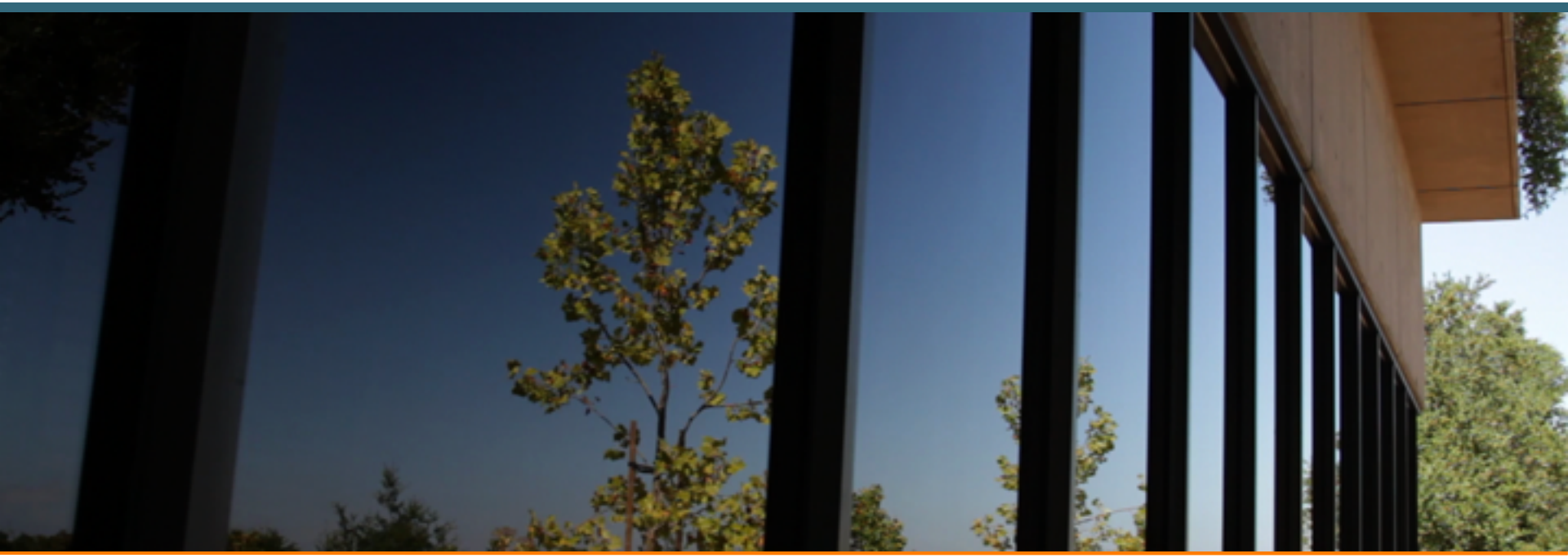
parc
A Xerox Company

PARC: International Collaboration for Industrial IOT

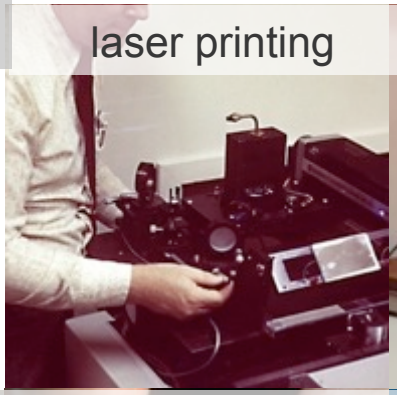
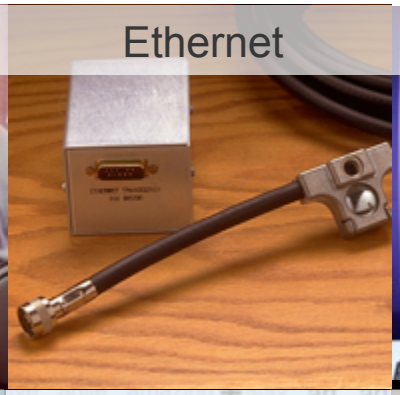
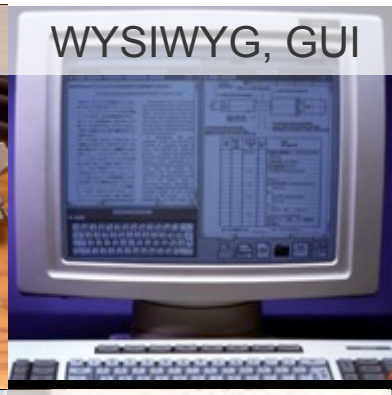
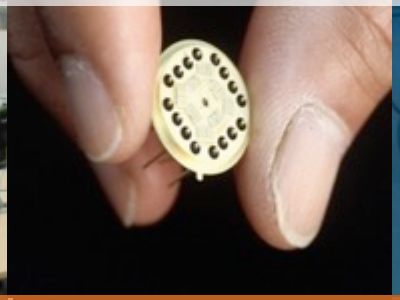
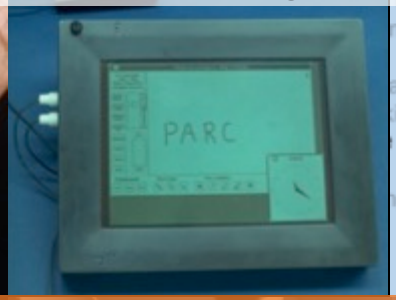
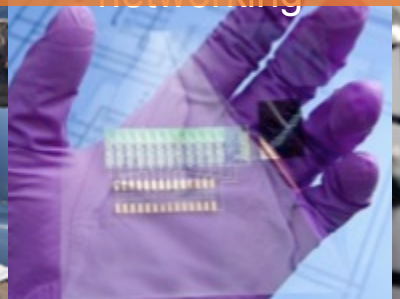
Rail Asset Maintenance Using Intelligent Systems




parc®
A Xerox Company
3333 COYOTE HILL ROAD

Palo Alto Research Center

The Business of Breakthroughs®

founded 1970	laser printing	PC workstation	Ethernet	WYSIWYG, GUI
				
corporate ethnography	multi-beam laser diodes	ubiquitous computing	collaborative filtering	AI/ model-based systems
				
incorporated 2002	UVLEDs	cleantech	printed & flexible electronics	content-centric networking
				

PARC spun out from Xerox in 2002 to focus on

Commercial Innovation

1970

XEROX PARC

founding mission to create:

“The Office of the Future”

2002

parc®
A Xerox Company

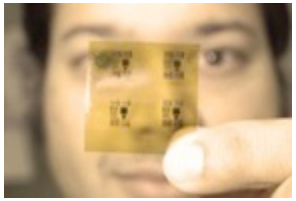
mission today:

The Business of Breakthroughs™

PARC by the Numbers

PEOPLE

250+ scientists, engineers, ethnographers, business staff from 35 countries; 80% doctoral degrees



RESEARCH

3 Software Labs (Computing Science, System Sciences, Intelligent Analytics)
2 Hardware Labs (Electronic Materials & Devices, Hardware Systems)

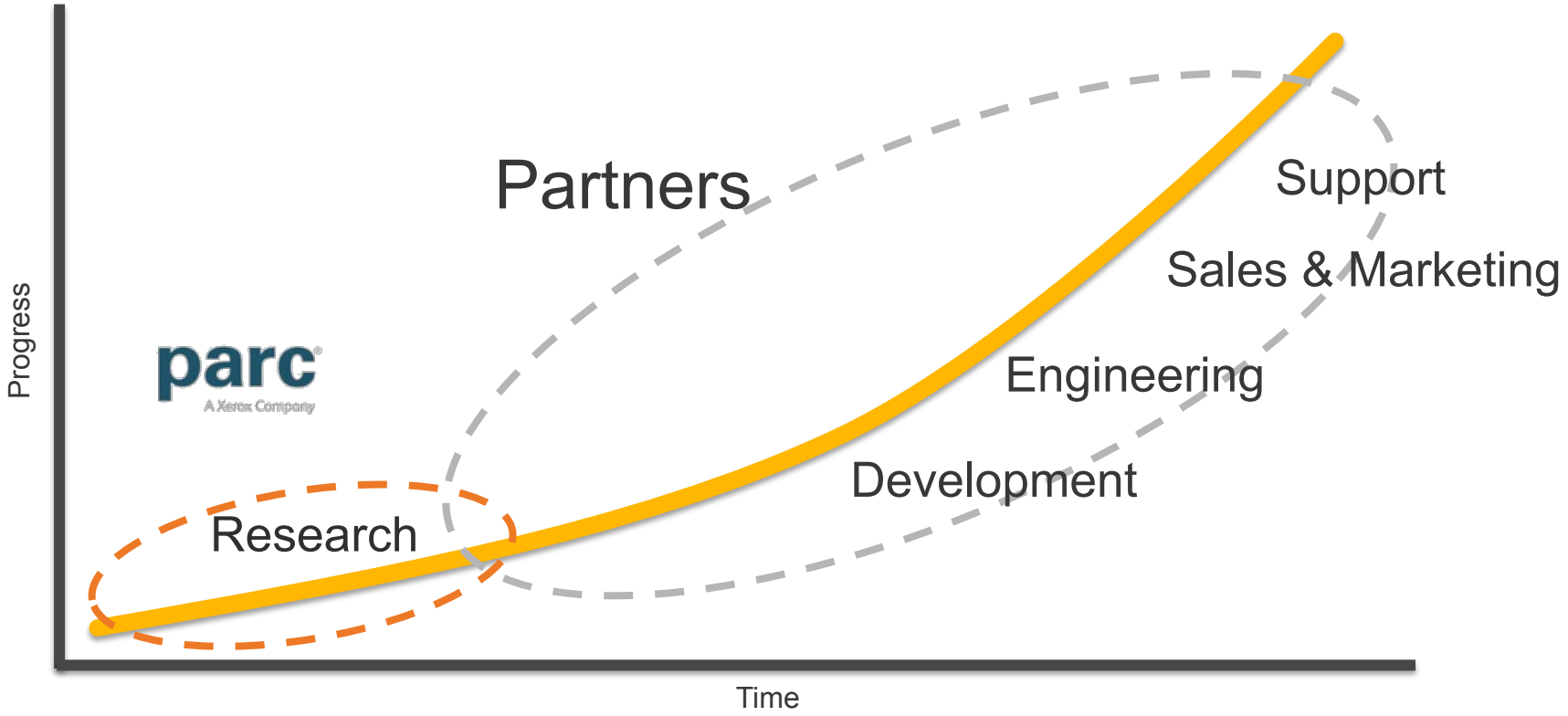
BUSINESS MODELS

4 lines of business: Client Service, Xerox, Government, Licensing

PORTFOLIO

(~150 per year), 4000 papers, 100 books

Product Development Process: PARC's Focus



We're now investing in the future

Energy

Printed & Flexible Electronics

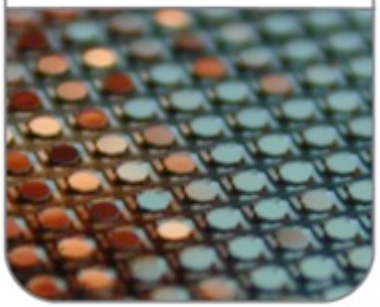
Prototyping Services

Networking & Distributed Systems

Digital Design & Manufacturing

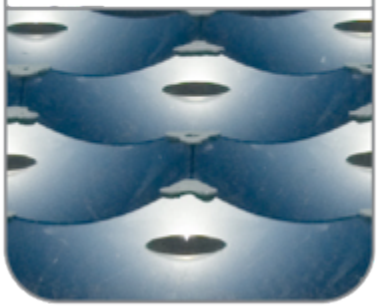
Innovation Services

Optoelectronics



Big Data

Cleantech



Health & Wellness

Our Core Research Programs

Some of our publically announced clients…(not full list due to confidential nature of our business)

DOWA

dentsu

SAMSUNG

NEC

FUJITSU

IHI

dpix®

meshin

Powerset
NATURAL LANGUAGE SEARCH.

DNP

Sun
ORACLE

PowerCloud
systems

SolFocus
Innovation Inspired by Nature

HONDA
The Power of Dreams

EMC²
where information lives®

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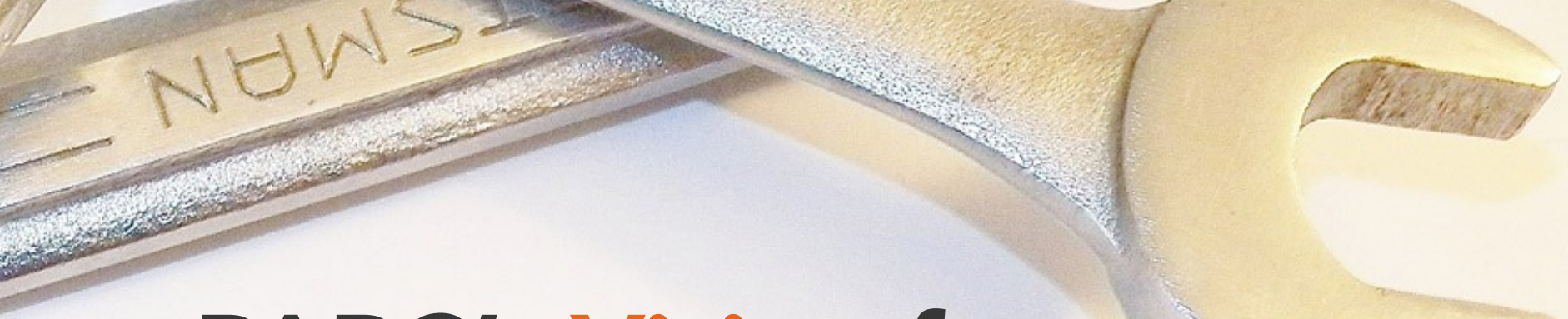


PARC's Vision for Maintenance

More Control

Time Based Maintenance (TBM)

Condition Based Maintenance (CBM)

Self Analyzing Systems

Self Adaptive Assets

Higher Awareness

TBM

Time Based Maintenance

...maintenance and/or inspections carried out on a periodic basis to prevent or reduce failure of equipment, machinery, and the like…

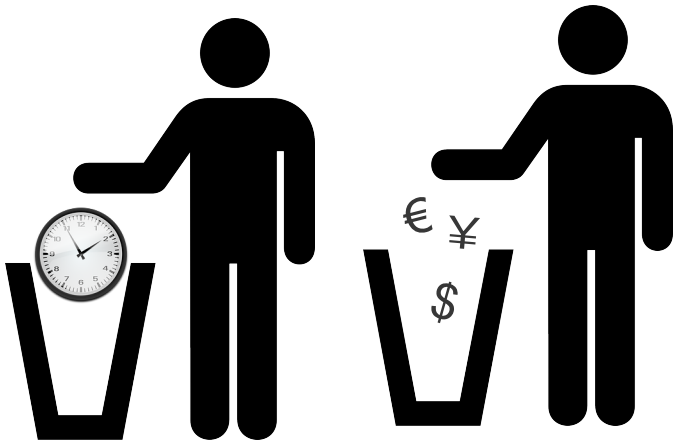
- *Oil change every 5,000 miles or 5 months*
- *Tune-up at 30,000 miles*
- *Tune-up at 50,000 miles*
- *Tune-up at 75,000 miles*

Etc…

TBM

Time Based Maintenance

...maintenance and/or inspections carried out on a periodic basis to prevent or reduce failure of equipment, machinery, and the like…



Too early

Too late

CBM

Condition Based Maintenance

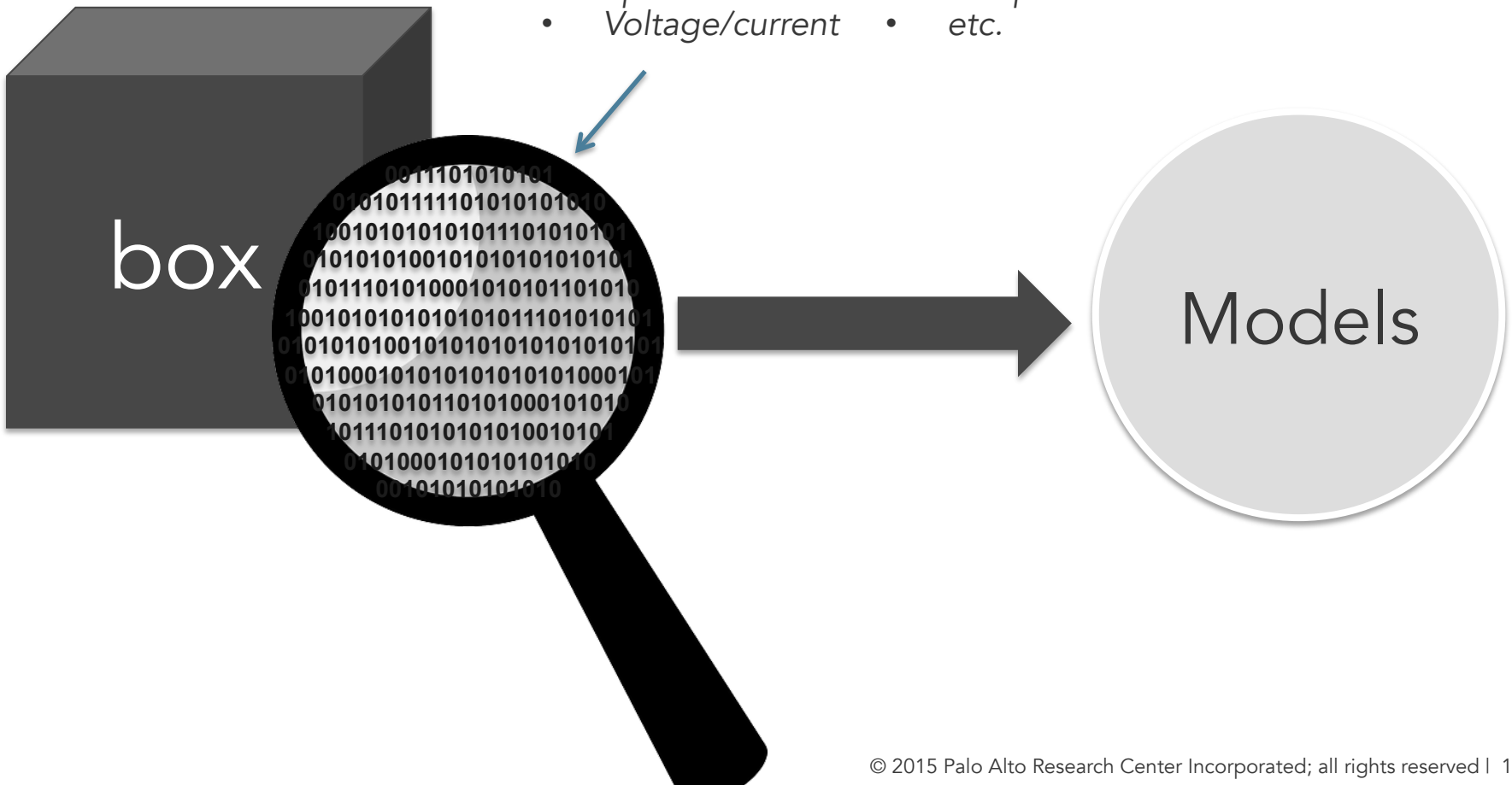
Perform maintenance only when needed

This results in:

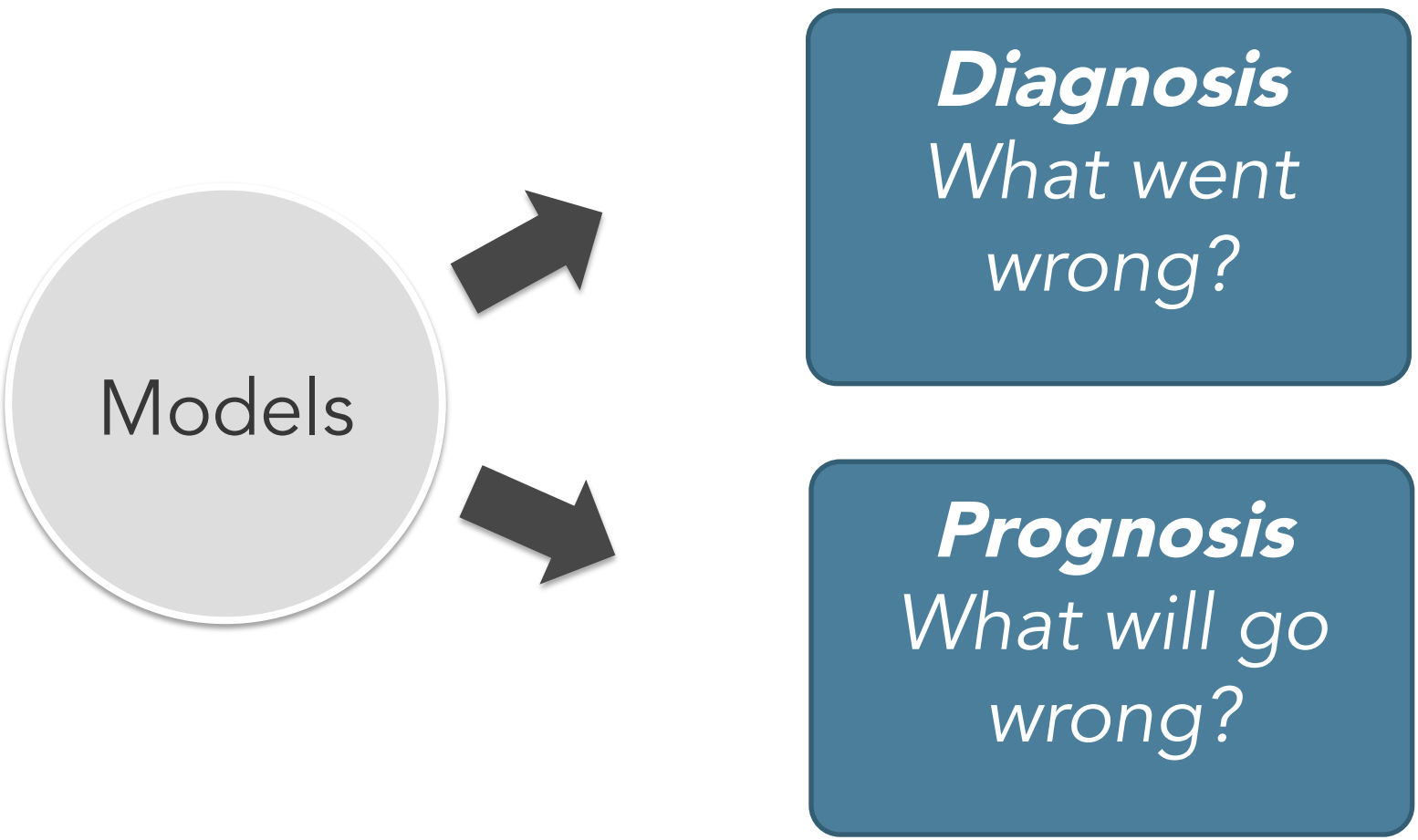
- *Reduce downtime of equipment*
- *Saved costs of unnecessary maintenance*
- *Extend the useful life of equipment*

Build models from data

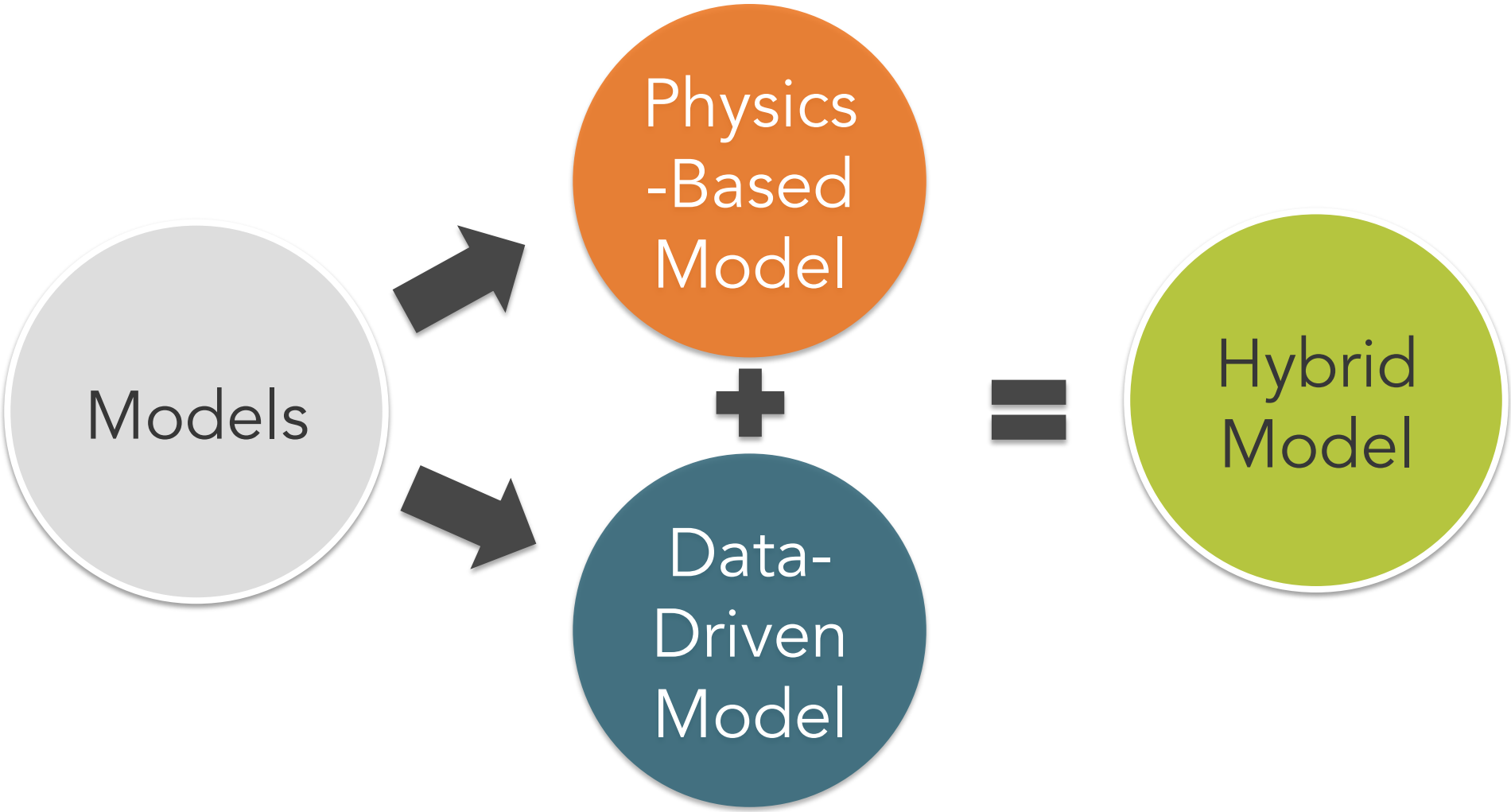
- *Vibration*
- *Temperature*
- *Pressure*
- *Speed*
- *Voltage/current*
- *Stress/strain/shock*
- *Position*
- *Particulate count/ composition*
- *etc.*



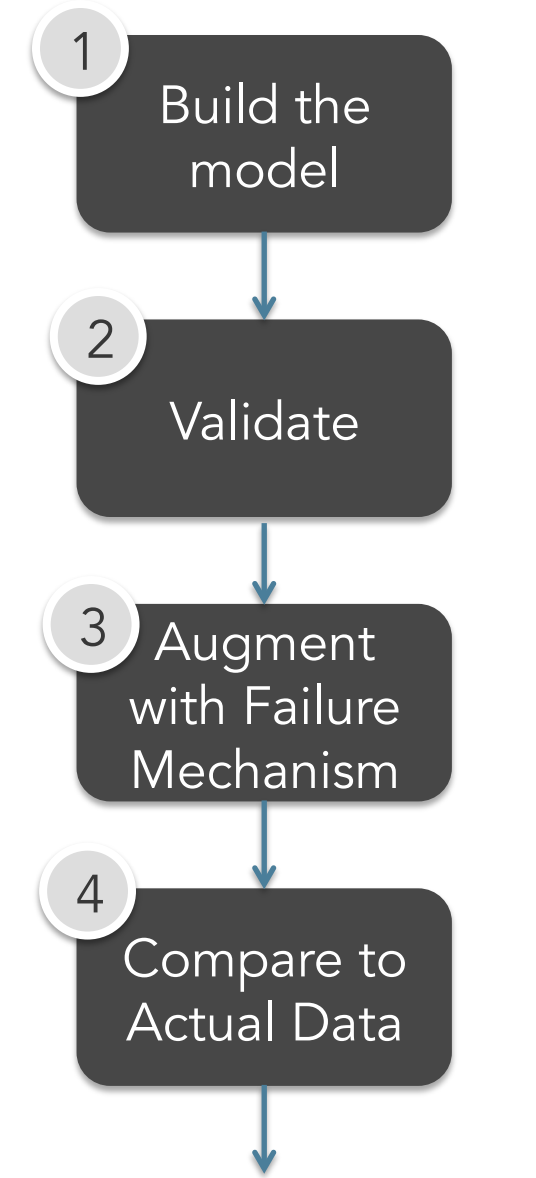
What?



How?

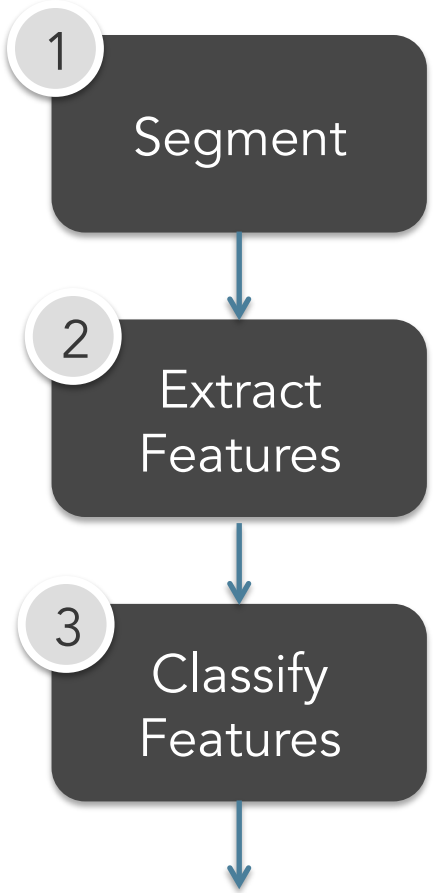


Physics-Based Model



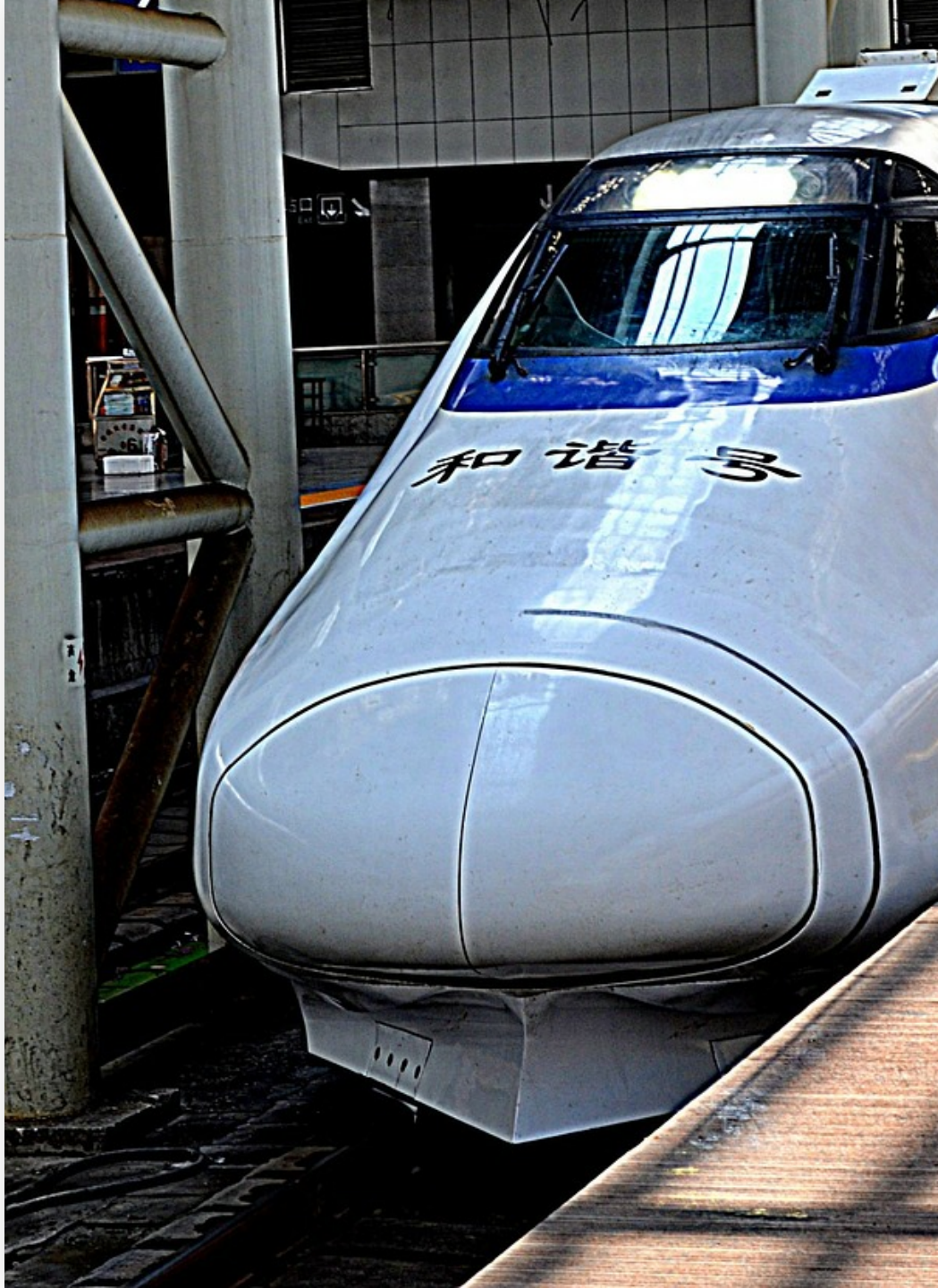
Diagnosis Results

Data-Driven Model



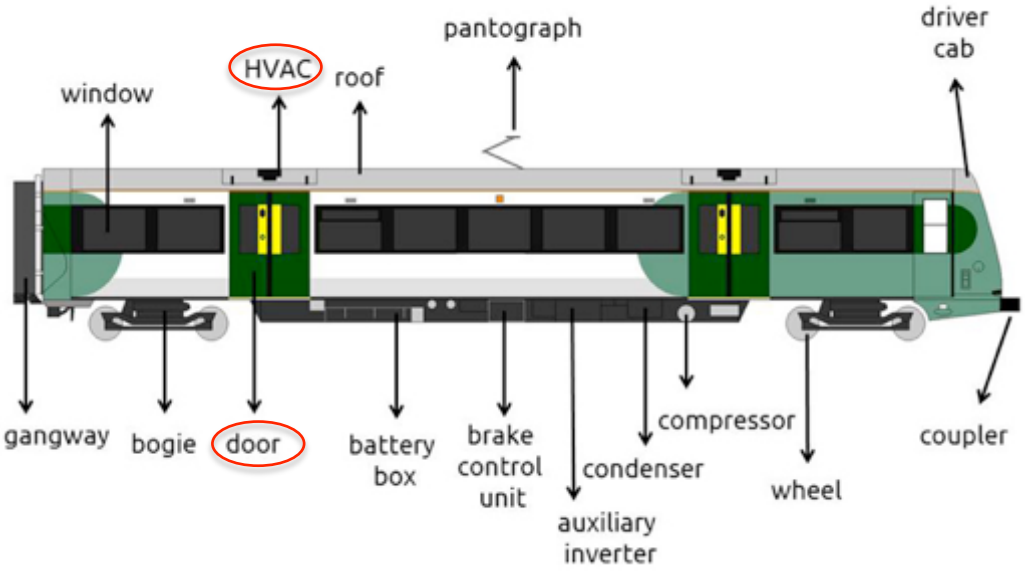
Diagnosis Results

Collaboration with Major Asian Railway Operator

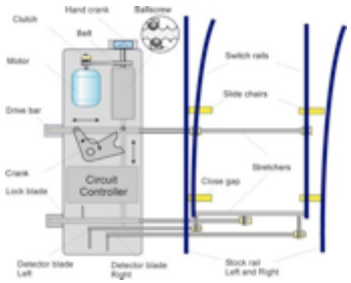


Railway asset maintenance

Doors, HVAC

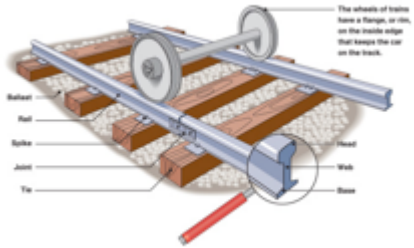


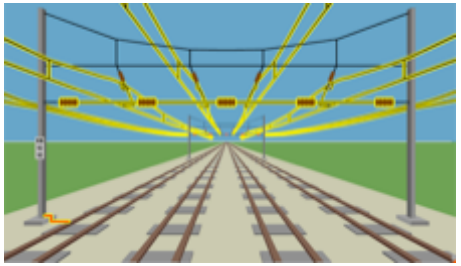
Rolling stock assets



Switch machine

Rails





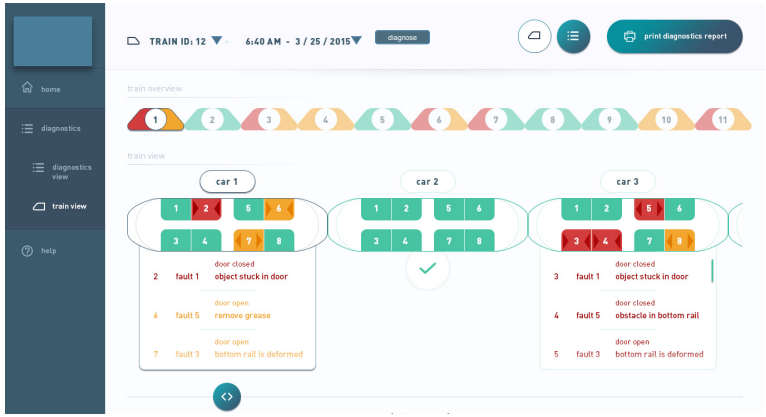
Overhead contact wire

Non-rolling stock assets

Case study 1: Sliding train doors

- Background
  - Train door problems are one of the largest causes of train delays
    - 30% of all delays in UK passenger trains attributed due to doors
  - Door operational failures are often due to some undetected underlying cause
    - Stuck obstacles, Deformity of guide rails, Loose bolts, Lack of lubrication
- Customer (Global 1000 company) problem
  - Detect underlying condition based on available sensor measurements
- PARC approach and results
  - Developed a data-driven model that achieved 98% accuracy in detecting and identifying one of 7 underlying causes
  - Currently developing software to integrate into client's maintenance workflow

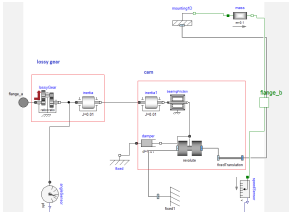
Engineer screen snapshot



Maintenance technician screen snapshot

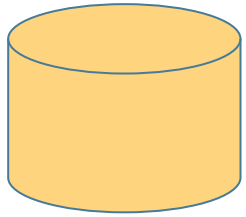
Case study 2: Switch machine

- Background
  - Critical to the smooth and safe operation of trains
  - Switch machine maintenance operations can be made more efficient if certain soft/ hard faults can be detected via analytics
    - Stuck objects, Loose bolts, Missing bearings
- Customer (Global 1000 company)
  - Detect underlying condition based on available sensor measurements
- PARC approach and results
  - Built a physics-based model of the switch machine
  - Developed a hybrid classifier that achieved 99% accuracy in detecting and identifying one of 5 underlying causes

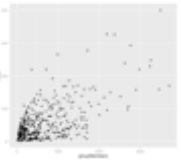


Partially validated model

+



Limited nominal data



Key insights, feature engineering

Case study 3: Rail surface defect analysis

- Background
  - Rail surface characteristics impact safety and ride comfort
  - Manual inspections are labor intensive and prone to errors
- Customer (Global 1000 company) problem
  - Develop image analysis techniques to automatically process large amounts of data and detect faults
- PARC approach and results
  - Developed a data-driven model that achieved >90% true positive rates in detecting various conditions with < 5% false positive rates

Examples illustrating defect types