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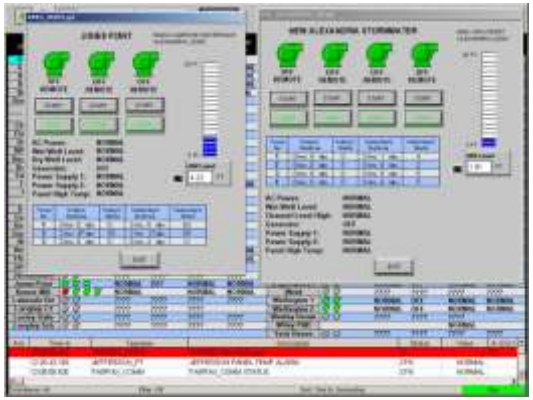
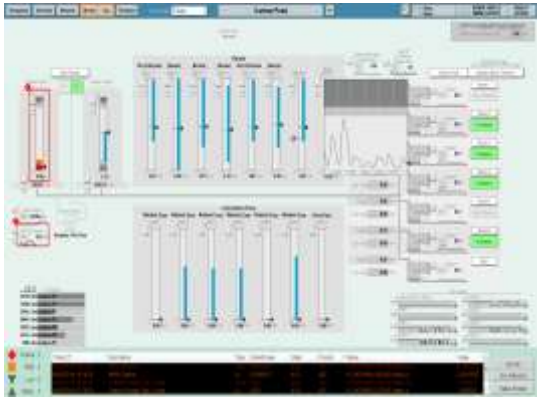
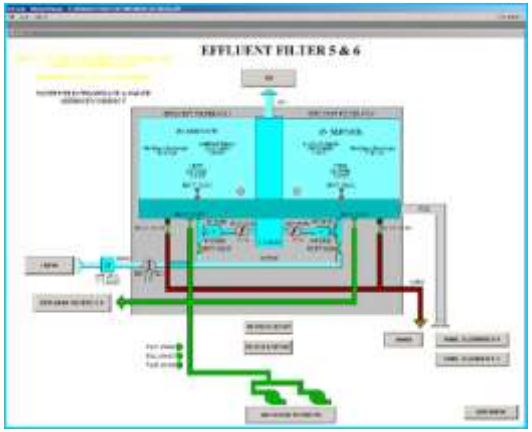
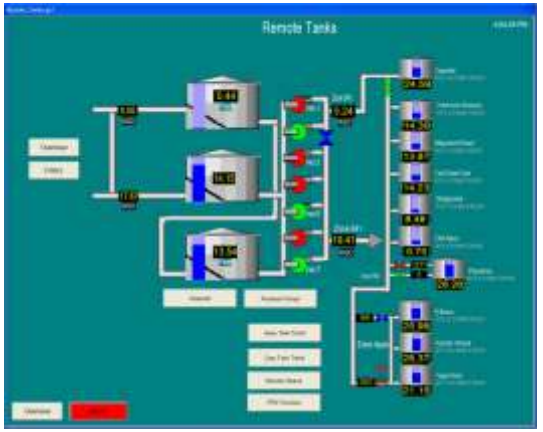








Asset Management and Data Analytics

June 26, 2018

michigan water environment association

mwea

the water quality people

Today's Agenda

1. Asset Management Drivers and Trends
2. Typical Asset Risk Assessment
3. Data Analytics Continuum
4. Machine Learning and Asset Failure Prediction

Asset Management Does Not Have to Be Complex

> Delivering a specified level of service to customers and regulators at an optimal life cycle cost with an acceptable level of risk.

Businesslike Management of Assets

Asset Management Drivers and Trends

Typical Asset Management Drivers

External Forces	• Regulatory compliance • Growth and demand • Pressures from the public and elected officials
Asset Age & Condition	• Aging and deteriorating infrastructure • Solid justification for capital investments and O&M programs
Service Levels	• Demand for improved service levels and reliability • Prevention of critical asset failures
Cost Efficiency	• Drive to do “more with less” through optimized decisions, effectiveness and efficiency • Move toward a “businesslike” culture

Current Industry Asset Management Trends

Focus on capital planning, business case development and project justification – ensures funding goes to the most critical projects and creates transparency

Ongoing CMMS procurement, implementation, enhancement and upgrades – large utilities aligning with top tier and medium/small utilities with mid-tier vendors with GIS integration

Large organizations embracing asset management as an organizational model – medium/small utilities focusing more on practices and processes within existing structure

Focus on business intelligence/analytics is growing rapidly – all industry organizations are focusing on intelligent water systems

Asset and Risk Management Strategy

- Know what assets you own
- Understand their criticality and condition
- Understand their serviceability, remaining life, and economic value
- Understand asset performance and failure history
- Identify largest risks and the likelihood and consequence of failure
- Have a documented life-cycle strategy for all major assets – linked to asset performance and service level goals

SIMPLE
Sustainable Infrastructure Management Program Learning Environment

Typical Asset Risk Assessment

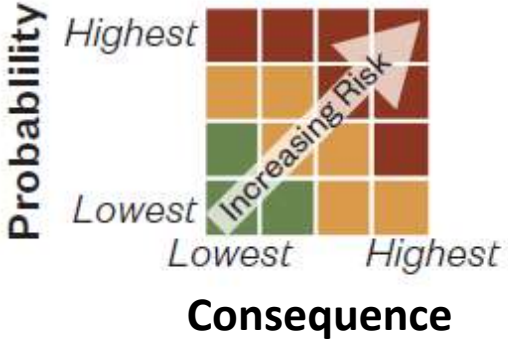
Asset Risk – *How is it Defined?*

Risk is defined as the quantification of the likelihood of failure (condition) times the quantification of the consequence of such failure (criticality), factoring in any required adjustments for redundancy or risk mitigation.

Failure Mode
- Mortality
- Level of Service
- Capacity
- Efficiency

Consequences
- Economic
- Social/Safety
- Environmental

Redundancy Factor



Condition Assessment – *Evaluates Probability of Failure*

Physical Condition: current state of repair and operation

- Visual inspection of facility assets
- Evaluate general condition of major process equipment and infrastructure & major electrical equipment
- Discipline-specific review (mechanical, electrical, structural, HVAC assessments)
- Building envelope evaluation

Performance Condition: current and future requirements

- Work order history
- Discussions with O&M staff

Condition	Failure Mode	Evaluation Criteria	Probable Approach
Physical	Mortality	Visual Assessment	Capital OR Maintenance
		Mechanical and Electrical Testing	
Performance	Mortality	Reliability (breakdowns)	Capital OR Maintenance
	Capacity	Current capacity testing	Capital OR Maintenance
		Future capacity needs	Capital
	Level of Service	Current and future regulatory needs	Capital
		Other LOS measures	Capital OR Maintenance
	Efficiency	Obsolescence	Capital
		O&M Issues (not breakdowns)	Capital OR Maintenance

Condition = (Physical x W1) + (Performance x W2)

Consequence of Failure – *Evaluates Asset Criticality*

- Expected system-wide consequence of failure associated with failure of an asset
- Evaluation Criteria:
  - Safety / Security
  - Level of Service
  - Financial Efficiency
  - Regulatory compliance
  - O&M
  - Resilience
- One set of criteria for all vertical (facility) assets

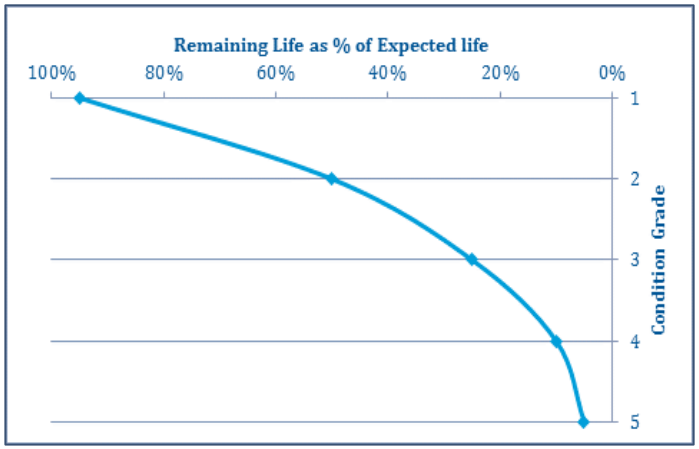
Criteria	Sample Scoring Criteria (1-3)	Proposed Weighting %
Safety	1. No Impact	25%
	2. NOT APPLICABLE	
	3. Failure creates potential for injury to staff or the public (i.e. significant bodily injury or may damage equipment or environment such as chemical leak/fire/explosion)	
Level of Service	1. No Impact	30%
	2. Eventual impact if no response (typical response time is expected to be adequate to avoid possible significant capacity reduction, service interruption, odor event, reduced operational flexibility, etc.)	
	3. Immediate and/or widespread impact before response (typical response time would not be adequate to avoid significant capacity reduction, service interruption, odor event, reduced operational flexibility, etc.)	
Regulatory Compliance	1. No Impact	30%
	2.Eventual non-compliance event if no response (typical response time is expected to be adequate to avoid possible overflow, permit violation, water quality violation, etc.)	
	3.Immeadiate and/or widespread impact before response (typical response time would not be adequate to avoid significant overflow, permit violation, water quality violation, etc.)	
O&M Impacts	1. No Impact	15%
	2. Moderate O&M cost / effort (i.e. short duration for O&M staff to repair and could typically repair with in-house staff with reasonable amount of overtime. Some loss of redundancy and some impacts to upstream/downstream processes)	
	3. Large O&M cost / effort to (i.e. longer duration for O&M staff to repair and requires outside/external expertise and/or significant overtime. Significant loss of redundancy and major impacts to upstream/downstream processes)	

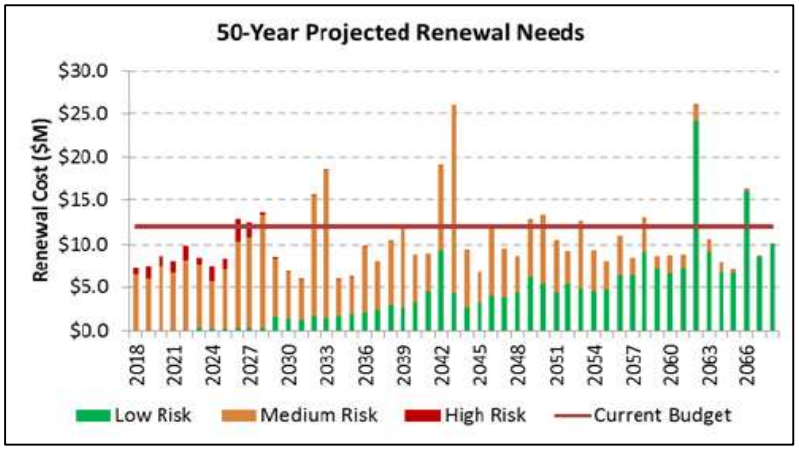
$$CoF = \sum(C1 \times W1) + (C2 \times W2) + (C3 \times W3) + (C4 \times W4)\ldots$$

Risk Assessment – *Prioritizes Assets for R&R*

Asset Risk Matrix

Risk Rating = PoF x CoF		Probability of Failure (PoF) 1 Very Good	2 Good	3 Fair	4 Poor	5 Very Poor	Criticality Totals	Risk Category	Risk Totals
Consequence of Failure (CoF)	3 Large Impact	65 (4.08%)	35 (2.2%)	9 (0.57%)	1 (0.06%)	0 (0%)	110 (6.91%)	High	2 (0.13%)
	2 Medium Impact	245 (15.39%)	501 (31.47%)	200 (12.56%)	36 (2.26%)	1 (0.06%)	983 (61.75%)	Medium	1048 (65.83%)
	1 No Impact	47 (2.95%)	250 (15.7%)	174 (10.93%)	28 (1.76%)	0 (0%)	499 (31.34%)	Low	542 (34.05%)
Condition Totals		357 (22.42%)	786 (49.37%)	383 (24.06%)	65 (4.08%)	1 (0.06%)	1592 (100%)		1592 (100%)



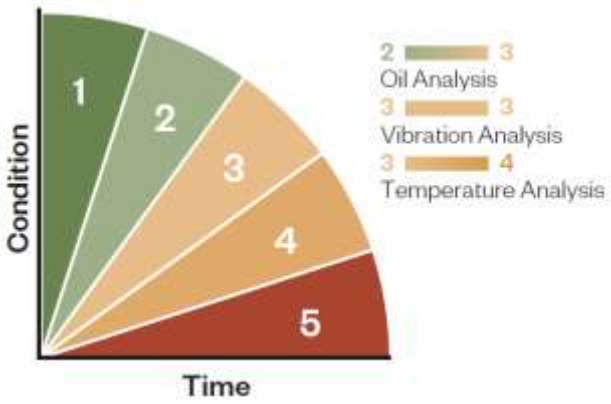


Preventive Maintenance Has Evolved Over Time…

Run to Failure | Calendar | Usage | Condition | RCM

…But It Is Still Not As Effective As It Should Be

Risk-Based Inspection & Maintenance Optimization



Benefits:

- Better estimate of EUL
- Avoid critical failures
- Optimize inventory and resources

Inspection Program	Criticality	Maintenance
Visual + Performance + Testing	Highest	Time + Use + Condition
Visual + Performance	Moderate	Time + Use
Visual	Lowest	Time

Data Analytics Continuum

Data and Key Processes Required to Support Asset Management

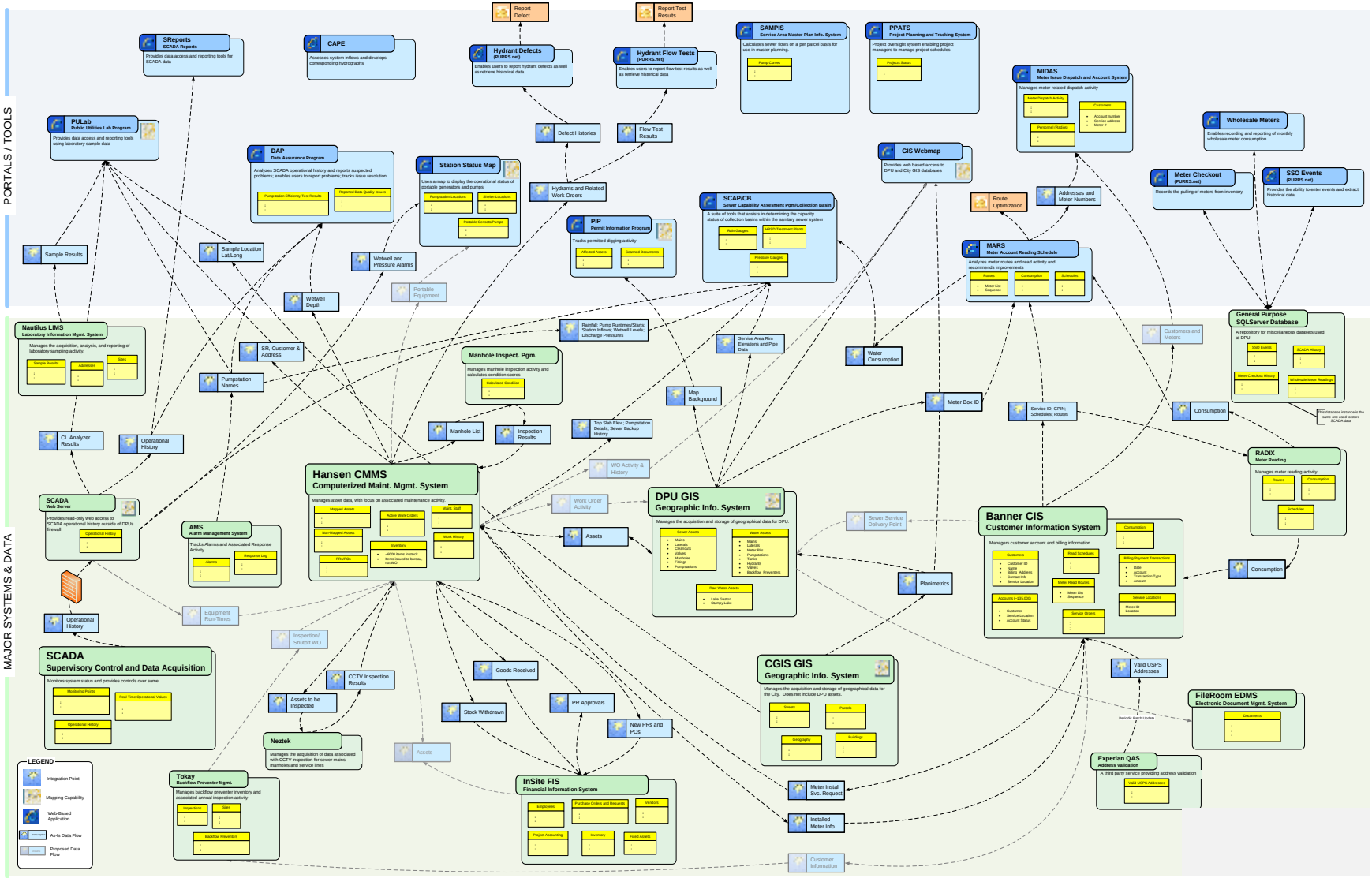
Tracking attributes: date created, created by, last edit, etc.

Physical attributes: make, model, manufacturer, capacity

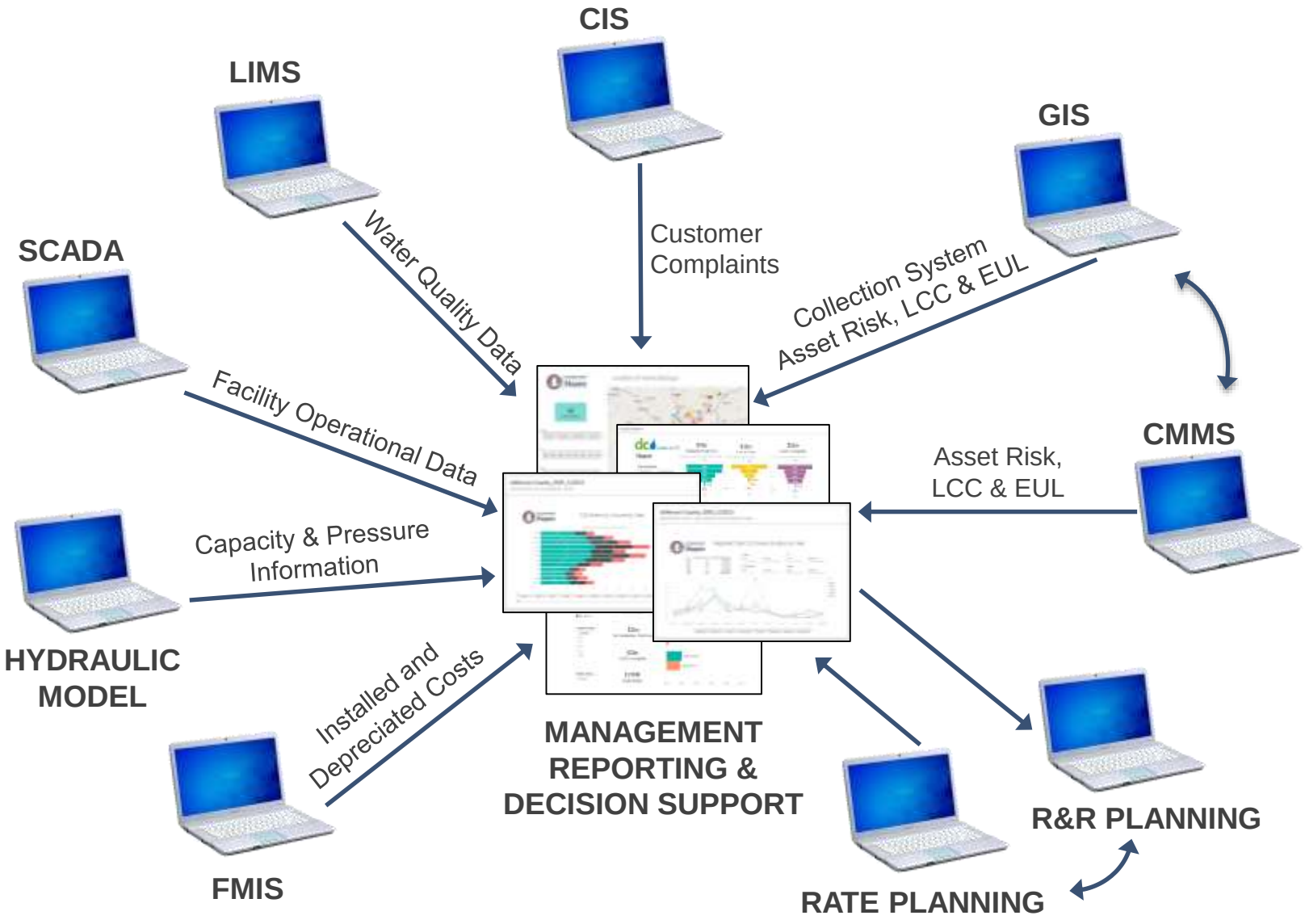
Financial attributes: install date, historic/replacement cost, effective useful life, remaining useful life

Asset management attributes: Likelihood of Failure, Consequence of Failure, Operational data (SCADA)

Typical Asset Management Systems and Data Flow



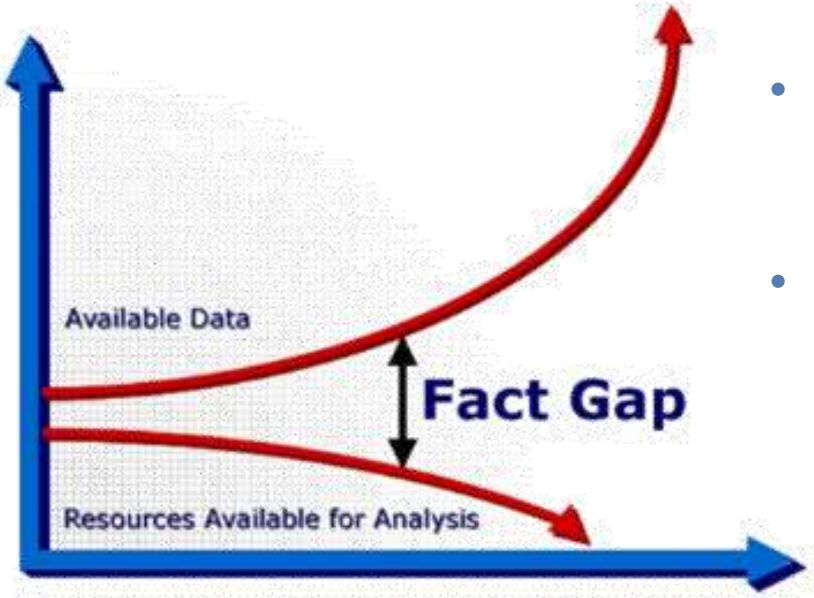
Streamlined Data Analysis and Integration



It's Not a Data Gap…It's a Fact Gap!

Utilities are experiencing a "gap" between the quantity of data they are generating and the resources available to collect, collate, and analyze it.

The amount of information managers are dealing with each day is increasing exponentially, but the resources available to sort, scrub, and analyze the data are decreasing.

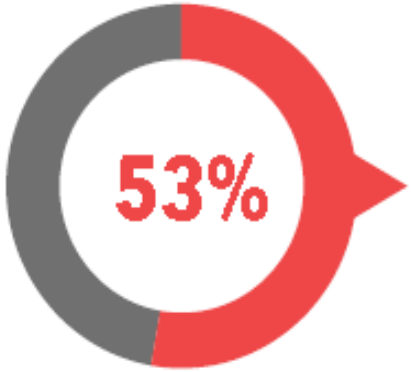


- Amount of data generated is growing by 50% each year (IDC)
- Storage costs decreasing: $600 – cost to buy a hard drive that can store all of the world's music!

What Do We Do with All the Data?

IDG conducted a recent survey of over 200 IT leaders throughout all industries in the U.S.

of IT decision makers said that their users report feeling **overwhelmed** by incoming **data and information**



said the influx of data has **delayed decisions** because they didn't have the right tools to manage it

IDG Enterprise, 2015

Is it only about capturing more and more data, or is it about making more, better, and/or faster decisions?

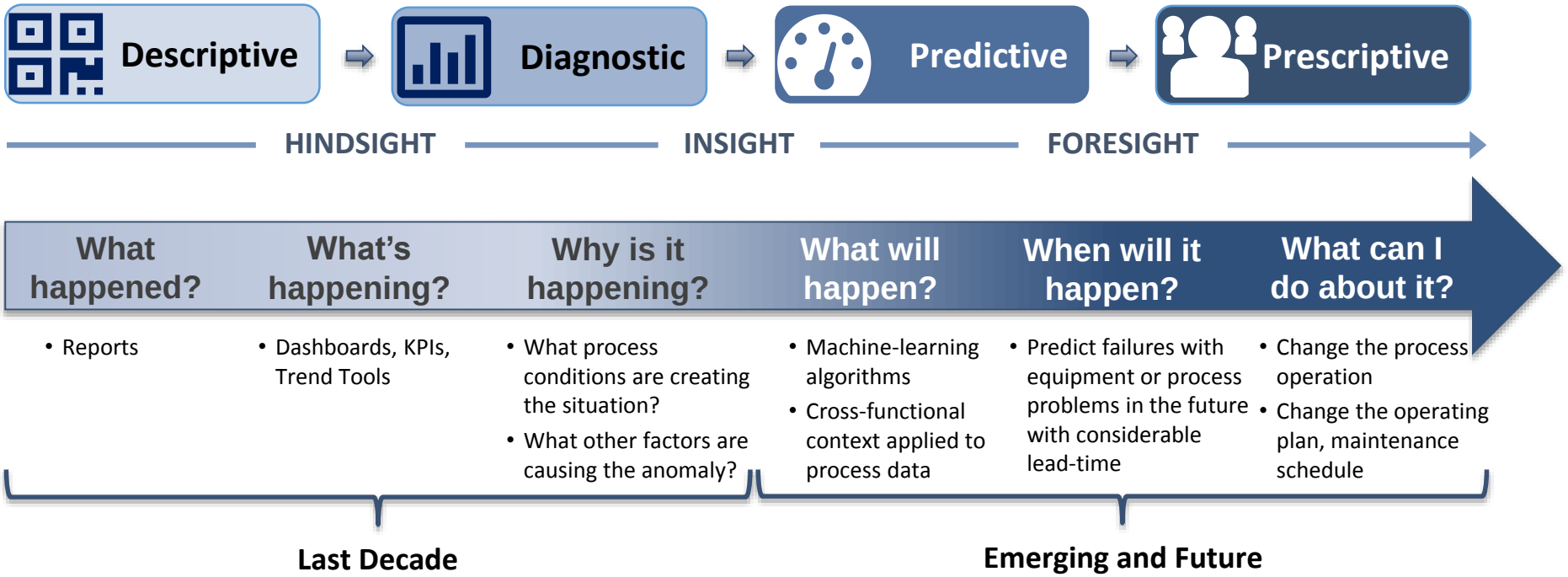
Learning from Other U.S. Industries

* Survey of 450 Data Scientists and Business Analysts, Executives, IT Application Managers – in a wide range of industries; research sponsored by Cloudera, SAS, SAP, and other vendors

The Data Analytics Continuum

1. Data capture
2. Data validation
3. Data curation (storage, query, transfer)
4. Data integration

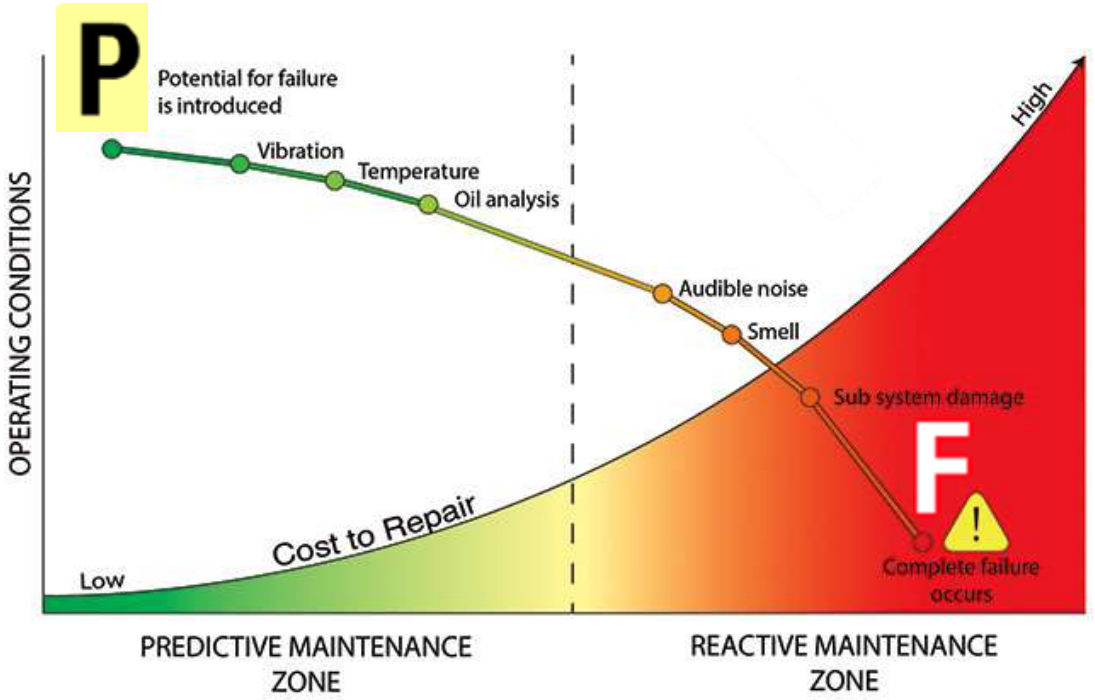
5. Data Analytics
6. Business intelligence/decision support
7. Knowledge sharing
8. Performance reporting & visualization



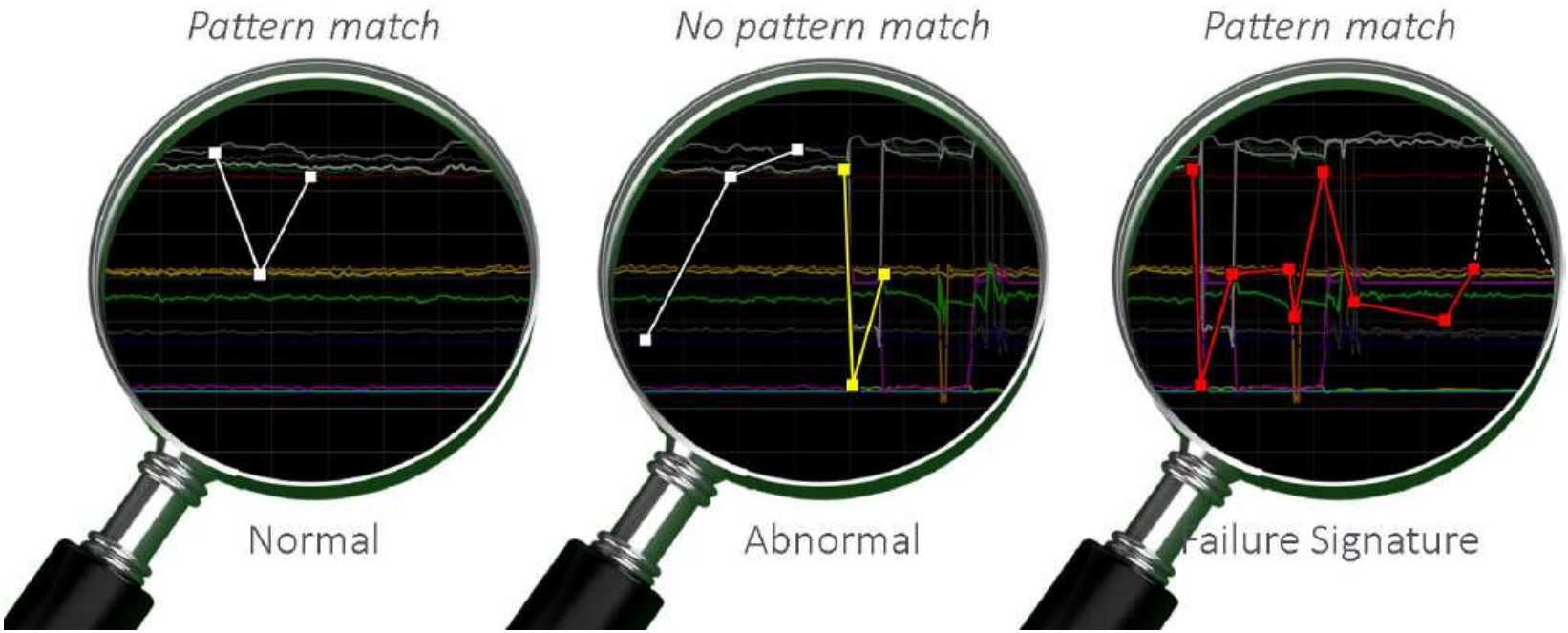
Machine Learning and Asset Failure Prediction

Typical Predictive Analytics – Asset Lifecycle Models

- Build a life-cycle model of each asset type
- Calibrate the model with actual failure data
- Highlight statistical deviations and anomalies and make corrections to the models



Predictive Analytics Based on Machine Learning



Standard SCADA System

Primary Sensors / Measurements

- Flow Rate
- Pressure
- Level
- Temperature
- Analytical parameters (e.g., pH, CL2 residual)

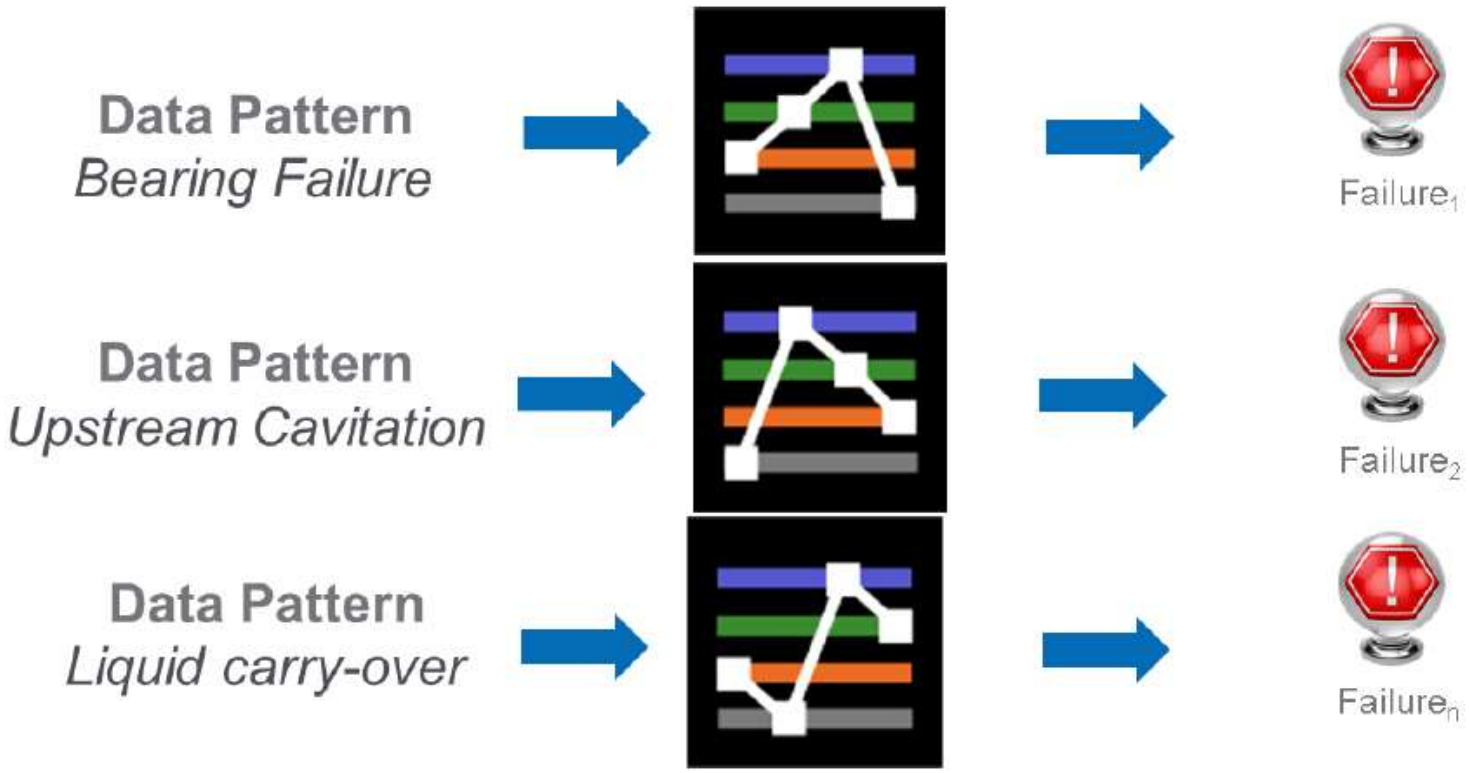
Secondary Instruments

- Indicators
- Hand switches
- Programmable controllers
- Computer systems
- Communication networks

Final Control Elements

- Valves and gates
- Pumps
- Chemical feeders
- Blowers
- Mixers
- CMMS

Patterns of Failure



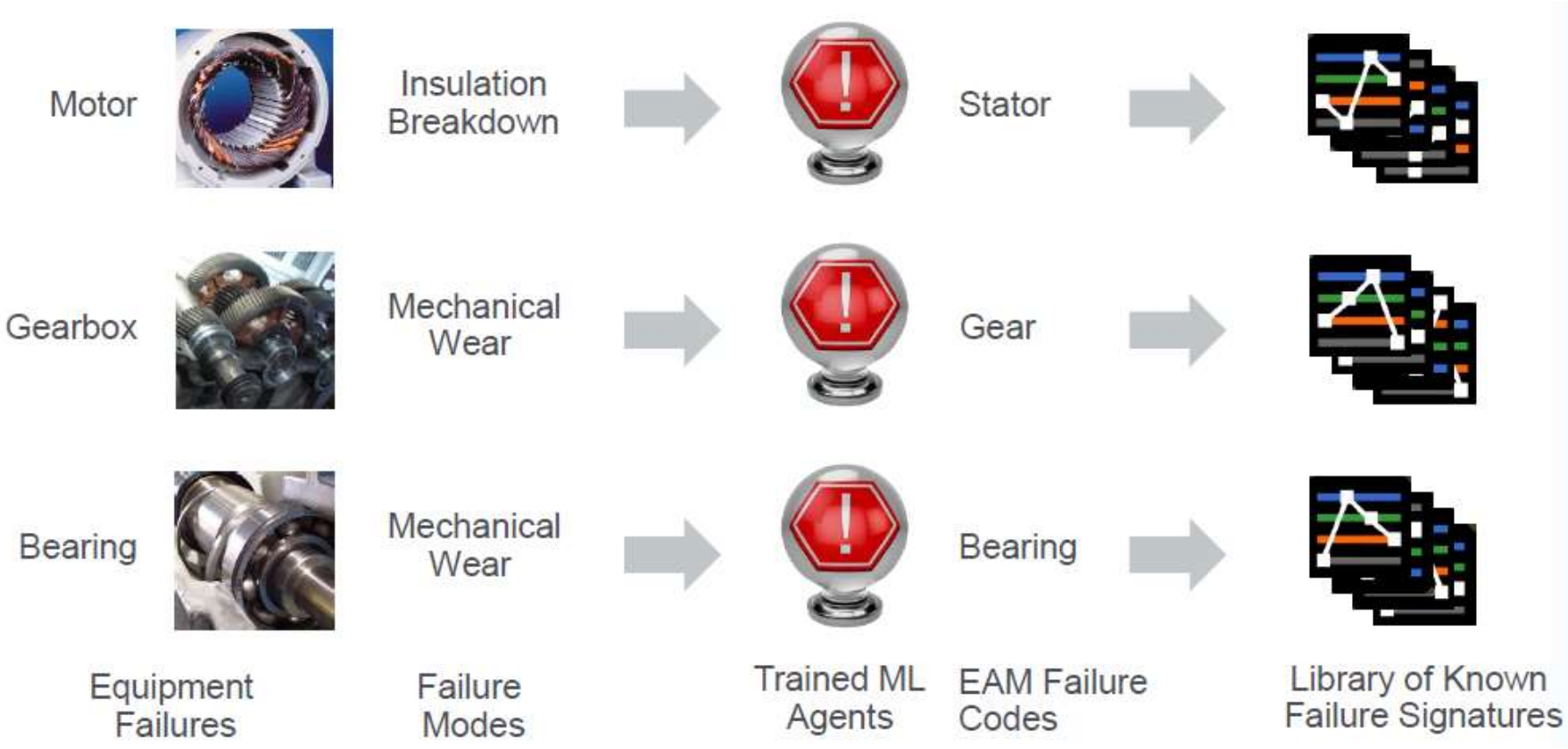
Anomaly Identification

Data Pattern
Normal Conditions

Anomaly

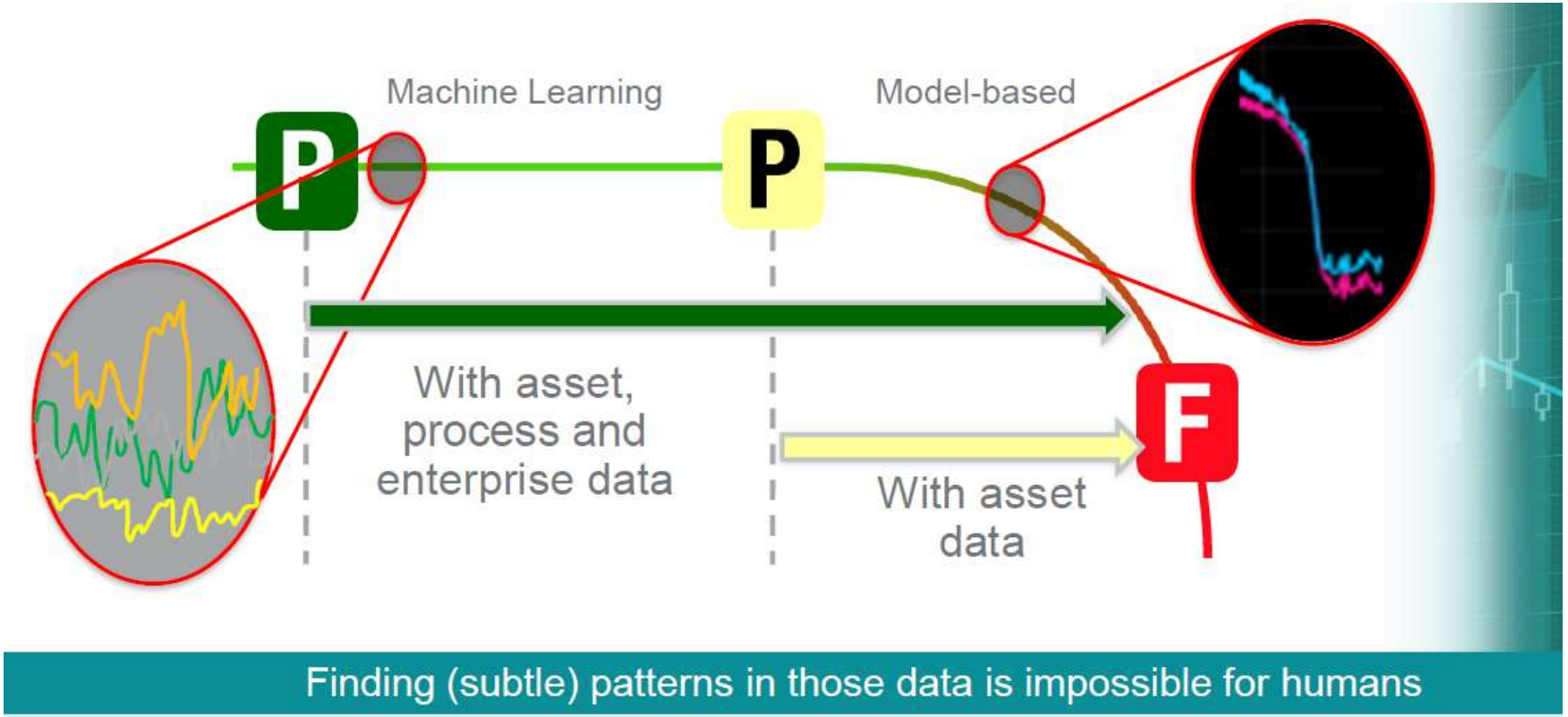
Anomaly or new normal?

A Signature Library Can Be Created



Machine Learning Extends the Prediction Horizon

- Initiate EAM action
- Make process adjustments
- Make inventory adjustments
- Order parts



Observations

- Machine learning in the water industry is here to stay
- Traditional asset planning and risk management are necessary
- Machine learning and predictive analytics can prolong asset life
- Result = Increased Savings!

(OpEx and CapEx)

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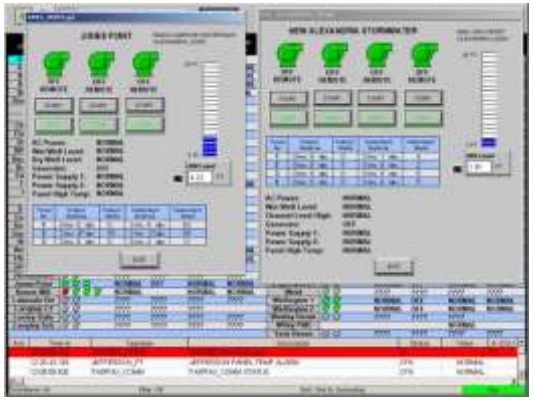

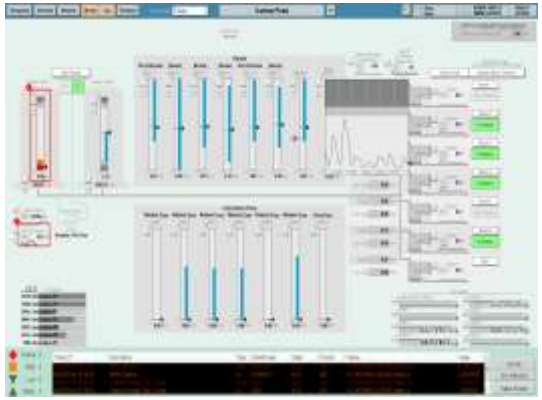

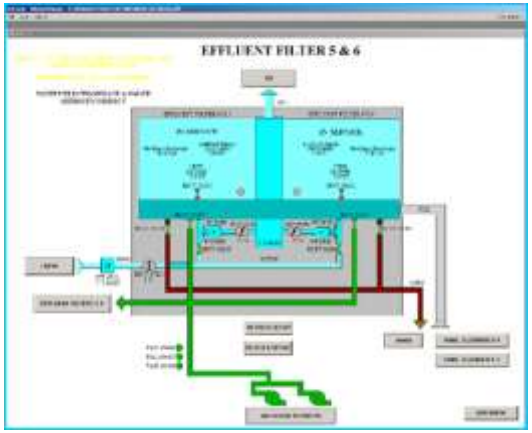

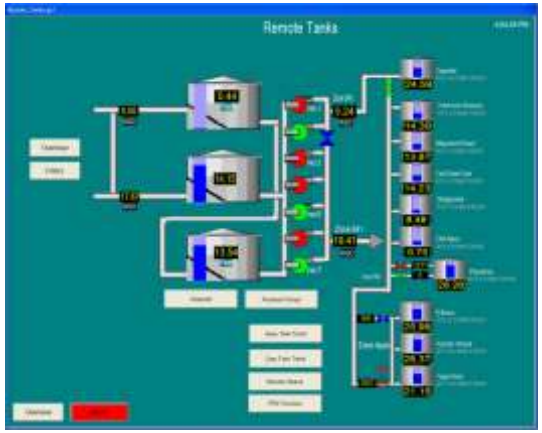

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