



Digital Solutions and Remote M&D for Gas Compression

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Reciprocating Compression, GE Oil & Gas

Imagination at work

Transforming Industrial Operations

Asset Performance Management



Maximize performance and asset availability

Operations Optimization



Increase system efficiency across operations

Digital Twin/Digital Thread



Optimize lifecycle of design, manufacturing, service, & repair cycles

Creating
New Value

1

Improved operational performance and efficiency

2

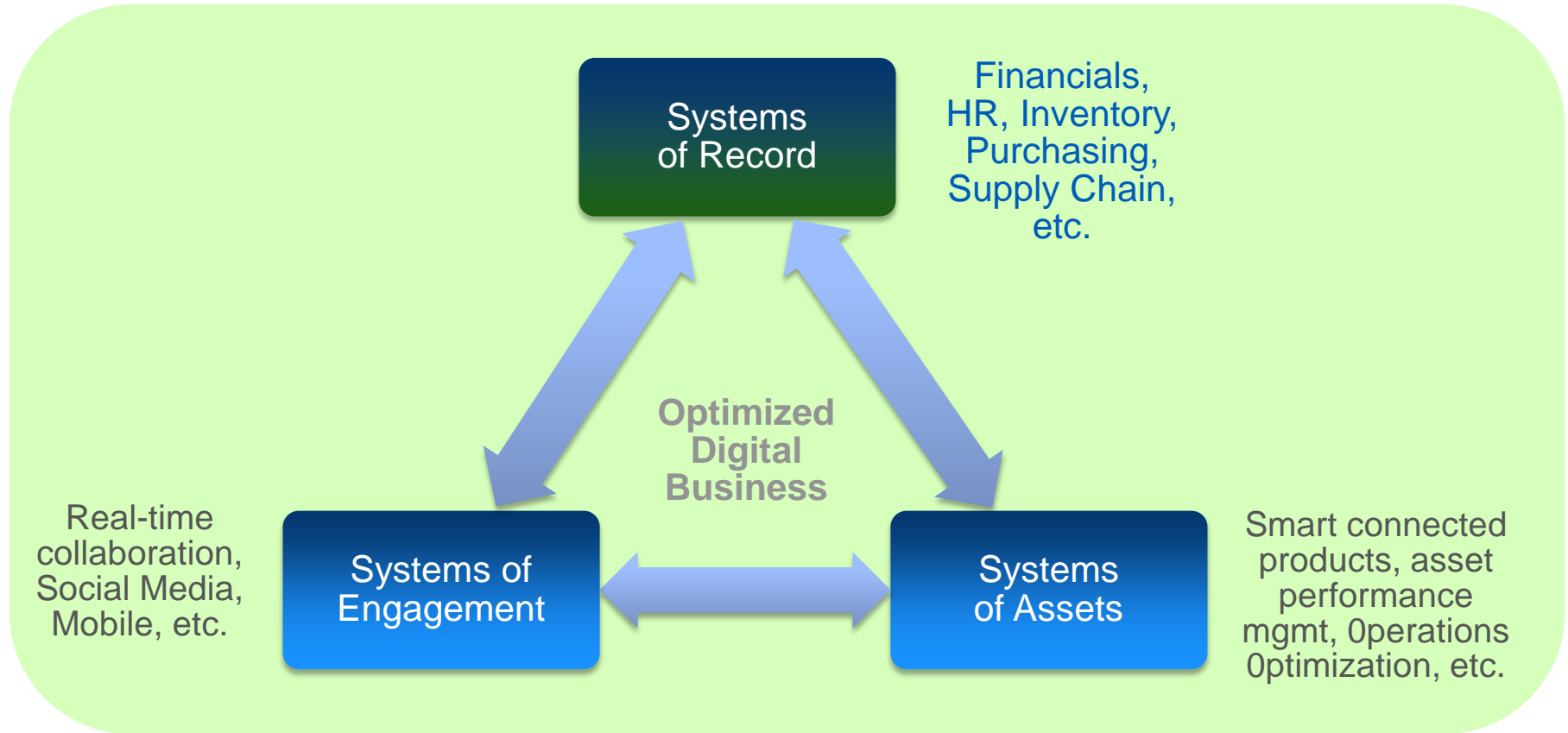
New customer services and business models

3

Continuous innovation and faster time to market



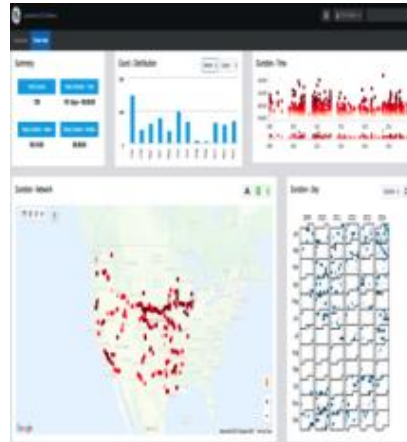
Operational Excellence is Key to Business Optimization



Asset-centric industries have the most to gain from the next wave of disruptive digital innovation



GE's Digital Industrial Journey



OIL & GAS

- Maximize Production
- Predictive Maintenance
- Remote Collaboration
- Reduced Risk
- Environmental Control

POWER GENERATION

- Maximize Production
- Longer Repair Intervals
- Reduce Emissions
- Predictive Maintenance
- Longer Asset Life

POWER DISTRIBUTION

- Revenue Protection
- Meter Health
- Power Quality
- Load Forecasting
- Predictive Maintenance

WIND

- Maximize Farm Power
- Wind Wake Protection
- Outage Detection
- Continuous Operation

WATER

- Operational Integrity
- Minimize Water Use
- Control Emissions
- Minimize Cost

AVIATION

- Maximize Fuel Use
- Risk Management
- Predictive Maintenance
- Efficient Operations
- Customer Satisfaction

RAIL

- Maximize Fuel Use
- Enhanced Operation
- Network Velocity
- Predictive Maintenance
- Supplier Collaboration

HEALTHCARE

- Patient Experience
- Improved Hand Hygiene
- Cost Reduction
- Efficient Operations
- Regulatory Compliance

MANUFACTURING

- Cost Reduction
- Consumer Protection
- Efficient Operations
- Regulatory Compliance
- Predictive Maintenance

MINING

- Maximize Production
- Efficient Operations
- Safe Operations
- Predictive Maintenance



The Need for a New Kind of Platform

Strategic Inflection Point: How to rapidly develop, manage, and secure Industrial IoT apps and services?



Industrial-grade
technology



Optimized for asset
data models and
operational
workflows



Designed for
Industrial Big Data
and Analytics



Modern
Development tools
for faster Innovation



Predix™ : Purpose Built for Industrial IoT

Cloud-based platform for Industrial Internet

Connected Assets

Industrial Data Management

Industrial Data Science

Cloud & Mobile



Optimized for Industrial Requirements

Asset Performance Mgmt

Operations Optimization

Industrial Analytics

Digital Twin



Reliability

Increase availability and longer asset life



Cost Reduction

Lower operating costs with greater efficiencies



Risk Mitigation

Lower operations and financial risk



Profitable Growth

Increase production for market advancement



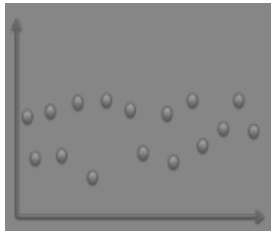
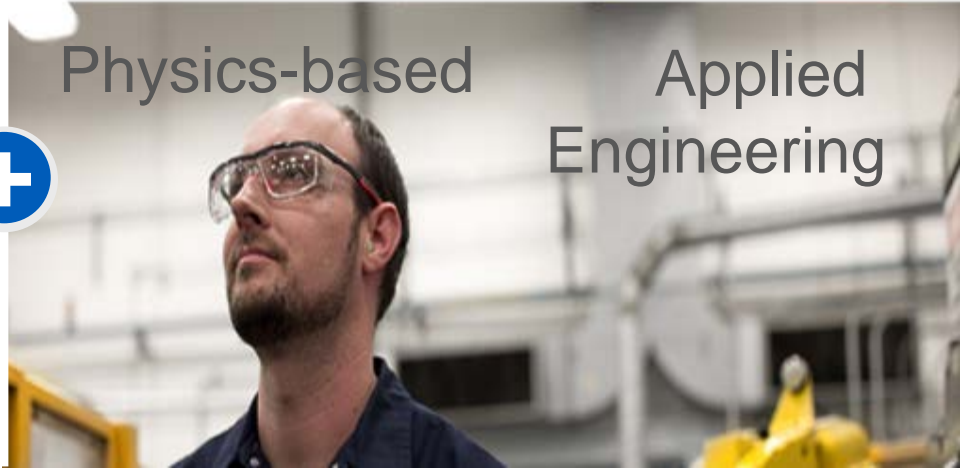
Predix and Industrial Analytics

Advanced Data Science

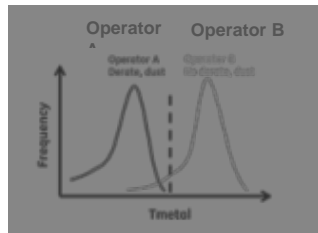


Physics-based

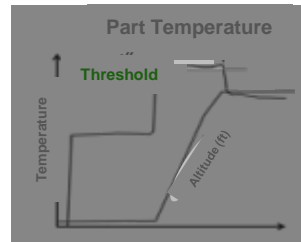
Applied Engineering



Data
Continuous,
accessible



Statistics
Identify trends
and anomalies



Physics
Apply asset
and domain
expertise

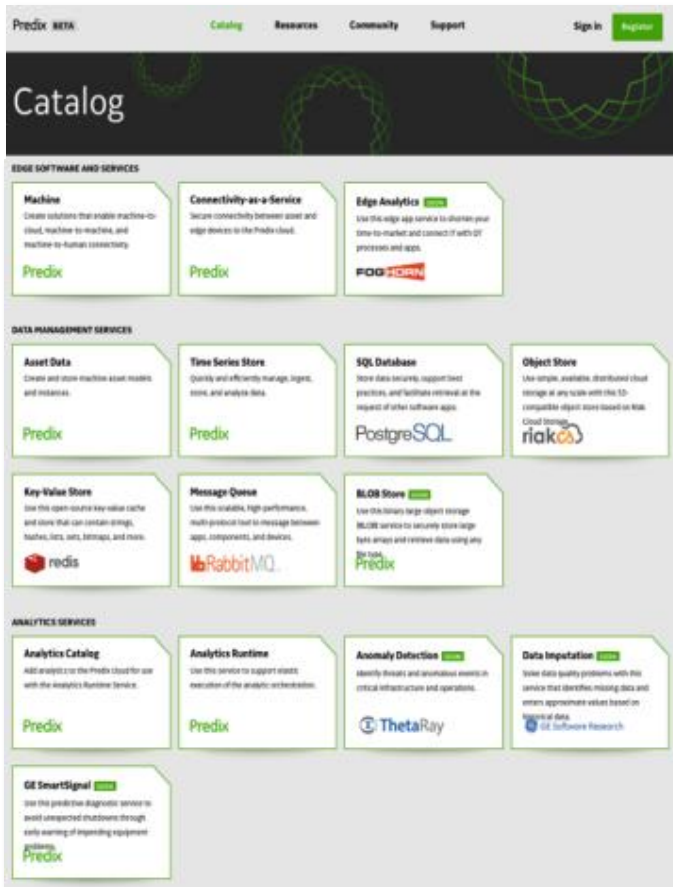


Industrial Outcomes

One platform for OT
and IT teams to
collaborate and
innovate



Predix Catalog and Marketplace



GE and 3rd-party Services...

User Account and Authorization

Use this service for a full-featured OAuth 2.0 authorization server.

Predix

Access Control Service

Use this service to provide a more powerful framework than basic User Account and Authorization.

Predix

SQL Database

Store data securely, support best practices, and facilitate retrieval at the request of other software apps.

PostgreSQL

Message Queue

Use this scalable, high-performance, multi-protocol tool to message between apps, components, and devices.

RabbitMQ

Asset Data

Create and store machine asset models and instances.

Predix

Time Series Store

Quickly and efficiently manage, ingest, store, and analyze data.

Predix

Logging

Manage all your app logs and save, search, and visualize them.

logstash

Key-Value Store

Use this open-source key-value cache and store that can contain strings, hashes, lists, sets, bitmaps, and more.

redis

Views

Control layout and components within your client-side web or mobile app.

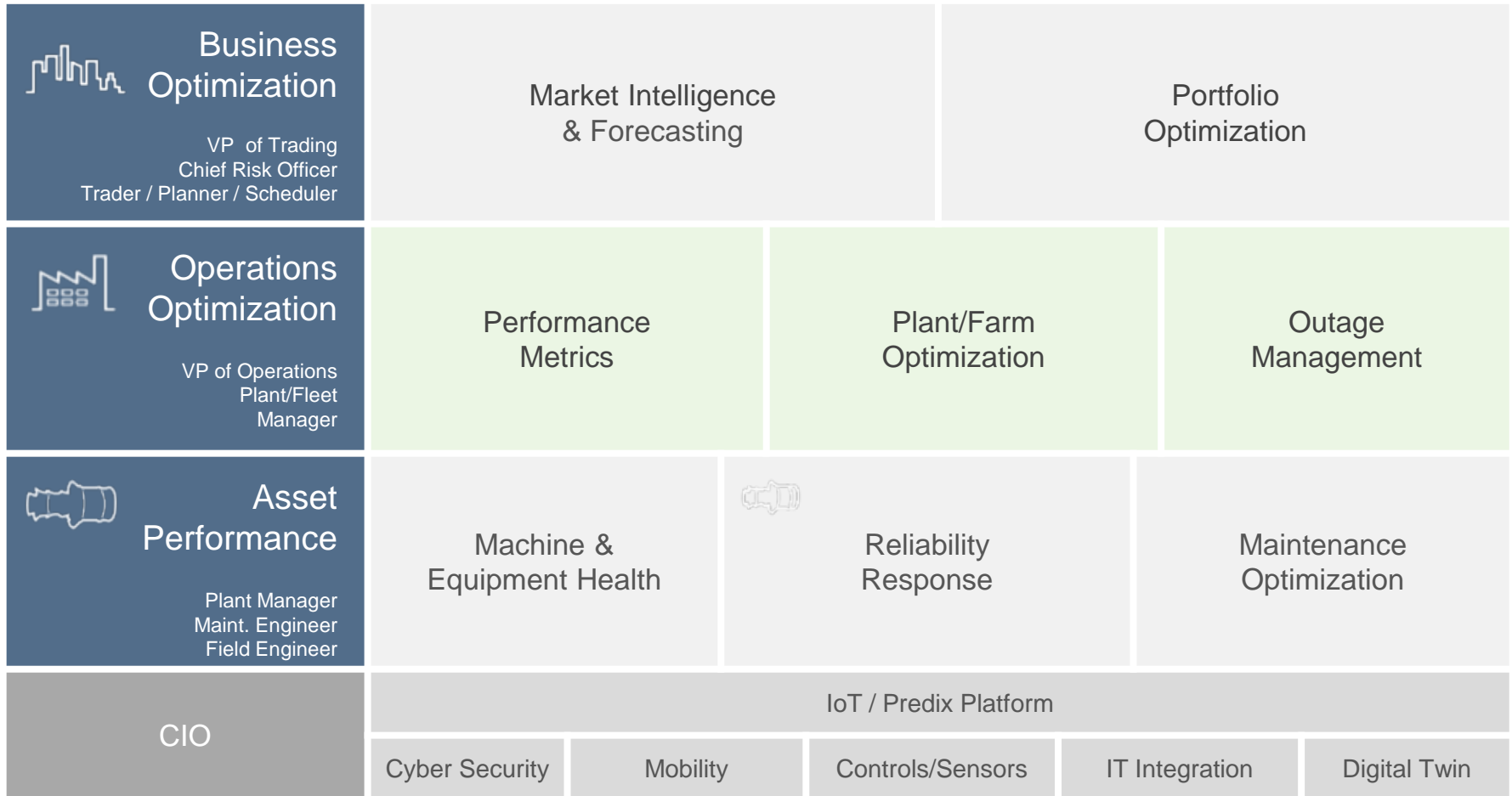
Predix



Our Approach



How do we Think About it Strategically



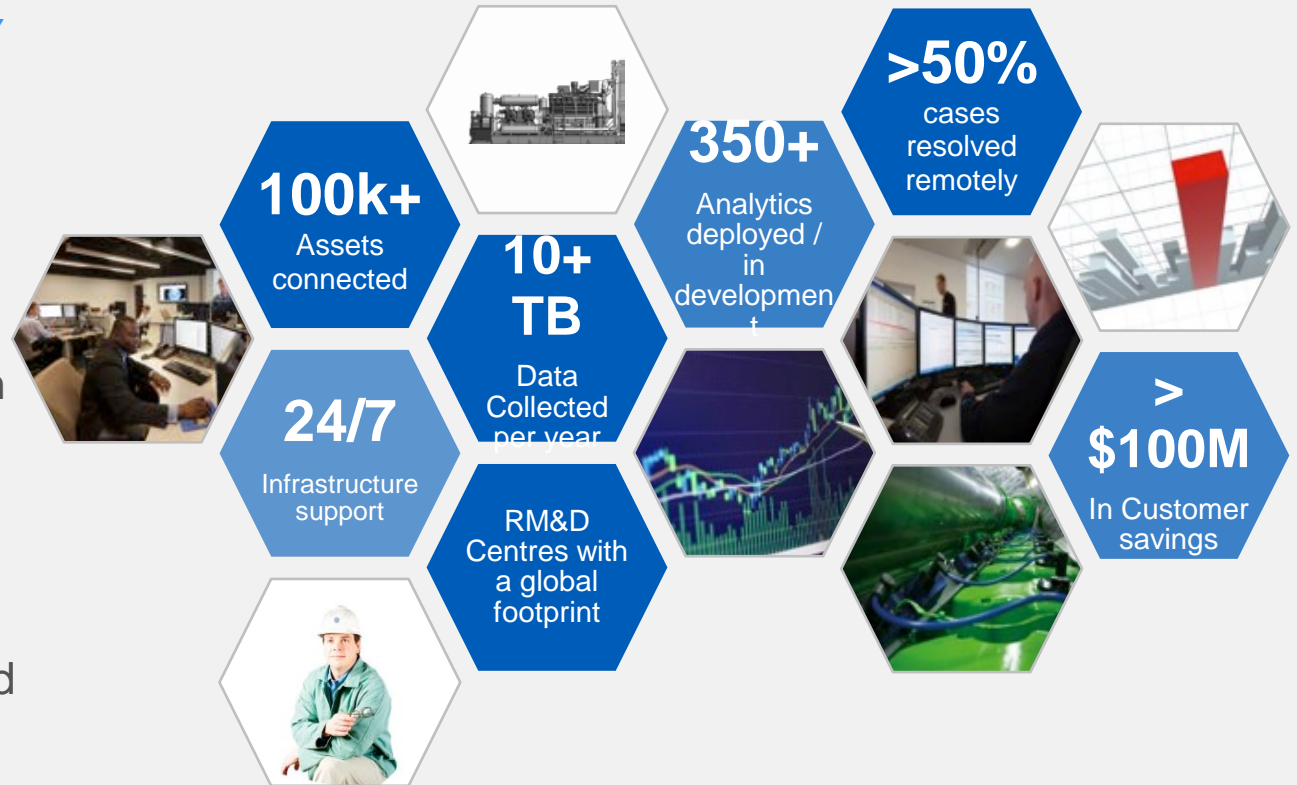
Asset Performance Management (APM)

<p style="text-align: center;">Asset Performance Management (APM)</p> <p>Asset Manager Plant Manager Central Engineering</p>	Machine & Equipment Health	Reliability Management		Maintenance Optimization		
	Connectivity	Predictive Diagnostics		Performance Benchmarking		
	Anomaly Detection	Notification Management		Asset Maintenance Strategy/ Scenarios		
	Asset Condition Monitor	Case Management		Financially Optimized Asset Strategy		
	Data Work Bench	Response Management		Work Scoping & Prioritization		
	Analytics Work Bench	Knowledge Management		Inventory Optimization		
	Integrated OT + IT Platform					
	Cyber Security	Digital Twins	Mobility	Controls	IT Integration	

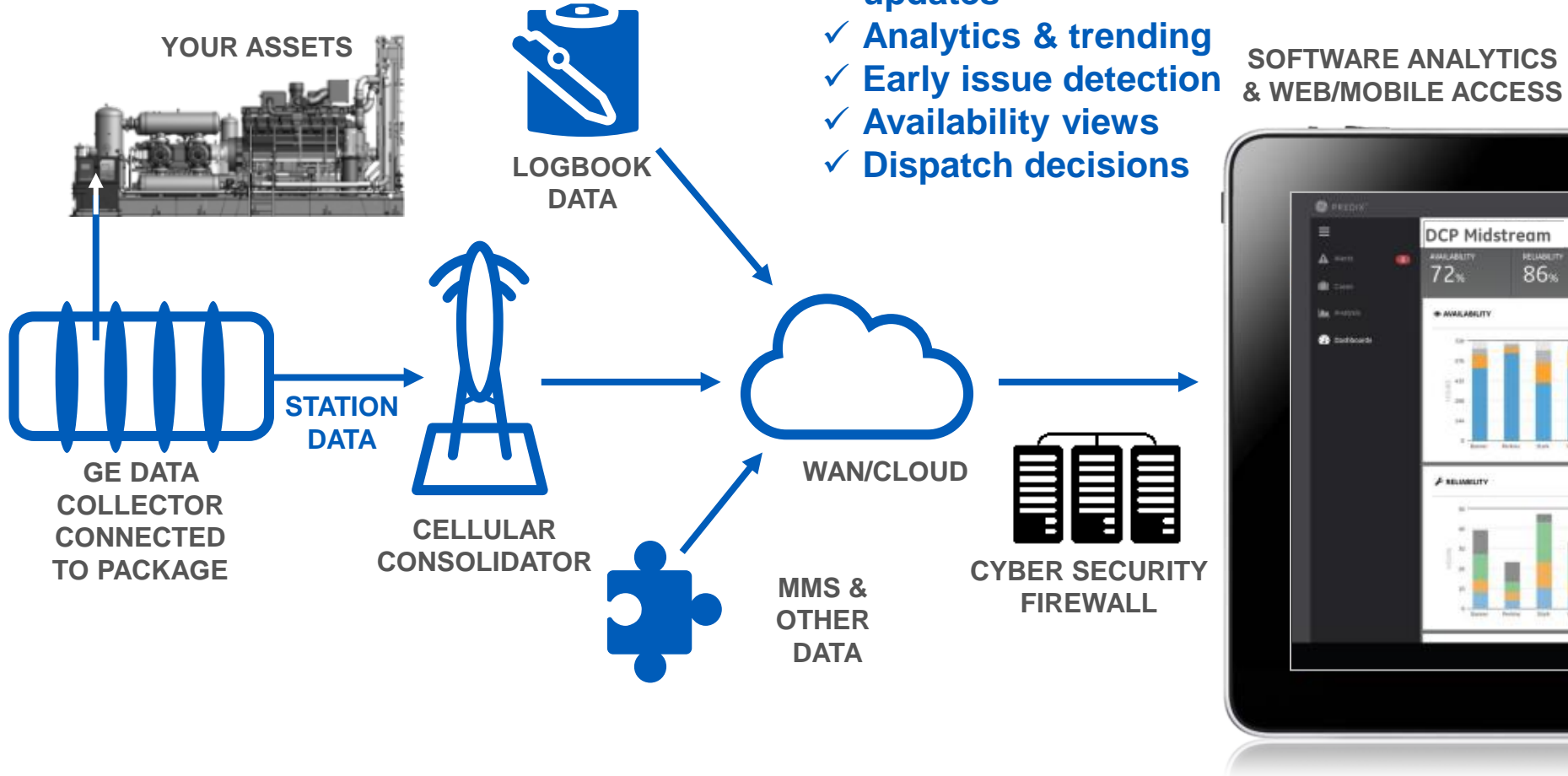


GE Digital Industrial Key Metrics

- Drive **RELIABILITY** with early issue detection & preventive maintenance
- Increase **AVAILABILITY** with OEM backed issue resolution
- Improve **PERFORMANCE** with diagnostics and recommendations



Deploying an asset performance management system



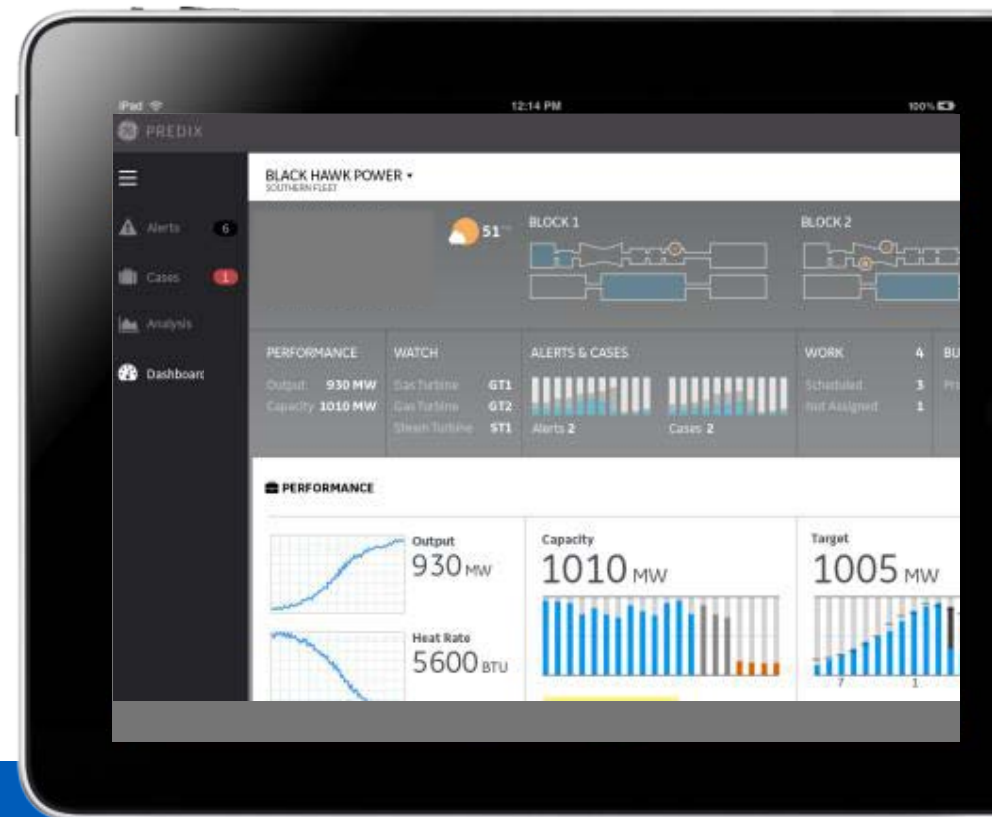
Implementation



Step 1. Data consolidation & asset visibility

- Stream package data
- Disposition downtime (e.g. planned vs unplanned)
- Transition from uptime to availability management
- Enable onsite/mobile field automation tools (iPad or M-health)

up to **1-2%**
INCREASED
AVAILABILITY



Making decisions... simpler & faster

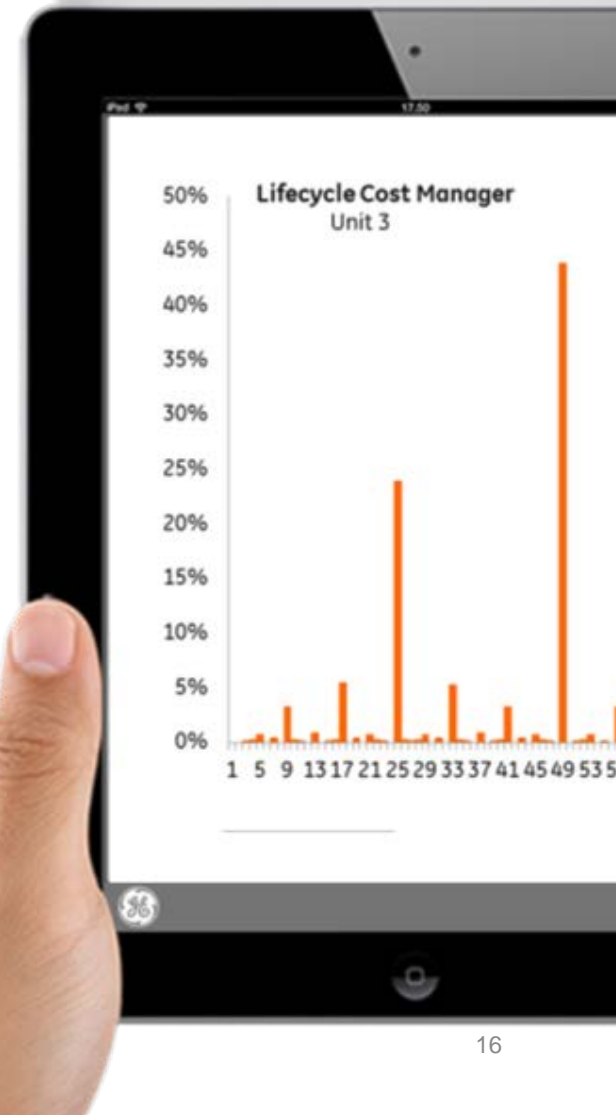


Step 2. Scheduled maintenance optimization

- Implement case management
- Integrate MMS, API/Micro services
- Advanced decision-making for capital expenses (pocket automation, piston mods, compressor bore changes, etc)
- Improved alignment and potential extension of PM intervals of plant assets

up to **2-3%** + **2-3%**
LOWER OPERATING COSTS INCREASED AVAILABILITY

Making decisions in new ways to enable greater productivity



Step 3. Unplanned downtime reduction

- Case management system
- Continuous improvement processing
- Monitoring and diagnostics tooling and services
- Unscheduled/forced-outage downtime & callouts reduced through predictive analytics
- Active emissions optimization



Minimize
production
loss



Prevent
additional
maintenance
cycles

up to **3-5%** + **1-2%**
LOWER OPERATING COSTS INCREASED AVAILABILITY

The most advanced decision making... turning unplanned into planned



Customer value, case studies and analytics



Business Case in Gathering & Processing

Value drivers: Productivity + maintenance cost ↓ + vol. flow



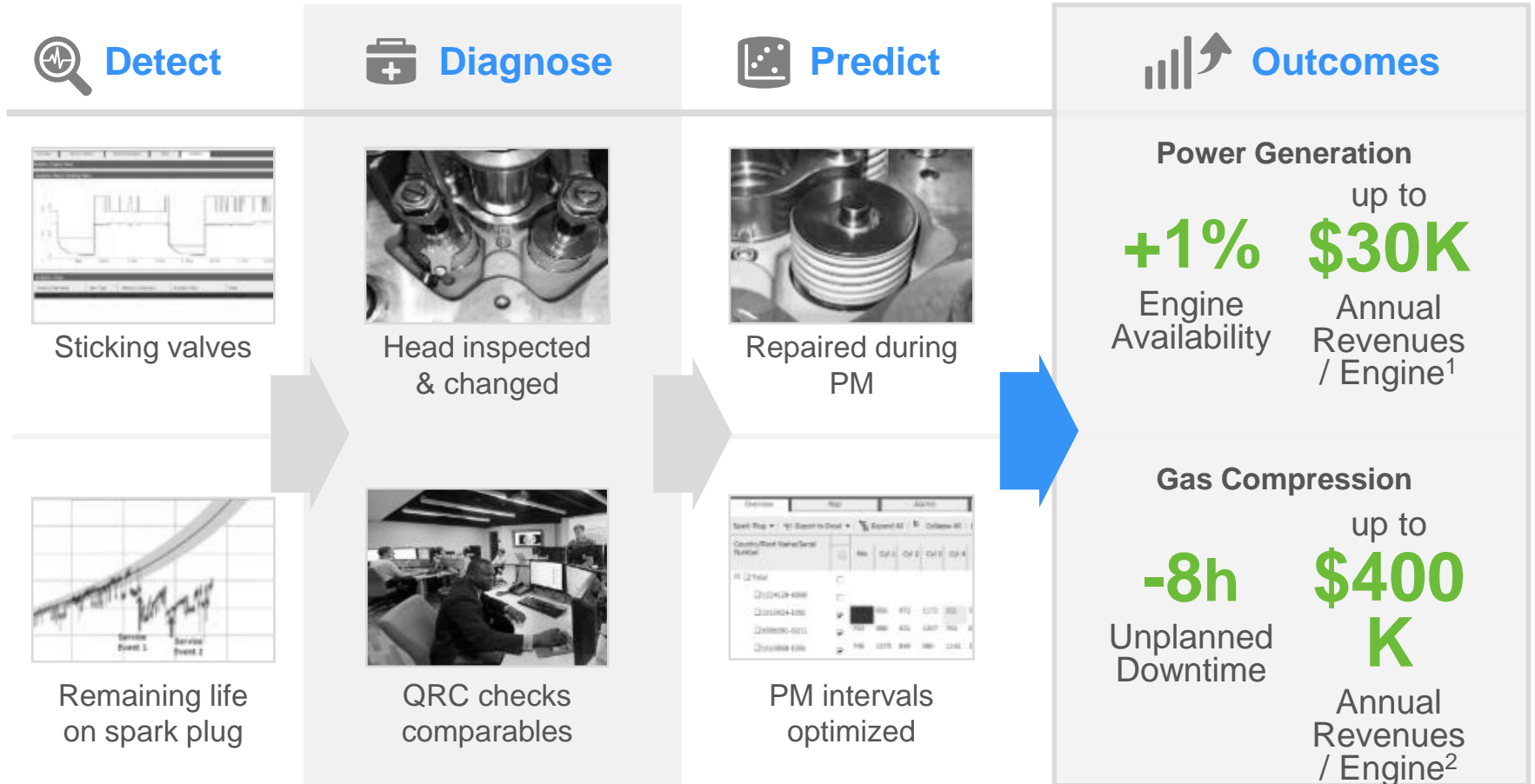
Field Operator Productivity	Maintenance cost reduction	Volumetric Flow increase
<p>Value prop Level 1: Remote asset visibility</p> <ul style="list-style-type: none"> • Avg FO site visits/day: 10 – 20 • Avg. visits/site: 1 per day • Avg. distance btn sites: 15 miles • Avg. # pkgs/site: 4 • Avg. work-hours/day: 10 hrs • Avg. FO rate: \$80/hr <p>• Outcome: 1 site visit/week</p> <p>• Savings: \$2.8k/pkg/yr</p>	<p>Value prop Level 2: Maintenance extension analytics</p> <ul style="list-style-type: none"> • Avg maint. cost/engine: \$90/hp/yr * • Avg. engine hp: 900hp • Avg. maint. cost/engine: \$81k/yr • Compressor maint. Cost: \$27k/yr (1/3rd) * • Total maint. Cost: \$108k/pkg/yr <p>• Outcome: 10% ↓ in maint. cost</p> <p>• Savings: \$10.8k/pkg/yr</p>	<p>Value prop Level 3: Flow optimization</p> <ul style="list-style-type: none"> • Avg. engine hp: 900 • Industry metric: 110hp/mmscfd * • Customer margin: \$ 0.2/mmbtu • Total margin/engine: \$ 500k/yr <p>• Outcome: 10% ↑ in flow</p> <p>• Addn. margin: \$50k/pkg/yr</p>
<p>Total customer margin ↑ per package: \$ 63.6k</p>		

Note: This is an illustrative example of potential value drivers and benefits

* Source: Spears & Associates, Inc.



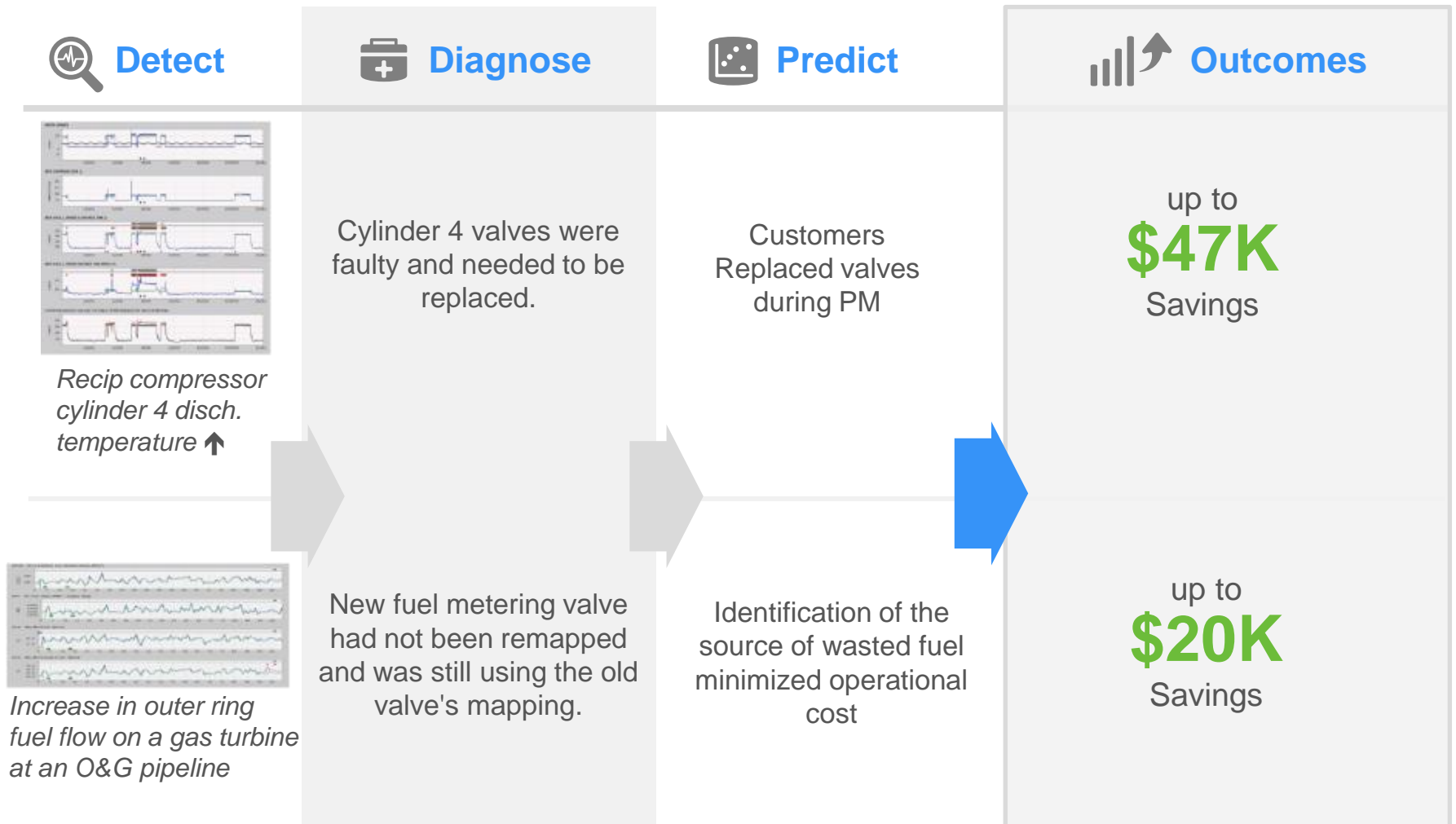
Increasing Customer Value with Analytics...



¹ – Jenbacher Engine: Analytic based on exhaust gas temp. worst case piston failure scenario, 4 days to repair, excl. collateral damage
² – Waukesha Engine: Analytic based on ignition voltage, highly utilized gas compression unit, \$50K/hour revenue generated



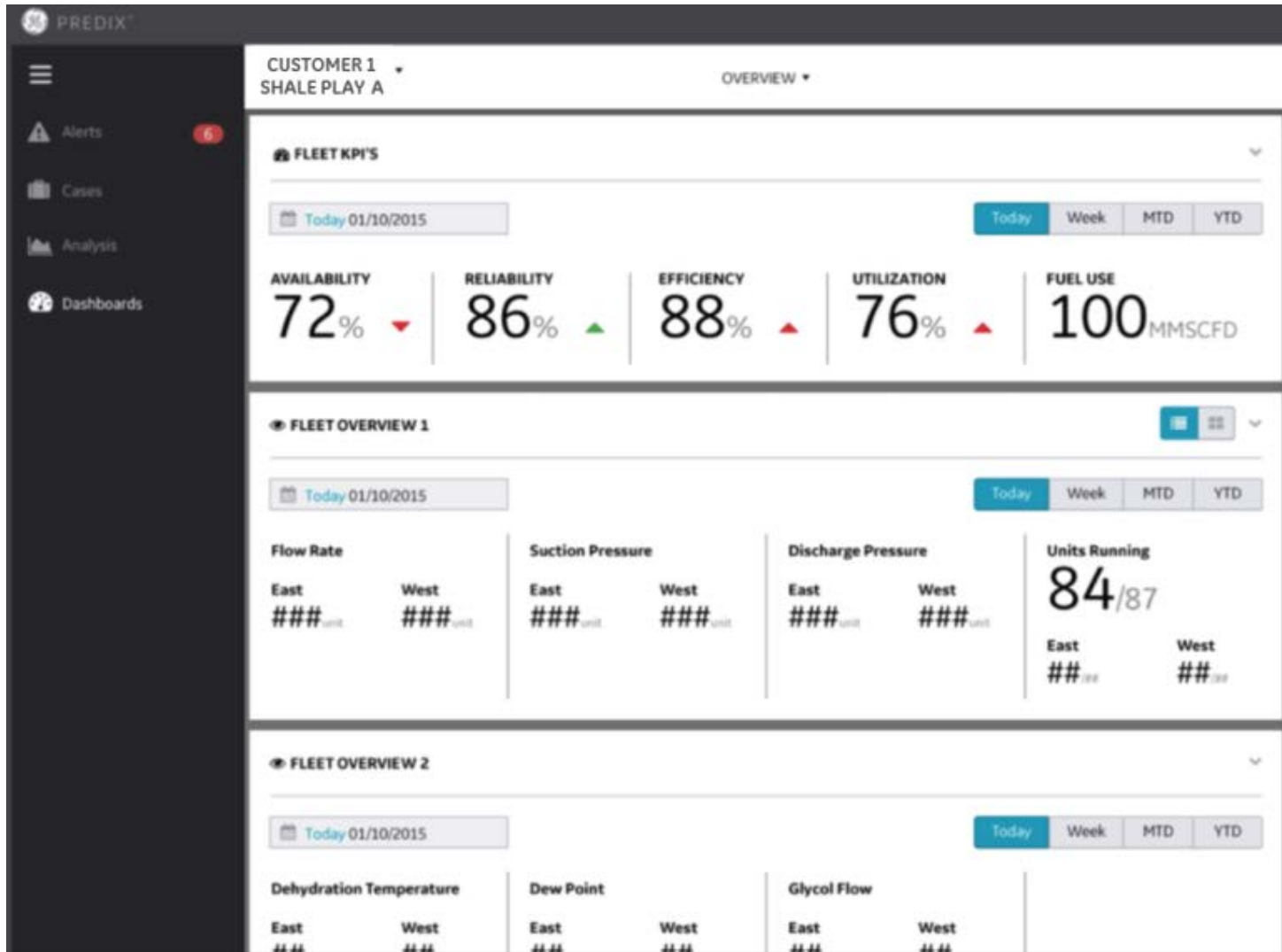
Increasing Customer Value with Analytics...



Gas Compression Dashboards



Fleet Overview



Station Selection

The screenshot displays the PREDIX interface for 'CUSTOMER 1 SHALE PLAY A'. The left sidebar contains navigation options: Alerts, Cases, Analysis, and Dashboards. The main content area shows a breadcrumb trail 'USA > SHALE PLAY A > Station 1' and a table of assets. The 'Station 1' entry is highlighted in blue with an 'OPEN' button. Below the table, there are two performance dashboards. The first dashboard, titled '01/10/2015', shows 'Flow Rate', 'Suction Pressure', 'Discharge Pressure', and 'Units Running' (84/187). The second dashboard, titled '01/10/2015', shows 'Dehydration Temperature', 'Dew Point', and 'Glycol Flow'. Both dashboards have 'East' and 'West' columns with placeholder values '###'.

SHALE PLAY	Asset	Asset ID
SHALE PLAY B	Q	ASSET 1
SHALE PLAY C	R	ASSET 2
SHALE PLAY A	Station 1	ASSET 3
SHALE PLAY D	T	ASSET 4
SHALE PLAY E	U	ASSET 5
SHALE PLAY F	V	
SHALE PLAY G	W	
SHALE PLAY H	X	
SHALE PLAY J	Y	
	Z	

Performance Metrics (01/10/2015)

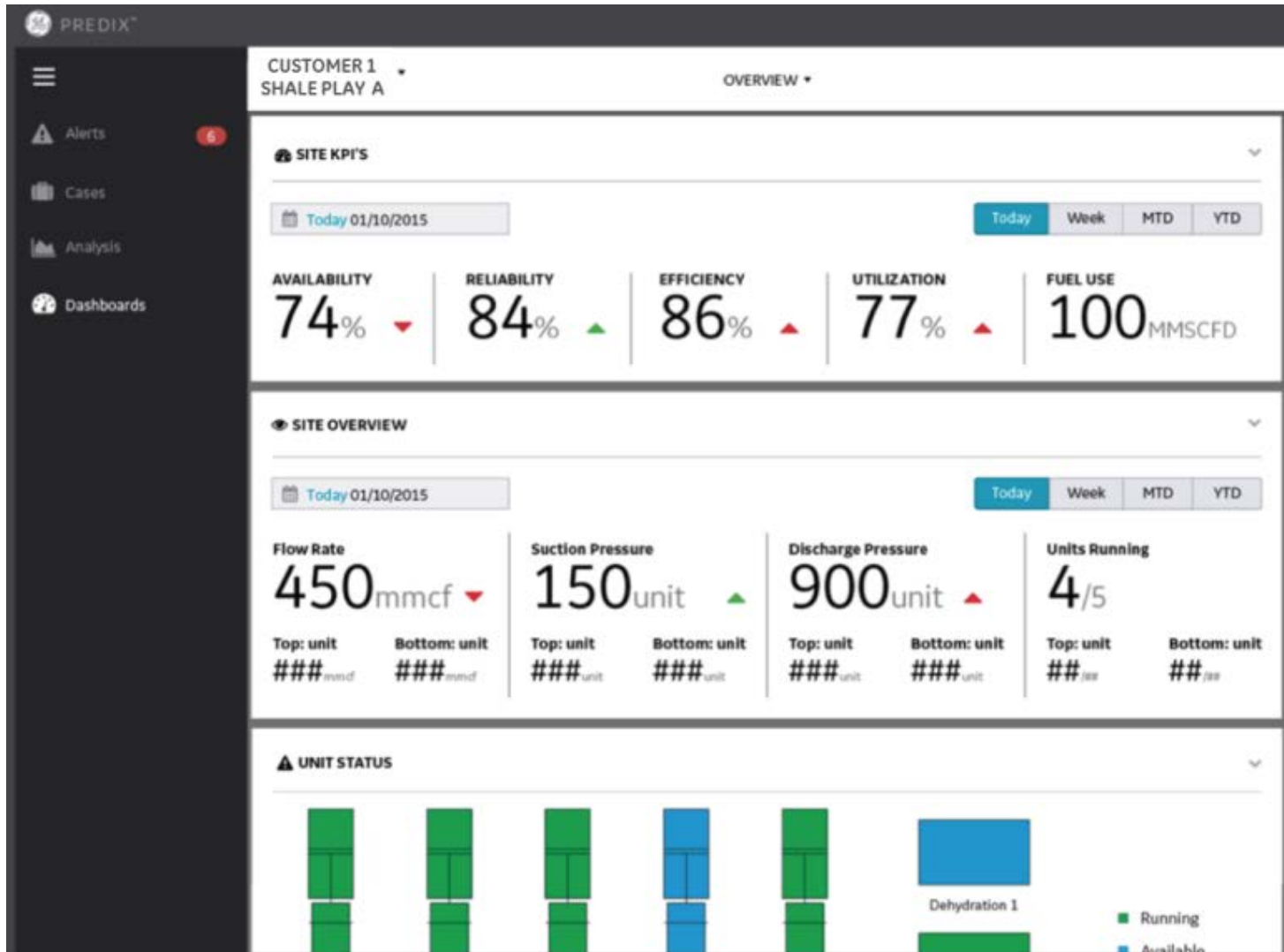
Flow Rate	Suction Pressure	Discharge Pressure	Units Running
East: ### West: ###	East: ### West: ###	East: ### West: ###	84/187

FLEET OVERVIEW 2 (01/10/2015)

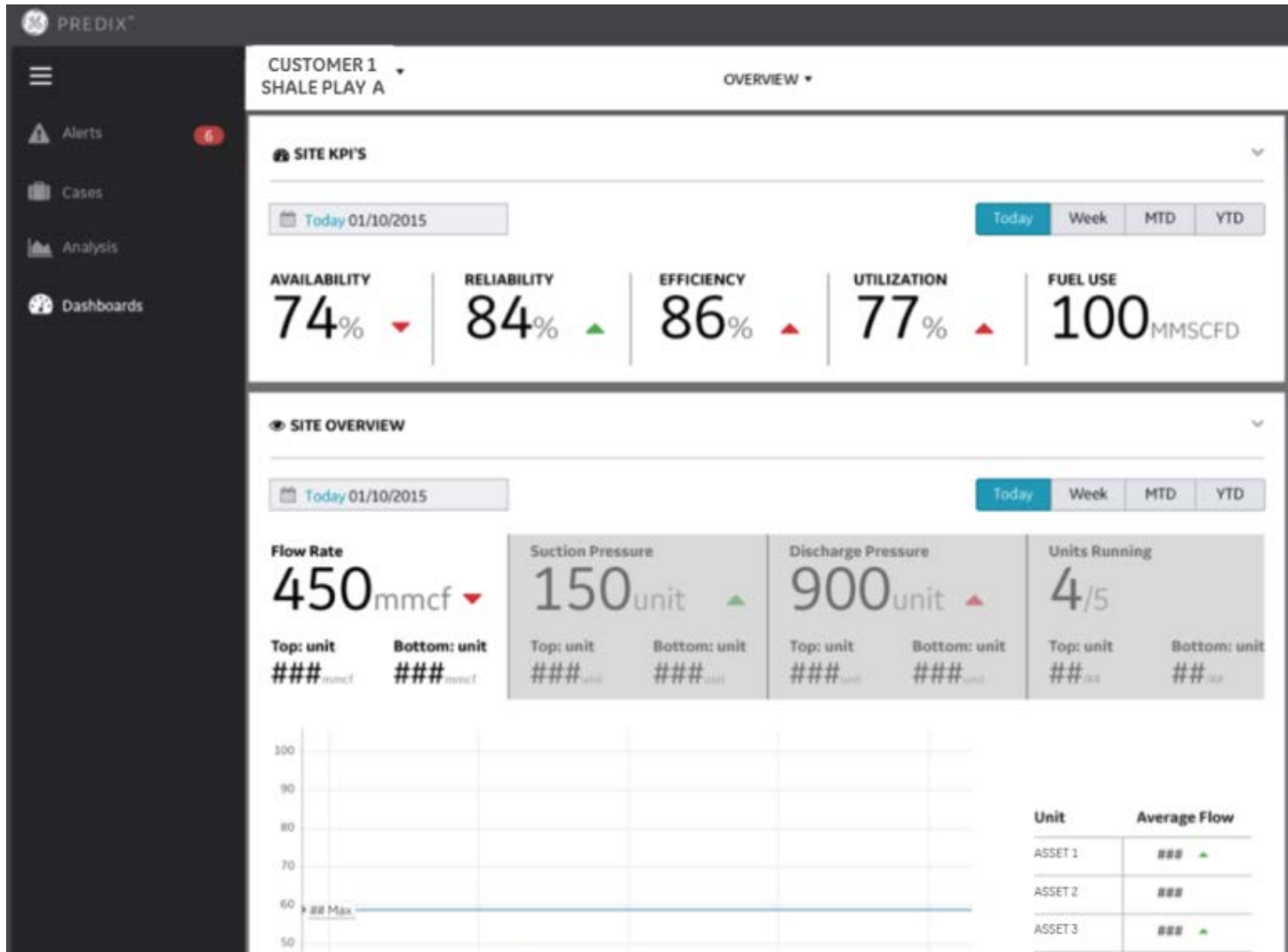
Dehydration Temperature	Dew Point	Glycol Flow
East: ## West: ##	East: ## West: ##	East: ## West: ##



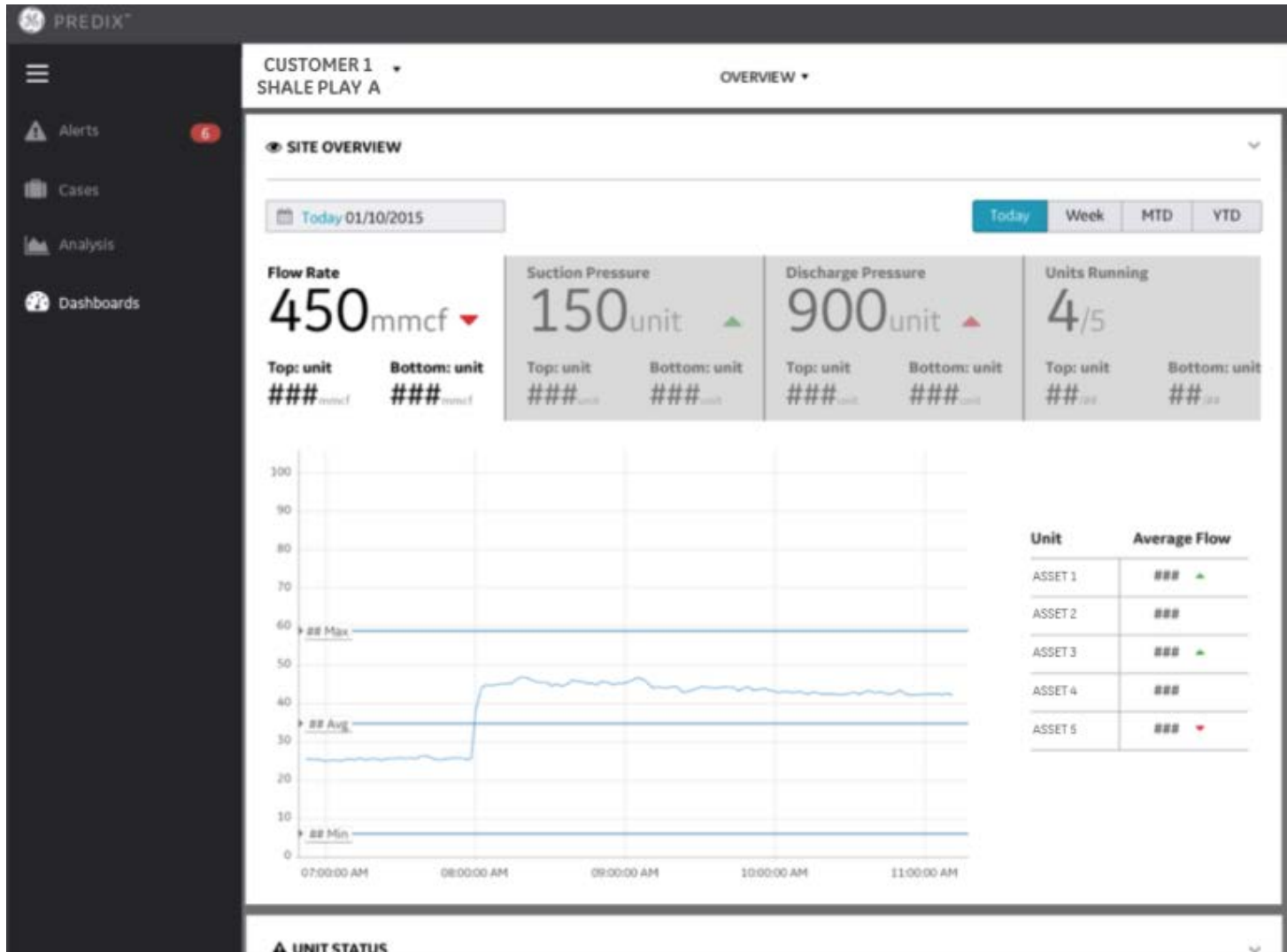
Station Overview - 1



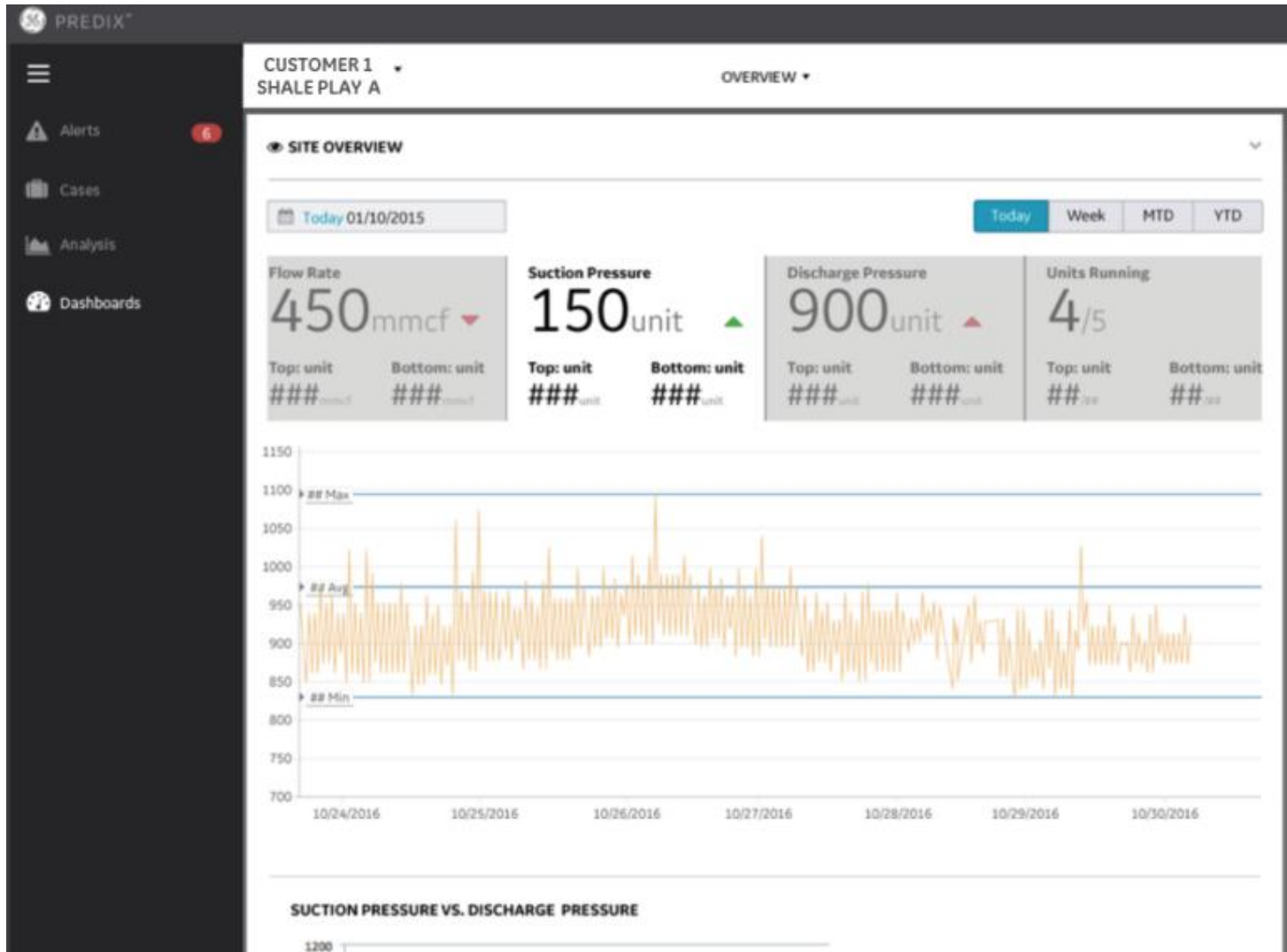
Station Overview - 2



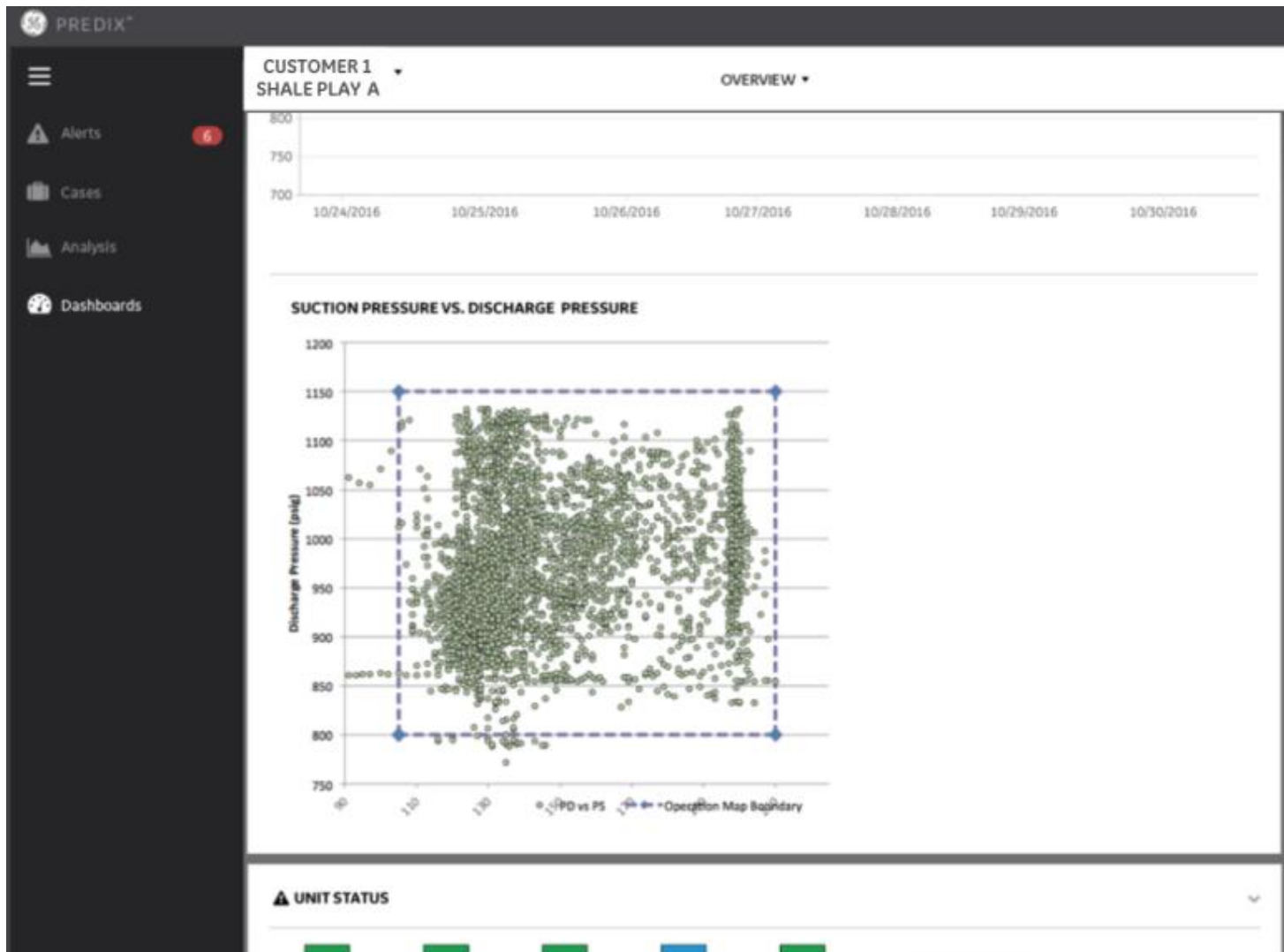
Station Overview - 3



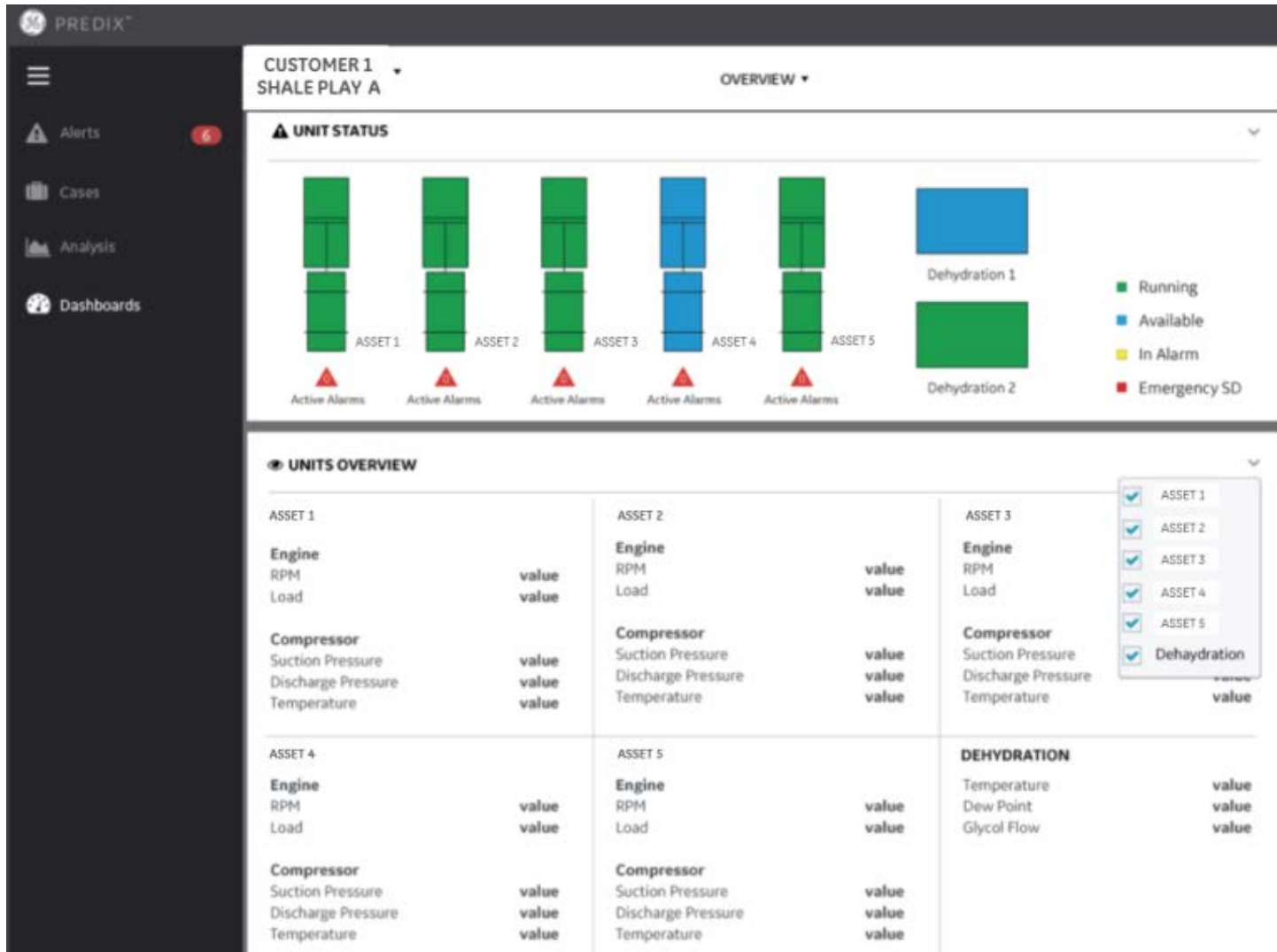
Station Overview - 4



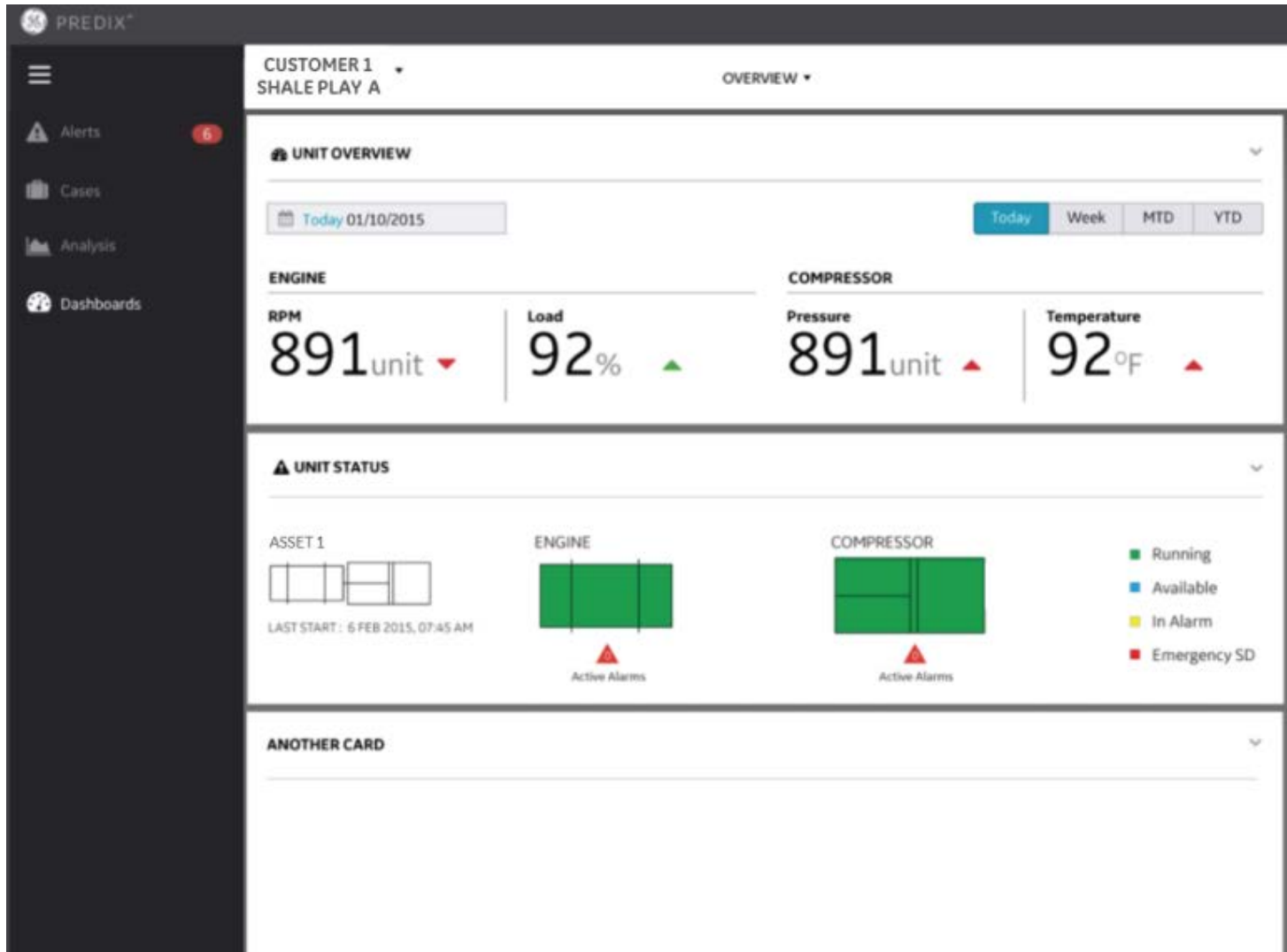
Suction vs Discharge Pressure View



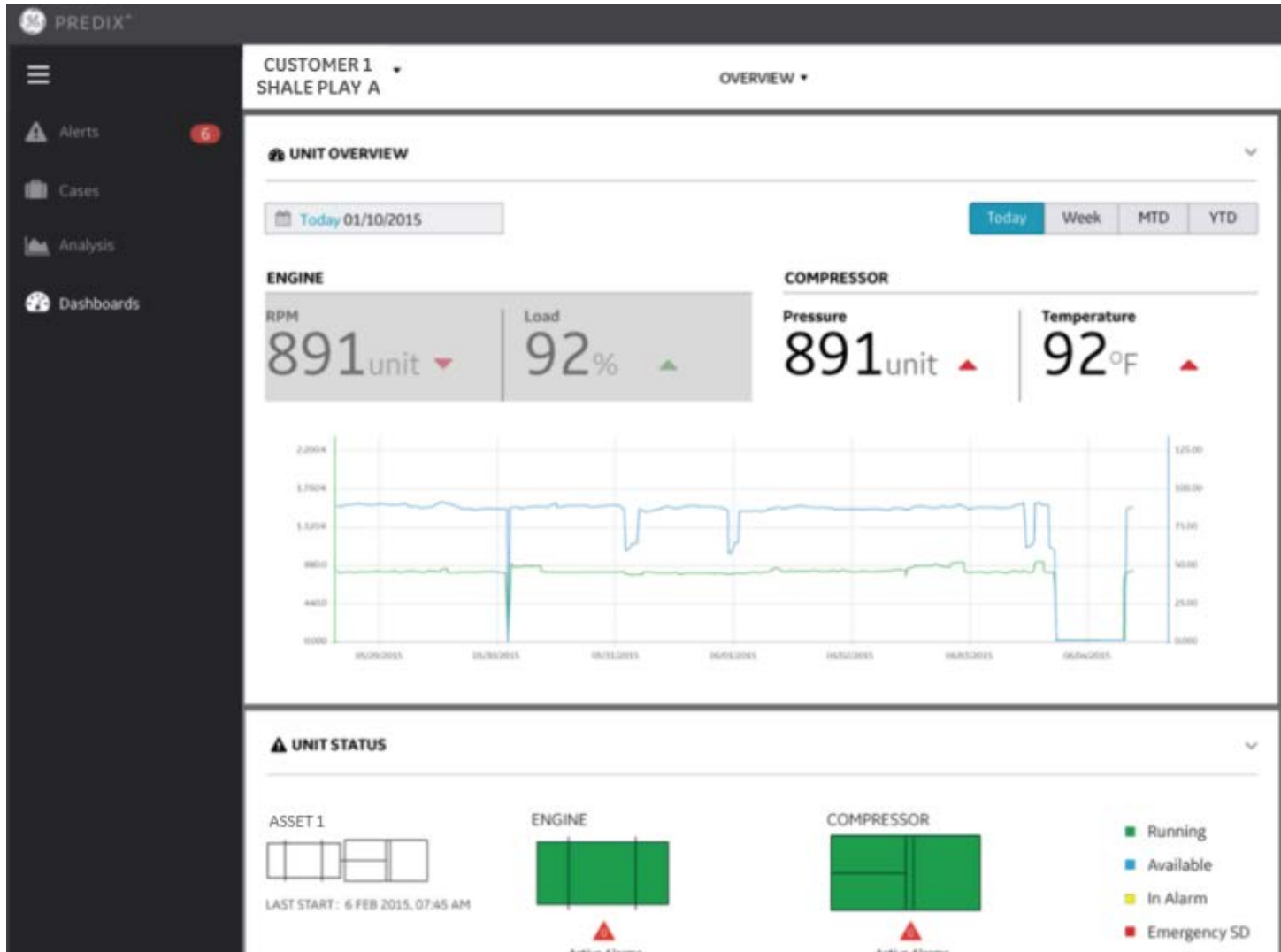
Station and Units Level Details



Unit / Compression Package Overview - 1



Unit / Compression Package Overview - 2



For more information, please contact:



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