April 20, 2011   Randy Schrieber, Paul Bower   ABB

Asset Health Center
Central Asset Management System to Alarm and Recommend Actions Based Upon Incoming Data

WPO-105-1

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Managing the Aging Installed Base

- Very aged infrastructure (average 40$^+$ years)
- Lack of expert knowledge (retirees, non-replacements, etc.)
- Utilities cannot afford to continue time-based maintenance
- Utilities cannot afford to replace aging equipment

- Utilities would like to move to condition-based maintenance to reduce cost and also reduce risk
- Data for asset management is often distributed in various locations and formats
- Monitoring systems are being installed to provide timely data

- Several utilities are pulling data from many places and concentrating it in new data servers, then prompting the questions …

  What do I do with all this data?
  and what data should I be gathering?

  And, I only want one system for all my assets!

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Traditional Scope of ABB Support Services

- **Transformers**
  - 70% of large power transformers are ABB legacy
  - Risk assessment and life extension
  - Advanced diagnostics and testing
  - LTC repairs and replacements
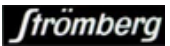 - Factory repair and remanufacturing

- **High Voltage Breakers**
  - Support capability for 60-70% of installed base
  - Parts, Refurbishment and Retrofit
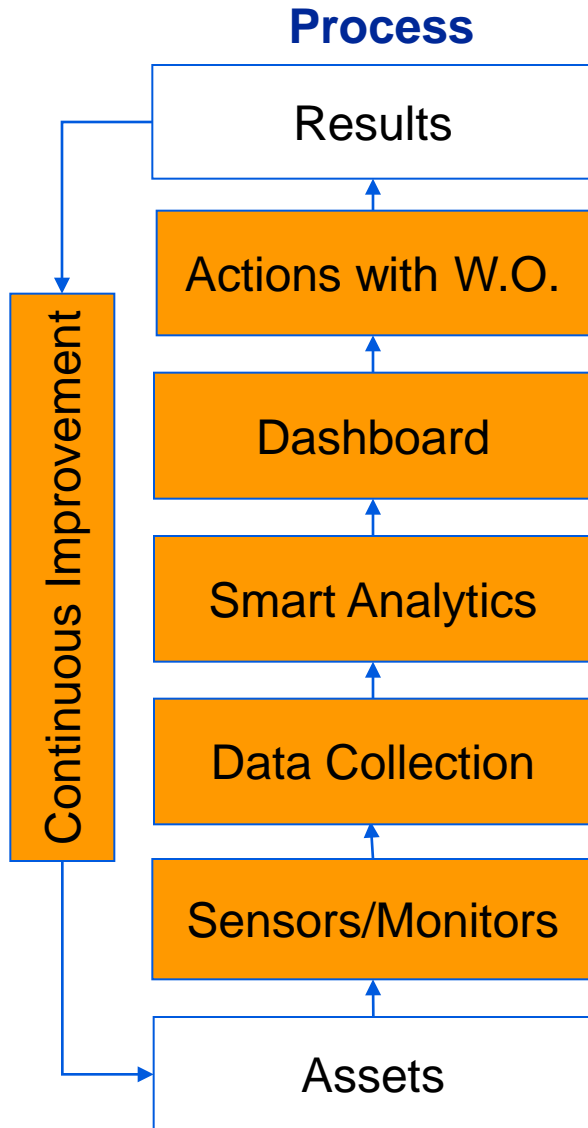 - Advanced diagnostics – radiography and SF6 leak detection
  - Risk assessment and life extension

- **Low- and Medium-Voltage Switchgear**
  - Over 1 million breakers in service in US
  - Parts, Refurbishment, Retrofit, Roll-in Replacement
  - Protection & Control assessment and upgrades
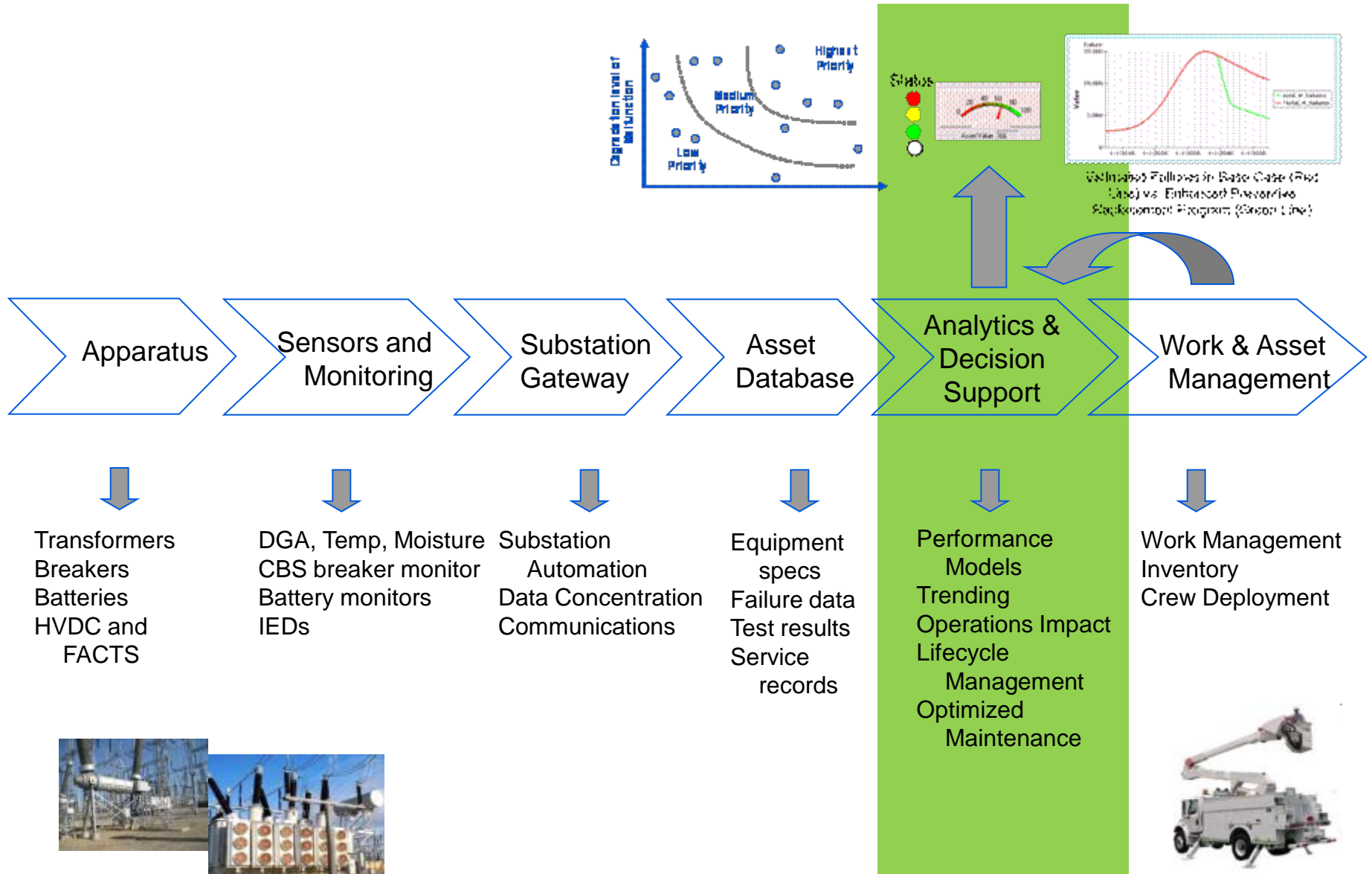 - Nuclear & Non-nuclear

Overall Asset Health Center Vision

Process

Results

↑

Actions with W.O.

↑

Dashboard

↑

Smart Analytics

↑

Data Collection

↑

Sensors/Monitors

↑

Assets

Continuous Improvement

Benefits

Business Management	Overview of system operational conditions with drill down capability
Service Levels	Clear and complete set of service performance levels
Decision Making	Business decisions based on data to minimize uncertainty and increase confidence in the direction of the business
Operation Improvement	Improved operational efficiencies by making high priority information available to employees
Life Cycle View	Life cycle cost analysis consistently applied to determine how to best spend funds – right-size O&M and CapEx replacement. Influence specs of new equipment.
Financial Impact	Forecasts of asset performance impact to future revenue requirements
Risk Management	Management of system operational risks with streamlined proactive sensing, analytic and data mining technology.

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End-to-End Solution to Drive Asset Performance

Apparatus	Sensors and Monitoring	Substation Gateway	Asset Database	Analytics & Decision Support	Work & Asset Management
Transformers Breakers Batteries HVDC and FACTS	DGA, Temp, Moisture CBS breaker monitor Battery monitors IEDs	Substation Automation Data Concentration Communications	Equipment specs Failure data Test results Service records	Performance Models Trending Operations Impact Lifecycle Management Optimized Maintenance	Work Management Inventory Crew Deployment

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End-to-End Solution to Drive Asset Performance

- **Performance models are key**
- **Leverage data to**
  - **Define risk factors**
  - **Quantify them**
  - **Recommend mitigation options**
  - **Optimize spending**

Asset Database

Analytics & Decision Support

Work & Asset Management

Transformers
Breakers
Batteries
HVDC and
    FACTS

FTU
CBS
Battery Monitors
IEDs

Substation
    Automation
Data Concentration
Communications

Equipment
    specs
Failure data
Test results
Service
    records

Performance Models
Trending
Operations Impact
Lifecycle
    Management
Optimized
    Maintenance

Work Management
Inventory
Crew Deployment

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ABB MTMProgram
Well Established Fleet Risk Assessment – Patented Process

Transformer Fleet

Fleet Screening

Advanced Life Assessment

Advanced Diagnostics

Design / Condition Assessment

Loss of Life Assessment

Corrective Maintenance Actions

Replacement

Refurbishment

Cooling Upgrade

Engineered Solutions
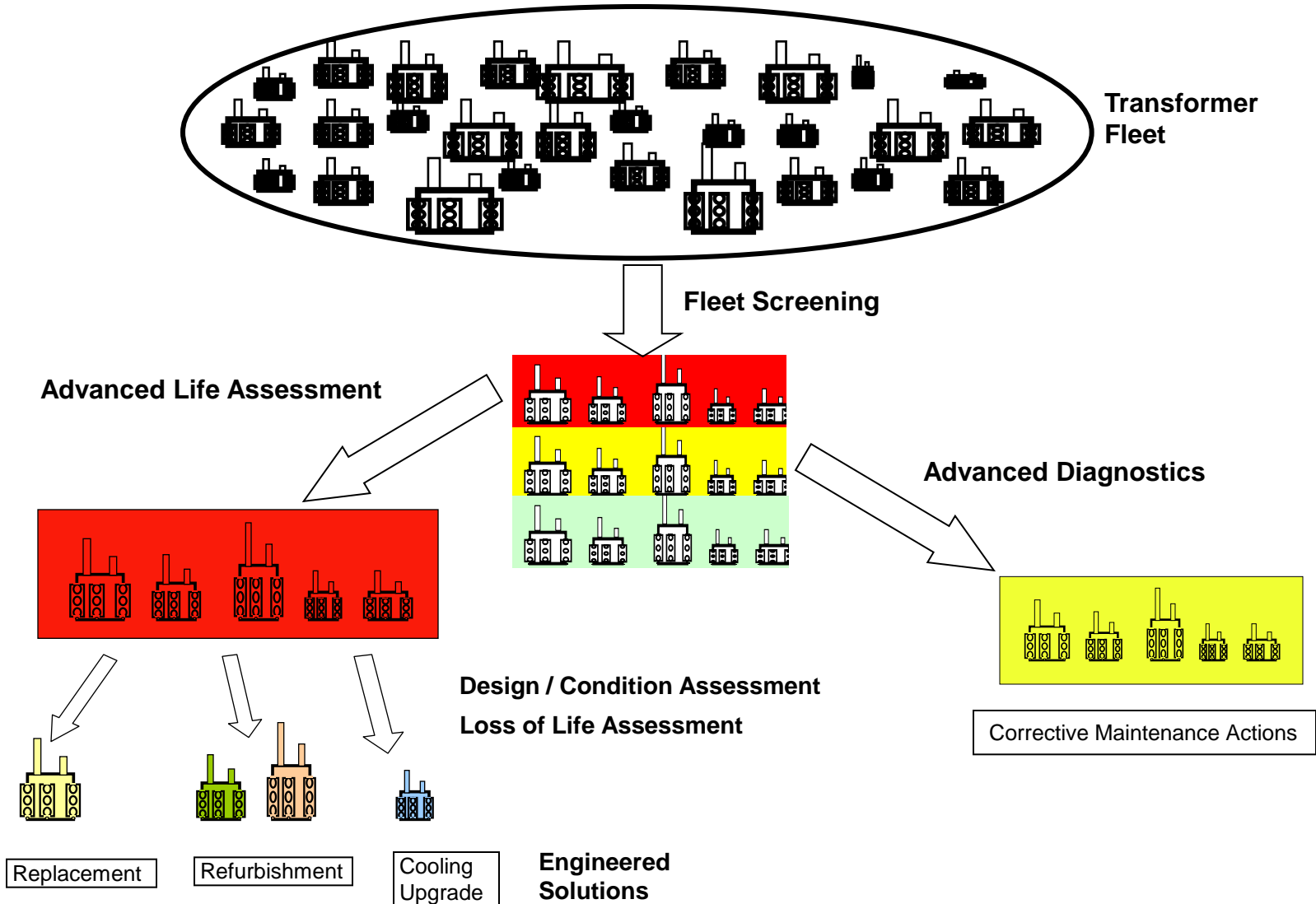
Transformer Fleet Assessment – Process Flow Map
Includes Risk Factors Specific to Individual Designs
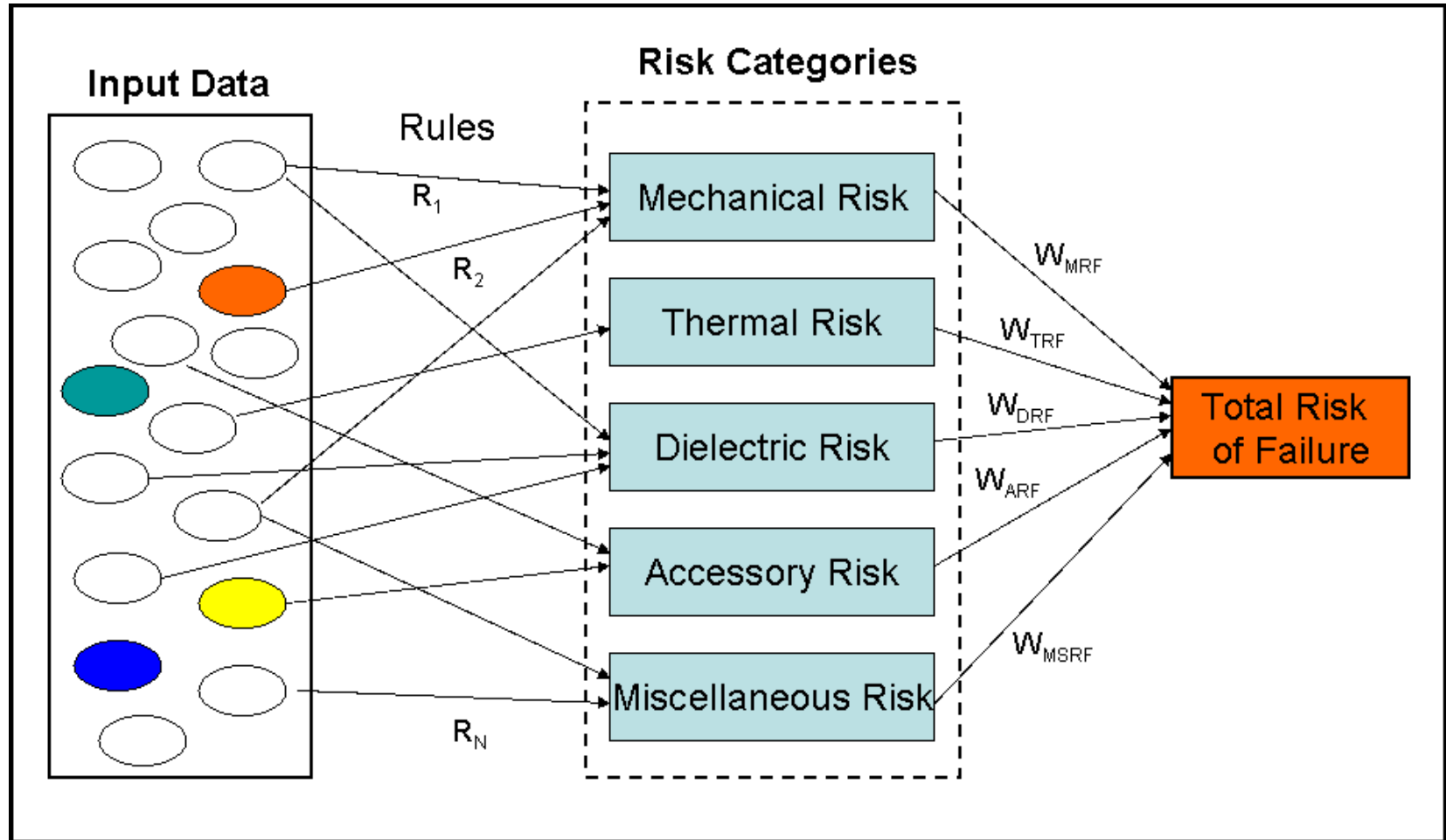
Transformer Fleet Assessment – Process Flow Map

- One-time data gathering process
- Utilizes ABB Risk of Failure algorithms developed using ABB legacy design knowledge and field experience
- Uses the unit criticality as defined by the utility to prioritize the work required to reduce risk
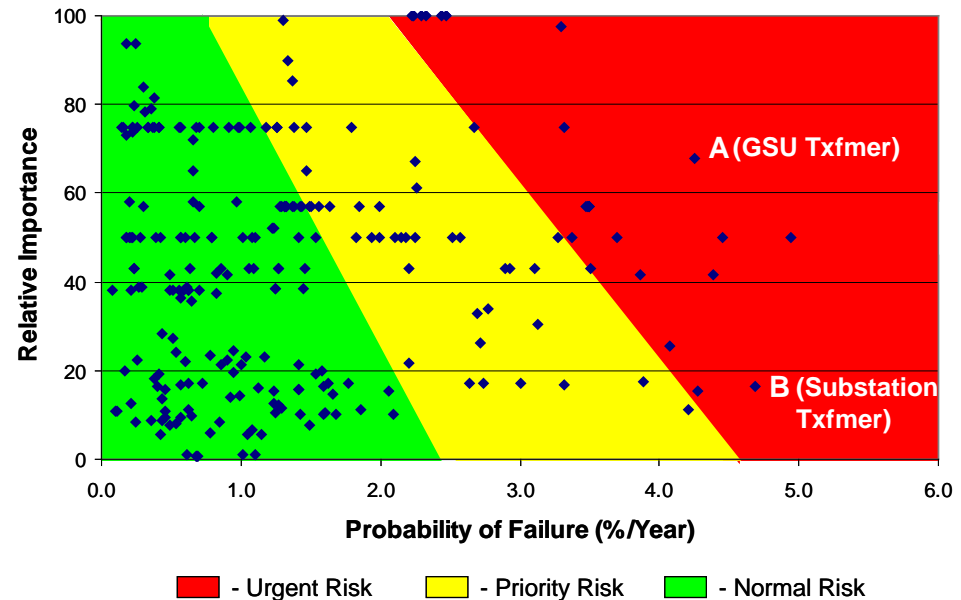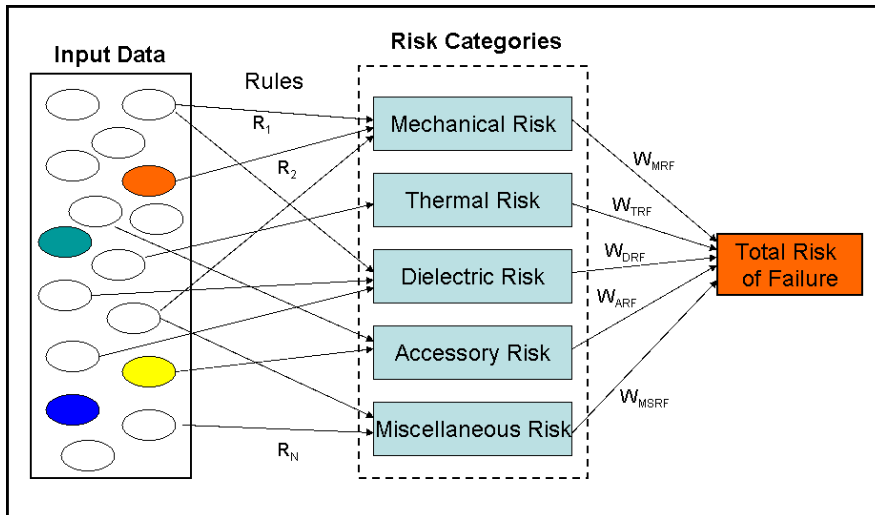
Transformer or Breaker Risk Assessment
Risk Monitoring with Remote Monitoring and Consolidated Data

- Remote monitoring can continuously update many factors in the risk assessment to provide a near-real time alert for critical risks as they develop
- Defer routine inspections and PM but still stay ahead of risks that can cause an unexpected outage
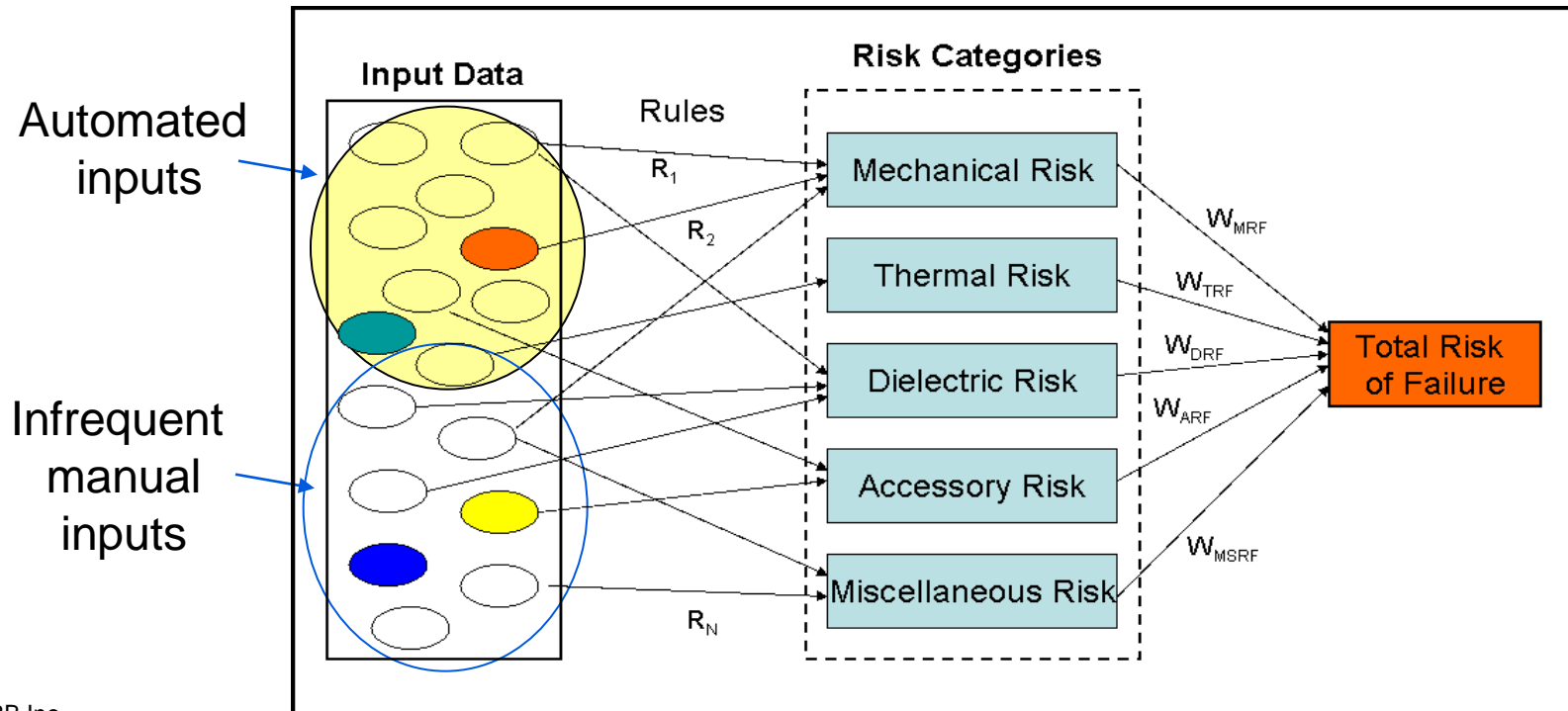
Mix of Sensor Usage
Units Shipped with ABB Transformers

Gas & Moisture sensors and Thermal Monitors are the predominant sensors installed on new power transformers

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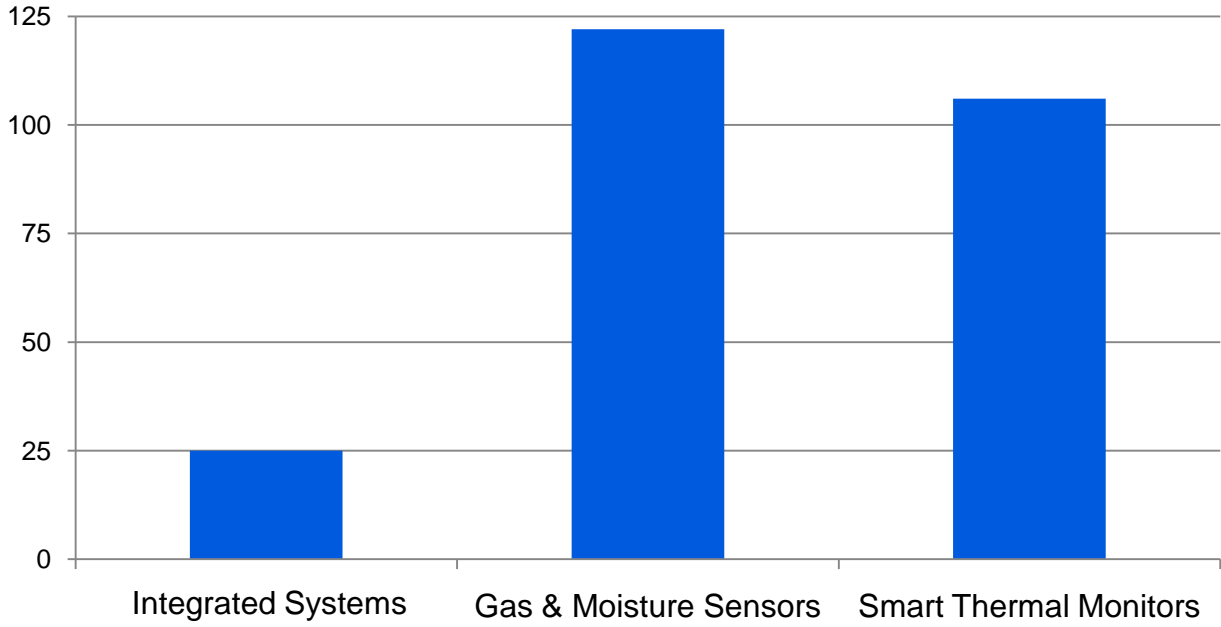
Sensor Price Range

System / Sensor	Price Range ($)
Integrated monitor	12 K – 60 K
Gas in Oil	5 K – 50 K
Moisture in Oil	1.5 K – 3 K
Thermal Monitor	5 K – 15 K
Bushing Monitor	3 K – 15 K

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Individual Asset Assessment

- Define contributing risks
- Quantification of Risk Factors
- Recommendation of mitigation actions and urgency
- Auto-notification of responsible parties
    - Everyone knows all we know
- Generation of draft work order for review
- Data mining capability to allow searches for similar issues and/or similar units in the fleet

Fleet Assessment

- Optimize spending across an asset fleet to address the highest risks first
- Quantify the unaddressed risks at selected spending levels
- Optimize the capital replacement program to evaluate the tradeoffs with continued maintenance expense and/or unaddressed risk
- Compliance reporting

Asset Fleet Performance Model
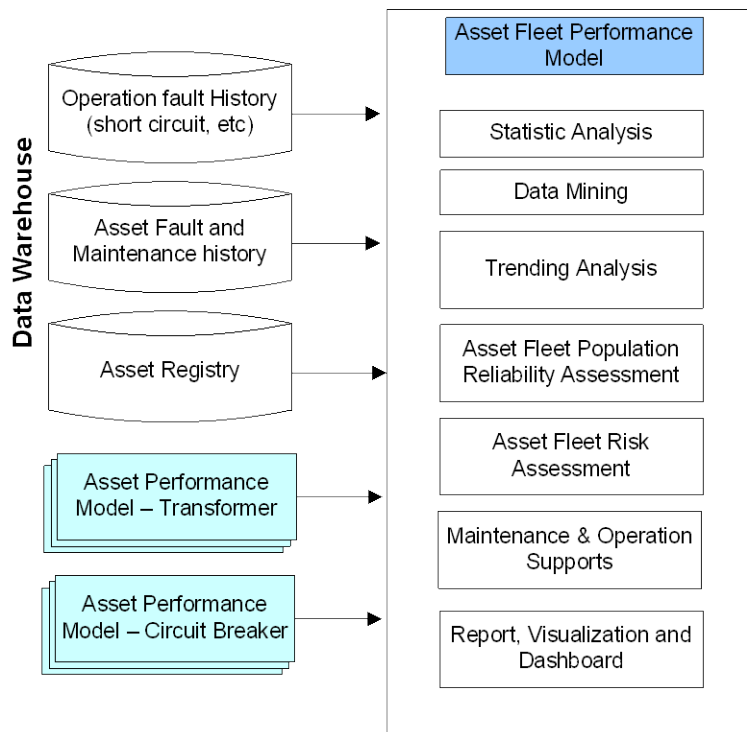
Sample Outputs
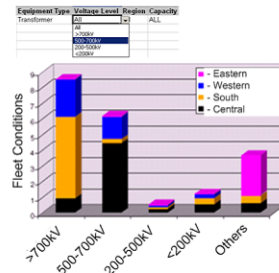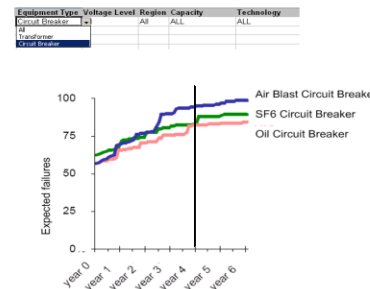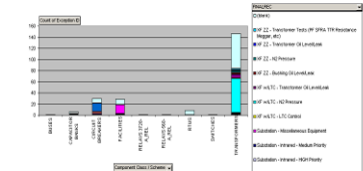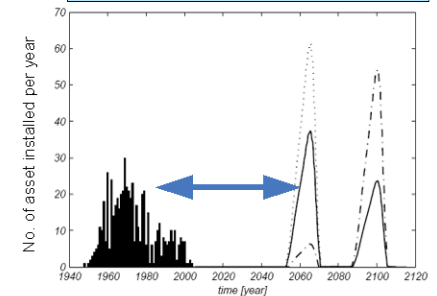
System-Wide Assessment

- Define risk by region or substation
- Optimize O&M and CapEx replacement spend across assets for a balanced risk mitigation plan
    - Transformers
    - HV Breakers
    - Station batteries, …

System Health Model
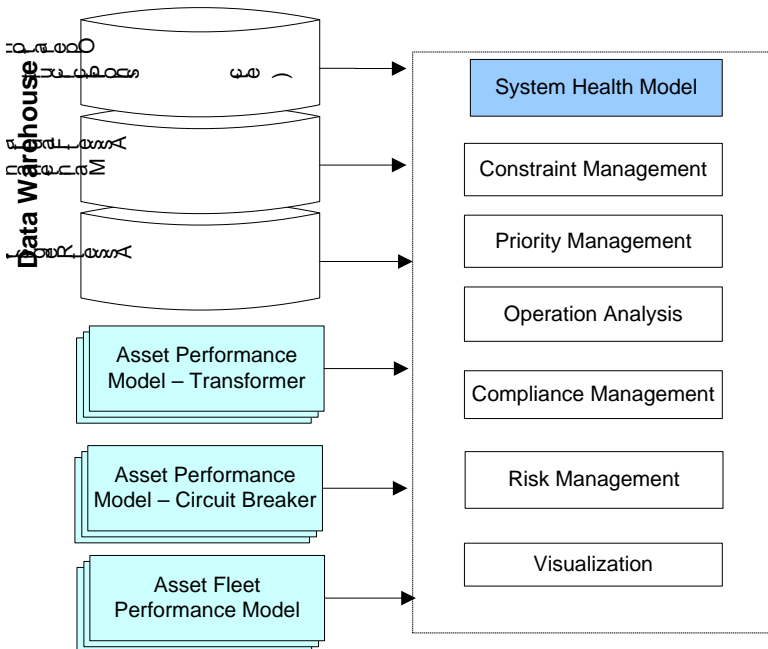
Sample Outputs

System Health Status

Resource Utilization

Resource Utilization — Seasons

Reliability Performance

SAIDI (hr) — Seasons

Corrective and Planned Tasks

| Western Region | Western Region | Eastern Region |

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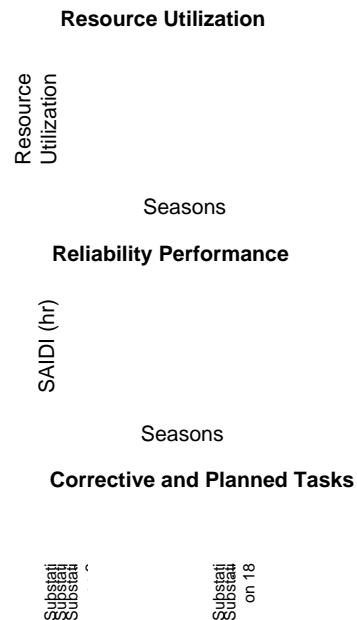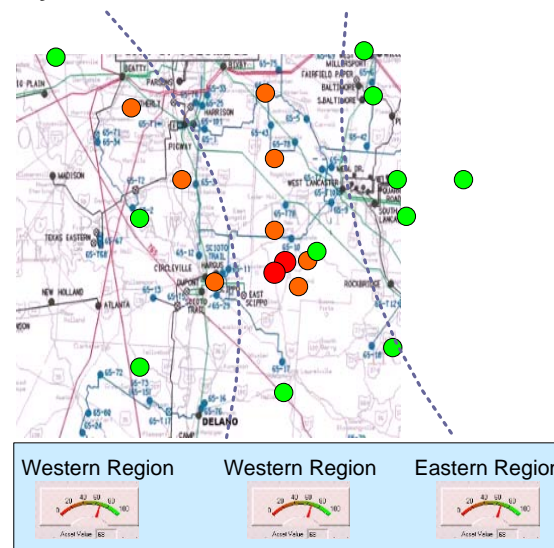
Integrating the Data, Algorithms, Reporting, ERP

- ABB acquired Ventyx in 2010
  - Leading business solutions provider offering software, data and advisory services
- Ventyx acquired Insert Key Solutions in Dec 2010
  - Reliability focused process improvement at nuclear and thermal plants
- Ventyx acquired Obvient Strategies in Jan 2011
  - Obvient's FocalPoint Platform provides data integration and visualization capabilities

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Asset Health Center – Solution Architecture

Ad Hoc Query, Reporting & Analysis

Activity Monitoring & Trending

Digital Dashboards

External Communications & Notifications

BI Applications Asset Mgmt., Cap Project Mgt., etc.
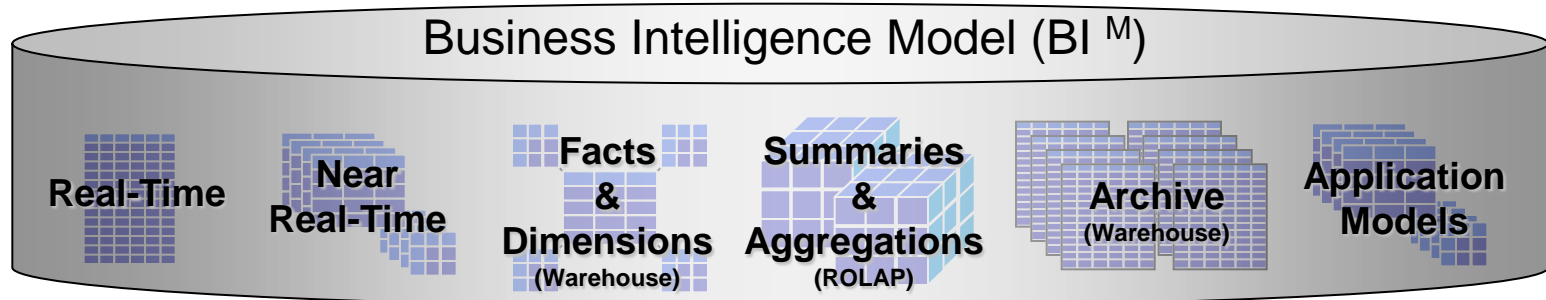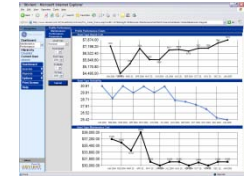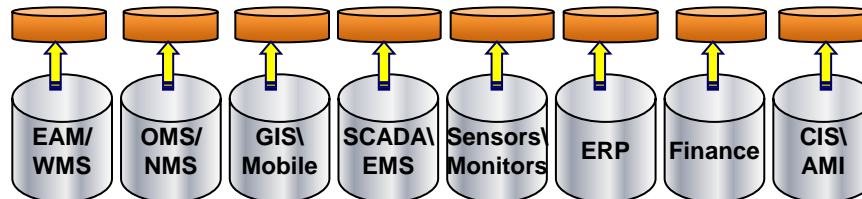
Business Intelligence Model (BI ^{M})

Real-Time

Near Real-Time

Facts & Dimensions (Warehouse)

Summaries & Aggregations (ROLAP)

Archive (Warehouse)

Application Models

Mapping   Identification   Filtering   Cleansing

Extract Transform Load

Internet

EAM/ WMS

OMS/ NMS

GIS\ Mobile

SCADA\ EMS

Sensors\ Monitors

ERP

Finance

CIS\ AMI

External Data
Industry Standards
Manufacturer's Data.
Geographic Demographics

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Asset Health Center – Information Flow and Analysis

Digital Dashboards

External Communications & Notifications

Workflow Dashboard

Summaries & Aggregations (ROLAP)

Work Management Maintenance Management Systems

Performance Model Analysis

Data Aggregation

Alerts & Notifications

Recommended Actions Work Order Initiation

Thermal Winding Risk Short Circuit Risk Dielectric failure Risk Etc.

Real-Time

Near Real-Time

Facts & Dimensions (Warehouse)

Mapping   Identification   Extract Transform Load   Filtering   Cleansing

Internet

EAM/ WMS   OMS/ NMS   GIS\ Mobile   SCADA\ EMS   Sensors\ Monitors   ERP   Finance   CIS\ AMI

External Data
Industry Standards
Manufacturer's Data.
Geographic Demographics

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Asset Health Center – Transformer Fleet

Asset Health Center – Transformer Fleet by Class

Asset Health Center – Transformer Fleet by Class

Asset Health Center – Transformer Fleet by Class

Asset Health Center – Asset Class Scorecard

Asset Health Center – Asset Class Loading Scorecard

Asset Health Center – Asset Class Age Distribution

Asset Health Center – Asset Class Age Distribution

Asset Health Center – Parameters & Equations

Asset Health Center – Functional Expansion

Performance Model Closed-Loop - Measure Algorithms

Inputs: Inspection Data, Loading Data, Nameplate Data, History of Work
Design Information, Actions to Take, Performance Model

Outputs: Individual Asset Health Status, System Health Status, Alarm Notification
Individual Asset Health Trends, System Health Trends
Action(s) to Take
Generated Work Orders – Inspection, PM, CM

Performance Model Analysis - Measure Algorithms

Inputs: Inspection Data, Loading Data, Nameplate Data, History of Work
Design Information, Actions to Take, Performance Model

Outputs: Individual Asset Health Status, System Health Status, Alarm Notification
Individual Asset Health Trends, System Health Trends
Action(s) to Take

Discreet Measure over time Asset Health – Factors, Weights & Trending

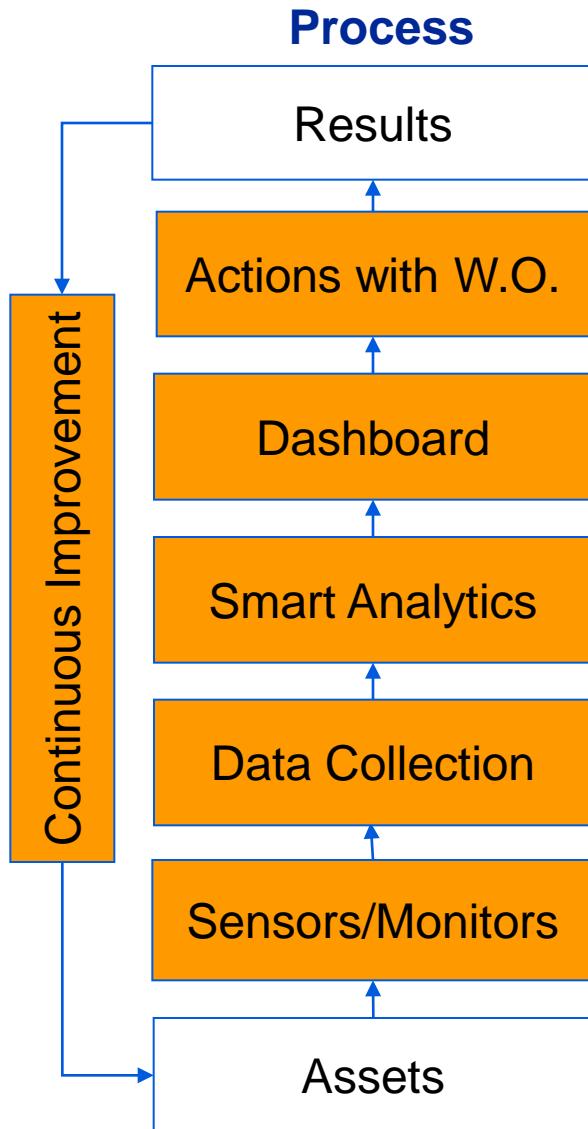**Inputs**: Inspection Data, Loading Data, Nameplate Data, History of Work

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Discreet Measure Analysis – Factors & Weights

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Asset Health Center

- We believe that the convergence of domain expertise and system integration can be a great step forward in quantifying risk and optimizing spending plans
- Early identification of incipient failures can avoid unexpected and costly outages
- We are working closely with utilities to define their requirements for the system
- Product risk algorithms are already well developed, and more are in process
- Ventyx's Obvient FocalPoint software platform is already applied at many utilities, and seems well suited for visualization and as a dashboard
- Target for pilot application late 2010

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