2017 Annual Conference & Centennial Celebration Technology Panel

Timothy Albers, Director, Marketing & Product Management, Nidec Motor Corporation
William Marscher, President, Mechanical Solutions, Inc.
Seth Morris, Director of Sales, SparkCognition
Today’s Panelists

• Timothy Albers, Director, Marketing & Product Management
  Nidec Motor Corporation

• William Marscher, President
  Mechanical Solutions, Inc.

• Seth Morris, Director of Sales
  SparkCognition
Nidec Corporate Profile

- Founded: July 1973
- Head Office: Kyoto, Japan
- Employees: Approx. 100,000
- Operations in 32 countries through 230 companies
- Publicly Traded: NYSE since 2001, Tokyo SE since 1988
- FY15 Sales $11B – FY17 Est $14B
- Market Cap: Approx. ¥ 2 T ($ 20 B)
- Business: World of “Spinning & Moving”

Precision manufacturer of motors and fans for IT/consumer electronics, office equipment, automotive, appliance, commercial and industrial applications. Also produces electronic/optical components and machinery.
Nidec’s Strategic Goal – Vision 2020

Becoming a Solution Company that supports people’s lives and the global environment.

- A new world is coming where connections between things and between people and things dramatically change people’s lives and society.

“Nidec connects people with things by providing products that spin and move, that enrich people’s lives, and that contribute to the conservation of the global environment.”
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Nidec’s Strategic Goal – Vision 2020

The spread of IoT is accelerated as motors used around the world are equipped with microcomputers/telecommunication capabilities.

Transportation (Cars, airplanes, ships, and railways)
Manufacturing (Factories and production lines)
Energy (Electricity and water)
Offices and households (PCs and appliances)

The Internet

Analytical engines

External data sources (Environmental data, etc.)
Internal data sources (Production data, etc.)

Analyze collected data and create new additional value

Message

The Nidec Group ships to the world 300 million motors each month. These motors, when connected to networks, create significant value. For example, Professor Jun Murai of Keio University said 20 years ago, “The time will come when you’ll be able to understand the extent of precipitation in any given place in the world by analyzing the movement of vehicles’ windshield wipers.” Such a prediction will now become reality. Likewise, analyzing the operation of motors in the world will yield new ideas on industrial and economic trends. Also, controlling motors to operate optimally will lead to a significant reduction in power consumption. Intelligent motors thus have great potential to transform society.

Yasushi Fukunaga
First Senior Vice President, General Manager of Nidec Research and Development Center, Japan
Market Driver – Energy and Industrial Revolution

We are facing two revolutions: an **energy revolution** and the **fourth industrial revolution**.

- The first is driven by environmental and energy independence concerns through **energy conservation** and the addition and integration of distributed, less predictable and intermittent **renewable energy sources**.
- The second is driven by an explosion of **data**, **computing power** and ubiquitous connectivity between machines and people, fusing the real world with the technological world.

- **Combination of Internet of Things (IoT) technologies, big data platforms and predictive analytics tools.**
- **The transition to a digital economy is going to change the way we do business, impacting us, our suppliers and partners, clients and end-users.**
What Is Driving Demand For ECM & VFD

End User Comfort
- Controlled Pump Flow or Pressure ensures pump operates to system requirements
- Low speed capability allows quiet, efficient constant flow
- Pump Flow & Pressure control adds value in residential and commercial systems

Energy Efficiency
- High efficiency lowers energy usage, especially in continuous operation
- Reduced wattage required to meet higher SEER ratings or Pump Efficiency Standards
- ECMs maintain efficiency across speed range

Green Initiatives
- Commercial building programs (LEED) reward use of higher efficiency motors
- Utilities incentivizing use of EC motors to lower demand
- Building engineers see EC as simple way to lower energy usage
- Green Building incentives & rebates

Regulatory Influences
- ECMs increasingly prescribed in regulation
- Increasing efficiency standards will drive use EC technology
- Requirements for variable speed offer additional opportunity for EC
Pump Technology Panel: Innovations in Pump Dynamics

Bill Marscher, P.E.
President & Technical Director
Mechanical Solutions, Inc.

Presented at the HI 100th Anniversary Gala & Meeting
March 8-13, 2017
**MSI Company Profile**

Founded: 1996

Head Office: 11 Apollo Drive, Whippany NJ

Labs in Albany NY (old Mechanical Technology Inc. facility)

Field Offices in CO, IN, NH, MD, OH, AL, TX

Employees: Approx. 40

Privately Held, USA S-Corp

Original **Standards Partner** of the Hydraulic Institute

Business Focus: Pumps, Motors, & Gas Turbomachinery

Contracts: About 65% Commercial, 35% DoD, DOE, NASA

R&D, design, analysis, and field troubleshooting consulting services, for OEMs, end-users, AE firms, and the US Government.

FEA, CFD, rotordynamics & torsionals, “bump” & ODS vibration tests, hyd. perf. tests, hydraulic design.
“Front End” Risk Reduction: 

9.6.8 Guideline for the Dynamics of Pumping Machinery (2013)

A first in the industry!

Answers the question: Is an analysis recommended?

Intent: Minimize those 2% of installations that are 90% of warranty costs

One size does not fit all: Level 1 ($) / Level 2 ($$) / Level 3 ($$$)

Decisions based on R-U-N: Risk & Uncertainty Number

Result: OEMs, AEs, & Plant Owners/Operators All Win

Other relevant HI standards that have just been updated: 9.6.4 Vib Acceptance, 9.6.5 Cond. Mon.
So, What’s Available After Installation?

*Condition Monitoring for the Masses:*

- Cheaper, Smaller Sensors
- Wireless Communications
- Tie-In to the Internet of Things (IoT, “Big Data”)
- Diagnostics- “Engineer-in-a-Box”
- Prognostics- “Can I Get to the Outage, & What Parts Do I Buy?”
- Condition-Based Maintenance (CBM)
Sensors:
MEMS, Wireless

Cheap
Don’t interfere with fit/form/function
Can be self-energizing (no battery)
“Install & forget”
Igor Karassik’s “little man on the impeller”?

A wireless probe’s antenna

0.0040 inches (100 microns)

A “Micro-Electronic Mechanical System (MEMS) strain gage, able to be wired for shaft torque.

A MEMS pressure sensor
Example of Why IoT Tie-In Is Important: Evaluating Vibration *in Context*, Accounting for Operating Point

Typical Double Suction Dual Volute Data:

- Observing percent BEP in addition to vibration level avoids nuisance warranty calls and needless consultant visits.

This also illustrates why it’s best to include some knowledge of pump behavior in any automated condition monitoring. We don’t just have to use operating statistics and blind criteria!
Coming Soon: Physics-Based Monitoring Software

**The Typical Modern Condition Monitoring System:**

- Pressure Probes
- Electric Current
- Tachometer
- Accelerometers
- RTDs

**DCS Inputs**

**IioT-4 Inputs**

**Physics-Based Health Monitoring Software:**

- Machinery vibration creates vib & pressure fields
- Internal Oscillating Forces are used in diagnosis & prognosis algorithms
- Signals are measured by accel, pressure, temperature & AC current probes
- Impulse response test + multi-physics FEA provide relationship between vibration and internal forces
- Location is compensated by FEA calculation to obtain vibration in other locations

**GOALS:**

- All common faults identified: Diagnosis and Prognosis
- CBM, No false positives
- Designed for different user expertise levels
- Windows-based or Android-based user-friendly SIMPLE & robust interface

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A 21\textsuperscript{st} Century Reality: DOE Compliance

1. The DOE focus is hydraulic performance assessment and improvement.
2. Sealing can be important to efficiency, especially for low Ns pumps.
   - Advances in sealing include dry gas seals and brush seals
   - Composite bushing seals are capable of long term operation at close clearance
   - Recent condition monitoring techniques can monitor seals & leakage
3. Effective condition monitoring & CBM can avoid preventable efficiency loss
4. We know operation near BEP can dramatically improve lifetime energy costs.
   - Operation near BEP can dramatically improve reliability, too!
   - However: If VFDs are installed, use HI 9.6.8 to help avoid likely mechanical resonances
Artificial Intelligence and Cognitive Analytics

SparkCognition is deploying a cognitive, data-driven analytics platform for the reliability, efficiency and security of the industrial internet.
“System of Systems”

Corporate, IT logs and compliance docs

Industrial and operational data
Like the human brain, A.I. turns data into insight

- Enables machines to penetrate the complexity of data to identify associations and reason
- Presents powerful techniques to handle unstructured data and infer
- Continuously learns not only from previous insights, but also for new data entering the system
- Provides Natural Language Processing support to enable human to machine and machine to machine communication
- Does not require rules, instead relies on hypothesis generation built on analyzed data
### What is Cognitive – Beyond Machine Learning

#### Natural language processing
- Enables recall of answers, in context
- Analysis of human readable text for clues, insights and evidence

#### Deep Learning and Reasoning algorithms
- Improves accuracy
- Learns complex patterns
- Scales efficiently: High speed, large data implementations

#### Automated Model Building and Infinite Learning
- Watches data and derives rules
- Incorporates human feedback to strengthen or dismiss conclusions
- Automatically learns from feedback and greater volumes of data
- More data = more accuracy, capability & insight

#### Powerful Visualization with Evidential Insights
- Provides transparency and evidence about what the cognitive system is learning and proposing
- Presents data elegantly – Analyst friendly interface, easy feedback
- Elevates evidence / reasoning for machine decisions
Failure prediction and condition monitoring yields massive value for companies

- Failure Mode based condition monitoring system
- Automated model building, selection & management
- Automate detection of asset operating states
- Estimated increase in productivity of 25% – 30%

- Predictive “Intelligent Maintenance” of heavy machinery optimizes repair & prevention costs, while minimizing unnecessary downtime
- Clients report 50X ROI on the cost of SparkCognition products and services
## Steps in the Process

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<th>Flexible Data Ingestion</th>
<th>Automated Model Building</th>
<th>Variation in Analyses</th>
<th>Root Cause &amp; Evidence</th>
<th>In-Context Remediation</th>
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<td>Ingest data from multiple sources/formats</td>
<td>Train SparkCognition algorithms to build models automatically</td>
<td>Yield Predictions based on various Machine Learning techniques</td>
<td>Perform Root Cause Analysis and feature extraction</td>
<td>Deliver contextual advise to remediate</td>
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<td>Automatic clean up and clustering</td>
<td>Leverage SMEs for input and refine results based on Domain Expertise</td>
<td>Generate a specialized asset component based Health Risk Index</td>
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<td>Anomaly Detection for unknown behaviors</td>
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SparkCognition delivers end-to-end advanced safety, reliability & security capabilities for IIoT

Detailed Evidence
- Provide evidence behind the insights
- Provide tools for expert analysis

Actionable Insights
- Extend asset life
- Avoid downtime
- In-field, real-time recommendations

System Optimization
- Optimize not at local but at a global level
- Plug insights into platforms such as BI, Inventory mgmt., PLM etc.
Flowserve
The Business Problem

Limitations
Current threshold based monitoring systems can only identify failures a few hours prior to them occurring, this limited the ability to respond fast enough and prevent unplanned failures. In addition, custom engineered algorithms for predictive capability for each pump type and application has proven to be a lengthy process.

Additional problems with the current approach were:
- Prevention of unplanned failures and related downtime
- Insufficient time to respond effectively
- Lengthy process to build and then maintain custom engineered algorithms
- Inadequate for detecting unknown states with various process conditions
Flowserve - Proven Use Case in Pump Monitoring

- Objectives
  1. Recognize Operating States
  2. Detect Anomalies
  3. Predict Pump Failure

- Data Analyzed
  - Pre-filtered FFT data (feature data)
  - 3 Years worth of run data on production asset

- Results
  - Identified operating modes with >99% accuracy
  - Accounted for four criteria defined by client to handle imperfect data and operating conditions
  - Predicted failures 5 to 6 days in advance (20x improvement)
    - Previous method predicted only 12 hours in advance
    - Completed with less than 2% false positive rates
Some Energy Sector Applications

**Objectives**

- Monitor Critical Assets during startups and coast-downs

**Client**

- Big Utility

**Asset**

- Turbine Generator

**Solution Feature**

- Data collection from multiple assets
- Detects failures, graduating to predictions
- Self-learning system with access to in-context advisory powered by IBM Watson

**Business Impact**

- Estimated increase in productivity of 25% – 30%
- 50X ROI

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**Objectives**

- Predict Remaining Useful Life

**Client**

- Big Utility

**Asset**

- Wind Turbine

**Solution Feature**

- RUL (Remaining Useful Life) prediction and anomaly detection
- Automated model building, selection & management
- Insights through deeper-order analyses

**Business Impact**

- Estimated savings of ~40% in O&M budgets
- ~$2MM per year for 100 MW power generation plant (wind), 40X ROI

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**Objectives**

- Analyze failures, alert on impending failures, optimize design

**Client**

- On-shore driller

**Asset**

- Electrical Submersible Pump

**Solution Feature**

- Failure identification and classification
- Automated failure alerting
- Critical variable identification
- Design and process optimization to reduce specific failures

**Business Impact**

- 3X increase in life of ESP through proper monitoring and design
- Savings of up to $150,000 per asset per year, 50X ROI
Valuable Insights - Automated Pump Failure Prediction

Identification of pump state
  - Is there a problem?
  - If so, what kind of problem?
  - Is there a problem we’ve never seen before? (signature DB approaches don’t work well here)
  - Is the pump operating in the right state?

Fleet State
  - Is the entire system operating well?
  - Is the entire fleet optimized?

Prediction
  - When will the problem or catastrophic failure occur?
  - When will it require maintenance?

Forensics
  - What factors were most responsible for a failure?
  - What factors were most responsible for a sub-optimal state?
  - Is this due to natural or malicious reason (cyber attack)?
Benefits of Machine Learning

The integration of machine learning provides many different benefits.

- **Scalability**: Automated model building capability does not require manual model building of every asset/component.

- **Adaptability**: Adapts to new and changing conditions automatically.

- **Security**: Out-of-band, symptom-sensitive approach beyond IT security.

- **External Factors**: Can incorporate external factors (e.g. environmental and weather data).

- **In-context Remediation**: IBM Watson advisor that understands natural language to help technical teams.

- **Feature Enhancement**: Automated feature enrichment and extraction.
Empowering the end-user to improve business operations

SparkCognition and the client developed an “Advisory” application for maintenance

Application enables Directors of maintenance and technicians to:

- Conduct machine to human dialog to troubleshoot with high accuracy
- Speedy identification to map the right fault codes and troubleshooting tips using Natural Language Processing (NLP) queries
- Optimize work flow and deliver relevant documentation for a faster turnaround of planes

Lowered the cost of maintenance and improved asset availability for operators by up to 10%
NLP can "understand" documents such as maintenance and injury reports

ID: XXXX
Time: 11/04/2012 13:03
Confidence: 99%
Building Owner: XXXXXXXXXXX
Actions: Had a meeting with the tech and talked about what happened
Description: While technician was driving to site on services rod to site the technician heard a thump when he looked in the passenger side mirror he saw that a deer had ran in to the side of the truck. There were no injuries to the technician. there was damage to the passenger side door.

ID: XXXX
Time: 21/05/2013 22:15
Confidence: 97%
Building Owner: XXXXXXXXXXX
Actions: NA
Description: While traveling SW on XXXXXXX Rd , an animal (believed to be a dog) ran out in the road ahead of me , causing me to swerve to the right , damaging the right front rim and right front lower bumper on the curb of the road. No other injuries occurred.
SparkCognition A.I. technology can accelerate Decision Making

- Identifies anomalous events
- Aggregates multiple data streams
- Recognizes known and unknown patterns
- Incorporates analyst feedback so that underlying models learn from human response
- Presents actionable evidence behind its conclusions

A.I software trains on historical events to recognize patterns and provide maximum business awareness
Q&A