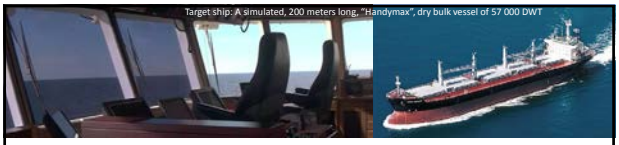

Human Factors in Remote Monitoring and Control of Unmanned Vessels (the MUNIN project)

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Chalmers University of Technology
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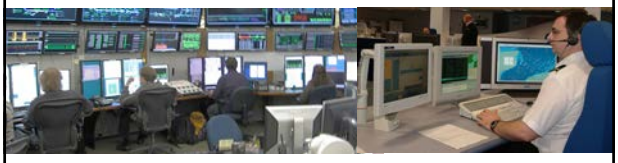

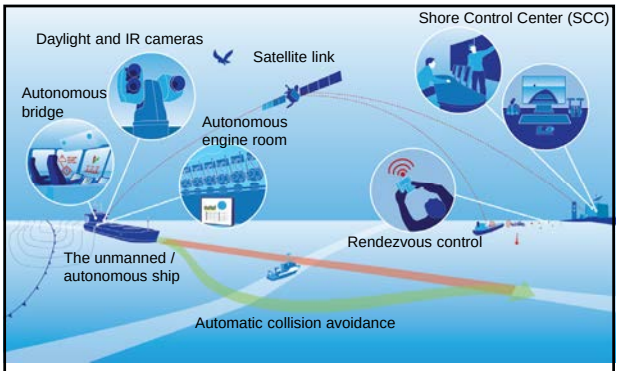

Maritime Unmanned Navigation through Intelligence in Networks

INTRODUCTION

- EU 7th Framework Program
- 3 years, Sep. 2012-2015
- 3.8 M Euros
- 7 Partners

Maritime Unmanned Navigation through Intelligence in Networks

INTRODUCTION

- EU 7th Framework Program
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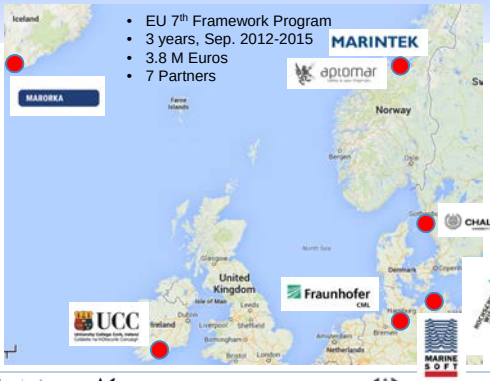
MARINTEK
aptomar
MARORKA
CHALMERS
Fraunhofer CML
UCC
MARINE SOFT

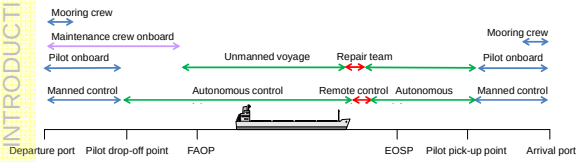


The Unmanned/Autonomous Ship

An **autonomous** ship
Automatic navigation and collision avoidance. Automatic engine control. Not necessarily unmanned. Can house maintenance and repair crew. Even be partly manned.

An **unmanned** ship
No-one onboard. Not necessarily under automatic navigation / engine control. Can be remote controlled from shore center.

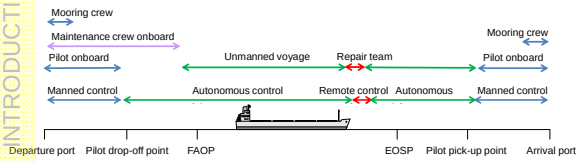
INTRODUCTION



Control modes

- **Manual control**
- **Autonomous execution**
- **Autonomous control**
- **Remote control**
- **Fail to safe**

INTRODUCTION



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

INTRODUCTION

1. Work environment
   Shortage of ship officers
2. Reduction of emissions
   Global warming and emission control: Slow steaming leads to lower emissions and lower fuel costs, (but also less efficient transport capacity). And also longer, socially less acceptable voyage durations.
3. Cost reduction
   Lower manning costs
4. Increased safety
   Reduce "human error"

THEORY

Human Factors in the Maritime domain.

Fitting the human to the ship,
or the ship to the human

Remote bridge concept

THEORY

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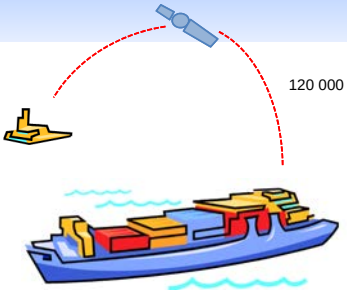
Remote bridge concept

120 000 USD per month



THEORY

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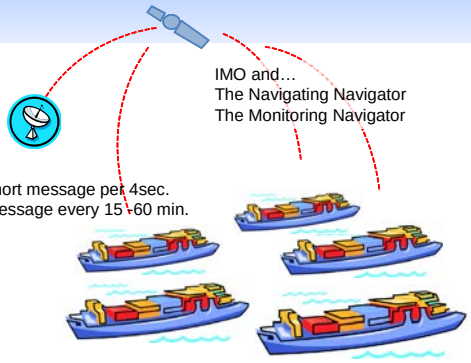
Autonomous ship concept

IMO and…
The Navigating Navigator
The Monitoring Navigator

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



THEORY

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Autonomous ship concept

1 very short message per 4sec.
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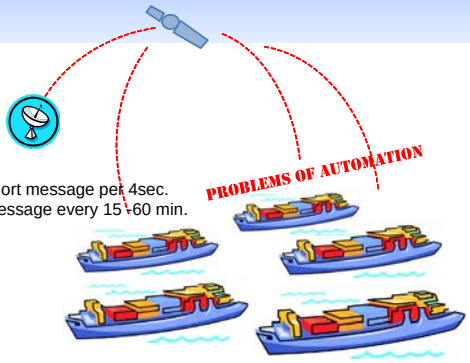
PROBLEMS OF AUTOMATION



THEORY

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THEORY

The 'problem' with automation: inappropriate feedback and interaction, not 'over-automation'

(Donald Norman, 1990)

Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, Vol. 327, No. 1241, Human Factors in Hazardous Situations (Apr. 12, 1990), pp. 585-593

THEORY

Automation bias

Automation complexity

Automation surprise

Automation irony

Trust in automation

THEORY

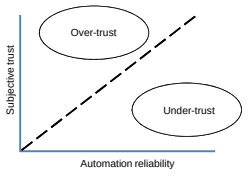
Automation bias

Automation complexity

Automation surprise

Automation irony

Over-trust and under-trust



THEORY

Automation bias

Automation complexity

Automation surprise

Automation irony

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

THEORY

Automation bias

Automation complexity

Automation surprise

Automation irony

… and that failure might come as a big surprise

THEORY

Automation bias

Automation complexity

Automation surprise

Automation irony

Automation is most reliable in simple tasks. The higher the workload the less reliable is automation.

THEORY

How to make automation a **"team-player"**

METHOD & RESULTS

Task: Design and evaluate a prototype Shore Control Centre

Situation awareness (1 vessel/6 vessels)
Work load
Time to get-into-the-loop
Sense of control (COCOM –Hollnagel)

METHOD & RESULTS

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

METHOD & RESULTS

What information needs to be transferred from the vessel to the Shore Control Centre in order to achieve enough situation awareness?

Nine groups of information

1. Voyage
2. Sailing
3. Observations
4. Safety/Emergencies
5. Security
6. Cargo/stability/strength
7. Technical
8. Shore Control Centre
9. Administration

METHOD & RESULTS

Voyage

1. Voyage plan
2. Itinerary
3. Set AIS transponder static message
4. Fuel

METHOD & RESULTS

Sailing

1. Longitude/Latitude
2. Course over ground
3. Heading
4. Speed over ground/through water
5. Dynamic predictor (min. turn radius, stopping dist., pos. 3/6/9 min. ahead))
6. Rudder angle/rate of turn
7. "Inside nav box" Y/N
8. Bearing/time to next WP
9. Auto/track pilot on/off/settings
10. Navigation lights/horn signals

METHOD & RESULTS

Sailing

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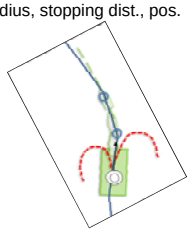

METHOD & RESULTS

Observations

1. List of targets (ARPA information for each target: name, CPA, TCPA, distance, bearing, COG, SOG)
2. GPS
3. AIS
4. Eco sounder
5. Wind/temperature/humidity/percipitation
6. Visibility (good/restricted)
7. Incoming VHF/MF/HF voice messages/GMDSS
8. Outdoor microphone
9. Radar images
10. Daylight video/IR images
11. Waves
12. Ships motions

METHOD & RESULTS

Observations

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METHOD & RESULTS

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8. Outdoor microphone
9. Radar images
10. Daylight video/IR images
11. Waves
12. Ships motions

METHOD & RESULTS

Safety/emergencies

1. Outdoor/indoor public announcement system
2. Anchors
3. Fire alarms/sprinklers
4. Water ingress/bilge pumps
5. Waters tight doors

METHOD & RESULTS

Security

1. Data security: Log-on to the ship
2. Intruder alarm
3. CCTV cameras
4. Door locks

METHOD & RESULTS

Security

1. Data secu
2. Intruder a
3. CCTV ca
4. Door lock

METHOD & RESULTS

Cargo/stability/strength

1. Tank levels
2. Ballast/tank pumps
3. Temperature/humidity/ventilation fans in cargo holds
4. Displacement sensors in cargo holds
5. CCTV cameras in cargo holds

METHOD & RESULTS

Technical

1. Main engine RPM
2. Thruster (water jet) on/off
3. Thruster force
4. Thruster rotation
5. Electricity main board /emergency board/battery
6. Engine parameters…
7. Pilot ladder starboard/port up/down

METHOD & RESULTS

Shore Control Centre

1. Control mode (Manual on-board, Autonomous, Remote controlled and Fail-to-safe)
2. Communication system…
3. Secondary communication system…
4. Incoming voice communication (VHF/MF/HF/…)
5. Incoming NAVTEX

METHOD & RESULTS

Administrative

1. Pilot card information
2. Logs
3. Accumulated communication costs

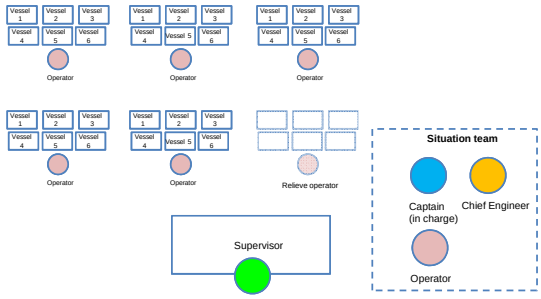
METHOD & RESULTS

Assumptions

The Shore Control Centre (mature technology)

1 SCC per 100 vessels
1 operator per 6 vessels
1 relieve operator per 5 operators
1 supervisor per 30 vessels/5 operators
1 situation room per 30 vessels
1 engineer per 30 vessels
1 bridge team (captain + the operator) per 30 ships

Shore Control Center (SCC)



METHOD & RESULTS

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Point of departure: instructor station at a full mission bridge simulator centre

METHOD & RESULTS

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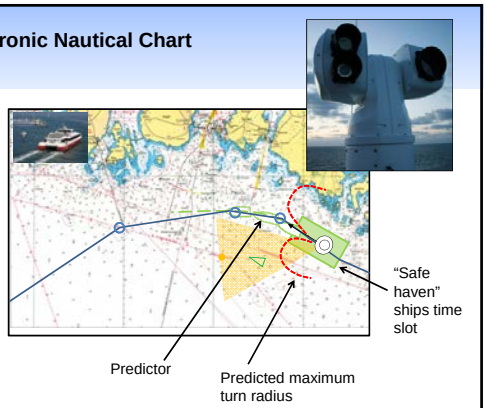
Electronic Nautical Chart



METHOD & RESULTS

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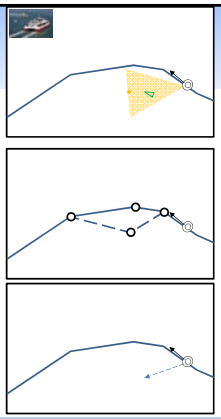
Shore Control Center

- Monitoring
- Indirect control
- Direct control
- Situation handling



METHOD & RESULTS

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METHOD & RESULTS

Shore Control Center

Picture insert from video/IR camera

- Monitoring
- Indirect control
- Direct control
- Situation handling

Situation room: Team work, Immersion

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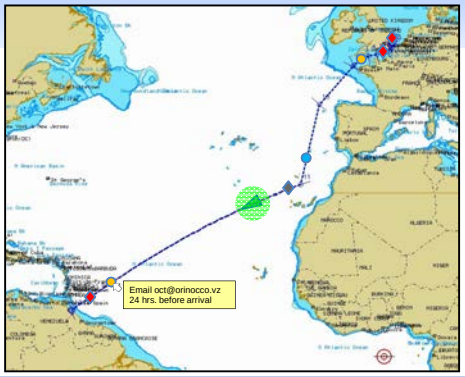
METHOD & RESULTS

Voyage overview (spatial)



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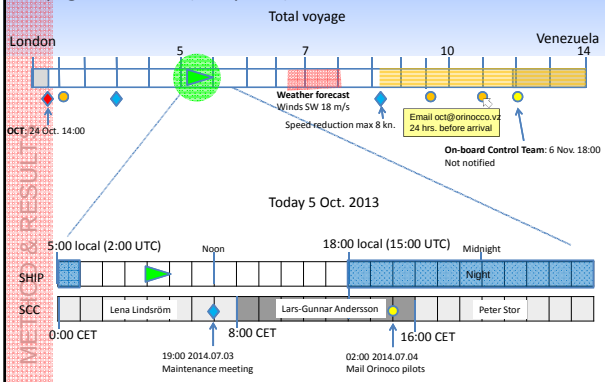
METHOD & RESULTS

Voyage overview (temporal)



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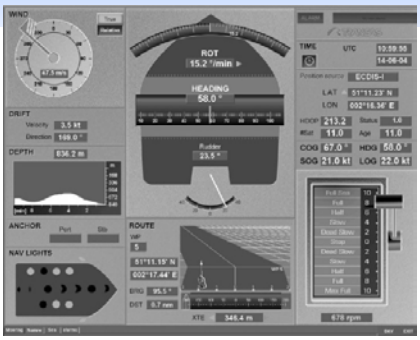
METHOD & RESULTS

Conning display



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Ship status

METHOD & RESULTS

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

Level of granularity slider

Level 1
(entire ship)

Level 2
(ship departments)

Level 3
(whole systems)

Level 4
(part systems)

Level 5
Etc.

Click on bar to go down to lower level

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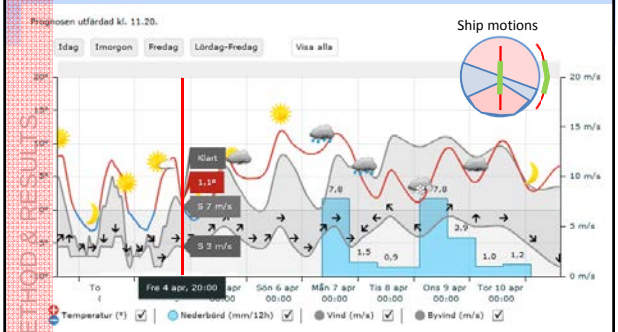
Weather

METHOD & RESULTS



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Watch schedule

METHOD & RESULTS

Time	Automat Express	Automat Emma	Automat Luna	Automat Beta	Automat Victoria	Automat Fox
Show ship	●					
Incoming comms			●			
Log & notes	Log book	Log book	Log book	Log book	Log book	Log book
Send to other	Op. 1	Op. 1	Op. 1	Op. 1	Op. 1	Op. 1
07.30	Hand-over ✓	Hand-over ✓	Hand-over ✓	Hand-over ✓	Hand-over ✓	Hand-over ✓
08.30	Check ✓	Check ✓	Check ✓	Check ✓	Check ✓	Check ✓
08.45	Operator 4	Operator 4	Operator 4	Operator 3	Arrive Open checklist	Operator 3
09.25	Retrieve ship	Retrieve ship	Retrieve ship	Retrieve ship	Retrieve ship	Retrieve ship
9.30	Check	Check	Check	Check	Check	Check

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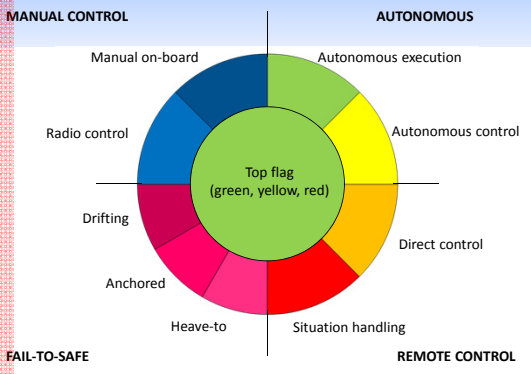
Control level indicator & top flag

METHOD & RESULTS



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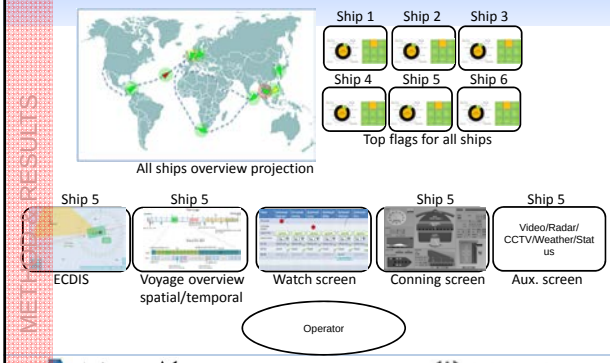
thomas.porathe@chalmers.s

Top level screen with control level indicators and dash board

METHOD & RESULTS

Screen arrangement operator station

METHOD & RESULTS



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

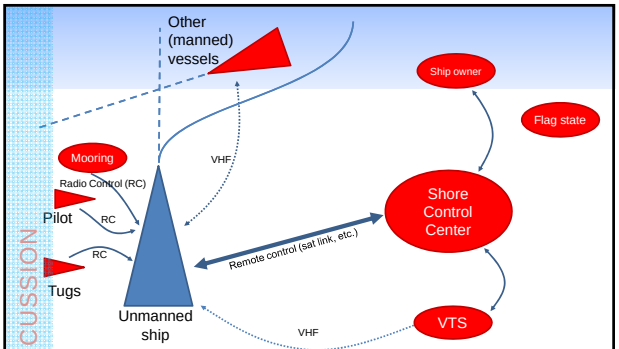
DISCUSSION

Major research question:

We know that the vast majority of all accidents at sea to some degree depends on ”human error.”

If we remove the human from direct operation of vessels, can we then remove “human error”?

DISCUSSION



Humans in the unmanned ship system

DISCUSSION

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.

DISCUSSION

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

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.

DISCUSSION

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. **Adverse weather** manual steering.

DISCUSSION

No unmanned ships in the Singapore strait (for a long time)

DISCUSSION

Low hanging fruits

Power nap during the dog watch
in the North Atlantic

An extra eye on the chart/radar in the Dover strait

DISCUSSION

http://www.bloomberg.com/news/2014-02-25/rolls-royce-drone-ships-challenge-375-billion-industry-freight.html