Maritime Unmanned Navigation through Intelligence in Networks
The MUNIN project

COMPIT 2013 conference, Cortona, Italy 15-17 April

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SST.2012.5.2-5: Grant no. 314286  
E-guided vessels: The ‘autonomous’ ship

www.unmanned-ship.org
The autonomous/unmanned ship

Target ship: A simulated, about 200 meters long, dry bulk vessel of 57 000 DWT
Autonomous/unmanned ships

An autonomous ship


An unmanned ship

No-one onboard. Not necessarily under automatic navigation / engine control. Can be remote controlled from shore center.
Objective of the project

To show the feasibility of autonomous/unmanned shipping
To show that an unmanned ship system is at least as safe as a manned.

Motivation

1. Shortage of mariners in Europe
2. Reduce “human error”
3. Ultra-slow steaming, using ocean currents, leads to lower fuel costs and lower emissions, but also less efficient transport capacity and socially unacceptable voyage durations.
4. Lower manning costs
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“Human error” contribution to shipping accidents

- 84-88% of tanker accidents
- 79% of towing vessel groundings
- 89-96% of collisions
- 75% of allisions
- 75% of fires and explosions

Various studies by TSB Canada, Cormier, UK P&I Club and Bryant. [http://www.wmu.se.fortet.funcform.se/o.o.i.s/71](http://www.wmu.se.fortet.funcform.se/o.o.i.s/71)
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The unmanned / autonomous ship

Daylight and IR cameras

Autonomous bridge

Autonomous engine room

Satellite link

Shore Control Center (SCC)

The unmanned / autonomous ship

Rendezvous control

Automatic collision avoidance
Work tasks and partners

- Architecture. To develop the necessary interface specifications for the ship and shore software applications to communicate effectively and safely (MARINTEK, Norway)
- Develop the autonomous bridge controller (Fraunhofer Center for Maritime Logistics and Services, Germany)
- Develop the autonomous engine controller (MarineSoft, Germany, MARORKA, Iceland)
- Develop the Shore Control Centre (Chalmers University of Technology, Sweden, Aptomar, Norway)
- Proof of concept, simulated ship and engine (Wismar University of Applied Sciences)
- Legal and liability analysis for automated and remote controlled ship systems (University College Cork, Ireland)
- Future concepts (All)
Communications

Functional Status Indicators sent each 5 sec.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Data reference</th>
<th>FSI Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Position, heading, speed, distance from planned position as well as a position quality flag.</td>
<td>0</td>
</tr>
<tr>
<td>Weather</td>
<td>Wind speed/direction, wave and swell height/length/direction</td>
<td>12</td>
</tr>
<tr>
<td>Visibility</td>
<td>Visibility IR/Normal, radar range and clutter. COLREG status of ship.</td>
<td>8</td>
</tr>
<tr>
<td>Collision</td>
<td>Vectors to targets, status/heading/speed of targets. 5 ships/objects in vicinity</td>
<td>40</td>
</tr>
<tr>
<td>Grounding</td>
<td>Depth, distance to shore, complexity</td>
<td>6</td>
</tr>
<tr>
<td>Communication</td>
<td>Critical communication directly to ship on VHF, GMDSS, NAVTEX, DSC, AIS</td>
<td>270</td>
</tr>
<tr>
<td>Stability</td>
<td>Trim, heel, draft, watertight integrity, void space, water ingress.</td>
<td>20</td>
</tr>
<tr>
<td>Environment</td>
<td>NOx, SOx, PM, Waste, Oil, GHG</td>
<td>12</td>
</tr>
<tr>
<td>Economy</td>
<td>Fuel use and potential for late arrival, off hire etc.</td>
<td>6</td>
</tr>
<tr>
<td>Hull Equipment</td>
<td>Hull monitoring, corrosion, equipment status, anchor, towing, ladders, etc.</td>
<td>12</td>
</tr>
<tr>
<td>Propulsion</td>
<td>Direction, speed anomalies</td>
<td>4</td>
</tr>
<tr>
<td>Machinery</td>
<td>Power, steam, auxiliary, hydraulic etc</td>
<td>10</td>
</tr>
<tr>
<td>Electric</td>
<td>Generators, switchboard, emergency</td>
<td>6</td>
</tr>
<tr>
<td>Safety</td>
<td>Main fire zones</td>
<td>16</td>
</tr>
<tr>
<td>Cargo</td>
<td>Temperature, humidity, levels, 5 holds</td>
<td>30</td>
</tr>
</tbody>
</table>
Communications

High seas; Satellite communication

Coastal waters: GSM/3G/4G, AIS, VDE

1. One main communication channel based on a commercial VSAT service operating in C-, Ku- or Ka-band. Capacity should be 4 Mbps or higher to cover the maximum aggregated bandwidth. This will enable unrestricted remote control of the ship.

2. A backup channel based on L-band Inmarsat or Iridium OpenPort with a capacity of 128 kbps or more. This would cover all but the high capacity links (e.g. video, voice communication). This will allow restricted remote control with full radar image, but only sporadic visual or IR images.

3. A dedicated and independent rendezvous communication channel based on, e.g., AIS or digital VHF technology. This allows recovery of ship even if main communication channels have been lost.
Shore Control Center

- Monitoring
- Indirect control
- Direct control
- Situation handling
Shore Control Center

- Monitoring
- Indirect control
- Direct control
- Situation handling

Picture insert from video/IR camera

3-D Nautical Chart *

Situation room: Team work, Immersion

Human Factors issues:
1. SCC bridge procedures.
2. What information must be available in different areas?
One Shore Control Centers may operate several unmanned ships?

Human Factors issues:
1. Manning of SCC? Same certification as on bridge: master and mates? Remote certificate?
2. The monitoring operator and out-of-the-loop syndrome.
3. De-skilling.
4. Bridge procedures.
5. How many ships can an SCC handle?
Human Factors issues:
1. Hand-over procedures.
2. How to transfer memory of ship conditions between crews
Scenarios

Release Vessel to Autonomous operation at pilot drop-off point
Scenarios

Open Sea Passage

Release Vessel to Autonomous operation at pilot drop-off point
Scenarios

- Piracy, boarding and retrieval of ship
- Open Sea Passage
- Release Vessel to Autonomous operation at pilot drop-off point
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- Open Sea Passage
- Piracy, boarding and retrieval of ship
- Periodic status updates from Vessel to Shore Control, planned maintenance
- Release Vessel to Autonomous operation at pilot drop-off point
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- Piracy, boarding and retrieval of ship
- Periodic status updates from Vessel to Shore Control, planned maintenance
- Reduced communication capabilities - retrieve ship
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- Reduced communication capabilities - retrieve ship
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- Collision detection and deviation through Autonomous control
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- Weather routing
- Request from other ship to participate in SAR
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Scenarios

Open Sea Passage

Piracy, boarding and retrieval of ship

Periodic status updates from Vessel to Shore Control, planned maintenance

Reduced communication capabilities - retrieve ship

Loss of GNSS position

System failure message from other component, e.g., rudder or propeller

Weather routing

Collision detection and deviation through Autonomous control

Retrieve manual control at pilot pick-up point

Small object detection that require support from shore control

Request from other ship to participate in SAR

Release Vessel to Autonomous operation at pilot drop-off point

Open Sea Passage
Scenarios

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- Flooding detection
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- Weather routing
- Retrieve manual control at pilot pick-up point
- Request from other ship to participate in SAR
- Collision detection and deviation through Autonomous control
- Flooding detection
- Intentional grounding
- Small object detection that require support from shore control
- Release Vessel to Autonomous operation at pilot drop-off point
- Autonomous control
- Request from other ship to participate in SAR
- Flooding detection
- Intentional grounding
- Small object detection that require support from shore control
- Release Vessel to Autonomous operation at pilot drop-off point
Scenarios

- Pilot unavailable, remote control into confined waters
- Open Sea Passage
  - Periodic status updates from Vessel to Shore Control, planned maintenance
  - Reduced communication capabilities - retrieve ship
- Loss of GNSS position
- System failure message from other component, e.g., rudder or propeller
- Piracy, boarding and retrieval of ship
- Weather routing
- Collision detection and deviation through Autonomous control
- Request from other ship to participate in SAR
- Flooding detection
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- Pilot unavailable, remote control into confined waters
- Retrieval manual control at pilot pick-up point
- Small object detection that require support from shore control
- Release Vessel to Autonomous operation at pilot drop-off point
I hope to be back in 2015 with the results.

Thank you.