Navigational shore support: A new perspective
Remote bridge concept
The Shore Control Centre

- Tugs
- Pilot
- Mooring
- Radio Control (RC)

Unmanned ship

Other (manned) vessels

- VHF
- Remote control (sat link, etc.)

Ship owner
Flag state
VTS

Humans in the unmanned ship system

www.unmanned-ship.org
Task: Design and evaluate a prototype Shore Control Centre
What information needs to be transferred from the vessel to the Shore Control Centre in order to achieve enough situation awareness?

Focus group with 6 nautical officers currently working within nautical education at Chalmers’ department of shipping and marine technology. The participants had a broad seagoing experience from different types of vessels, e.g. cruise ships, car carriers, long and short haul dry and wet cargo and ferries.

145 information items in 9 groups
Operator’s workstation

Situation room

www.unmanned-ship.org
Top level screen with control level indicators and dashboard.

AUTOMAT EXPRESS, SGJT/44056738
Time: Local 09:49:24/UTC 15:49:24

Top level

MANUAL CONTROL
- Manual on-board
- Radio control
- Drifting
- Anchored

AUTOMONUS
- Autonomic control
- Autonomous execution
- Direct control
- Heave-to
- Situation handling

FAIL-TO-SAFE
- Remote control

1. Voyage
2. Sailing
3. Observations
4. Safety Emergencies
5. Security
6. Cargo Stability Strength
7. Technical
8. Shore control centre
9. Administration

Switchboard
- Conning
- Chart
- Timeline
- Weather
- Status
- Camera
- Radar

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thomas.porathe@chalmers.se

The Shore Control Centre
Control level indicator & top flag

MANUAL CONTROL
- Manual on-board
- Radio control
- Drifting
- Anchored

AUTONOMOUS
- Autonomous execution
- Autonomous control
- Direct control
- Situation handling

FAIL-TO-SAFE

REMOTE CONTROL
The Shore Control Centre

Low level control

- Situation handling
- Monitoring
- Indirect control
- Direct control

Situation room: Team work, Immersion

Virtual reality 3-D Nautical Chart

Picture insert from video/IR camera

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High level control

- Situation handling
- Monitoring
- Indirect control
- Direct control
Electronic Nautical Chart

AUTOMAT EXPRESS, SGJT/44056738
Time: Local 09:49:24/UTC 15:49:24

ECS (operational view)

Vanguard

240 deg.
(240 deg.)

12.3 kn
(12.5 kn)

Course speed vektor length

+ 12 min. -
Voyage overview (spatial)

AUTOMAT EXPRESS, SGJT/44056738
Time: Local 09:49:24/UTC 15:49:24

Email oct@orinoco.vz
24 hrs. before arrival

www.unmanned-ship.org
Voyage overview (temporal)
Conning display

AUTOMAT EXPRESS, SGJT/44056738
Local shiptime: 09:49:24/UTC 15:49:24

Ship in Autonomous execution
Go to Situation handling

Set HDG 063.4
Thruster 0°/0 %

ROT
Sb 15°/min
Rudder
Sb 5.4°

UKC
323 m

Speed

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The Shore Control Centre

Roll 5°/8°

Heave 3°/5°

Roll 5°/8°

Heave 3°/5°

Roll 5°/8°

Heave 3°/5°

Roll 5°/8°

Heave 3°/5°

Roll 5°/8°

Heave 3 m/5 m

Slamming

www.unmanned-ship.org
Ship status

Operational status of unmanned vessel
Expected remaining running hours to next service based on guarantee or condition

- Level 1 (entire ship)
- Level 2 (main systems)
- Level 3 (sub systems)
- Level 4 (part systems)
- Level 5 (Etc.)

Remaining critical life: 380 hrs.

Time left to destination: 240 hrs.
Possible repair Grand Canarias: 135 hrs.
Ship status

Operational status of unmanned vessel
Expected remaining running hours to next service based on guarantee or condition

Level 1 (entire ship)
Level 2 (main systems)
Level 3 (sub systems)
Level 4 (part systems)
Level 5 (et al.)

Operational status of unmanned vessel
Expected remaining running hours to next service based on guarantee or condition

Level 1 (entire ship)
Level 2 (main systems)
Level 3 (sub systems)
Level 4 (part systems)
Level 5 (et al.)

www.unmanned-ship.org
Weather
2.20 “Restricted manoeuvrability” lanterns on/off
   - Off

2.21 Environment alert
   - No dangers with CPA < 15 nm

2.22 Execute voyage plan from next waypoint
   - Choose waypoint: Next

2.23 COG to next WP
   - 215.0 deg.

2.26 Fog horn auto on/off (1 blast/2 min)
   - Off

2.26 Horn (manual)
   - Horn
3. Observations (1/7)

Top level > 3 Observations

3.1 Observations flag colour

3.4 Relayed sensor data

<table>
<thead>
<tr>
<th>Name</th>
<th>MMI</th>
<th>Range</th>
<th>Brg.</th>
<th>TCPA</th>
<th>CPA</th>
<th>BCR</th>
<th>Details</th>
<th>Flag</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Fulko Express</td>
<td>4402736</td>
<td>23 nm</td>
<td>014 deg</td>
<td>23 min</td>
<td>18 nm</td>
<td>23 nm</td>
<td>Details</td>
<td>○ ○</td>
</tr>
<tr>
<td>2 ACL Victoria</td>
<td>2395674</td>
<td>48 nm</td>
<td>122 deg</td>
<td>53 min</td>
<td>23 nm</td>
<td>--</td>
<td>Details</td>
<td>○ ○</td>
</tr>
<tr>
<td>3 Unidentified</td>
<td>--</td>
<td>3 nm</td>
<td>63 deg.</td>
<td>5 min</td>
<td>1.2 nm</td>
<td>--</td>
<td>Details</td>
<td>○ ○</td>
</tr>
</tbody>
</table>

Set CPA alarm envelop

3.5 Object identification failed

Image Object identification failed 20140413_1255.jpg

3.6 Visibility: (good/restricted)

Set alarm threshold

> 20 nm

Good

Set to Restricted

Switchboard  Conning  Chart  Timeline  Weather  Status  Camera  Radar

www.unmanned-ship.org
3. Observations (3/7)

3.14 Incoming GMDSS message

3.15 Outdoor microphone: No detected.

3.16 Emergency flare detected

3.17 Radar 1 (S-band) on/off

3.18 Radar 1 range

3.19 Radar 1 image

3.20 Radar 2 (X-band) on/off
4. Safety/emergencies (1/2)

4.1 Safety/emergencies flag colour

4.2 Outdoor loudspeakers

3.15 Outdoor microphone: No sound detected.

4.3 Drop/heave port anchor with 40 m of chain

4.4 Drop/heave starboard anchor with 40 m of chain

4.7 Fire alarm
Detection in cell XX

4.9 Water ingress

No alarms

Squelch 6

Listen

Talk

Drop anchor

Open fire fighting procedures

Water tight doors, pumps & ballast

Up and secured

Up and secured

No alarms

VOLUME: 75 %

www.unmanned-ship.org
AUTOMAT EXPRESS, SGJT/44056738
Local ship time: 09:49:24/UTC 15:49:24

6. Cargo/stability/strength (1/2)

Top level > 6 Cargo/stability/strength

6.1 Cargo/stability/strength flag colour

6.2 Get list of tank levels: Select tank(s) ▼ Tank level Sb trim tank 2 20140413 1652.txt ▼

6.3 Fill/empty tank Handle ballast & pumps

6.4 Draught forward: 11.6 m Enter port readings

6.5 Draught aft: 12.7 m Enter port readings

6.6 Temp. cargo Hold 1 ▼ 18.4 deg. C List of cargo temperatures 20140413 1652.txt ▼ Get detailed temp list

6.7 Humidity cargo Hold 1 ▼ 68.6 % List of cargo humidity 20140413 1652.txt ▼ Get detailed humidity list
7. Technical (1/3)

7.1 Technical flag colour

7.2 Main engine RPM
Set RPM: 125
Set speed: 15.6 kn
123 RPM
15.3 kn

7.3 Thruster 1 (water jet) on/off
Turn on
Off

7.4 Thruster rotation (head-up direction)
Set rotation ±0-180
+90 deg.

7.5 Thruster force
Set force: 0 %
0 %

7.6 Electricity, main board
OK

7.7 Electricity, backup
Stand-by

www.unmanned-ship.org
AUTOMAT EXPRESS, SGJT/44056738
Local ship time: 09:49:24/UTC 15:49:24

7. Technical (3/3)

Top level > 7 Technical

7.14 Event printer

20140413 1730 Voyage emission report
20140413 1645 Cooling water warning
20140413 1350 Low lubrication level, shaft 3

20140413 1730 Voyage emission report.pdf
So that takes care of one vessel...
The Shore Control Centre

North Sea Region estimated traffic 2025 (2012)

- 20,000 (13,711)
- 80,000 (54,448)
- 65,000 (43,192)
- 50,000 (33,672)
- 30,000 (19,441)
- 45,000 (29,441)
- 90,000 (58,412)
- 25,000 (16,882)
- 200,000 (131,444)

www.unmanned-ship.org
Autonomous ship concept

1 very short message per 4 sec.
1 long message every 15 - 60 min.

Shore Control Centre
Watch schedule

<table>
<thead>
<tr>
<th>Show ship</th>
<th>Automat Express</th>
<th>Automat Emma</th>
<th>Automat Luna</th>
<th>Automat Beta</th>
<th>Automat Victoria</th>
<th>Automat Fox</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16/72/2182</td>
<td>16/72/2182</td>
<td>VHF ch 16</td>
<td>16/72/2182</td>
<td>16/72/2182</td>
<td>16/72/2182</td>
</tr>
</tbody>
</table>

**Watch schedule Wednesday 2014-08-18**

<table>
<thead>
<tr>
<th>Time</th>
<th>Task</th>
<th>Task</th>
<th>Task</th>
<th>Task</th>
<th>Task</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>07.30</td>
<td>Hand-over</td>
<td>Hand-over</td>
<td>Hand-over</td>
<td>Hand-over</td>
<td>Hand-over</td>
<td>Hand-over</td>
</tr>
<tr>
<td>08.30</td>
<td>Checked</td>
<td>Checked</td>
<td>Checked</td>
<td>Checked</td>
<td>Checked</td>
<td>Checked</td>
</tr>
<tr>
<td>08.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Boarding CL</td>
</tr>
<tr>
<td>09.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>OCT boards</td>
<td></td>
</tr>
<tr>
<td>9.30</td>
<td>Check CL</td>
<td>Check CL</td>
<td>Check CL</td>
<td>Check CL</td>
<td>Check CL</td>
<td>Check CL</td>
</tr>
</tbody>
</table>

Enter schedule note for: Automat Emma

Date time | Write free text

www.unmanned-ship.org
Screen arrangement operator station

All ships overview projection

Ship 1
Ship 2
Ship 3

Ship 4
Ship 5
Ship 6

Top flags for all ships

Operator

www.unmanned-ship.org
The Shore Control Centre (SCC)
Shore Control Center (SCC)

Vessel 1  Vessel 2  Vessel 3  Vessel 1  Vessel 2  Vessel 3  Vessel 1  Vessel 2  Vessel 3
Vessel 4  Vessel 5  Vessel 6  Vessel 4  Vessel 5  Vessel 6  Vessel 4  Vessel 5  Vessel 6

Operator

Vessel 1  Vessel 2  Vessel 3  Vessel 1  Vessel 2  Vessel 3  Vessel 1  Vessel 2  Vessel 3
Vessel 4  Vessel 5  Vessel 6  Vessel 4  Vessel 5  Vessel 6  Vessel 4  Vessel 5  Vessel 6

Operator

Vessel 1  Vessel 2  Vessel 3  Vessel 1  Vessel 2  Vessel 3  Vessel 1  Vessel 2  Vessel 3
Vessel 4  Vessel 5  Vessel 6  Vessel 4  Vessel 5  Vessel 6  Vessel 4  Vessel 5  Vessel 6

Operator

Vessel 1  Vessel 2  Vessel 3  Vessel 1  Vessel 2  Vessel 3  Vessel 1  Vessel 2  Vessel 3
Vessel 4  Vessel 5  Vessel 6  Vessel 4  Vessel 5  Vessel 6  Vessel 4  Vessel 5  Vessel 6

Operator

Vessel 1  Vessel 2  Vessel 3  Vessel 1  Vessel 2  Vessel 3  Vessel 1  Vessel 2  Vessel 3
Vessel 4  Vessel 5  Vessel 6  Vessel 4  Vessel 5  Vessel 6  Vessel 4  Vessel 5  Vessel 6

Relief operator

The Shore Control Centre

www.unmanned-ship.org
The Shore Control Centre (SCC)
The 'problem' with automation: inappropriate feedback and interaction, not 'over-automation'

(Donald Norman, 1990)

Human factors issues related to remote monitoring and control of unmanned ships

1. **Situation awareness** in the SCC: mistakes due to not understanding the true situation of the vessel.

2. **Misunderstandings in interaction with manned vessels**: latency in VHF communication, bad communication links, language issues same as for manned systems, but worsened by lack of situation awareness.
3. Delays in decision making due to lengthy time for operator to get into the loop (human-out-of-the-loop syndrome).

4. Stress and information overload because several ships might need the operators attention at the same time.
Human factors issues related to remote monitoring and control of unmanned ships

5. Human error due to “carry over effects” …between two vessels as operator monitors several vessels at a time.

6. How to train SCC Operators

7. Adverse weather manual steering.
Automation bias
Automation complexity
Automation surprise
Automation irony
Automation bias
Automation complexity
Automation surprise
Automation irony

Over-trust and under-trust

Subjective trust

Automation reliability
Automation bias

**Automation complexity**

Automation surprise

Automation irony

The more complex a system is the greater the risk that something, somewhere, sometime will fail.
Automation bias

Automation complexity

Automation surprise

Automation irony

... and that failure might come as a big surprise
Automation bias

Automation complexity

Automation surprise

Automation irony

Automation is most reliable in simple tasks. The more functionalities needed the less reliable automation becomes.
Next Steps: Low hanging fruit?

- Development of decision support systems for current vessels
- Power nap during the dog watch in the North Atlantic
- An extra eye on the chart/radar in the Dover strait
Thank-you for your attention!

Acknowledgements

- Thomas Porathe (PhD)
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