Road & Maritime Positioning in the Arctic:

Aurora Snowbox Innovation Platform &
Information Crowdsourcing

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CONTENTS

1. Positioning, Navigation, and Timing in Autonomous Driving
2. Arctic-PNT Innovation Platform Project
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PNT IN AUTONOMOUS DRIVING

**PERFORMANCE METRICS**

**Absolute Positioning Techniques**
- GNSS-based
  - GNSS-only (multi-GNSS, multi-frequency)
  - GNSS + Assistance (SBAS, FInnRef, etc.)
  - GNSS + Sensors (Vehicle OBD, wheel sensors, INS)
  - GNSS + Maps
- Non GNSS-based
  - Ultra-wideband
  - Wi-Fi
  - 4.5G/5G

**Relative Positioning Techniques**
- Environmental Perception
  - (what is around us)
  - On-board Sensors
    - LiDAR
    - RADAR
    - Camera
    - SONAR

**SOFTWARE & ALGORITHMS**

Source: Texas Instruments ADAS Solutions Guide
KEY PERFORMANCE METRICS FOR PNT IN AUTONOMOUS DRIVING (AD)

- Accuracy of position, velocity, (and time) of the AV
- Availability
- Integrity
- Continuity
- Sensitivity
- Time-to-first-fix
- Robustness to interference
- Communication latency

**Would be very interesting to investigate!**

ESA-funded Arctic-PNT Innovation Platform
Accuracy of AV Position

Minimum accuracy requirements*

<table>
<thead>
<tr>
<th>ACCURACY LEVEL</th>
<th>95 CEP ACCURACY REQUIREMENT (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN-LANE LEVEL</td>
<td>0.1 – 0.3</td>
</tr>
<tr>
<td>LANE-LEVEL</td>
<td>0.5 – 1.0</td>
</tr>
<tr>
<td>ROAD LEVEL</td>
<td>5 – 10</td>
</tr>
</tbody>
</table>

Accuracy performance classes for autonomous driving**

<table>
<thead>
<tr>
<th>ACCURACY CLASS</th>
<th>50 CEP (m)</th>
<th>75 CEP (m)</th>
<th>95 CEP (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASS 1</td>
<td>Better than 0.2</td>
<td>Better than 0.3</td>
<td>Better than 0.5</td>
</tr>
<tr>
<td>CLASS 2</td>
<td>0.2 – 2</td>
<td>0.3 – 3</td>
<td>0.5 – 5</td>
</tr>
<tr>
<td>CLASS 3</td>
<td>Worse than 2m</td>
<td>Worse than 3m</td>
<td>Worse than 5m</td>
</tr>
</tbody>
</table>


Availability of AV Position

Availability performance classes for autonomous driving*

<table>
<thead>
<tr>
<th>AVAILABILITY CLASS</th>
<th>AVAILABILITY (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASS 1</td>
<td>Better than 99</td>
</tr>
<tr>
<td>CLASS 2</td>
<td>95 – 99</td>
</tr>
<tr>
<td>CLASS 3</td>
<td>Worse than 95</td>
</tr>
</tbody>
</table>

### Integrity of AV Position - 1

Requirements for position integrity in safety critical road applications*

<table>
<thead>
<tr>
<th>INTEGRITY RISK</th>
<th>CONTINUITY RISK</th>
<th>HORIZONTAL ALARM LIMIT (m)</th>
<th>TIME TO ALARM (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRINGENT (every 5–150 s)</td>
<td>LOOSE (every 10–60 min)</td>
<td>STRINGENT (every 5–150 s)</td>
<td>LOOSE (every 10-60 min)</td>
</tr>
<tr>
<td>$1 \times 10^{-8} – 1 \times 10^{-7}$</td>
<td>$1 \times 10^{-7} – 1 \times 10^{-5}$</td>
<td>$1 \times 10^{-6} – 1 \times 10^{-5}$</td>
<td>$1 \times 10^{-5} – 1 \times 10^{-3}$</td>
</tr>
</tbody>
</table>

MINIMUM PERFORMANCE REQUIREMENTS FOR AD - 3

Integrity of AV Position - 2

Horizontal Protection Level performance classes for autonomous driving*

<table>
<thead>
<tr>
<th>HPL CLASS</th>
<th>50 CEP (m)</th>
<th>75 CEP (m)</th>
<th>95 CEP (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASS 1</td>
<td>Better than 1</td>
<td>Better than 1.5</td>
<td>Better than 2.5</td>
</tr>
<tr>
<td>CLASS 2</td>
<td>1 – 10</td>
<td>1.5 – 15</td>
<td>2.5 – 25</td>
</tr>
<tr>
<td>CLASS 3</td>
<td>Worse than 10</td>
<td>Worse than 15</td>
<td>Worse than 25 m</td>
</tr>
</tbody>
</table>

Integrity Risk performance classes for autonomous driving*

<table>
<thead>
<tr>
<th>IR CLASS</th>
<th>AVAILABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASS 1</td>
<td>Better than 1e-6</td>
</tr>
<tr>
<td>CLASS 2</td>
<td>1e-6 – 1e-4</td>
</tr>
<tr>
<td>CLASS 3</td>
<td>Worse than 1e-4</td>
</tr>
</tbody>
</table>


Question is, can these MPR’s be met under Arctic conditions?
AURORA TEST ROAD SECTIONS

Intelligent road sections for testing autonomous vehicles

Under Arctic conditions

Finland = Snowbox (10 km)

Norway = Borealis (35 km)

AVAILABLE INFRASTRUCTURE

- GNSS Satellites
- SBAS (EGNOS) Satellites
- Ionosphere
- EGNOS EDAS Service (ESA)
- Digital Data Archive (FTA)
- Cellular and Dedicated Network Coverage (4G/5G)
- Laser/RADAR Scanners

- Finnr/CPOS Reference Network Stations
  - DGNSS corrections
  - RTK corrections
  - SSR corrections

- Autonomous Car
- Embedded Road Sensors
- UWB Transmitters
- Other Built Facilities

25.4.2018
LOCAL CONDITIONS

FinnRef stations in the Snowbox area

Reference: Finnish Transport Agency, (FTA)

25.4.2018
- Funding by ESA, until Aug 2019.
- FGI Dept. of Navi. and Geodesy.
- www.arctic-PNT.org

ARCTIC-PNT INNOVATION PLATFORM

We are here now

FGI Dept. of Navi. and Geodesy.
www.arctic-PNT.org

25.4.2018
WHAT ABOUT MARITIME NAVIGATION UNDER ARCTIC CONDITIONS?

- Not feasible to install sensors along Arctic maritime routes
- Information "Crowdsourcing". Sharing Or, Information of Opportunity
- Information about visibility and sea condition (drift ice, wave heights, strength of currents)
- ...deep within an archipelago
- ...can be distributed instantly and regularly
- ...by a ship that has already passed through to future ships taking the same route...
Our vessel unable to find broken route in the dark. In snowstorm, spatial range of headlights degrade.

Ice-breaker in the front of the convoy shares its ice radar image showing the location of the broken route.

Our vessel reorients itself onto the broken route using the shared ice radar image.
EU BONUS ESABALT: ENHANCED SITUATIONAL AWARENESS TO IMPROVE MARITIME SAFETY IN THE BALTIC

Near Real-Time Maritime Situational Awareness Platform (Fusion with ESABALT Data)

- Space-Based Remote Sensing
- Crowdsourced Maritime (Raw) Data
- Aerial Remote Sensing
- Other Data Sources (AIS, VTS, etc.)

ESABALT DATA SERVER (CLOUD)

- Maritime Information Crowdsourcing
- Value-added MSA Information
- Data Oversight

Baltic Region Advisory Partners (Project Steering Committee)
- National and Cross-National Maritime/ Coastal/ Border/ Environmental Authorities
- Stakeholder Organizations
- Companies

Main-User Groups & Examples

- Commercial Vessels
  - Cargo Ship or Tanker
  - Cruise Ship or Ferry
- Authority Vessels
  - Coast Guard
  - Ice-Breaker
- Pleasure Craft
  - Sail Boat
  - Motor Boat

Ship Sensors & Situational Awareness Data Aggregation & Reduction

Ship-System Platforms

ESABALT Validation Scenarios
- Maritime Safety
- Intelligent Navigation
- Environmental Monitoring

25.4.2018

www.ESABALT.org
CONCLUSIONS

- Minimum Performance Requirements for Autonomous Driving have been defined.
- The Aurora Ecosystem consisting of intelligent test roads will help validate AVs and MPRs under Arctic conditions.
- Arctic-PNT Innovation Platform is an ESA-Finland project to perform PNT experiments on the Aurora Snowbox and Borealis intelligent roads.
- Information Sharing between vessels can potentially aid Maritime Navigation in Arctic conditions.