On-Line Monitoring System Diagnostics

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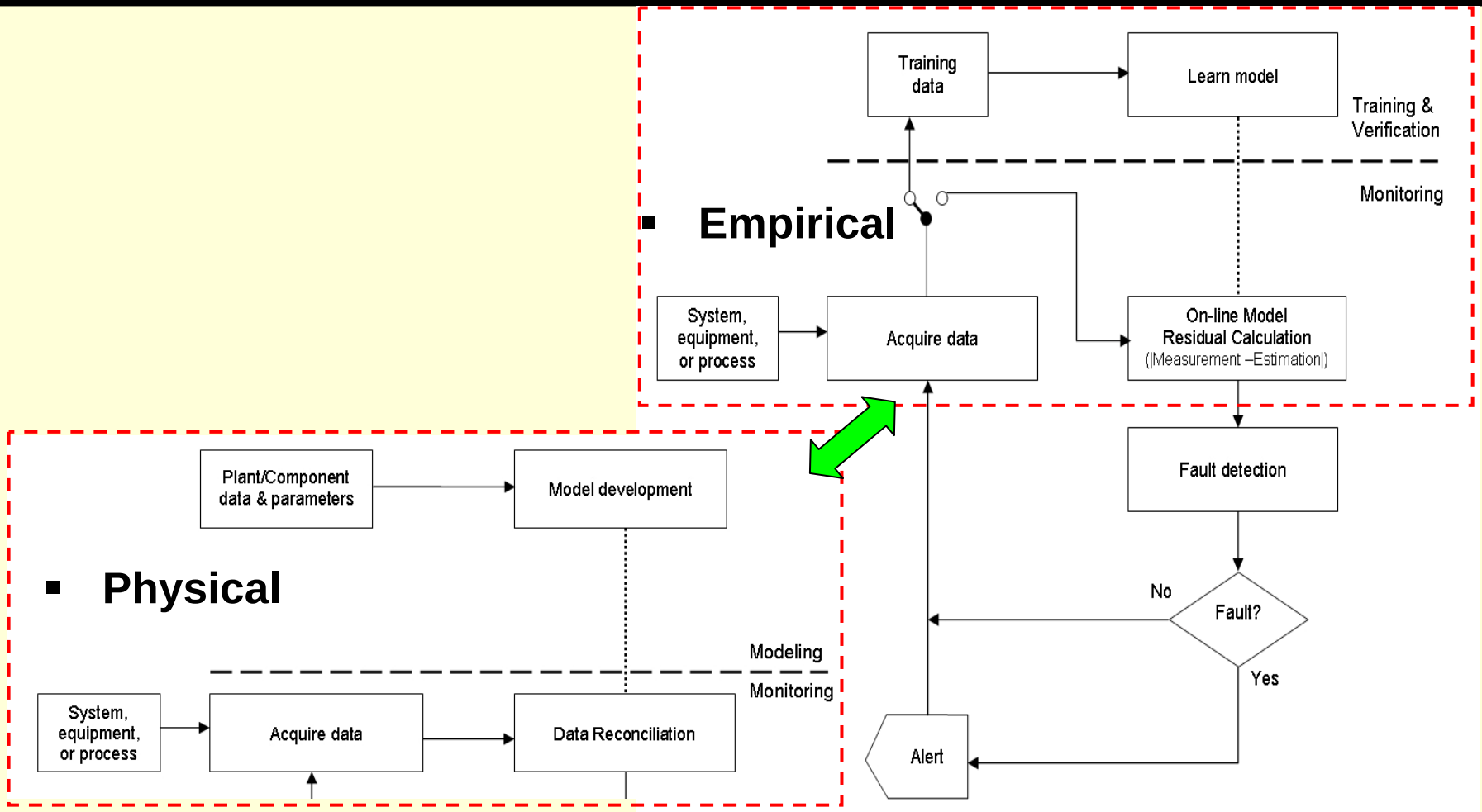
On-Line Monitoring Systems

- **On-line monitoring is an automated method of monitoring instrument performance and equipment condition while the plant is operating.**
- **Monitoring assessments can be performed in real-time and are based on process models receiving input from the plant computer (database, historian), without user intervention.**
- **The instrument channels are not disturbed by the monitoring process.**
- **Process models can be empirically derived or based on physical laws and equations.**

On-Line Monitoring Systems

- **On-Line monitoring can be applied to instrument channels, equipment, or systems.**
- **Furthermore, it can be used to calculate estimates of measured process variables or to calculate plant performance indications.**
- **Degrading conditions are identified through an increasing or decreasing trend in a performance indication or in the residual difference between a measured variable and its estimations.**

On-Line Monitoring Flow Diagrams



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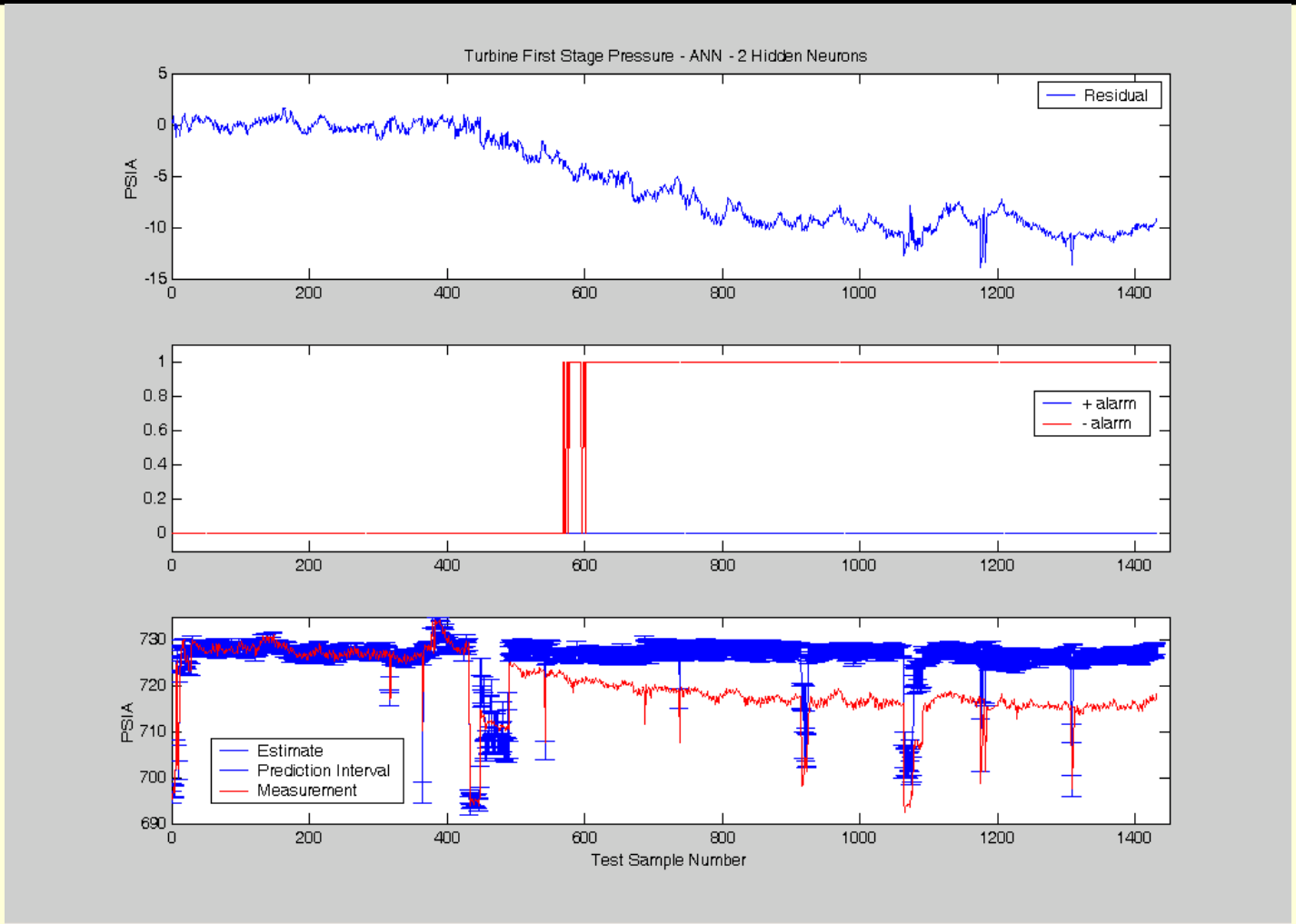
Typical OLM System Output



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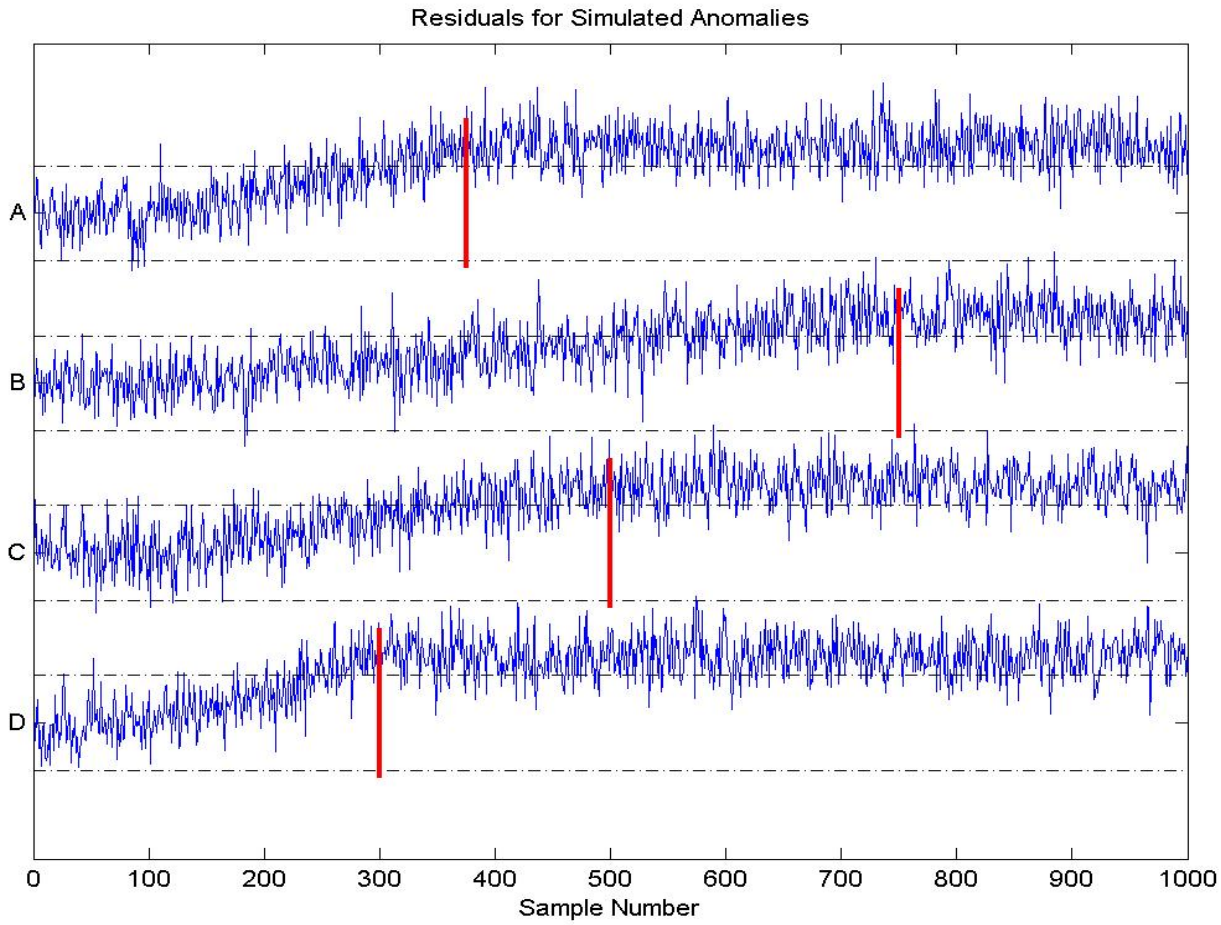
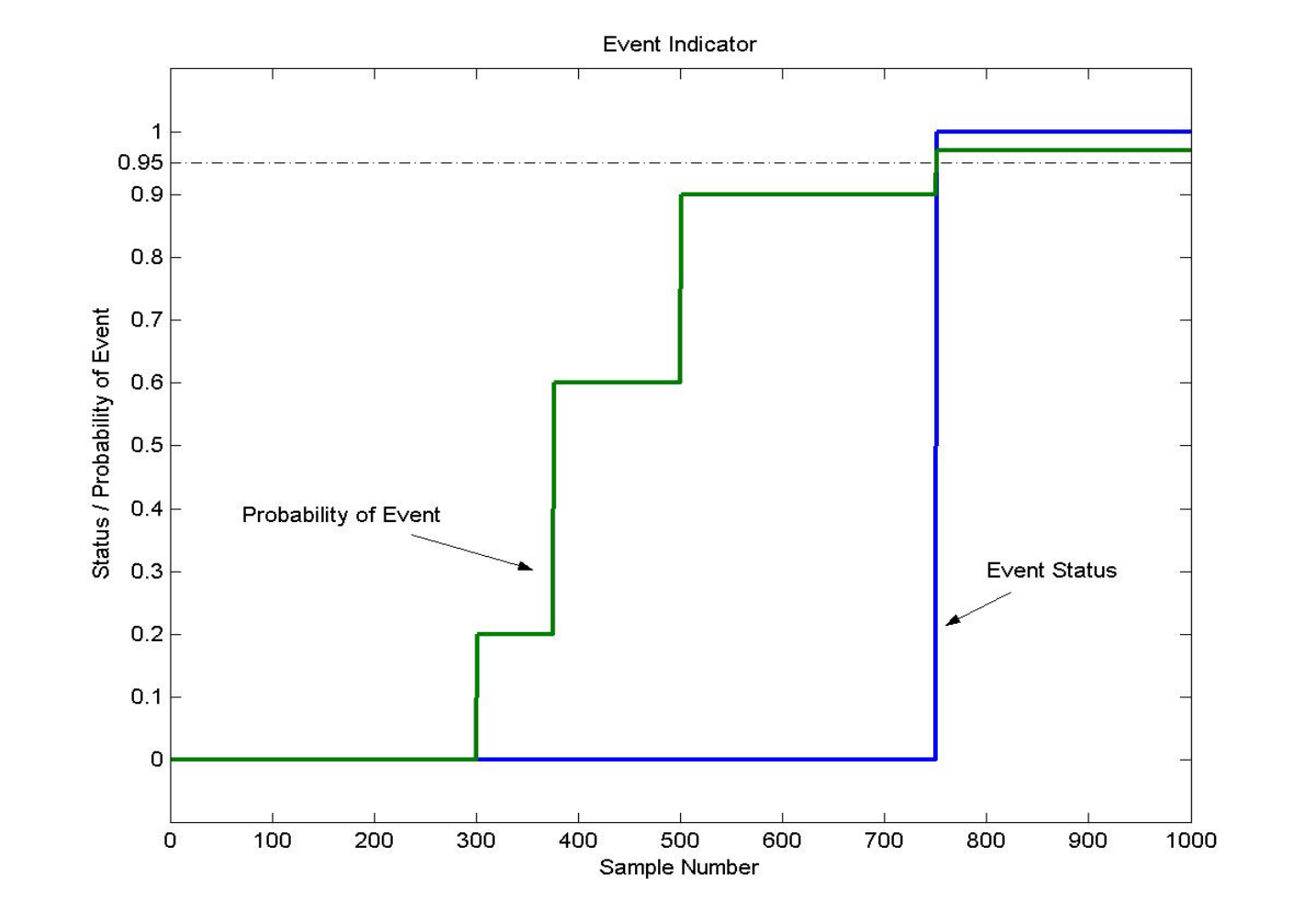
Simulated Anomalies



Event Notification



Requirements for ***Accurate & Reliable*** Early Warning

- **Successful OLM models will provide early warning of impending failure or warning of sufficient degradation. Several requirements must be met in order for these capabilities to be available:**
  - **D**ifferentiability – The various failure modes or degradation mechanisms for a component or piece of equipment must be differentiable from one another so that the diagnosis is accurate and unambiguous.
  - **A**nomalous – Indications of the condition must be identifiable by an OLM model.
  - **R**epeatability **–** All occurrences of a given degradation mechanism or failure must consistently produce the same precursor indications.
  - **T**imely – Indications must occur and be properly identified with enough lead time to provide some advantage (e.g. event avoidance).

Establishing a Failure Signature Database

EVALUATE

- **Failure Modes & Degradation Modes**
  - consider probability of modes based on history or manufacturers data
  - consider effect of failure with respect to personnel safety, loss of production, maintenance and related costs

DEFINE

- **Potential indicators of these modes (with respect to information contained in or produced by an OLM system)**
  - consider the requirements for accurate identification (DART)
  - consider input from various modeling tools deployed
  - construct interpretation logic to combine resultant information from multiple monitoring tools and other information streams to present a concise diagnosis (in some cases, prognosis)

OLM and Traditional PM

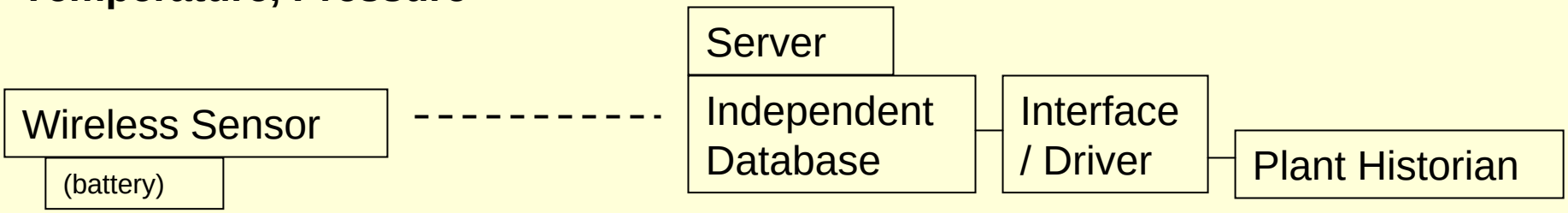
- **As equipment ages, the probability of failure will increase.**
- **Historically successful PM intervals may no longer be as effective beyond the 60y mark**
- **Augmenting an overall O&M strategy with an OLM system may allow a greater use of condition-based maintenance schedules**
  - The potential for excessive costs from too frequent maintenance is reduced
  - The potential for missed maintenance is reduced due to real-time health assessments

Incorporating Wireless Sensors

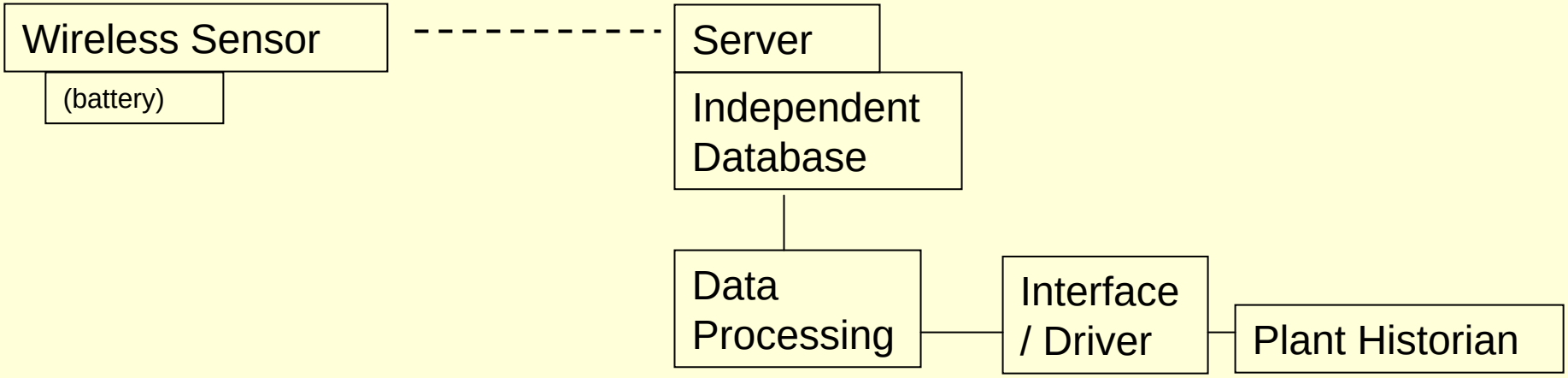
- **The addition of new data streams into empirical models is a relatively simple process**
- **Rapid advances in the development of wireless sensors and related technology present new cost-effective solutions to improving monitoring coverage**
- **Wireless vibration sensors have the potential to improve OLM system diagnostics and reduce (or eliminate) the efforts required to perform routine (manual) vibration monitoring**

Common Wireless Sensor Configurations

Temperature, Pressure



Vibration



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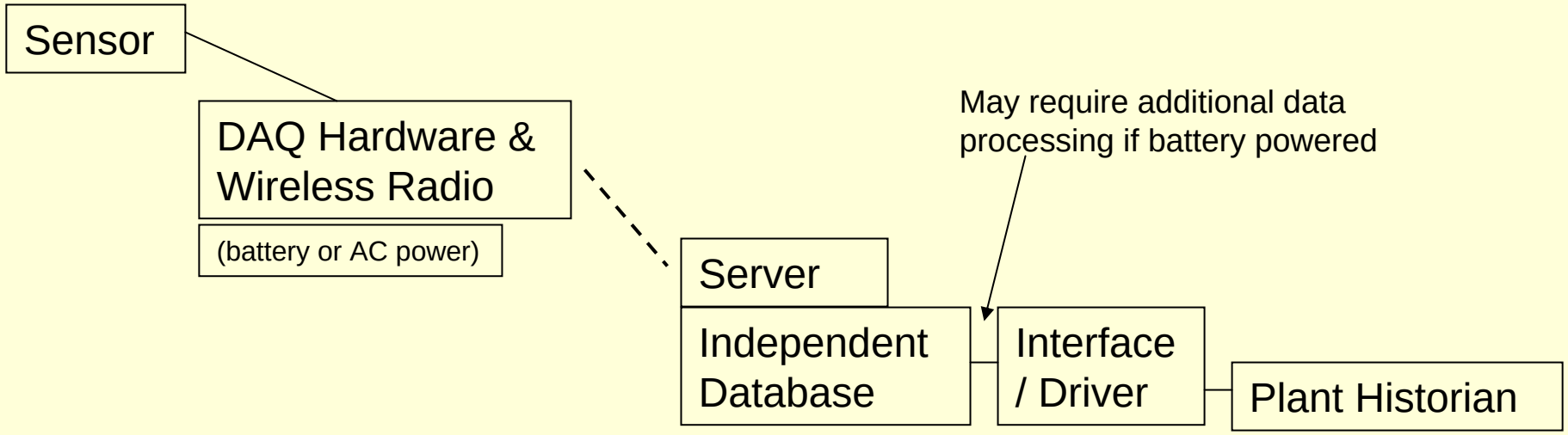
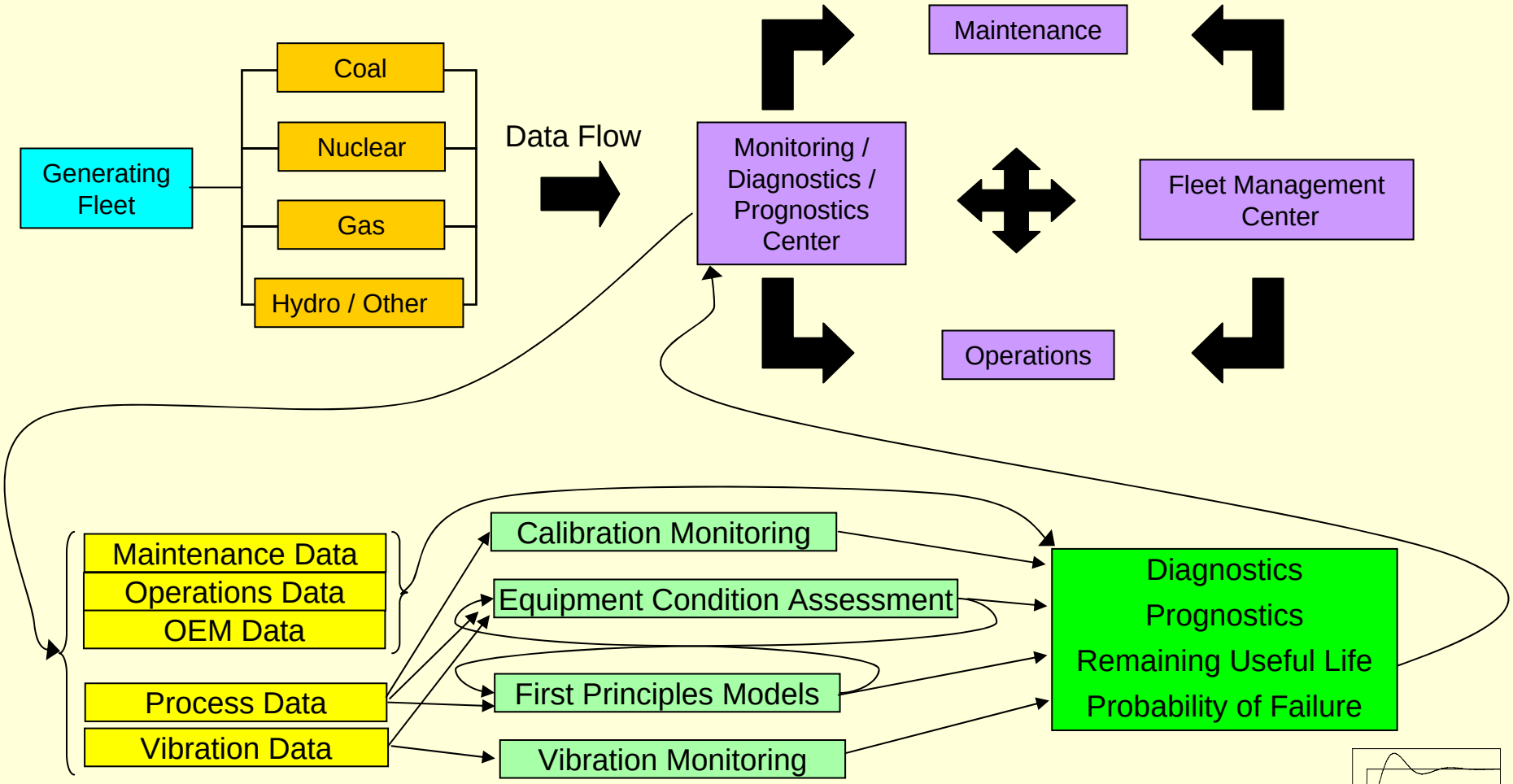


On-Line Monitoring Across a Fleet



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Conclusions

- **The deployment of OLM systems with the necessary diagnostic capabilities may assist in the safe and economical operation of NPPs beyond 60years.**
  - Early warning potential (of failure or degradation)
  - Condition based maintenance schedules
  - Knowledge capture and retention (through failure signatures and diagnostic rules)
- **Taking advantage of wireless sensors and related hardware can improve the coverage of monitoring systems and provide additional diagnostic benefits**
  - Real-time (cost-effective) vibration monitoring for critical equipment
  - More comprehensive diagnostics