UIC Railway Asset Management
Global Conference 2017

4 - 6 October 2017
UIC Headquarters, Paris

Lessons learned in Heavy Assets Predictive Maintenance

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5 Octobre 2017

Challenges

- Demand is increasing **while budgets are shrinking**
- Infrastructure aand Rollong Stock are **under stress**
- Regulatory bodies are more demanding on **Quality of Service**
- Trains have to be on-time and mission ready
- MRO costs need to be drastically reduced
- Sacrifying Customer Service for Cost reduction is not an option

Doing more with Less

Maturity driven by safety, availability and TCO

	Safety	Availability	Costs	Maturity
Air Forces				
Airlines				
Aircraft Manufacturer				
Aircraft Engines Manufacturer				
Railway Company				
Rolling Stock Manufacturer				
Turbine Manufacturer				
Truck / Tractor manufacturer				
Manufacturing Process				
Electrical Grid				
Telco				
Mining Industry				
Facility Management				
Ol & Gas				
Car manufacturer				

Even though Railway pays lot of attention to availability and TCO, it's still lagging behind on predictive maintenance

Hard constraint

Average constraint

Soft Constraint

Use Cases

US Army

- Predictive Maintenance program has produced for a fleet of 120 helicopters:
  - **11 % increase in fleet availability**
  - **41 000 Maintenance Man Hours saved in a year**

Navistar

- Telematics data is enabling
  - Failures predicton
  - Fleet operator notification
  - Proactive routing od spare parts
- **Logistic response enhanced from 7 to 2 days**

Caterpillar

- Monitoring and analysis of Truck engines sensor data has led to **100 M$ savings in executing Performance Based Contracts**

Union Pacific

- 3350 trains/day on a 32,000 miles network
- Infra red sensors installed every 20 miles
  - 20 millions readings / day
  - Monitioring of mechanical wear, overheating and derailments
  - 1500 problems qualified every day
- **Reduction of damages, delays and customers claims**

More availability and 5-10 % reduction in life cycle costs

Siemens Vision 2020

2015 BRONZE STEVIE WINNER INTERNATIONAL BUSINESS AWARDS

Teradata wins a Stevie® Award

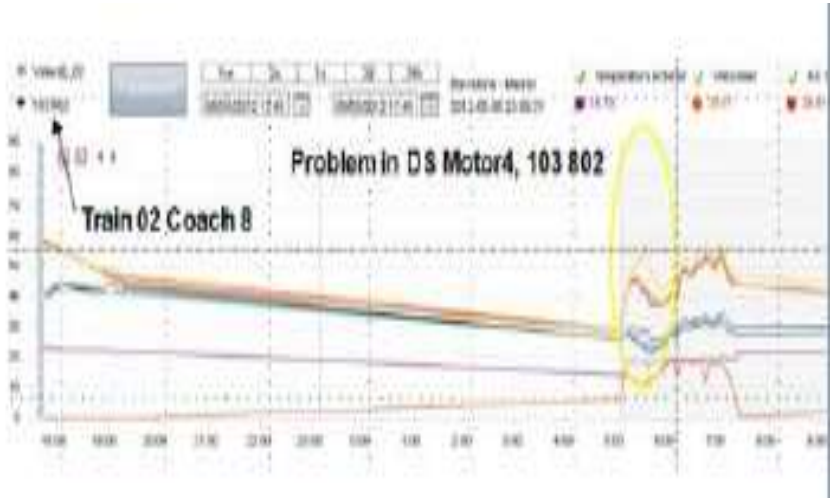
http://www.teradata.com/Resources/Videos/Siemens-Capitalizing-on-Digitization,-the-In

Teradata was named a Bronze Stevie Winner for the video "Siemens: Speeding Down the Path of a Successful Future with Big Data and Analytics" in the "sales & technology video" category.

Identifying risks and anticipating breakdowns

Predictive Maintenance

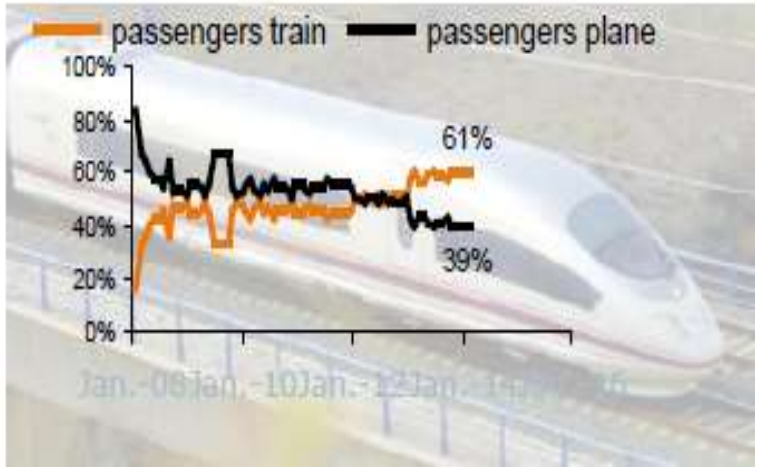
- Sensors continuously gather a breadth of data
- Most of the data is analysed on the fly
- Drafts are identified
- Alerts are triggered on abnormal situations



Identifying risky situations

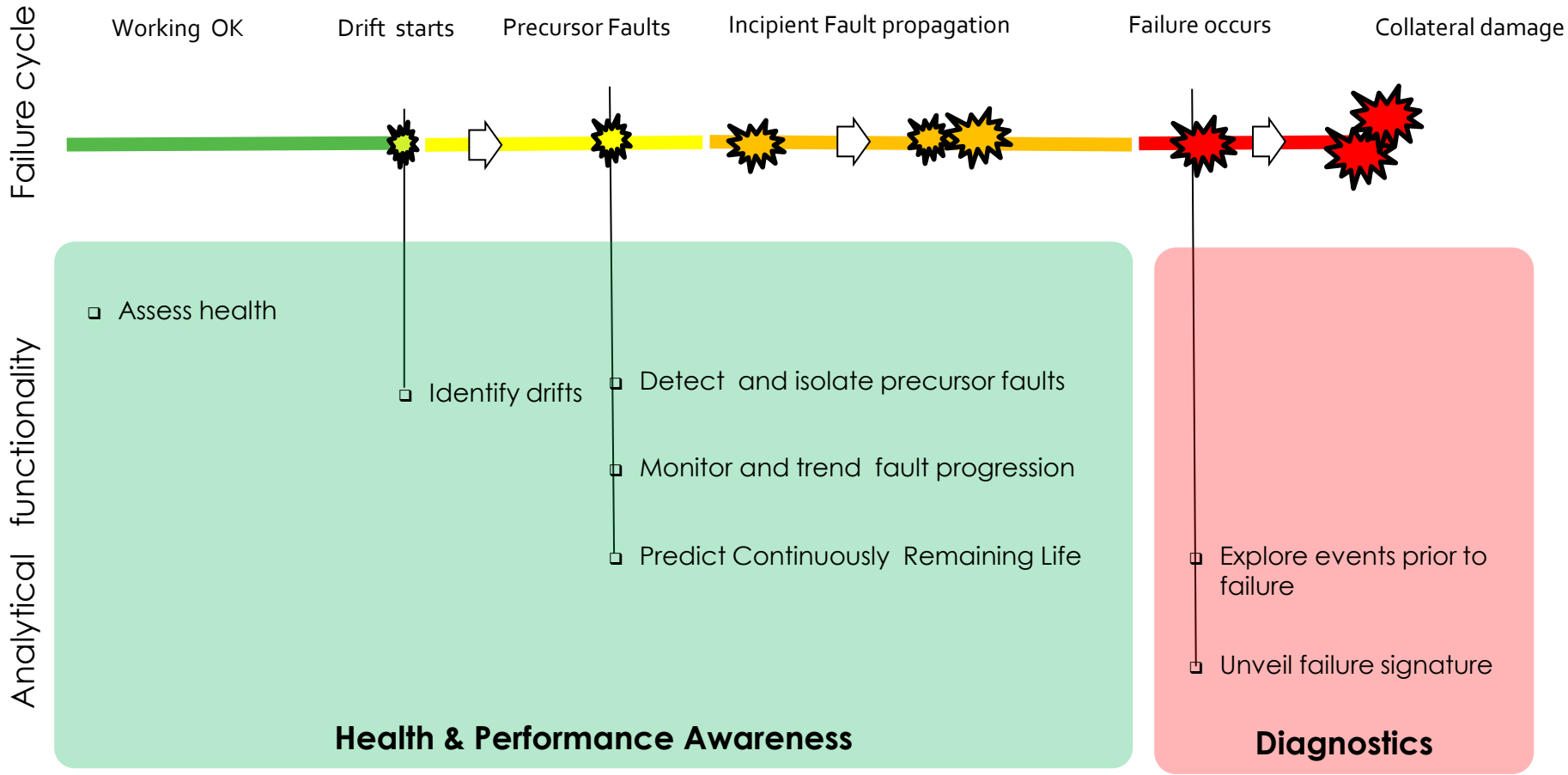
Benefits

- «Performance-based-contracting
- One delay out of 2300 trips
- Valero E est the reliable RENFE High Speed Train
- Big market share on Madrid – Barcelone leg

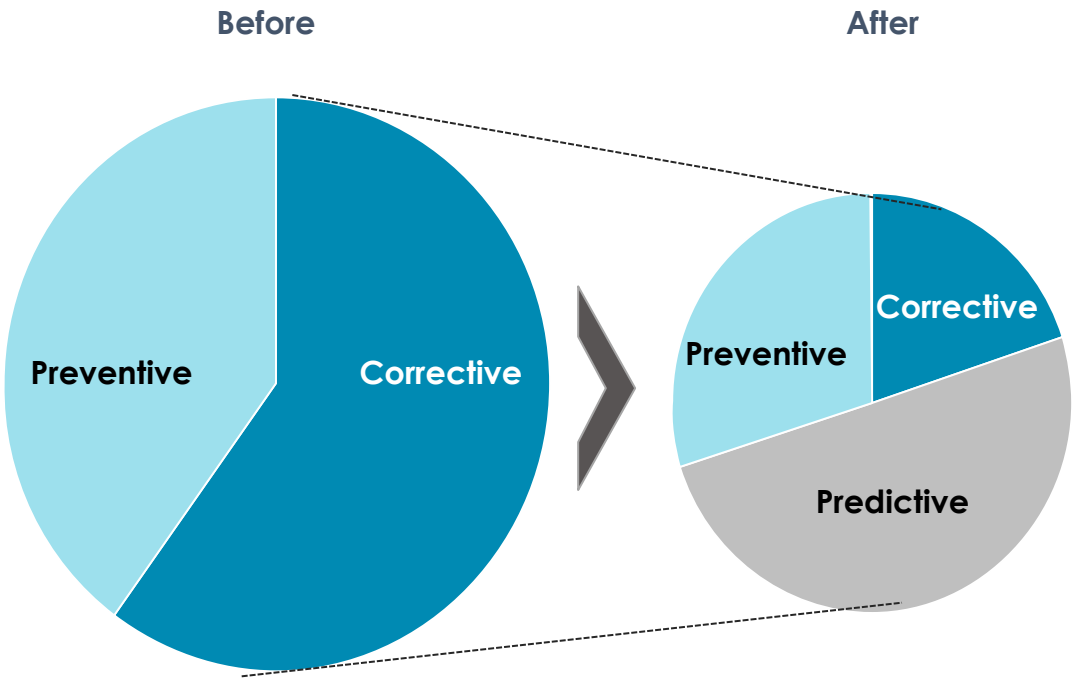


Market share Railway vs Airlines

Prognostics & Health Management



Impact of Predictive Maintenance



- Develop a deeper knowledge on equipment health and aging effects
- Improve Equipmement reliability and maintainability
- Optimise Maintenance Planning and Execution
- Make better trade off between Repair vs. Leave in field with Partial Mission readinesss
- Increase the sharing ot equipmenent life cycle data
- Process Reengineering

The amount and mix of Maintenance workload will change

Focus on Predictive maintenance

Track

Intelligent Asset Tracking

Analyse asset demography

Plan

Health and performance Surveillance

Scrutinise asset operations & pathologies

Maintenance Planning

Fine tune the maintenance ailor maintenance pro

Material Management

Predict spare parts demand and align supply & inventories

Execute

Maintenance & Repair Efficiency

Accelerate MRO tasks completion

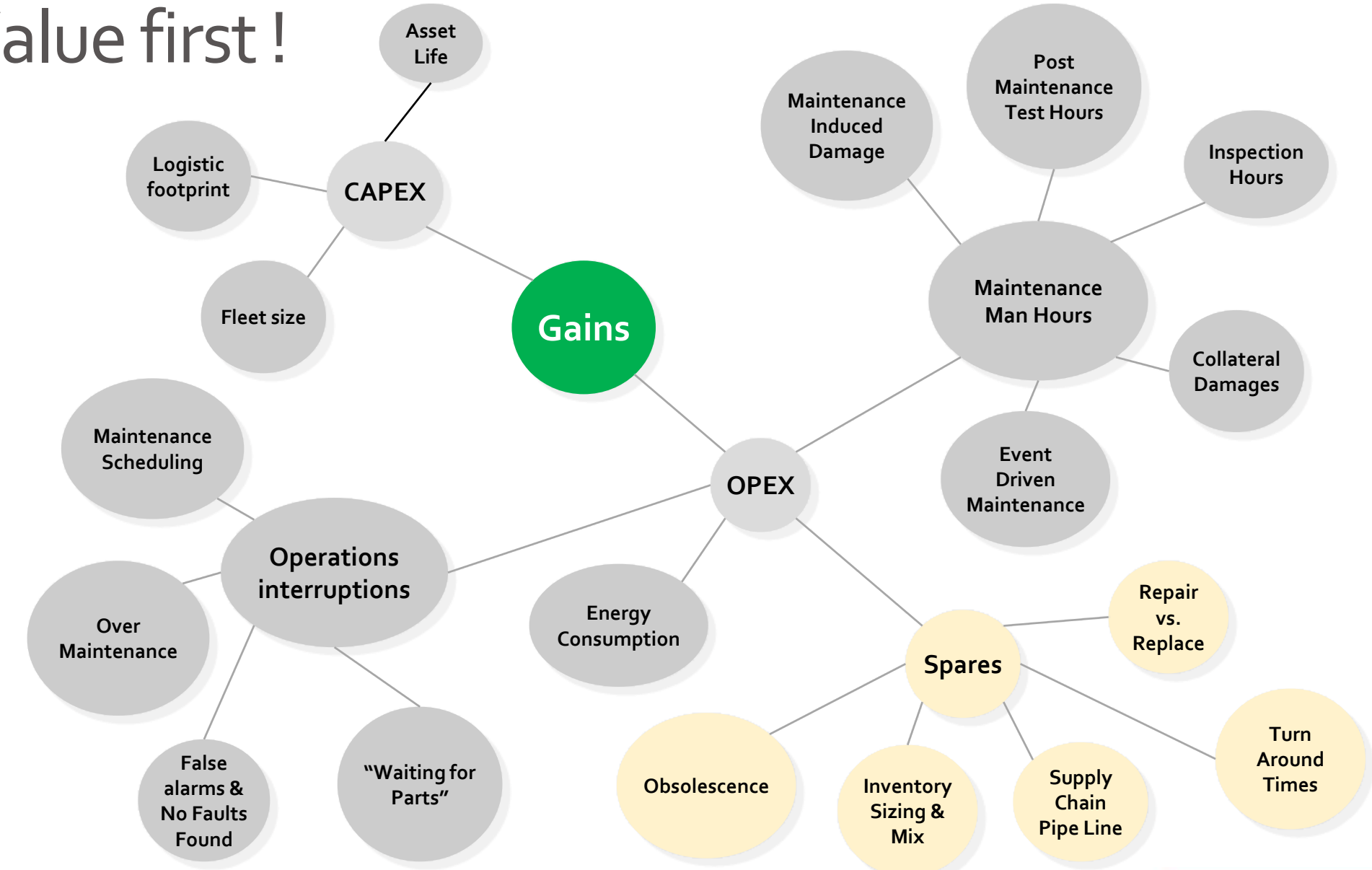
LifeCycle Costing

Planning and controlling MRO costs over the asset life

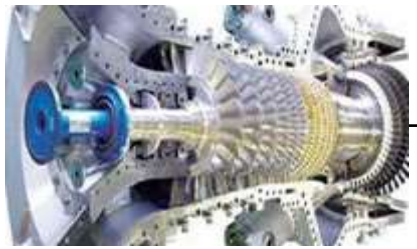
Asset Improvement & retrofit

Upgrading and extending asset capabilities

Value first !


Asset Life
Logistic footprint
CAPEX
Fleet size
Gains
Maintenance Induced Damage
Post Maintenance Test Hours
Inspection Hours
Maintenance Man Hours
Collateral Damages
Event Driven Maintenance
OPEX
Maintenance Scheduling
Operations interruptions
Over Maintenance
False alarms & No Faults Found
"Waiting for Parts"
Energy Consumption
Spares
Repair vs. Replace
Turn Around Times
Obsolescence
Inventory Sizing & Mix
Supply Chain Pipe Line

Focus first on organs that actually drive failures



compressors, turbines, pumps, motors, etc

Bearings

Gears

Shafts

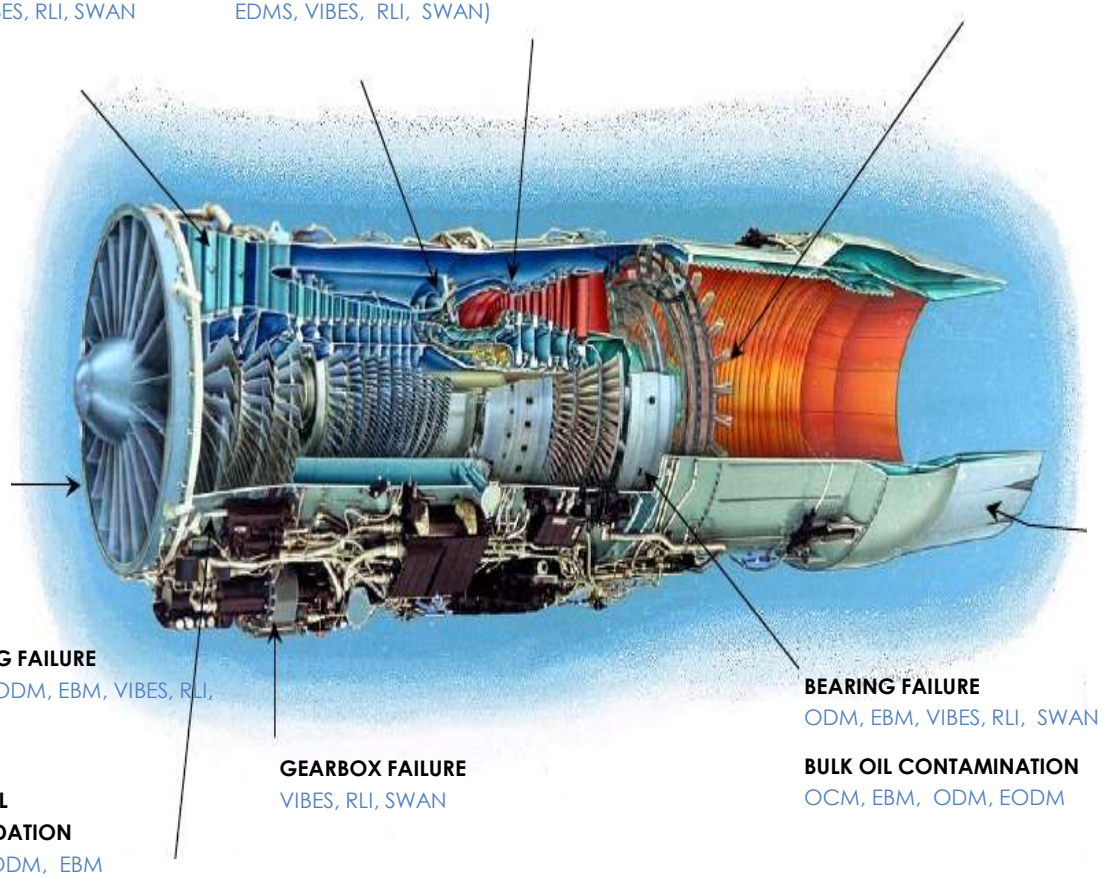
Leverage any kind of data

FAN 1 ROTOR TIP/ CRACKS
(ECS, BVM, AFD, IDMS, EDMS, VIBES, RLI, SWAN

OVERFLOWING / BLOCKED FUEL NOZZLE
EDMS, VIBES, RLI, SWAN)

COMBUSTOR/HPT EROSION
EDMS

LPT BLADE RUB
EDMS,VIBES, RLI,SWAN



BEARING FAILURE
ODM, EODM, EBM, VIBES, RLI, SWAN

BULK OIL DEGRADATION
OCM, ODM, EBM

VAPOR PHASE COKING
OCM, ODM, EODM, EBM

GEARBOX FAILURE
VIBES, RLI, SWAN

BEARING FAILURE
ODM, EBM, VIBES, RLI, SWAN

BULK OIL CONTAMINATION
OCM, EBM, ODM, EODM

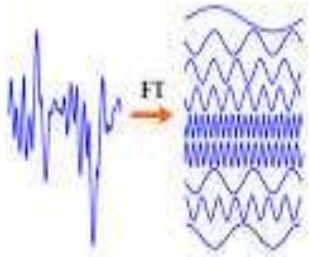
AFD	Acoustic FOD Detector
BVMX	Blade Vibration Meter
EBM	Electrostatic Bearing Monitor
ECS	Eddy Current Blade Sensor
EODM	Eletrosatatic Oil Debris Monitor
EDMS	Engine Distress Monitoring
IDMS	Ingested Debris Monitoring
ODM	Oil Debris Monitor
PZT	Piezoceramic Patch Crack Detection
RLI	Robust LASER Inferometer
SWAN	Stress Wave Analysis
VIBES	Vibrations sensor

Understand the dynamic of the machinery

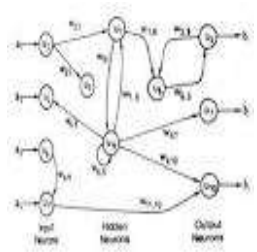
	Failure modes	Sensor Data	Data characteristic
 Bearings	• Failure of outer/inner races, rollers or cage	• Vibration • oil debris • acoustic • emission	• high noise in raw data
 Gears	• Tooth pitting • Gear crack • Wear	• Vibration • oil debris • Acoustic emission	• High noise • Signal modulatlion (coupling with bearing, shaft transmission path)
 Shafts	• Misalignment • Unbalance • Bend • Crack • Rubbing	• Vibrations	• Vibration signal is relatively clean and harmonic • frequency components of rotating speed can indicate the defects

Pick and train relevant analytical technique

- **Feature extraction**
  - Fourier Transform Analysis
  - STFT Analysis
  - Wavelet Packet Decomposition
  - Autoregressive Modeling

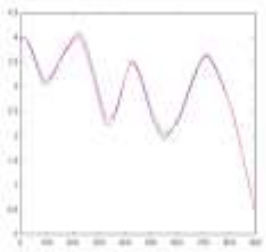


- **Diagnosis**
  - Feature Map
  - Hidden markov Model
  - **Bayesian Network**
  - Neural network

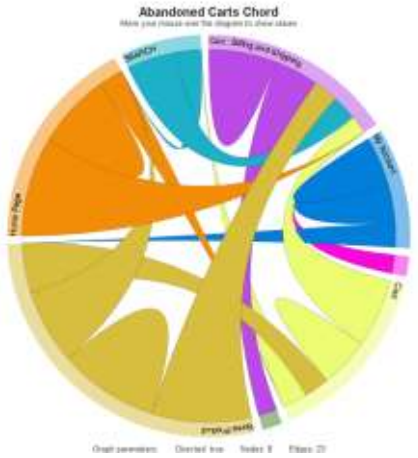


- **Pattern Recognition**
  - Logistic Regression
  - Feature Map
  - Statistical Pattern Recognition
  - Hidden Markov Model

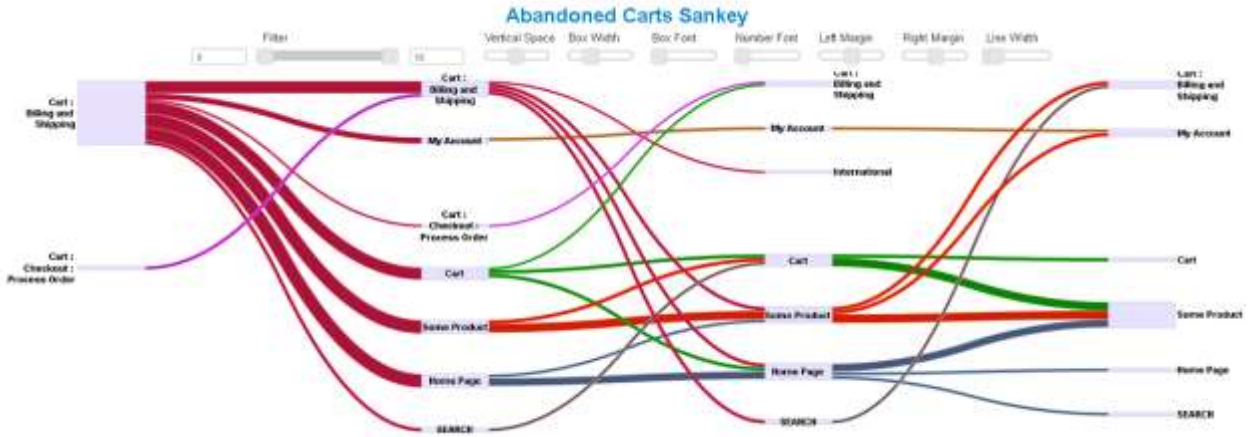
- **Forecasting** ***(Remaining Life)***
  - Autoregressive Moving Average
  - Match Matrix Prediction
  - Fuzzy Logic Prediction
  - Neural Network Predicton



Visualise and share

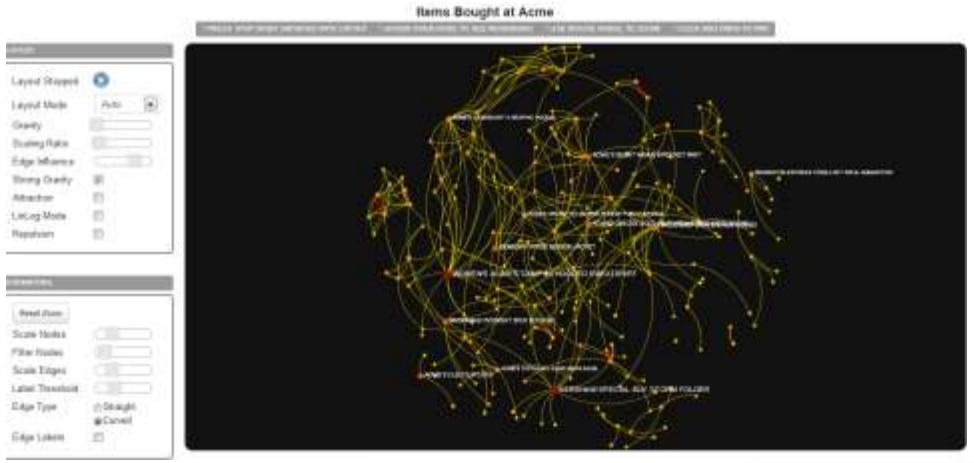


Accord



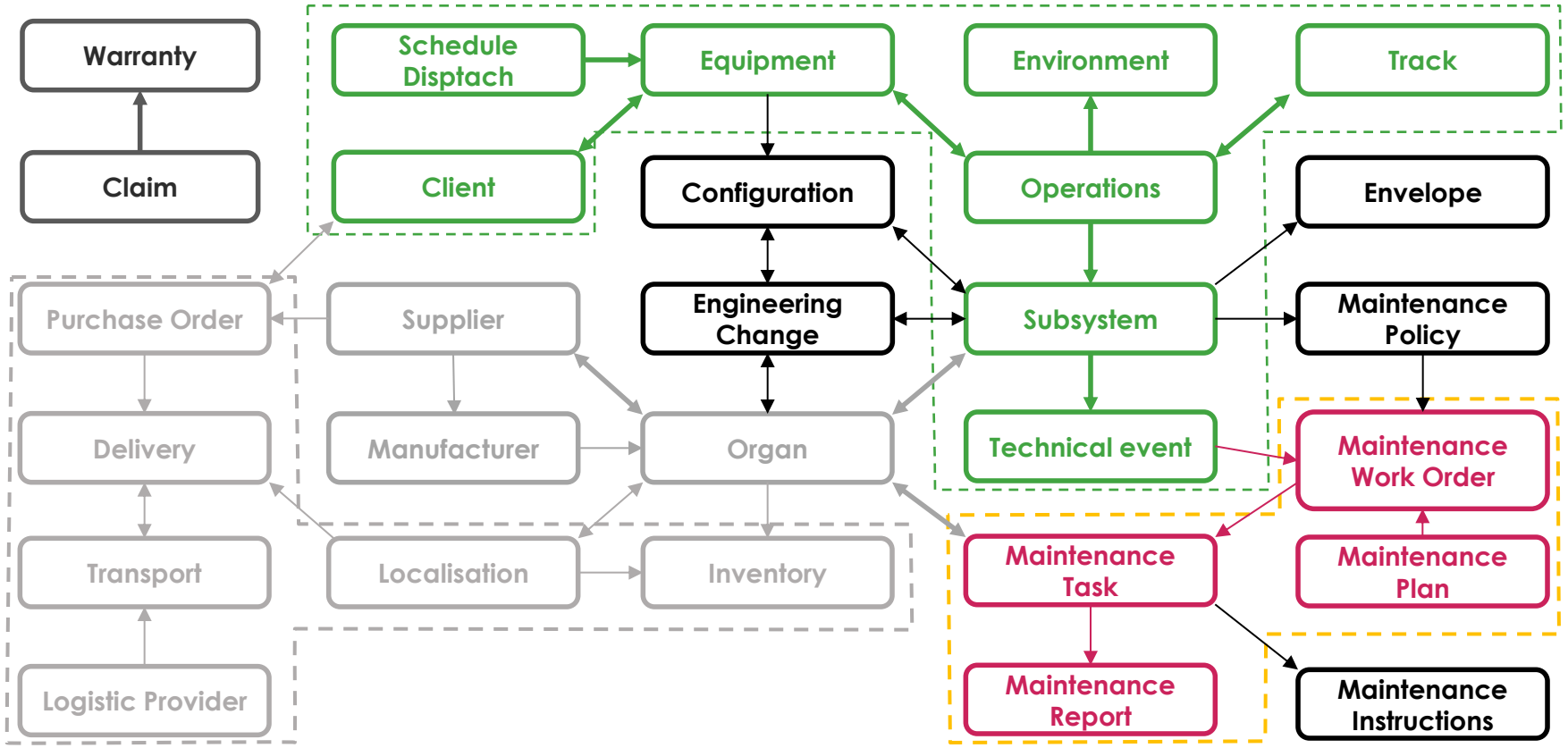
Flux

Hiérarchie

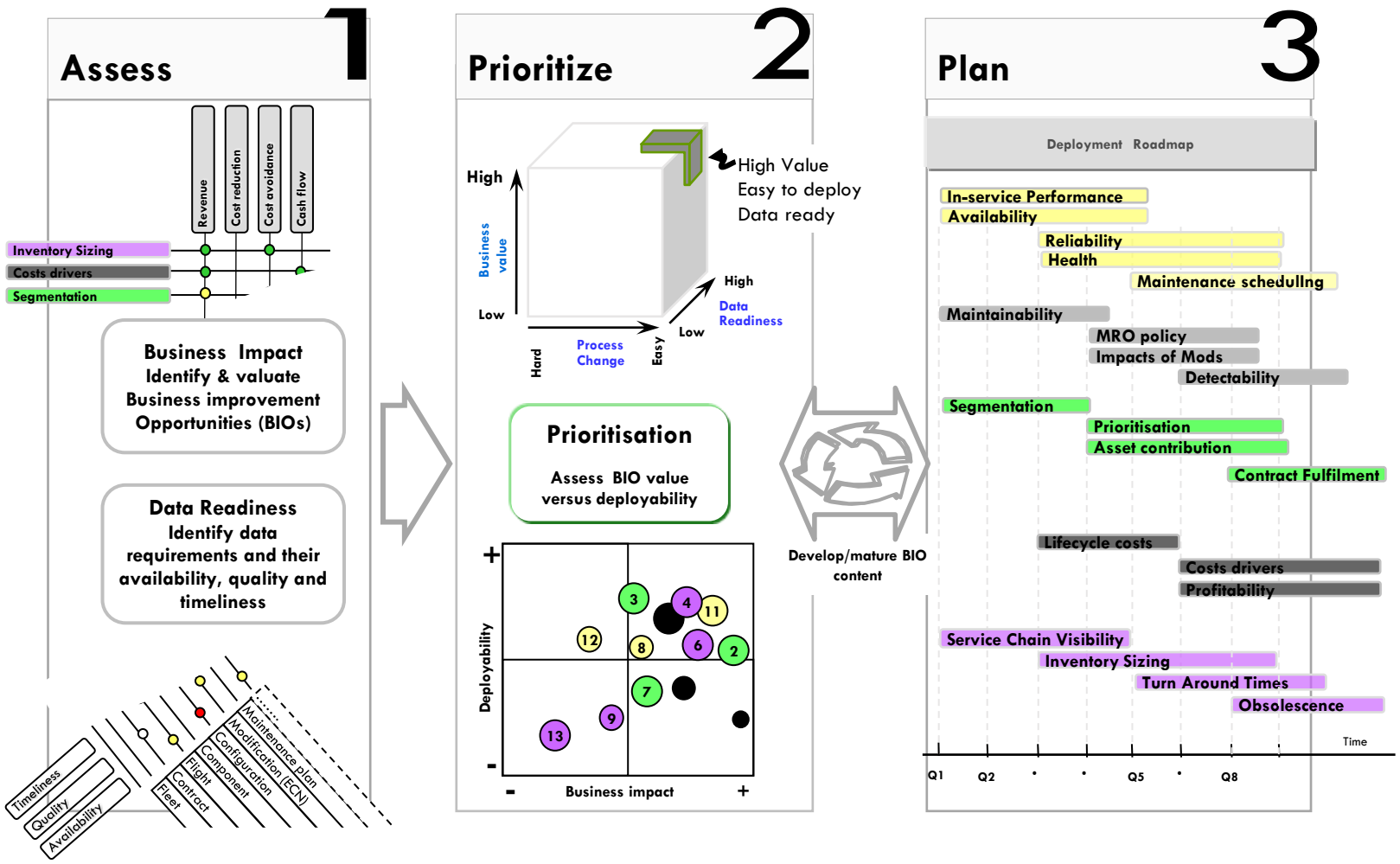


Affinité

Enlarge progressively your data scope



Adopt a step by step approach



Thank you !

Q & A