Driver assistance functions for safety inland vessel navigation

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Motivation

Inland shipping:
- Important pillar of the European transport system
- Ecological way to transport goods
- Safety related especially when transporting dangerous goods

Challenging: due to increasing ship size, dense traffic, reduced visibility
Motivation

Accidents by collision of ships with bridge superstructure

It is necessary to enhance security and efficiency of inland vessels

This is addressed by new driving assistance systems to support the navigator
Project LAESSI

LAESSI: (Guiding and assistance systems to improve safety of inland navigation)

Duration: 10/2015 till 03/2018 (final demonstration March, 2018)

Objectives: Development of driver assistance systems to support the skipper

Founding: German federal ministry for economics affairs and energy
Project LAESSI - Assistance Functions

- **Mooring assistant**
  - distances to map contours and direct measurement of distances

- **Bridge approach warning**
  - Monitoring the height of the ship

- **Conning-Display**
  - Display of the movement of the ship

- **Track control system**
  - Automatic guidance of the ship along a given track

High accuracy requirements: Transition from code to phase-based GNSS methods (RTK)!
System Setup - Overview

- Transponder / DGNSS on board (PNT)
- AIS/VDES base station
- GNSS land DGNSS-server
- Traffic services (NtS, water level, etc.)
- Track control assistant
- Conning display
- Mooring assistant
- Bridge collision warning
- GNSS reference
- GNSS reference
- GNSS reference
System Setup – Shore side

- Transponder / DGNSS on board (PNT)
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System Setup – Shore side

- Providing correction data with integrity messages
System Setup – Data transmission

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- GNSS reference

- Track control assistant
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- Mooring assistant
- Bridge collision warning
System Setup – Data transmission

Inland AIS
(Automatic Identification System)

- Standardized by the IMO since 2002
- Data exchange between ships and shore
- Mandatory for vessels
- Land infrastructure available

Can be used for data transmission, but data capacity is limited.
System Setup – Data transmission

Communication by **VDES (VHF Data Exchange System)**:

- Enhancement of AIS standard
  - Additional transmission capacity, additional channel

**Standardization phase**

<table>
<thead>
<tr>
<th>VDE - TER</th>
<th>ASM 1</th>
<th>AIS 1</th>
<th>ASM 2</th>
<th>AIS 2</th>
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<tr>
<td>2024</td>
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<td>xxxx</td>
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<td>161.800</td>
<td>161.950</td>
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<td>161.825</td>
<td>161.875</td>
<td>161.900</td>
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</table>

**Legend:**
- **Function**
  - channel no Freq. MHz
- **SAT**
- **VDES channels for test purposes**
- **AIS channels**
System Setup – Ship side

- **Transponder / DGNSS on board (PNT)**
- **Track control assistant**
- **Conning display**
- **Mooring assistant**
- **Bridge collision warning**

**AIS/VDES base station**

- **Traffic services (NtS, water level, etc.)**

**GNSS land DGNSS-server**

- **GNSS reference**
  - **GNSS reference**
  - **GNSS reference**

**DGNSS - server**

- **Traffic services** (NtS, water level, etc.)
System Setup – Ship side

- Estimation of position, velocity and ambiguities
- Ambiguities fixing
- Correction of position and velocity

Integrity check to prove the solution

Information shore-based
- State Ephemeris and clock quality indicator

Data communication channel
- Age of correction data

RTK-algorithm
- Ratio of ambiguities
- Plausibility check of ambiguities
- Variance estimation
- Residuum check
Measurement campaign - Koblenz

- Geodetic GNSS receiver
- PNT-Unit
- Reference station: Koblenz (~3 km)
- Reference: Tachymeter
- GPS/GLONASS, 2Hz
- GSM Communication channel
Measurement campaign - Koblenz

<table>
<thead>
<tr>
<th></th>
<th>Reliable solution</th>
<th>RMS [cm]</th>
<th>99 % [cm]</th>
<th>Max. [cm]</th>
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</thead>
<tbody>
<tr>
<td>horizontal</td>
<td>82%</td>
<td>1.1</td>
<td>4.0</td>
<td>7.3</td>
</tr>
<tr>
<td>vertical</td>
<td></td>
<td>1.3</td>
<td>5.0</td>
<td>8.2</td>
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</table>
Measurement campaign - Main

- 2 days campaign
- AIS/VDES and GSM (backup)
- 2Hz, GPS+GLONASS
Measurement campaign - Main

Communication aspects with AIS/VDES:

<table>
<thead>
<tr>
<th>Complete RTCM 3.x Message</th>
<th>Shore side</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASM 1</td>
<td>Transmission</td>
</tr>
<tr>
<td>ASM 2</td>
<td>Board Side</td>
</tr>
<tr>
<td>Complete RTCM 3.x Message</td>
<td></td>
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</tbody>
</table>

Age of Correction: Number of epochs/second from the last received correction data set
Measurement campaign - Main

Less but larger outages

More but shorter outages

Correction Age for the two communication channels

Time to alarm 4s
Measurement campaign - Main

Results based on 2 days measurement campaign

<table>
<thead>
<tr>
<th>Reliable solution [%]</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>AIS/VDES</td>
<td>52.0</td>
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<tr>
<td>GSM</td>
<td>78.2</td>
</tr>
<tr>
<td>AIS/VDES+GSM</td>
<td>84.1</td>
</tr>
</tbody>
</table>
Driver function: Mooring Assistance

Installation of the sensor at the bow of the ship

Near quay wall

Passing other vessel
Driver function: Bridge Warning System

GNSS based approach:
- Inspection of the geodetic height of the ship against the height of the bridge
- for different components of the ship
- Two time horizons of alerts: warning, alarm
Driver function: Display Concept

- Bridge approach warning
- Docking assistant (Laser Scanner)
- Conning—Display and Docking assistant
- Distances to map contours
Driver function: Track Control System

- **Basic track:** Guiding line stored in navigation system (black line)

- **Easy Adaption of track while cruising:** Lateral displacement of commanded track (red line)

- **Traffic situation has to be monitored by skipper**
Conclusion

• Results of LAESSI will help to make inland shipping easier and safer

• LAESSI provides examples for usage of AIS-VDES in inland navigation

• Next project in preparation: automatic guidance into a waterway lock

• Future: autonomous inland vessels?
Thank you for your attention

Questions?

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