



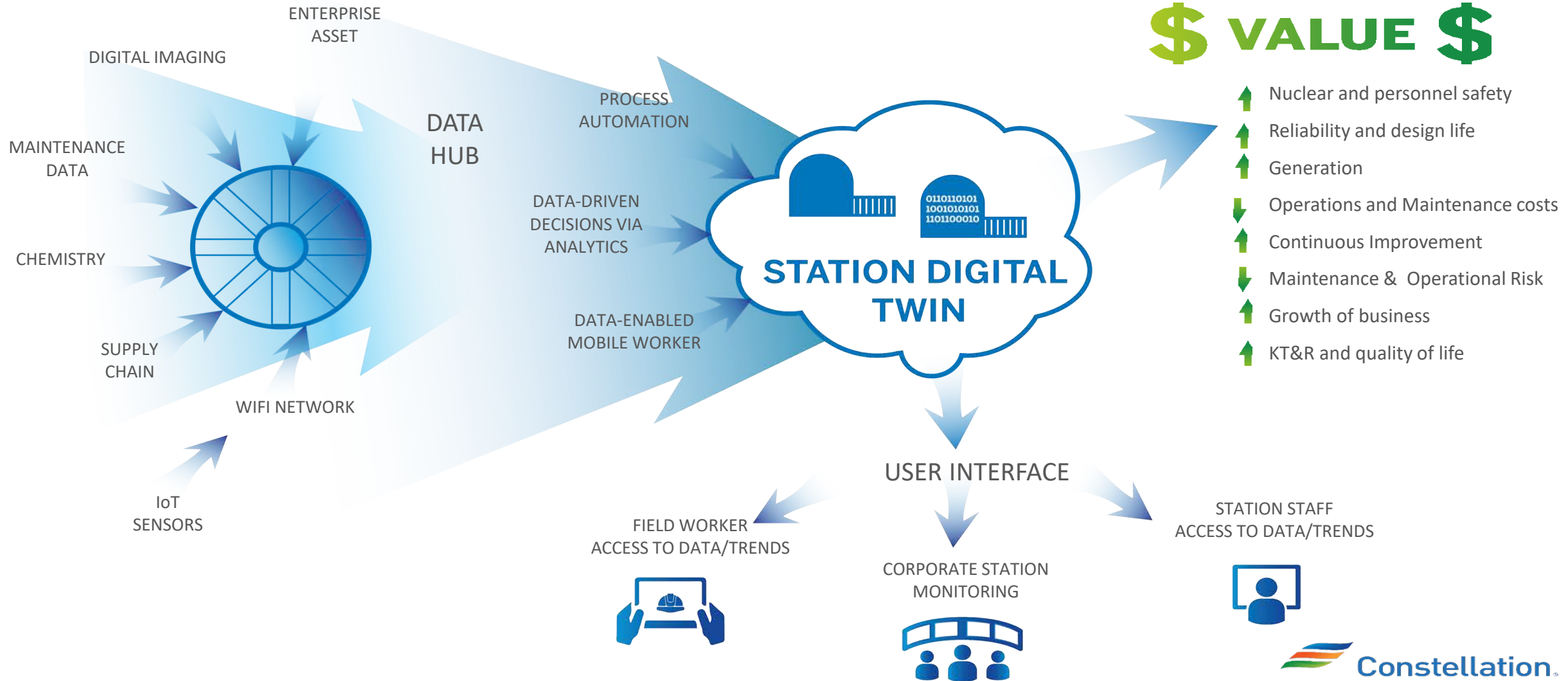
V&V of Data-driven Decisions using Artificial Intelligence/Machine Learning

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Rick Szoch, Senior Manager, Nuclear Innovation
Constellation Energy Generation

Jonathan Hodges, Ph.D., Director of Advanced Modeling
Jensen Hughes

CONSTELLATION NUCLEAR DIGITAL TRANSFORMATION



Current Analytics Examples

- Advance Pattern Recognition (APR) – *averts equipment failures*
- Initial License Training analytic – *improves student pass rates*
- Maintenance Rule Functional Failure analytic – *streamlines categorization*
- Condition Report Screening analytic – *streamlines screening*
- License Extension reviews – *automates data collection*
- Preventive Maintenance Optimization – *optimizes maintenance frequencies*
- Work Order optimization – *automates work order/planning process*

Requirements and Guidance on Quality Assurance

- Software used by NPPs for safety-related processes must comply with the requirements established in 10 CFR Part 50 Appendix B
 - Focused on traditional modeling and analysis software
- There is no clear industry-specific V&V guidance for:
 - Software that is not directly related to facility safety
 - Software that is driven by DA/AI
- The methodology and techniques presented here provide an example of V&V for DA applications deployed at NPPs

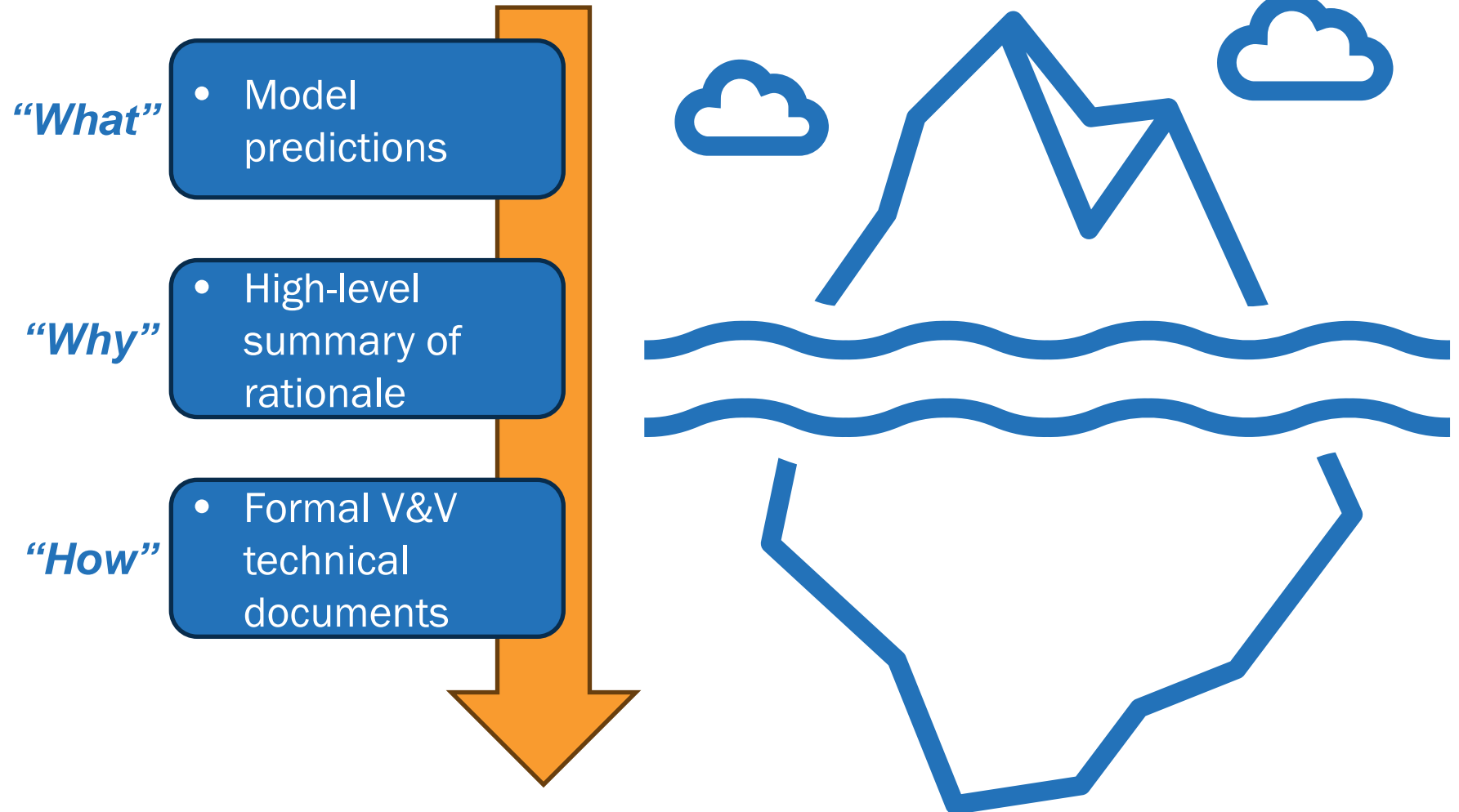
Who Needs to Know What... The Explainability Iceberg

Goals of the V&V

- Building trust in the algorithm
- Auditing the predictions
- Technical basis for use

Differs by role and responsibilities

- Licensees
- Individual users
- Dispensation committees
- Program owners
- Regulator



Facilitate CR Routing and Committee Review

Focus on the “what”

- Automate routing of CRs
- Reduce number of CRs to be reviewed for specific criteria
- Summarize data for staff and committee review

The screenshot displays a software interface for managing Critical Reviews (CRs). The main header shows the issue ID: "SOC: IR 04698879 - Received alarm 305 A-4 'Minor Trouble Turbine Control'". Below this, there are tabs for "ISSUE DETAILS", "SHIFT COMMENTS", "SOC COMMENTS", "ASSIGNMENTS", "DYNAMIC ATTRIBUTES", "WORK REQUESTS", and "ROUTING".

Issue Details:

- Title:** Received alarm 305 A-4 'Minor Trouble Turbine Control'
- Required Review:** STATION OWNERSHIP COMMITTEE (CR-OSC)
- Affected Unit:** UNIT
- Affected System:** [Empty]
- Discovered Code:** H02 ~ SELF-IDENTIFIED
- Facility:** [Empty]
- Repeat Event:** Yes
- Work Against:** By Equipment By UTC By Name N/A
- Name:** tcv-3
- Location:** U/3 MS area

Shift Comments:

Tech Spec/SLC: Yes

Appl Mode: PWROPS

Operable: No

Operable Basis: TCV-3 is not operable to support its Condition A (Function 9) and its documented on a SDTC.

TCV-3 had minor oscillations in valve position and coil voltage. The other turbine control valves responded as expected to maintain reactor pressure (no noticeable reactor pressure changes observed). TCV-3 is now closed per AO 1D.8-3 and Fast closure logic is defeated per AO 60F.2-3. With reactor power greater than 22.6% RTP, restrictions on plant operations IAW GP-5-2 would apply with a TCV out of service. This includes maintaining reactor power less than or equal to 90% RTP and steam and if TCV remains out of service for 7 days, than reactor power would have to be further reduced to below 22.6% RTP. The crew also performed AO 2A.14-2 to bypass EOC-RPT trip logic, however, thermal limits were applied to comply with TS

IV: Batdorf

Reportable: No

Reportable Basis: Not reportable IAW RRM.

Functional: N/A

Functional Basis: See operable basis.

Comments:

- Reviewed by: 08/28/2023 11:02:14 CDT
- Reviewed by: 08/28/2023 15:21:50 CDT
- Reviewed by: 08/28/2023 15:27:00 CDT
- Reviewed by: 08/28/2023 16:34:32 CDT

Reviewer Comments: PWL B1 generation

Equipment Related: More than 5 days old

- 04698879 **Ret'd To SOC** **WR/ECHR Created** **CAP** **WR** **CCF** **High Priority WR** **FIN**
- 04699907 **Follow Up** **WR/ECHR Created** **CAP** **WR** **UCR** **High Priority WR** **FIN**

Less than 5 days old

- 04700255 **Follow Up** **WR/ECHR Created** **CAP** **WR** **High Priority WR** **FIN**
- 04700630 **WR/ECHR Created** **CAP** **WR** **UCR**
- 04700663 **WR/ECHR Created** **CAP** **WR** **UCR**
- 04700681 **CAP**
- 04700688 **CAP** **WR** **High Priority WR** **FIN**
- 04700721 **CAP** **WR** **High Priority WR** **FIN**
- 04700762 **CAP** **WR**
- 04700804 **WR/ECHR Created** **CAP** **WR** **CAQ** **UCR**
- 04700812 **WR/ECHR Created** **CAP** **WR** **UCR** **High P** **FIN**
- 04700843 **CAP**
- 04700847 **WR/ECHR Created** **CAP** **WR** **CAQ** **UCR** **High Priority WR** **FIN**
- 04700848 **CAP** **CCF**
- 04700849 **CAP** **WR** **High Priority WR** **FIN**

End User Explainability

Focus on the “why”

- Provide user information on why a specific determination was made
- Indicate similar records to the one being reviewed
- Support final determination process

IR 04698879 - CCF

Flagged for Review: Yes

DataAdvisr has identified this IR as a potential Critical Component Failure.

Last Processed On -Sep-2023

Location: Plant | Unit:

Metrics Exceeded ?

1. The combination of binary, numeric, and textual data had a high confidence.
2. At least one text field was highly indicative of the identified class.

Subject

Received alarm 305 A-4 "Minor Trouble Turbine Control"

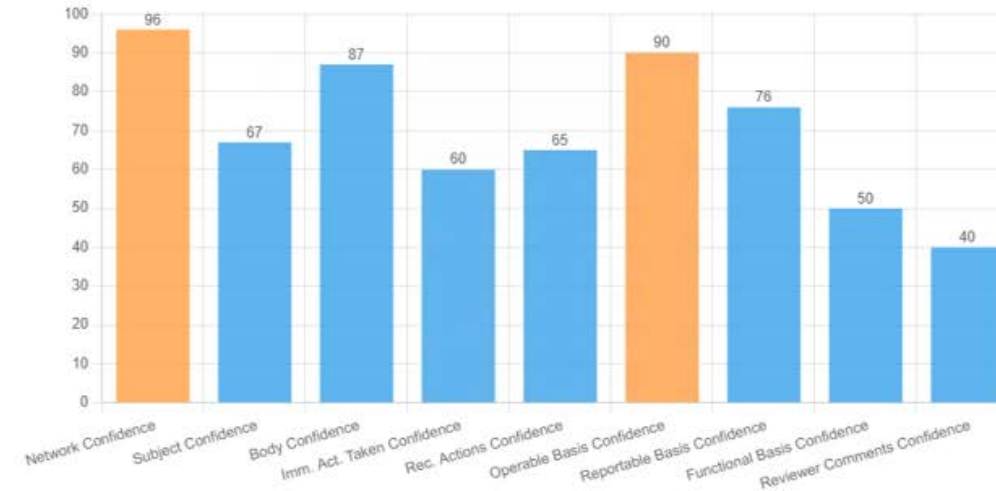
Related IRs ?

Most Similar IRs ?

IR	WR	Facility	Unit	Subject	WR Status	WR Priority	WR Discipline	Score
4515977	01521740			Received alarm 305 A-4, "Minor Trouble Turbine Control"	COMPLETE	B2	IM2	100.00%
4353927	01470955			Received Alarm 005 A-5	COMPLETE	B3	IM3	68.31%
4418363				MCR Received Alarm 005 A-5 Ri-9103C				54.49%
4500393	01517157			Received ALARM 313 A-3 U/3 RECIRC ASD PDC TROUBLE alarm	COMPLETE	C	FN	50.71%
4700433	01546665			Received ALARM 313 A-3 U/3 RECIRC ASD PDC TROUBLE alarm	APPROVED	B2	FINR	50.71%

0 selected / 5 total

Confidence Values ?



Platform Formal Verification and Validation

Focus on the “how”

- Build trust with the end users of the AI algorithms
- Provide licensee confidence in quality of algorithms
- Provide auditors documentation of methods and statistical performance

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CONSTELLATION V&V REPORT
XXXXXX-RPT-XX

Version 1.0
2022

DATA ADVISOR
Data-Driven Incident Report Classifications

JENSEN HUGHES
2020 Kraft Dr., Suite 3020
Blacksburg, VA 24060
USA
+1 540-808-2800
www.jensenhughes.com

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Summary

- Constellation continues to explore and deploy artificial intelligence (AI) to streamline business processes and data-driven decision-making
- Current projects are giving Constellation experience with AI to inform future decisions on the potential value of AI in other areas
- Constellation AI applications are designed to keep subject matter experts fully engaged in the decision-making process

Additional Slides for Q&A



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Definitions

- **Verification** – The process used to ensure that the software is operating consistent with the intended design.
- **Validation** – The process of assessing software performance in a test environment under a range of input conditions in order to quantify the level of performance that can be expected.

Example Verification – Implementation

- **Implementation verification involves the comprehensive testing of each software component and function in a development environment**
 - Coverage
 - Unit Tests
 - Integration Tests

Text Field Cleaning

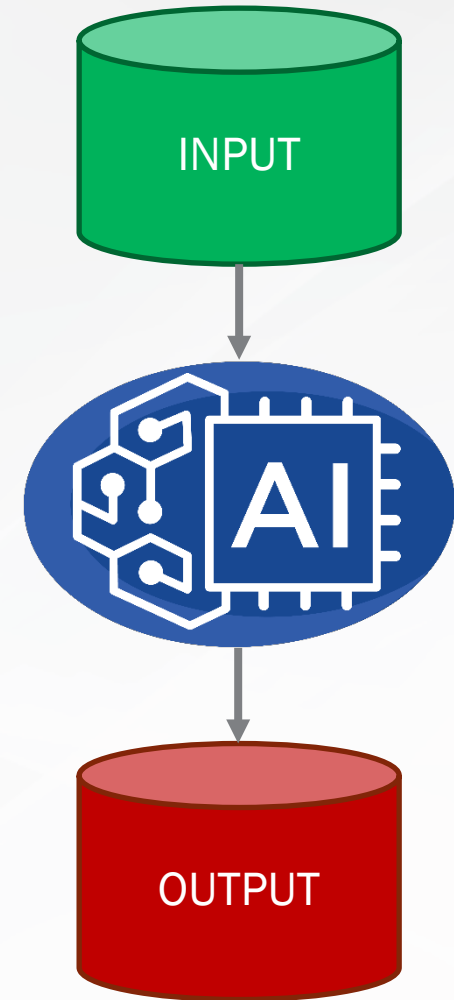
The input text fields in the IRs are cleaned according to the following operations:

1. Remove digits
2. Remove punctuation, brackets, and braces
3. Remove special characters
4. Remove extra spaces
5. Make all text lowercase

Input Text Field	Expected Output Text Field
Plant***reactor***1234567890	plant reactor
.!@#\$%^&*()--_+={}[]\	
GAUGE NOT READING CORRECTLY	gauge not reading correctly
GAGE #4444 --- 20.0	Gage
pressure exceeded	pressure exceeded

Example Verification – Deployment

- Deployment verification applies to an installed instance of the software and focuses on testing summary outputs and features which have external dependencies rather than comprehensive testing
- Is the application being called at specified interval?
- Does the application run to completion?
- Are input/output streams being correctly sent/received?
- Do classification distributions fall within expected ranges?
- Does data sourcing, typing, and processing in production match training?



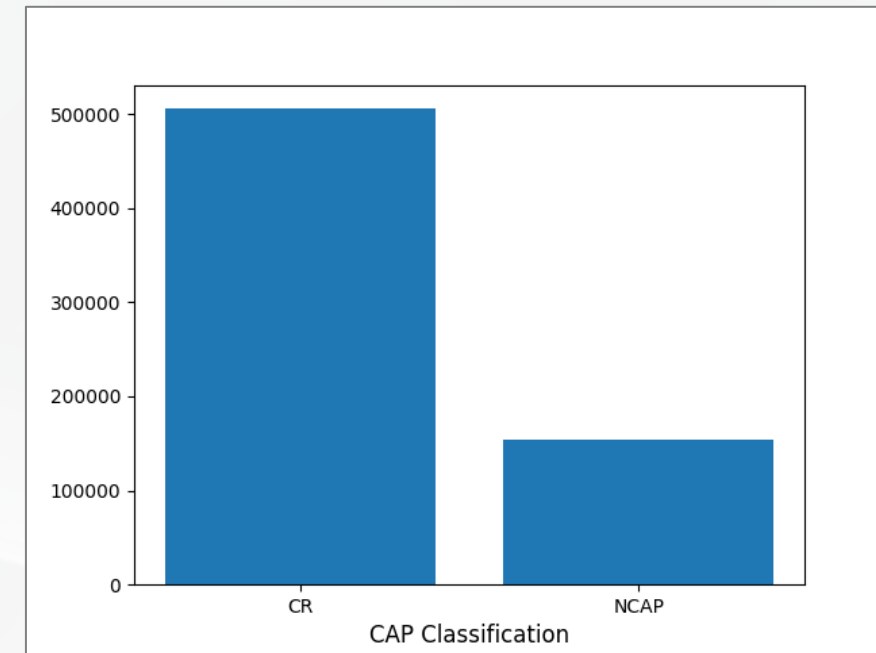
Example Validation – Performance Quantification

- Binary Classification Models can be Evaluated using a Confusion Matrix
- Type I Errors (False Positive)
- Type II Errors (Miss)

	Prediction = 0	Prediction = 1
Truth = 0	True Negatives	False Positives
Truth = 1	Misses	True Positives

$$\text{Miss Rate} = \frac{\text{Misses}}{\text{Positives}} ; \text{FP Rate} = \frac{\text{False Positives}}{\text{Negatives}}$$

- The choice of appropriate performance metric(s) depends on distribution of class values and the cost/benefit of misses and false positives



Example Validation – Sensitivity Analysis

Input Data Variability

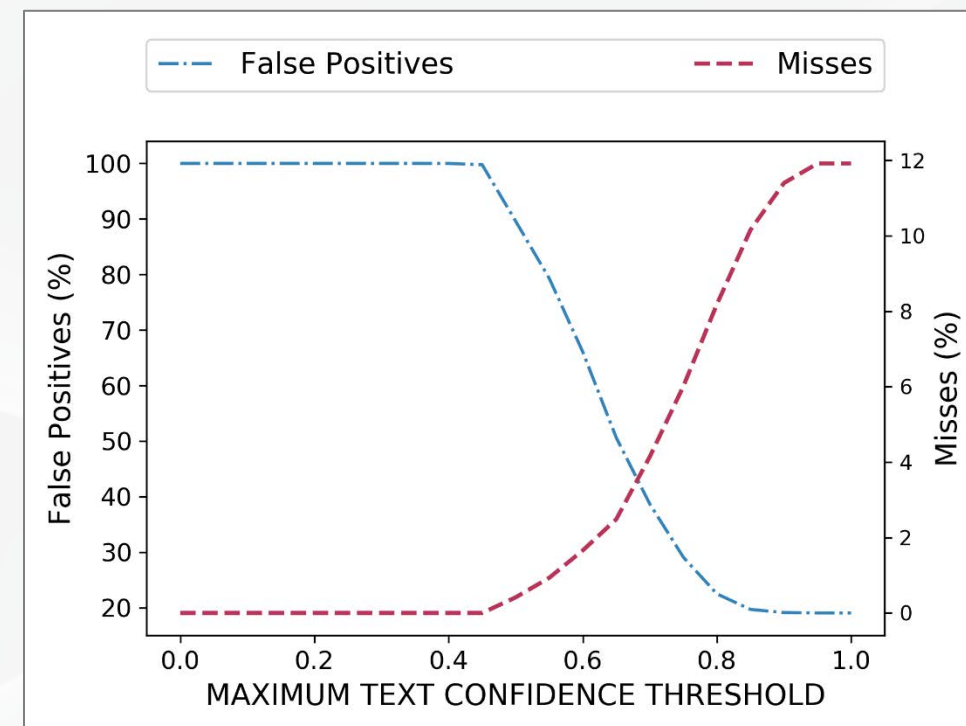
- Validate robustness of models by modifying input data during training and testing

Model Parameter Variability

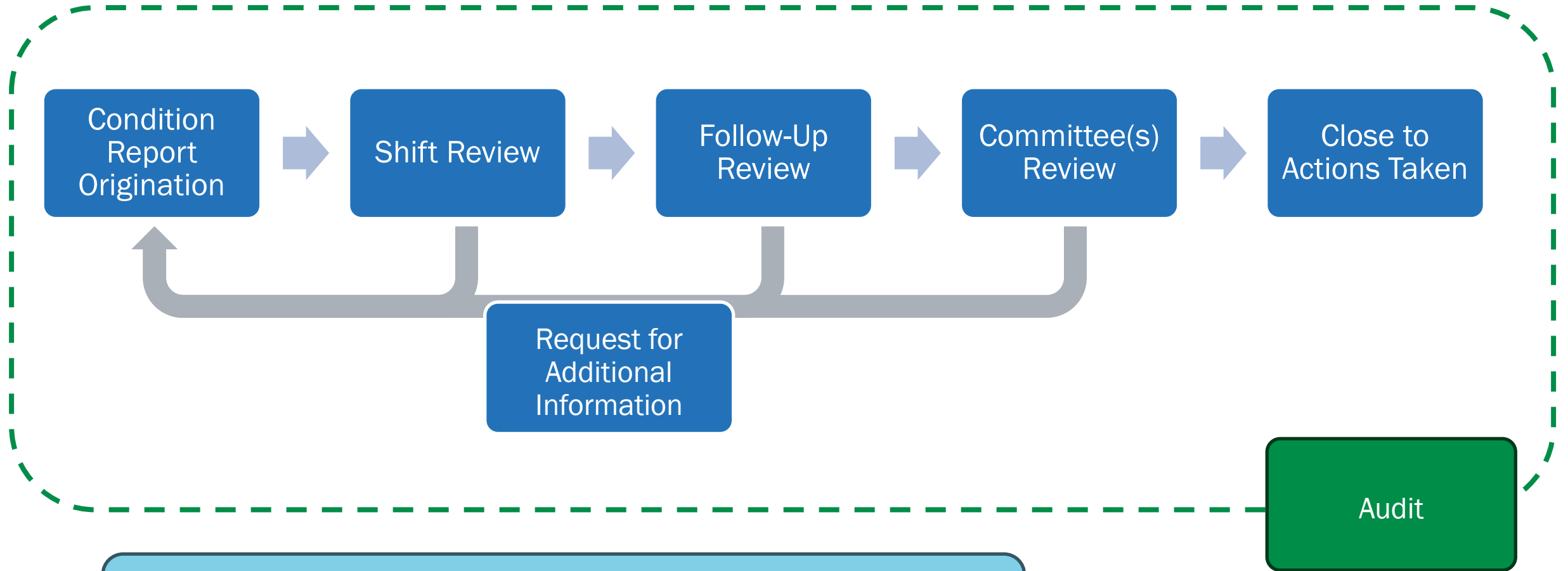
- Validate stability of models by modifying developer-defined hyperparameters
- In addition to validating the platform, parameter sweeps are also useful for optimizing model parameter assignments and identifying problematic aspects of the models

Example baseline performance:

Miss Rate	6.8%
False Positive Rate	25.9%

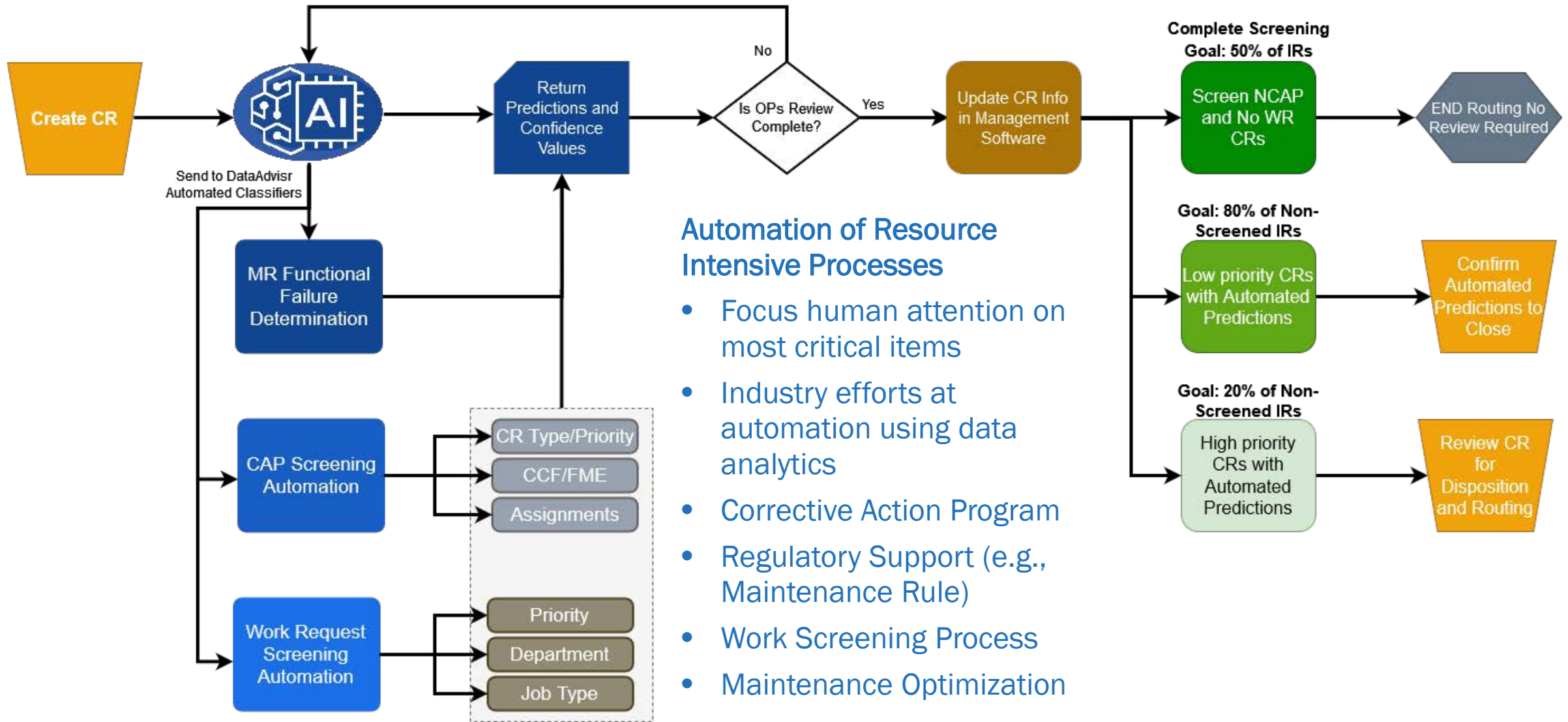


Prior Screening and Disposition Process



Condition Report (CR) process is time consuming and costly.
Estimated man-hours per record X.
ML/AI technologies can provide significant improvements to this process.

AI-Informed Screening Process



Automation of Resource Intensive Processes

- Focus human attention on most critical items
- Industry efforts at automation using data analytics
- Corrective Action Program
- Regulatory Support (e.g., Maintenance Rule)
- Work Screening Process
- Maintenance Optimization

Vision for a Digital Generation Business



Automated Work Processes

Streamlined workforce



Smart Processes

Electronic procedures/work instructions



Decision making through analytics/AI

Faster, more accurate decisions by right level



Field workers instant access to information

No time wasted, improved HU



In-field training through virtual reality and video

More wrench time



Predictive plant performance

Zero transients/trips



Centralized information backbone

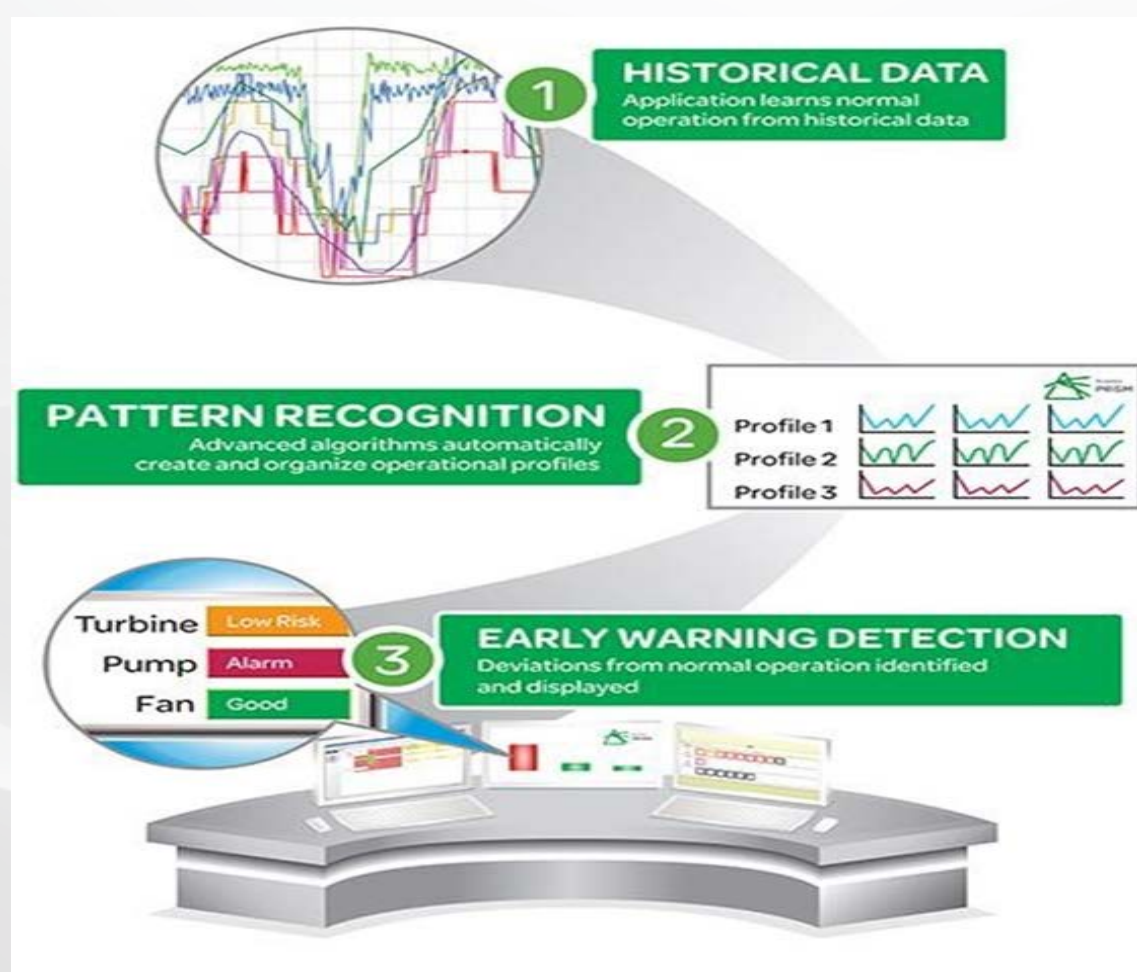
Ability to leverage additional technologies



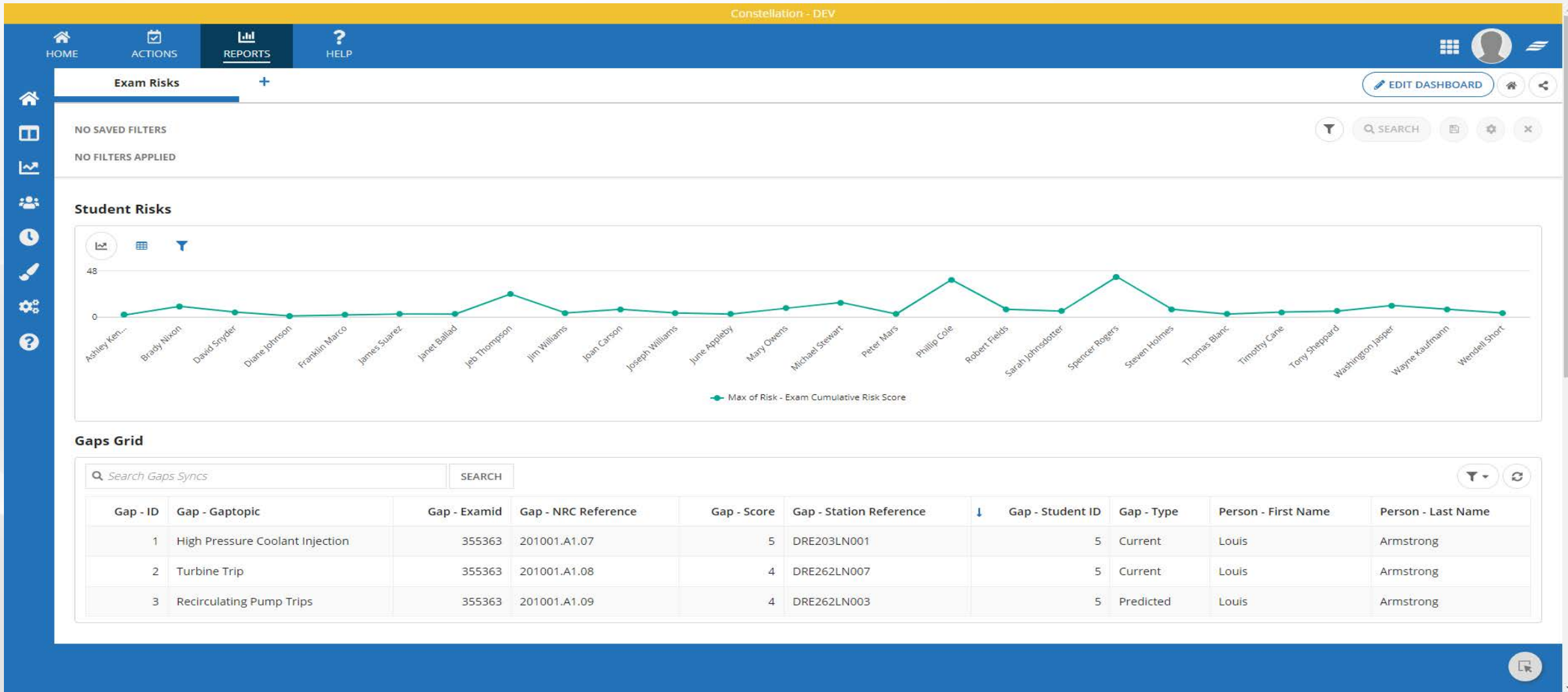
Innovative culture embedded

Workers continuously improving

Equipment Reliability – Advanced Pattern Recognition to Avert Failure



Initial License Training Student Performance



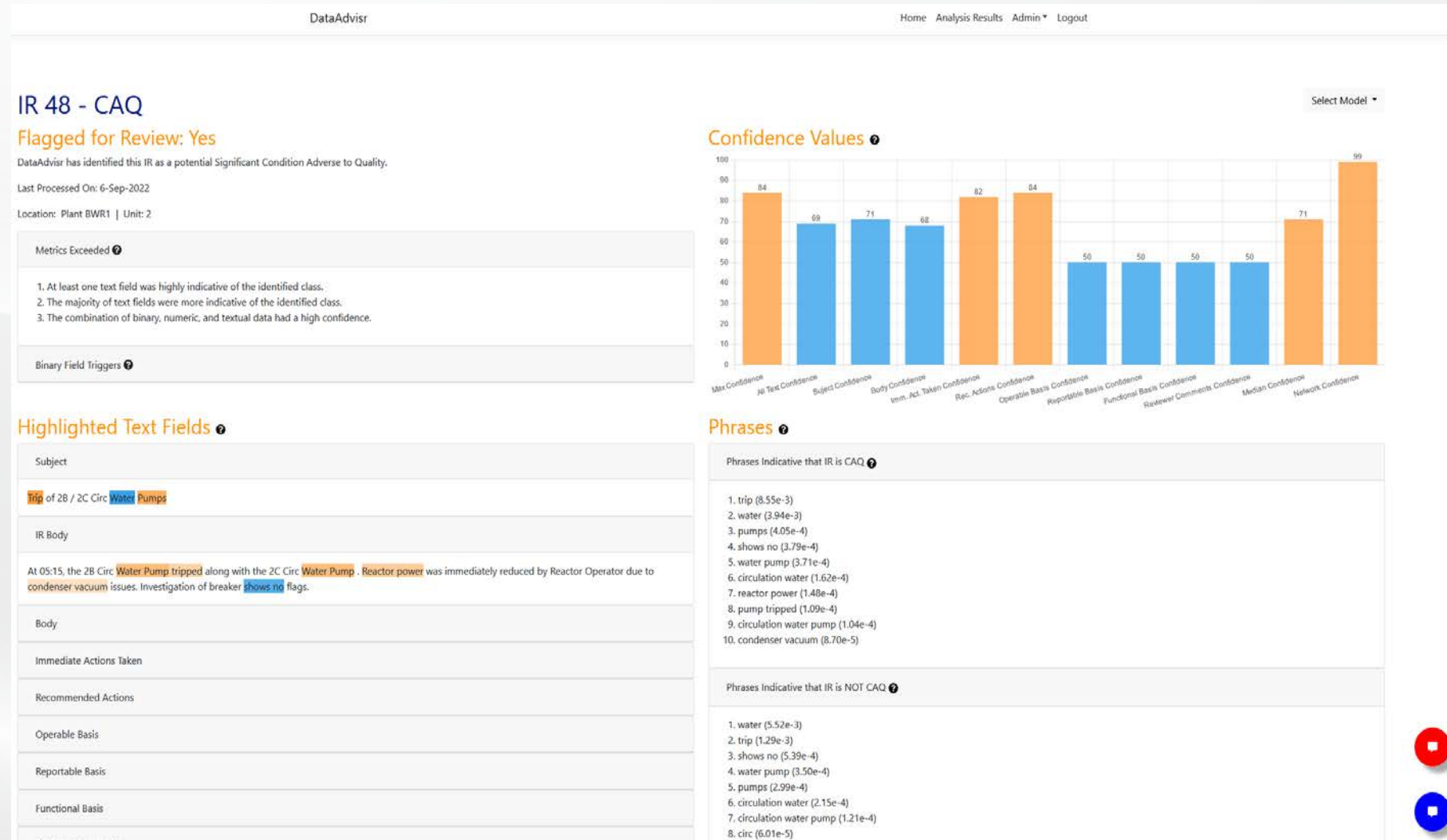
Maintenance Rule Functional Failure Analyzer

- In place successfully for two years
- The software is *not* making failure determinations ... it is pre-screening/flagging potential functional failure CR's for human review
- Biased towards high safety-significant component failures
- Equipment monitoring still occurs (i.e., human element backstopped)
- Confidence in results is gained through continuous feedback

Issue Report Screening Analytic

Displays the “why”

- Summarize data for user review
- Provide users detailed insights into how the predictions were made
- Indicate potentially similar IRs to the one being reviewed
- Orange means over the threshold for review; blue wouldn't trigger the need for a review



Future Analytics

- Predictive analytics – *Work Order generation*
- Corrective Action Program – *Predictive trending to avert operational challenges*
- Advanced equipment performance analytics – *avert equipment failure and operational risk*
- Outage schedule predictions – *improve outage schedule adherence*
- No intent to apply artificial intelligence to control the plant