Tuples

TRUSTWORTHY AI

From OR to Trustworthy AI: the experience of the Tuples project

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EURO Practitioners' Forum
5th Annual Conference
Coimbra, October 14th, 2024

Who is Optit?

We support decision-making providing tailored Systems & Services based on

Operations Research, Data Science, Advanced Analytics & Artificial Intelligence

A Team made of 50+

Engineers, Mathematicians,

Physicists, Data Scientists

and SW Developers

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Bologna: HQ

Cesena: Software Factory

New York: US Office

BUSINESS OBJECTIVES → **DATA MANAGEMENT** → **MODELLING, ANALYTICS AND OPTIMIZATION** → **SOLUTIONS** → **CONSULTING & SERVICE MANAGEMENT**

This project has received funding from the European union's Horizon 2020 research and innovation programme under grant agreement n. 101070149

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Who is Optit?

ENERGY

CHCP Systems' Generation Management

DHC Operations and Development Optimization

DHC Network Maintenance Planning

INDUSTRY & SERVICES

Digital Innovation support (industry 4.0)

Process Workflow Digitalization

Optimized Scheduling

Customized Decision Support Services

ANALYTICS & OPTIMIZATION

Advanced & Customized Models And Algorithms

Business Intelligence

Machine Learning And Data Science

Data Mining

LOGISTICS & SUPPLY CHAIN

Distributive Logistics

Network Design

3-2d Bin Packing

Workforce Strategic Placement

Fleet Track & Tracing

WASTE

Collection Services

On Demand Logistics

Waste Supply Chain

Waste Asset Allocation

Strategic Support Services

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Different approaches: Symbolic vs. Data-driven vs. hybrid DSSs

Symbolic Decision support systems	*Hybrid Decision support systems*	Data-driven Decision support systems
Interpretability ↑	***Best or worst of both..?***	**Interpretable??** ↓
Formally verificable ↑	↑ ↓	**Verificable??** ↓
Need explicit knowledge ↓		**Does not need explicit knowledge** ↑
Robustness vs. uncertainty? ↓		**Robustness to uncertainty** ↑

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Trustworthiness in Human-Centric A.I.

International Outreach for Human-Centric InTouch AI.EU

1. Human Agency and Oversight.
2. Technical Robustness and Safety.
3. Privacy and Data Governance.
4. Transparency.
5. Diversity, Non-discrimination and Fairness.
6. Societal and Environmental Well-being.
7. Accountability.

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The TUPLES project

Trustworthy Planning and Scheduling with Learning and Explanations

- **3-year project** (Oct 2022-Sep 2025)
- Budget: € 3.798.285,00
- Objective: **Building trustworthy AI for planning and scheduling**
- Focus: **Robustness:** Stability vs. small changes in the input
  Safety: Avoid risk of injuries or death
  Transparency: Explain why particular decisions are favoured
  Scalability: Tackle significant problems from the real world

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The TUPLES consortium

- 8 partners: 5 Universities + 3 companies with 5(+1) use cases

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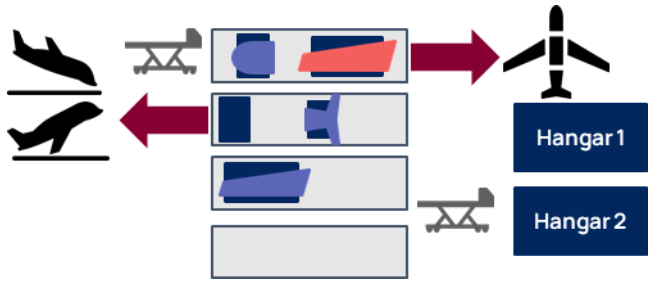
UC1: Scheduling and logistics in aircraft manufacturing (AIRBUS)

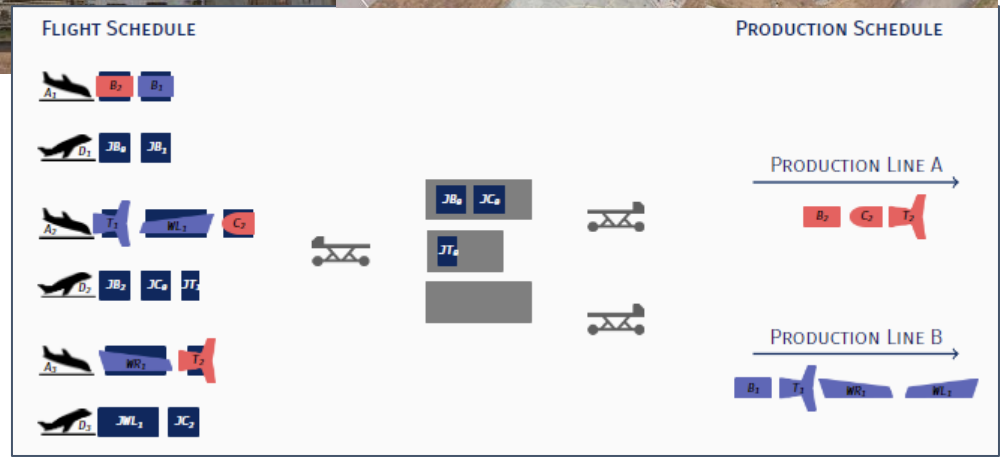
Production demands

+

Availability of Beluga flights, jigs & trailers

Scheduling of manufacturing logistics





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UC1: Scheduling and logistics in aircraft manufacturing

Logistics planning	Challenges	Approaches
Production demands and Beluga flights are uncertain. *Currently planned manually by 2-3 teams, using large rack space buffers to absorb uncertainty*	**Scalability**: the system has to generate or update the logistics plan for 3-4 weeks of operation in 15 mn. **Robustness**: under disruptions, system has to propose a feasible plan with high success probability in less than 15 minutes. **Explainability**: the system has to provide different options and explain consequences of what-if scenarios	Supervised Learning to learn PDDL heuristics (GOOSE algorithm) Reinforcement learning for policy learning Psychology study on planning workers' perspectives and needs from an AI support tool Minimum Unsatisfiable Property Subset Explanations

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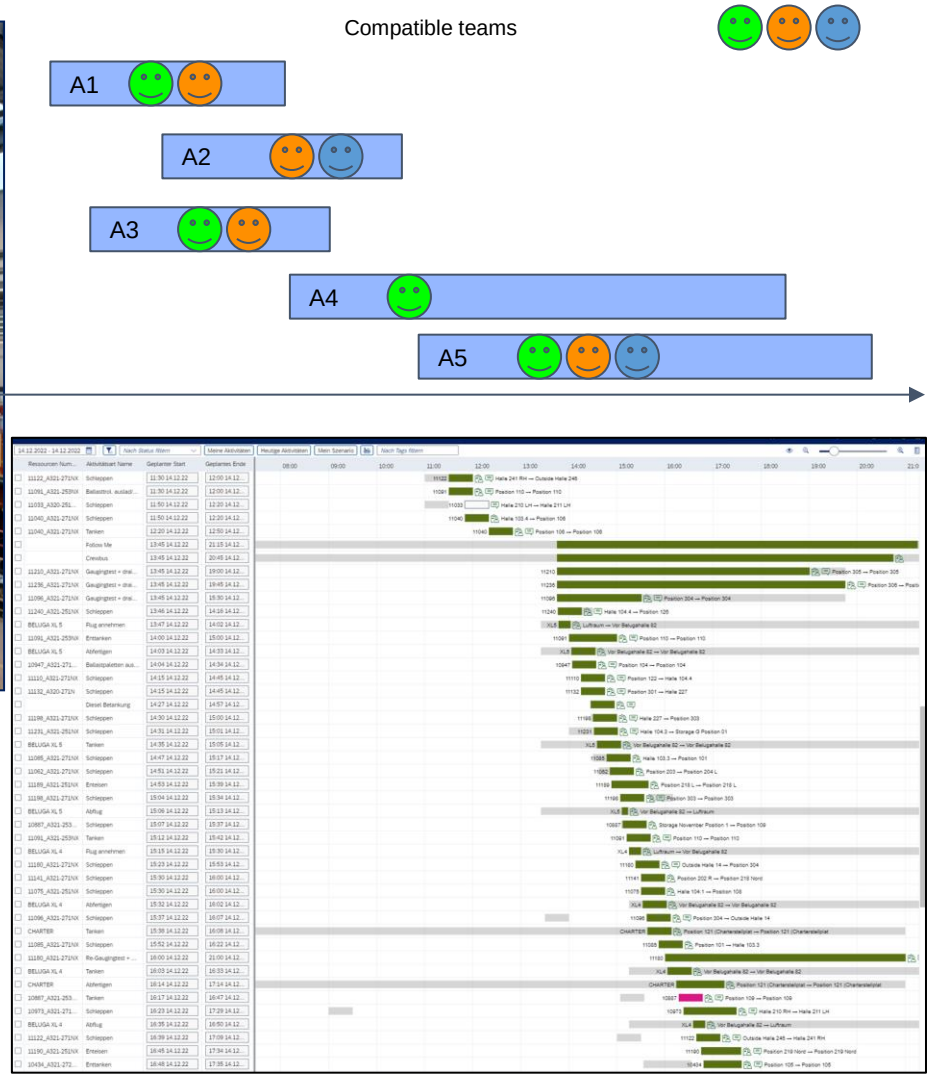
UC1bis: Manufacturing Resource Allocation (AIRBUS)

Production demands

+

Teams & resources availability

Scheduling of manufacturing operations



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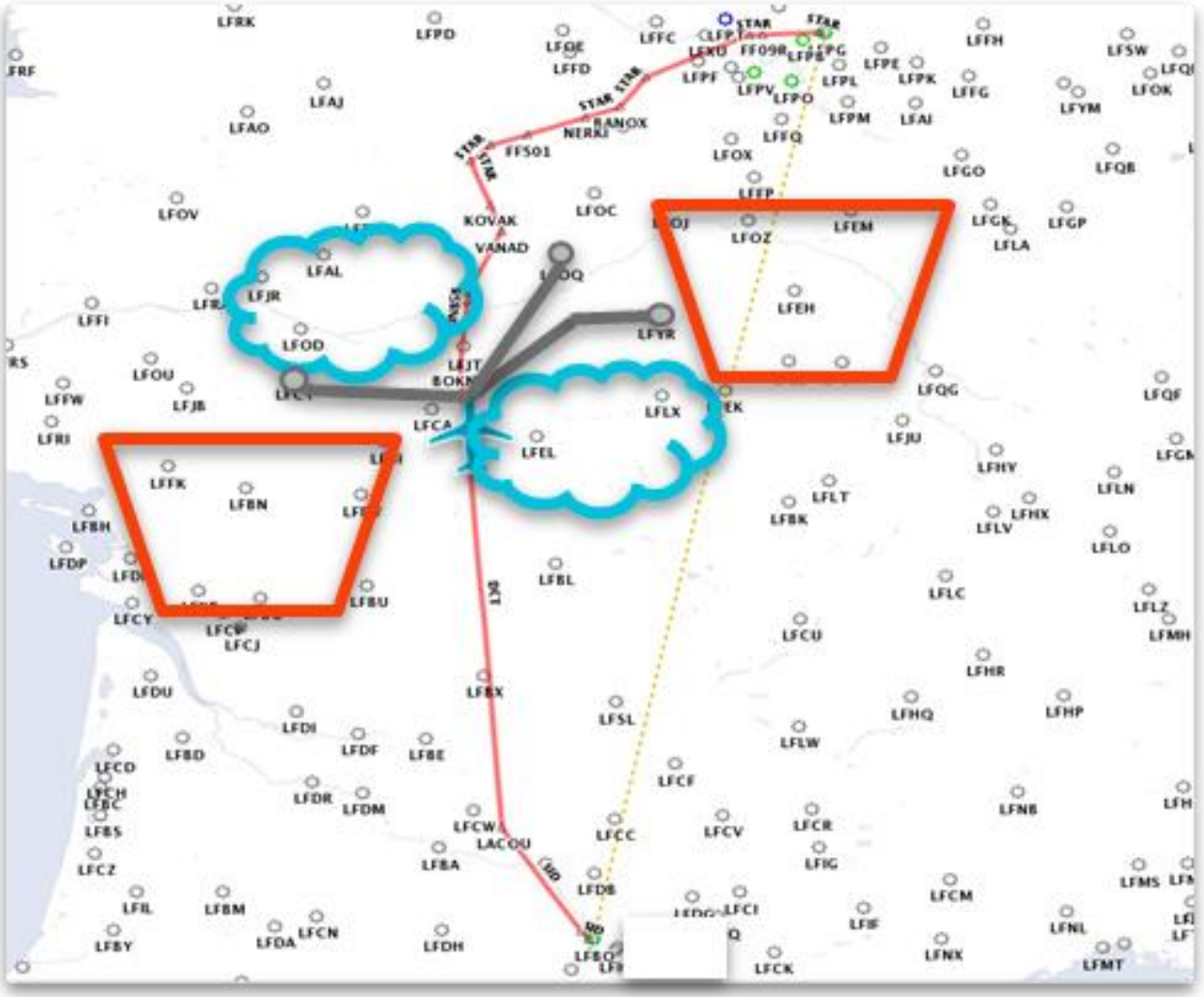
UC2: Virtual AI assistant for pilot aircraft operation (AIRBUS)

An emergency occurs during a flight

+

Location, fuel, weather conditions

Planning to which airport divert the aircraft



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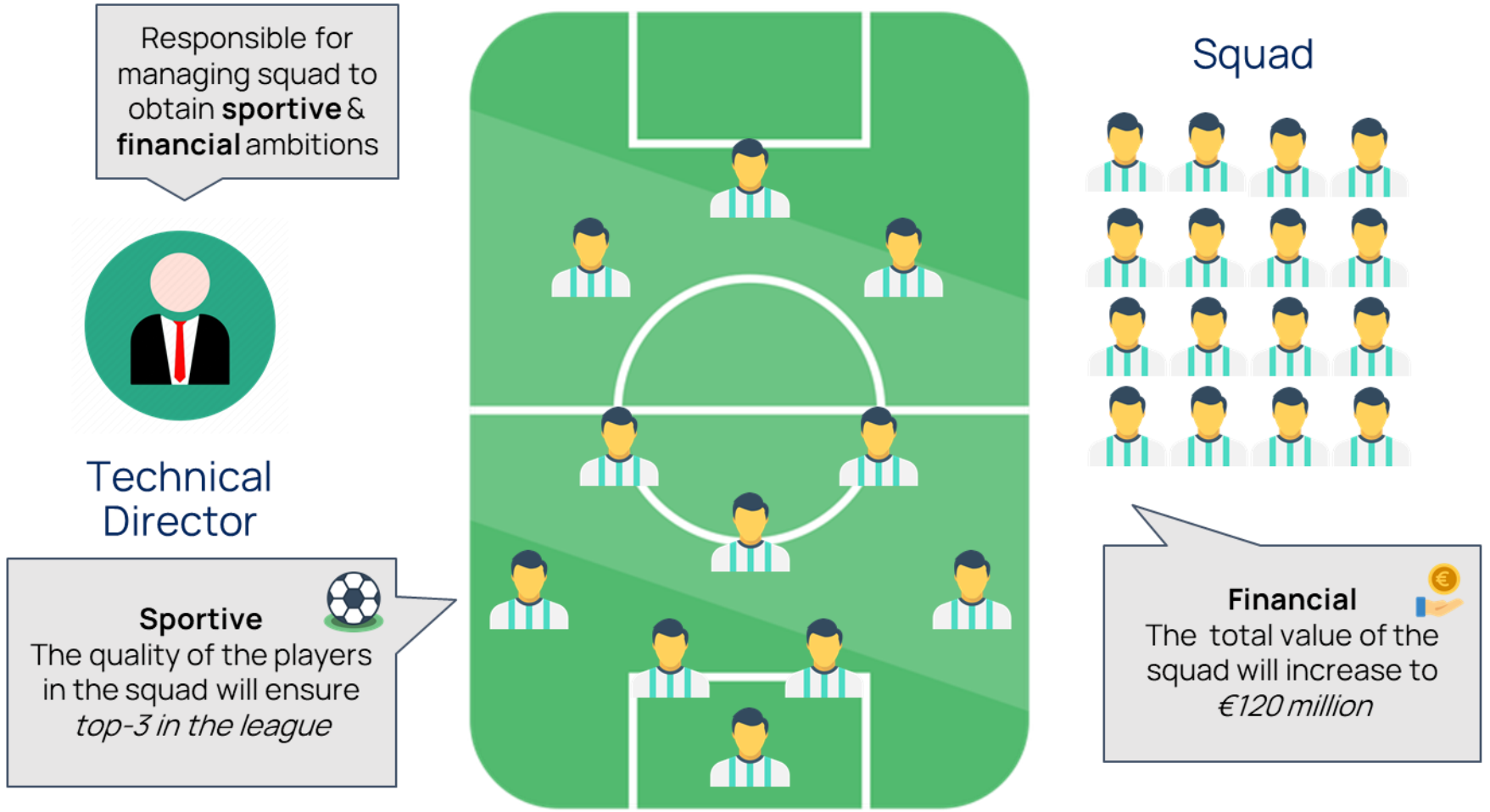
UC3: Squad management for professional football clubs (SciSports)

Sportive ambitions
e.g. win the Cup

+

Financial
constraints

Planning of buying
and selling players



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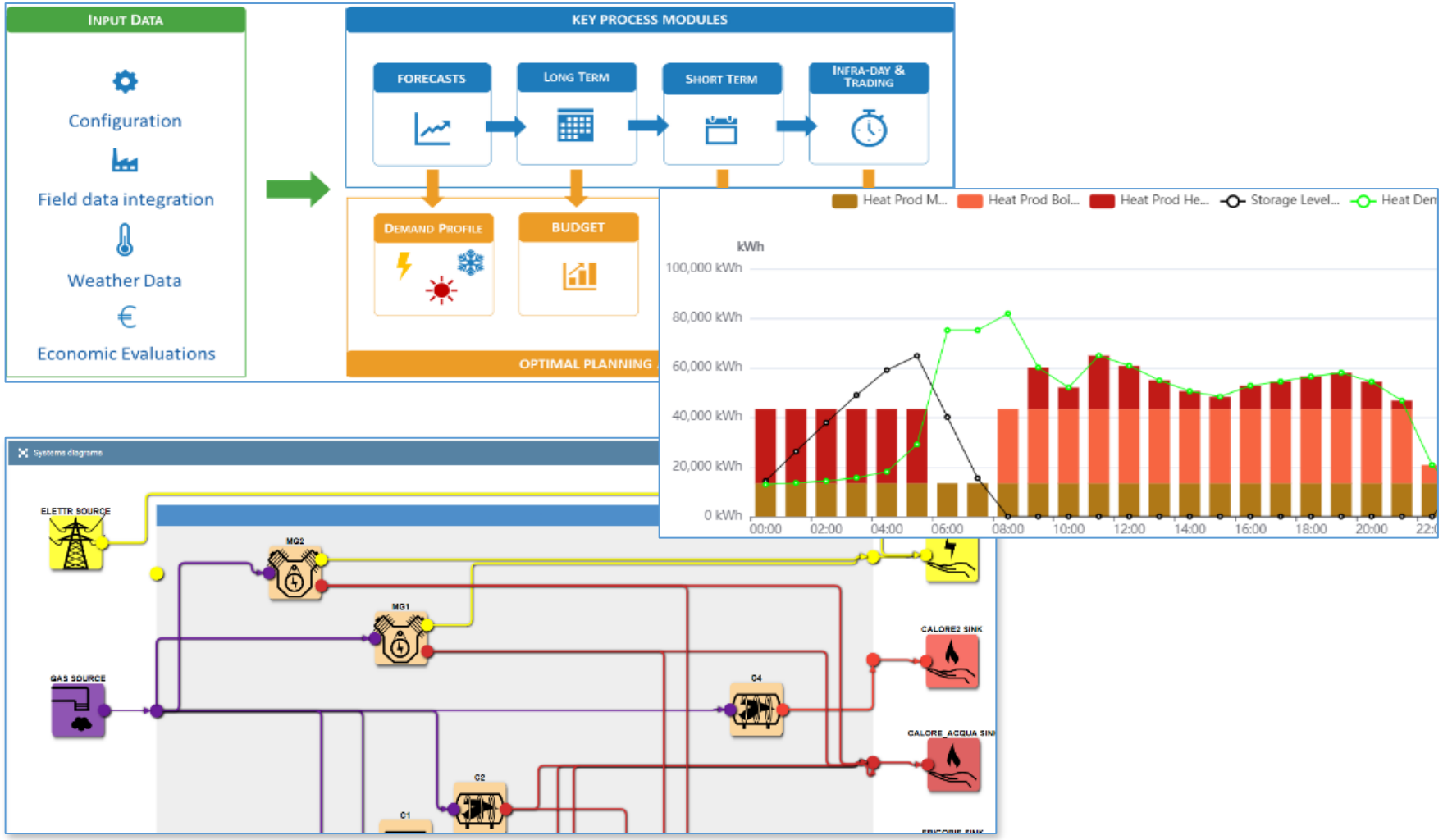
UC4: Smart energy systems optimisation (OPTIT)

Energy demand to be met

+

Complex energy generation plant

Scheduling of plant operation



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UC4: Smart energy systems optimisation

Unit committment problem	Challenges	Approaches
*Now managed as deterministic, but **inputs are NOT deterministic***	**Robustness**: heating or cooling demand, electric market prices, and sometimes production unit availability, are stochastic **Explainability**: being able to explain why a given plan has been generated instead of another.	UNIFY method, a generalised **Decision Focused Learning** hybrid approach that combines RL and Constrained Optimization **Contrastive explanations.**

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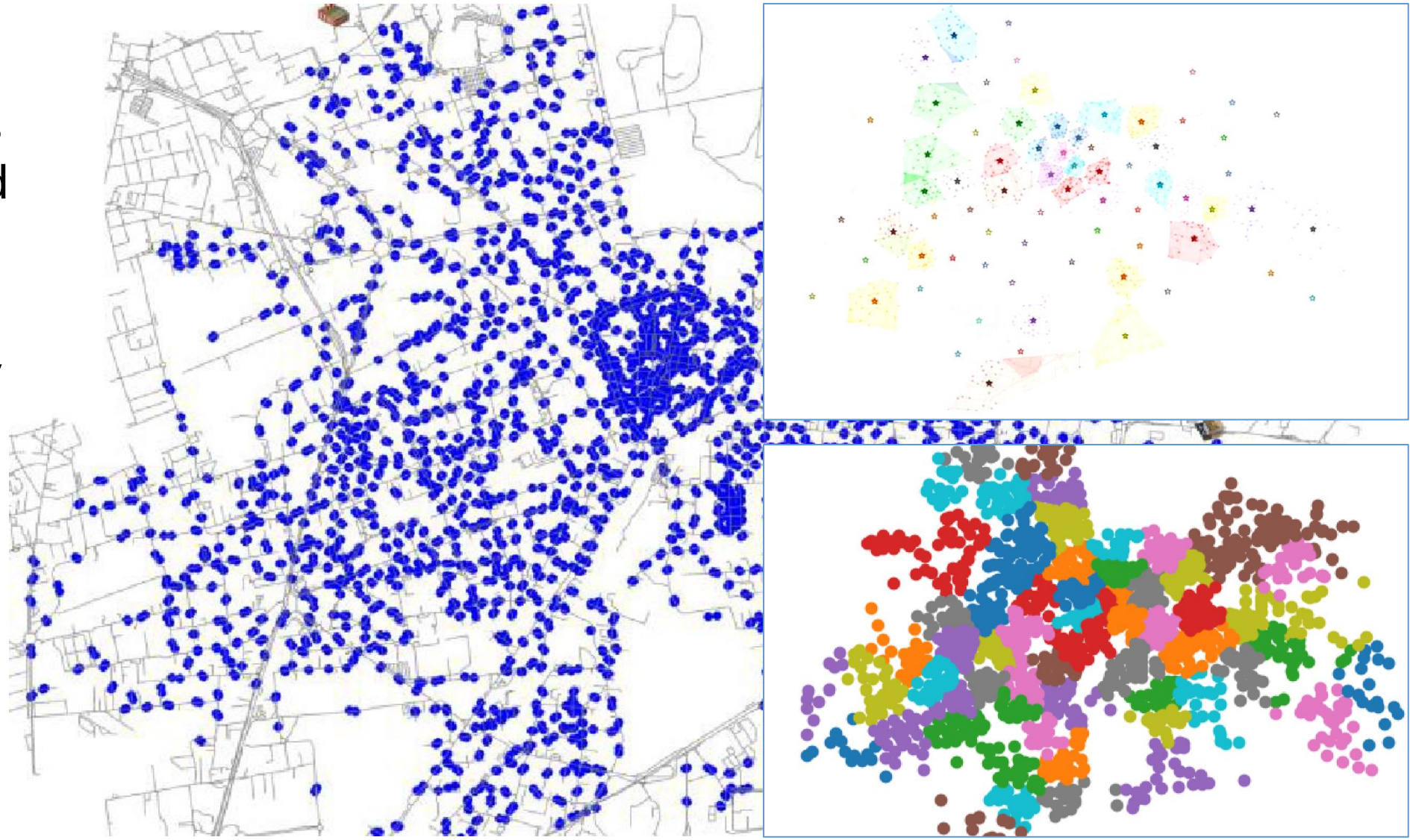
UC5: Waste collection optimisation (OPTIT)

Several thousands bins to be collected

+

Max shift time,
Max truck capacity

Routing of waste collection trucks



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UC5: Waste collection optimisation

Multi objective CVRP	Challenges	Approaches
Total number of trucks and shifts; *Total distance of trips;* *Total duration of trips;* *Compactness of trips;* *Overlapping of areas covered by trips;* *Fairness of duration between trips.*	**Robustness**: quantity of collected waste, service-time duration, and travel-time duration are stochastic **Explainability**: being able to explain why a given bin has been assigned to one trip instead of another.	Psychology study on the relative impact that human-AI agreement and outcome quality have on trust in the AI system. Alternative clustering and visualization techniques (Pareto front exploration, Constrained clustering) Contrastive explanations, Explainable constraint solving.

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A multi-disciplinary approach, to include several perspectives with a focus on the quality of Human-machine/Human-AI interactions

PARTIES INVOLVED

- AI researchers
- OR researchers
- Use case owners (domain experts, end customers, business consultants)
- Psychologists
- Ethics and AI regulations consultants (legal experts)

COLLABORATION MEANS

- Multi-disciplinary teams tailored to each use case challenge
- Joint discussion on the Trustworthiness implications in each case
- Focus on approaches that improve robustness and explainability of the models
- Distill findings in a Self Assessment Tool intended for non-experts

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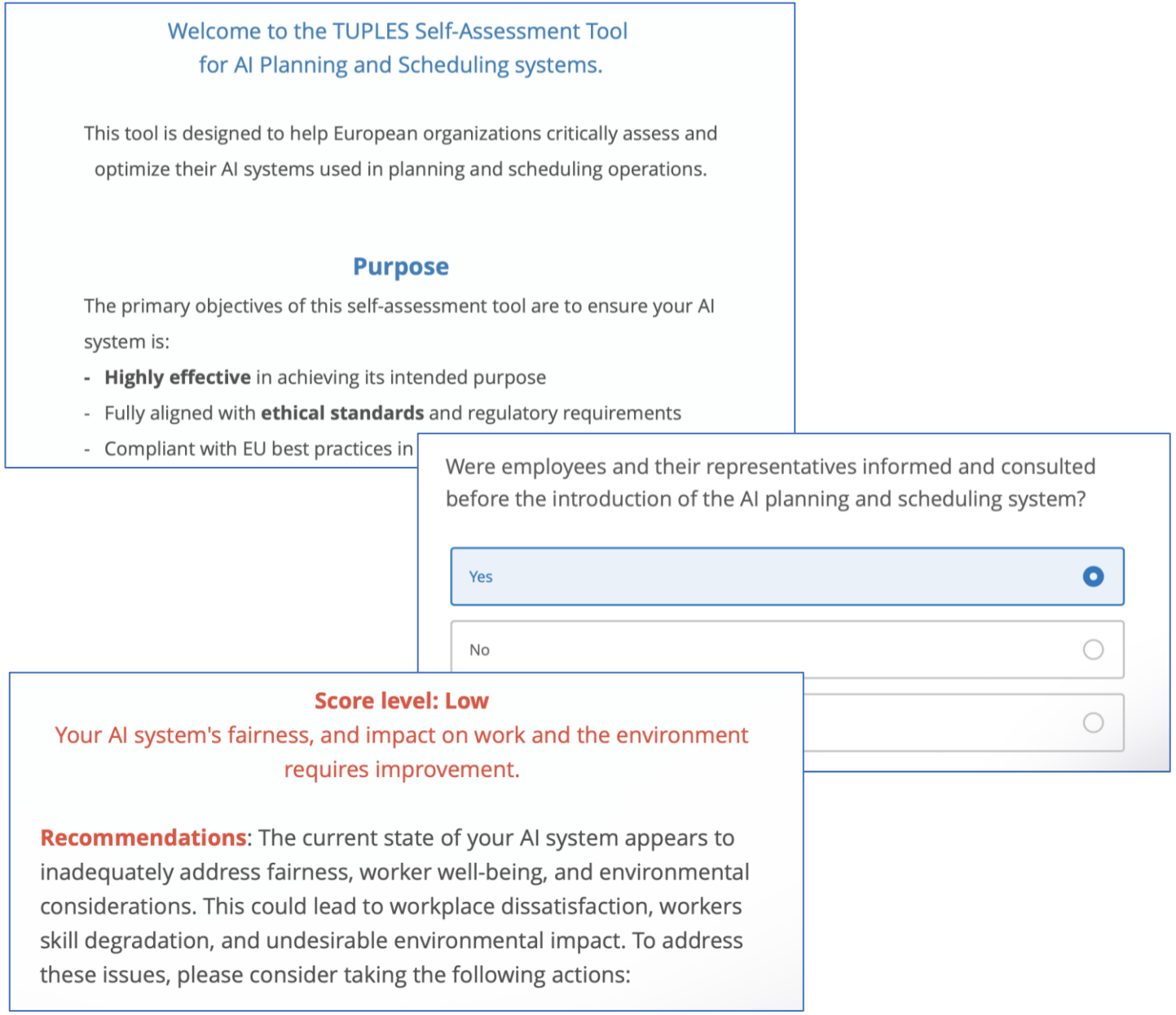
The Self Assessment Tool

An **easy-to-use diagnostic survey** that any solution provider may adopt to evaluate the coherence of their specific method with respect to the key EU guidelines on trustworthy, reliable, robust and safe AI

It has the objective of fostering awareness on Trustworthiness of AI and supporting developers of **planning and scheduling solutions** in the **evaluation of the compliance of their systems** in work environments.



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The Beluga™ AI Challenge: a chance to be engaged

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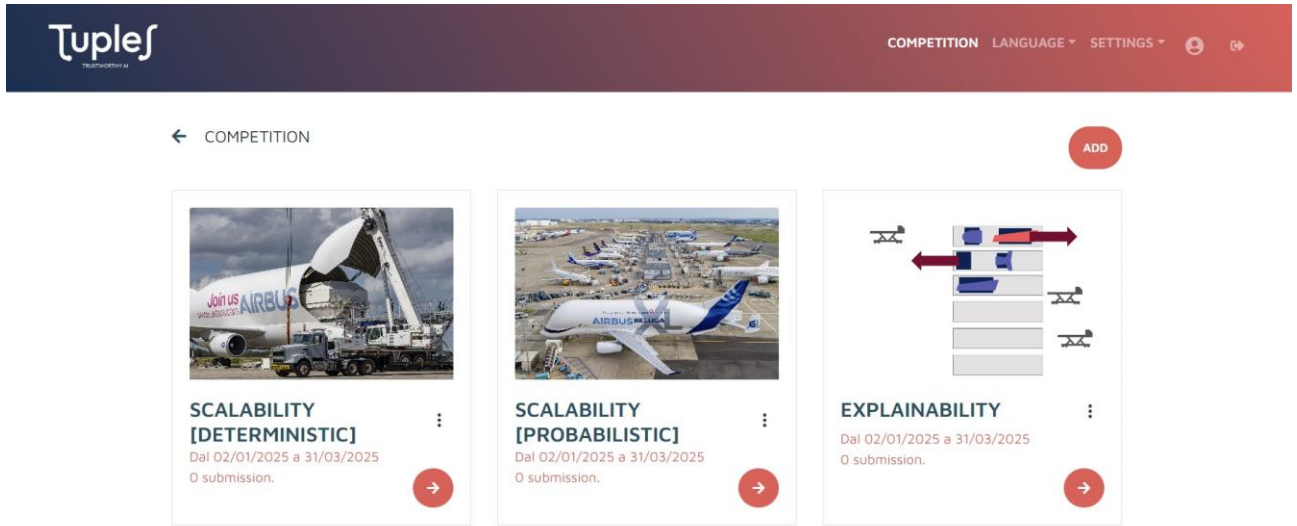
A novel competition platform to compares models (not results)

- When faced with launch of competition, it was realised no platform was adequate
- Leveraging on microservice model orchestrator developed by Optit and expertize of a partner operating in Open Innovation, a novel tool was developed
- The Models' Competition Platform represents an additional exploitable result



Platform front-end	Platform backend	Models orchestrator
Description of use cases	Manage submissions	Models orchestator
Competition rules	Evaluate models scores	Run instances on scalable cloud infrastructure
Access to data & resources	Manage competition rules	
Leaderboard		

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