LTE Advanced(1) massive MIMO (Pre-5G) tests land-to-boat in Oslo fjord

Presented by Prof. Em. NTNU Terje Røste

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(1) 3rd Generation Partnership Project (3GPP) Release 10/11/12

Overview of the presentation

- Definition of the research program in which tests were made
- Land to sea/open sea communications challenges
- Description of the measurement site in the Oslo fjord (Horten – Moss)
- Measurement results
- Discussion of results and performance
- Conclusion

The Mamime Project Program (2016-2019)

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- The Mamime research program acronym: LTE, WIFI and 5G Massive MIMO Communications in Maritime Propagation Environments (MAMIME)
- Funded 50% by the Research Council of Norway (RCN) within the MarOff program
- Budget: total 13640 KNOK. Super-Radio: Project owner, administrator PhD Kun Yang)
- NTNU: Project leader prof Torbjørn Ekman

PARTNERS:

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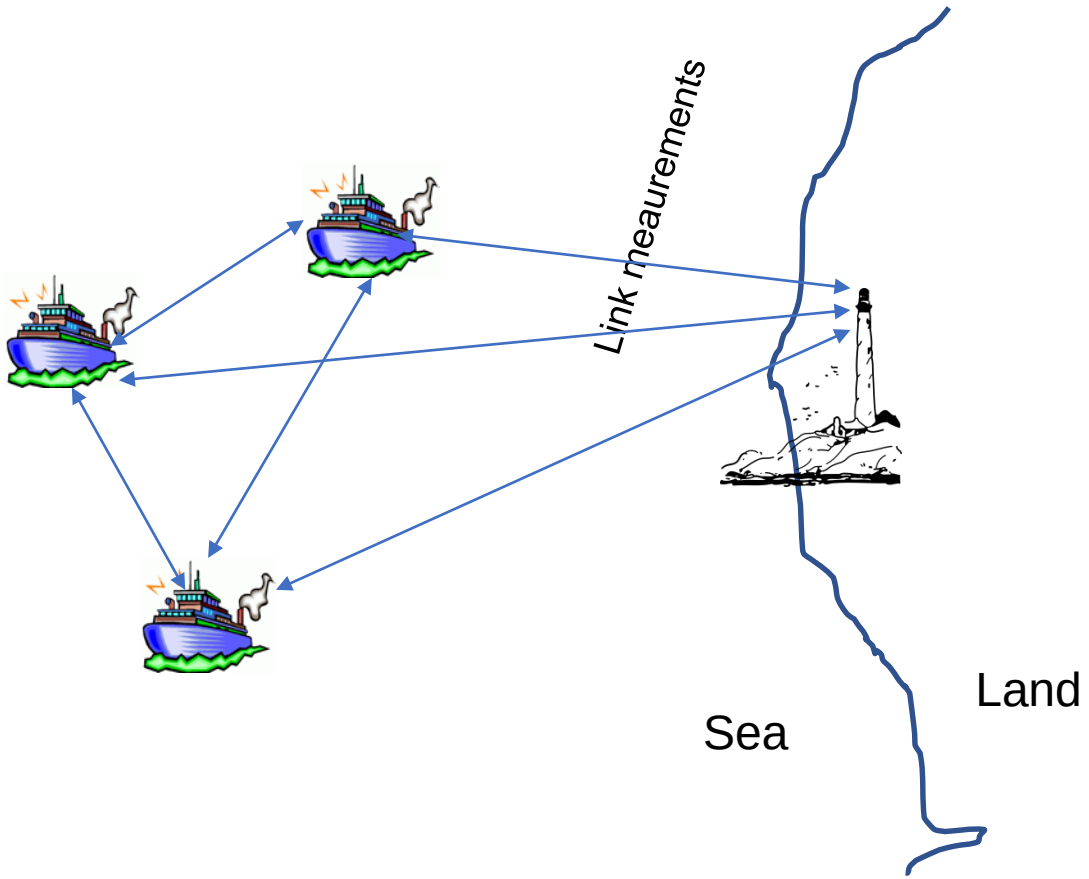
The Mamime project objective

Focus on maritime applications: Land-to-ship (L2S) and Ship-to-ship (S2S).

- Optimize LTE and WIFI systems (2016-2017)
- Research dedicated to 5G Massive MIMO (MM) solutions (2016-2019)
- Channel measurements and modelling. Sintef/NTNU design of a channels sounder with 128 antenna elements
- Measurement at Trondheim harbor 2017
- Optimized ships terminal design



Land to sea communications performance challenges

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- LTE Advanced and 5G are mainly designed and optimized for land areas (urban, sub-urban and rural areas) exploiting massive MIMO to enhance capacity.
- The propagation conditions from land to sea are different from land areas, and MIMO gain is not obvious
- Land to sea propagation conditions and challenges:
  - Line of Sight (LOS) and non-LOS conditions
  - Movement of the ship in heavy sea
  - Radio wave reflections from the sea surface
  - Shadowing/blocking of radio waves by islands and the coast topography (non-LOS)
  - Reach far out in the open sea (100 km?)

Description of measurement site. The base station in Horten

- Telia LTE advanced massive MIMO Base Station type RRU3278 (3GPP Release 10/11/12)
- MIMO with 64 antenna elements
- Time Division Duplexing (TDD)
- LTE TDD Band 42 (3.7 GHZ)

Description of measurement site

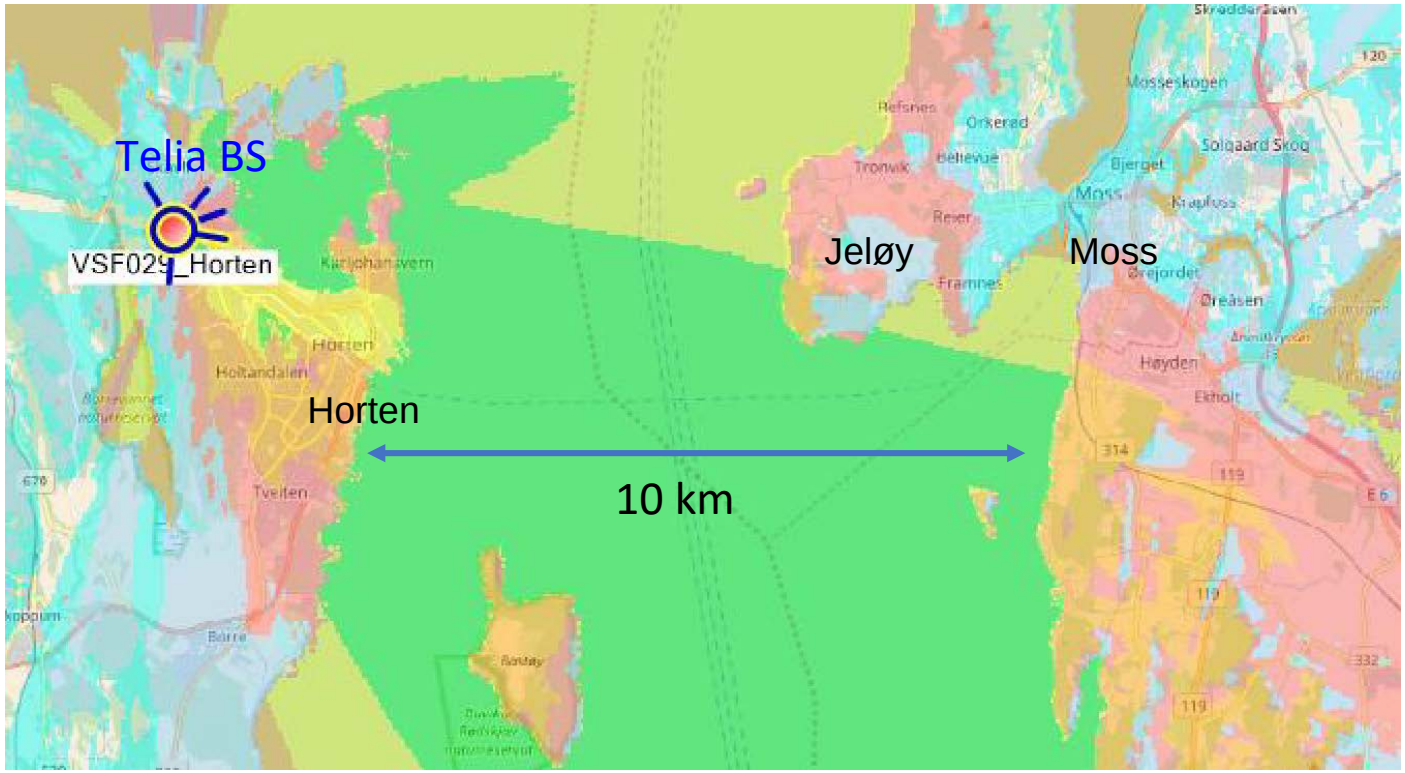
The user terminal (CPE)

- 2 CPE's installed on a 40 feet sailboat at the front and the rear, 1.5 m above sea level
- Telia LTE CPE type B2368 covering bands 3400 – 3800 MHz

The 40 feet sailboat

Description of measurement Site

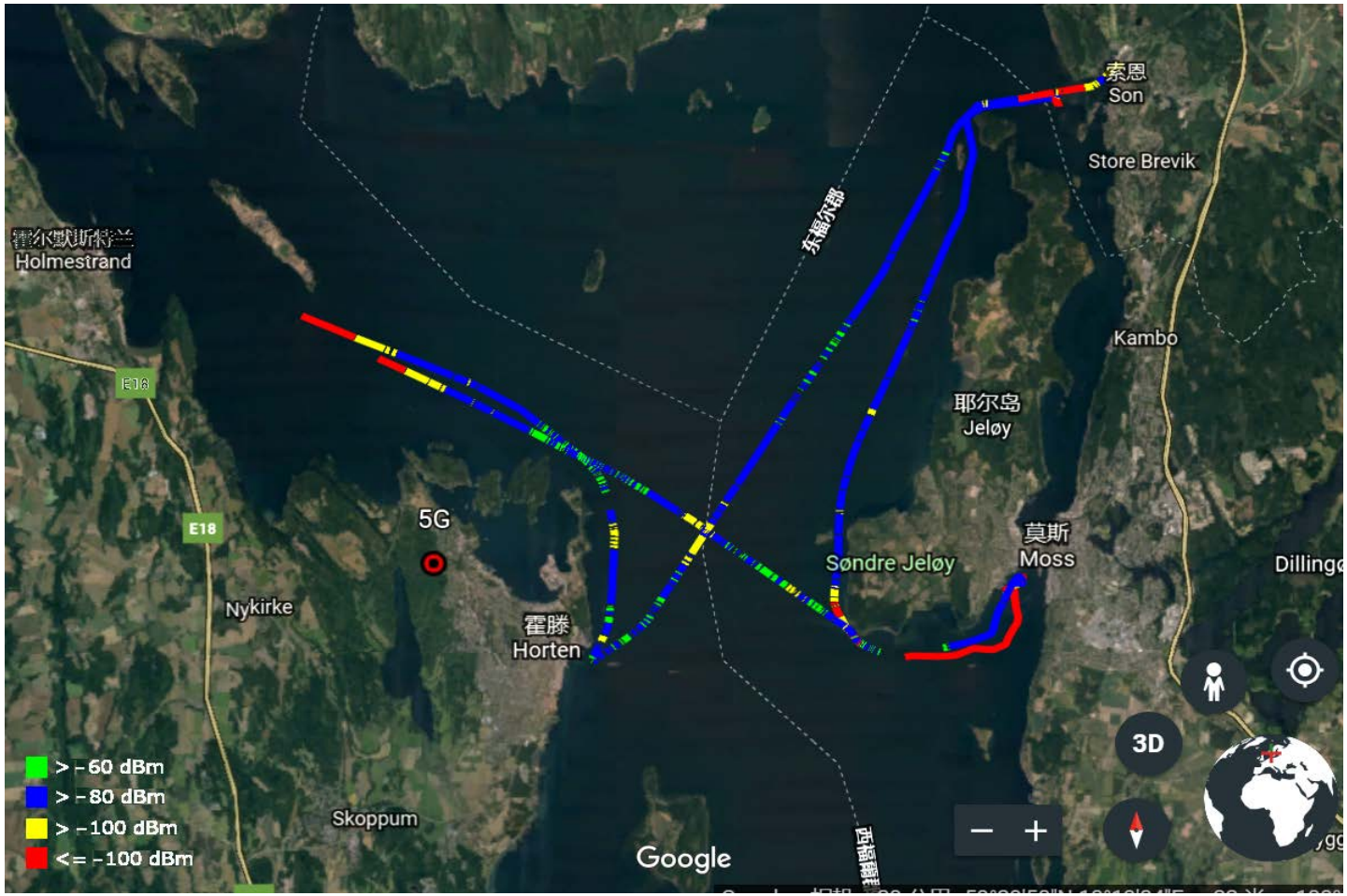
Teleplan Asterix radio coverage analysis tool. Results



- Strong signal in the open sea area
- Weaker in Moss due to Jeløy area shadowing of the radio propagation

Measurement results.

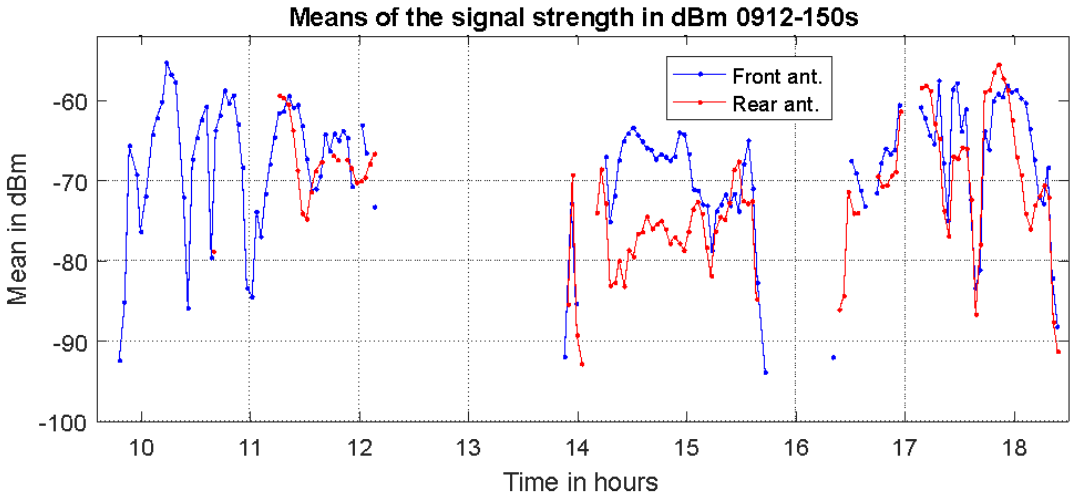
Three days with different routes sept 12, 13 and 14 in 2018. Day one Holmestrand – Horten – Son- Moss – Holmestrand.

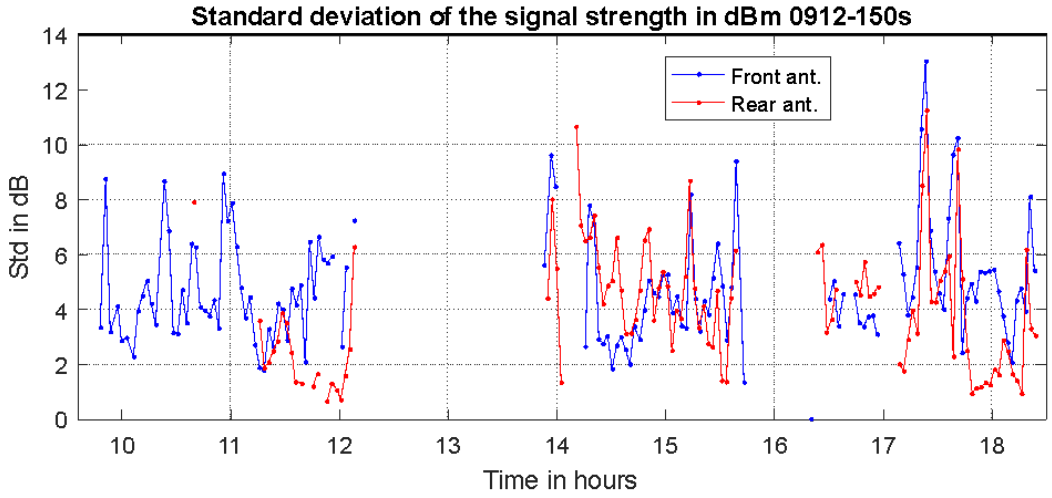


Route day one

Measurement Results day one.

- Measurement of received signal strength (dBm) averaged over 150 sec time windows
- Diagrams show plots over the route day one (9:30 – 18:30)
- Missing observations caused by shadowing and pauses





Measurement results

Conditions during the measurements

- Day one strong breeze (10-12 m/sec), wave height 1.5-2 m. Other days fresh breeze (8-9 m/sec), wave height 1-1.5 m
- Ships rms (root mean square) angular movement: Roll ≈ 2-8 deg, pitch ≈2-8 deg
- Ships speed around 7-9 knots (3.6 m/sec - 4.6 m/sec)

Discussion of results and performance

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Some observations, focus on day one

- The variation of of the signal level (i.e. fading) in the open sea, e.g. around 10:30 day one, front antenna, varied from -55 dBm to -85 dBm or 30 dB variation. This variation will cause unstable data throughput along the route.
- This variation appeared within a time span as short as 5-10 minutes, or a distance of 1.2-2.4 km (boat speed 8 knots)
- Loss of communication outside the Moss area and outside Son (day one) is explained by shadowing/blocking of the radio waves by topography.
- Throughput Mbit/sec in varied from 0 Mbit/sec (loss of connection) to 80 Mbit/sec (LOS close to Horten)

Discussion of results and performance

CPE design impact

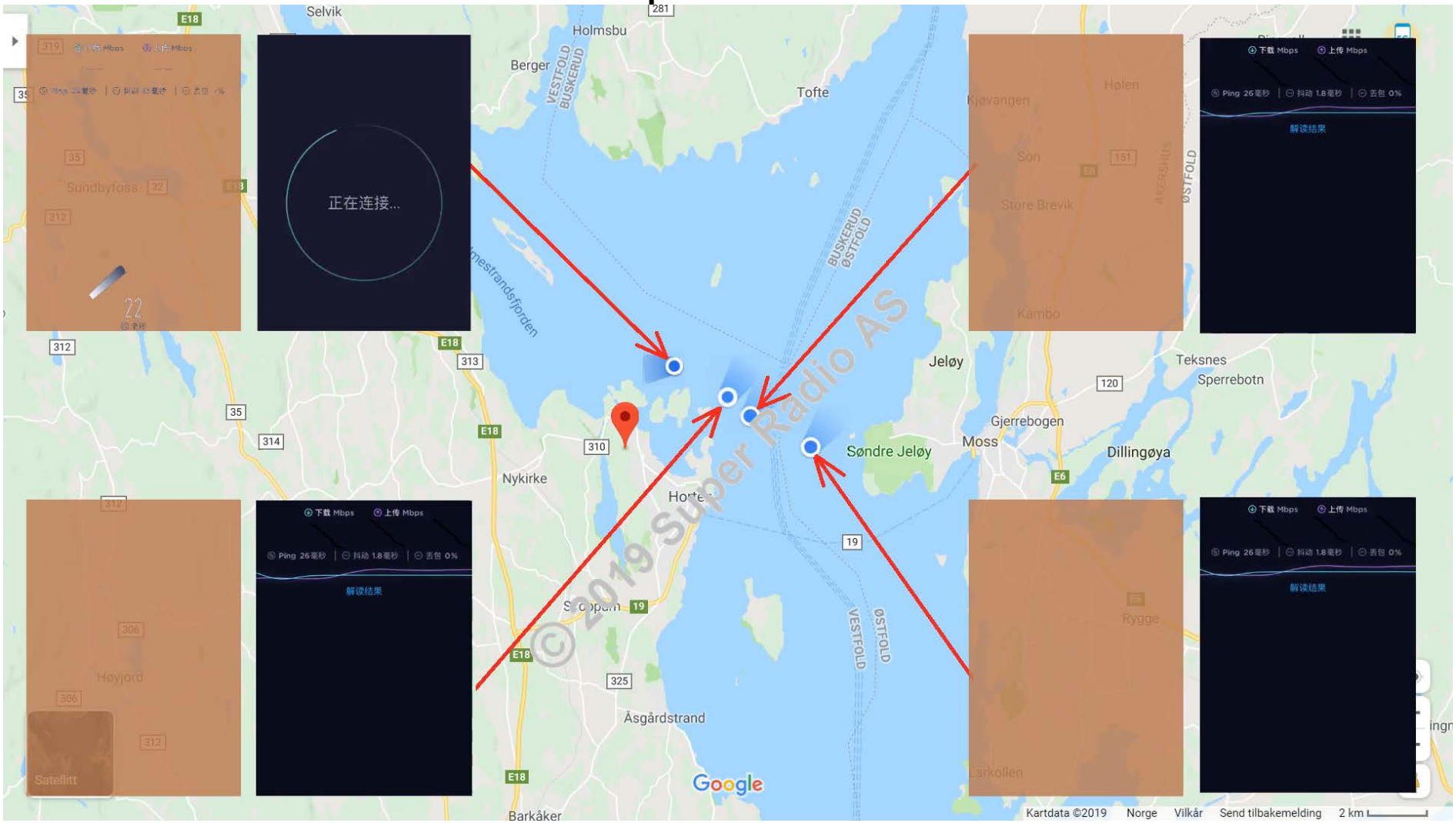
- The CPE used is designed and optimized for fixed installations on land and not for maritime conditions
- With that CPE, not designed for maritime application, signal level instability will be a severe disadvantage for applications that need stable high throughput

Discussion of results and performance

New CPE Design adapted to Maritime environments

- In the Mamime project we designed a new optimized CPE antenna that has been tested this autumn (sept 2019)
- Showing stable Download throughput > 100 Mbit/sec in the open sea outside Horten.

Video showing comparison between new CPE design connected to Telia BS RRU3278 and the 4G network with a mobile phone. Tests autumn 2019



Conclusion

- The CPE used in this measurements (in 2018) is optimised for conditions on land (urban, sub-urban and rural areas).
- Ship movements (angular and linear) and reflections from the moving sea waves will cause variations in received signal level. In our case as much as 30 dB. This will cause unstable throughput
- A new optimized CPE has been designed and tested this autumn (sept 2019) with an increase in throughput and showing a stable throughput > 100 Mbit/sec in the open sea outside Horten.