ALigning Architectures for DIgital twiN of the Organization (ALADINO)

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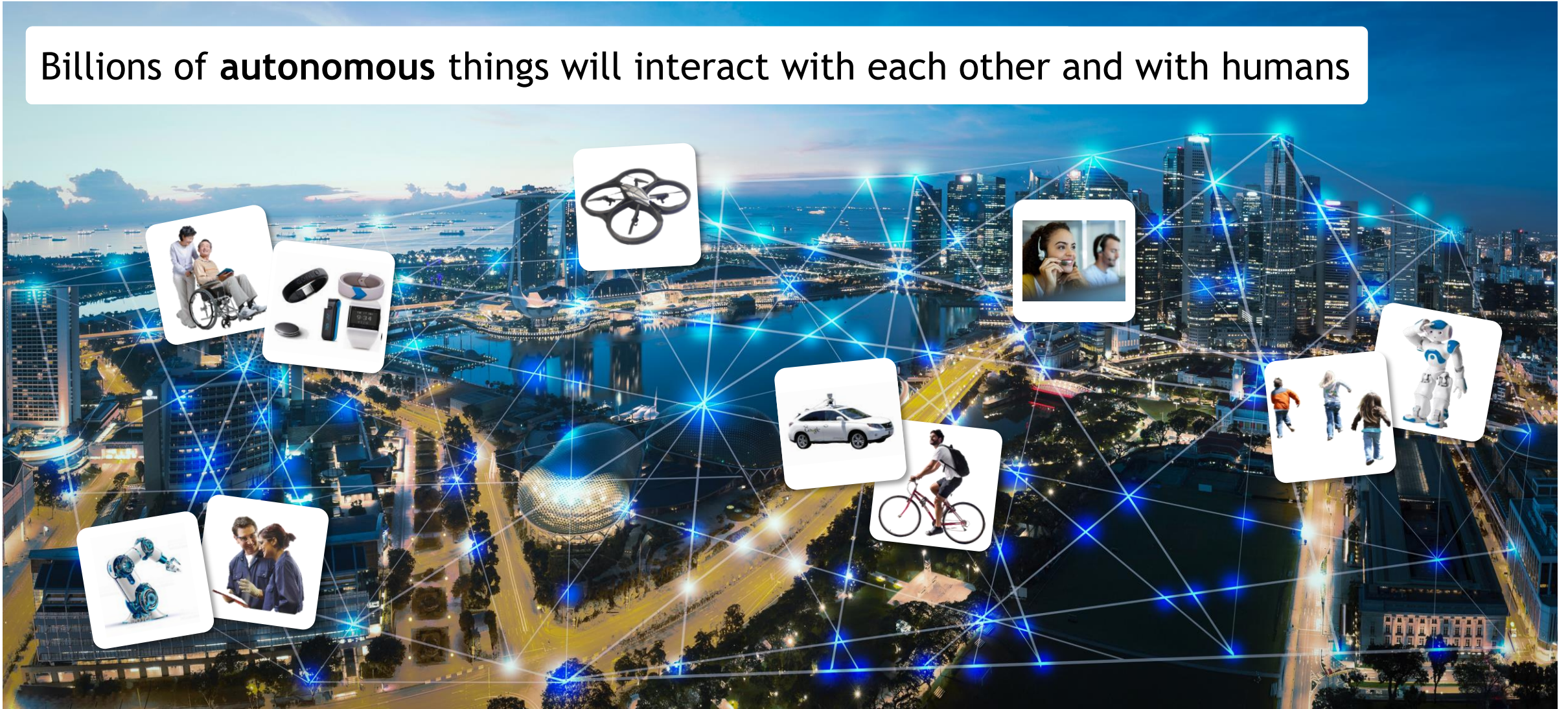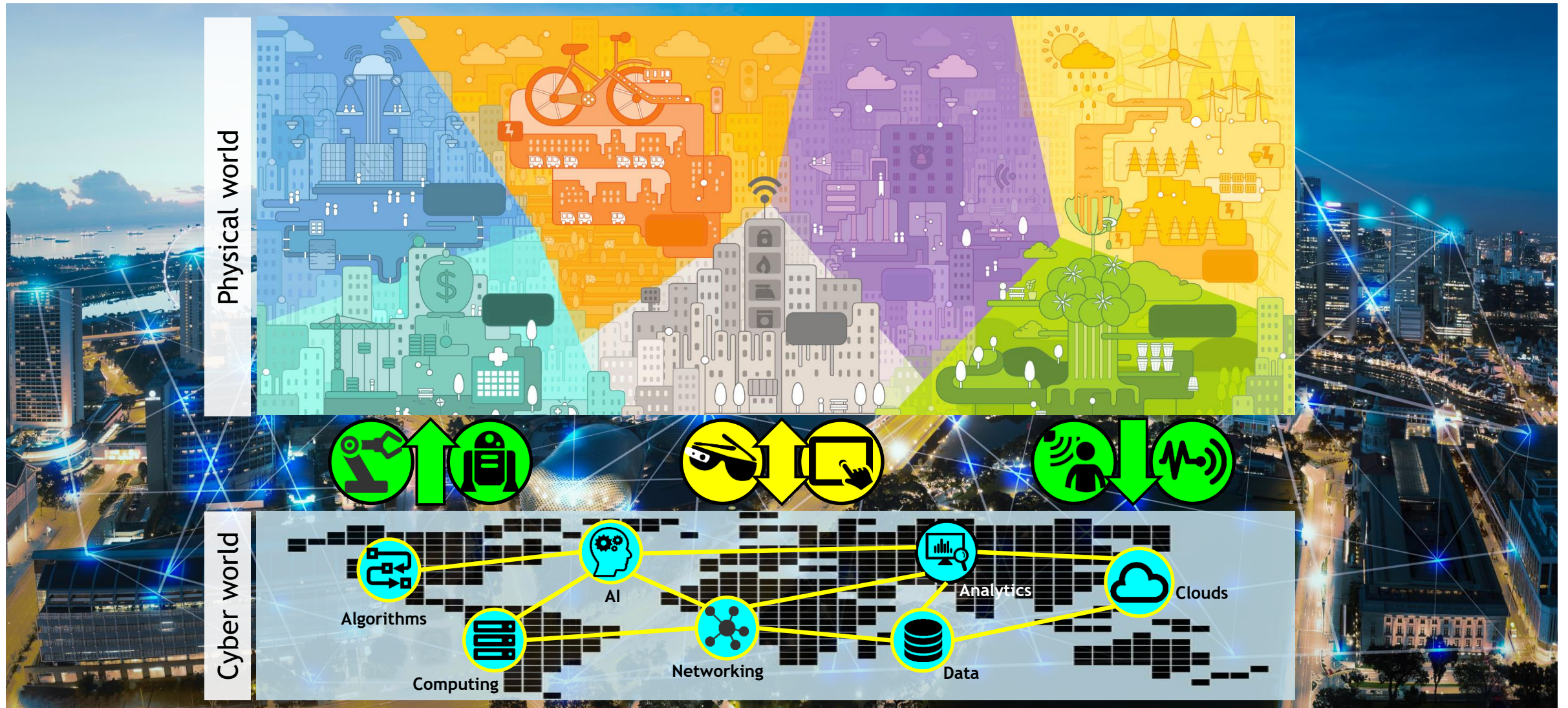
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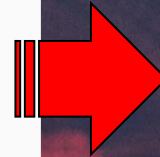
Myriads of pervasive connected devices

Billions of **autonomous** things will interact with each other and with humans

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Digitalization is a grand challenge
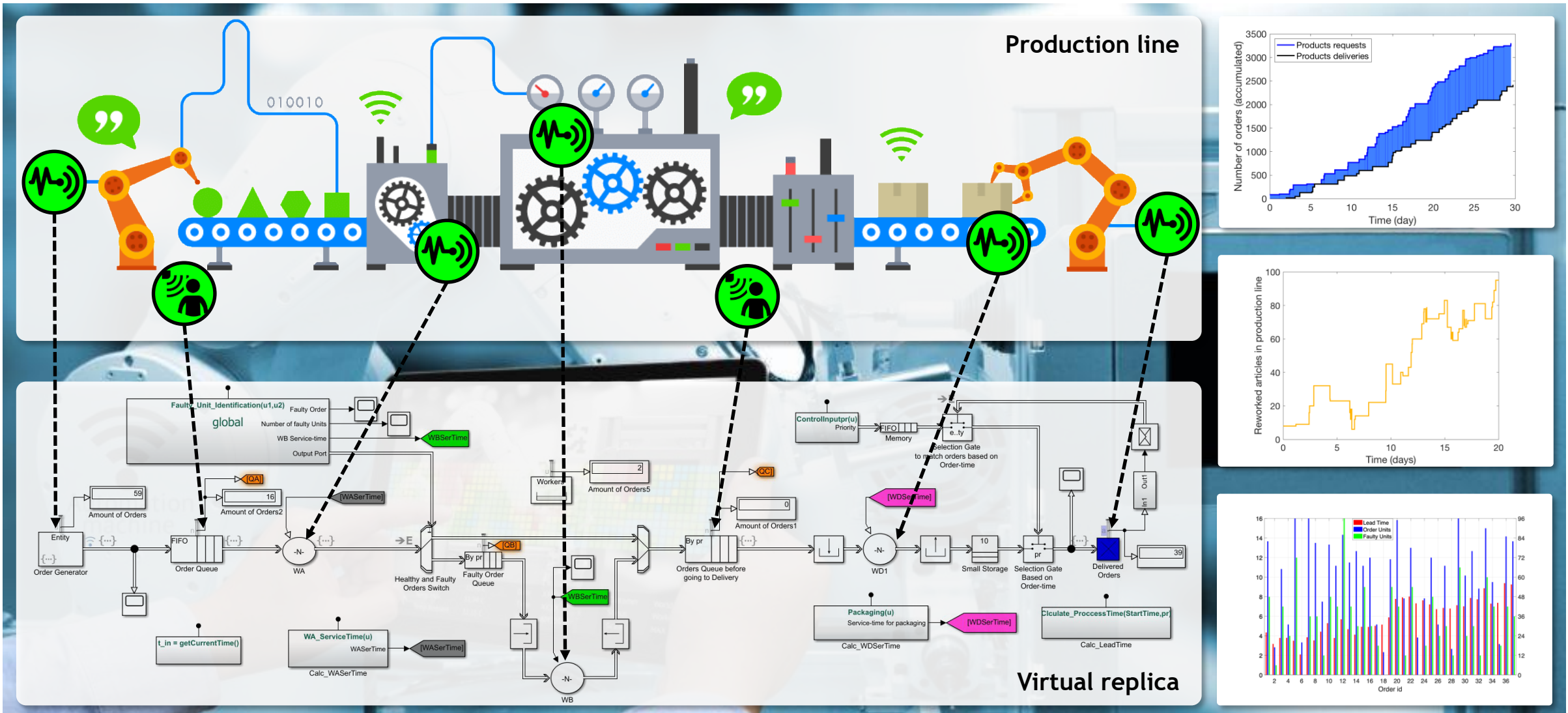
Complex systems

Complexity → Uncertainty

How can we execute the decision-making process and make informed decisions?

Digital Twin of Organization represents all the elements and connections of an organization in virtual replicas

Can be **simulated** and **analyzed**

- Assessment, health diagnosis, optimization

Digital Twin of the Organization

Opportunities

Employing a well-defined DTO can help organizations to develop, change and innovate, and consequently enhance the organizations sustainability

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Challenges

DTO Evolution
"Digitalization is a long-running process that must manage new and changed requirements and constraint. How can we effectively and efficiently maintain and evolve DTOs in order to adapt to future needs?"
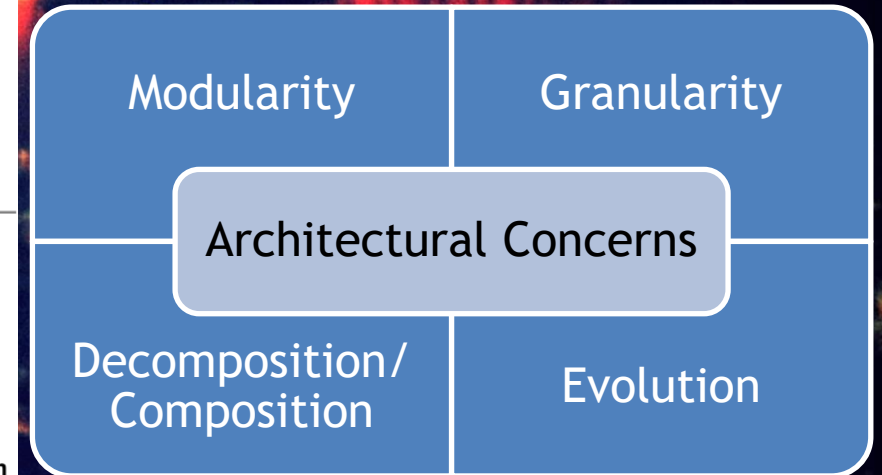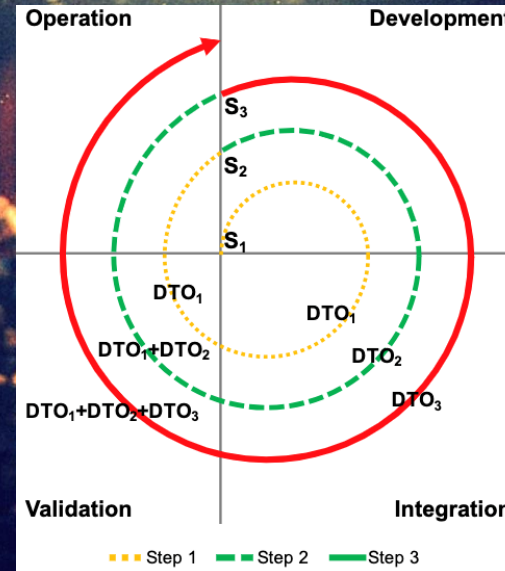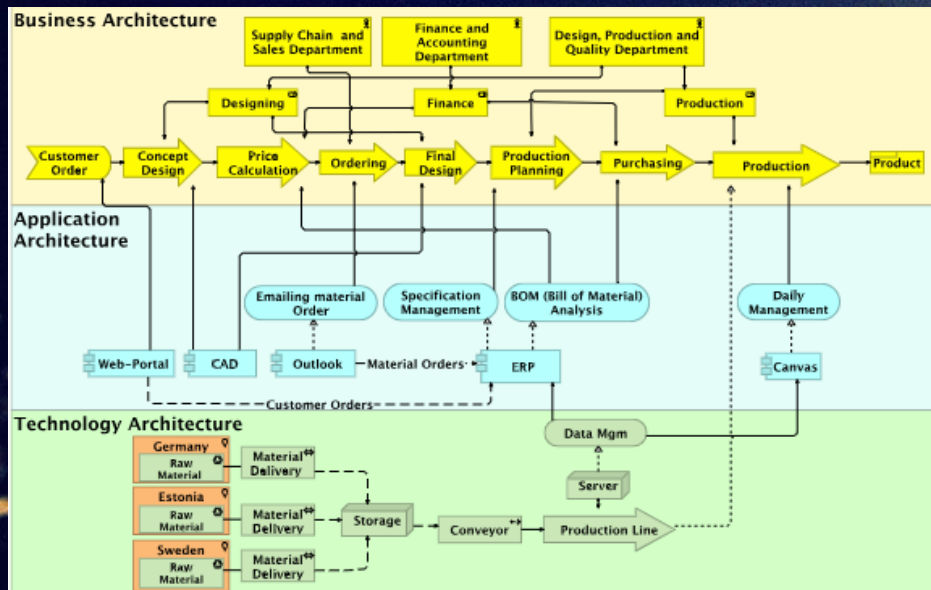
DTO Development
"Digitalize the organization is a cumbersome and error-prone process. How can we gradually introduce, and iteratively develop a DTO that satisfies the organizational needs?"

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The ALADINO Approach
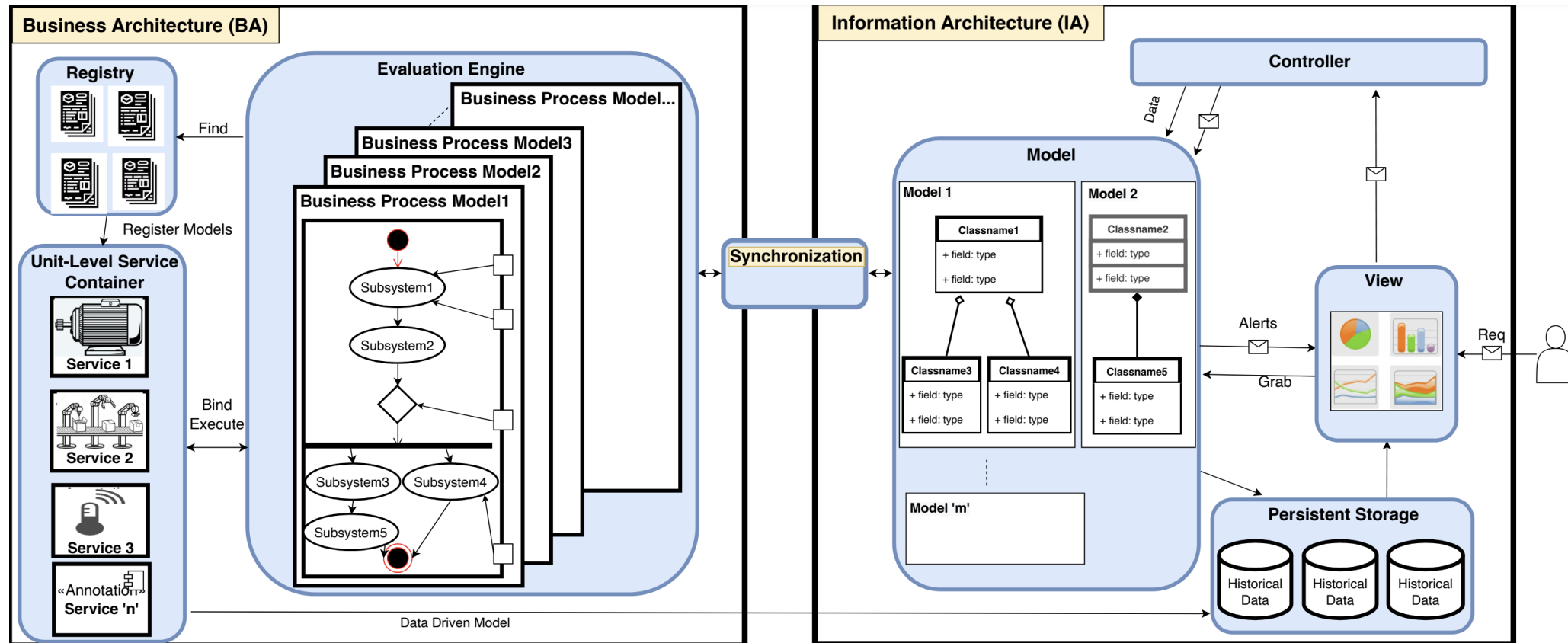
DTO Functionality

DTO should **mimic** the organization that produced it*

DTO consists of:
- **Structure**: Elements and relationships
- **Behavior**: How the elements interact with each other
- **Data**: state, context, input, output

* Caporuscio, M., Edrisi, F., Hallberg, M., Johannesson, A., Kopf, C., & Perez-Palacin, D. (2020). Architectural concerns for digital twin of the organization. In *Software Architecture: 14th European Conference, ECSA 2020, L'Aquila, Italy*.
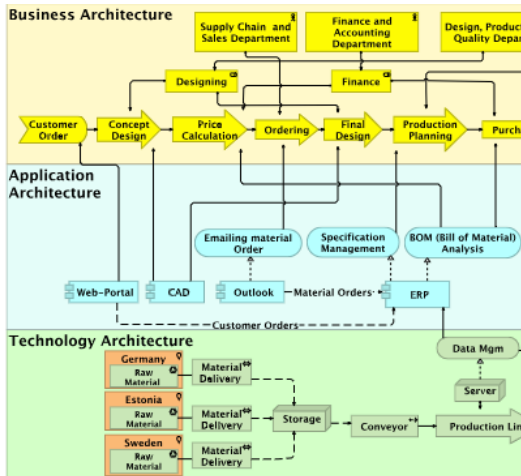
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EA Blueprint Pattern*

1. **BA** represents business processes and interactions at organization level
2. **IA** manages the data representing the current status of the organization
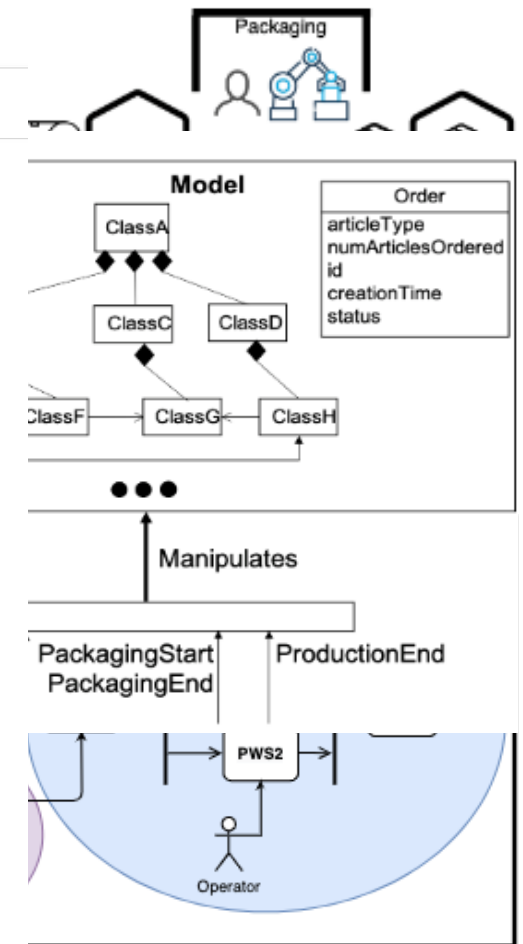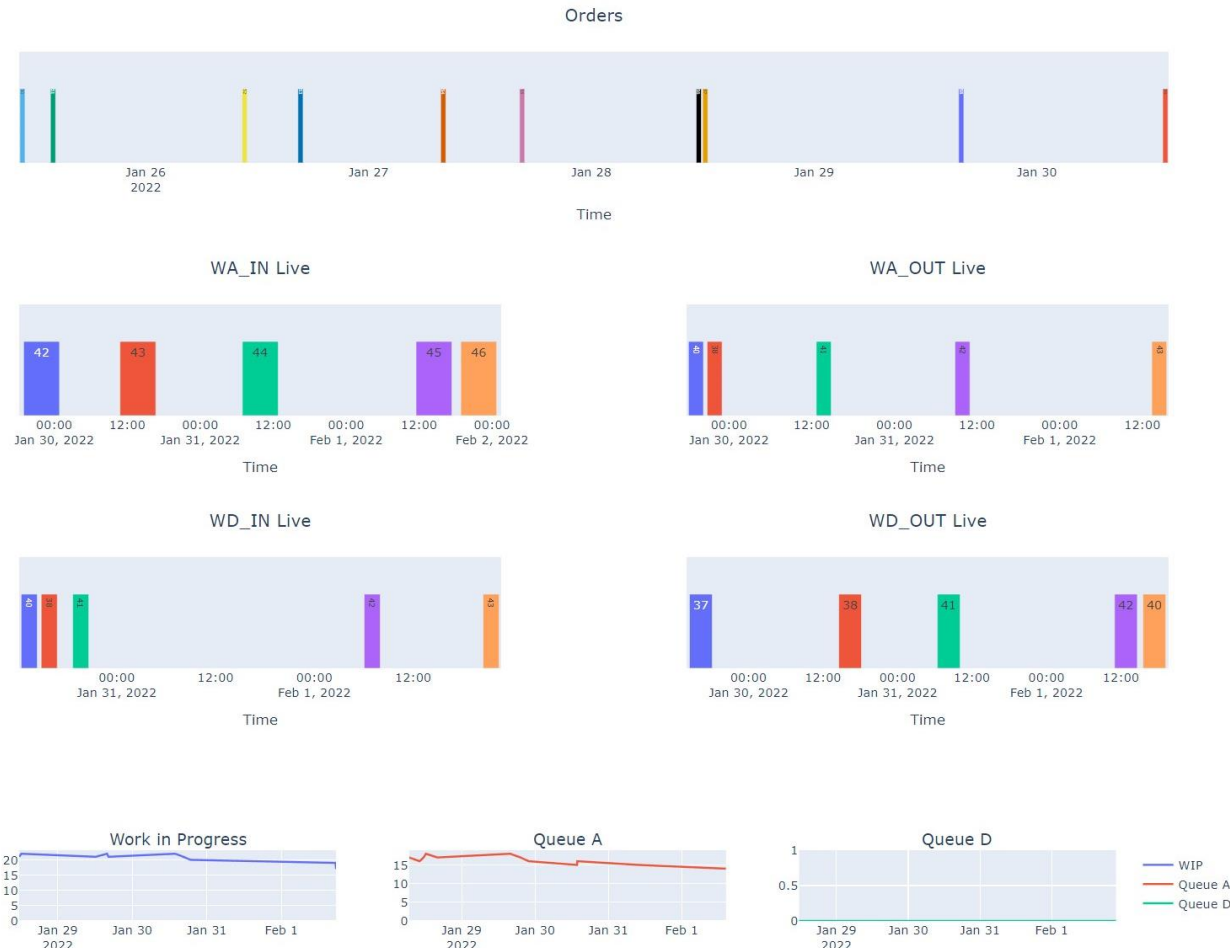3. **Synchronization** handles the information exchange between BA and IA.

Production Business Process*

* Edrisi, F., Perez-Palacin, D., Caporuscio, M., & Giussani, S. (2024). Developing and Evolving a Digital Twin of the Organization. *IEEE Access*
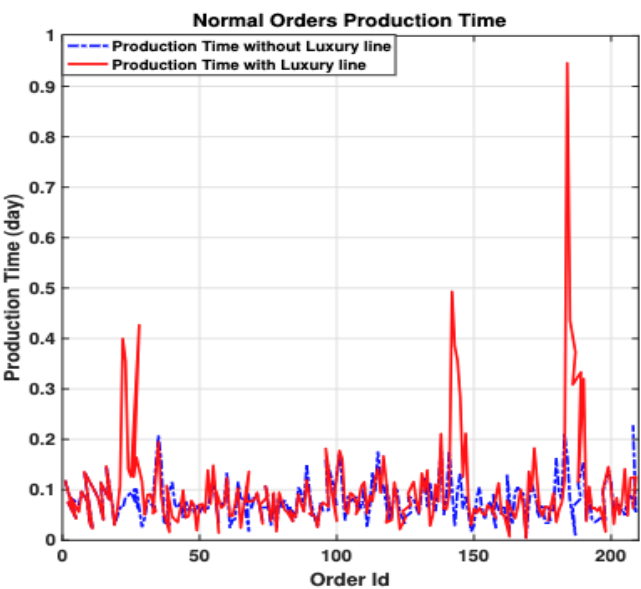
Added Values*

- Adding Transportation and Luxury Production business Processes to the basic Production process.

- Production Time comparison for normal orders in as-is DTO (without luxury line - blue dashed plot) and to-be DTO (including luxury line - red plot)

    Maximum difference = <u>18.69</u> hours

    Average difference = <u>32</u> minutes

Normal Orders Production Time

- Simulation results of what-if scenarios for resource allocation of Transportation.
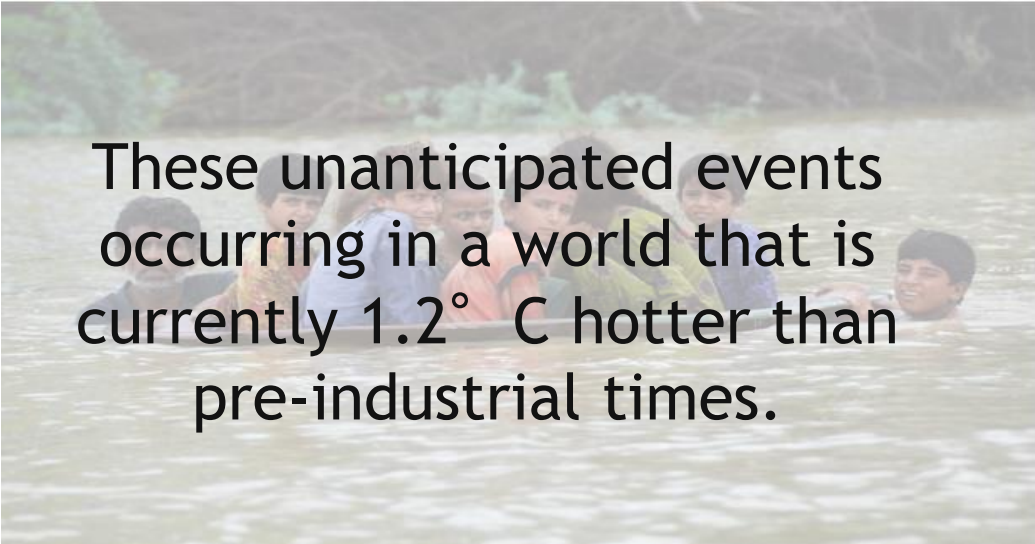
Departure Policy	10			8			6			4			2			1		
No. of Trucks	AW[a]	AL[b]	AU[c]	AW	AL	AU	AW	AL	AU	AW	AL	AU	AW	AL	AU	AW	AL	AU
1	0.51	5.28	0.99	0.49	5.1	0.99	0.48	5	0.99	0.46	4.85	0.98	0.52	5.47	0.94	0.54	5.65	0.76
2	0.31	3.32	0.99	0.32	3.38	0.99	0.32	3.34	0.98	0.31	3.27	0.96	0.32	3.4	0.83	0.41	4.34	0.44
3	0.24	2.54	0.99	0.23	2.48	0.98	0.25	2.66	0.97	0.24	2.54	0.92	0.22	2.32	0.59	0.41	4.34	0.3
4	0.17	1.81	0.99	0.18	1.95	0.97	0.18	1.92	0.95	0.18	1.95	0.85	0.22	2.29	0.45	0.41	4.34	0.22

[a] AW: Average Waiting Time in Delivery Queue, [b] AL: Average Length in Delivery Queue, [c] AU: Average Utilization of trucks

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ALADINO's Potential Role in Net-Zero Emissions

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Why Net-Zero!?

These unanticipated events occurring in a world that is currently 1.2° C hotter than pre-industrial times.

Extreme weather events, amplified by global warming, are coming faster and more severe than predicted.

Agreement to do everything to hold increases to 1.5° C
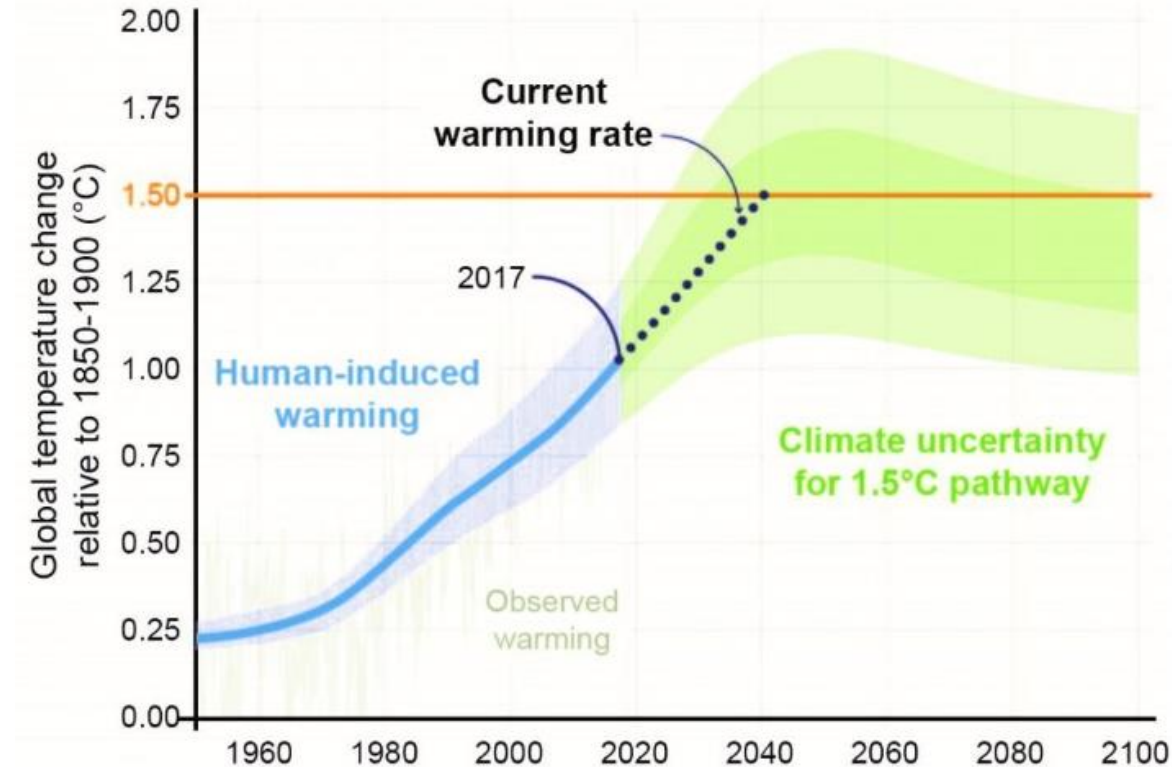
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To achieve net-zero carbon emissions by 2050 and avoid exceeding the 1.5° C global temperature increase:

Reducing emissions by 5%-7% each year!

Current situation: Emissions are increasing by 1% to 2% annually!

Manufacturing and Production sector is responsible for 20% of the world's carbon emissions (directly)

New Ideas are required!

Global temperature change relative to 1850-1900 (°C)

Current warming rate

2017

Human-induced warming

Climate uncertainty for 1.5°C pathway

Observed warming

2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00

1960 1980 2000 2020 2040 2060 2080 2100

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ALADINO Can Take Responsibilities!

Real-time insights through Simulations: Identifying inefficiencies and optimizing resource usage by twinning manufacturing processes, energy consumption, and emissions.

Predictive Maintenance and Energy Efficiency: Reducing downtime and preventing energy-intensive breakdowns, minimizing waste and emissions.

Supply Chain Optimization: Reducing emissions associated with transportation and storage, by twining logistics, transportation, and inventory management.

Carbon Footprint Reduction: Minimize carbon footprint by exploring different production methods, materials, and energy sources through what-if scenarios.

Collaboration and Decision-Making: Making Informed decisions based on accurate, up-to-date information among stakeholders to decide on new sustainable policies.

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Thank You!

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