inter airport FOCUS CONFERENCE

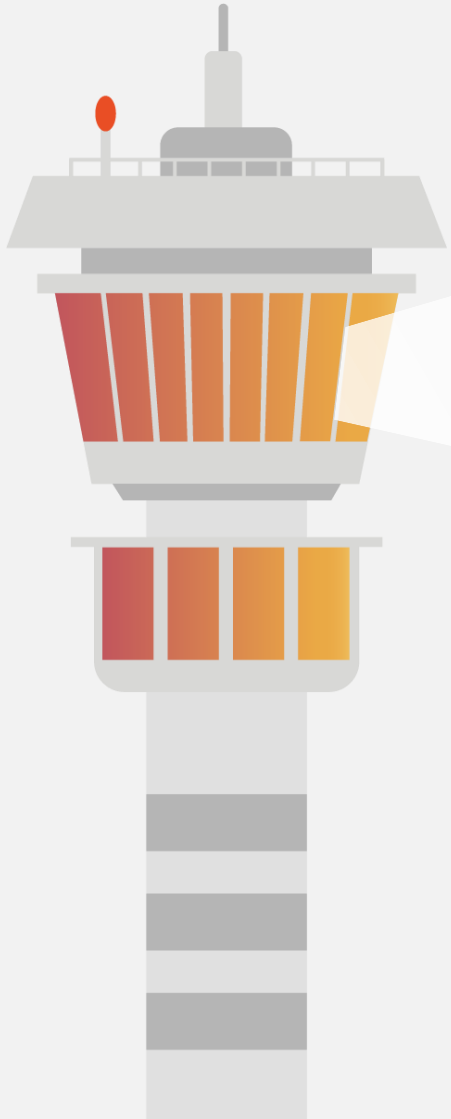
inter airport europe 25TH EDITION

Manuel Wehner ◦ 25th Inter Airport Europe
Messe München, Munich ◦ 10 October 2025

A Deep Dive into Airport Robotics

RX In the business of building businesses

PITCH TOPICS



- **AMR* development** for autonomous end-to-end airport cargo handling
- **Fleet monitoring and AMR control** through state-of-the-art software
- **Simulation and sensor tests** for specific and neuralgic airport traffic situations

** AMR = Autonomous Mobile Robot*

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Asking an AI software to design a ULD handling robot for airports…

Generated with Fraunhofer Society's AI tools

Market overview

© Stuttgart Airport (2021)

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© EasyMile (2023)

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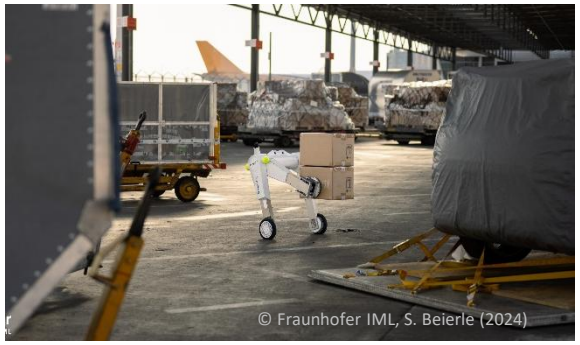
Autonomous cargo vehicles at airports worldwide

- **Increasing number of applications** (67 cases in 16 countries since 2017).
- **Focus on tests and demonstrations**, mostly transportation cases.
- **Limited transfer of scientific knowledge** from other industries so far.

© Swissport (2022)

Phase 1: Use case identification	Phase 2: Testing & demonstration	Phase 3: Implementation & operations	Phase 4: Scaling-up & optimization
Analysing pain points, requirements and solutions	Integrating technology into existing systems and processes	Adapting operations for long-term implementation	Increasing the fleet and/or optimizing operations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Fraunhofer IML - R&D focus topics in aviation

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Who we are:
Fraunhofer Society (Germany)

~ 32.000
employees

76 institutes (incl. IML)
and research centers

Fraunhofer IML

€ 3.4 bil.
annual research volume

We are Europe's largest **non-profit organization** for applied research.

IML's Focus Dept.

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Total funding: €13.7m.

100%
Aviation Logistics

	PAX	Baggage	Cargo	Other
Aircraft	(Dis) Embarkation	(Un)loading & Servicing		Ground Handling
Apron	Passenger Transport	Cargo, Airmail, and Baggage Handling		Security Infrastructure Customs IT VAS ...
Terminal	Passenger Handling	Baggage Handling	Cargo and Airmail Handling	
Pre and On Carriage	Passenger Transport	Baggage Transport	Cargo and Airmail Transport	

Airport Automization

Airport Digitalization

Green Aviation

Current research project DTAC: Focus on air cargo digitization and automation

© Fraunhofer IML

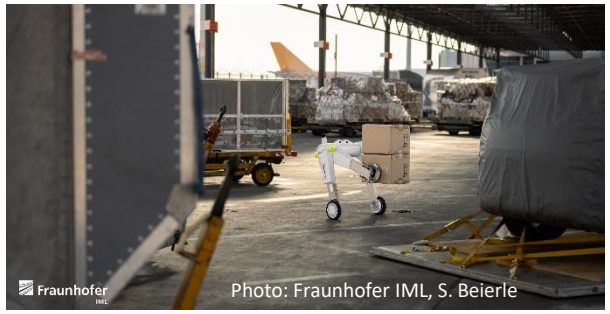
DTAC research focus (2021 – 2026)

Focus today – our robotic tests in 2024:

HOW can next-gen AMRs* support Air Cargo Handling?

* AMR: Autonomous Mobile Robot

Autonomous Warehouse Handling & Apron Transports

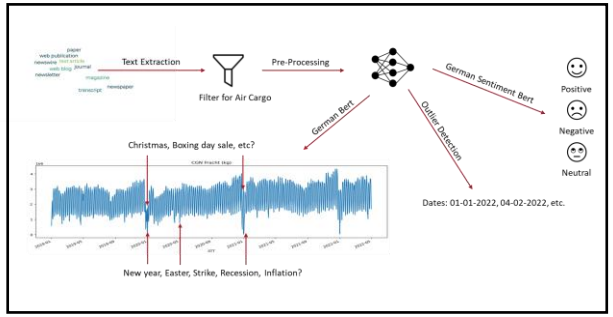


Our approach: R&D with own and market solutions

DTAC focus on AI:

HOW can AI improve Air Cargo efficiency?

Predictive Analytics



Our approach: analyses based on historic cargo data

DTAC focus on data:

Why is Data Sharing still so difficult ?

Data Platform & Digital Avatar

Our approach: open-source server NE:ONE and IoT

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Picture: Fraunhofer IML, V. Neugebauer

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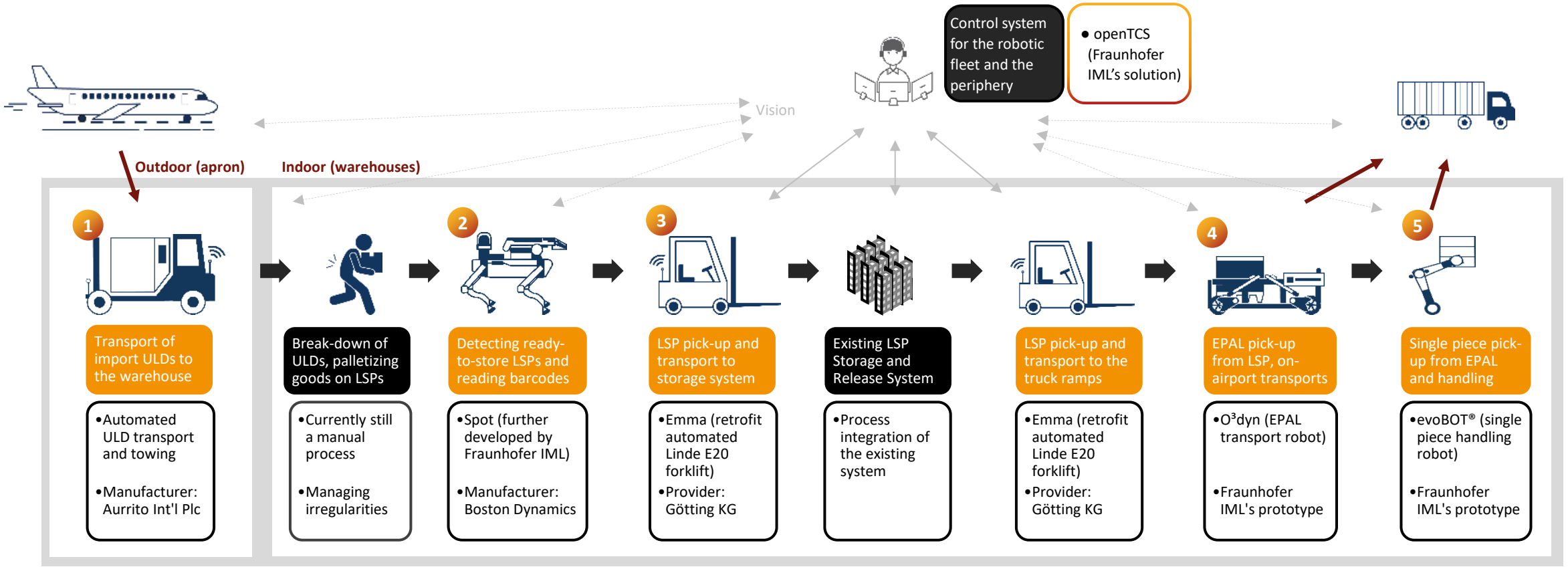
Our 2024 multi-robot testbed for cargo flow automation



***ULD**: Unit load device (air cargo containers / build-up units, various sizes)*
***LSP**: Large metal storage pallet (130 x 130 cm or 200 x 200 cm)*
***EPAL**: Standardized wooden Euro-pallet (120 x 80 cm)*

Fraunhofer
IML
DTAC
»Digitales Testfeld Air Cargo«

2024 results - 2 airports, 5 robots, 12 test weeks, 674 tests

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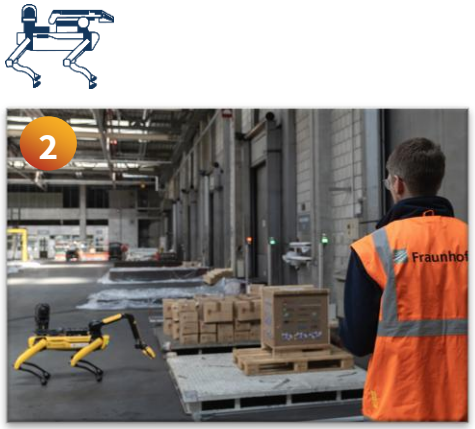
Auto-DollyTug® (Aurrigo)

Tests: n = 178
Success rate: 65 %
Autonomy level: 30 %

- ✓ Outdoor functionality
- ✗ Load handling



Spot® (Boston Dynamics & IML)

Tests: n = 77
Success rate: 95 %
Autonomy level: 60 %

- ✓ Autonomy level
- ✗ Assessing obstacles

LindeE20 (Götting KG)

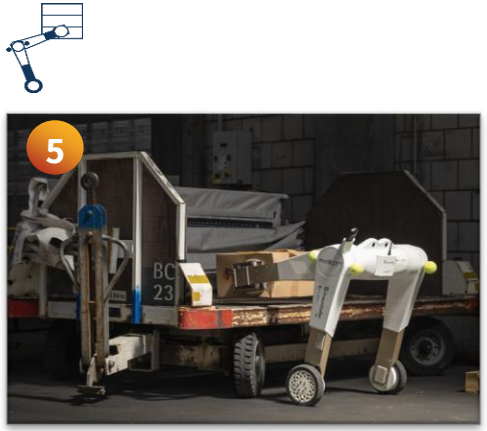
Tests: n = 202
Success rate: 86 %
Autonomy level: 20 %

- ✓ Repetit. storage tasks
- ✗ Unbalanced loads

O³dyn (Fraunhofer IML)

Tests: n = 146
Success rate: 97 %
Autonomy level: 20 %

- ✓ Pick-up from pallet
- ✗ Busy intersections



evoBOT® (Fraunhofer IML)

Tests: n = 71
Success rate: 89 %
Autonomy level: 0 %

- ✓ Different shapes
- ✗ Automation outside lab

Pictures: Fraunhofer IML, V. Neugebauer

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Awards and nominations

Winner

1st place: „Air Cargo Sustainability Award“

„Start-Up and Small Business“ category, The International Air Cargo Association (TIACA)

TIACA Exec. Summit 2025, Hongkong, 25 June 2025

Photo: TIACA

Highly Acclaimed

Highly Acclaimed: „International Award for Excellence in Air Cargo“

„Innovative Logistics Solutions in Air Cargo” category, STAT Times

air cargo africa, Nairobi, 20. February 2025

Photo: STAT Times

Top 5

Top 5: „Air Cargo Technology Solution Provider of the Year“

„Air Cargo Technology Solution Provider of the Year“ category, Air Cargo Week (ACW)

transport logistic, Munich, 03 June 25

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Further activities 2024/25

Education

Japanese „School Reference Book“

DTAC robots as part of the new “Working Robot Encyclopedia: Industry Robots”, 2nd grade.

Source: Working Robot Encyclopedia, supervised by T. Hirasawa

Primary School

Workshops with Primary Schools in Germany

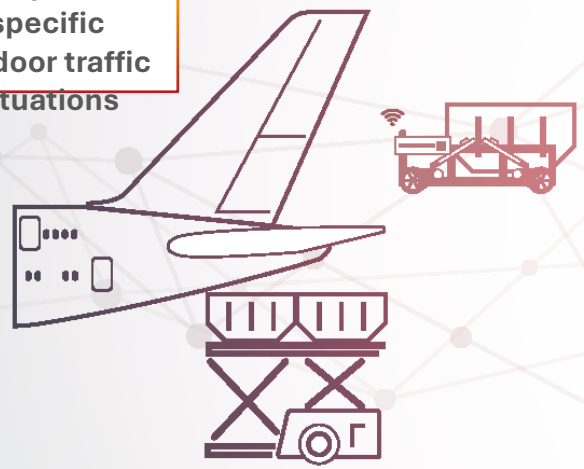
Workshops for airport robot development, 1st and 2nd grade, Munich.

Photos: Fraunhofer IML, M. Wehner

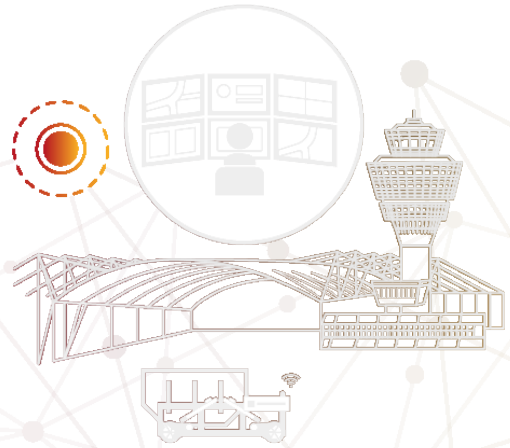
DTAC 2024 - 2026

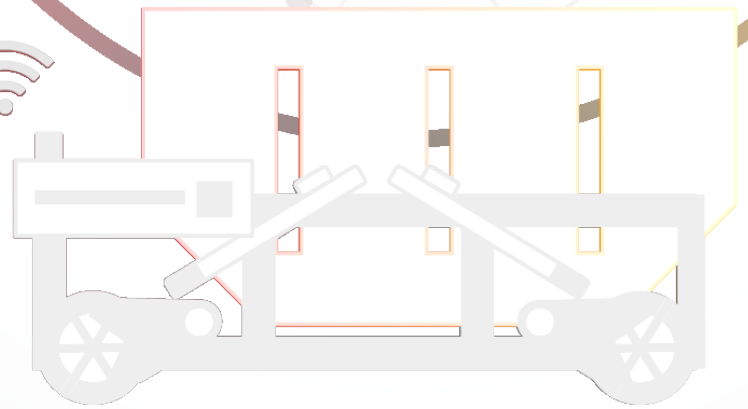
WP1 - Process analysis, concept development and demonstration planning

Neuralgic, airport-specific outdoor traffic situations



Aircraft - highloader handover





Integration of robotic control center and warehouse management systems

Intralogistics indoor automation

Public road handover

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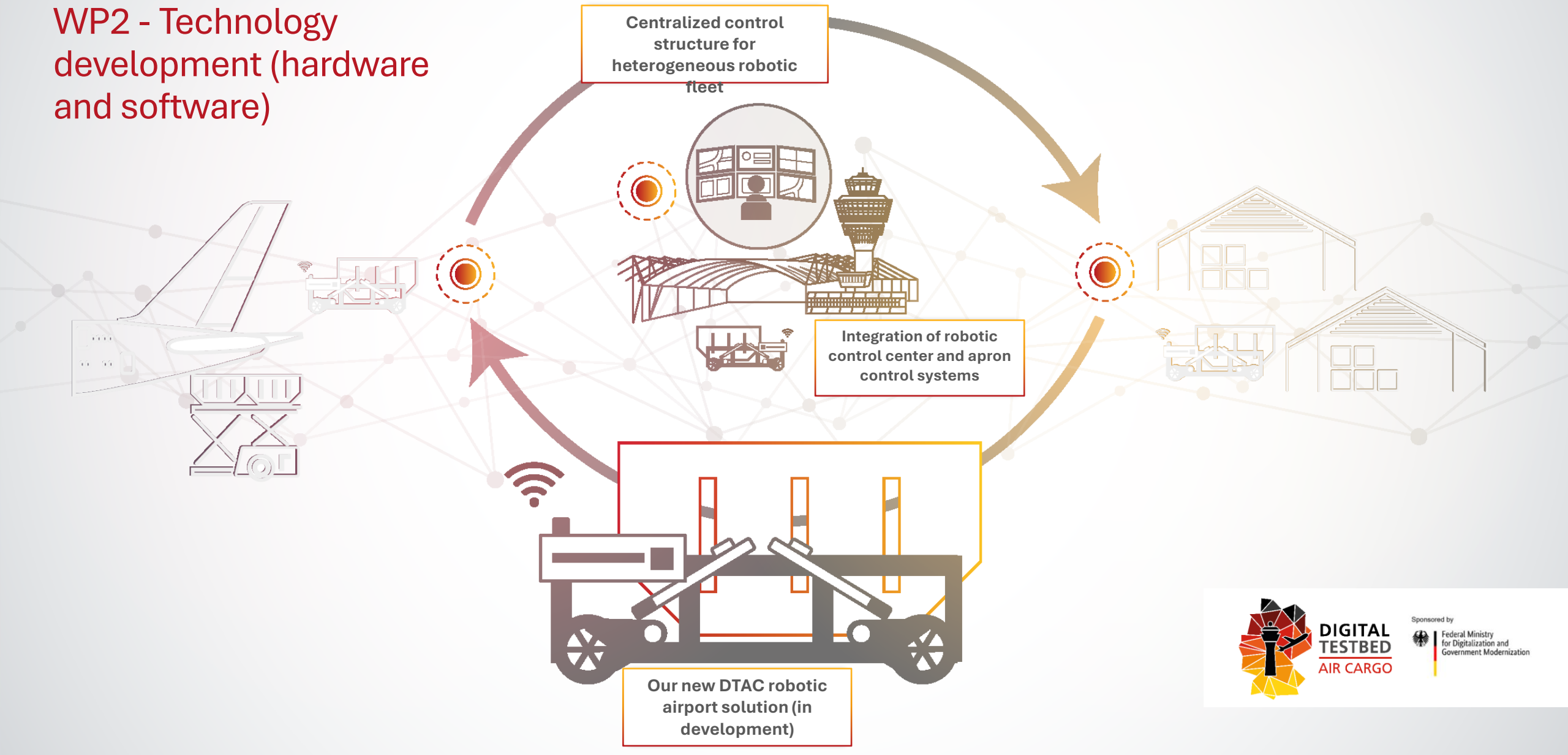
WP2 - Technology development (hardware and software)



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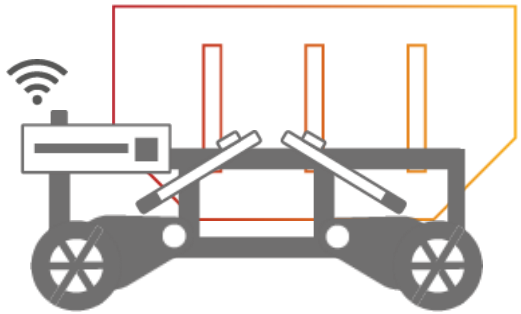
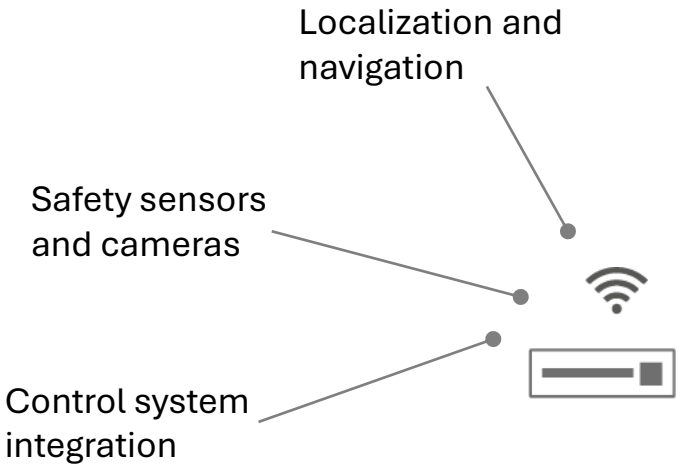
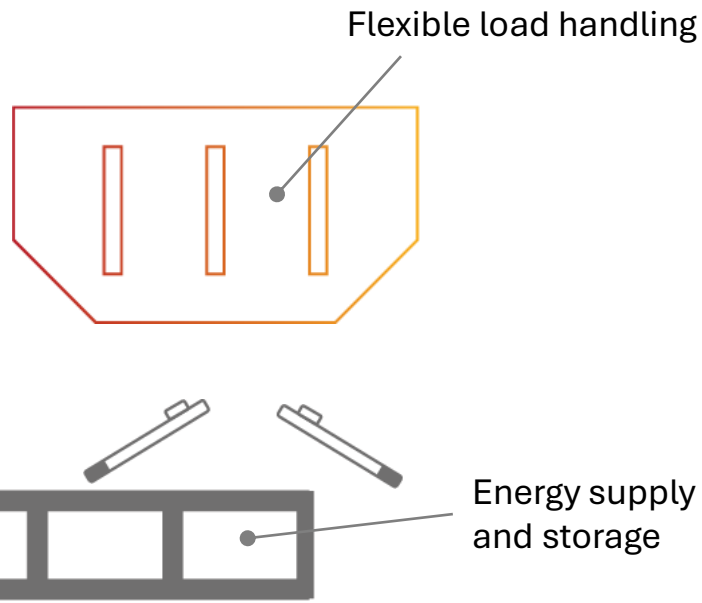
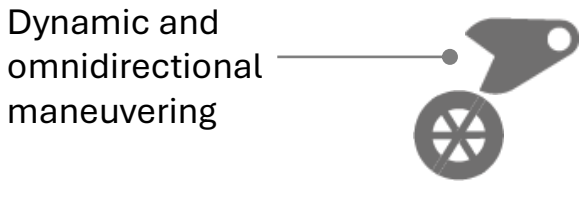
Vehicle requirements (selection)

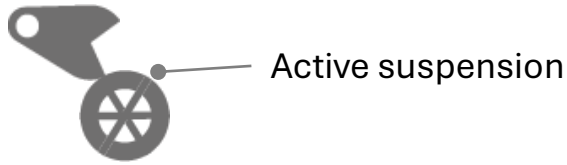


Vehicle requirements (selection)









8 operating modes for our new robot

#1 Docking

Reliable detection of highloader or docking stations

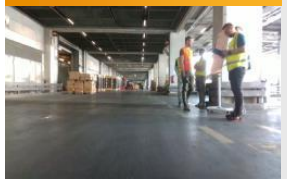
Docking at handover points indoor and outdoor (final approach)

#2 Cargo Indoor

Dynamic obstacle avoidance (free navigation)

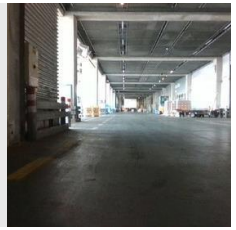
Maneuvering indoor handover points

#3 Travel Indoor



Sensing and reacting to dynamic objects

Navigation in highly dynamic indoor/semi-indoor environment



#4 Aware Indoor

Sensing and reacting in aware areas

Gates passages, intersections, warning field, traffic priority passages

#5 Cargo Outdoor

Spatial and featureless environment

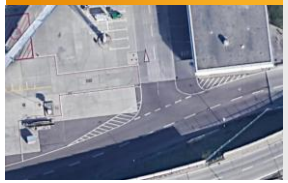
Maneuvering outdoor handover points

#6 Travel Outdoor

Sensing and reacting to dynamic objects

Navigation in highly dynamic outdoor environments

#7 Aware Outdoor



Sensing and reacting in aware areas

Pushbacks, intersections, uneven terrain, traffic priority passages, security checkpoints

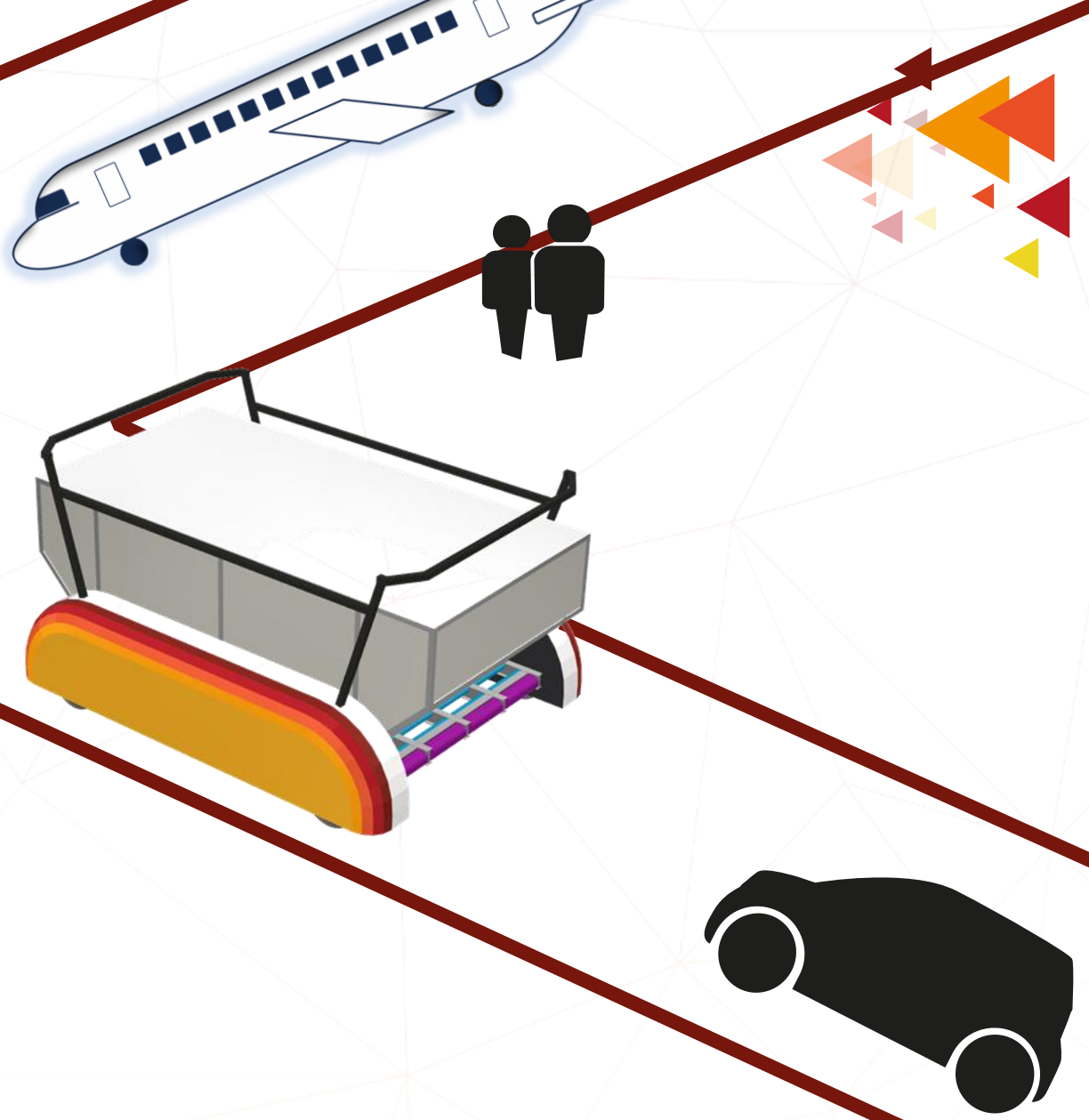
#8 Freeway

Spatial and featureless environment

Outdoor routes with high velocity

#7 Aware Outdoor

- Outdoor area
- Checkpoints, intersections
- People, aircraft, vehicles
- Vehicle kinematics
- v = 2 m/s = 7,2 km/h



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#7 Aware Outdoor

- 2D Laser Scanner
- Ultrasound
- Radar

Odometry-based warning field switching

DIGITAL TESTBED AIR CARGO

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#7 Aware Outdoor

- 2D Laser Scanner
- Ultrasound
- Radar
- Friction value

Odometry-based warning field switching

DIGITAL TESTBED AIR CARGO

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#7 Aware Outdoor

2D Laser Scanner	Odometry-based warning field switching
Ultrasound	
Radar	
Friction value	
Periphery	Intersection areas Road users

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#7 Aware Outdoor

- 2D Laser Scanner
- Ultrasound
- Radar
- Friction value
- Periphery
- 3D Laser Scanner

Odometry-based warning field switching

Intersection areas
Road users

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#7 Aware Outdoor

- 2D Laser Scanner
- Ultrasound
- Radar
- Friction value
- Periphery
- 3D Laser Scanner
- RTK dGPS

Odometry-based warning field switching

Intersection areas
Road users

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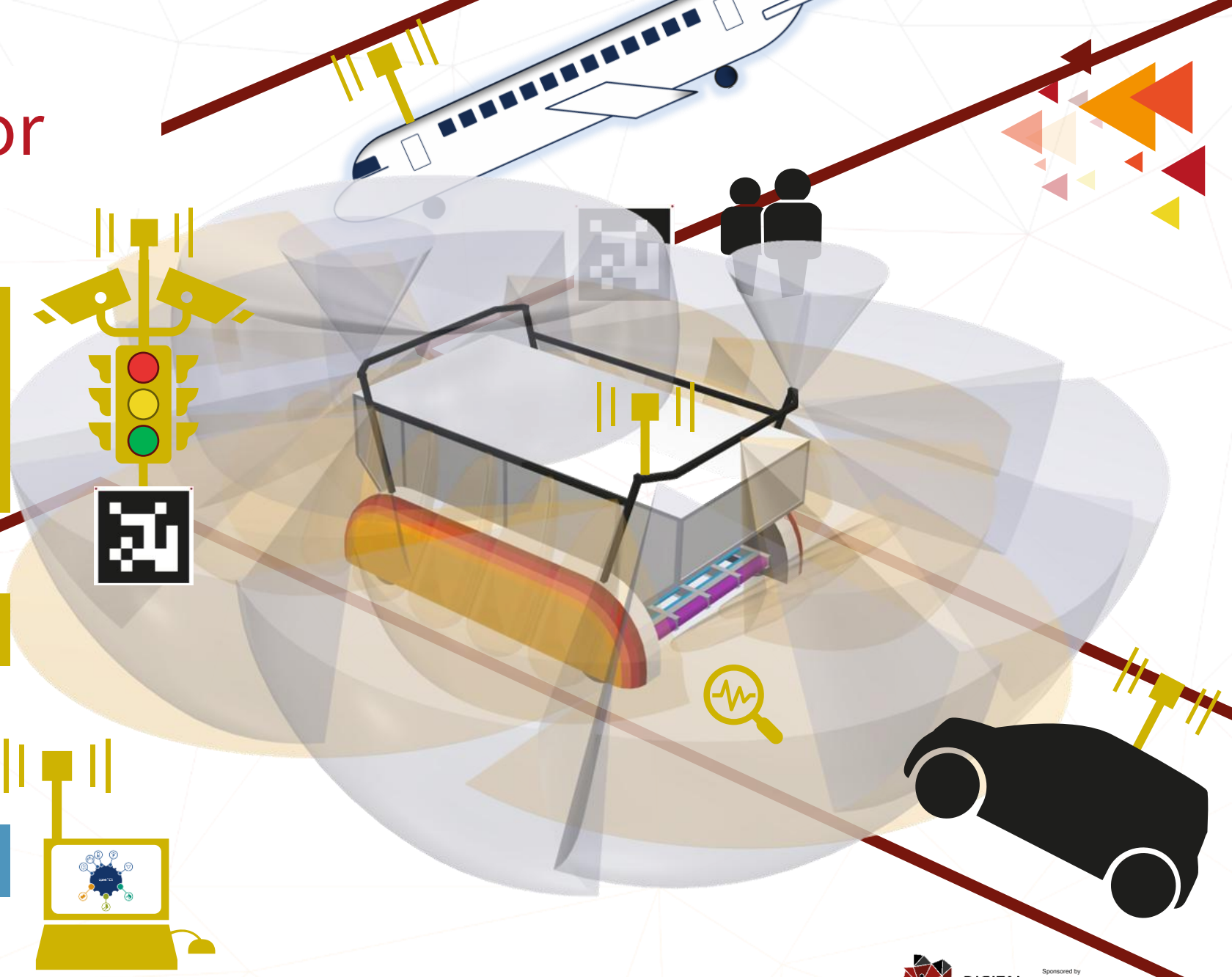
#7 Aware Outdoor

2D Laser Scanner	Odometry-based warning field switching
Ultrasound	
Radar	
Friction value	
Periphery	Intersection areas Road users
3D Laser Scanner	
RTK dGPS	
2D Camera	Optical markers



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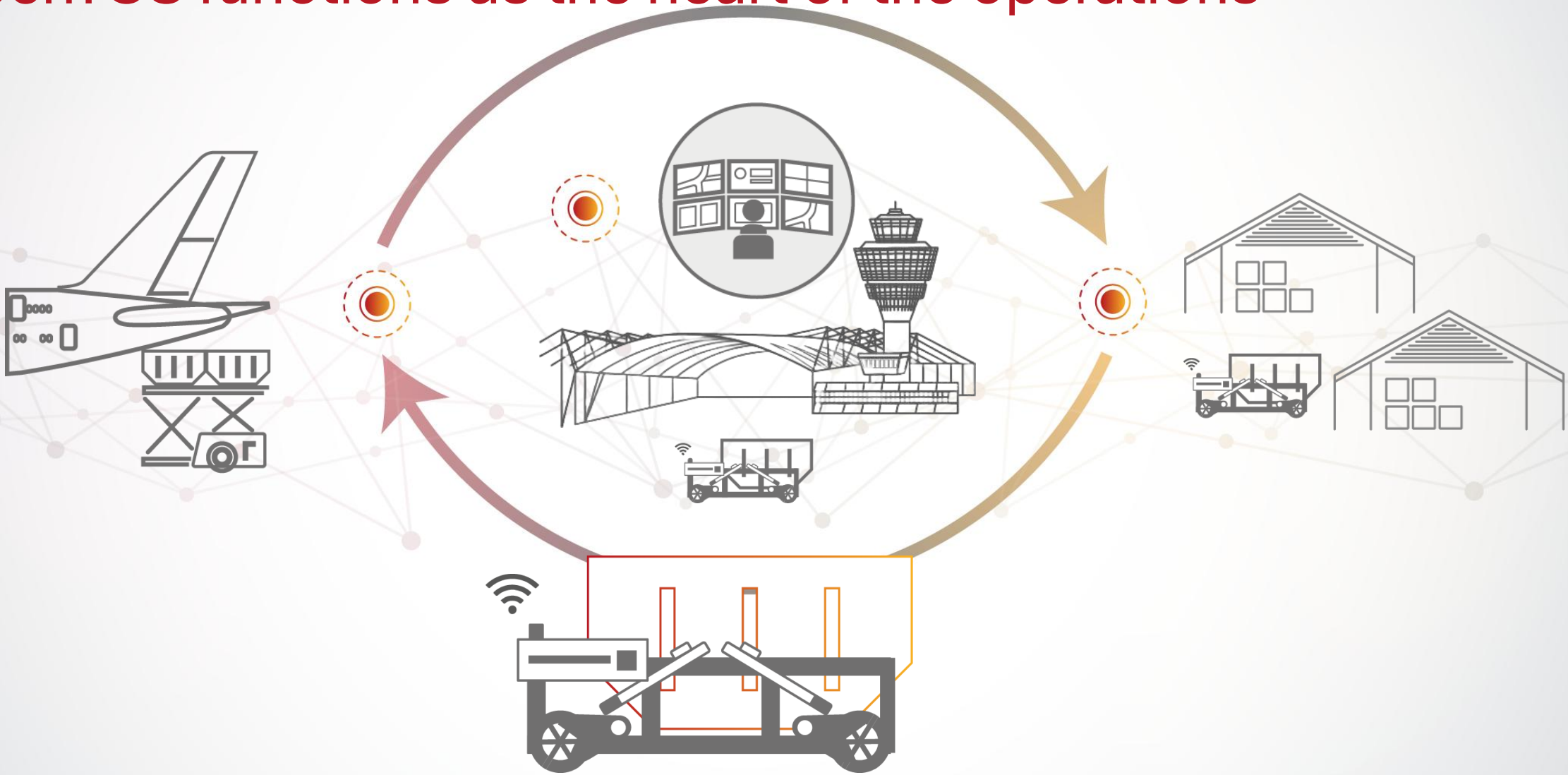
Safety sensor availability and challenges

Operating mode	Lidar (2D)	Camera (3D)	Ultra-sound	Radar	Odometry	Friction value (det.)	Periphery
#1 Docking	✓		✓		✓		
#2 Cargo Indoor	✓	(✓)	✓	✓	✓		
#3 Travel Indoor	✓	(✓)		✓	✓		✓
#4 Aware Indoor	✓	(✓)	✓	✓	✓		✓
#5 Cargo Outdoor	✓		✓	✓	✓	✓	
#6 Travel Outdoor	✓			✓	✓	✓	✓
#7 Aware Outdoor	✓		✓	✓	✓	✓	✓
#8 Freeway	✓			✓	✓	✓	✓

	Available
	Partially available
	Not available

Centralizing monitoring and control:

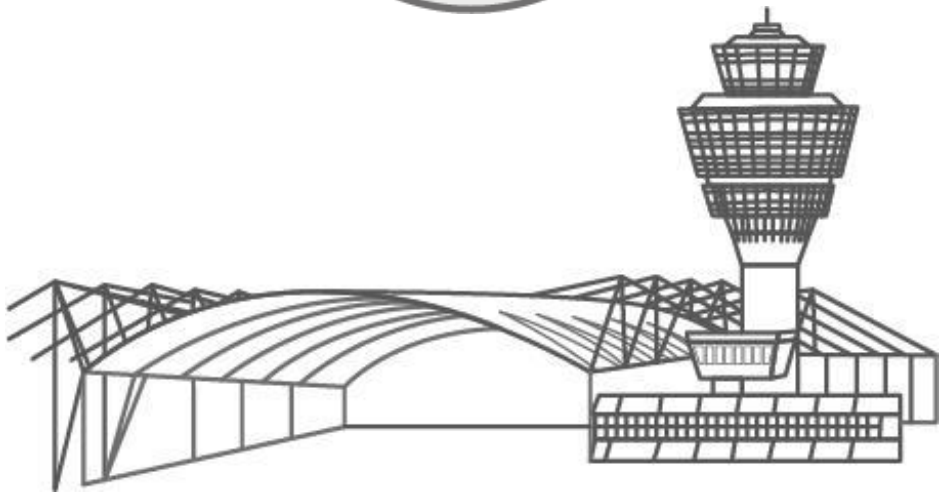
openTCS functions as the heart of the operations



openTCS functions as the heart of the operations

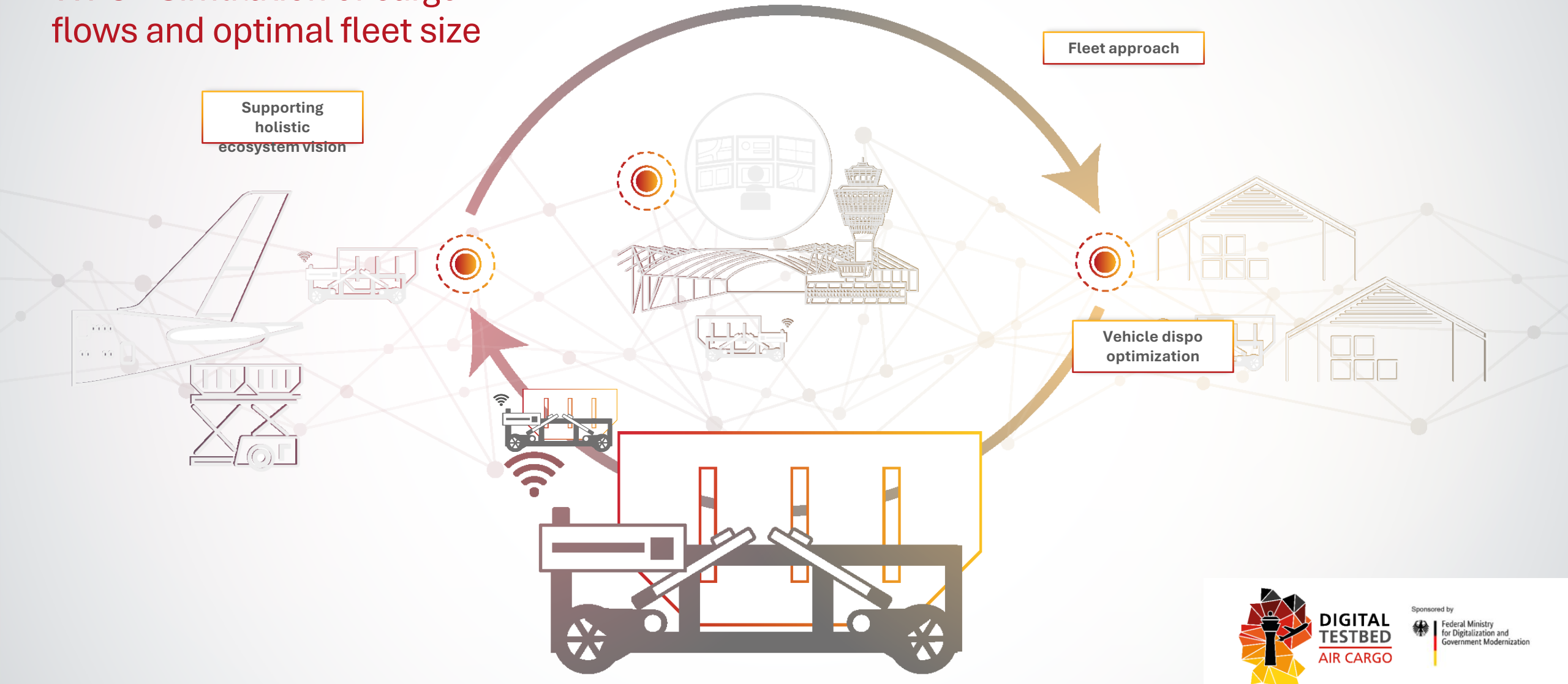
- Open-source
- Manufacturer independent
- VDA5050 communication standard
- Airport specific control center for DTAC
- Web-based, mobile devices
- Integration with airport AI/Flightradar

→ **Control system software for trials and implementations**



DTAC 2024 - 2026

WP3 - Simulation of cargo flows and optimal fleet size



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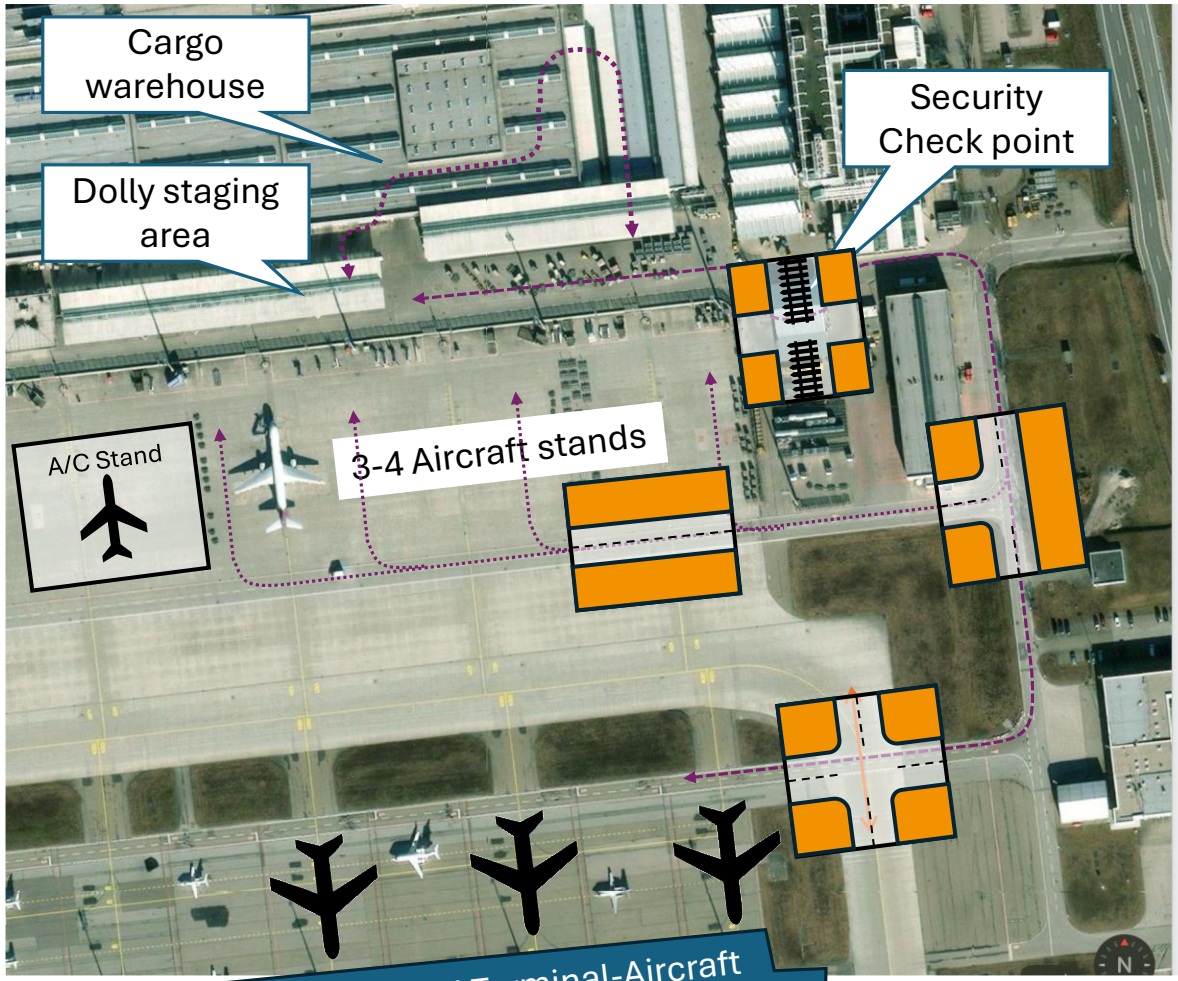
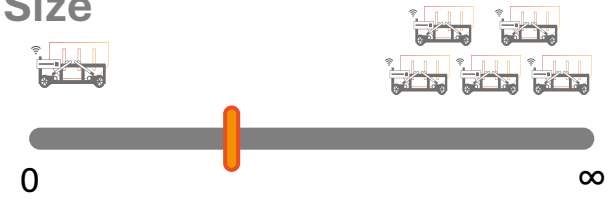
Modular simulation concept - analysis of different fleet scenarios

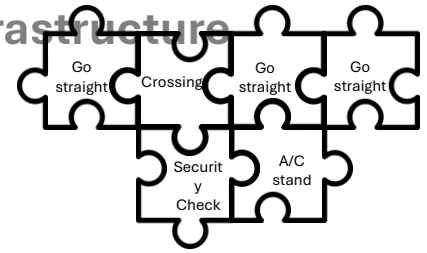


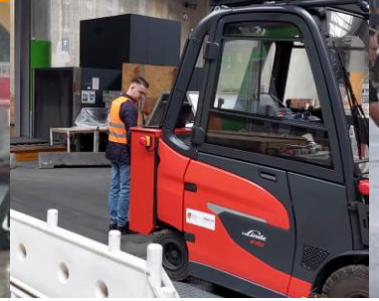
Fleet Size

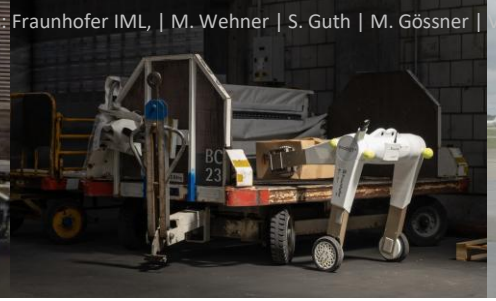


Cargo Volume

Traffic Infrastructure







Photos: Fraunhofer IML, | M. Wehner | S. Guth | M. Gössner | V. Neugebauer

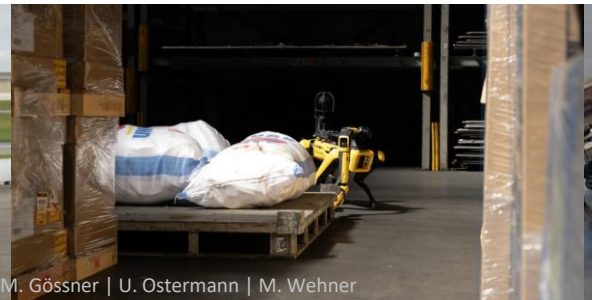
"The control of airport surface traffic today can be described as <u>manual</u>.

(...) Many of the tasks [could] be done more easily, more reliably, and more efficiently <u>with automation</u>.

(...) A new [airport] surface surveillance and communication system <u>must be developed</u> to (...) <u>provide surveillance and classification</u> of surface vehicles."

Hollister, W. M., "Airport Surface Traffic Automation Study"
*Massachusetts Inst. of Tech., Technical Report ADA194553, ATC-156, DOT/FAA/PS-87/1 ,**1988**.*

Has the time finally come?



Photos: Fraunhofer IML, V. Neugebauer | M. Gössner | U. Ostermann | M. Wehner

Next steps – outlook until 08/2026

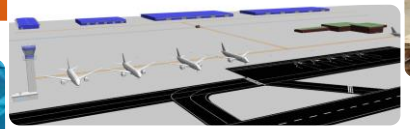
Vehicle developed

Develop rolling chassis

Control system integrated

New robot integration

Simulation prepared



Finalize simulation model

Laboratory testing completed

Evaluate lab tests

Field test prepared

Finalize test concepts

Target: new vehicle ready for airport tests from 09/2026

Thank you for your participation !

Contact details:

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