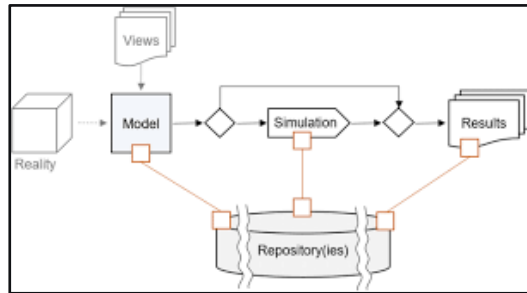
# Toolchain Concept



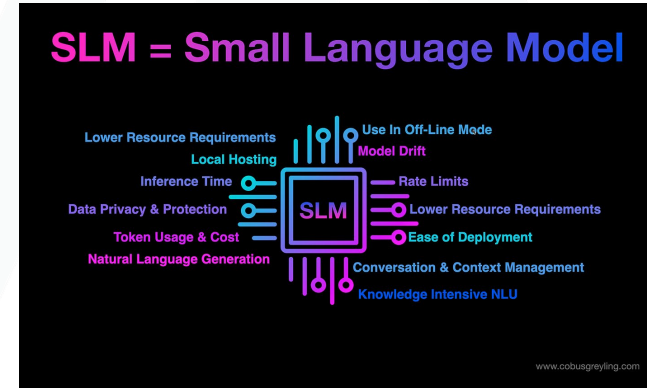
**DATABASE**



**BOK System MODEL  
(descriptive)**



**OPERATIONS SIMULATION  
System MODEL (executable)**



**SLM  
Small LM  
or  
Specialized LM**

# Database/Model/SLM Model Toolchain

# Concept & Implementation

- Foundational:** “rooted” in the science of systems  
[Mobus in MBSE BOK Handbook]  
[MSFC QD-QE-001: QEs are Systems Engineer focus on control.]
- Actionable:** based on tools currently (or soon to be) used by Center  
[“soon to be” includes Dassault’s instantiation of SysML2]
- Relatable:** based on an “evolvable” system we all know intimately

**Purpose: To Evolve A Forward AE Path**

# 4 x 4: Definitions Aid Clarity

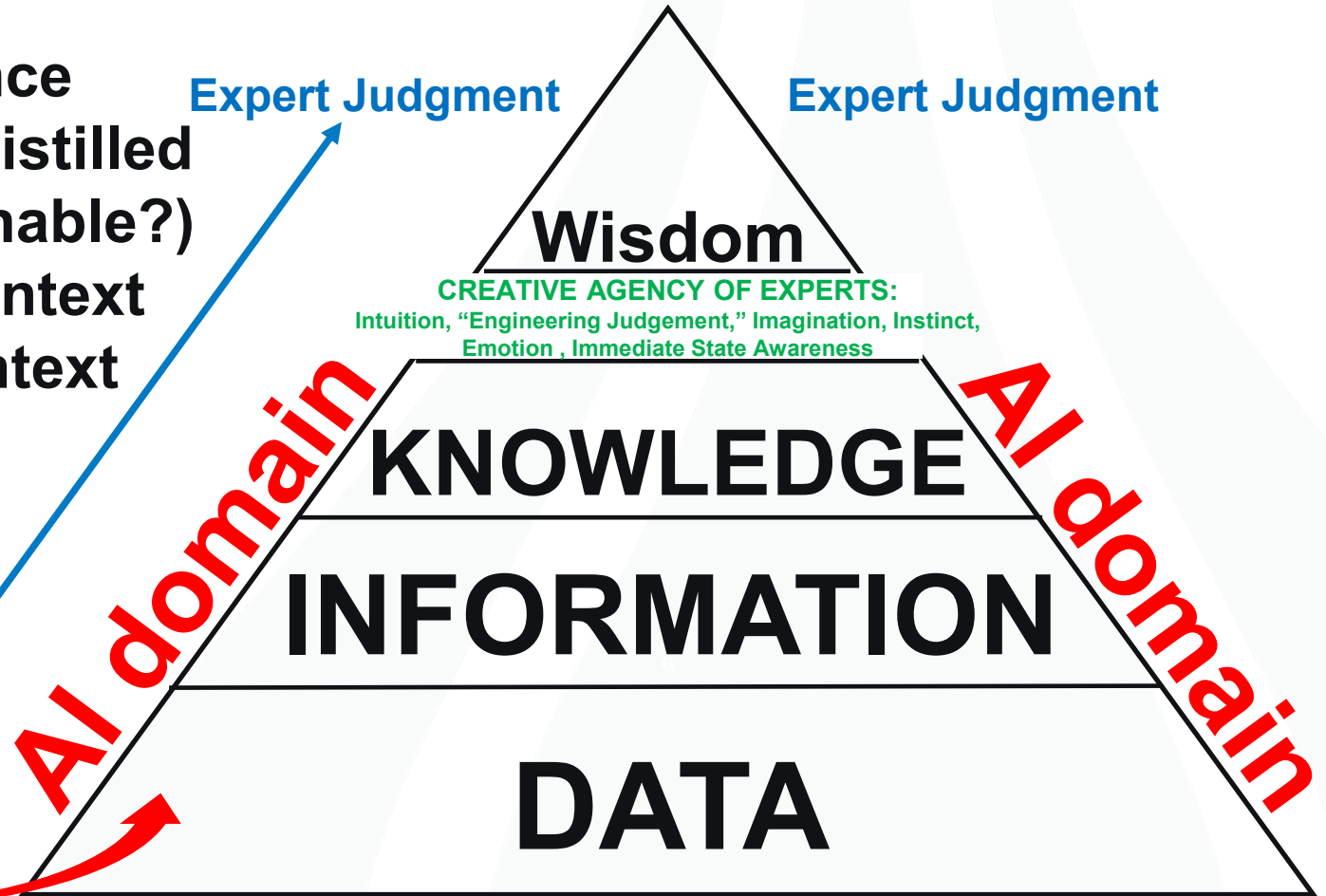
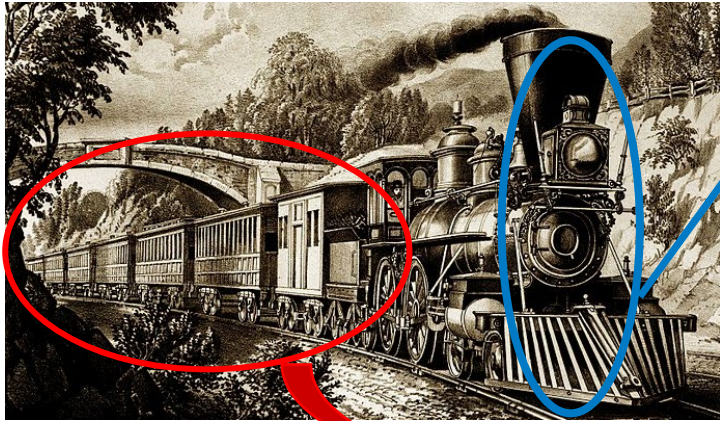
- **INCOSE** Definitions
- **Data = facts with no context**
- **Information = data in context**
- **Knowledge = patterns distilled from information**
- **Wisdom = knowledge combined with experience**



**Purpose: Precision and “Funnel”**

# DATA, data: Agency and Pirsig's ZAMM Train

- Wisdom = knowledge combined with experience
- Knowledge = patterns distilled from information (actionable?)
- Information = data in context
- Data = facts with no context



# 4 x 4: System Types

- **FOUR SYSTEM TYPES:**

- **Simple Systems (SS)**

Can easily see how entire system operates

- **Complex Systems (CS)**

Cannot easily see entire system operations – many disciplines required to engineer

- **Complex Adaptable Systems (CAS)**

System adapts to changing environment within a range

- **Complex Adaptable and Evolvable Systems (CAES)**

System evolves itself to expand or shift range of adaptability



**Purpose: Aware of Types, esp. CAES**

# Engineering Background: History

- Systems science result of complexity (CAD/CAM geometric models in the 80's, electrical models in the 80's, SW logic models in the 90's)
- “Problem” of complexity is the problem of integrating all knowledge accumulated in silos (Mobus’s theory: an artifact of engineering “reflecting” scientific reductionism)
- Need organizational path integrating what we know (silos are a challenge)
- Mobus on Scientific Analysis (reductionism); Crisis/Possibilities of Human Knowledge
- If all disciplines base work in systems thinking, some challenges naturally overcome...

## Purpose: Systematic vs Siloed

# Agency Background: Goals

- FAIR (findable, accessible, interoperable, reuseable)
- Increase Decision Velocity
- Downward assignment of decision authority – part of push for Decision Velocity
- Vision 2040 – long-term thinking/planning/goal-setting – new Admin wants urgency
- Technical Debt (not a goal, but a “fact”)

## Purpose: Alignment with Agency

# Calculability, Agency, the Emergent

- Safety + Reliability/Maintainability Are Different From Quality (Deterministic vs Probabilistic)
- Mobus on agency/autonomy (truly autonomous agency makes Quality most probabilistic)
- Emergence: All SMA disciplines work in areas that are considered emergent properties of systems
- Mobus thinks the word “emergent” is placeholder for things that are currently incalculable
- With “Deep Analysis” should be able to design for Emergent Properties
- System equation 4.1:  $S_{i,t} = C, N, G, B, T, H, \Delta t_{i,t}$

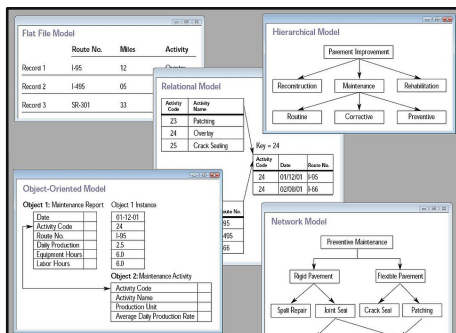
## Purpose: Challenge Ahead for SMA

# Complexity, Ontology, Systemness

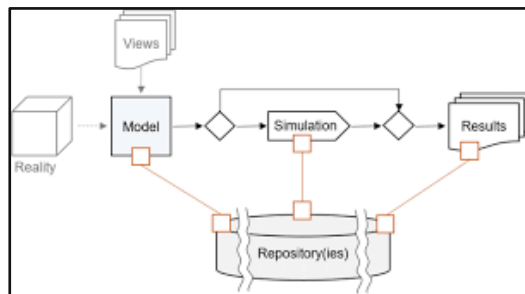
- 40+ definitions per M Mitchell *Complexity: A Guided Tour* (comparable to “digital twin)
- Ontology defined as “what is” (every discipline has an ontology – set of domain things)
- Mobus’s ontology starts with energy/mass and information/knowledge
- Systemness defined as “patterning algorithmic” understanding of everything
- Human mind organized with “systemese” (Mobus’s term)

## SMA: Emergent System Properties

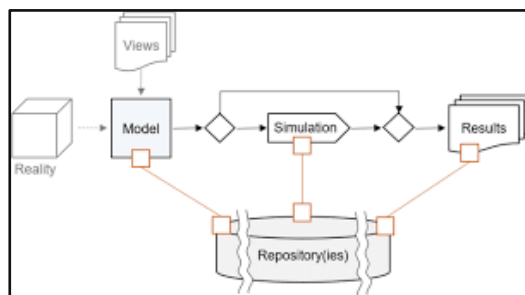
# Toolchain Concept



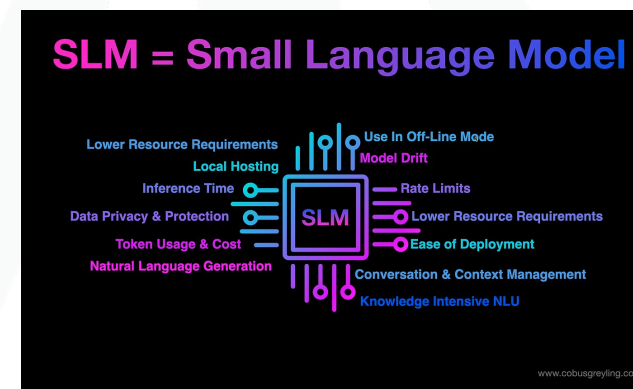
**DATABASE**



**BOK System MODEL  
(descriptive)**



**OPERATIONS System  
SIMULATION MODEL (executable)**

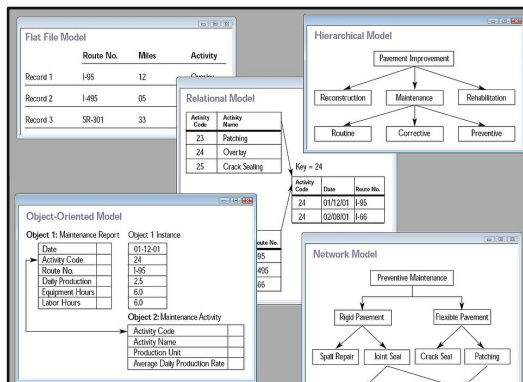


**SLM  
Small LM  
or  
Specialized LM**

# Database/Model/SLM Model Toolchain

# Toolchain Components: Database

- Imprecise, colloquial use of term “data”
- The earliest form of “preliminary knowledge” capture; mostly in Excel at MSFC (everywhere)
- “Data-driven” conceit; “In God we trust. All others bring data” conceit.
- DB categories overused and misused; always a “free-form” field for text entry; 80% unstructured

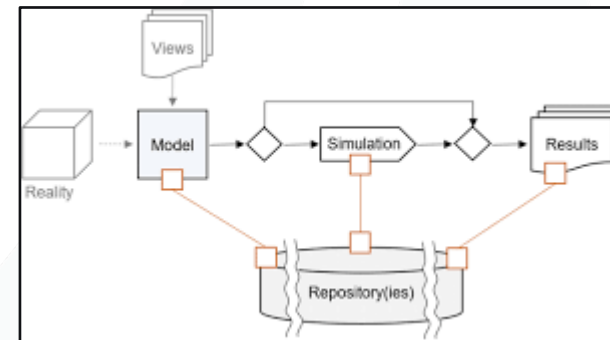


**DATABASE**

## Database = Permanent Record

# Toolchain Components: BOK Model

- Modeling BOK brings advantages of manipulability, flexibility, history of knowledge of “states”
- Definition cross-checks and cross-reference
- Repository for axioms and axiom rationale
- Rapid querying and learning (training purposes)
- Use to train SLMs and new employees
- Simulate training scenarios
- Generate documents out of system models



**BOK System MODEL**  
(descriptive)

**BOK Model = What We Know**

# Toolchain Components: Ops Model

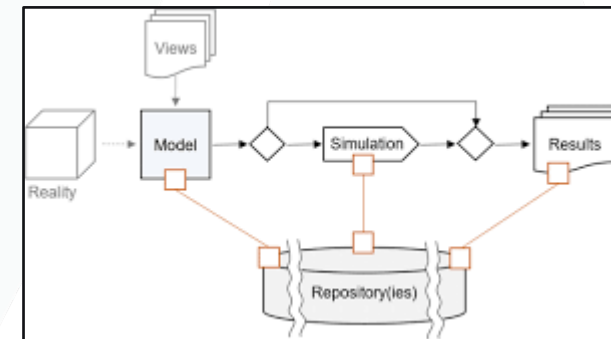
-Models extend human capabilities of imagination like tactile tools extend manual capabilities, such wrenches extending gripping power of opposing thumbs and microscopes extending the range capability of the human eye.

-Much of the operations knowledge of Centers is captured in OIs

-Model could “flag” out of “review date” elements; might not be needed (if models were worked in and continually updated)

-Some operations might benefit from simulation

-Monte Carlo analyses of hardware

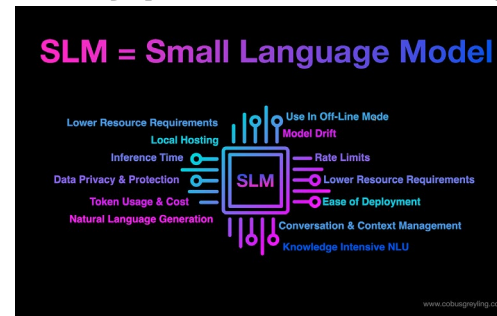


OPERATIONS SIMULATION System MODEL (executable)

# Ops Simulation Model = Imagination

# Toolchain Components: SLM

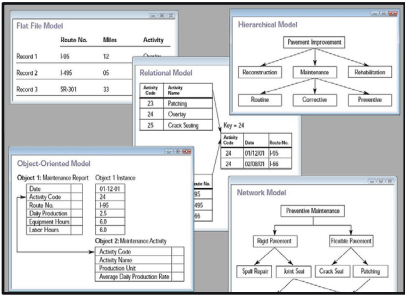
- SLM = Specialized Language Model
- Inference Engine = AI mechanism for “deep learning,” as opposed to “shallow learning”
- SLM inference engine utility: extracting the 80% of knowledge that is unstructured
- SLM inference engine could help manage the categories of DBs via use analysis
- SLM inference engine could identify patterns that might otherwise go undetected



SLM (small or specialized LMs)

# SLM Model = Reasoning

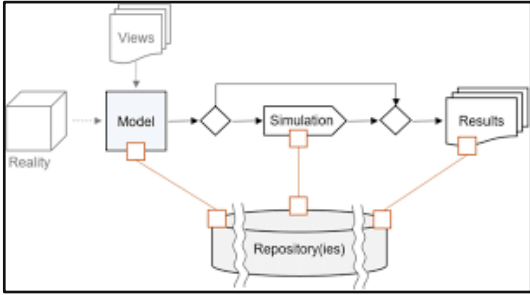
# Toolchain: Models and Minds



**DATABASE**

**MEMORY**

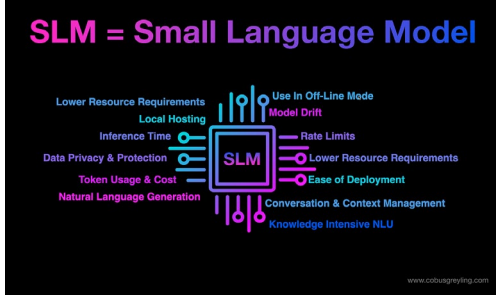
manipulable fact warehouse



**BOK MODEL (descriptive)**

**KNOWLEDGE**

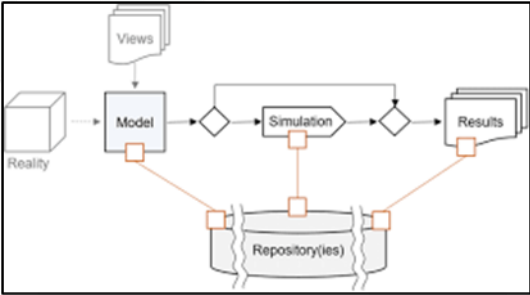
able, archival



**SLM (small or specialized LM)**

**REASONING**

inference, patterns



**SIMULATION MODEL (executable)**

**IMAGINATION**

future state solution assessment

**FULLY AUTONOMOUS AGENCY:** Creation, Intuition (Engineering Judgement), Instinct, Emotion, Immediate State Awareness



Engineering Mind

**CAUTION:** Experience is key to using Intuition (Engineering Judgement), be wary of **biases\***, Creativity, Emotion\*, Immediate State Awareness

\*see Kahneman, *Thinking Fast and Slow*

# TC Concept: Tools & Mind As CAES

# Toolchain: Where To Start

- Start with the neural networks in your head (exercise emotion, become curious, learn, PDCA)
- Axioms: “constitutive assumptions” (explanation of colloquial vs mathematical); axioms enable rapid knowledge absorption
- Use the toolchain concept to model Quality systems
- Start SMA Innovation Working Group (database experts, modelers, discipline SMEs for Agile pilots)
- Definition subscripts: example of QE definition of “complex”
- SMA opt for V.2 of Cameo Systems Modeler (funding secured per MBSE working group Dec.)

**MORE TO COME ON THIS ONE**

# Bibliography

**Mobus GE, *Systems Science: Theory, Analysis, Modeling, and Design* (2022)**

**Friedenthal S, Moore A, Steiner R, *A Practical Guide to SysML: The Systems Modeling Language* (2015)**

**Russell S, Norvig P, *Artificial Intelligence: A Modern Approach* (2021)**

**T.S. Kuhn, *The Structure of Scientific Revolutions* (1962)**

**Burkov, A, *The Hundred-Page Machine Learning Book* (2019)**

**Goodfellow I, Bengio Y, Courville A, *Deep Learning* (2016)**

**Ferriera F, Kahle R, Sommaruga G, *Axiomatic Thinking I* (2022)**

**Mitchell, M, *Complexity: A Guided Tour* (2009)**

**Daniel Kahneman, *Thinking Fast and Slow* (2011)**



# THANK YOU!

## Upcoming Webinars

- QLF Virtual Series: Risk-based Assessment and In-line Assessment Methodologies – June 18, 2026

Please visit <https://sma.nasa.gov/sma-disciplines/quality/qlf/virtual-series> for upcoming virtual events