Low-latency broadband communication between vessels and port landside: perspectives and challenges

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Outline

• **Motivations:**
  – connected vessels;
  – benefits in ports.

• **Gap analysis:**
  – end-user devices;
  – digital platforms;
  – satellite and terrestrial networks.

• **Port of the Future:**
  – Sensors, Networks, and Digital Platforms in Livorno.
Connected Vessel

• Connected Vessel:
  – Goods Management (Tracking, Status Recording)
  – Journey Management (Real-Time Tracking, Planning & Optimization, Navigation Safety)
  – Machinery Management (Failures & Logs, Predictive Maintenance)
  – Personnel Services (Internet, Voice, Task Assignment, etc.)

• Connected to:
  – Ship Builder, Owner, Operator;
  – Terminal, Port Authority, and Coast Guard;
  – Logistics operators (Freight Forwarders, intermodal fleet managers).
Vessel connected to Port IT

- Port Community Systems are rolled out by Port Authorities and used by private and public institutions to:
  - enable intelligent and secure exchange of information,
  - improve the efficiency and competitive position of the seaports,
  - automate smooth port and logistics processes through a single submission of data and by connecting transport and logistics chains.

- PCSs
  - are being used for real-time processes;
  - are expected to host "official data" about bathymetry, cameras, meteo observation;
  - 3d rendering of the waterfront.

- Can PCS support VTS for:
  - traffic management and
  - vessel manoeuvring?

- What is the role of IaaS and notably 5G?
PRELIMINARY GAP ANALYSIS
Information provided by AIS equipment, such as unique identification, position, course, and speed, can be displayed on a screen or an Electronic Chart Display and Information Systems (ECDIS).
Assist pilots and other marine professionals in their daily routine, helping them to maintain efficient pilotage and other onboard operation.
Full e-Navigation

• Complementary information set:
  – bathymetry, meteo, and real-time streaming of the port scenario;
  – real-time 3D rendering.

• Need of broadband (and the Internet)
Networks (SAT and mobile)

As the vessel enters the communication range of the port it can switch from satellite to terrestrial networks.

SAT:
- Point-to-Point bidirectional
- Bandwidth:
  - typical 10-20 Mbps,
  - dedicated 150 Mbps.
- Latency: order of 100 ms
- Reliability: High
- Cost: High

LTE:
- Mobile Broadband
- Bandwidth: 100/50 Mbps
- Latency: < 10 ms
- Reliability: High
- Cost: Medium
ACCURATE AND LOW-LATENCY COMMUNICATIONS
Where is the vessel?

- Automatic Identification System (AIS) systematic inaccuracy:
  - position:
    - $\delta x$, $\delta y$, $\delta z$ from GPS;
    - $\delta L$ (length, width, height --> antenna positioning on the vessel) from manual inputs.
  - time:
    - timely information coming from local receivers (in the range of VHF waves, 10 to 20 miles);
    - other delays:
      - central services (Pelagus Portal) from the Command Center in Rome (some seconds);
      - 3d rendering process (10-20 seconds).
Broadband Communication

• What features of 5G...
  – Millimiter Waves, Small Cells, **Massive MIMO**, Beam Forming, Full Duplex, ...

• ...really matter for the "Connected Vessel"?
  – High Capacity (10 Gbps peak demand):
    • willing to accommodate real-time multimedia streams.
  – Low Latency (< 1 ms):
    • willing to neglect network transmission delays in Vessel Traffic Services.
  – Beam forming:
    • tracking the vessel and delivering data at specialized QoS.
CONNECTED VESSEL IN THE PORT OF LIVORNO DIGITAL AGENDA
Sea Ports for ICT/ITS

- Sea ports are genuine intermodal points located at the edge of Trans-European corridors.

- Sea ports are smart spaces, natural testbeds, IoT playgrounds, focal point of several industrial and institutional communities.
Port of Livorno ICT

**IaaS:**
- Connecting the port in itself, LAN of the communities;
- Connecting the port with other nodes along the transport and logistics chains;
- Pervasive monitor and control port activities gathering data from humans and machines.

**SaaS:**
- Re-designing and encompassing all applications;
- Tuscan Port Community System is expected to run at SaaS layer.

**PaaS:**
- A middleware of services:
  - custodial, access, and information retrieval;
  - I/O from the Internet of Port Communities;
  - external repositories.
Livorno 2020

- Connected Vessels
- Connected Cargo
- Connected/ Autonomous vehicles
- Photonic Radar
- Smart Cameras
- 5G coverage
- Connected Sensors (bathymetry, pollution, metering)
- Other Transport Modes

http://www.monicapmslivorno.eu
Local Detection Network

• AIS positioning can be corrected:
  – by the port detection infrastructure.

• Reliable, high-resolution solution:
  – Integration of photonic radar technologies into coast surveillance systems;
  – Coherent multi-band solution;
  – Integration in PCS.
Livorno and 5G

5G for Italy provides an open ecosystem for research and implementation of innovative projects enabled by 5G - the next generation of wireless technology - in order to accelerate the country’s digitalization.

- Livorno is the official testbed for experimenting 5G in port operations.

https://www.ericsson.com/en/networked-society/innovation/5gtuscany/digitalizing-port-operations-with-5g
Conclusions

• **Port Communities:**
  – are extending their scope to real-time services.
• **Connected and automated vessels are already being tested.**
• **Port Communities are intended to gather information from all equipment installed at the port landside and in the waterfront:**
  – they will offer the “certified data set” of the port.
• **Navigation services can be offered...**
  – Line operators (captain), port pilots, coast guard (officer on shift)
• **... provided:**
  – a real-time sensing and communication infrastructure is set-up.
• **To implement a real-time sensing and communication infrastructure...**
  – new detecting devices (notably radars) to correct IAS;
  – a pervasive 5G terrestrial network
• **... are needed.**