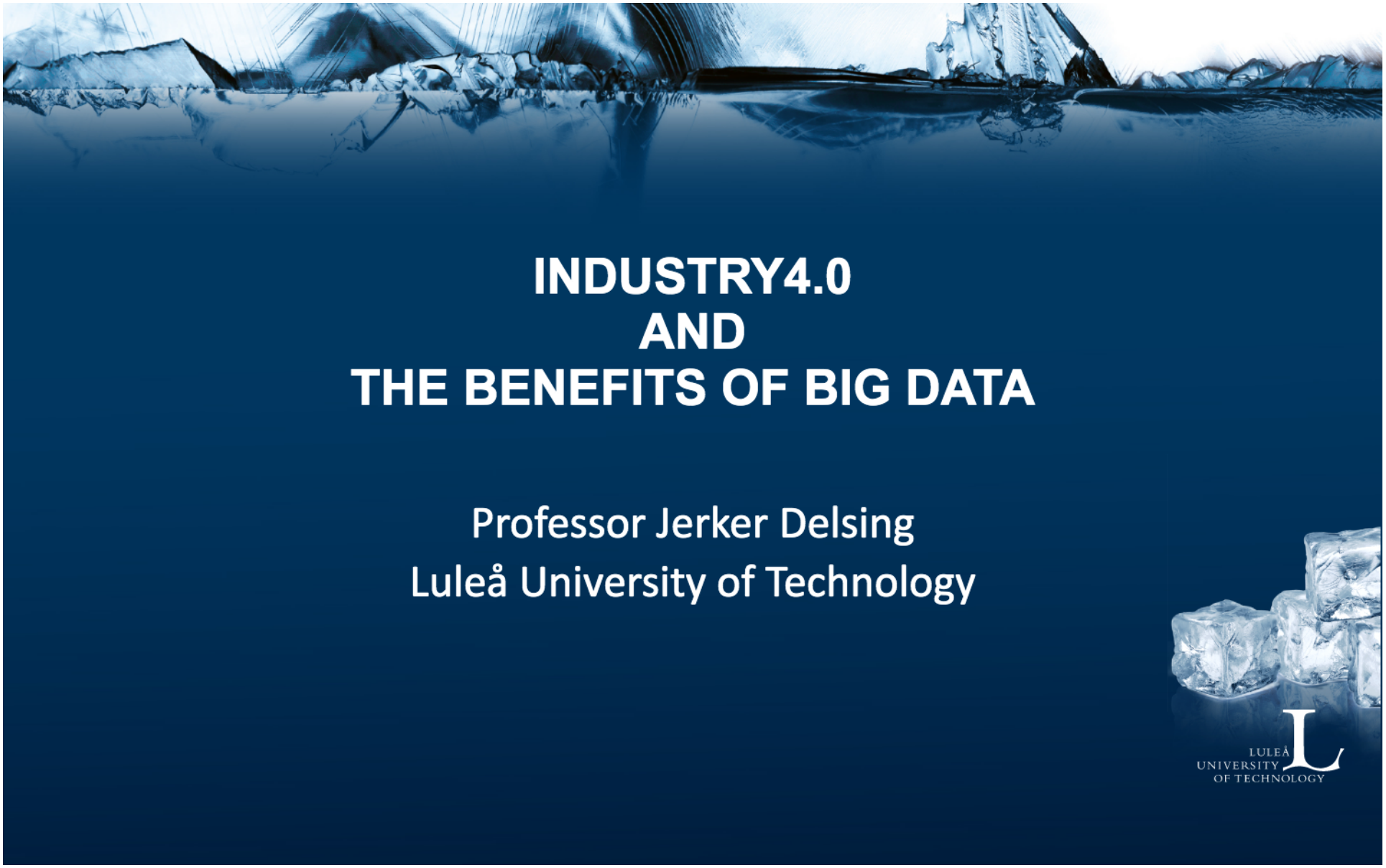
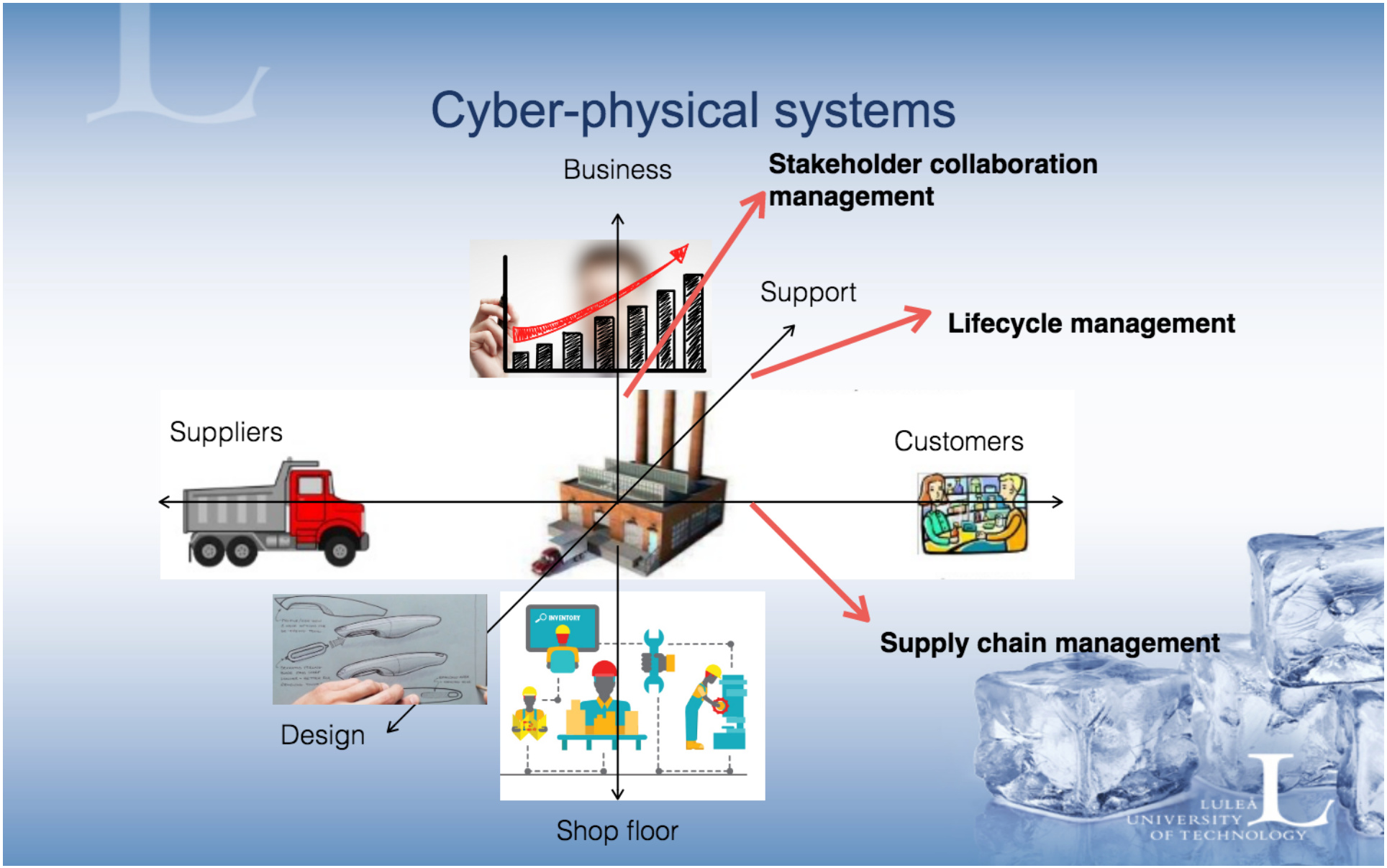
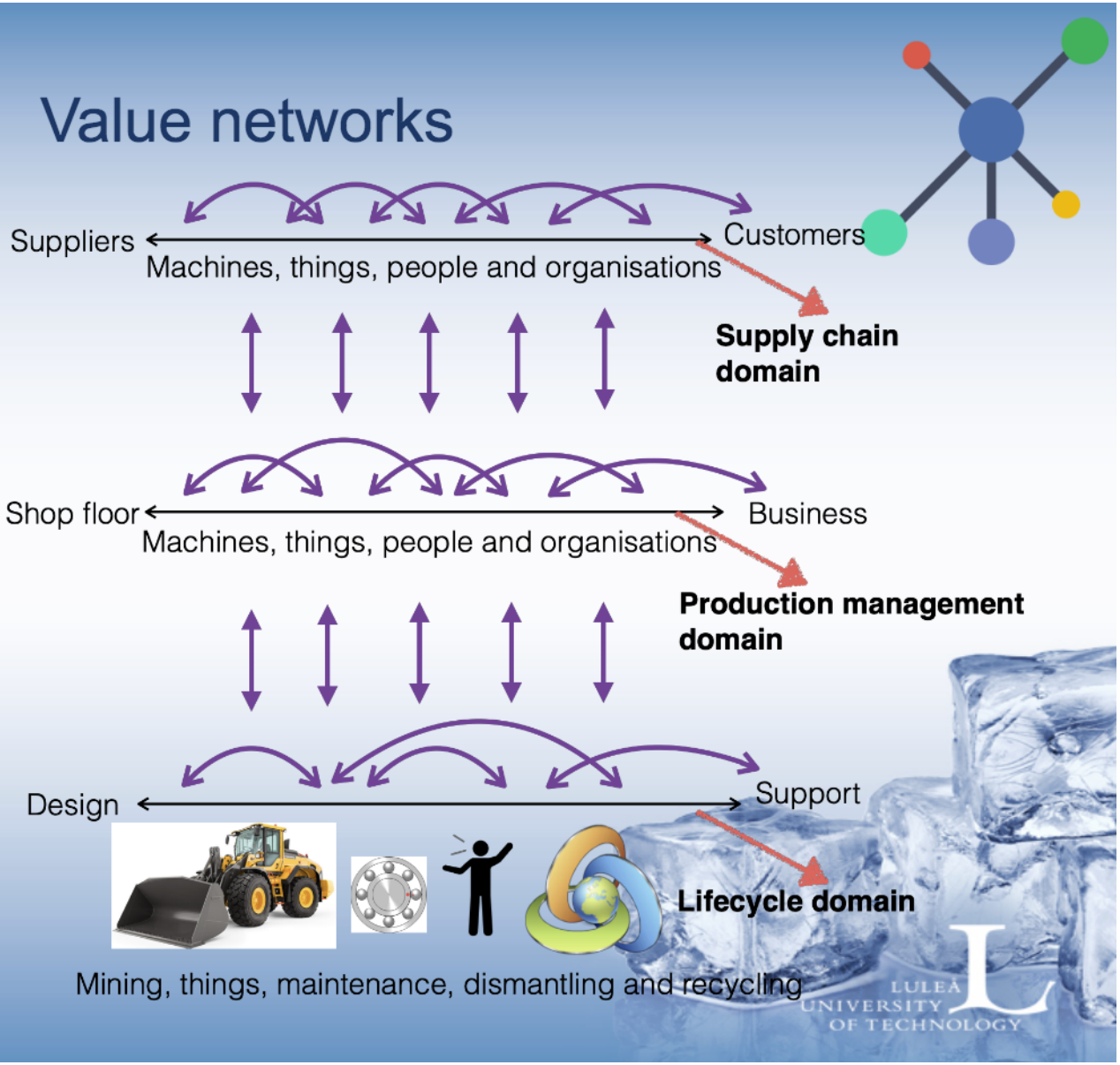

INDUSTRY4.0
AND
THE BENEFITS OF BIG DATA
Professor Jerker Delsing
Luleå University of Technology
LULEÅ
UNIVERSITY
OF TECHNOLOGY

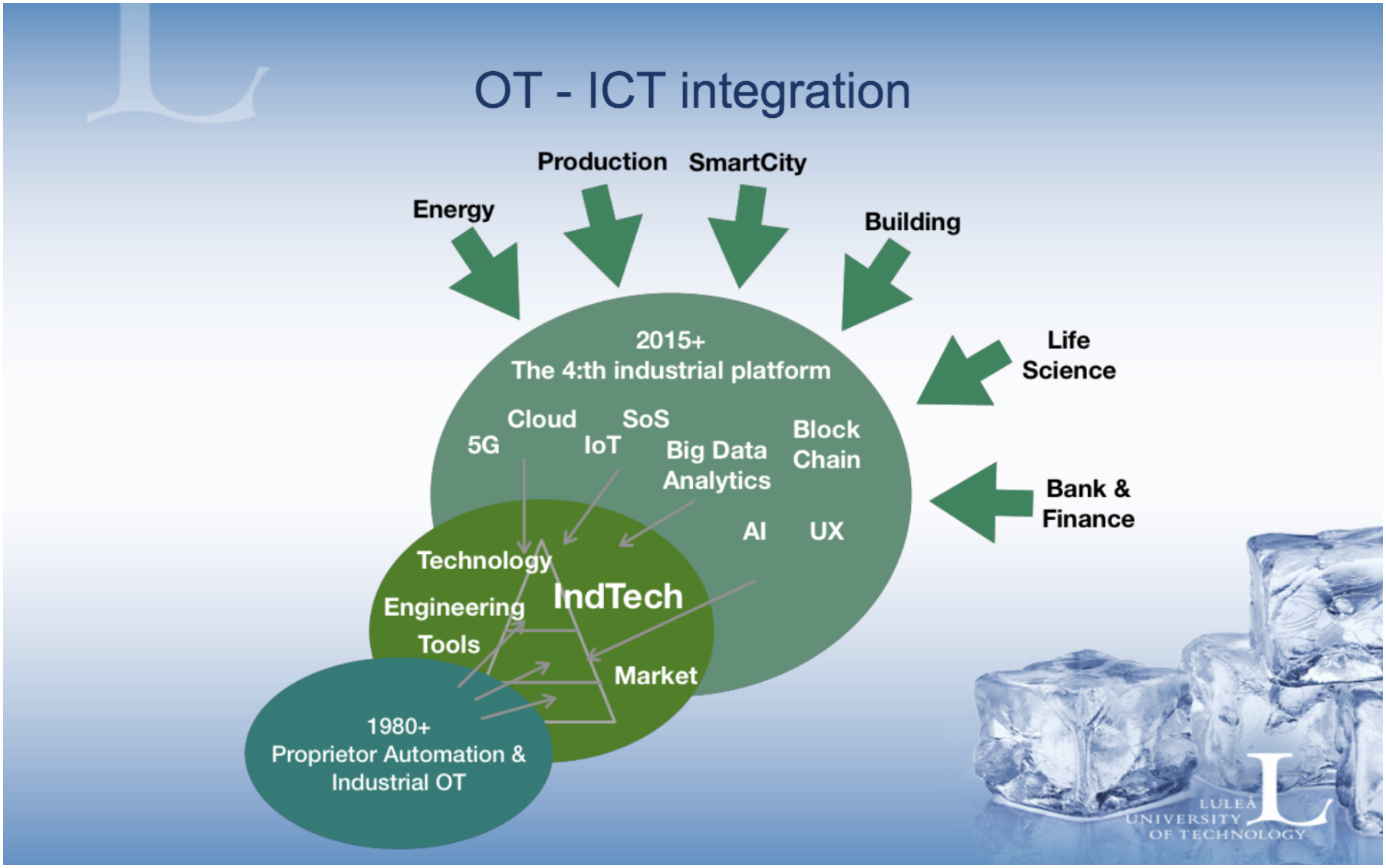
Cyber-physical systems



Value networks

- Security interoperability
- Safety interoperability
- Data ownership
- Access to data
- Real time data
- Trusted logs of actions
- M2M business
- Real time monetisation
- …
- …

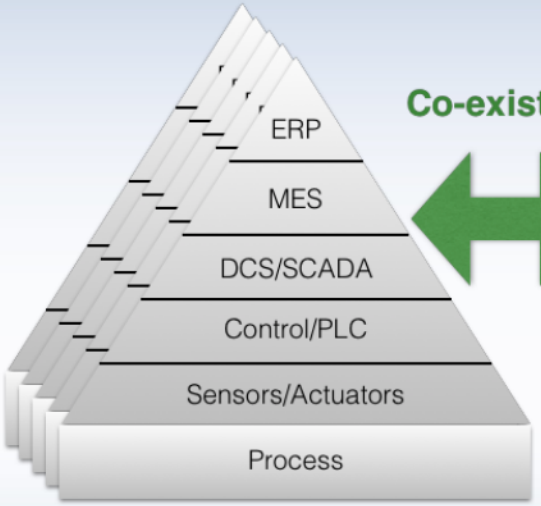



OT - ICT integration
Production
SmartCity
Energy
Building
Life Science
Bank & Finance
2015+
The 4:th industrial platform
Cloud
SoS
5G
IoT
Big Data Analytics
Block Chain
AI
UX
Technology
Engineering
Tools
IndTech
Market
1980+
Proprietor Automation & Industrial OT
LULEÅ UNIVERSITY OF TECHNOLOGY

Moved to value network operation

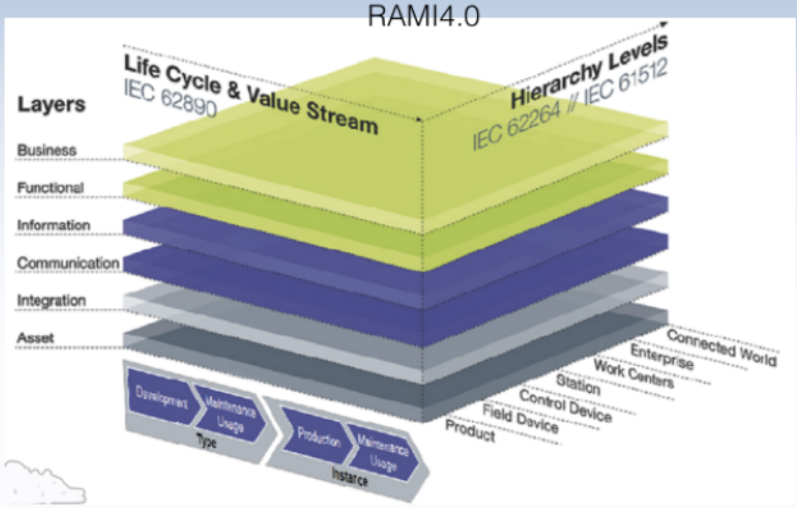
ISA 95

ISA-95

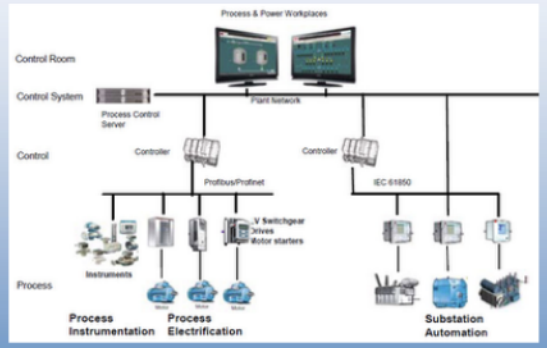


Co-existens

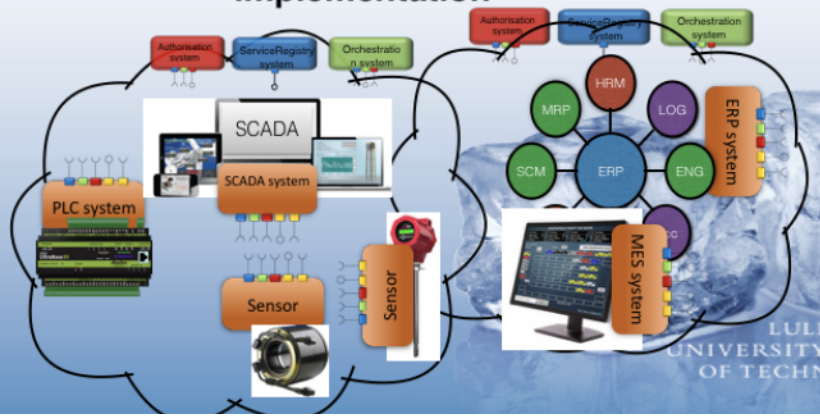
RAMI4.0



Industrie4.0



Local automation cloud implementation



LULEÅ UNIVERSITY OF TECHNOLOGY

Interoperability between what

- Sensors, actuators, controllers
- Machines
- Tools; Analysis, Optimisation
- Groups
- Organisations
- Management: Operational, security, safety, …
- Engineering: Tools, Engineering procedures, ..

- ALL PRODUCES DATA USEFUL FOR ANALYTICS

Data interoperability for what

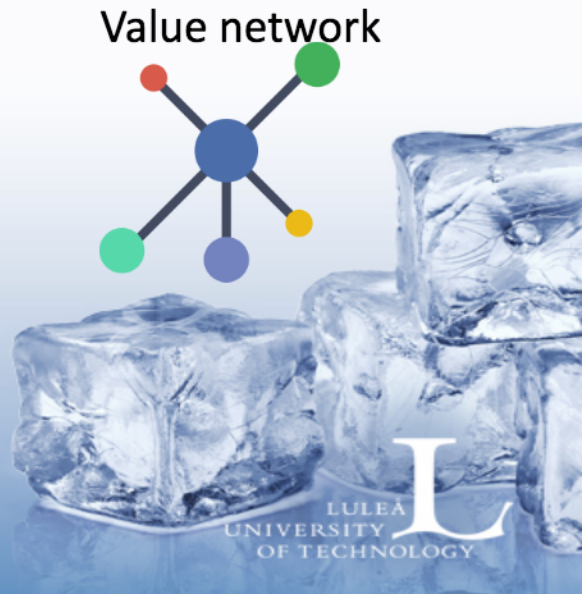
- Product quality
  - individual details
  - combined details
  - complete product
- Production performance
  - Quality
  - Time
  - ….
- …….

German 2030 Industrie 4.0 roadmap

- **Interoperability**
  - Cooperative and open ecosystems permit plurality and flexibility
  - Regulatory framework, Standards and integration, Decentralised systems and artificial intelligence
- **Autonomy**
  - Scope of action delivers competitiveness and control of personal data in digital business models
  - Technology development, Security, Digital infrastructure
- **Sustainability**
  - Modern industrial value creation ensures high standard of living
  - Decent work and education, Climate change mitigation and the circular economy, Social participation

All this new technology - any better?

- Flexible production - lot size one
  - Flexible automation system
- Pre-production validation of production system
  - Virtual twins
- Earlier defect detection
- Productive and prognostic maintenance
- Robotisation
  - Less human errors



All this new technology - any better?

Flexible production - lot size one

- Flexible automation system

Pre-production validation of production system

- Virtual twins

Earlier defect detection

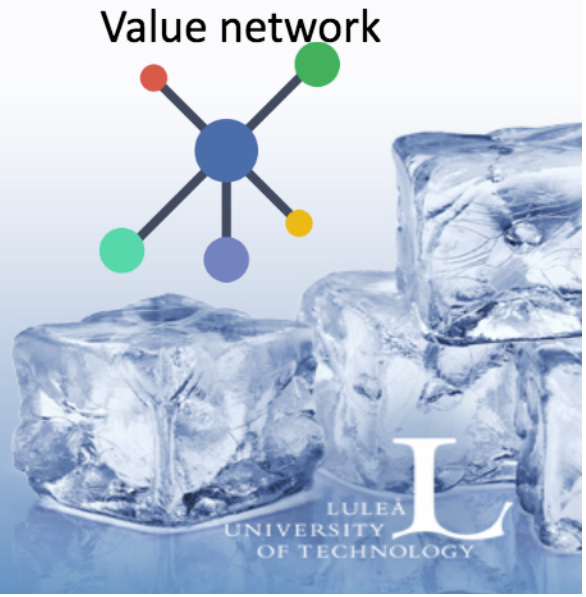
Productive and prognostic maintenance

Robotisation

- Less human errors

BETTER - YES!!!

- **BUT WE HAVE CHALLENGES**



Implementation

- Industry 4.0 acceptance?
- Industry 4.0 usage?
  - Can staff understand the machines
    - Right staff skills?
    - Right staff training?
      - How to interact with a robot?
  - Can machines understand each other?
  - Can we obtain useful data from our factories?

HINDER FOR ANALYTICS

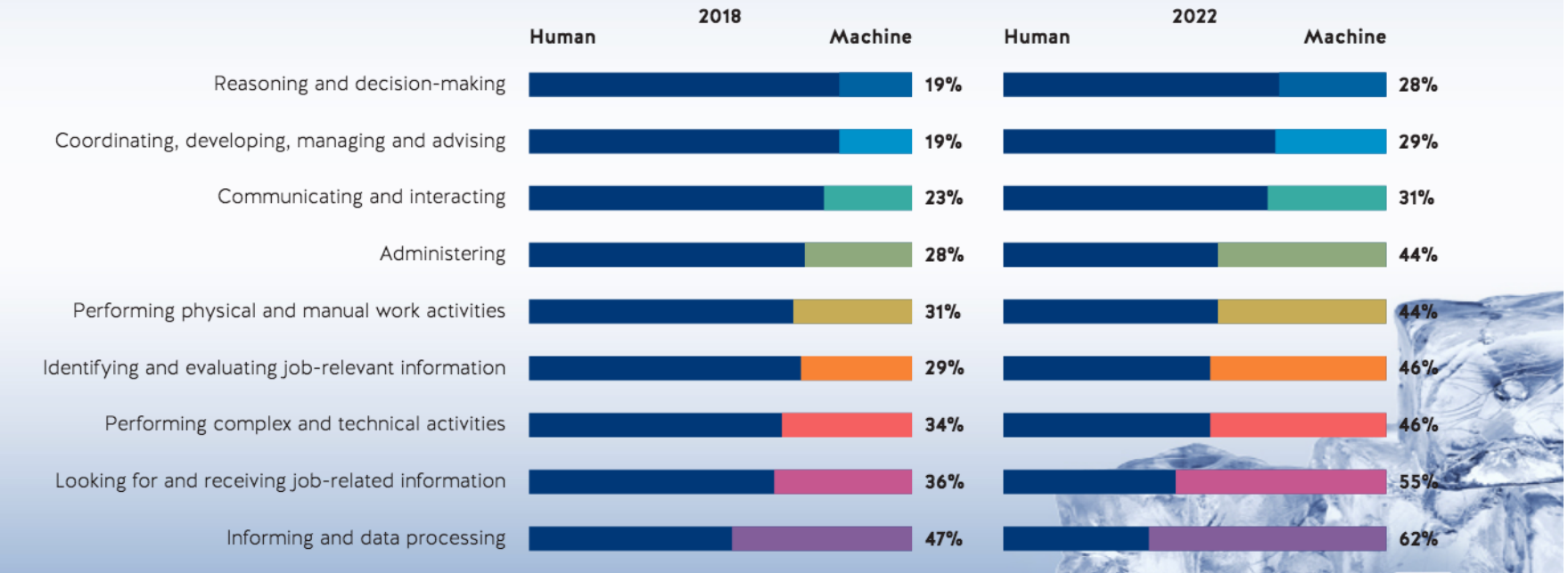
World Manufacturing Forum

https://www.worldmanufacturingforum.org/report-2019

Can you speak to a robot?

RATIO OF HUMAN-MACHINE WORKING HOURS, 2018 VS. 2022 (PROJECTED)

(Source: World Economic Forum)



Can robots speak to each other?

Data interoperability is still a major bottleneck and cost

ABB language

KUKA language

Data interoperability

Machine A message

```
[
        {“n”: “OO_temp_sensor”,
         “t”:  318350,
         “u”: “K”,
         “v”: 294.05}
]
```

Machine B message

```
[
        {“bn”: “temp_sensor”, “bt”: 318350},
        {“u”: “Cel”, “v”: 20.9},
        {“u”: “Lon”, “v”: “1”},
        {“u”: “Lat”, “v”: “-1”}
]
```

Same standard
Same ontology
Same data
Do not look the same!!

Interoperable????

ARROWHEAD TOOLS

Data interoperability strategies

Standards - do like me and we are interoperable!?

- Asset descriptions
  - ISO 15926
  - ISO 10303 (AP 223)
  - Asset administration shell DIN ….
- Sensor data
  - SenML (RFC 8428) developed by OMA
  - SensorML (OGC standard)


ISO 15926
READI
SEIIA.SE
Swedish Industrial Interoperability Association
POSC Caesar Association
CFIHOS
THTH
Teollisuuden hajautetun tiedonhallinnan yhdistys THTH ry
THTH Association of Decentralized Information Management for Industry
Changing How the World Builds
International Association of Oil & Gas Producers
MIMOSA
USPI-NL
Uitgebreid Samenwerkingsverband Procesindustrie-Nederland
DEXPI
Data Exchange in Process Industry
ENA
LULEÅ UNIVERSITY OF TECHNOLOGY

Data interoperability considerations

New standards are created

Standards are updated - 5-15 years

Technology life times and update and upgrade cycles

- Mechanical life time - 20-100 years
- Automation/IT HW life time - 10 years

Semantics/ontologies

- New once invented every hour

Data interoperability considerations

New standards are created

Standards are updated - 5-15 years

Technology life times and update and upgrade cycles

- Mechanical life time - 20-100 years
- Automation/IT HW life time - 10 years

Semantics/ontologies

- New once invented every hour

Automation/IT **SW lifetime - ….. months to a few years?!**

ARROWHEAD TOOLS

Data interoperability engineering

Design time engineering

- Write a situation specific and dedicated middleware
- Make use of general translator - service buses

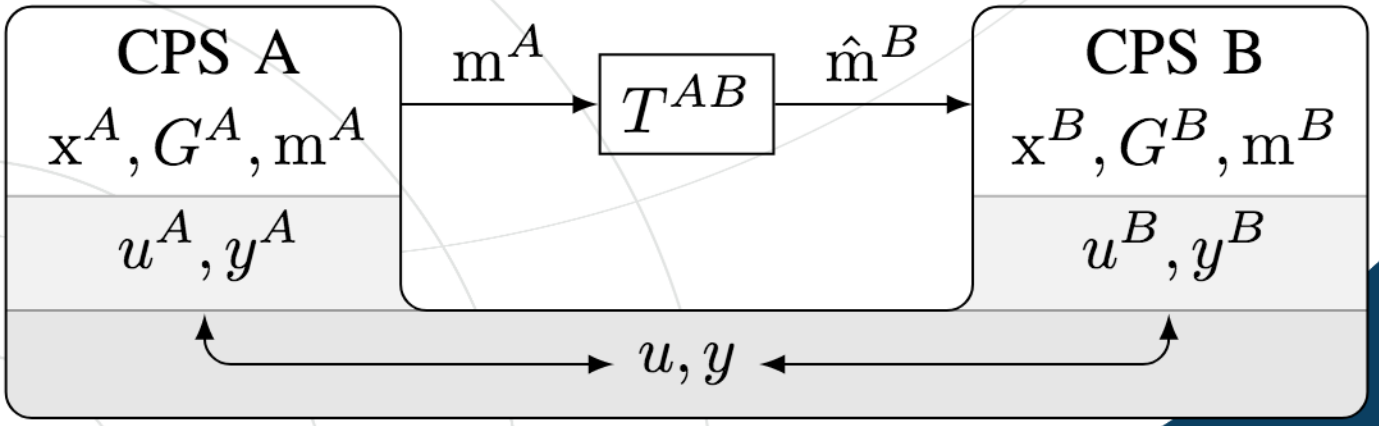
Run time engineering

- What can be automated and made autonomous?
  - Autonomous indemnification of service contract mismatches
  - Inject protocol and encoding translation
  - Inject missing consumer capabilities
  - Inject servitisation of legacy API

Interoperability strategies

Machine learning approach

- Model of communicating cyber-physical systems (CPS) with different data representations and semantic definitions that interact in a physical environment (gray) and service-oriented architecture (white) via messages m translated by a function T^{AB}



www.arrowhead.eu

J. Nilsson, F. Sandin and J. Delsing, "Interoperability and machine-to-machine translation model with mappings to machine learning tasks," 2019 IEEE 17th International Conference on Industrial Informatics (INDIN), Helsinki, Finland, 2019, pp. 284-289.

ARROWHEAD

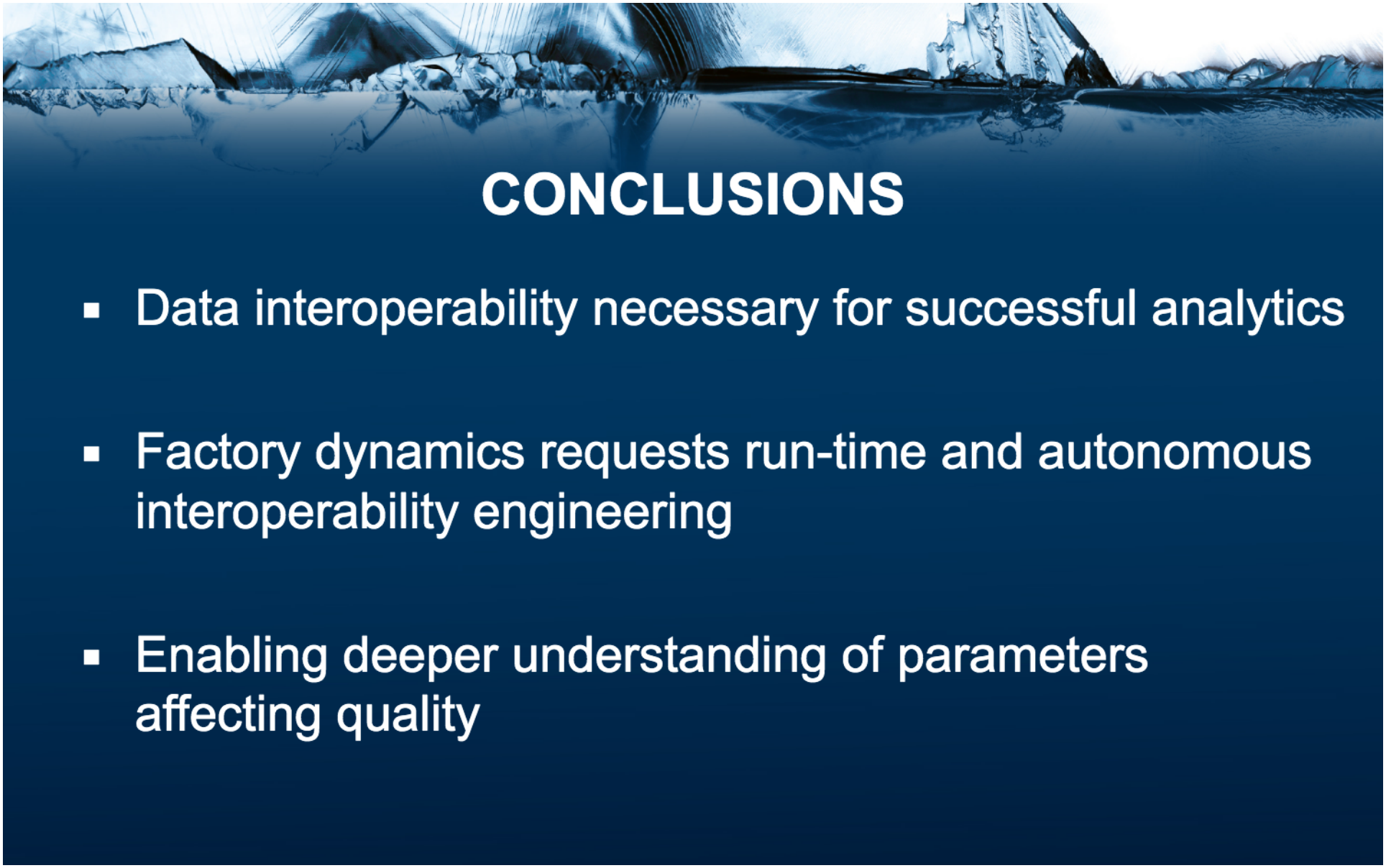
Data semantics interoperability - early results

Semantics translation results

TABLE I: Tested models and their results.

Model	Kind	Strategy	Size	Accuracy		Error	
				Max	Mean	Min	Mean
0	non-shared	2	1-layer	0.70	0.44	0.57	4.0
1	non-shared	2	2-layer	0.73	0.38	0.50	4.9
2	non-shared	1	1-layer	0.66	0.39	0.48	6.7
3	non-shared	1	2-layer	0.74	0.34	0.71	12.0
4	shared	2	2-layer	0.70	0.34	0.54	15.0
5	shared	3	2-layer	0.75	0.41	0.43	2.7
6	shared	1	2-layer	0.69	0.33	0.53	12.0
7	supervised	–	1-layer	1.0	1.0	0.16	0.17
8	supervised	–	2-layer	1.0	0.99	0.16	0.19

ARROWHEAD TOOLS


CONCLUSIONS
Data interoperability necessary for successful analytics
Factory dynamics requests run-time and autonomous interoperability engineering
Enabling deeper understanding of parameters affecting quality


QUESTIONS?
JERKER.DELSING@LTU.SE
LULEÅ
UNIVERSITY
OF TECHNOLOGY


LULEÅ
UNIVERSITY
OF TECHNOLOGY