MUNIN’s Communication Architecture

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E-guided vessels: The 'autonomous' ship
Contents

- Communication drivers
- On-board network architecture
- Ship-shore communication
- Information exchanges and standards
- Conclusion and further work
Communication drivers

- More monitoring and automation: Increased integration
- No crew: Increased redundancy
- Danger from cybercrime: Higher security

- Shore status monitoring and control: Data volume
- Remote control and rapid response: Latency
- Disturbances, spoofing and jamming: Security and fail safe

- Several ships per SCC: Data standards
- Open integration: Data standards
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Integration on board

Full connectivity to shore.

Integration between different networks.

Integration within each different network.
Integration and security

Developed in IEC 61162-460 (Network) and IEC 62940 (Integrated Communication).
On board redundancy

All critical functions must be duplicated

Networks must have redundancy and support redundant functions (IEC 61162-460).
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- Communication drivers
- On-board network architecture
- **Ship-shore communication**
- Information exchanges and standards
- Conclusion and further work
Internet at sea is not Internet on land!

- Slower
- More expensive
- Longer latencies
- More outages
- Not always available
SatCom business model
Priority of service areas – Thor 7 as example

- 11 Ku beam transponders (TV)
- 25 Ka beam transponders + 1 adjust.
- Total about 9 Gbps, 5000 W power
- Lifetime approx. 15 years
- Cost approx. EUR 200 Million

Illustration:
Telenor Satellite Broadcasting AS

You need to point transponders to areas where there are customers!
Jamming and spoofing: Weak signals

GEO (Inmarsat, VSAT)

MEO (GPS)
Ionospheric scintillation

- Well known phenomena
- Normally more pronounced around equator
- Known to impact GNSS accuracy
- May also impact low frequency communication L-band, VHF etc.
- Effect varies with solar activity, time of day and other parameters.
Rain fade

The rain rate (mm/h) exceeded for 0.01% of the average year from Recommendation ITU-R P.837-5.

\[ D^2 = R^2 - r^2 \]
\[ r = 6371 \]
\[ d = 9 \]
\[ D = 339 (=38*9) \]
Off-ship interfaces

Duplicated SatCom interfaces – L band and Ku/Ka band

Backup Rendezvous Control Unit
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Data standards and interoperability is complicated!

- Several different uncoordinated efforts in different areas
- Several areas that are not covered
- However, we do what we can ...
Data standards and interoperability is complicated!

- Several different uncoordinated efforts in different areas
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Data model standardisation

Authorities’ support and regulation
- Port and coastal states
- Flag state and class
- Information services
- Emergency management
- Traffic management
- Transport regulations

Transport usage and demand

On board support and control

Ship owner and operator

Port and channel operations
- Logistics and planning
- Information services
- Equipment and crew
- Consumables
- Agent services
- Technical systems support

On board: IEC 61162

Ship-shore: IMO e-Navigation

Ship-shore: ISO 28005

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Conclusions and further work

- MUNIN has provided an advanced test bed for the future of ship ICT systems, not only fully unmanned ships!
B0 – Periodically unattended bridge

Automated Lookout / Watch free bridge
- Single source of reliable data provision
- No reduced lookout capability due to fatigue

Autonomous deep-sea navigation
- COLREG compliance
- Hull and motion monitoring in harsh weather

Shore-side situation monitoring / Backup watch from shore
- Human-oriented information management
- Remote situation awareness concept
Sea Traffic Management: SESAME Straits

Traffic management: SESAME Straits

VTS suggestions evaluated
Ship reduces speed and changes route
Suggestion for a new route and speed
Traffic prediction
Route & Speed optimization
Hot spot detection
VTS Centre
Conclusions and further work

- MUNIN has provided an advanced test bed for the future of ship ICT systems, not only for fully unmanned ships!

- Thus, MUNIN has contributed significantly to standardisation work in IMO, IEC and ISO.

- Work is still ongoing and needs to be followed up!
  - IEC 61162-460 expected finished early 2016
  - IEC 62940 probably late 2016 or early 2017
  - e-Navigation compatibility probably after that
Thank you for your attention!