

Münchner Kreis
Fachkonferenz „Neue Produkte in der digitalen Welt“
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Cyber Physical Systems for Logistics



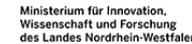
Prof. Dr.-Ing. Christian Wietfeld



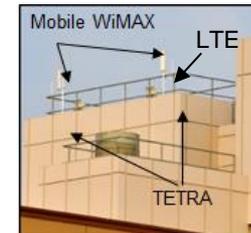
TU Dortmund University
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TU Dortmund's ComNets Institute (CNI) in a nutshell

- **Team of 15+ full-time researchers**
(75 % third party funded)
- **Research focus: highly reliable wireless networks for Cyber Physical Systems** in energy, transport, logistics and production



- **Model-driven** research methodology:
 - **Interdisciplinary, cross-layer** system modelling and **multi-scale system simulation**
 - **Sophisticated Lab** (2G-4G network emulators, wireless channel emulators, SDR, SDN) and **Outdoor Testing Site** with research licenses at 400MHz to 2,6 GHz



- **Successfull technology transfer:**
 - On-going contributions to **standardization** (IETF, ISO/IEC, ITU) and **open source** projects (Omnet)
 - Award-winning **spin-off** comnovo (SME)

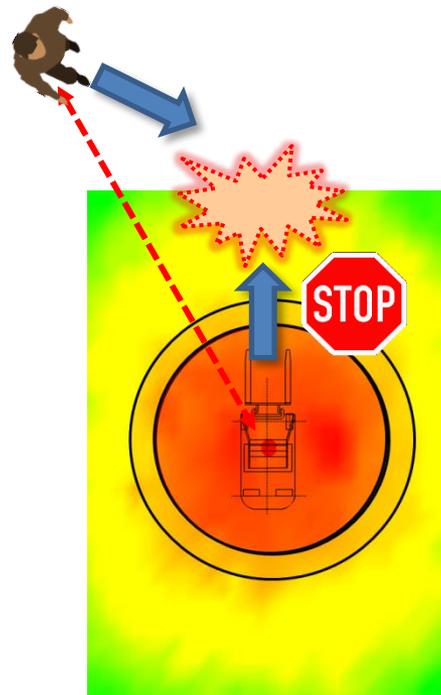


Cyber Physical Systems-enabled Logistics

**Self-organized
Intralogistics:**
Intelligent Bin



Safe Logistics:
Collision Avoidance



Aerial Logistics:
UAV Networking
& Control



Cyber Physical Systems-enabled Logistics

**Self-organized
Intralogistics:
Intelligent Bin**

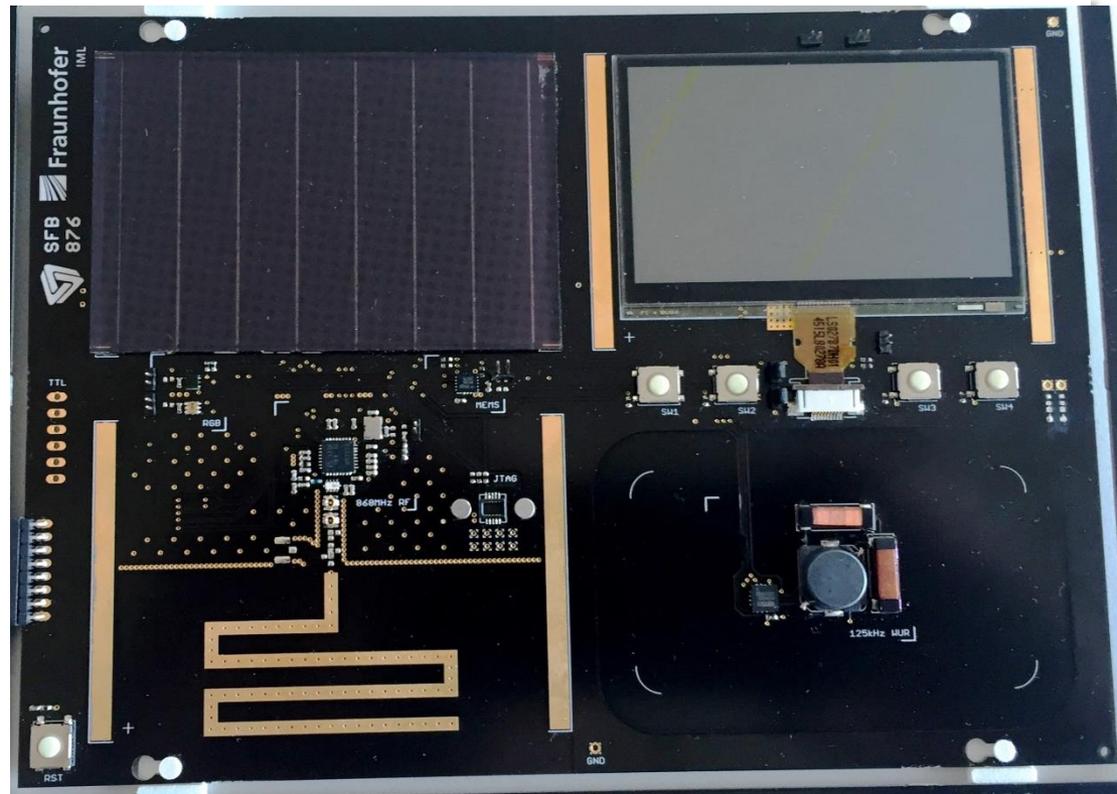
**Safe Logistics:
Collision Avoidance**

**Aerial Logistics:
UAV Networking
& Control**



DFG SFB 876 Data Analysis with resource constraints

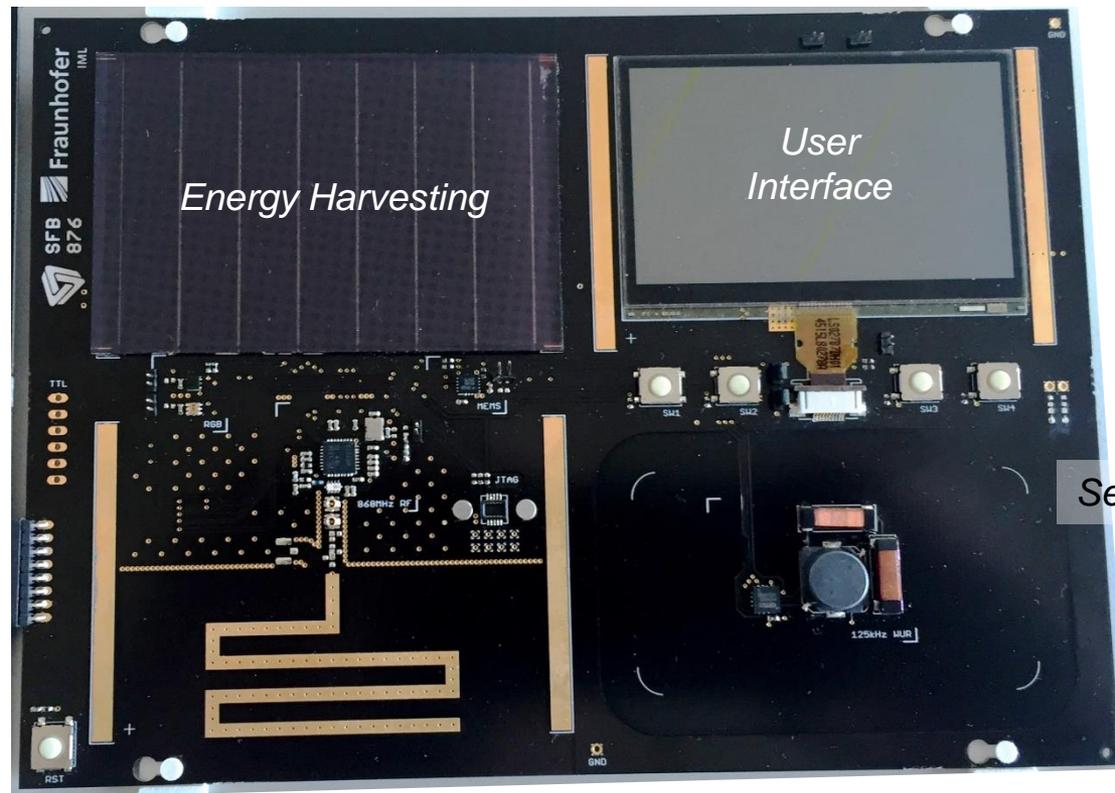
- Resource efficient and distributed platforms for integrative data analysis
- Embedded platform – Wireless communications – Logistics
- Use Case: **Solar-power intelligent Bins (inBins) know their content**



DFG SFB 876 Data Analysis with resource constraints

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inBin Plattform:

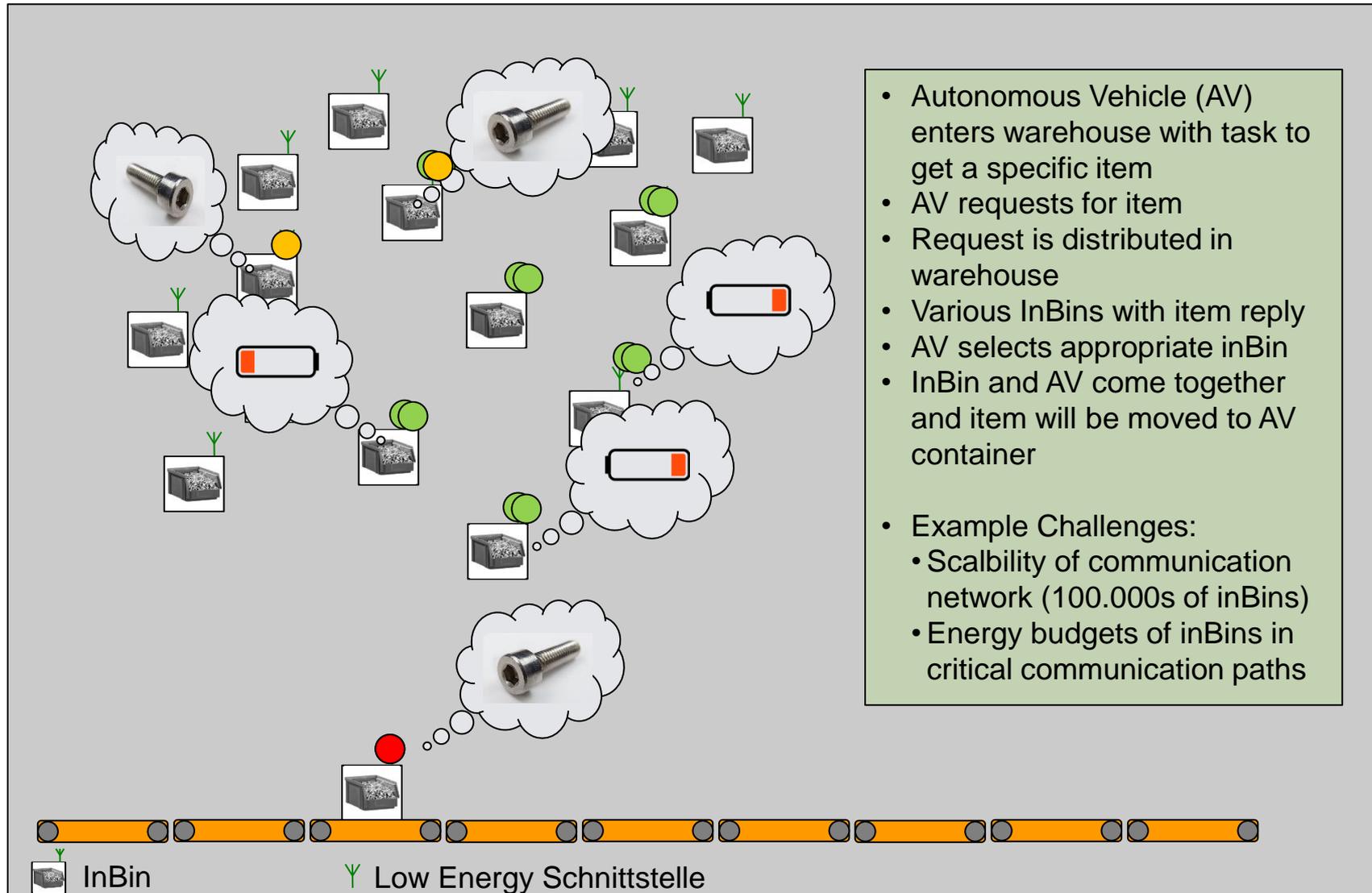


*Embedded
Operating System*

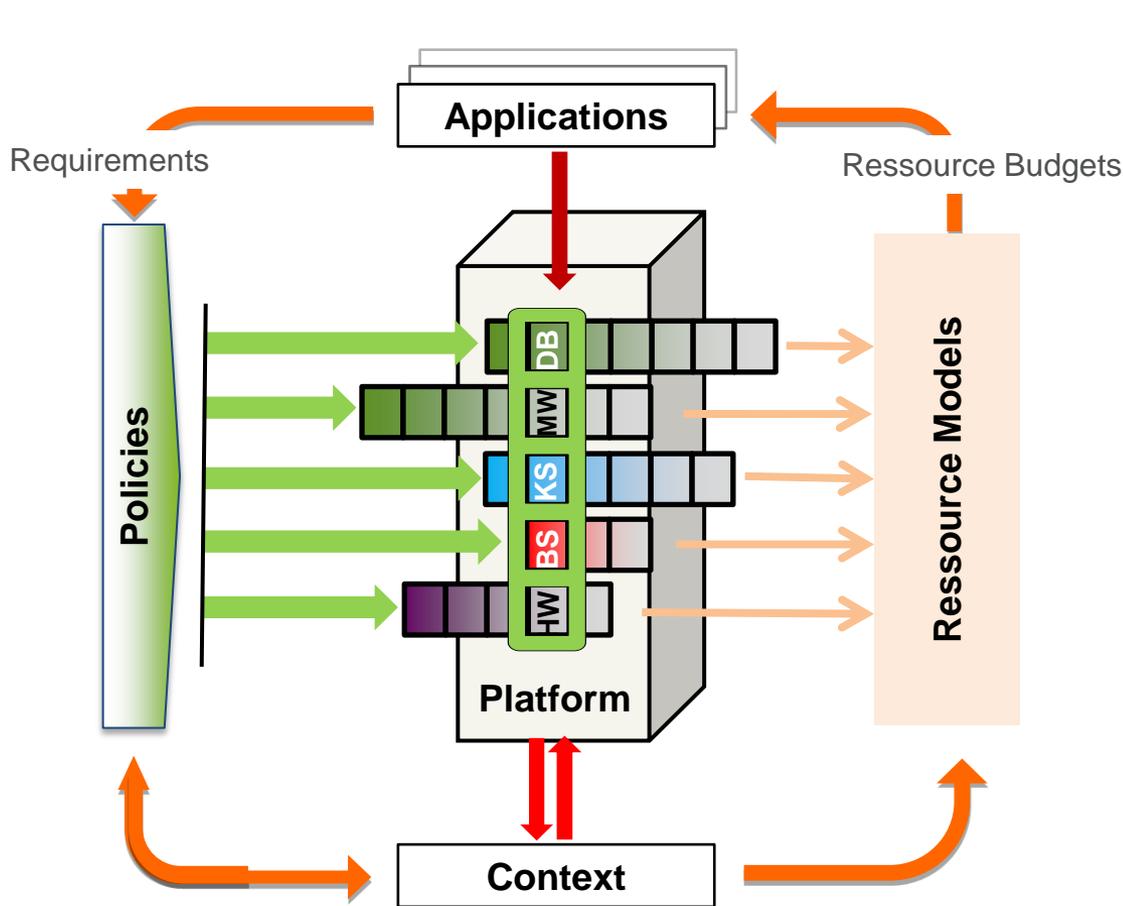
*Low Power
Communications*

Sensor Integration

Vision of Self-Organizing, Decentralized Logistics based on Intelligent Bins (inBins)



Accurate Ressource Models enable application-aware tayloring of ressources to constraints



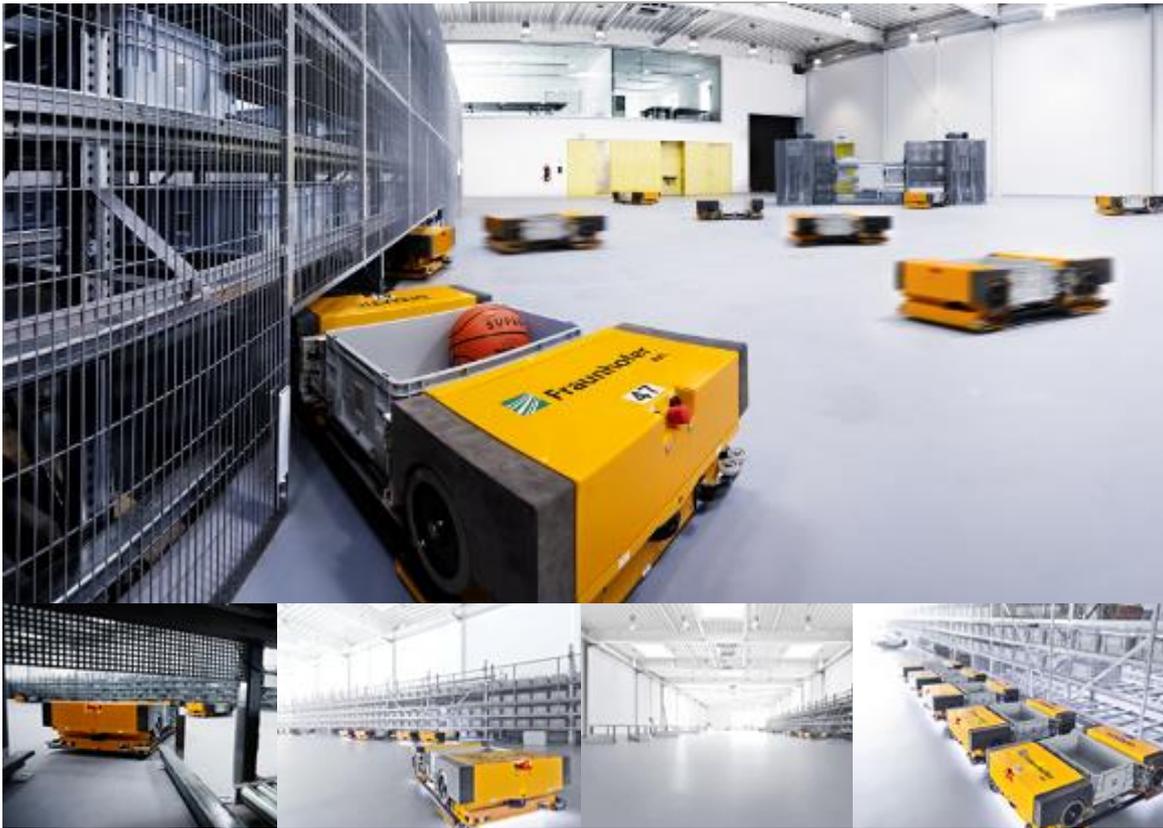
Low-Power processing and communications

Energy Models and Budget optimization

Wireless communication in challenging environments

Scalability for 100.000s of devices

Validation by experiments: large(st) experimental testbed for cellular transport systems in combination with inBins



**Low-Power processing
and communications**

**Energy Models and
Budget optimization**

**Wireless communication
in challenging
environments**

**Scalability for
100.000s of devices**

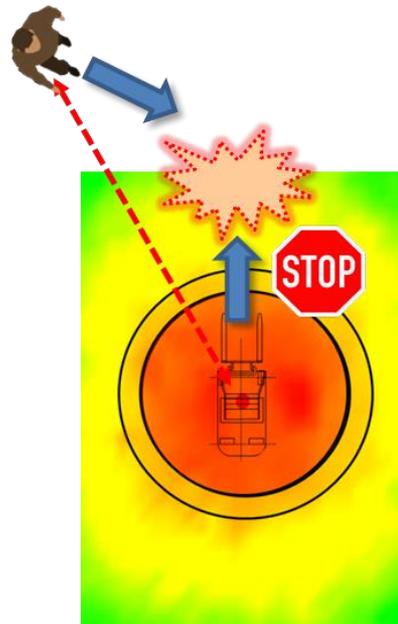
**Validation in Real-life-
environment**

Logistics can be very dangerous



Key requirements for collision warning systems

Recognition of persons



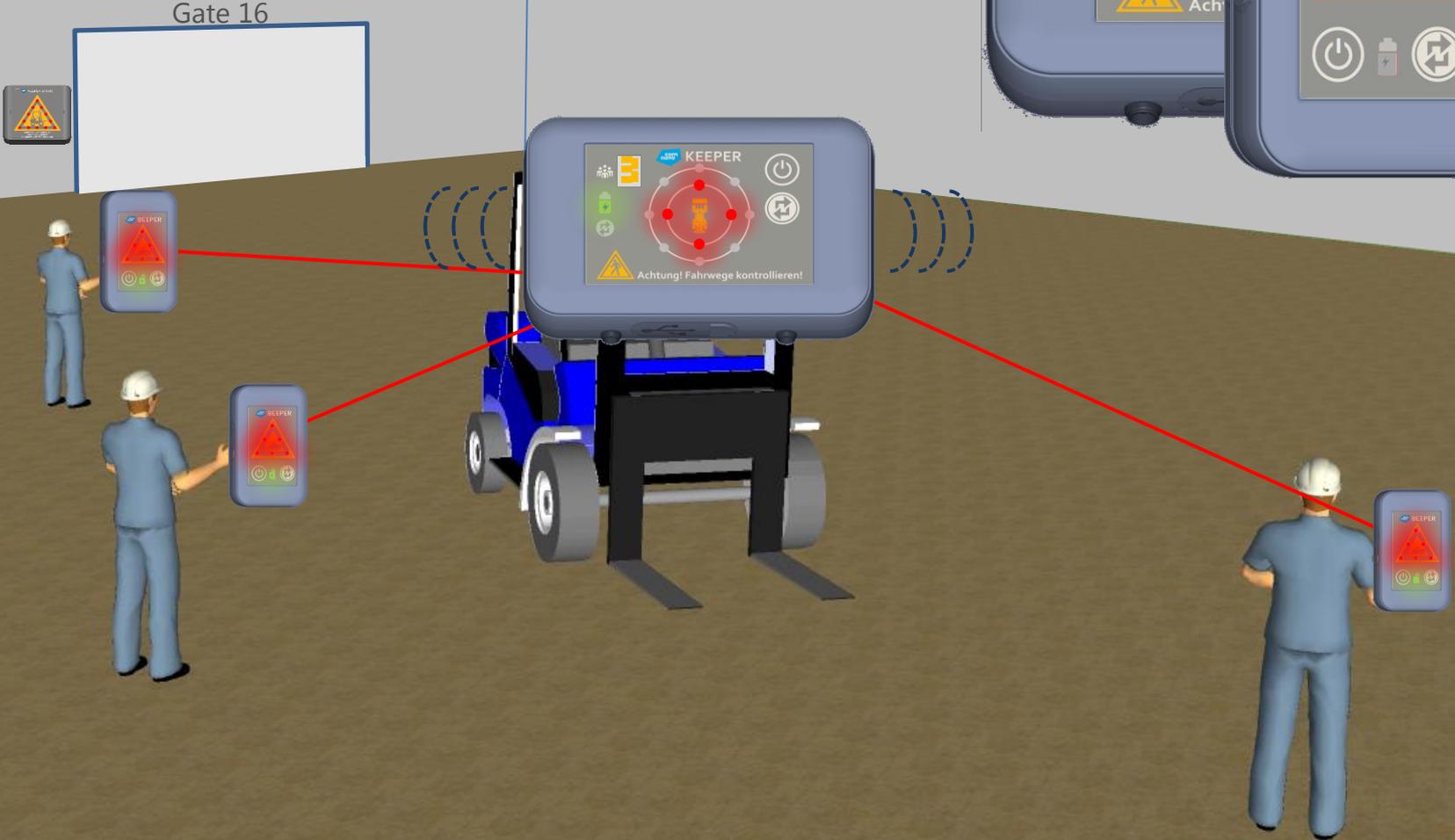
*D2Sense technology originally developed at chair, now available from comnovo GmbH, Dortmund

Comparison of different technology approaches

	Ultrasound / Radar	Camera	RFID	Long wave	Ultra Wideband*
Recognition of persons					
Adjustable warning zone					
Automatic detection of persons					
Two-sided Warning (Driver/pedestrian)					
Speed dependent zone size					
Easy retrofit					

*D2Sense system originally developed at chair, now available from comnovo GmbH, Dortmund

Collision avoidance by UWB- Distance measurements



Implementation Example: Truck Loading

- Configurable warning zone
- Direction detection
- Accuracy up to 10cm → no delays introduced



Source: comnovo



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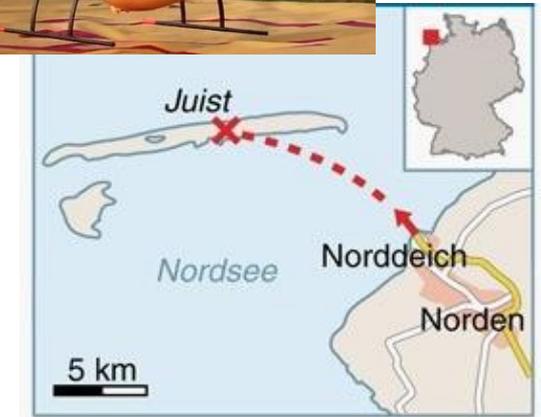
Is this the future of Logistics?



Source: dronelife.com

Outlook: Aerial Logistics

- On-going trials in all over the world:
 - Amazon Prime Air
 - DHL Paketcopter
 - Alibaba



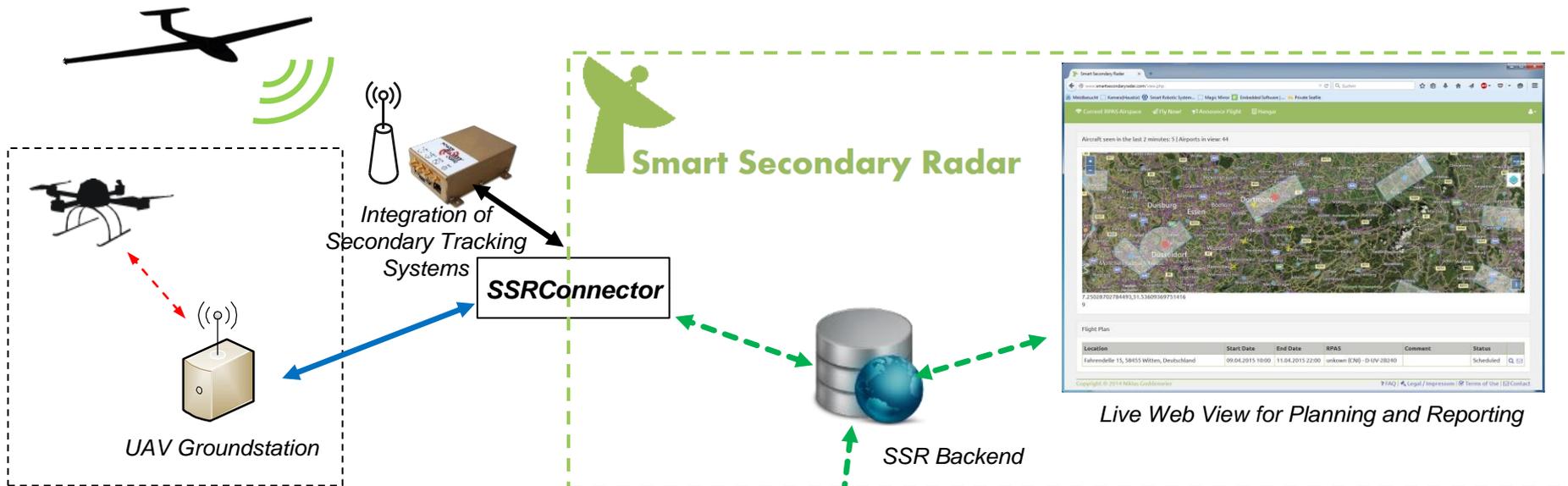
Outlook: Aerial Logistics

Challenges:

- **Weight limitations** → Focus on individual transport
 - 86 % of Amazon deliveries weigh below 2,25 kg*
- **Safety** → Flight across inhabited areas
 - Redundant drives
 - Emergency procedures
 - Continuous tracking for collision avoidance
- **Flight Regulations** → Enabling of commercial flight operation
 - Fully automated flight
 - Beyond Line of Sight (BLOS)
 - Integration in civil airspace

* Source: Forbes Tech: <http://www.forbes.com/sites/connieguglielmo/2013/12/02/turns-out-amazon-touting-drone-delivery-does-sell-lots-of-products-that-weigh-less-than-5-pounds/>

Safe UAV operation CNI Smart Secondary Radar (SSR)



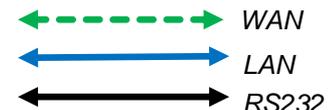
- Real-time inter-system aircraft position exchange
- Integration of additional flight monitoring system (e.g.: FLARM, ADS-B, Radar, etc.)
- Connect over Open API or SSRConnect Box

- Aircraft registration & management
- Flight zone reservation
- Automated flight logging

Goddemeier, Rohde, Wietfeld, „Two-Tiered Approach for Collision Avoidance – A System introduction“, AERO 2015, Friedrichshafen



Smartphone App



Conclusions

Cyber Physical Systems enable disruptive developments in logistics:

- *Self-organized logistics*
- *Safe and efficient logistics (zero accidents)*
- *Aerial logistics*

Research results have been / are transformed into new digital products:

- *inBin*
- *D2Sense Beeper/Keeper*
- *Aerial Paketcopter & Smart Secondary Radar*

**Technology readiness has matured significantly
→ It is time to move now!**

Acknowledgements

- Collaborative Research Centre (SFB) 876



- CPS.HUB NRW

