

The Role of Digital Shadows in The Value Chain – insights from the S4M Tracking Experiment

S4M – Cruise Ships of the Future – Sustainability for the Entire Shipbuilding Ecosystem Seminar 23.4.2026



M.Sc Janne Siivonen, Ph.D student ÅA
Lecturer at Turku University of Applied Science

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SHIPBUILDING 4.0

- Refers to advanced manufacturing concept of Industry 4.0.
- Vertical- and horizontal integration of processes (systems).
- End-to-end engineering of Cyber-physical systems =>
- Digital twins (DT) and Digital Threads (DTH)
- Leads to smart shipbuilding, smart products and smart services.

Kagermann, D., Wahlster, W. and Helbig, J. (2015), Securing the Future of German Manufacturing Industry: Recommendations for implementing the strategic initiative INDUSTRIE 4.0. Final

Zhang, X., Chen, D., 2024. Shipbuilding 4.0: A Systematic Literature Review. Applied Sciences 14, 6363.

S4M SUSTAINABLE
MATERIAL MANAGEMENT
MATURITY MODEL

The Role of Digital Shadows in The Value Chain – Results from the S4M Tracking Experiment

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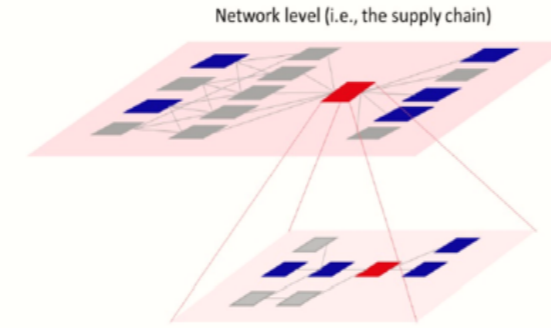
21.4.2026 S4M CRUISE SHIPS OF THE FUTURE – SUSTAINABILITY FOR THE ENTIRE SHIPBUILDING ECOSYSTEM SEMINAR



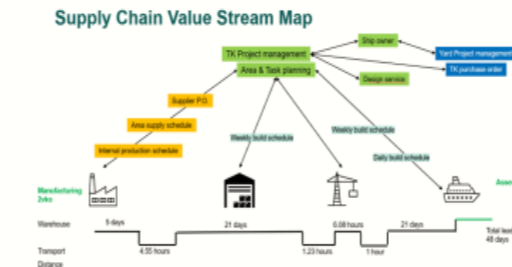
Digital twins in supply networks

- vertical- and horizontal integration of processes and information

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As its physical counterpart, the SCDT is a federated network of interconnected digital twins.



KPI's name	Descriptions
Product quality / %	Number of poor quality products delivered
On-time delivery / %	Number of orders delivered at acknowledged time
Total lead time / days	Total lead times of total supply network, from original order to materials at construction place
Inventory / pcs	Quantity of items on inventory
Distance / km	Distance that materials have travelled in supply chain
CO ₂ & gCO ₂ /t/m emissions	Cumulative CO ₂ emissions of supply chain operations
Load meters / delivery	Load meters used for each shipment
Pallet density / pcs/pallet	Number of items in a pallet delivered



- Using electromagnetic fields to automatically identify and track tags attached to objects
- Intelligent Sensor Networks
 - Industrial monitoring
 - Healthcare monitoring
 - Environmental sensing
- Interconnectedness of things
 - Ubiquitous computing
 - A network infrastructure with self-configuring capability

Virtual Representation of Physical Objects (firms, flows, planning and control algorithms)



Descriptive Analytics (performance visualization)



Digital Supply Chain Twin

Digital Technology with data about the supply chain (Internet-of-Things, Blockchain, Sensors, Cloud, ERP)



Predictive and Prescriptive Analytics (simulation and optimization)



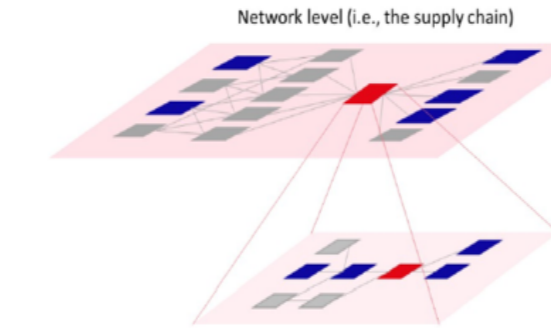
- Cyber Physical System (CPS)
- Emerging new ICT

Industry 4.0

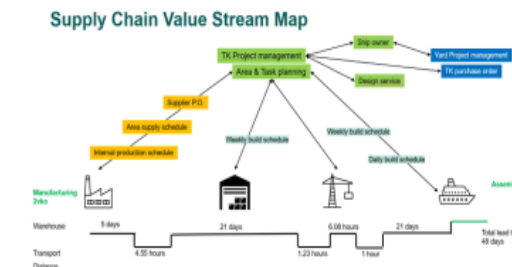
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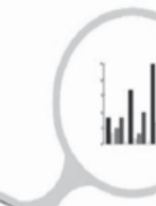


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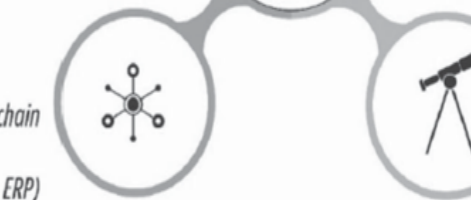


Descriptive Analytics (performance visualization)



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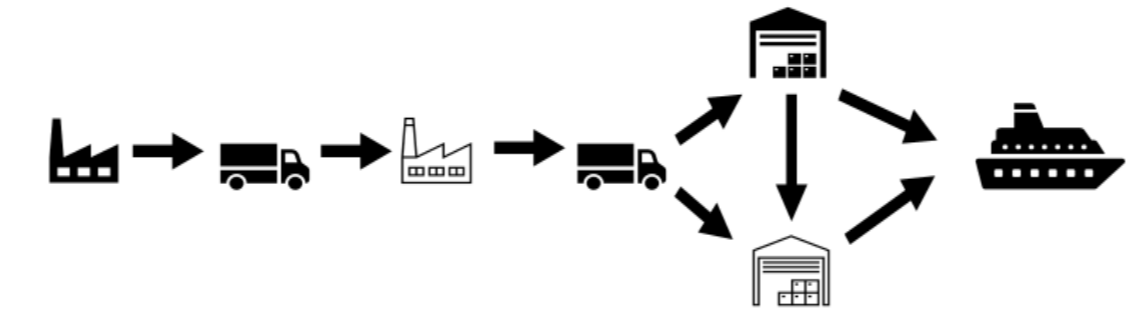
S4M- material tracking: Technology, Data, Information and Objectives

S4M- material tracking: Technology, Data, Information and Objectives, **TURKU AMK**

Technology

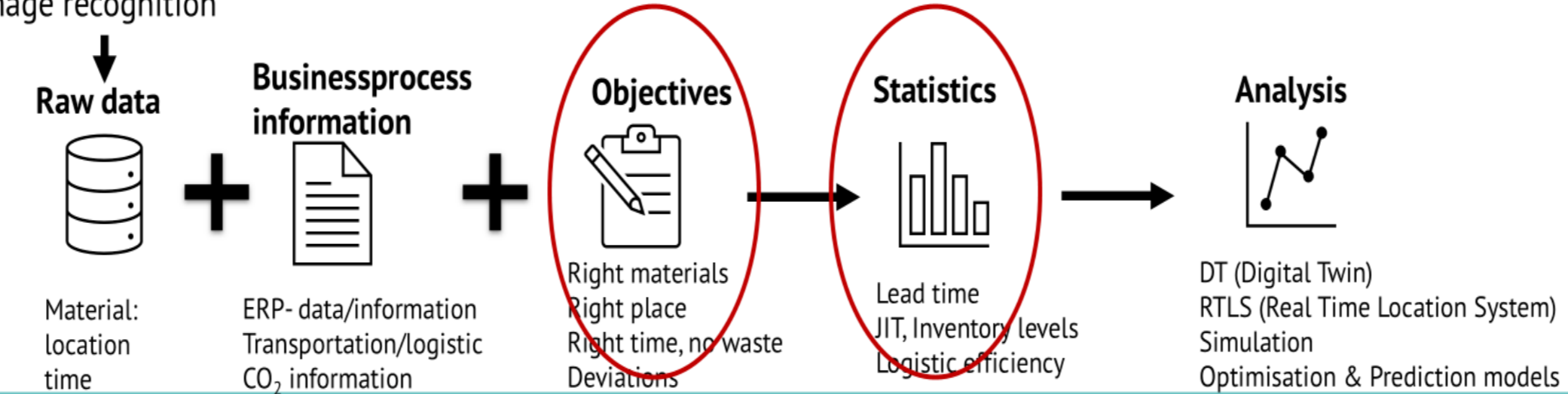


- LoRaWAN
- NB-IoT, GPS-sensor
- RFID-tags
- Smartphone QR-code
- Image recognition



Questions

- How efficient are operations in term of time, cost /waste
- Benefits that may be achieved.

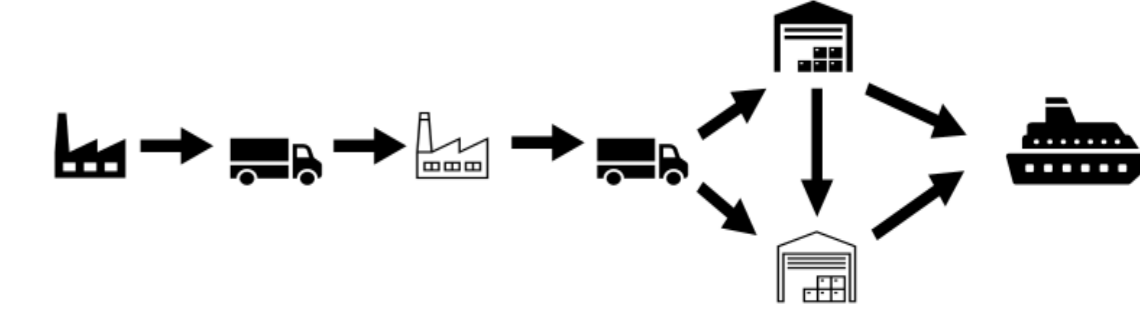


S4M- material tracking: Technology, Data, Information and Objectives, **TURKU AMK**

Technology

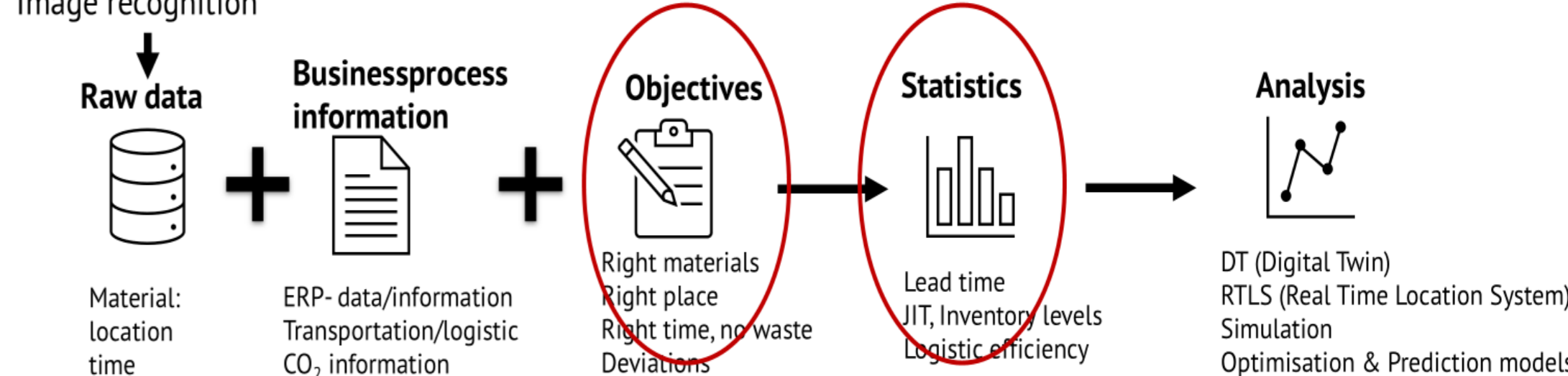


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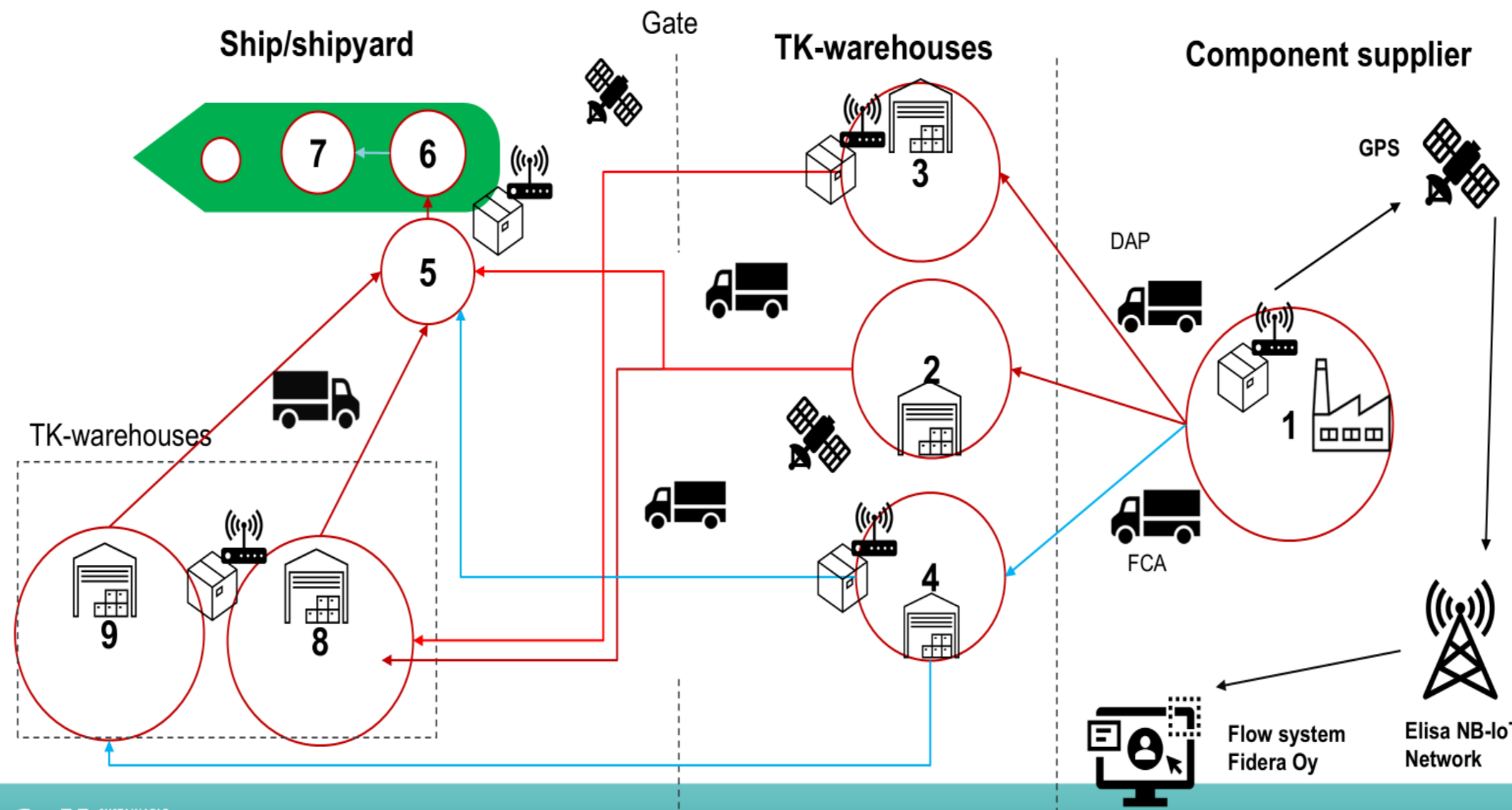
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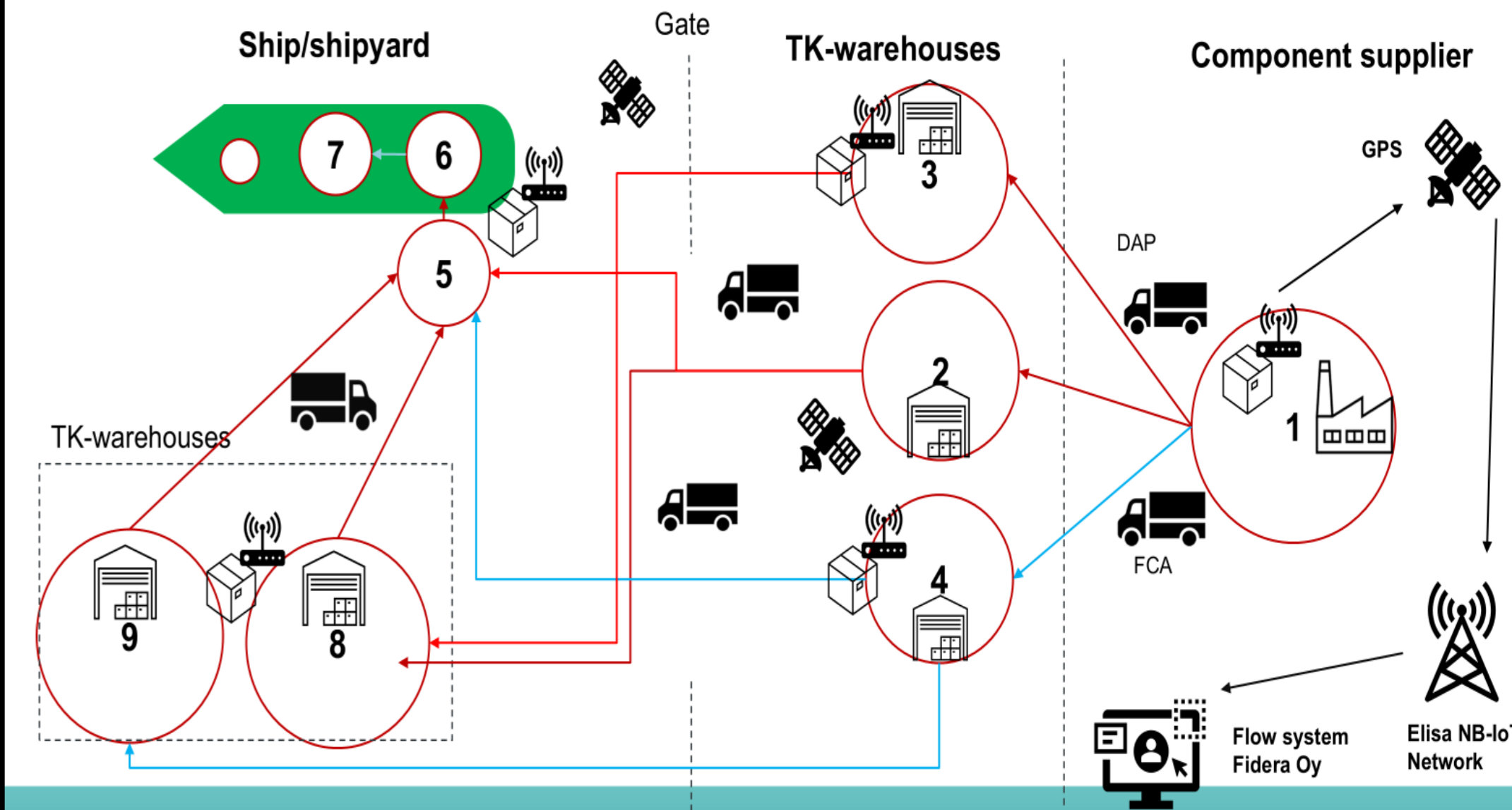


Real-time location tracking setup

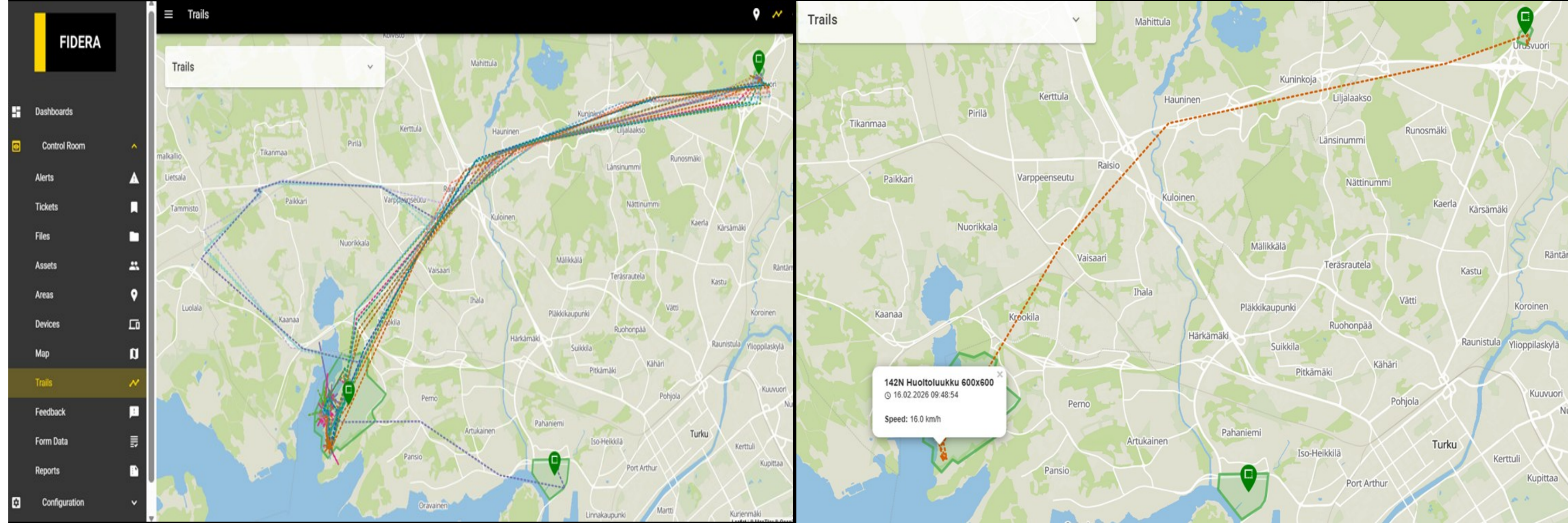
1.Case: Material flows and tracking areas GPS-IoT



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One of a kind Digital shadow of supply network



One of kind Digital shadow of supply network

FIDERA

- Dashboards
- Control Room
- Alerts
- Tickets
- Files
- Assets
- Areas
- Devices
- Map
- Trails**
- Feedback
- Form Data
- Reports
- Configuration

Trails

142N Paneeli, part 60
© 19.02.2026 10:58:08
Speed: 0.0 km/h

FIDERA

- Dashboards
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Map

Objectives of shipbuilding

Operational performance capabilities are evaluated thru lenses of LEAN value creation paradigm.

- Just In Time (JIT) and
- waste elimination.

Wastes identified in CSSC (Cruise Shipbuilding Supply Chain):

Order of wastes are based on Total waste score (TWS). TWS is calculated from Waste priority index (WPI) which assess waste based on occurrence, severity and complexity. Analysis cover several shipbuilding research articles.

Waste Types	TWS
Waiting & Delays	78,6
Defects / Rework	68,2
Inventory	68
Transportation	48,2
Overprocessing	43,8
Underutilized-Talent	39,92
Overproduction	35,2
Motion	20,8

Objectives of shipbuilding

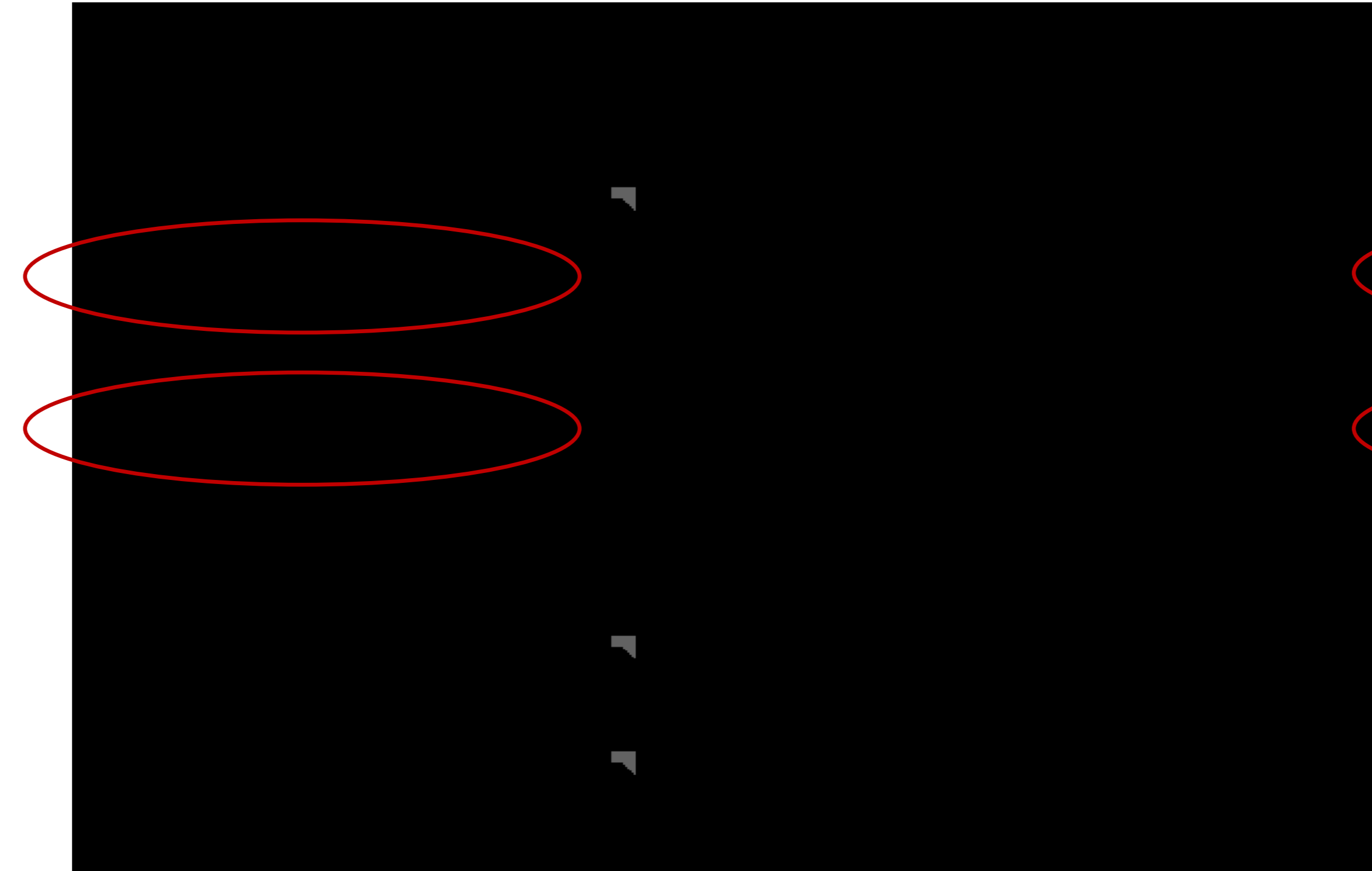
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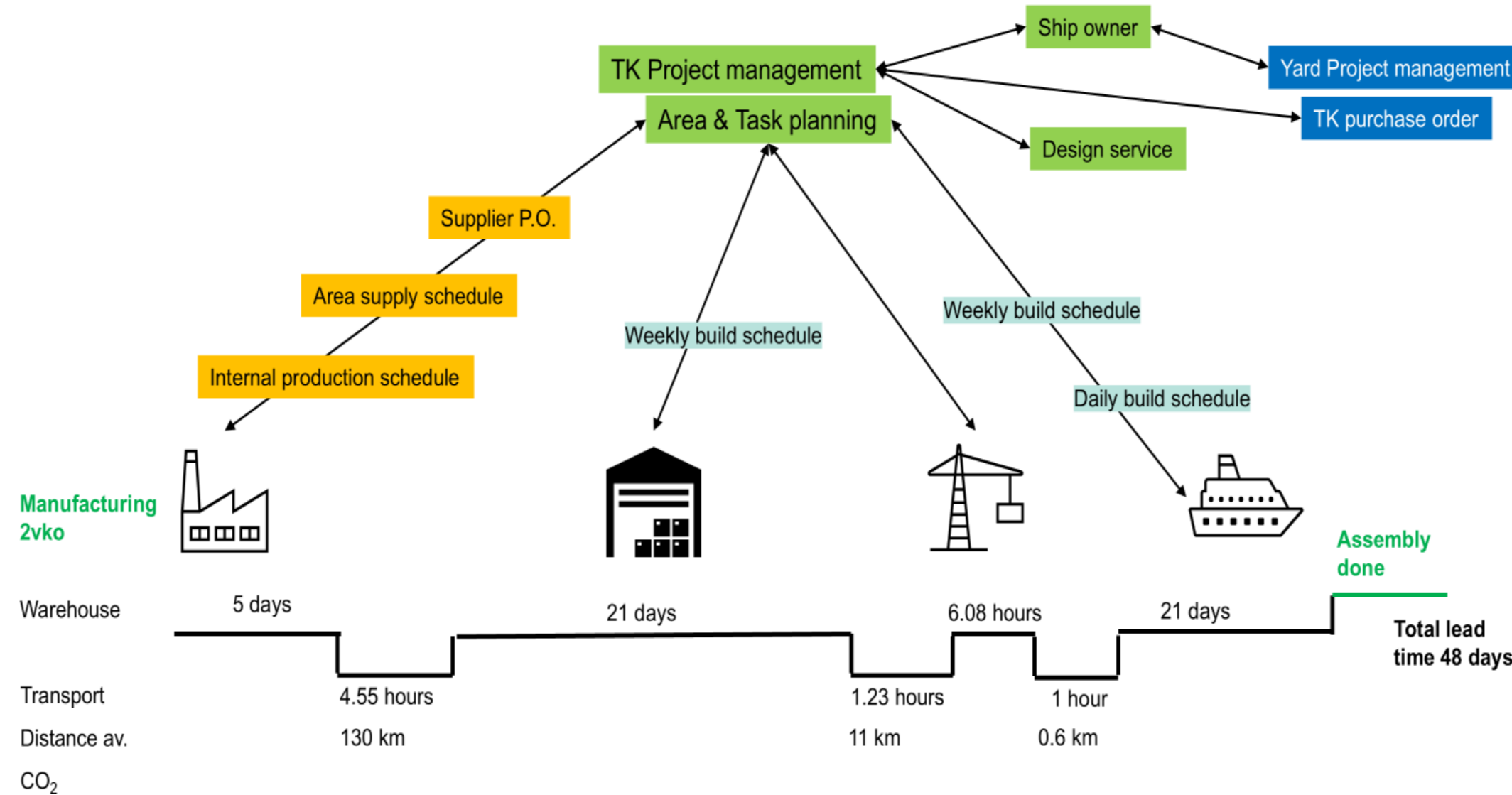
Operational KPI's identified in shipbuilding



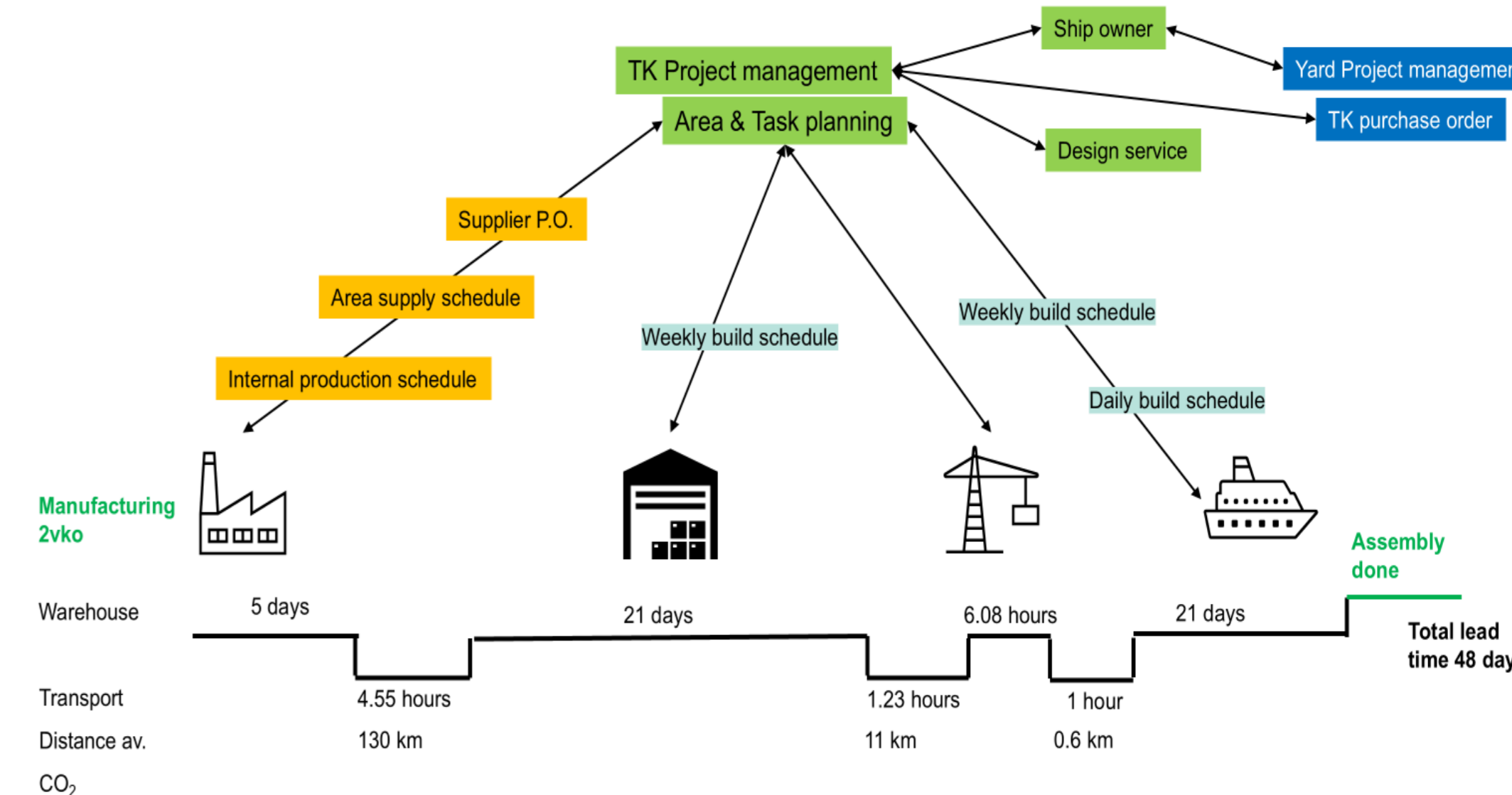
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SC Value Stream Map

Supply Chain Value Stream Map



Supply Chain Value Stream Map

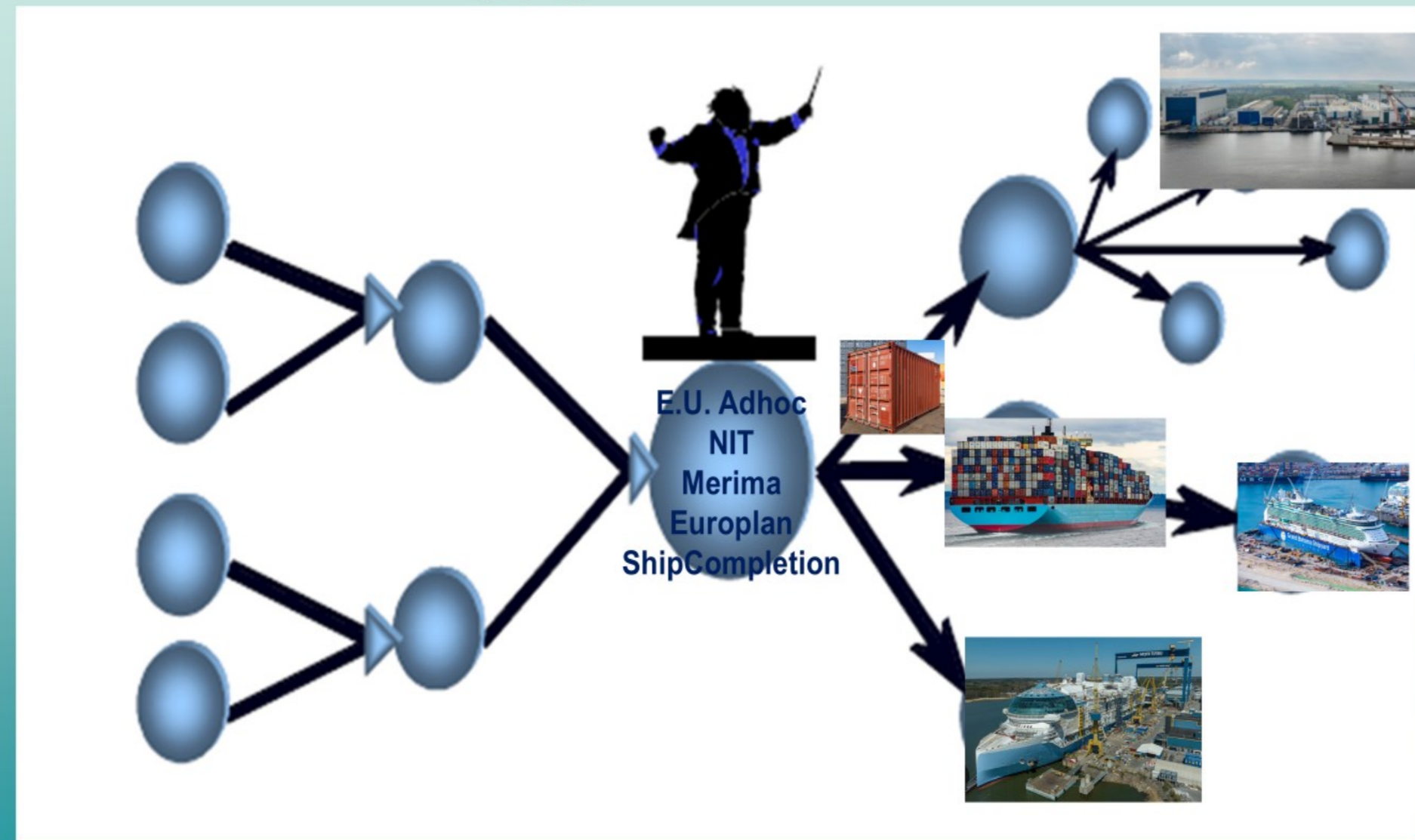


The Role of Digital Shadows in The Value Chain

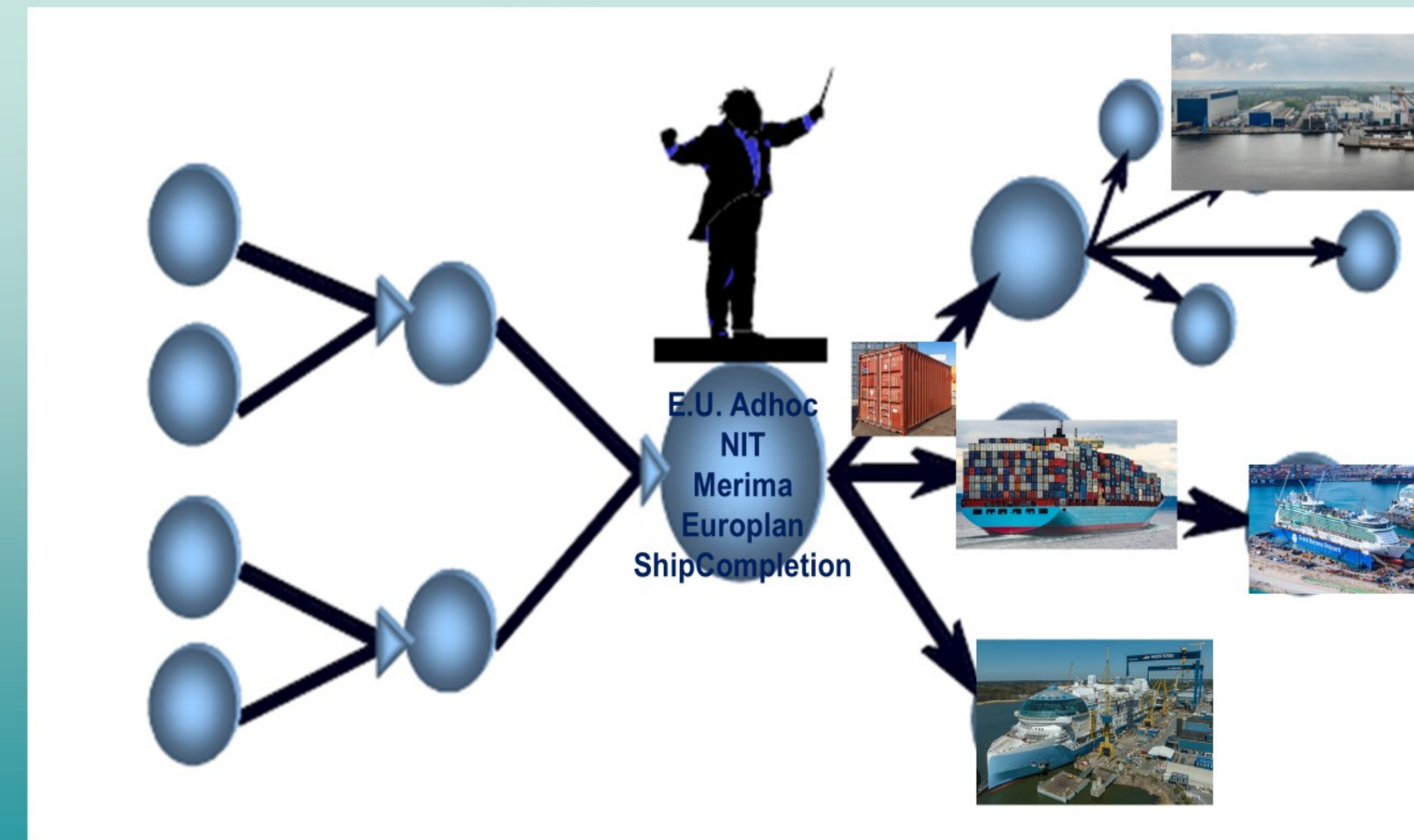
Create visibility and control over network

Enable value creation and data driven decision making by utilizing federated dataspace

Orchestration of supply networks



Orchestration of supply networks





E.U. -ADHOC PROJECT OY

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