Digitalization in manufacturing maintenance

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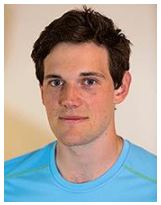
Production Service & Maintenance Systems



Jon Bokrantz
- Maintenance in digitalized manufacturing
- Quality of production data

Mahesh Gopalakrishnan
- Criticality analysis
- Priority-based maintenance

Mukund Subramaniyan
- Big Data analytics
- Decision support systems

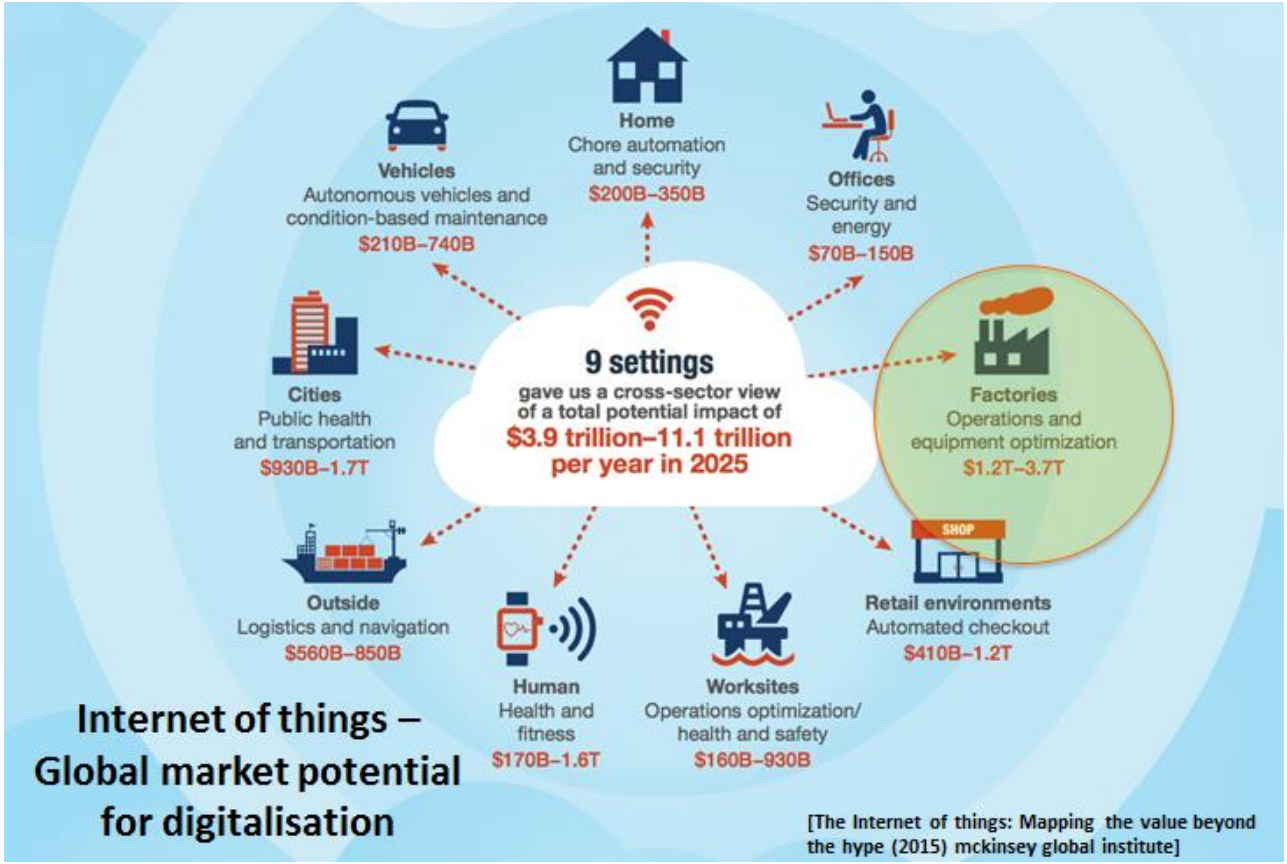
Torbjörn Ylipää
- Social sustainability in maintenance
- Engineering tools in maintenance

Ulf Sandberg
- Machine vendor interaction
- Data sharing

Camilla Lundgren
- Simulation
- Quantifying the value of maintenance

Anders Skoogh
- Production data management
- Group leader

The potential of Smart Factories



Digitalization – Smart Industry

- Higher levels of automation
- Autonomous factories
- Internet of Things
- High-speed connectivity (5G)
- More available sensors
- Big Data analytics
- Cloud solutions
- Advanced IT tools
- Digital twins

OEE values in industry

Average in Swedish industry in the 1990's

OEE components	Average
Planned stop %	5
Availability %	80
- Breakdowns %	12
- Set-up losses %	8
Utilization %	77
Speed Rate %	91
Operational Efficiency %	68
Quality rate %	99
OEE %	55

Average in Swedish industry between 2006 - 2012

OEE components	Average
Planned Stop %	6.60
- Unplanned Stop %	9.60
- Setup %	11.50
Availability %	78.90
Utilization %	80.20
Speed Rate %	86.10
Operational Efficiency %	67.10
Quality Rate %	96.90
OEE %	51.50

Low availability and operational efficiency are two main contributors of OEE losses

Maintenance generations

Maintenance 1.0 (before 1950)
- Corrective maintenance

Maintenance 2.0 (1950 – 1975)
- Preventive maintenance
- Maintenance department created

Maintenance 3.0 (1975 – 2000)
- Academic interest
- Prevent the effects of failures
- Condition-based maintenance
- Design for maintainability
- Collaborations, e.g. TPM

Maintenance 4.0 (20??)
- Design to eliminate failures
- Even wider collaborations, compare Asset Management
- Holistic view
- Digitalization

Current industrial needs

- Data-driven maintenance planning
- From descriptive to predictive
- Internal trust in data and decision support
- Maintenance with a systems perspective
- Dynamic prioritization
- Attract and develop competence
- Quantify the effects of maintenance
- Create maintenance strategies for the digital transformation

Data analytics

Descriptive

Description of what has already happened

What happened?

Diagnostic

Exploration of meaningful information

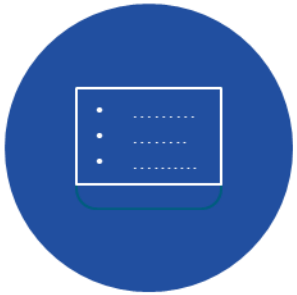
Why did it happen?

Predictive

Prediction of future outcomes based on historical data

What will happen?

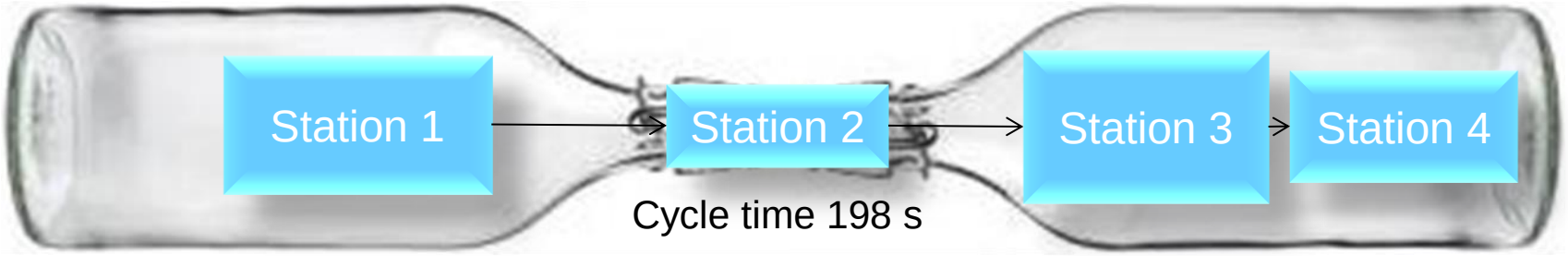
Prescriptive



Recommendations on predictive model output

What should I do?

Example from manufacturing

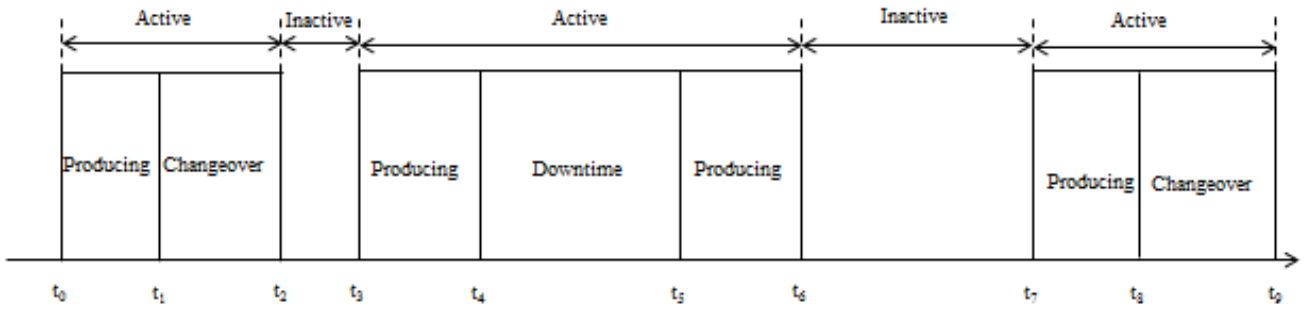


Cycle time 183 s

Cycle time 198 s

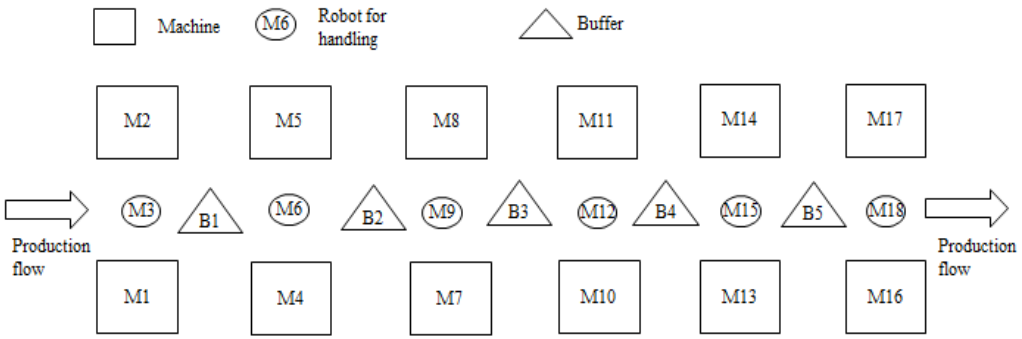
Cycle time 150 s

Cycle time192 s

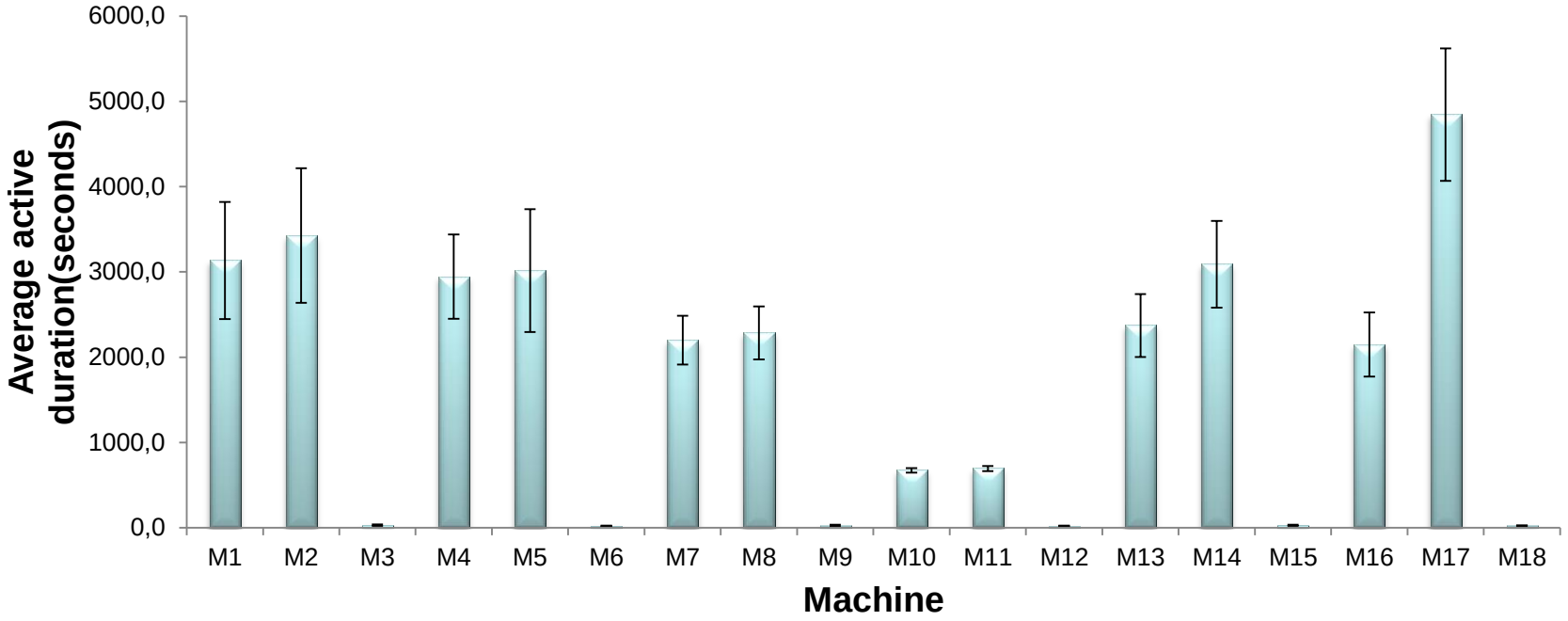


MES example

Production Area	Work Area	Date with Time	State of the machine
Line 1	M1	01-09-2014 06:28:02	Not Active
Line 1	M1	01-09-2014 06:28:25	Comlink Up
Line 1	M1	01-09-2014 06:29:20	Not Active
Line 1	M1	01-09-2014 06:29:34	Waiting
Line 1	M1	01-09-2014 06:29:34	Waiting
Line 1	M1	01-09-2014 06:42:46	Producing



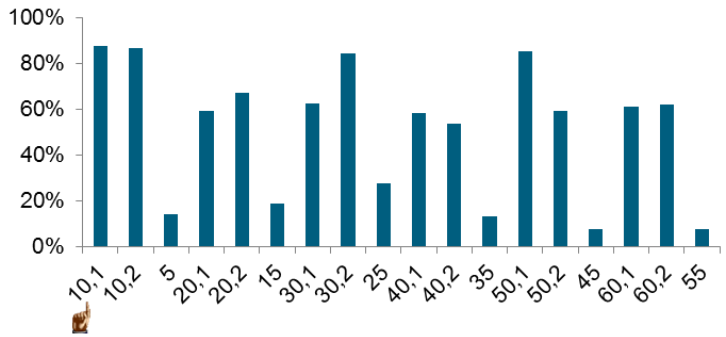
Example from a serial production line



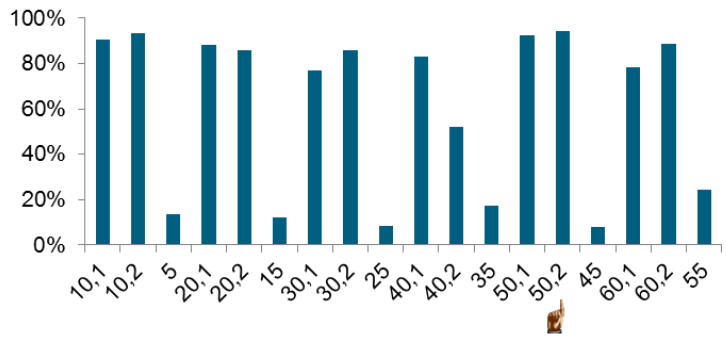
- M17 is a primary bottleneck
- M2 could also be a primary bottleneck
- M17 and possibly M2 should be prioritized in maintenance and improvements

Data analytics and systems view

Descriptive: What happened?



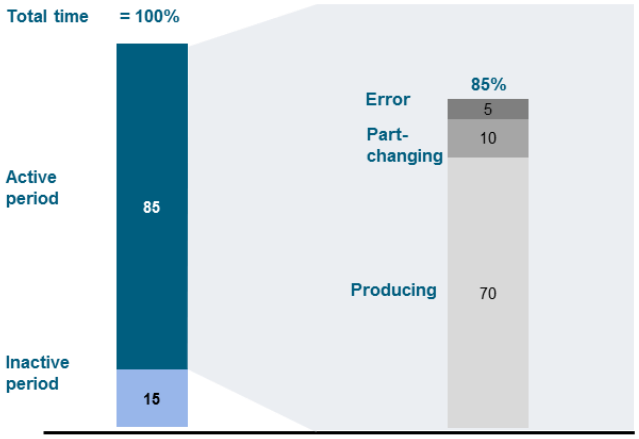
Predictive: What will happen?



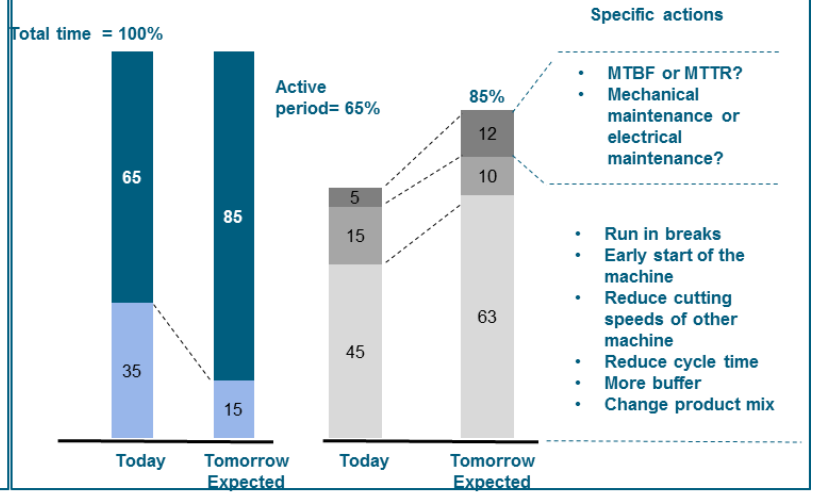
Today's bottleneck

Tomorrow's bottleneck

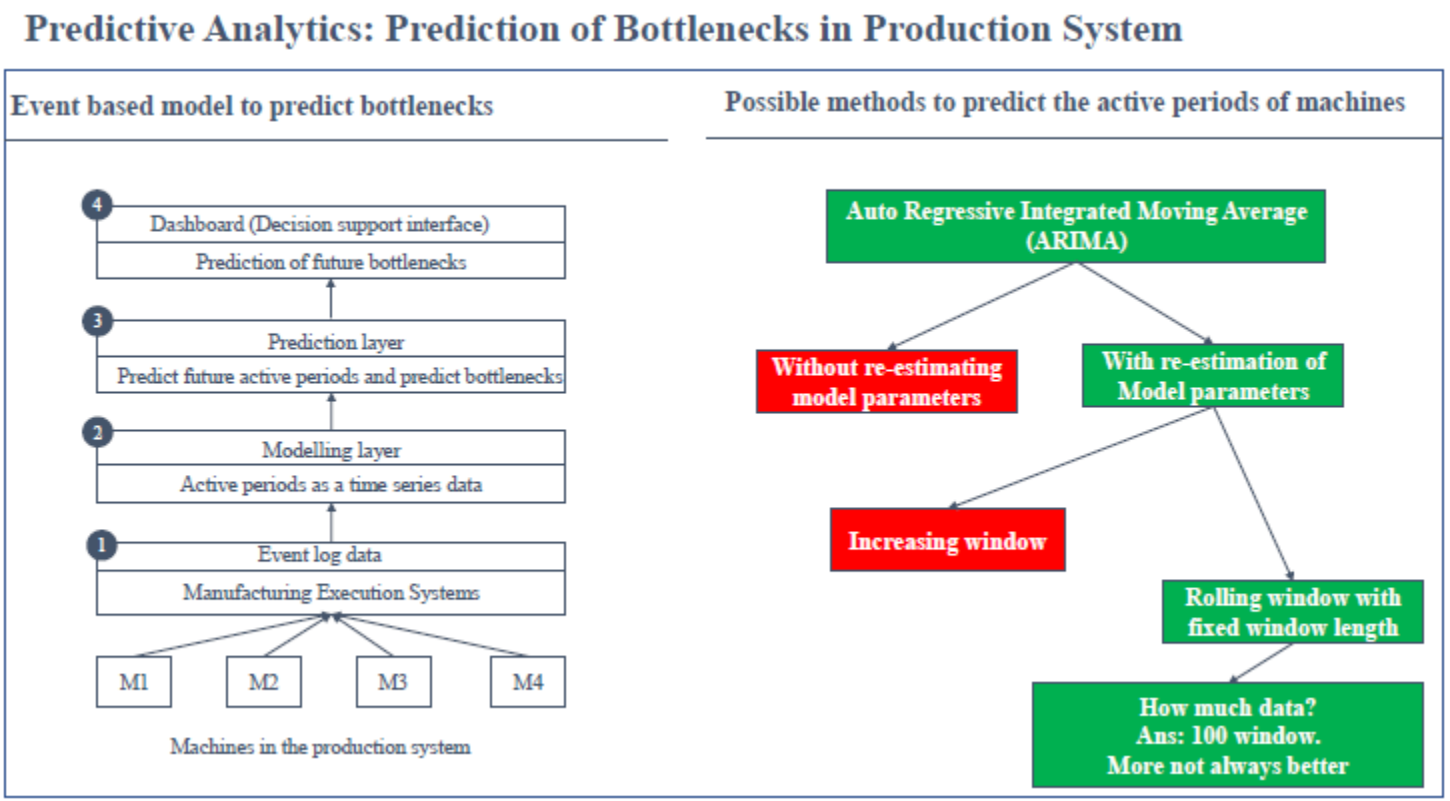
Diagnostic: Why did it happen ?



Prescriptive: What should I do?



Case approach



Subramaniyan, 2017

Industrial contribution

From	To
▪ Lot of unactionable data	▪ Lot of actionable insights
▪ Bottleneck detection by gut feeling or simulation model based approach	▪ Real-time data-driven bottleneck detection
▪ Production system dynamics not well represented (Machine Perspective)	▪ Full view and better knowledge on the systems (systems perspective)
▪ Reactive activities	▪ Proactive activities and faster decisions can be made
▪ Don't resolve the same problem in same way	▪ Prescriptive analytics recommends the best actions
▪ Siloed approach to decision making	▪ Decision model is "pervasive"! Production and maintenance engineers will ask "What does the algorithm say"

Subramaniyan, 2017

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Next steps

- Increase precision to above 80%
- Cluster analysis of failure categories
- Multiple sensor analysis
- Combine sensor level with CMMS, MES, and quality systems

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Prescriptive maintenance

Systems level (MES-data)

Real-time observation and prediction of bottlenecks and critical resources

Systems level (MES-data)

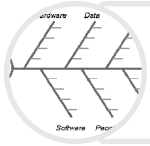
Prioritize improvements and maintenance on future needs in critical resources

Equipment level (MES-data)

Real-time analysis and prediction of trends in failure frequencies and repair times

Sensor level

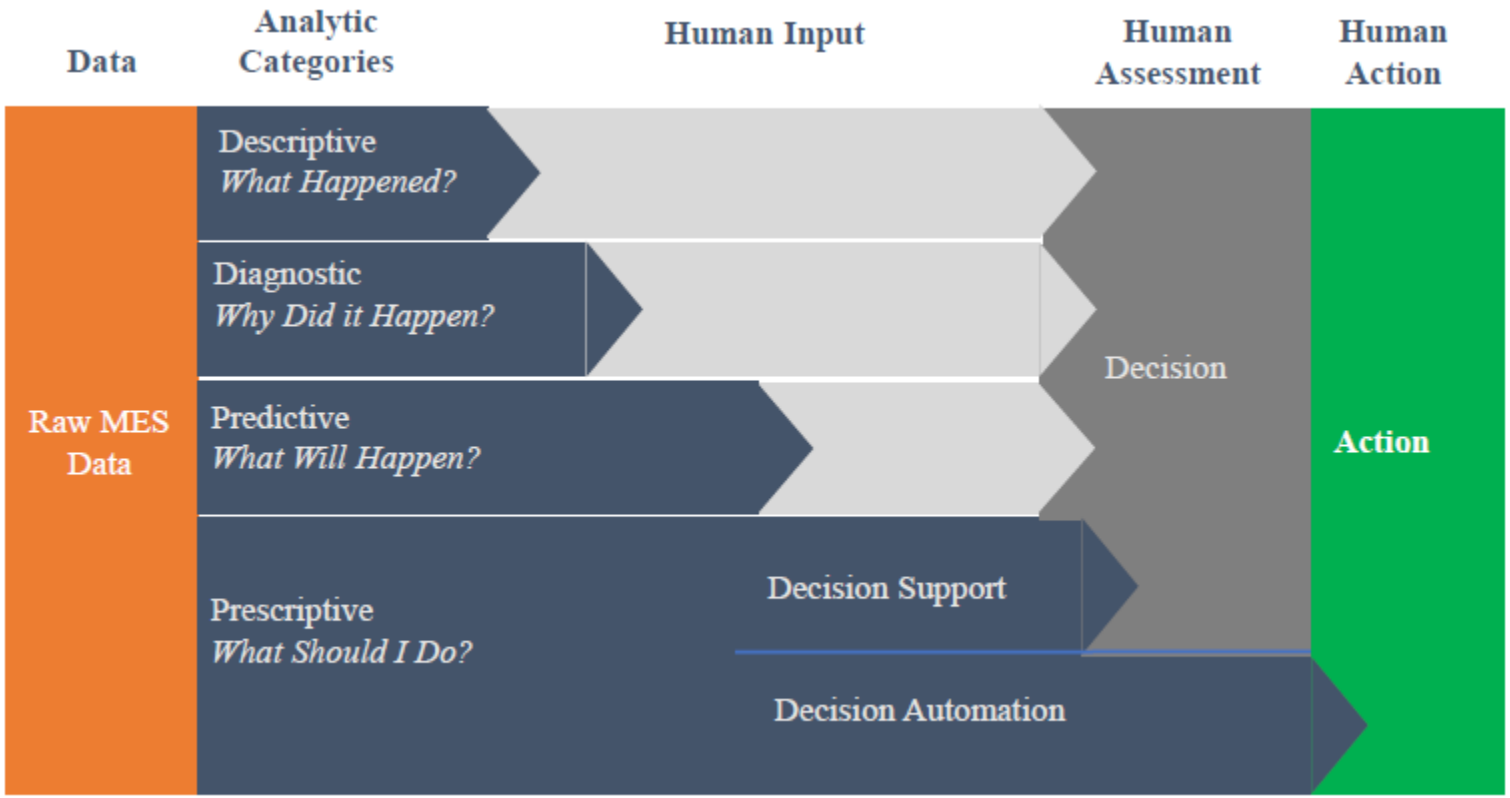
Detect patterns in alarm and sensor data



Combined MES and sensor level

Identify and predict root causes

Automated decision support



5G Enabled Manufacturing

- Maintenance work package

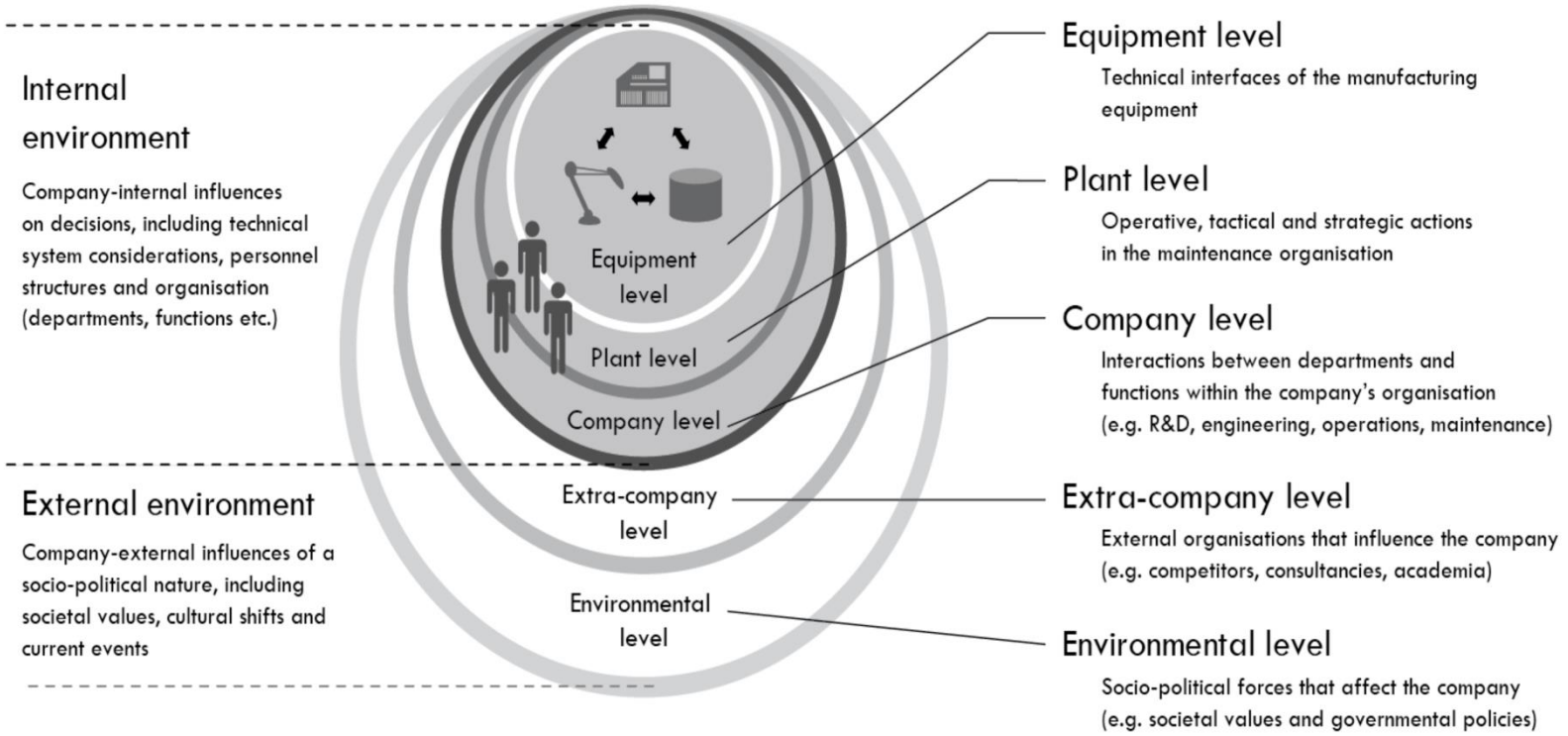
- Big Data analytics from multiple sensors
- Mobile support in maintenance
- Quantify the value of Smart Maintenance
  - productivity, flexibility, sustainability

5G-Enabled Manufacturing

5GEM

ERICSSON SKF CHALMERS VINNOVA

How IoT effects maintenance organizations



What is Smart Maintenance?

- Projections from industry experts and researchers

Equipment level

1. Equipment upgrades
2. Data analytics
3. Machine intelligence
4. Modularization
5. Software maintenance
6. Cloud computing
7. Interoperability
8. Big data management

Plant level

9. Digital and social competence
10. Education and training
11. Work environment
12. Decentralized decision-making
13. Fact-based maintenance planning
14. Smart work procedures
15. Maintenance improvements
16. Digital tools
17. Maintenance planning with a systems perspective

Company level

18. Organizational integration
19. Internal benchmarking
20. Maintenance department
21. View on maintenance
22. Enlarged maintenance function
23. Zero failure vision

Extra-company level

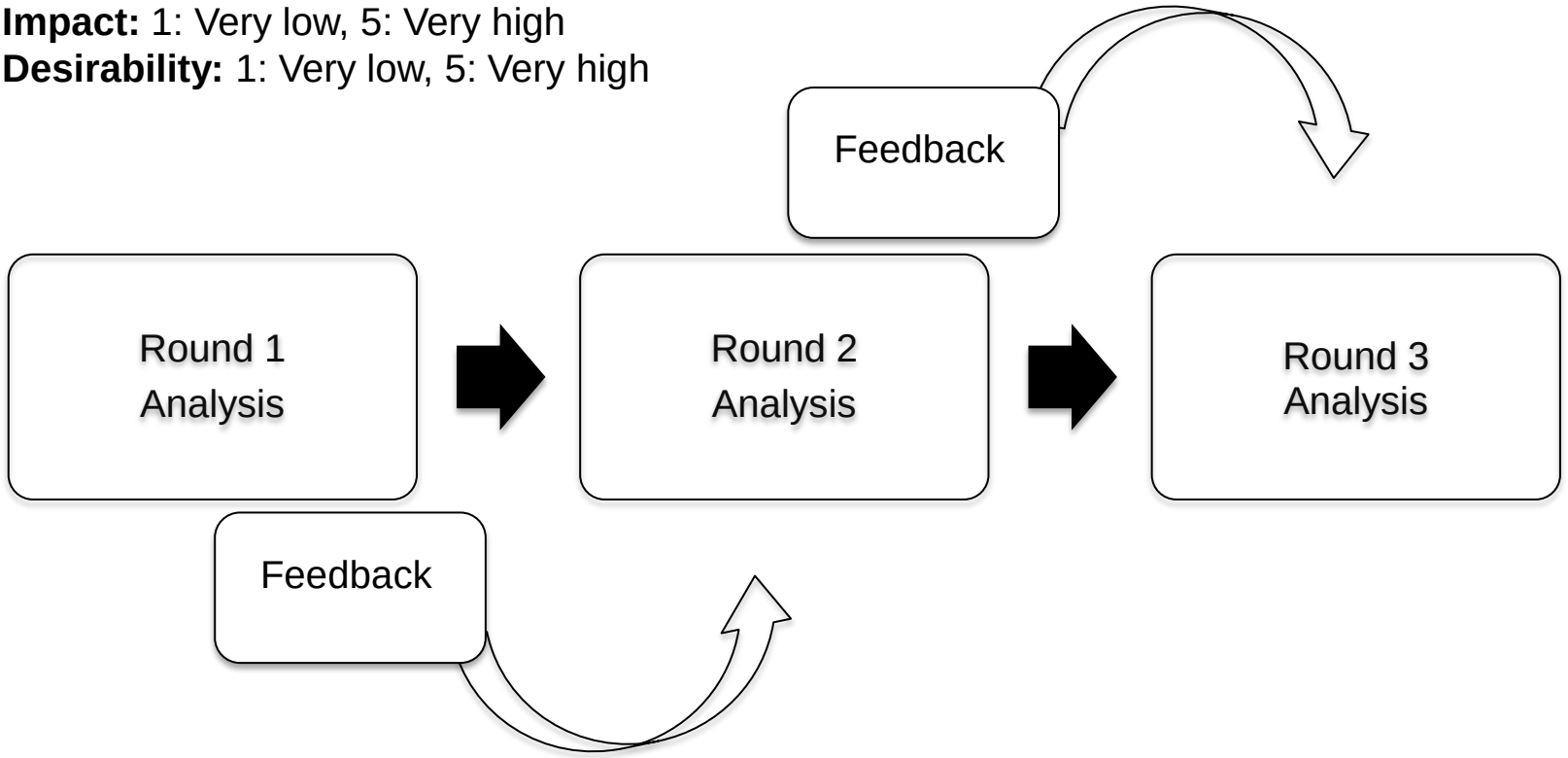
24. Business models
25. Maintenance services
26. Partnerships
27. Digital market
28. Digital networks
29. Industry and academia

Environmental level

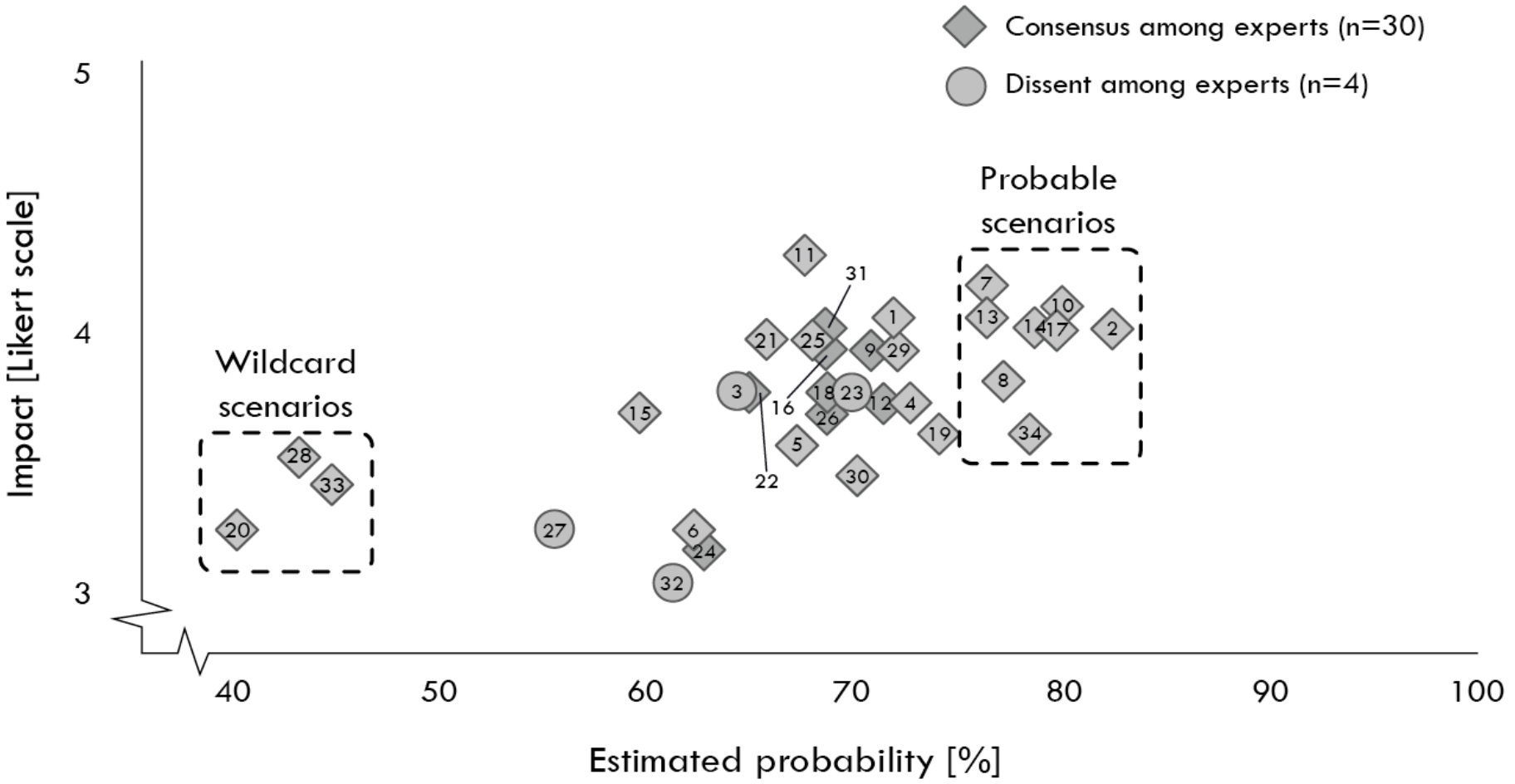
30. New actors
31. Cyber attacks
32. E-jurisprudence
33. Maintenance in social debate
34. Environmental legislation and standards

Delphi Study with 25 industry experts

Probability: 0-100%
Impact: 1: Very low, 5: Very high
Desirability: 1: Very low, 5: Very high



Smart Maintenance - expert opinions



8 probable scenarios

2. Data analytics – combination of different types of data
7. Interoperability
8. Big data management – Which data to collect and analyze?
10. Education and training
13. Fact-based maintenance planning – predictive and prescriptive analytics
14. Smart work procedures – real-time monitoring and remote maintenance
17. Maintenance planning with a systems perspective
34. Stronger environmental legislation and standards

3 wildcard scenarios

20 Maintenance departments disappear
28 Digital business networks
33 Maintenance in the social debate

Interesting comments and analyzes

- Clear demand for simple, user-friendly decision support systems
- Two hinders against industrial collaboration: competition and IT-security
- Hesitance towards sharing data
- Optimism!

Thanks for listening!