NTNU | Norwegian University of Science and Technology

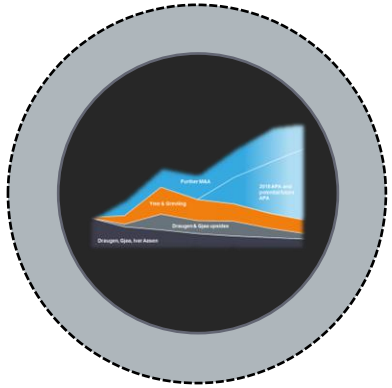
A Smart Maintenance approach towards extending the lifetime of existing Norwegian oil and gas installations

A BRU21 project with NTNU and OKEA

Background of the PhD project

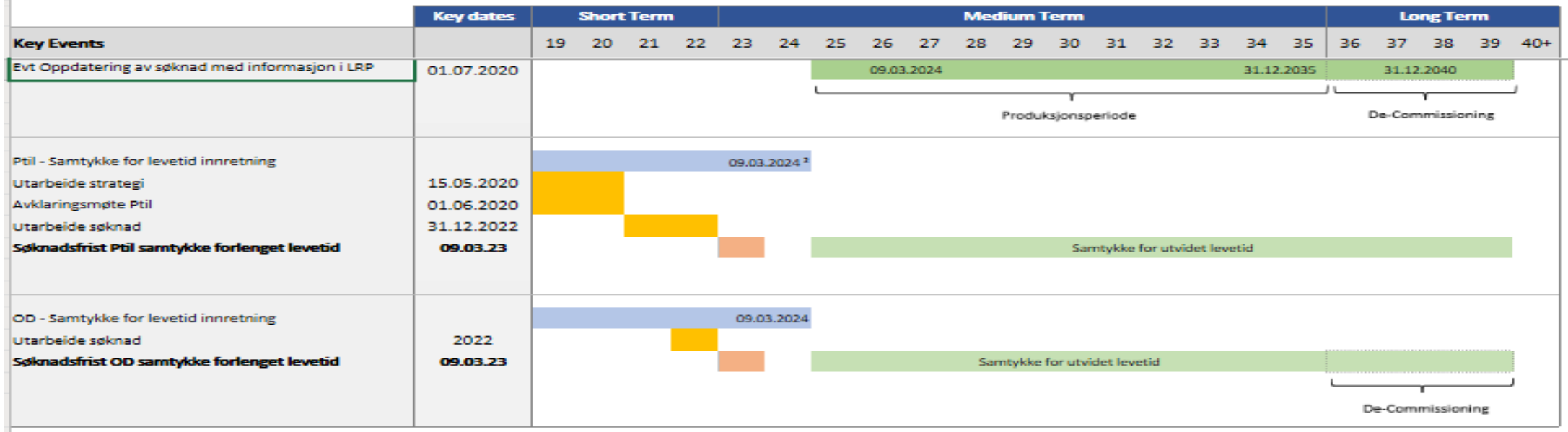
Figures: (BRU21, NTNU) (Draugen platform, Wikipedia)

The OKEA journey continues

	OKEA is founded	*Acquiring Grevling to assess development*	*Closing of the Yme acquisition*	*Acquire Draugen and Gjøa from Shell*	*Listing at Oslo Børs*	*Roadmap to future value creation*
	2015	*2016*	*2017*	*2018*	*2019*	
OKEA's size measured in reserves[1]						
	0 mmboe	***1 mmboe***	***11 mmboe***	***52 mmboe***	***55 mmboe***	
Key strategic decisions and milestones	• Defining a niche as a NCS operator	• Turning Yme from an abandonment field to a development opportunity	• Approved as an operator on NCS • Starting to attract interest from international investors	• Bangchak enters into OKEA as a long term strategic investor • Able to extend field life for Draugen from 2027 to 2035 • Producing more than 20,000 boepd	• OKEA IPO and prepared for further growth • Sanctioned developments of Yme and P1 at Gjøa • Not yet sanctioned Grevling development, Hasselmus and Draugen infill • Other prospective resources	✓ Increase daily production ✓ Continue to explore for additional reserves, identify stranded assets and M&A opportunities ✓ Join exploration companies to develop their discoveries ✓ Continue to cooperate closely with the service industry when developing fields

1) 2P reserves from CPR

Draugen Life time Extension – Work Process



¹ Lisenser i forlengelsesperioden og hvor det er søkt om samordning av lisensperioden til 2040

PL 093 - 09.03.2024
PL 176 - 01.03.2028
PL 093C - 09.03.2024
PL 093D - 09.03.2024

² Analyser

Analyser lagt til grunn i eksisterende samtykkesøknad la den gang til grunn at innretningen kunne drives med et akseptabelt sikkerhetsnivå til 2037. Dette vil verifiseres igjen i neste søknad

Andre kommentarer:

Lisenser hvor forlengelse /samordning av datoer vurderes senere
PL 093B - 19.02.2010 til 19.02.2020
PL 158 - 03.03.1989 til 03.03.2028

Integrated part of Long Range Plan Draugen Process: Annual updated together with lience partners.

• Long Range Plan - Vision and Strategic Priorities

Vision: Draugen 2040+

Value Drivers	Ambition	Short Term <2023	Medium Term 2023-2035	Long Term >2035+
Safe Production	**No harm no leaks**	• Build/maintain a strong safety culture • Evaluate WE and safety improvements in lifetime extension project	• Maintain a strong safety culture • Safe execution of projects • Implement WE and safety improvements in lifetime extension project	• Maintain a strong safety culture • Health and safety in decommissioning
Environment	**Prudent Operator and Partnership**	• Environment and energy management plans • Establish a water disposal strategy • **Further mature Power from Shore** • Flare Gas Recovery decision • Electrification of PWRI pumps decision	• Continuously improve environmental footprint • Continuously improve energy efficiency • Implement water disposal strategy	• No leaks • No acute discharges • Compliant and sustainable decommissioning
Well and Reservoir Potential	**Ultimate Recovery beyond 70%** **Prove additional reserves** **Develop Draugen as hub**	• **Identify and execute IOR projects** • **Identify infill drilling targets** • **Explore prospects nearby the field** • **Develop Hasselmus project** • **Be an attractive hub to nearby discoveries** • Acreage management (APA) • Water flooding strategy incl. NWIT	• Continued identify and execute of IOR projects • Development of near field discoveries • Continued near field exploration • Improve reservoir understanding (new data) • Evaluate and perform new 4D seismic • Tie-backs / 3rd party processing	• Harvest mode
Production, Availability and Reliability	**Production to beat the plan** **Availability 91%** **Reliability 95%**	• Maximise well productivity, PSO and surveillance • Ensure technical integrity long term • **Power robustness** • **Equipment lifetime review and extension** • New technologies and digitalisation	• Maximise well productivity, PSO and surveillance • Maintain technical integrity • Define «harvest mode» • Kick off abandonment decision • New technologies and digitalisation	• Harvest mode • Maintain technical integrity • Maximise well productivity, PSO and surveillance
Cash Flow	**Always cash positive** **Robust at 40 dollar/barrel** **TQ performance among competition**	• **Cost effective operations** • **Mature Draugen 2040+** • **Application for consent Draugen LTE** • **LTE cost and engineering requirements** • Contract strategy enabling cost reduction • Activity based budgeting and cost ownership • Benchmark to assess and improve	• Cost effective operations • Contract strategy enabling cost reduction • Activity based budgeting and ownership • Define cost-effective decom strategy	• Cost effective operations and decom • Investment «ramp down» • Contract strategy enabling cost reduction • Activity based budgeting and ownership
People and organisation	**Engaged and competent people** **Robust organisation**	• Recruitment/Apprentices/Succession • Continuous improvement culture • Agile and flexible organisation • Human Engineering (MTO) • Strong 3rd party cooperation	• Recruitment/Apprentices/Succession • Focus on retention • Continuous improvement culture • Agile and flexible organisation • Human Engineering (MTO) • Strong 3rd party cooperation	• Retention of key competence • Continuous improvement culture • Agile and flexible organisation • Human Engineering (MTO) • Strong 3rd party cooperation • Organisation and people plan for decom

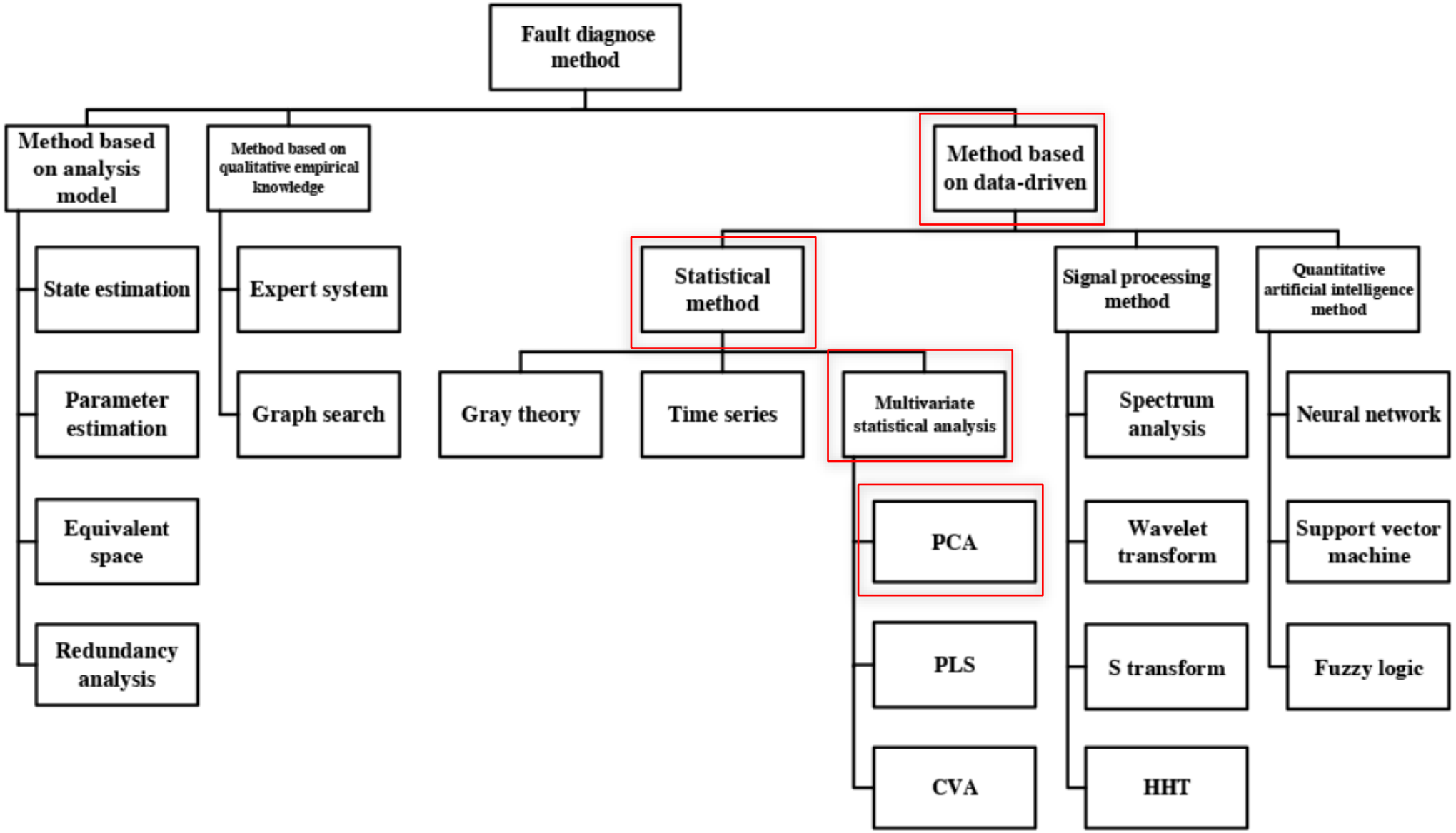
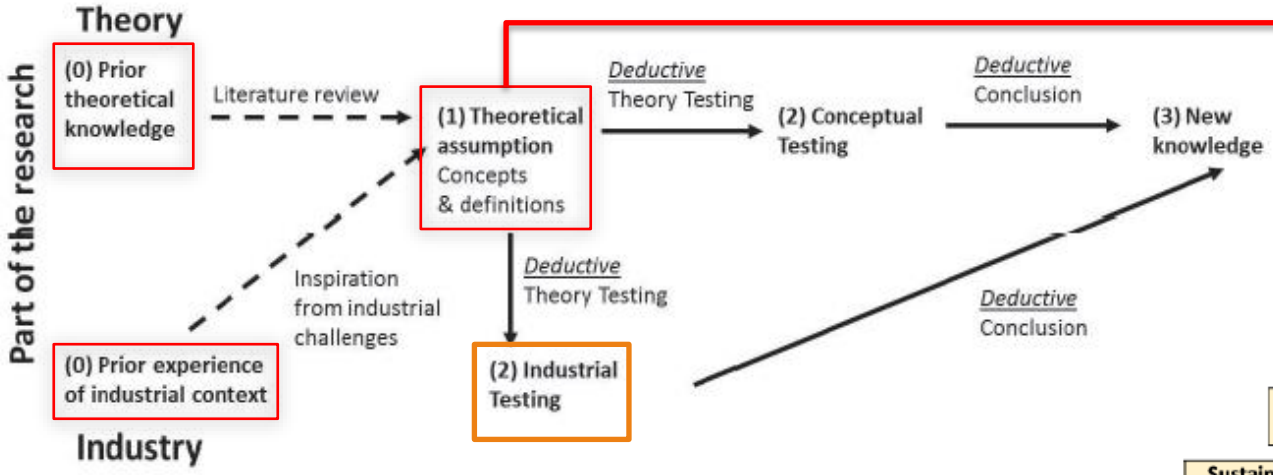
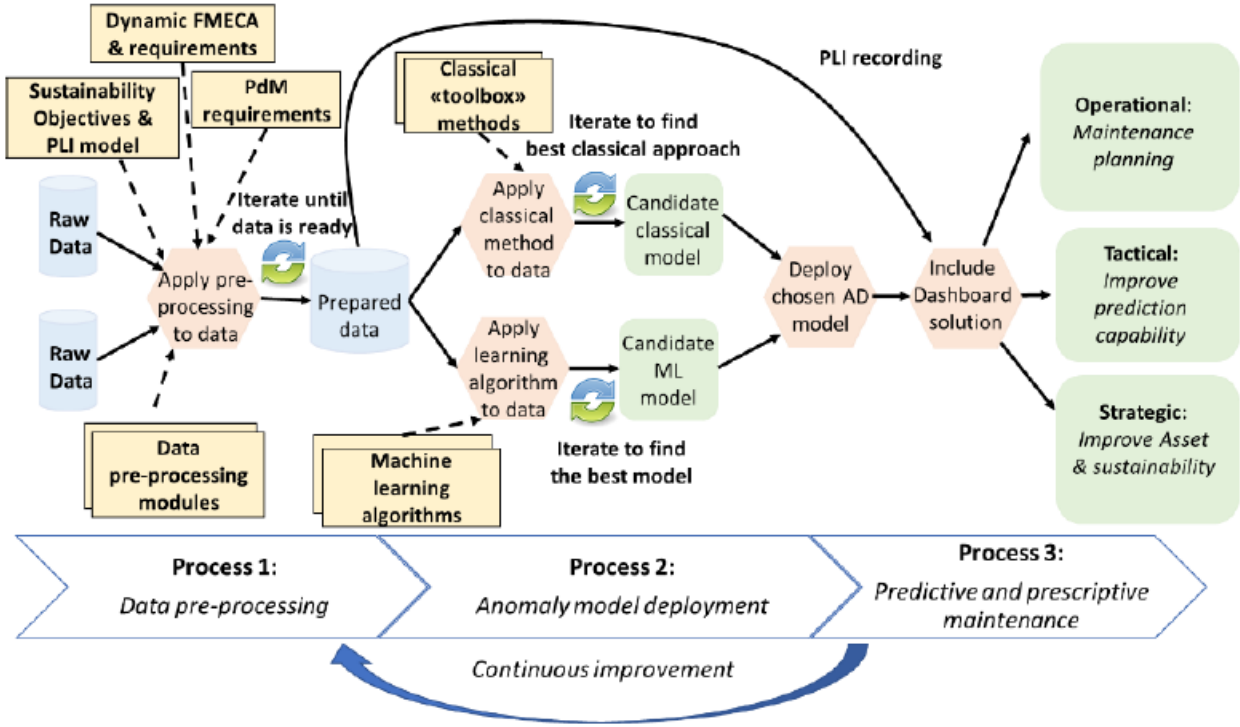


Figure: (Fault diagnose methods, SCi4.0)

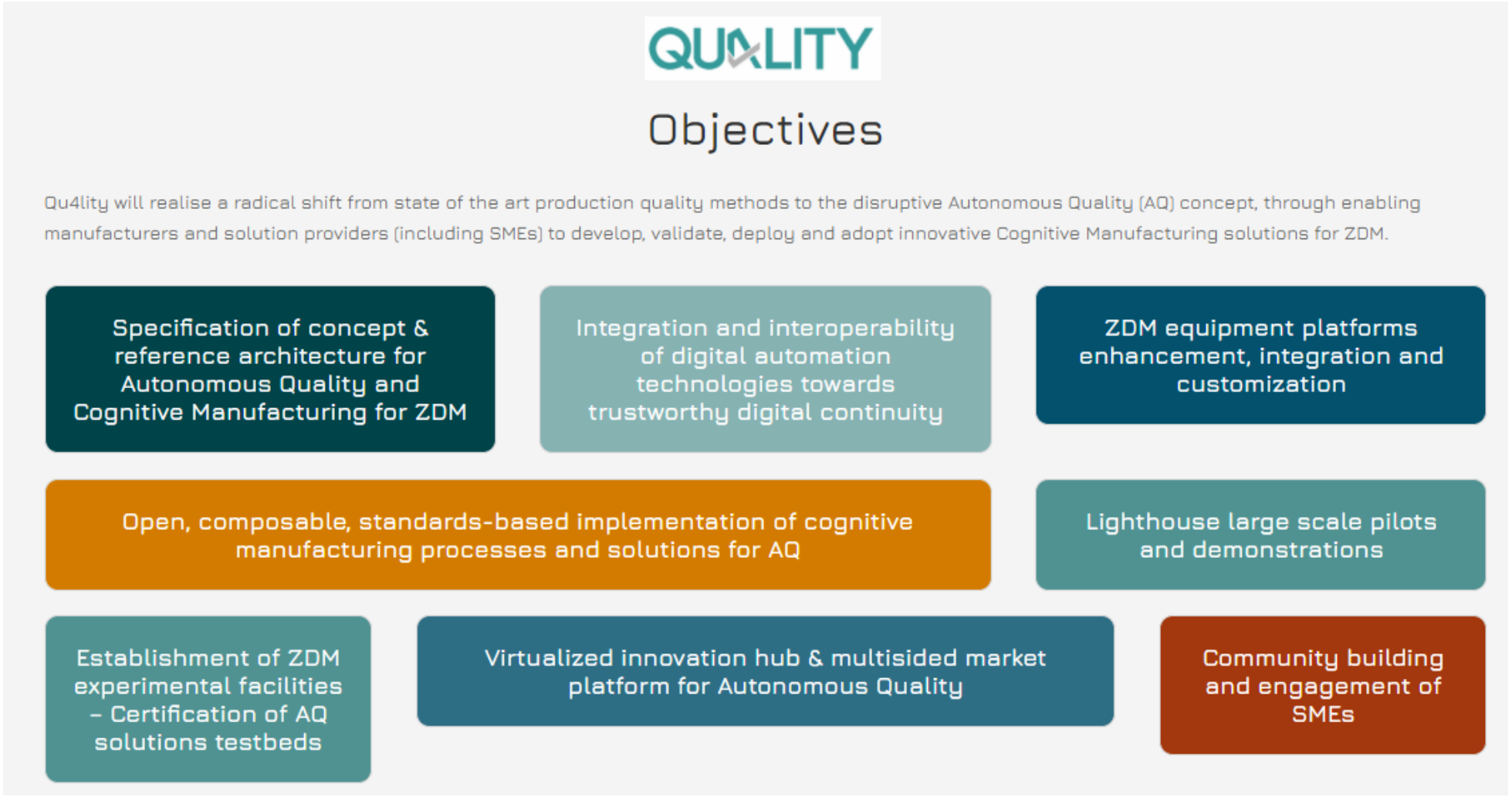
Analysis



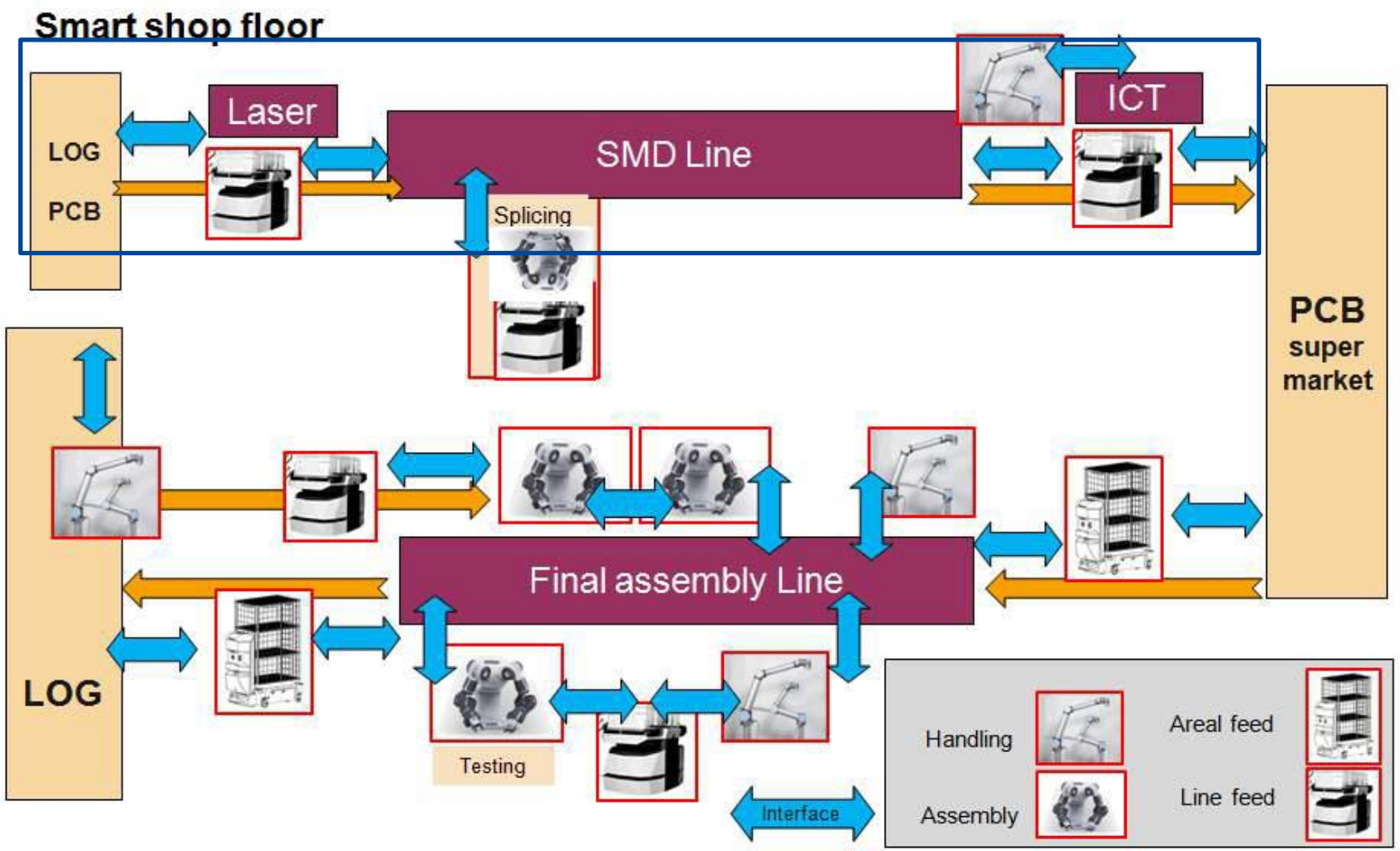


Figures: (Holistic Smart Maintenance model, Rødseth et al.)

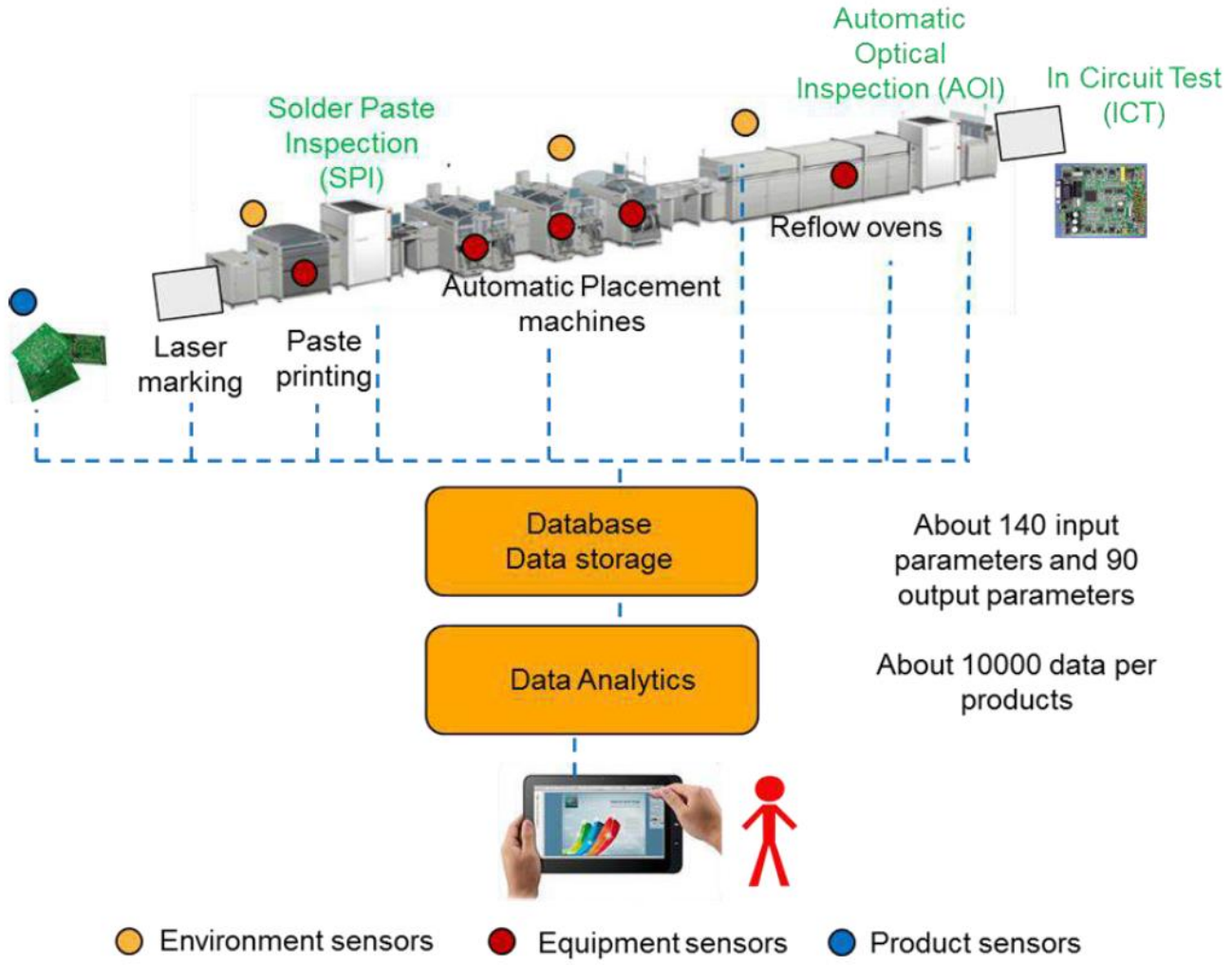
The QU4LITY EU Project



Continental: Autonomous Quality in PCB Production for Future Mobility



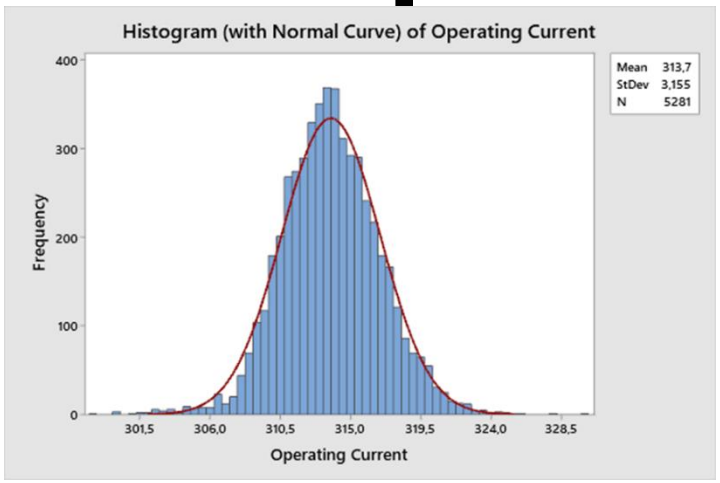
Challenge

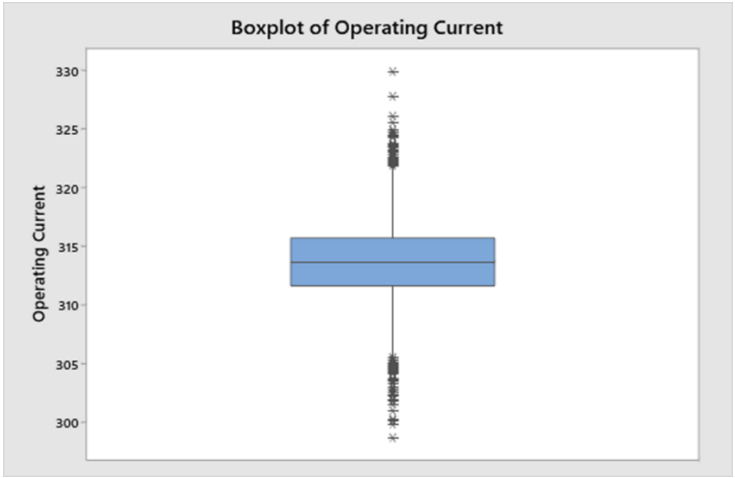

Automatic
Optical
Inspection (AOI)
In Circuit Test
(ICT)
Solder Paste
Inspection
(SPI)
Reflow ovens
Automatic Placement
machines
Laser
marking
Paste
printing
Database
Data storage
Data Analytics
About 140 input
parameters and 90
output parameters
About 10000 data per
products
Environment sensors
Equipment sensors
Product sensors

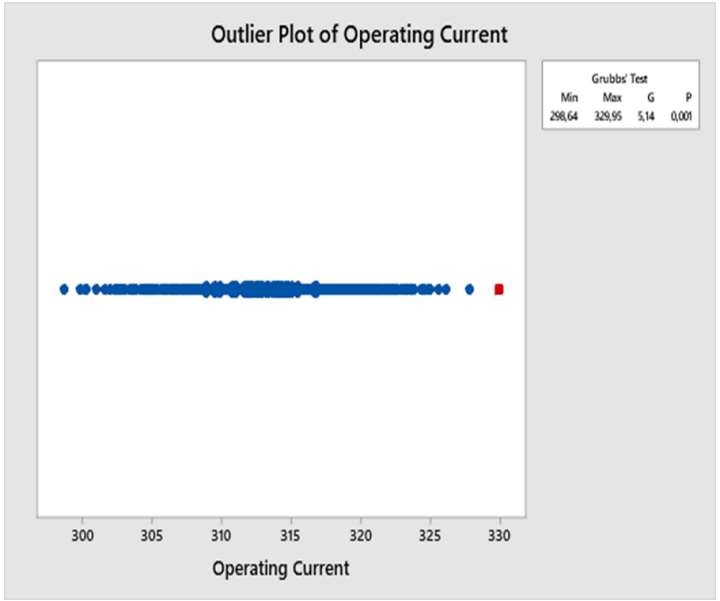
Analysis

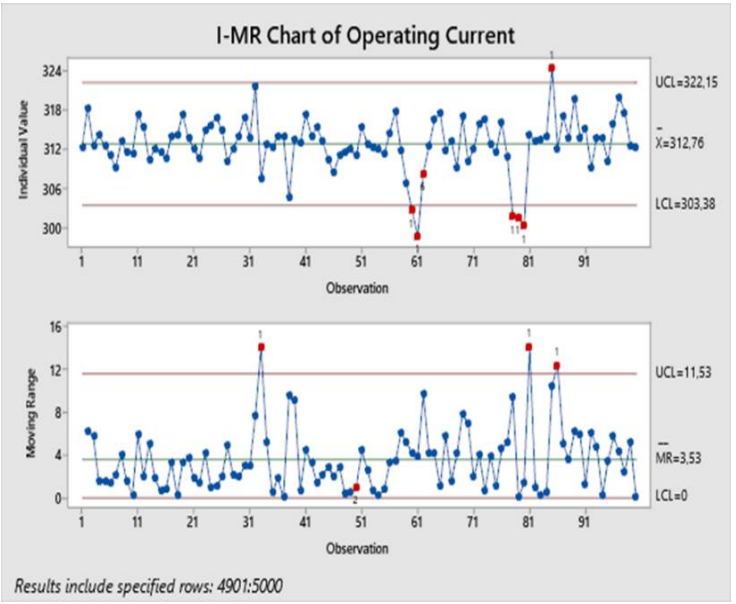
- PCB data is stored in a datalake in 3 dimensional datasets, where 30-40 columns and about 1700 rows describe one unique PCB
- Extraction of data from datalake
- Preprocessing and formatting for analysis
- Identifying critical variables using domain expertise
- Deciding on the most suitable method

Descriptive and exploratory analysis

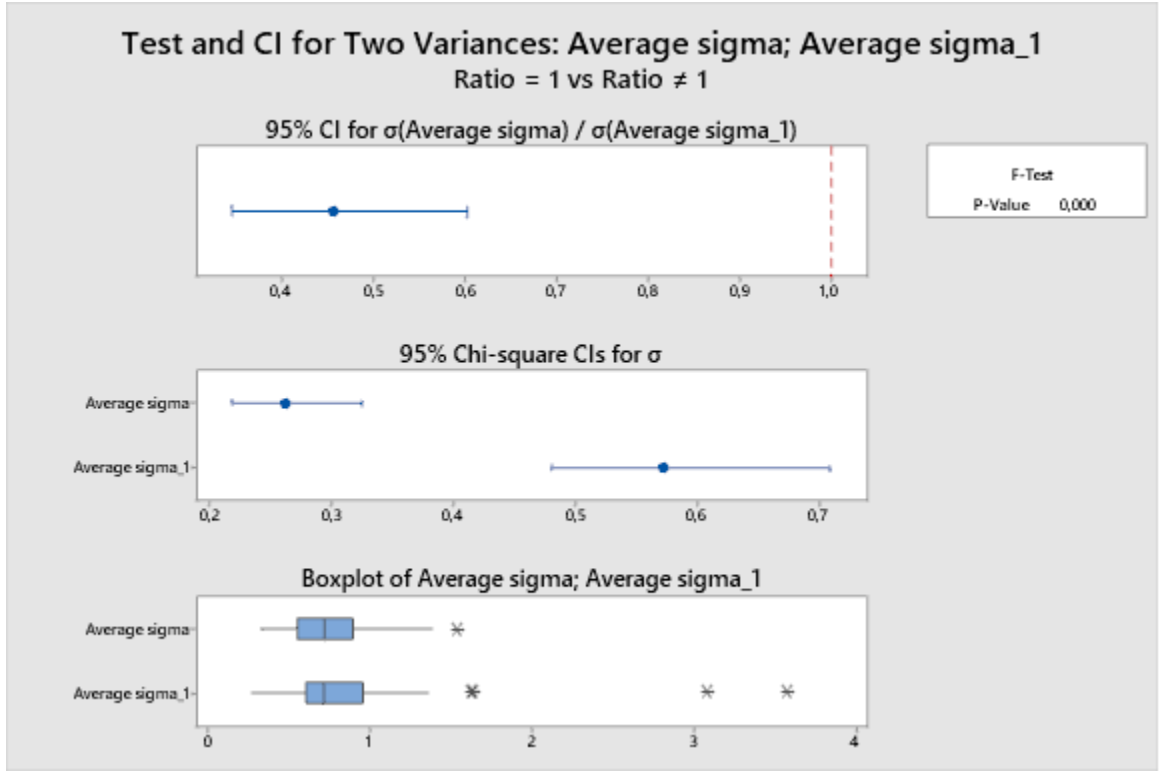


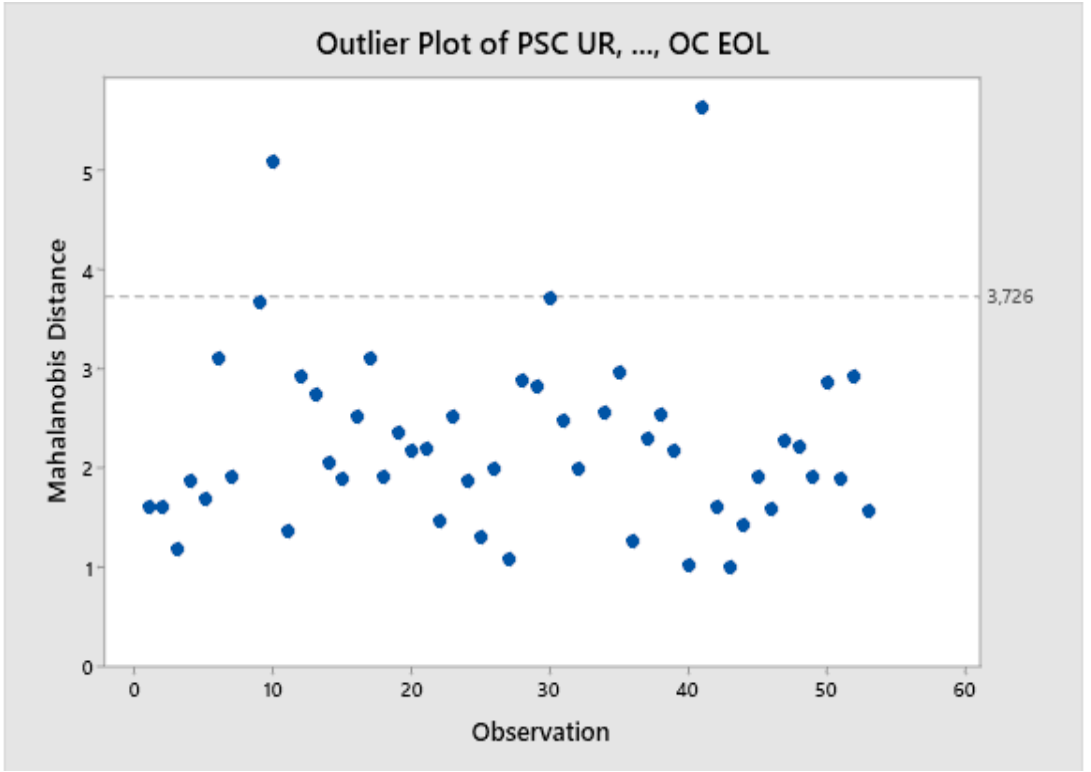






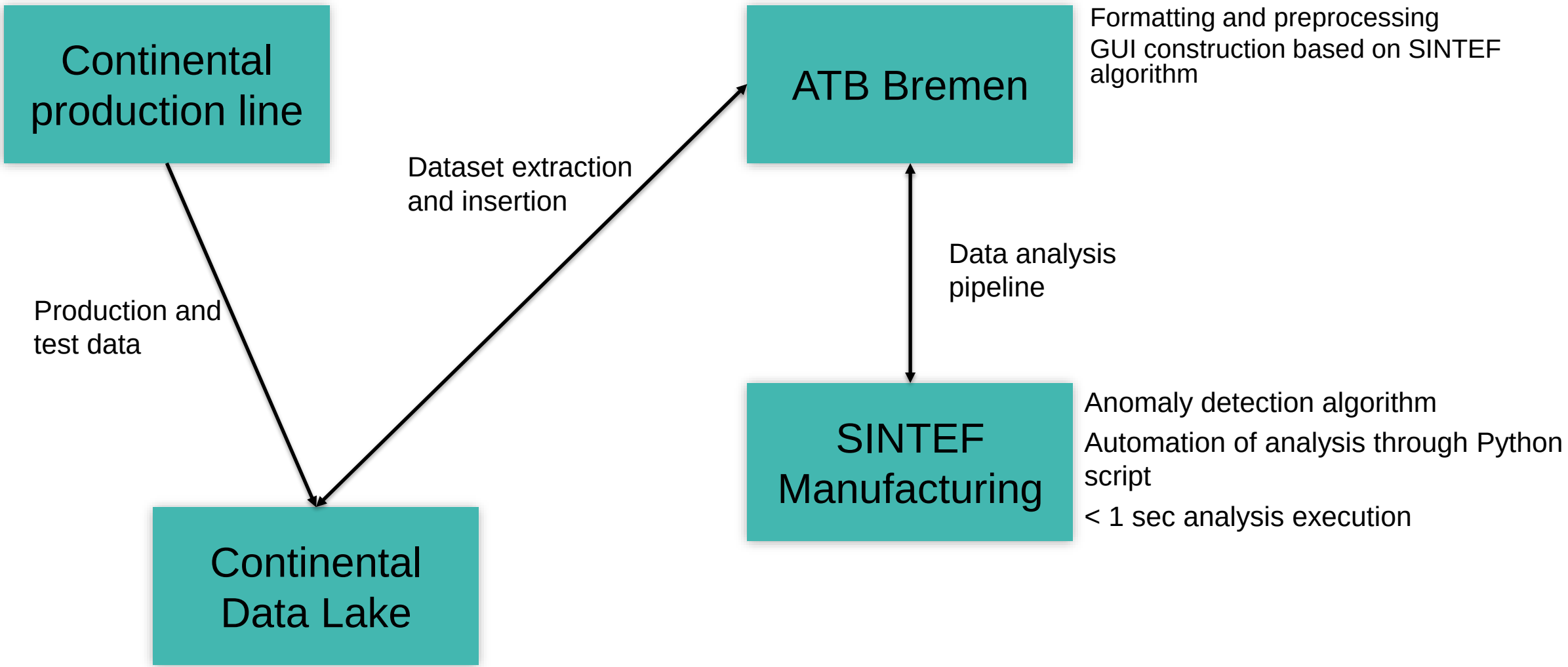
Multivariate analysis





PCA and Mahalanobis Distance

	X	Y	Z							
	64	580	29		var(x)	11,5		covar(xy)	50	
	66	570	33		var(y)	1250		covar(xz)	34,75	
	68	590	37		var(z)	110		covar(yz)	205	
	69	660	46							
	73	600	55							
					covar mat=		x	y	z	
Mean=	68	600	40			x	11,5	50	34,75	
						y	50	1250	205	
	n=5					z	34,75	205	110	
					inv covar=		3,688519	0,062731	-1,28214	
							0,062731	0,002219	-0,02395	
							-1,28214	-0,02395	0,458771	
	v=	64	580	29			tmp=	-1,90511	-0,03182	0,561149
	v-m	-4	-20	-11						
							MD sq=	2,084269		
		trans=	-4							
			-20				MD=	1,4437		
			-11							


Continental production line
ATB Bremen
Formatting and preprocessing
GUI construction based on SINTEF algorithm
Dataset extraction and insertion
Production and test data
Data analysis pipeline
SINTEF Manufacturing
Anomaly detection algorithm
Automation of analysis through Python script
< 1 sec analysis execution
Continental Data Lake

Norwegian University of Science and Technology

Thank you!

Endre Sølvsberg