Schleswig-Holstein
Der Ministerpräsident
Staatskanzlei

Project: KI-5G
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Bundesministerium
für Verkehr und
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Projects:
BalticFuturePort (165GU056F)
5G-TELK-NF (165GU135L)

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5G COVERAGE MEASUREMENTS INSIDE A VESSEL DURING THE UNLOADING AND LOADING IN THE HARBOR

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1. Task Description

2. Hypotheses

3. Measurement Strategy

4. Results

5. Discussion & Conclusion

1. Task Description

Research Project Baltic Future Port

- Installation of a 5G Campus Network
- Real-time data exchange
- Logistics applications
- Digital twins
- Monitor the flow of cargo

Goal: Optimization of the Harbor Logistics

✓ Reduce unused storage space
✓ Accelerating the movement of cargo
✓ Reduce costs and increase profit

5G Advantages

- Licensed frequency band
- Higher coverage range and Tx power compared to WiFi6

1. Task Description

Problem: How do we expand the 5G network to ensure wireless communication links inside the vessel?

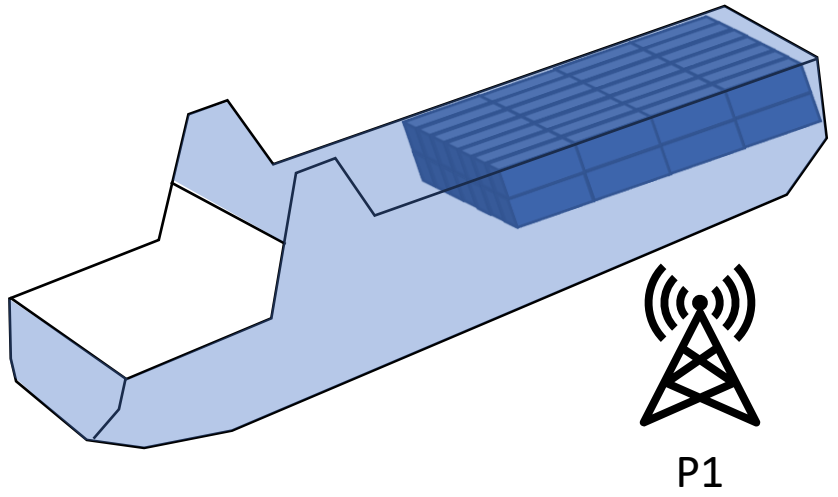
Coverage Map (Simulated) for Lübeck Harbor - Skandinavienkai

2. Hypotheses

Hypothesis 1:
By directing the antenna with a high transmission power of 5 W towards the vessel's hull, the transmitted signal strength is sufficient for communication over 5G at the relevant positions for loading and unloading.

Hypothesis 2: By directing the antenna with 5 W power towards the open stern ramp during loading and unloading, the signal penetrates the vessel's interior through the effect of multi-path propagation for sufficient communication over 5G at the relevant positions for loading and unloading.

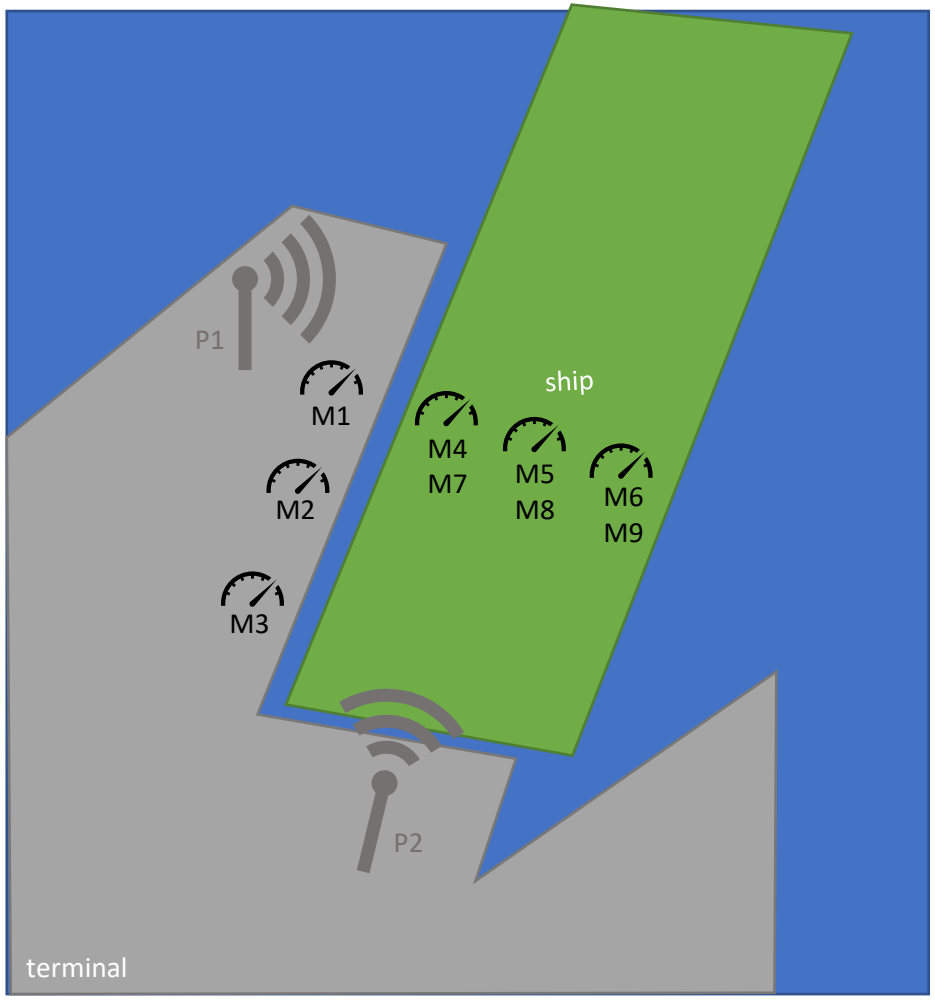
P2



P1

3. Measurement Strategy

- Measurements were performed with COTS UE (Samsung Galaxy S21)
- 3 positions outside, 3 positions at the main deck, and 3 positions at the lower deckMeasurement of RSRP values
- Sporadic/additional throughput measurements with iperf3 (TCP for 60 s, 10 s omitted)
- Measurement of 5G Networks:
  - Public mobile network operator (5G-NSA)
  - Installed 5G campus network (5G-SA)
  - Portable 5G Network / TH Lübeck Trailer in P1 (5G-SA)
  - Portable 5G Network / TH Lübeck Trailer in P2 (5G-SA)



3. Measurement Strategy

- Hydraulic antenna height up to 16 m
- RRU 5 W Tx Power + 15 dBi directional antenna
- 100 MHz bandwidth, TDD adaptable
- Workplace with monitor and equipment
- Autonomous operation with batteries (2.4 kWh → ~5h independent from external power supply)
- 5G SA system with open5Gs core

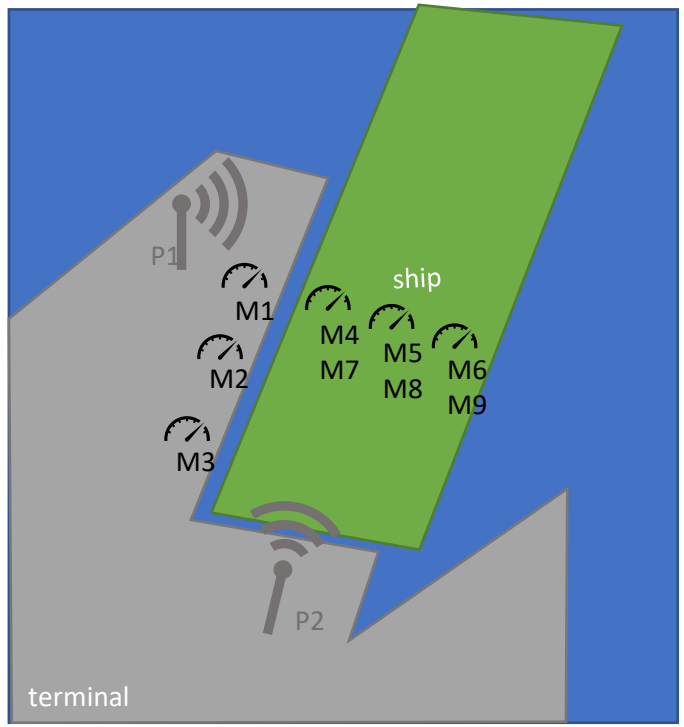
THL 5G Trailer

Hydraulic Antenna (max. 16 m height)

4. Results

Deck	M	RSRP in dBm			
		PMNO	Inst. 5G SA	THL P1	THL P2
Outside	M1	-100	-114	-84	
	M2	-101	-109	-71	
	M3	-101	-104	-84	
Main deck	M4	-113	-129	NC	-89
	M5	-105	-123	-120	-80
	M6	-118	-138	-131	-91
Lower deck	M7	-111	-132	NC	-95
	M8	-116	-131	NC	-94
	M9	-110	-126	NC	-90

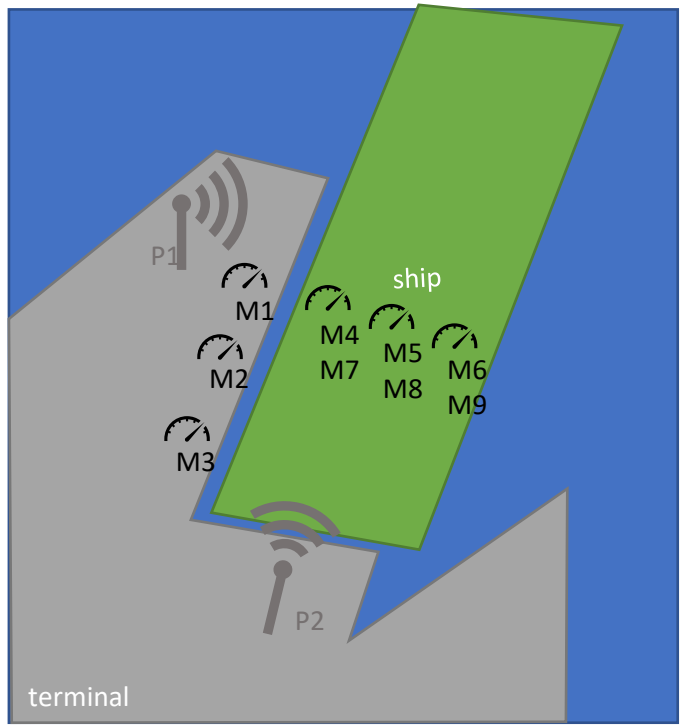
RSRP measurement results for: Public Mobile Network Operator (PMNO); Harbor Installed 5G SA Campus Network; THL 5G Trailer in P1 and P2
NC: Not connected



Quality RSRP range in dBm
Excellent > -90
Good -90 to -105
Fair -106 to -120
Poor < -120

4. Results

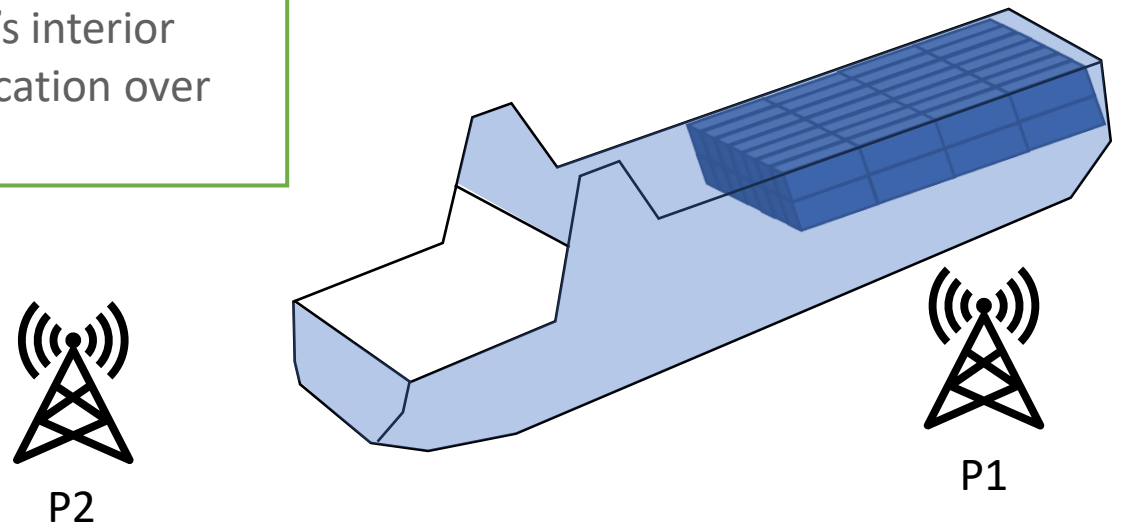
Deck	M	RSRP in dBm			
		PMNO	Inst. 5G SA	THL P1	THL P2
Outside	M1	iperf: Uplink: 13.9 MBit/s Downlink: 240 MBit/s		iperf: Uplink: 51.9 MBit/s Downlink: 328 MBit/s	
	M2				
	M3				
Main deck	M4				
	M5			-120	-80
	M6	Internet Speed Test: Uplink: 0.09 MBit/s Downlink: 2.9 MBit/s		iperf: Uplink: 29.3 MBit/s Downlink: 386 MBit/s	
Lower deck	M7				
	M8				
	M9		-126		-90



4. Discussion

Hypothesis 1:
By directing the antenna wit**Not confirmed**er of 5 W towards the vessel's hull, the transmittec**Not confirmed**it for communication over 5G at the relevant positions for loading and unloading.

Hypothesis 2: By directing the antenna with 5 W power towards the open stern ramp during loading and unloac**Confirmed**etrates the vessel's interior through the effect of multi-path**Confirmed**fficient communication over 5G at the relevant positions for loading and unloading.



5. Conclusion and Future Work

Problem: How do we expand the 5G network to ensure wireless communication links inside the vessel?

Conclusion

- Investigation of antenna positions based on 2 formulated as hypotheses
- First study/measurements were performed for existing networks and the portable THL network
- Results confirmed our second hypothesis (signal propagation **via the open stern ramp**)
- Presence of the existing 5G-SA network inside the vessel was unexpected

Next Steps

- Follow-up measurement with the 5G-SA network in P2 to create heatmaps for RSRP, Uplink, and Downlink inside the vessel
- Prepare automated measurement systems (with indoor localization)
- Investigate the signal quality inside the vessel during unloading and loading of the vessel

Thanks for your attention!

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Lufthansa Industry
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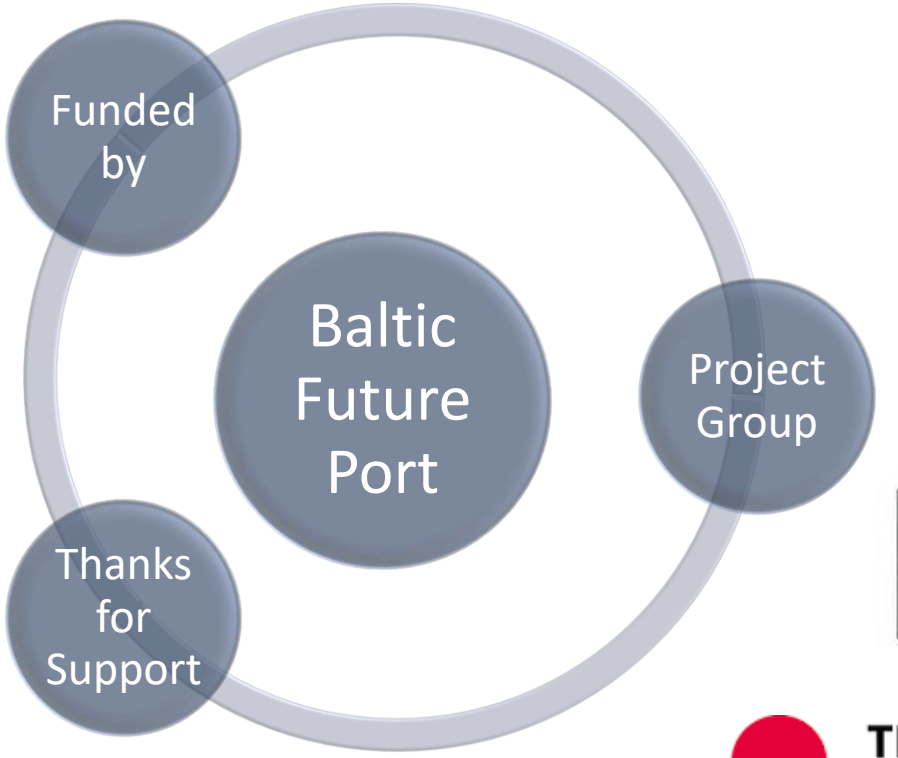

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