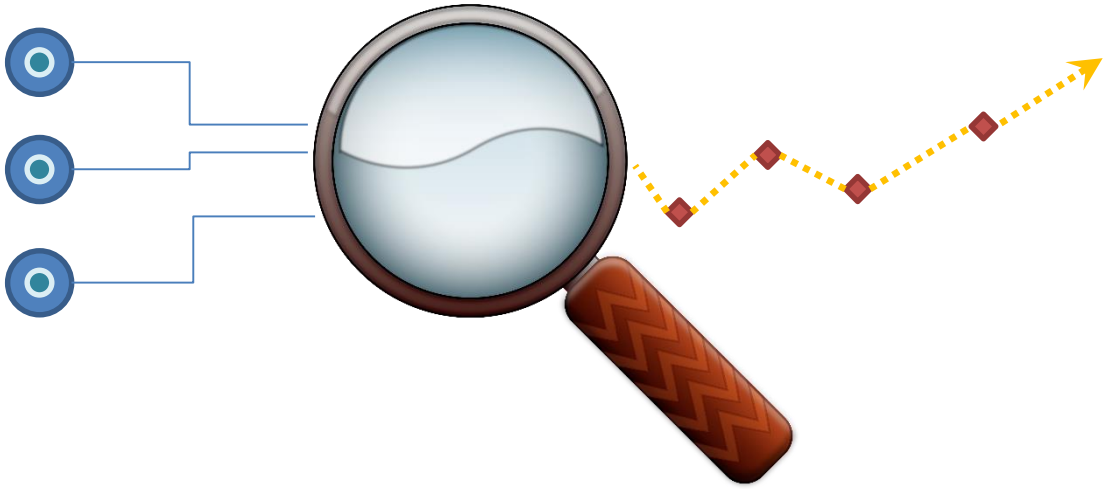
Harnessing Reliability Information for Better Decision Making



Connecting what you know
to what you want to know

Disclaimer:

Commercial equipment and materials might be identified to adequately specify certain procedures. In no case does such identification imply recommendation or endorsement by the U.S. National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

Harnessing Reliability Information for Better Decision Making

- Modern manufacturers are awash with information, some without any real sense of how to utilize these assets

- Many face a constant struggle to try to collect and contextualize a myriad of information sources
  - Product Quality Inspects
  - Process Throughput Efficiency
  - Maintenance Workorders
  - Live Equipment Sensors
  - Product Design Specifications
  - Supply Chain Availability
  - Etc.

- How can one sort through the huge amount of data to best answer maintenance, operations, and logistics questions?

Harnessing Reliability Information for Better Decision Making

- **Utilization of Networked Reliability Information**
  - **Using models for:**
    - Diagnostic Monitoring
    - Prognostics / Predictive Analytics
    - Capability / Capacity Monitoring
    - Etc.
  - **Can be used to capture various types of reliability:**
    - Process Reliability
      - Product Quality
      - Process Efficiency
    - Equipment Reliability
      - Degradation
      - Capability / Capacity
    - Personnel / Operator Reliability
      - Education / Training
      - Decision Making

Harnessing Reliability Information for Better Decision Making

- NIST is investigating the creation of guides to help SMEs and 3rd party providers develop rapidly deployable custom solutions for reliability information monitoring and utilization

- Part of this plans to be a series of documents and 'best practices' guides that will help SMEs sort through the confusion of :
  - *How do I know if I am collecting enough information, or the right kinds of information?*
  - *Even if all the correct information is available, how do I determine if it is being used correctly?*
  - *Is it worth the extra effort to make a predictive model more accurate?*
  - *What do I do if part of my system changes?*
  - *What is my expected ROI for a particular reliability monitoring program?*

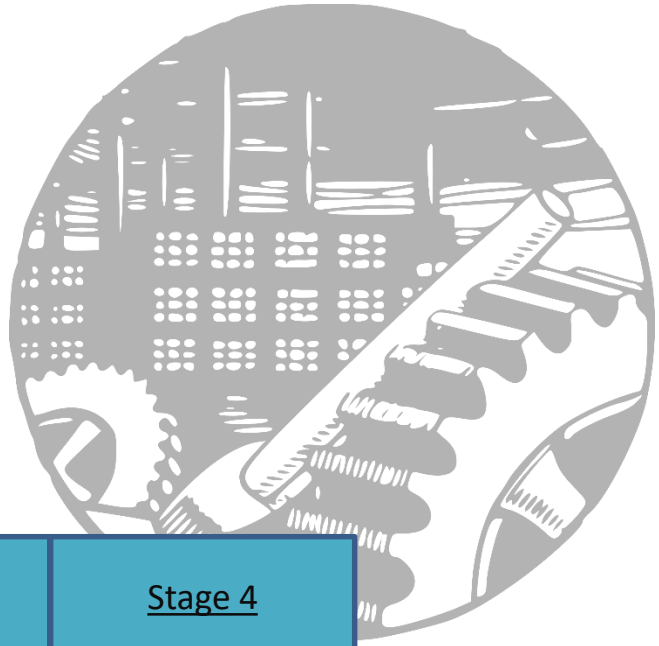
Harnessing Reliability Information for Better Decision Making

Areas of Focus:

- Information Networking
  - *Modular hierarchical modeling*
  - *Data provenance*
- Dissimilar Information Synthesis
  - *Continuous / Discrete*
  - *Nonsynchronous sampling*
- Closing the Loop With AI
  - *Knowledge extraction*
  - *Facilitating knowledge transfers*
- PHM Model Verification & Validation
  - *Standardization of benchmarks*
  - *Build trust between users and models*

Creating an Information Utilization Network

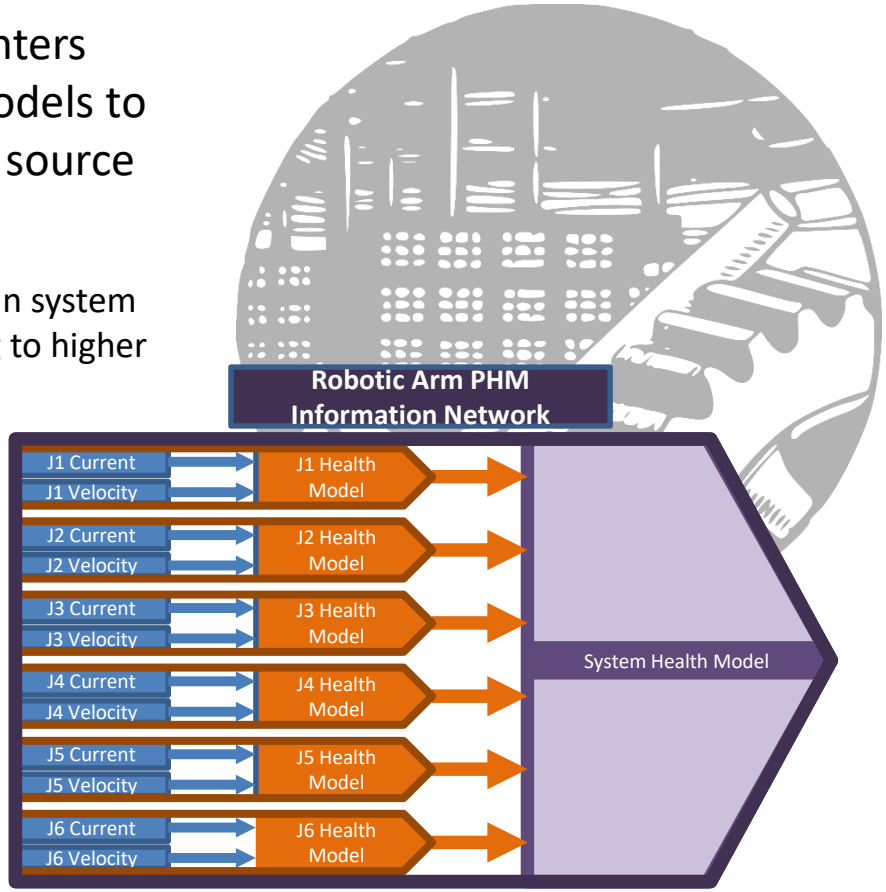
- **Goal:** Create processes for rapidly identifying and utilizing potential PHM information assets
  - Make 'best practice' guides for construction of viable reliability programs
- Provide realistic recommendations for 'first steps' reliability improvements
  - Integrating existing knowledge sources
  - Identification of critical systems / problem areas
  - Etc.



Stage 1	Stage 2	Stage 3	Stage 4
Information Asset Discovery	Information Capture	Information Contextualization	Knowledge Utilization
• **A**ssess **S**ources of **K**nowledge	• **S**tructure • **E**nhance • **E**xtract	• **M**odel • **A**lert • **P**redict	• **D**irect Operations • **O**ptimize

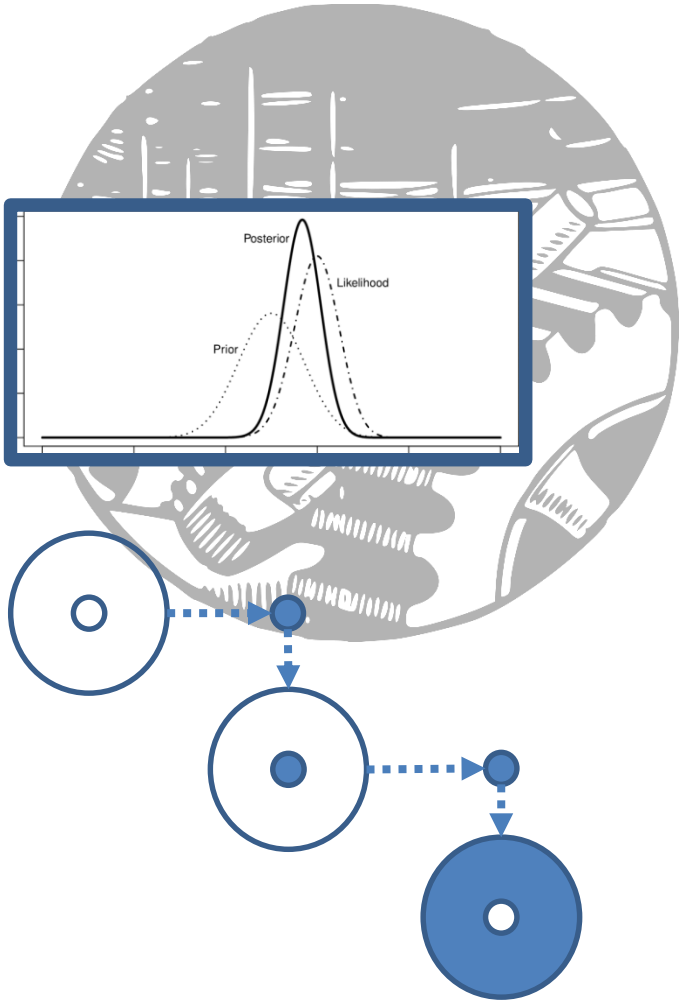
Creating an Information Utilization Network

- One aspect of 'Networked Information' centers around sensibly linking information and models to provide better information than any single source
  - Increased Diagnostic Capability
  - Right Amount / "Filtered" Information
  - Mirrors physical and relational connections within system
  - Smaller/modular interconnected models feeding to higher level information synthesis model
  - Facilitate adjustment to facility modifications
  - Shorten V&V process after retraining



Merging Dissimilar Information

- **Goal:** Identify viable procedures for incorporating information from sources that are not traditionally compatible
  - Continuous / Discrete
    - Maintenance Work Order Events
    - Live Sensor Data
  - Nonsynchronous sampling
    - High/Low Frequency Data
    - Batch / Continuous Updating
  - Multi-medium / incompatible file formats
    - 3D Digital Product Model (STL)
    - Planned Cut Path (G Code)
    - Machine Position Data (MTConnect)
    - Product Quality (QIF)
  - Inconsistent information between machines
    - Different Sensor Sets
    - Non-standardized data recording



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Closing the Loop with AI

- **Goal:** Use AI as a tool to help streamline workflows:
  - Knowledge extraction
    - Help to discover nonintuitive relationships
    - Data driven monitoring
    - Unstructured data
  - Facilitating specialized (tribal) knowledge transfers
    - Train Models to Train Workers to Train Models
    - Maximize efficiency of 'human in the loop' procedures

- **Main Goal:** Make models the worker will use
  - Demystify Algorithms
    - Pair AI with more intuitive algorithms
  - Build trust in AI as a tool
    - Educate on use
    - Manage realistic expectations from AI
- "Bob and the Box"
  - More closely pair workers with AI model development
  - Show how AI will help workers / not replace them

Developing Standardized Verification and Validation in PHM

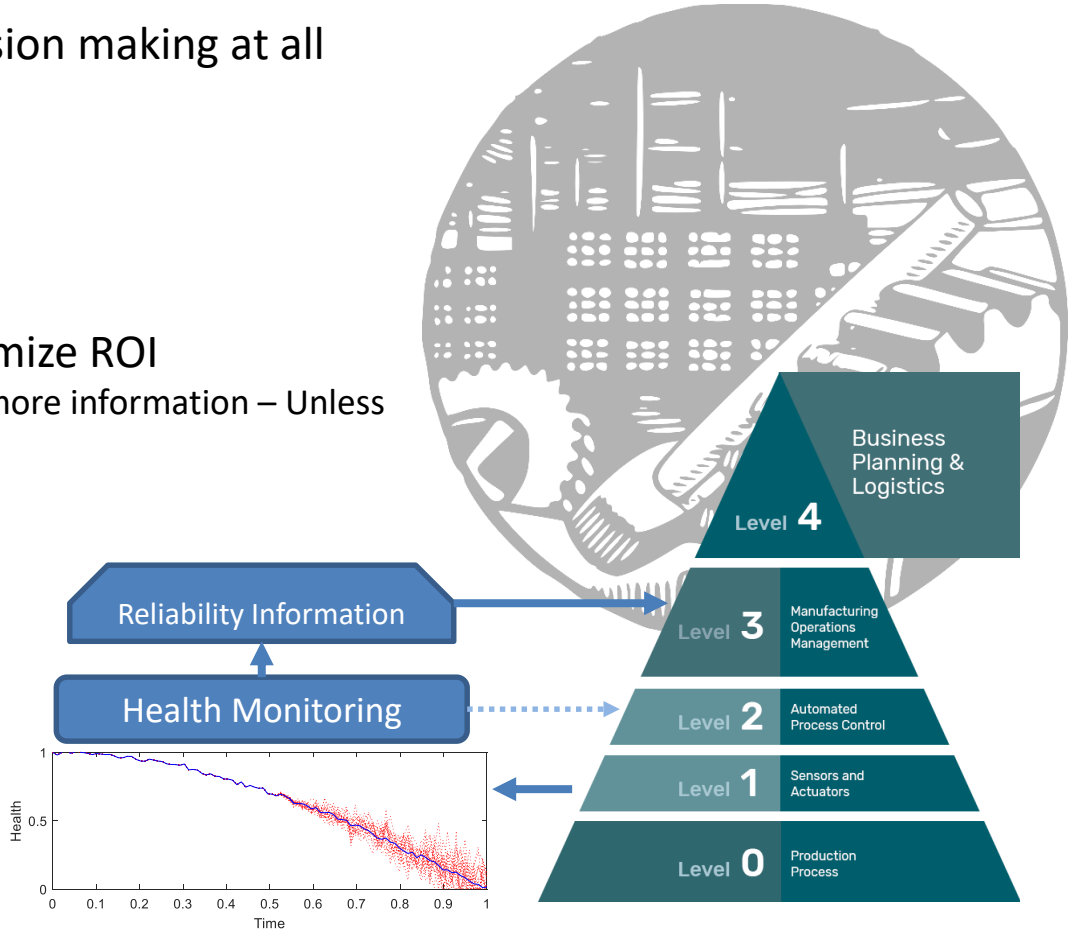
- **Goal:** Provide intuitive evaluation of reliability programs 'at a glance'

- Standard PHM Model KPIs
  - Some exist but are not seeing wide spread use
  - Needs:
    - Compare novel algorithms / models / programs:
      - *Objectively*
      - *Quantitatively*
      - *Intuitively*
    - Help justify continued investment in existing programs
    - Help provide ROI on new or additional reliability programs
    - Appropriate to various types of model output

- Standardization of benchmarks
  - Build trust between users and models
  - Curated data sets useful for development of new technologies

Keeping The Goal In Mind – Don't Work in a Void

- PHM should work to inform decision making at all levels
  - Proactive Control
  - Directed Maintenance Activities
  - Logistics and Operations Planning
- Manage the information to maximize ROI
  - Don't work 90% harder to get 10% more information – Unless that 10% *Really* matters
- Focus on the User
  - Give users what they need
  - When they need it
  - How they need it
  - *The best information in the world is worthless if the recipient*
    - *Doesn't see it*
    - *Doesn't trust it*
    - *Doesn't understand it*




The End