anoprecise

Automated Predictive Maintenance

Machine Doctor

MIT $100K

startupbootcamp InsurTech

Canada NRC·CNRC

MIT | Sandbox Innovation Fund Program

ALBERTA INNOVATES

AI·50 AI x IoT x Smart City

SCSE @ Taipei

2019 Mar.26-29 Smart City Summit & Expo

Taipei World Trade Center, Nangang Exhibition Hall 1

The Problem

$100B per year
Unplanned Downtime Cost for global economy

82%
Companies experienced unplanned downtime for 4 Hours(avg.)
Vanson Bourne Research Study

$2 Million
Average cost of an unplanned downtime
Vanson Bourne Research Study

91%
Companies major goal to reduce downtime using **IoT & AI**
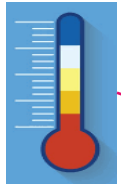CXP Group Study

75%
IIoT based PdM PROJECTS FAIL
A Cisco Study

➢ Data inaccuracy
➢ Data Insufficiency

➢ Inaccurate feature correlation
➢ Delayed implementation

The Problem: Process Variations vs Faulty Components

Input Parameters

Data acquired from user's DCS, PLCs using Nanoprecise's sensorless model
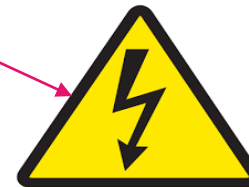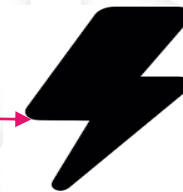
Rotating Equipment

System Response Variables

UNITS OF MEASUREMENT

DISPLACEMENT	-	MICRONS
VELOCITY	-	MM / SEC.
ACCELERATION	-	MM / SEC^2 , G

All the process variations can be summarized as:

1. Load Variations
2. Speed Variations
3. Load & Speed

Acoustic Sensor robust to changing load and speed variations.

Thus, no process parameters such as pressure, temp, flow rate etc. are needed.

Machine Doctor

FEEL
Sensation using **Vibration technology**

HEAR
Sensation using **Ultrasound technology**
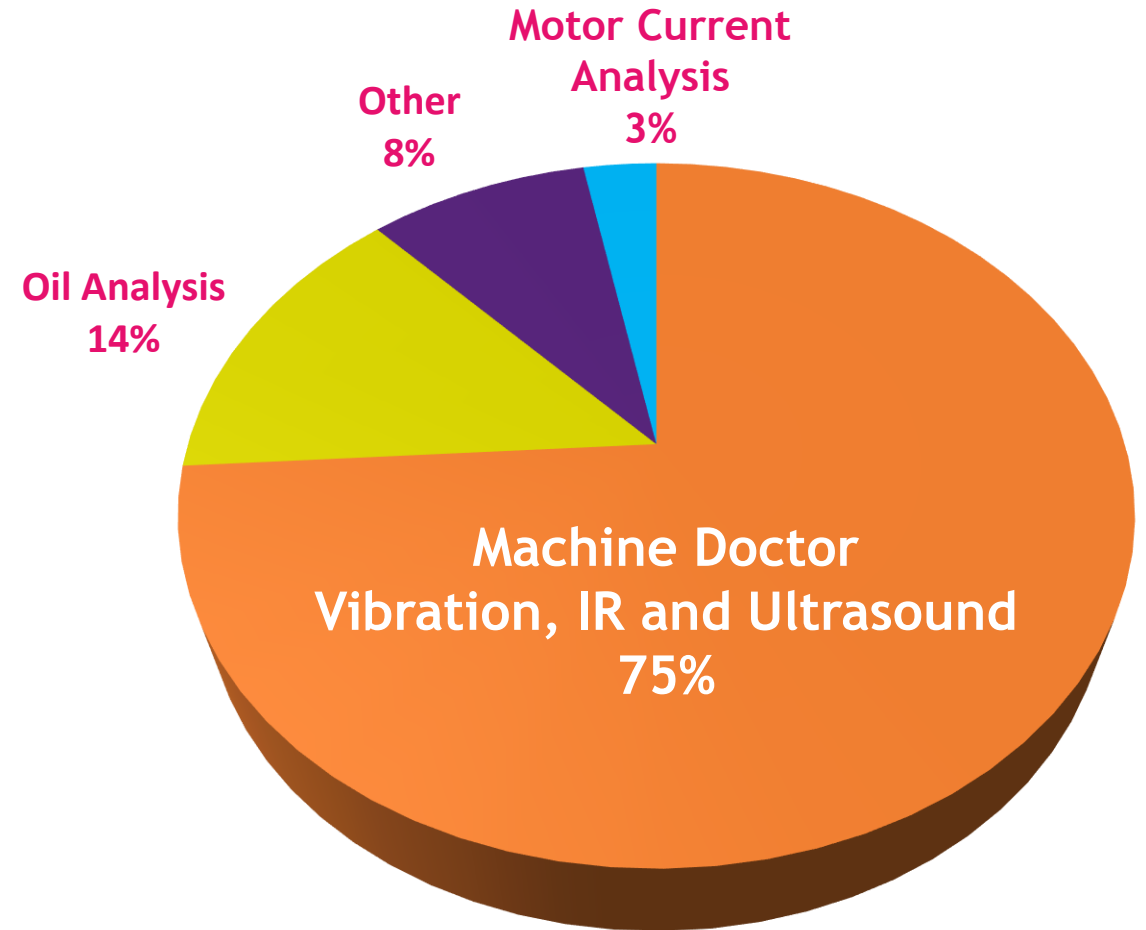
TOUCH
Sensation using IR **Thermology technology**

MOTION
RPM measurement using advanced signal processing

BEHAVIOUR
Relative humidity measurement using a **Humidity** sensor
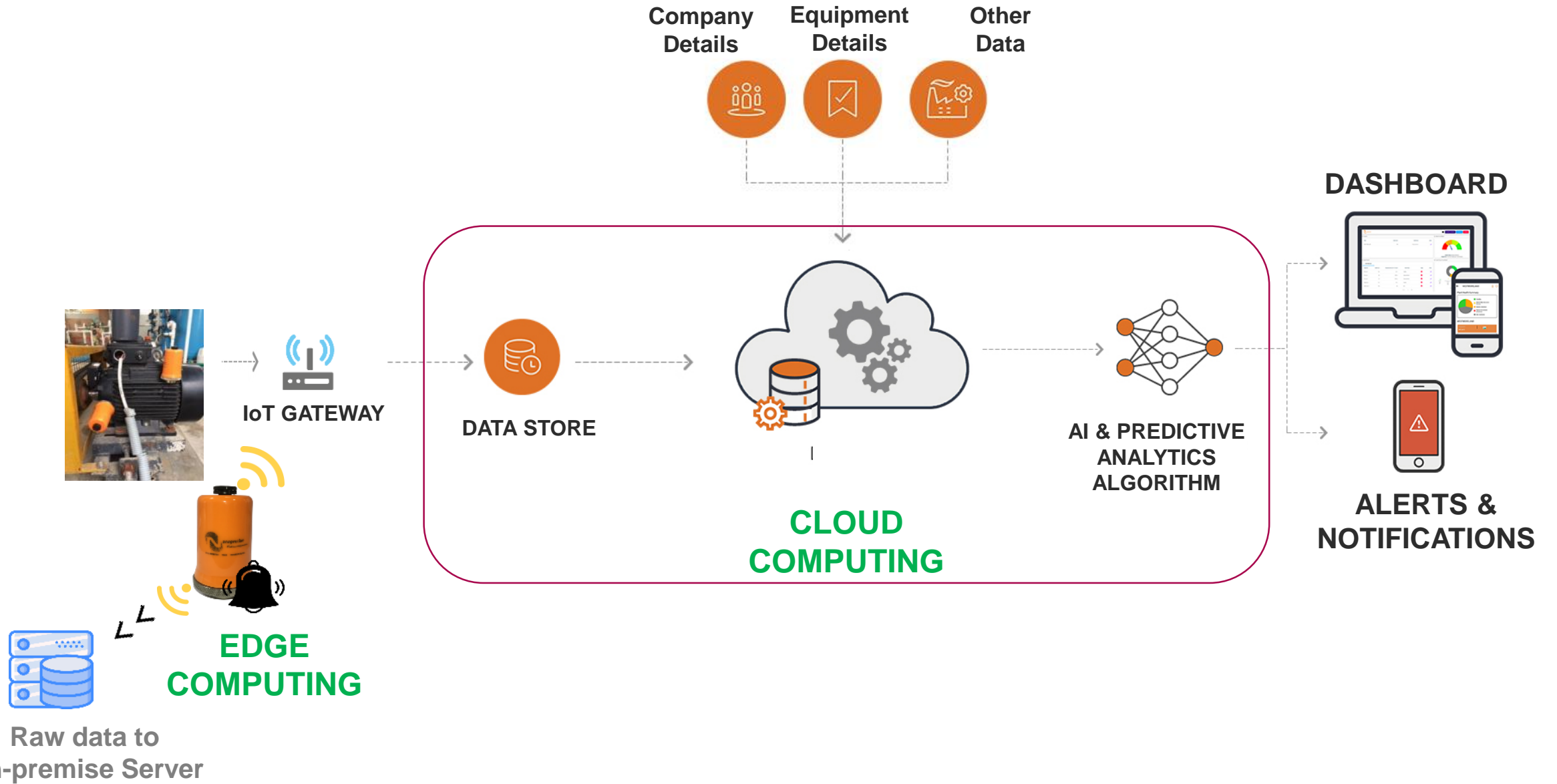
1 Sensor 5 Technologies

Motor Current Analysis
3%

Other
8%

Oil Analysis
14%

Machine Doctor
Vibration, IR and Ultrasound
75%

Our IoT + AI Technology

Results

Example: Single Mid-Level Manufacturing Company

>2K

Rotating Equipment in Single Plant

>1.8K
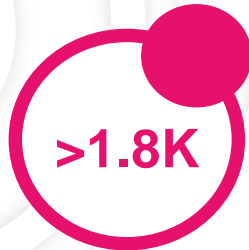
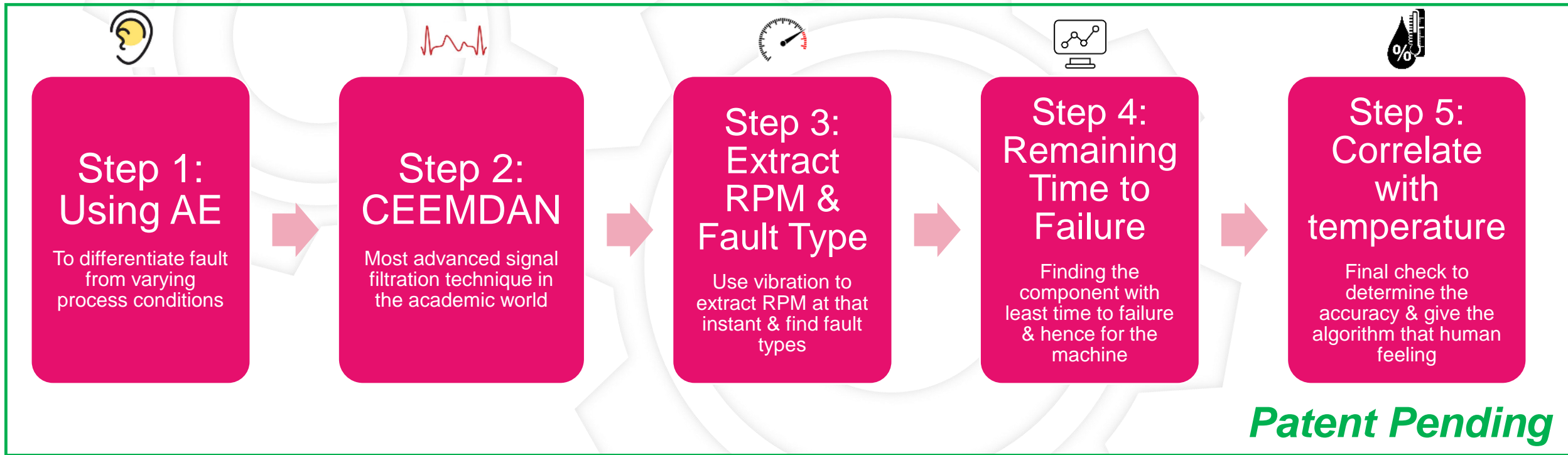**No. Sensor Devices for most critical equipment in one plant**

<3
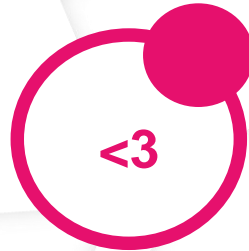
Less then 3 months of sales cycle for one plant

HUGE SAVINGS

$200K

RECENTELY SAVED FROM JUST ONE GENERATOR FAILURE FOR ONE OF OUR CUSTOMER

Nanoprecise USP: A Process

Step 1: Using AE
To differentiate fault from varying process conditions

Step 2: CEEMDAN
Most advanced signal filtration technique in the academic world

Step 3: Extract RPM & Fault Type
Use vibration to extract RPM at that instant & find fault types

Step 4: Remaining Time to Failure
Finding the component with least time to failure & hence for the machine

Step 5: Correlate with temperature
Final check to determine the accuracy & give the algorithm that human feeling

Patent Pending

Differentiates between signals coming from process variations vs actual fault, determines fault type & predicts time to failure

Competitor Analysis

FEATURE	NANOPRECISE	GE	EMERSON	ABB	SKF	AECOM	DIGIVIBE	BlueVision
Vibration, AE, Surface Temperature, RPM & Humidity	Yes	No	No	Yes	-	-	Yes	-
Vibration Frequency Bandwidth	1.9 kHz - 8 kHz	5 – 1 kHz	2hz - 1 kHz	1 Hz – 1.6 kHz	10 Hz to 1 kHz		0.32 – 1.3 kHz	50 Hz to 1 kHz
Speed Analysis	200 RPM – 5000 RPM	No	No	No	No	No	No	No
Order Tracking Analysis	Yes	No	No	No	No	No	No	No
RUL Prediction	Yes	No	Yes	No	No	No	Yes	No
Advanced AI Method	Yes	No	Yes	Yes	No	Yes	Yes	No
Advanced Signal Processing	Yes	No	Yes	Yes	No	Yes	Yes	No

Technology Risk & Mitigation

INSTALLATION TIME

Upto 96 sensors can be installed within 4 hours

CONNECTIVITY & POWER

Electrical & Battery Powered WiFi,GSM & Bluetooth Model

DATA TRANSFER SECURITY

Certified to UL2900-2-2 Cybersecurity Standard

QUICKLY VARYING CONDITIONS

Using CEEMDAN as an algorithm for accuracy

DATA LOSS MANAGEMENT

Server level Data Masking to prevent loss of information

DATA PRIVACY

On-Premise model for data control

Various versions

		Power Mode	
		Battery Power	**Electrical Power**
Connectivity Protocol	**Wi-Fi**	• Current Model • Data is sent to the Public Cloud • Cannot be used on enterprise/corporate Wi-Fi • High level of data security according to the UL 2900-2-2 • Access to the dashboard and analytics (fault detection and fault characterization)	• Like the battery powered version but powered through an electrical port
	Wi-Fi + Bluetooth	• Sensor can connect to the routers through Wi-Fi or Bluetooth (Connecting through Bluetooth provides a better battery life) • Ideal for customers who want to use their own Wi-Fi and want to store data on their own cloud/server • Low level of data security (When transferring data to the public cloud) • Data can be sent either to the public cloud or corporate cloud/server • Can be used on enterprise/corporate Wi-Fi (Customer needs to open a port in their network if they want the data to be transferred to a public cloud) • If the data is stored on corporate cloud/server, the dashboard and analytics will not be available (no fault detection or fault characterization available) • The customer will only have excess to the raw data in csv format	• Like the battery powered version but powered through an electrical port
	LED Sensor (No Connectivity)	• No connection to the internet is required • All analytics will be done on the edge (on the sensor itself) • LED lights will indicate the status of equipment	• Like the battery powered version but powered through an electrical port

Existing & Upcoming Installations

6 Referenceable Customers with 10+ additional pending commercial projects

Oil & Gas

cenovus ENERGY ⓟ
Chevron ⓟ
Husky ⓟ
BJ
IndianOil ⓟ
ExxonMobil Energy lives here ⓟ

Mining & Metals

ⓟ TATA STEEL
WESTMORELAND COAL COMPANY
vedanta transforming elements
TransAlta
AltaSteel

OEM

GRUNDFOS
SULZER ⓟ

HVAC

Kempegowda INTERNATIONAL AIRPORT BENGALURU
EIA we'll move you.
EDMONTON INTERNATIONAL AIRPORT

Fertilizer

ⓟ Nutrien
IFFCO

ⓟ *Planned installations*

Pricing* & RoI**

Volume	CAPEX (CAD/sensor)	OPEX (CAD/sensor/month)	RoI*** (Payback in months)	CAPEX + OPEX (CAD/sensor & /sensor/month)
51-100	$500	$48	10	$475 + $39/month
101-200	$475	$43	9	$452 + $35/month
201-300	$450	$38	8	$428 + $31/month
301-400	$425	$34	7	$404 + $28/month
401-500	$400	$26	5	$380 + $21/month
501-1000	$350	$22	4	$333 + $18/month
Above 1000	$300	$17	3	$285 + $14/month

* This pricing is for the end users globally, not the distributor.

**As per Chevron study, Predictive Maintenance can provide savings of $10,000/year for 1 250HP motor

***Above calculations are assuming 16HP motors throughout the plant.
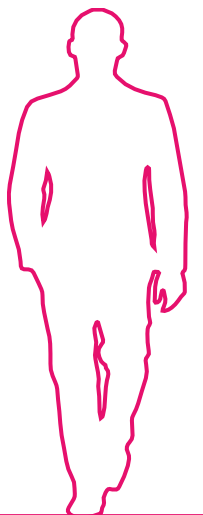
Milestones

Revenue Growth - A true hockey stick

Sept 2019
- Signed agreement with Chevron
- Team: 25 people
- 8 paid clients
- 500+ sensors installed

May 2019
- Raised $1 million
- Team: 16 people
- 5 paid clients

Dec 2018
- Hardware certifications (IP68, FCC/IC, ASME C1D2)
- Team: 12 people
- 2 paid clients: IFFCO & AltaSteel
- 200+ sensors installed

Nov 2017
- $1 million
- Team: 2 people
- 2 customers (India & Canada)

Apr 2017
- Founded
- Basic prototype
- 3 trials

Y-axis: X1000 $USD — 0; 2,000; 4,000; 6,000; 8,000; 10,000; 12,000; 14,000; 16,000

X-axis: Dec-17; Apr-18; Jul-18; Oct-18; Feb-19; May-19; Aug-19; Dec-19

Thank You

Team

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LIBIN LIU
CTO
PhD, Condition Monitoring

FARHAD HAQIQAT
Head, Software
MSc, Comp. Science

ARUN DESIRAJU
Head, Hardware

PRASHANT VERMA
Head, India

* Prior successful startup experience
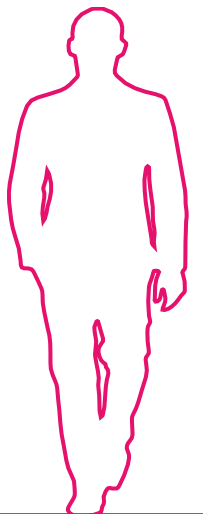
APPENDIX
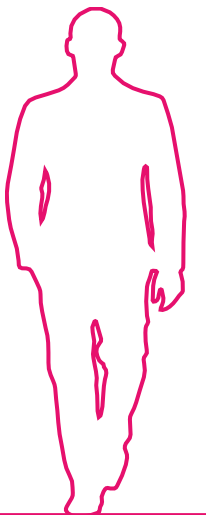
Automated Diagnostics

Step - 1

Data Collection – Less then 1 min interval of time & Data sent to cloud through cyber secure way. **(UL 2900-2-2 Certification)**

Step - 2

Raw data decomposed into multiple IMFs and FFT is taken to **characterize energy for each fault**.

Step - 3

We collect **top 10 harmonics** & for each fault we trend the amplitudes over time.

Step - 4

Calculate the Remaining Time to threshold limit for every fault mode and **find the dominant faults**.

Step - 5

We signal the required action & **alert** is sent to user in terms of email & text message.

Step - 6

Dashboard displays specific details on evaluation company health, equipment, plant & health of sensor.
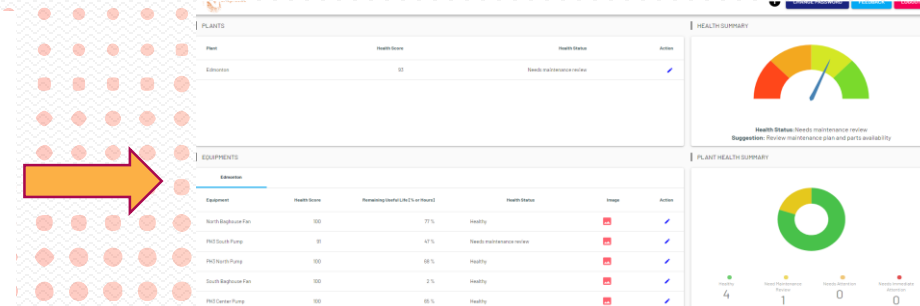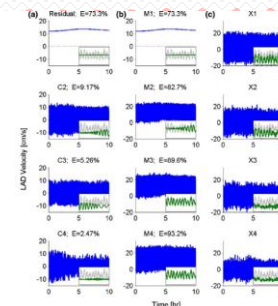
Case Studies

Edmonton International Airport

Challenge: Failure of the drive motor or gearbox in any section of the baggage system results in slow, manual and often the error-prone movement of luggage.

Solution: RotationLF diagnosed accurately the leading fault on such gearbox & motor assembly and predicted the time in which the failure can happen and alerted the airport officials 250 hours in advance.

Result:
- RotationLF diagnoses accurately the leading fault on such gearbox & motor assembly.

Acoustic Data Analysis and Fault detection

- Acoustic emission (AE) is radiation of elastic waves when a material undergoes irreversible changes like crack due to material fatigue

- AE signal is excited at the initial stage of a fault, thus working as the indicator to early fault stage

- Our AE data covers high frequency range from 12kHz to 40kHz

➢ Case study with AE RMS
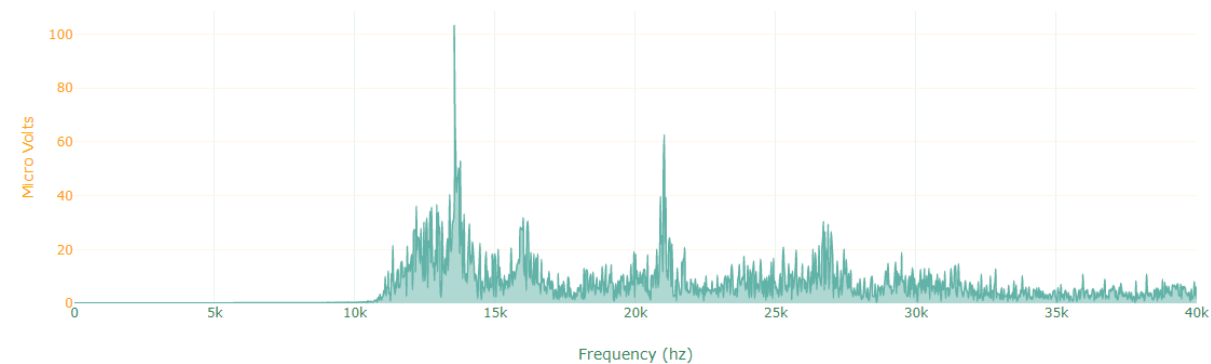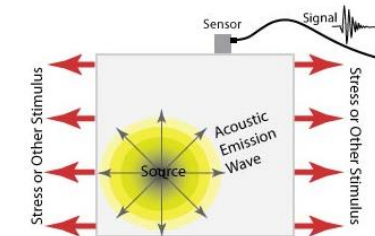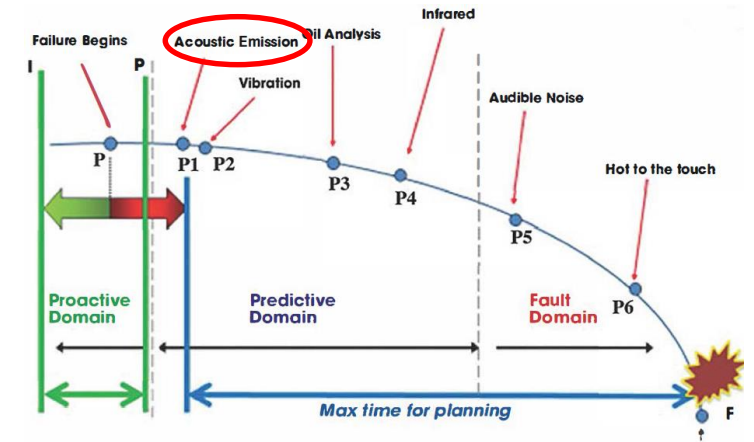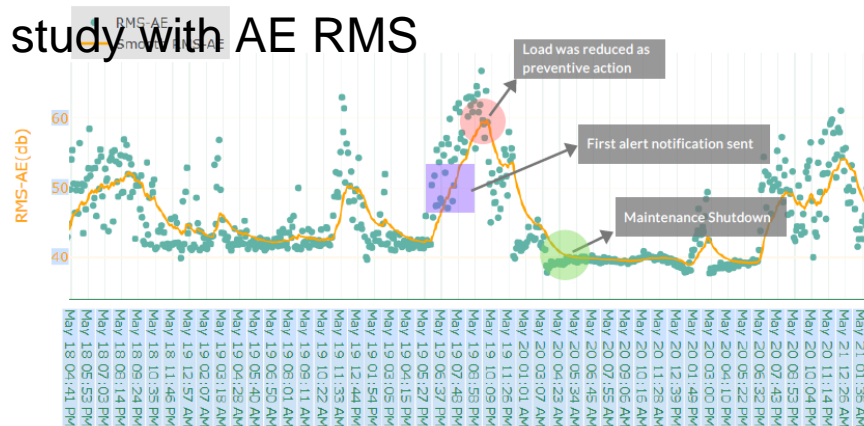
Case Studies

Pinnacle Renewable Energy

Challenge: Ring Plugging was a very common issue faced due to diverse feed quality into the machines

Solution: Product ring plugging can be detected as sound levels increase in specific roller bearings

Result:
- The acoustic emission pattern indicated an early stage failure
- After the shutdown and completion of maintenance, acoustic emission levels returned to normal level

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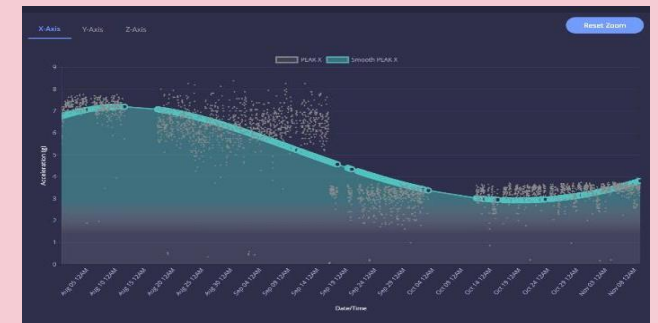
Case Studies

Hindustan Zinc Limited

Challenge: Detection of misalignment and unbalance problem in most critical SO2 blower

Solution: It was detected that there is a fault due to unbalance in blower and misalignment between blower and gearbox. The severity of unbalance is higher than misalignment .The fault detection happened in very early stage when the existing system not able to identify the changes with this equipment.

Result:
As that was a peak time for production so shutdown of the equipment was not possible. Nanoprecise system monitor the equipment very precisely and update HZL maintenance department frequently.
Maintenance team got the same indication after more than 10 days from Nanoprecise system in their system.
They planned a short time shutdown to clean the blower and after cleaning the unbalance effect gone from the system and its effect on gearbox as a symptom of misalignment has also reduced.
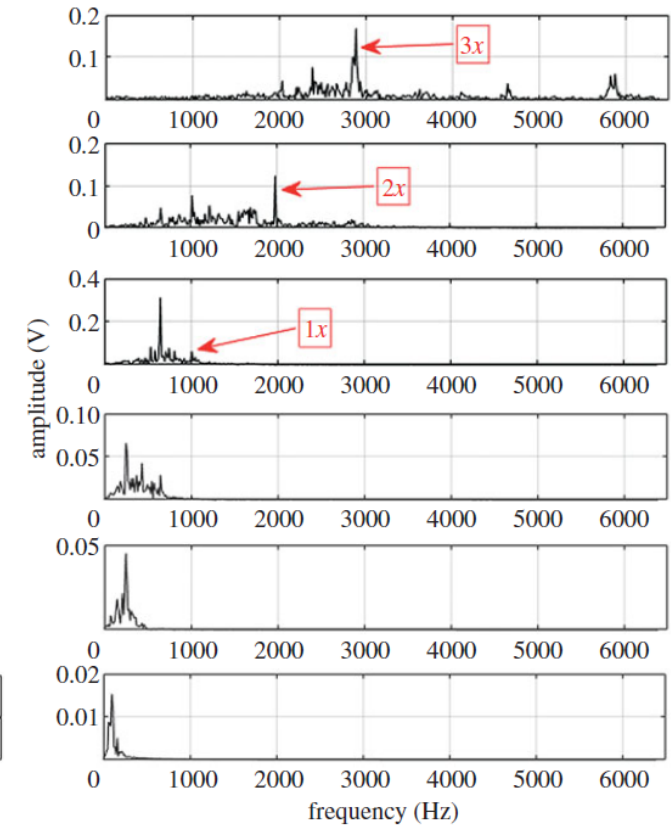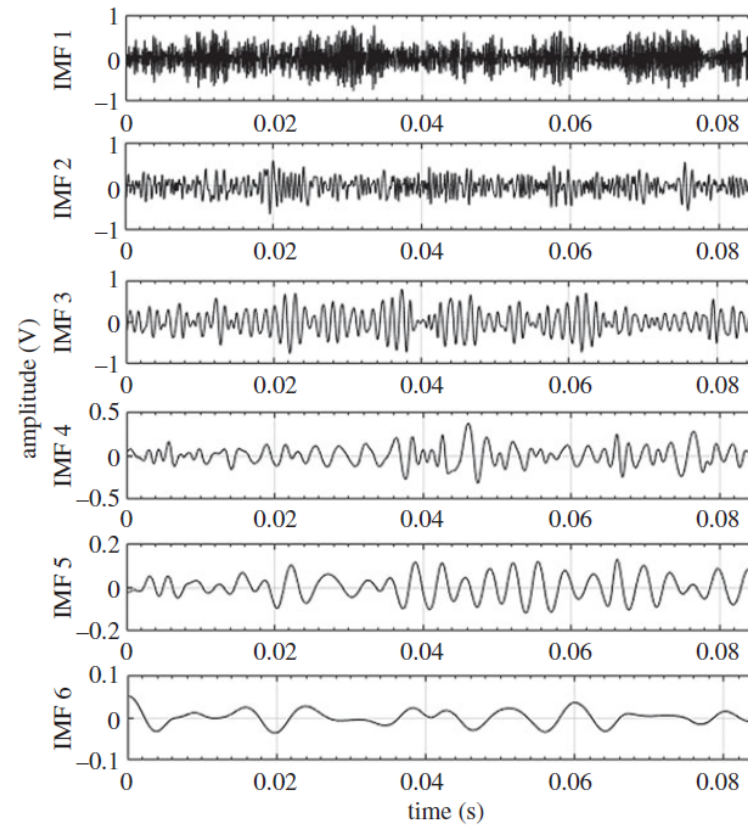

Before Maintenance   **Fault detected**   **After maintenance**
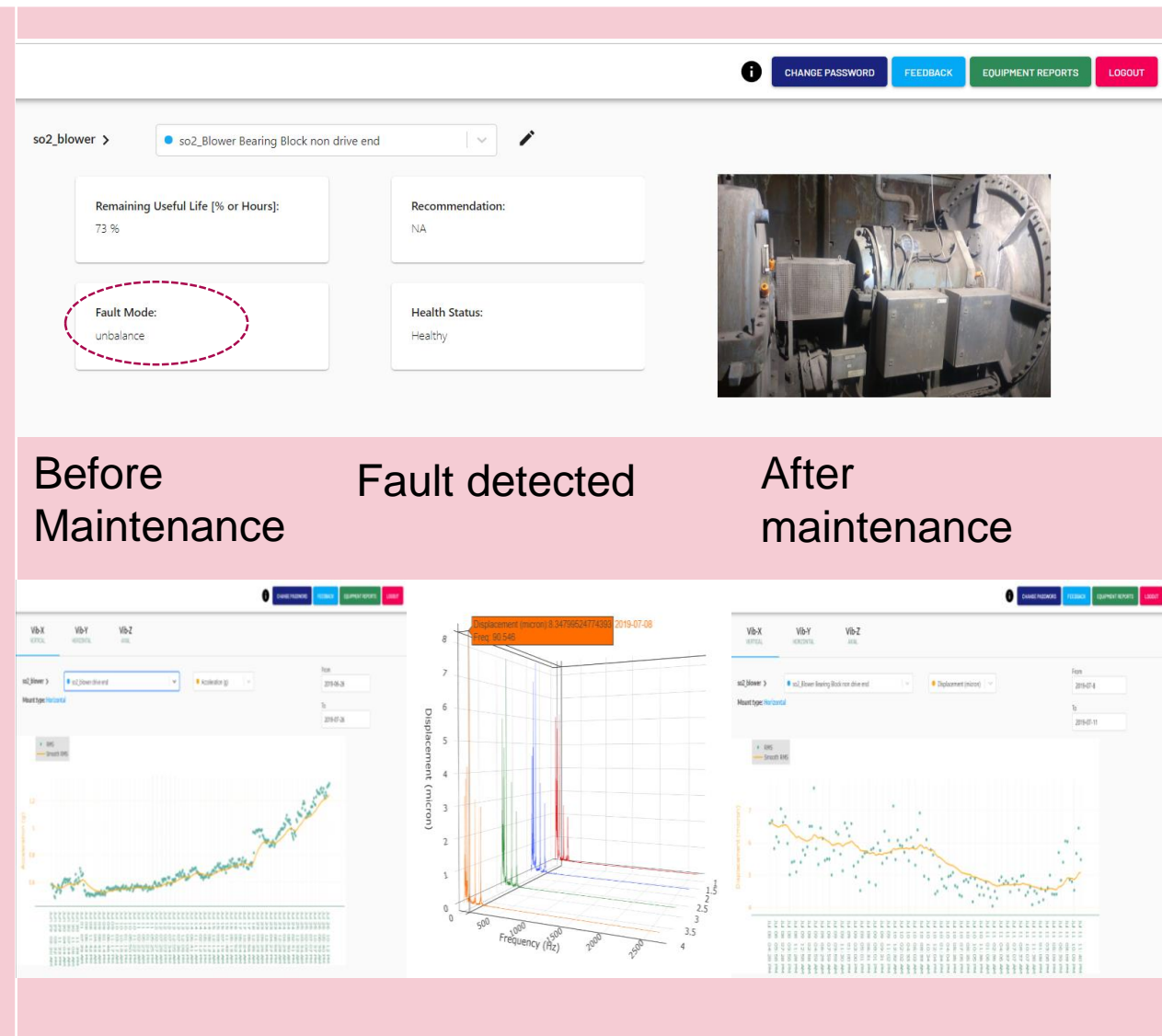
Signal Processing & Feature Extraction

Complex signal processing techniques help RotationLF differentiate between Process Upset vs Actual Fault.

Original Signal

Vibration signal
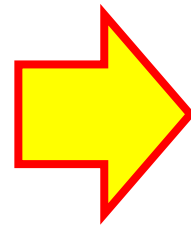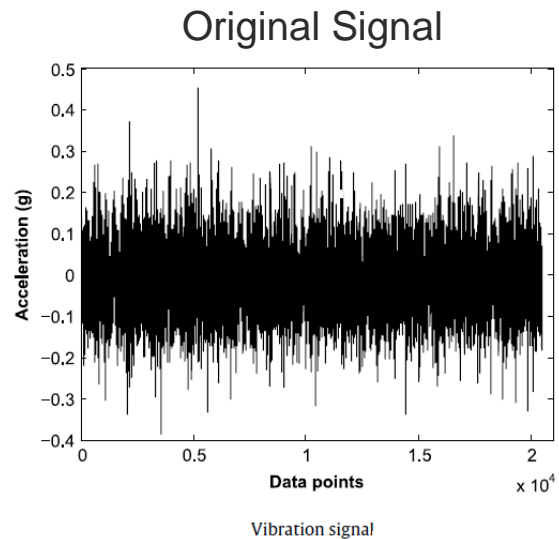
Decomposition into IMFs through CEEMDAN

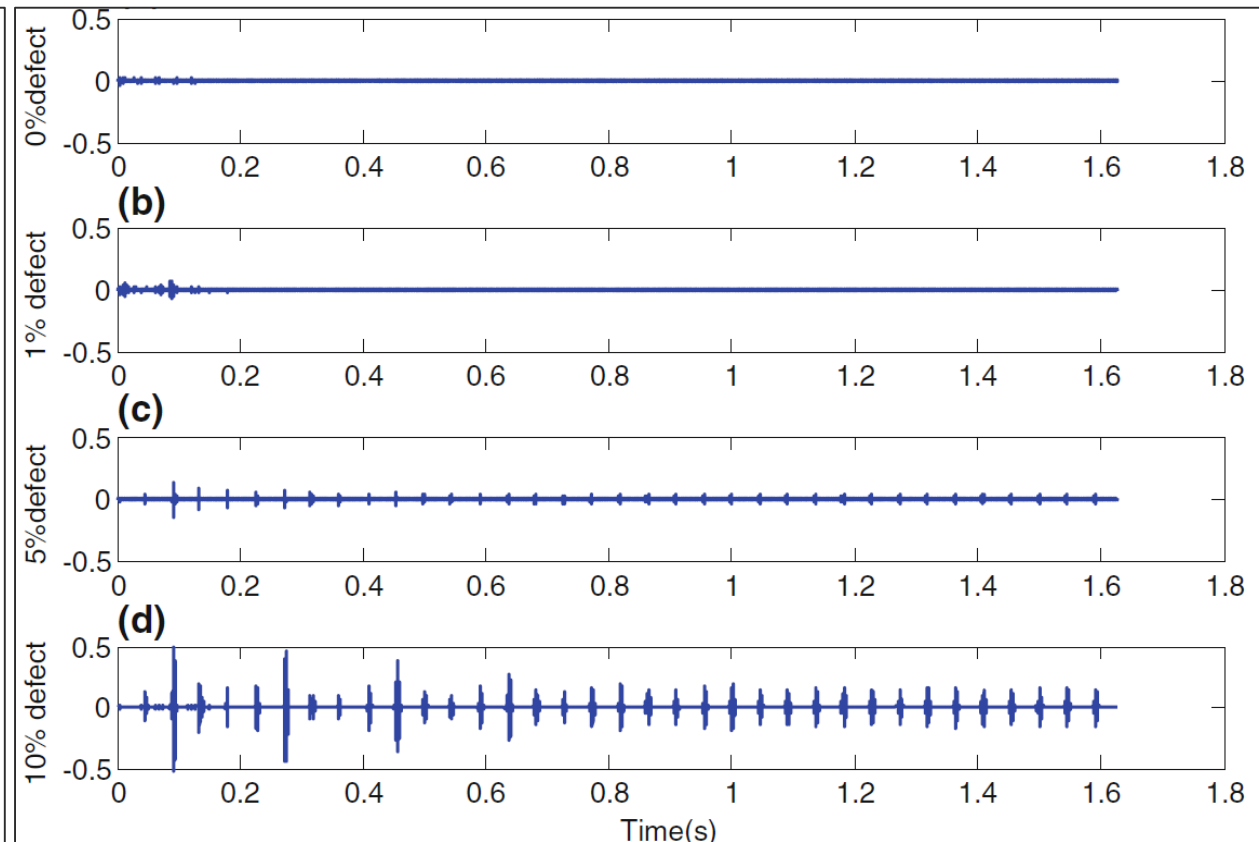Multiple Intrinsic Mode Functions(IMFs)

Fourier spectrum of each IMF

How is our algorithm different ?

Effect of CEEMDAN in order to reduce the noise from data drastically and increase the accuracy for Remaining Time to Failure prediction.
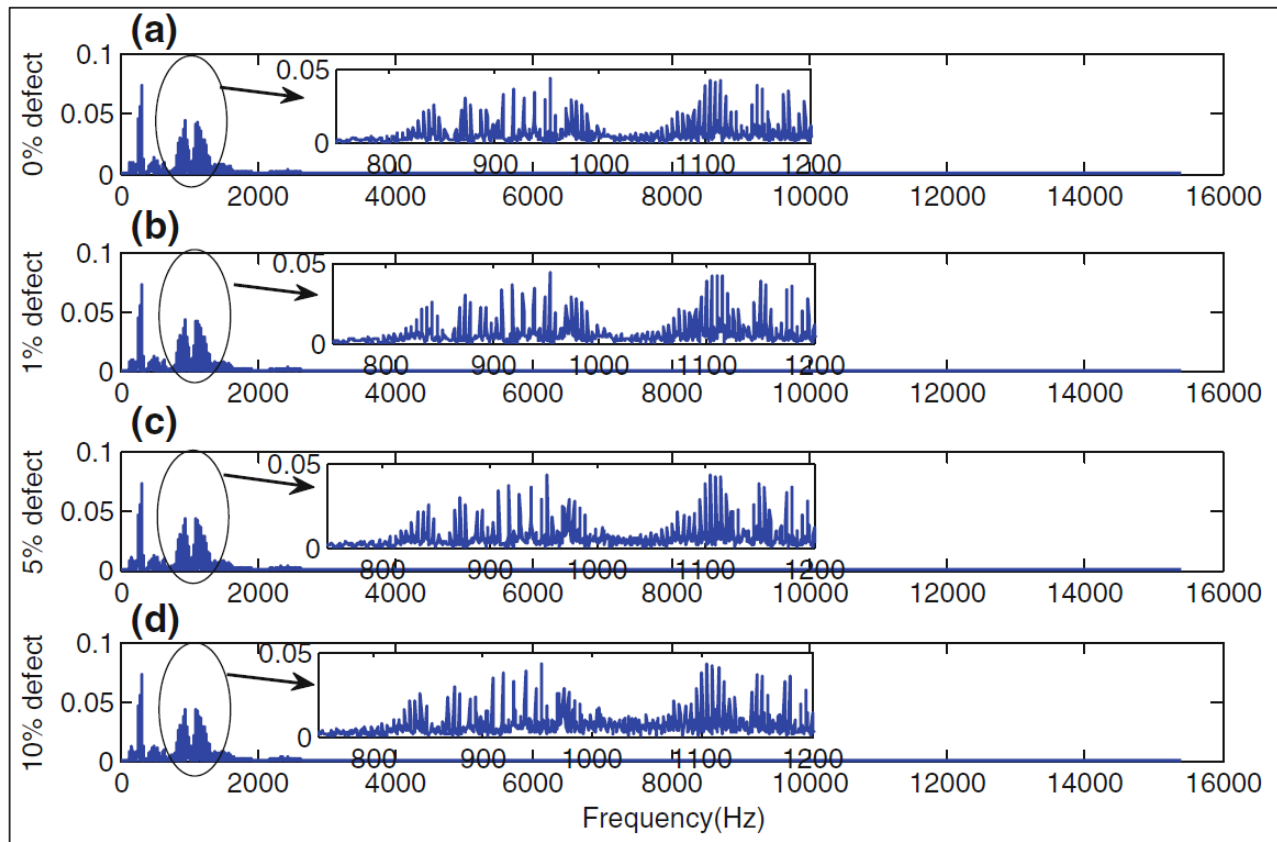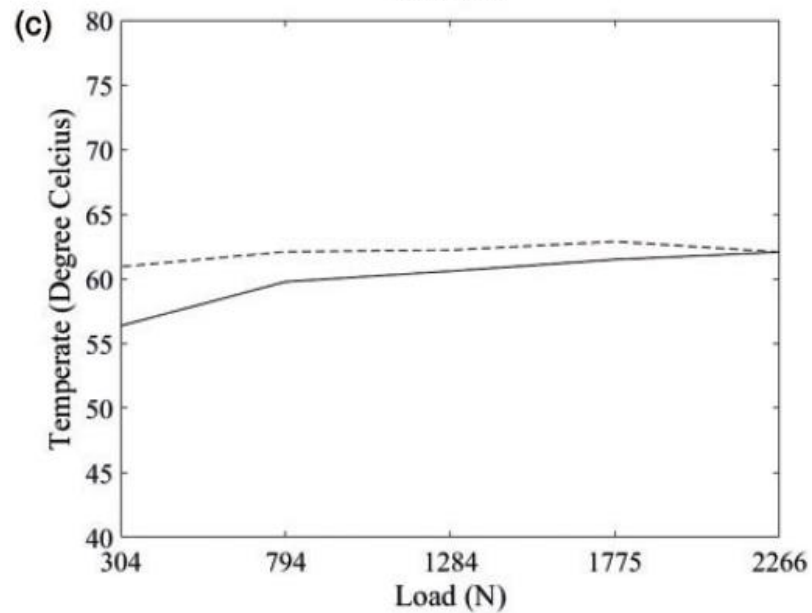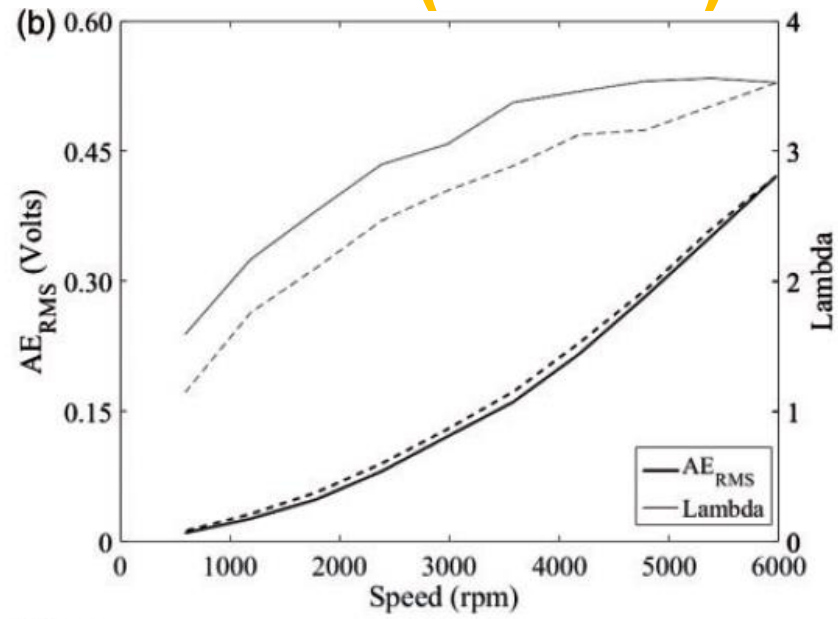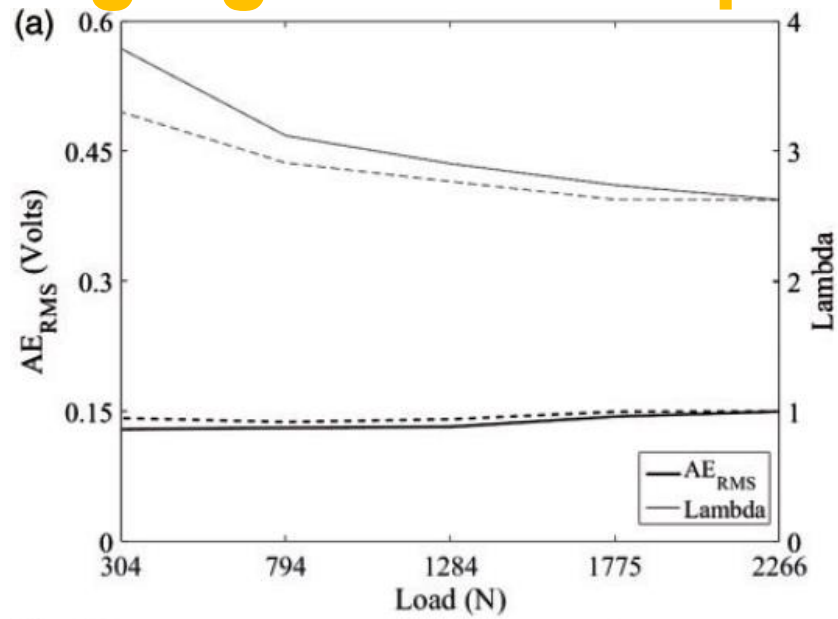

INDUSTRY FAMOUS FAST FOURIER TRANSFORM

OUR METHOD (CEEMDAN)

| Speed	Load	RotationLF Capability	Comments
Yes	No	Yes	Order Analysis
No	Yes	Yes	Not significant in case of AE or Vibration
Yes	Yes	Yes	Order Analysis
No	No	Yes	Not really an issue

Managing Variable Speed & Load (contd.)
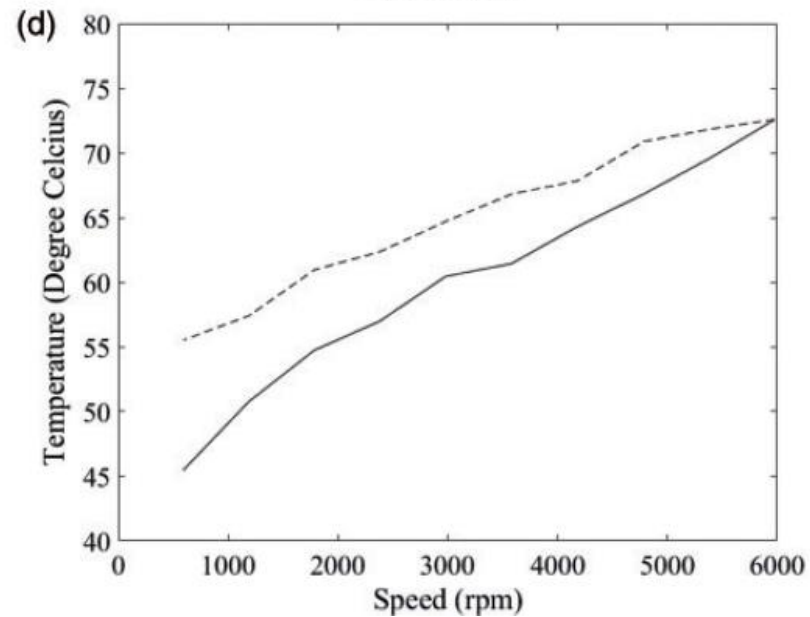
Remaining Time to Failure(RTF) and Remaining Useful Life(RUL)

Predicting the time of a specific fault mode progressing from its incipience to the final failure.

Gamma Distribution, Weibull Distribution, Laplace distribution, Fourier
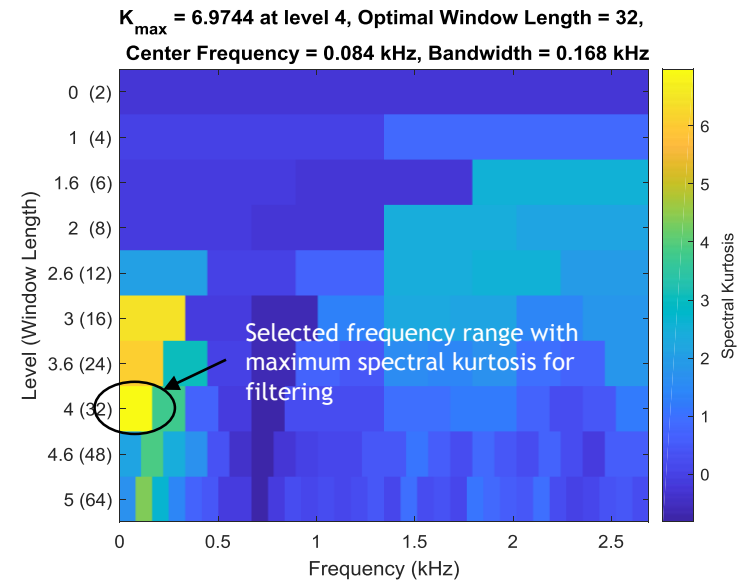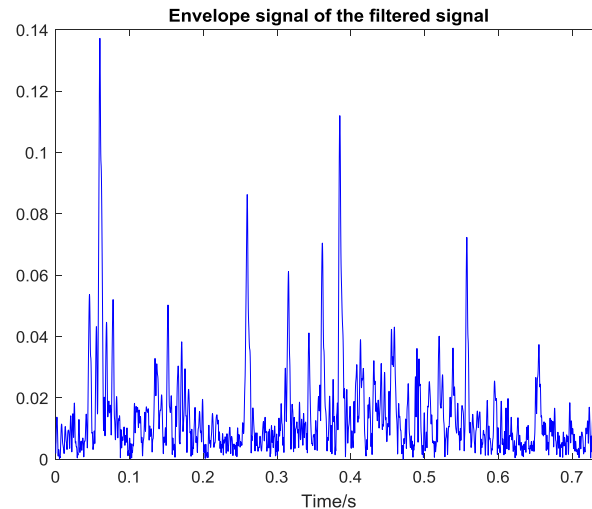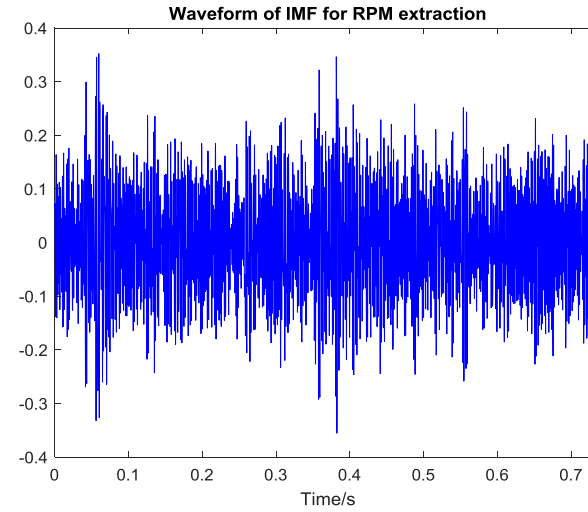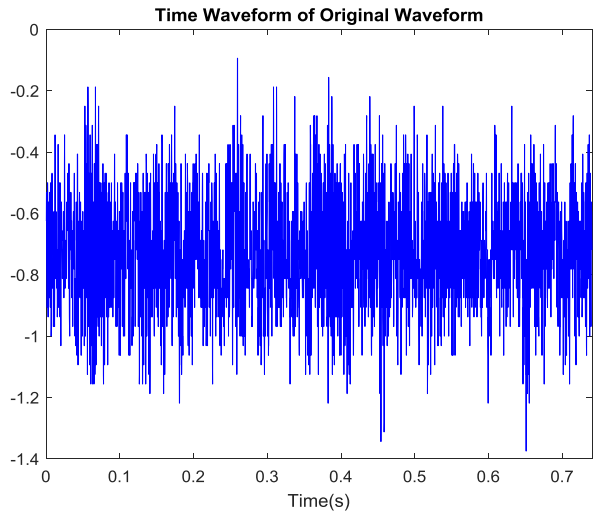Distribution, & 21 other such fitting techniques used as pre-trained models.
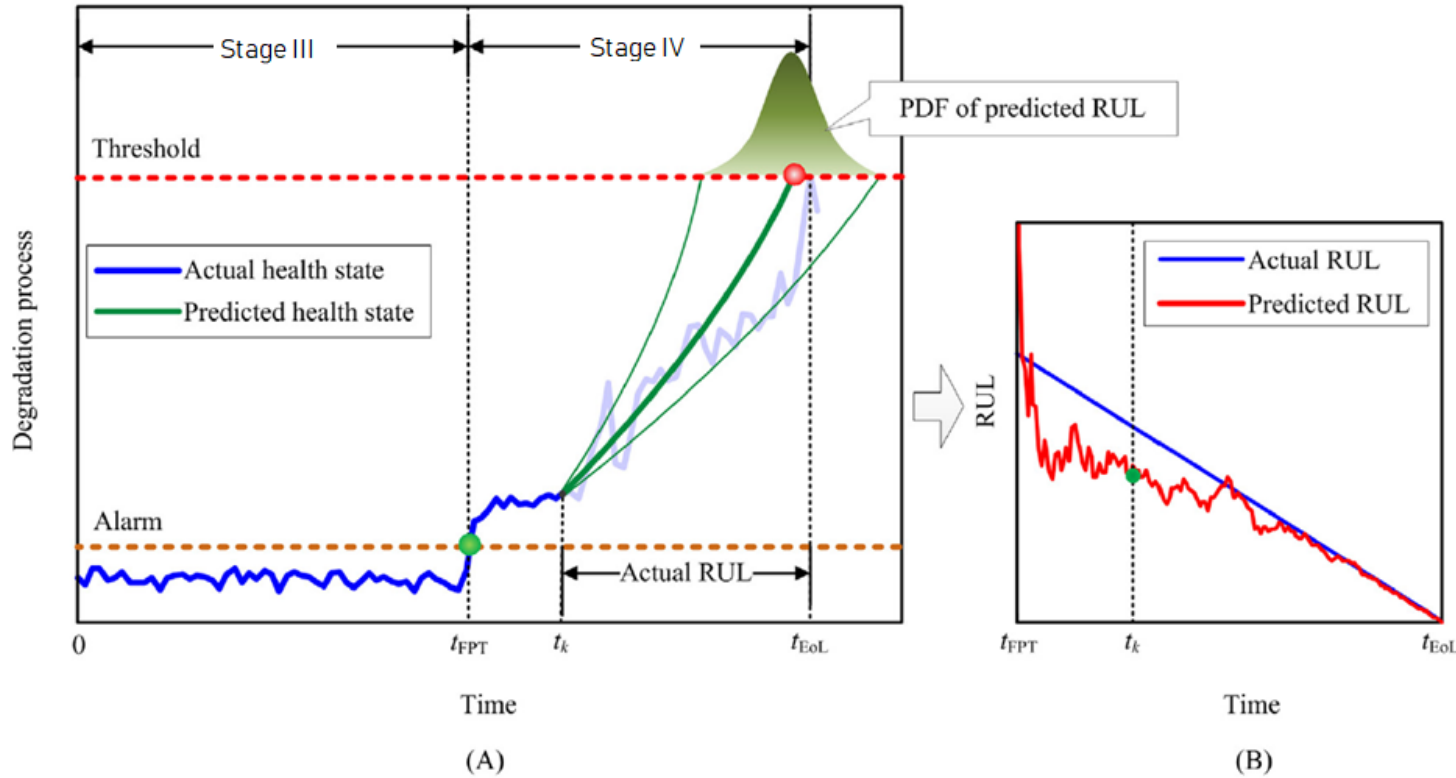
Dashboard Snapshot

Equipment	Health Score	Remaining Useful Life [% or Hours]	Health Status
	100	77 %	Healthy
PH7	100	67 %	Healthy
PH3	100	68 %	Healthy
South Fan	83	17 hrs	Needs attention
	100	65 %	Healthy

RPM Extraction

*Patent pending

Time Waveform of Original Waveform

Waveform of IMF for RPM extraction

Envelope signal of the filtered signal

K_{max} = 6.9744 at level 4, Optimal Window Length = 32,
Center Frequency = 0.084 kHz, Bandwidth = 0.168 kHz

Selected frequency range with maximum spectral kurtosis for filtering

Extracted RPM: 1260
Real Value: 1239
Accuracy > 98%

Understanding Customer Problems

MOTOR	FAN	PUMP	GEARBOX	COMPRESSOR
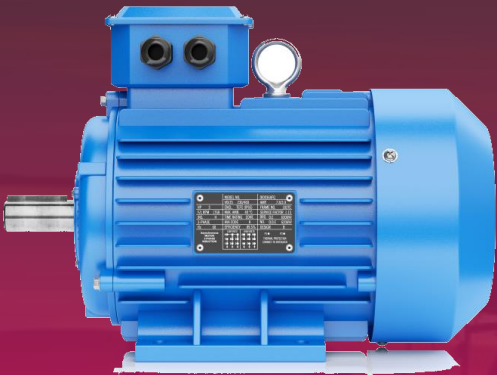
MOTOR
- Unbalance
- Misalignment
- Bearing Problem
- Rotor Bar Problem
- Winding Problem
- Phase Related Problem

FAN
- Unbalance
- Misalignment
- Bearing Problem
- Impeller Related Problem
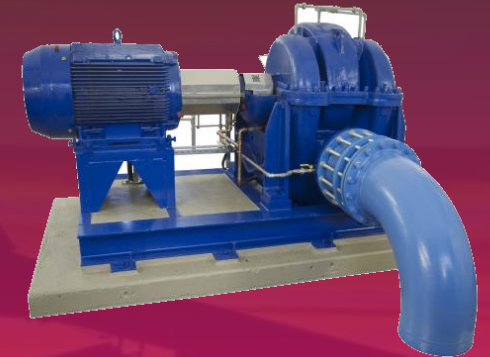- Looseness Problem

PUMP
- Unbalance
- Misalignment
- Cavitation
- Blade/ vane Failure
- Flow Related Problem

GEARBOX
- Unbalance
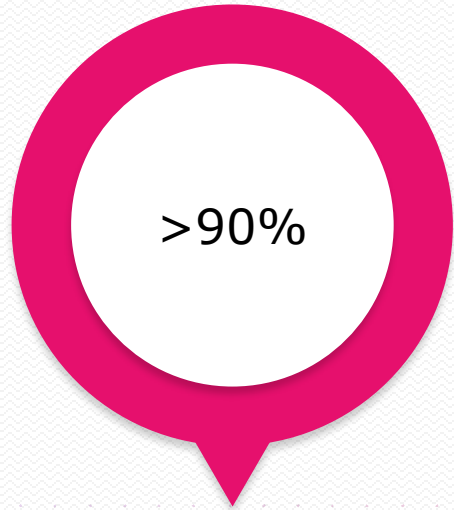- Misalignment
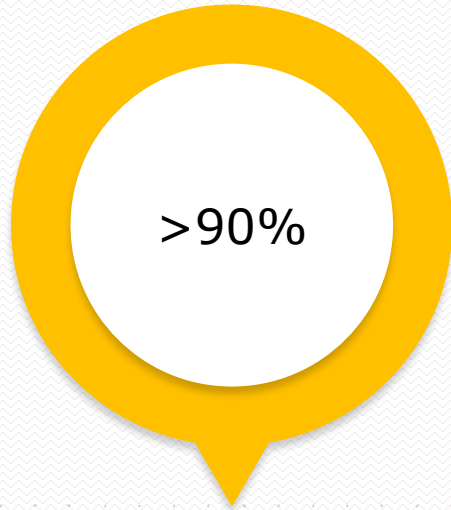- Bearing Problem
- Gear Problem

COMPRESSOR
- Unbalance
- Misalignment
- Bearing Problem
- Screw Mesh Problem
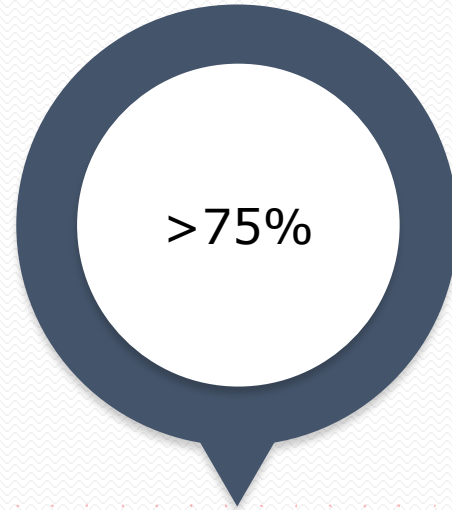- Lobe Mesh Problem
- Looseness Problem

Key Performance Indicators (KPIs)

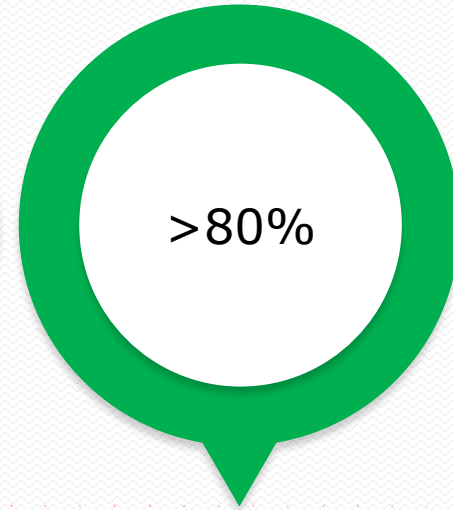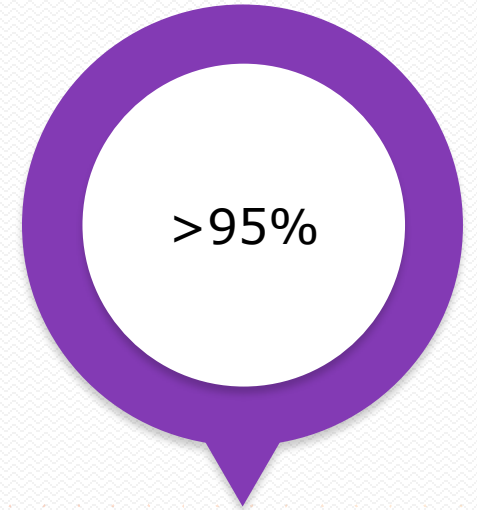| >90%	>90%	>75%	>80%	>95%

Reliability of IOT Network.

Reliability of sensor under any atmospheric conditions.

Reliability on Data accuracy.

Reliability on equipment Fault detection.

Reliability on dashboard uptime.

Management

Sunil Vedula
P.ENG,MBA,CEO,Founder

Expert in stress analysis, material science & finite element modelling.

Brian Craig
PRINCIPAL,ADVENTURE CAPITAL LP

Director, Solium Capital
Director, Better Participation Group

Rod Heard
BSC. ENG., GEOPHYSICS, MBA, CEO, SMARTBE WEALTH

Director, Di Corp
Director, YMCA Calgary

Krishnakanth Kodukula
MBA, BSC. ENG., DIRECTOR OF DIGITAL STRATEGY, ZAMIL INDUSTRIAL

Investments professional with 11 years experience in asset intensive industries.

Advisors

Dr. Anand Parey
PHD | IIT Indore

Researching Machine Design, Condition Monitoring, Noise and Vibration Isolation, Signal Processing of Mechanical Systems.

Dr. Zhipeng Feng
PHD

Researching Condition Monitoring and Fault Diagnosis of Machinery; Complex and Nonstationary Signal Analysis; Planetary Gearbox Fault Diagnosis.

Dr. Ming Zuo
PHD, PENG

Professor, Department of Mechanical Engineering, University of Alberta. Head, Reliability Research Lab, University of Alberta.

Dr. Mohammed Haddar
ADVISORS

Professor in Mechanical Engineering, National School of Engineers, Tunisia. Director of the Laboratory of Mechanics, Modeling and Manufacturing. Focus on vibration of mechanical systems..

Dr. Fakher Chaari
ADVISORS

Professor in Mechanical Engineering, National School of Engineers, Tunisia. Principle research in dynamics and fault detection of rotating machinery.

Machine Doctors In Emerging Markets

We read and interpret data to be able to predict the remaining useful life of any asset in any industry during any point in its lifetime with more than 90% accuracy.

We worked hard, innovate continuously and crafted a solution where we effectively combine physics, material science & data analytics to provide significant value proposition to industry.

This is the reason why we call ourselves an "Engineering Analytics" company.

We're the trusted reliability solution provider to industry.