Automotive & Rail Innovation Center (ARIC)

Overview

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Introduction Automotive & Rail Innovation Center

Content

➢ ARIC in general

➢ Navigation: The Galileo-Project
  • Galileo-Testbeds: System und Infrastructure
  • Galileo Application Projects Automotive & Rail
  • Galileo Application Center for Rail and Road

➢ Wireless Communication: R&D & Testing on Connected Mobility (V2V & V2I)

➢ GNSS Reference and Calibration Field REDUS

➢ SMART Rail Inspector SRI

➢ EFTEC

➢ ANCHOR

➢ Detector
Electronic Competences: all Around the Vehicles

- Function- and System- Integration
- Energy management
- Advanced Power Distribution and control
- Sensors (Laser, LIDAR)
- Camera systems
- Body electronics
- GNSS based systems
- Communication
- In-vehicle networking
- Positioning
- Control devices
- Alternative Transmissions
- Safety systems /
  Driver assistance systems
Main Focus

ARIC Main Subjects

- Advanced Driver Assistance Systems ADAS
- Train Control Systems
- Electric Mobility & Infrastructure
- Connected Vehicles and Infrastructure for Rail & Road
- E/E System Development: Vehicle Networking & Electrical System Architecture
- Function- and System Integration

Satellite Navigation, Positioning & Communication are core technologies on systems!!
• The Automotive & Rail Innovation Center is a Research Facility fostering applied research on vehicle technologies

• We are your partner for all phases in research, development and testing of electronically functions for any application in Automotive and Rail

• Long-term industrial experiences guarantee substantial know-how and highly professional, accurate quality work

• Accurate vehicle positioning by multi-sensor modules

• Communication between vehicles (V2V) and to infrastructure (V2I)

• Contribution to the intermodal mobility of the future

• Geodetic calibration and validation test-bed: analyse the dynamical performance of your positioning sensor

• Interdisciplinary teams combining Research Institutes, Universities and Industry can be installed very quickly for solving any challenges at any development phase - from research to advanced engineering to production
Focus: **Dynamic Positioning**

GNSS bases Systems for ADAS and autonomous driving
Focus: Vehicle Communication

- GNSS / SatNav
- Inertia module (IMU)
- V2x communication
- GSM-5G / RSU
- Environment sensing
- On-line maps
Near-by Test Centres for Automotive & Rail

**Aldenhoven Testing Centre (ATC)**
(incl. Heavy Duty up to 40t)
Aldenhoven-Siersdorf

**The Test and Validation Centre of Siemens AG (PCW)**
(rail tracks on 30 km)
Wegberg-Wildenrath
Their location in the Aachen Region

Rail Test and Validationscenter Wegberg-Wildenrath

Automotive Test Centre Aldenhoven
Both test beds are being enhanced by adding Galileo positioning:

- Installation of terrestrial pseudolites (PSL) to transmit Galileo signals locally at the test field
- Development and test of GNSS based Advanced Driver Assistance- and Security Systems (ADAS) for rail and road vehicles
- Provide infrastructure to industry for testing and adjusting their systems to be ready for market with the operational start of the Galileo-Satellite-System.
- Highly precise reference tracks for dynamic measurement of GNSS receivers available at railGATE
- Communication technology available, too:
  - 4G/LTE mobile communication
  - pWIFI (802.11p)
  - 5G Mobility Lab (Aldenhoven)
GNSS Test Environments (GATE) for Rail and Road

railGATE

and

automotiveGATE

(GNSS Global Navigation Satellite Systems, i.e. GPS, GALILEO, EGNOS)
Proofing Ground & automotiveGATE in Aldenhoven

Aerial view ARIC by courtesy of tim-online.nrw.de

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railGATE : GNSS Validation Center in Wegberg

Aerial view by ARIC with courtesy of tim-online.nrw.de
Exploration: PSL-Position analysis
Construction of railGATE – the GALILEO Pseudolites

Galileo Transmitting Unit

Height of poles: 40 – 60m

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Galileo-Pseudolites at railGATE in Operation
Galileo-Pseudolites at railGATE in Operation
Co-operative Vehicle Applications

Adaptive Cruise Control (ACC)

- Independent from the driving route (curves, inclination, buildings, …)
- Safety and cost effective in traffic jam, stable convoys, fuel savings

Requirements at both:
- Exact determination of velocity
- Exact positioning
- V2V - communication

Application in Rail: Adaptive Block Control
-> Moving Blocks
Co-operative Vehicle Applications

GALILEO based Collision Avoidance System
- Detection of potential collisions
- Calculation and transmission of trajectory for evasion manoeuvre
- Stand-alone linear and lateral control
  - Emergency braking
  - Escape manoeuvre
  - GALILEO-based tracking

Requirements at both:
- Exact determination of velocity
- Exact positioning
- V2V – communication

Application in Rail: Secure single track operations
Rail Application

Automatic Positioning of rail vehicles for coupling

- Exact positioning of locomotive
- Exact determination of speed over ground
- Determination of slippage for dynamic braking and acceleration
- Precise braking-to-target and impact detection

Automatic Electronic Fences
Rail Application: Shunting automation & control

- The need of de-centralised, cost-effective train shunting yards will increase in the future
- High safety, reliability and quality requirements
- Idea: remote controlled locomotive for shunting wagons automatically
  - Requires knowledge of exact position of moving and parking vehicles wagons
  - Dispatching and process control
Applicat. Centre for Ground-based Mobility by ARIC

- Customer support for product development and testing
- Initiating and accomplishment of R&D projects in relation with GALILEO/GNSS
- Include communication links for V2V & V2I like LTE and pWiFi
- Provision of accurate data on positioning and timing even for conventional testing
- Interface between institutes and industry -> „Science to Business Centre“
- Easy access to automotiveGATE and railGATE test- and validation facilities
- Operation od Geodetic Reference Field REDUS
Holistic Capabilities: Test- and Development Center on Connected Mobility

GNSS: Galileo, GPS, EGNOS, ...

4G/LTE & 5G Innov.Lab for vehicle-to-infrastructure-communication (V2I)

pWIFI for vehicle-to-vehicle communication (V2V)
Testbed for Connected Mobility: Positioning

- GNSS
- EGNOS
- PSL
- PSL/LTE
- train-No.
- position
- speed
- time
- direction
- track No.

Position- and alert information at PCW main control
R&D Vehicle 1 of IFS

- GNSS Dir.1
- IMU 2g
- Acc 2D
- DG1 Turning off
- RFID Dir.1
- v_RS1
- v_RS2
- v_Correvit
- v_Doppler FR1
- v_Doppler FR2
- Proxitron
- Baumer
- v_MLR_L
- v_RS3
- DG2 Turning off
- GNSS Dir.2
- v_MLR_R
- GNSS Center
- RFID Dir.2
rail2X Communication

- Train position & schedule
- Train Completeness Control
- Control of wearing and infrastructure (tracks, sleepers, switches, ...)
- Tracking of wagons w/o power supply
- Track-workers’ alert
- .....
Position of ARIC as Integrator and Mediator

- Acting at the cutting edge of positioning / communications and the vehicle
- ARIC can talk to all players in their origin language.
REDUS

Highly precise reference and calibration field
Dynamic testing of positioning devices

Position accuracy:

dynamical

testing, validation, calibration

by geodetic reference tracks

(realised within EU-Project Galil-EU)

The usage of GNSS in vehicles requires a very high accuracy within the cm-area on highly dynamical application. Now, the available geodetic reference tracks allow for adequate testing, validation and calibration of positioning modules, as GNSS-receivers, IMUs, MEMS, amongst others, under real driving conditions.

It has been realised by using a train turning loop at railGATE providing a length of 550 m for driving.

The project has been funded by EU / CIP.
Galil-EU – Realisation within railGATE

- Set-up of an highly precise dynamical Reference- and Calibration Field in co-operation with Geodesy partner.

Diagram: Reference Track

- Galileo Pseudolites
- Reference Station
- Monitor-and Control-Station
- LTE

Grafik: ARIC mit freundlicher Genehmigung von tim-online
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Geodetic Reference Field

Positioning of Observation Poles

Accuracies:
Relative Position: <1 mm
Absolute Position: 2 cm
Reproducibility

S/S = Start-Stop for driving a closed loop line

Verwendung der Luftaufnahme mit freundlicher Genehmigung von tim-online.nrw

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Geodetic Reference Field Zero Measurements

Relative Accuracy within Sub-mm
Gang Car: a Sensor Carrier Platform

- Elect. drive / remote control
- Fixations for measurment equipment
- IMU on board possible
- Carries device under test (DUT)
Geodetic Instruments in Use
Tracking and Recording
Geo-referenced System for Dynamic Positioning Measuring
(principal view)

Complete tracking und recording of the test- and calibration drive by tachymeter

Graphics: ARIC w/ kind permission from tim-online
Re-validation on Accuracy of Geo-Reference Field

Track position in July and deviation in September 2014 (magnif. x200)
Difference in air temperature: 10° C
Accuracy of Geo-Reference Field

Track position in July and deviation in September 2014

Difference of air temperature: 10° C

**Track Gauge** at Measurement Point
Geodetic Reference System

- Use available infrastructure railGATE to set-up a geodetic basic environment, i.e. a reference network
  - Usage of tracks as 3D quasi-invariance in free space
- Independent of public tracks manifold test-, validation and calibration drives can be done with real vehicles, i.e. a special designed gang-car as carrier vehicle for measuring equipment and test specimen.
- The GALILEO pseudolites and the tracks are setting up a geodetic reference system
- Dynamical measuring, adjustments and calibration of any kind positioning sensor and GNSS-based systems
Investigations on dynamic driving processes

Dynamic driving processes on the reference tracks:

The gang-car as sensor carrier platform
Geodetic Reference System

- Absolute and relative tracking of carrier vehicle w/ GNSS, tachymeter and/or laser scanners
- Operation and calibration of devices and sensors in practical applications mounted to gang-car
  - testing of prototypes
- Comparison and documentation of different sensors, reproducibility and error analysis.
Usage of 3D quasi-invariance in free space

Benefits & Applications (1)

- Dynamic measurements, analysis and validation of any kind of positioning sensors (GNSS, IMU, others)
  - Required by Rail and Vehicle Industry
- Monitoring of moving and pos./neg. accelerating targets
- Correlation of positioning and inertial measurement unit (IMU)
- Extensive documentation of reachable accuracy and error analysis / calculations
Usage of 3D quasi-invariance in free space

Benefits & Applications (2)

- Operation und calibration of devices and sensors for practical applications -> probes and prototype testing
- Comparison on results of various sensors used
- Documentation Further development on test methods and procedures
- Apply methods from geodesy to transportation
SRI – SMART Rail Inspector

Detection of Defects on Rails and inside Tracks During Normal Operation of Trains and Trams

The Partners:

Funding:

This project has been public funded under registration no. EFRE-0800869
Rail Applications

• SMART RAIL INSPECTOR is an integrated system for the detection of impacts and defects on rails

• This allows continuous control, inspection and assessment of the infrastructure

• Rail Operators may use it while standard operation of their trains. The SRI-unit is mounted to the regular train / tram and will be carried during their regular operation

• A specific and very expensive measuring train is **not being needed anymore**

• Instead the entire rail network is continuously being measured within relatively short time periods, i.e. weekly.

• Registration of defects on rails and around the tracks an its environment

• Detection of defect within various scales. Even very small and hardly visible defects like riffles, squats, head checks, etc. will be detected and registered

• Highly accurate Geo-referencing on all defects’ locations for fast and secured retrieve for repair work
Defects on Tracks (1)

SQUAT

HEAD CHECK

RAIL BREAK

Riffles

Pictures with courtesy of INRABEL
Defects on Tracks (2)
Rail Anwendung

Observation of Tracks

Inspection of Fixations & Screws

Obstacle Detection
Sensors und Data Acquisition

Galileo, GPS, EGNOS

LIDAR  Pos.

Data Acquisition and Synchronisation

Monitoring for Driver

Rough Analysis & Buffering

Communication & Cloud-Connection

Sensors

LTS: laser-based Triangulation Sensor
GES: Optical Obstacle Detection
Acous.: Noise Sensor
Pos.: Position Sensor
LIDAR: Laser Scanning
Highly Accurate Positioning

Objective:
- Speed 120 km/h
- Position accuracy: cm-area
Data Analysis

- Rough analysis & buffering of recorded drive
- Detailed analysis of current data of tracks
- Maintenance- / repair jobs
- Technical Data manuals
- Long-term memory records of previous drives
- Data assessment w/ history
- Abrasions, wear, predictive maintenance, predictable repair jobs
Rail Application

Sensor Testing
Rail Applications

First sensor testing
Rail Application

First System Integration Session
• Detailed evaluation and analysis of recorded data at trains’ depot. Visualisation for inspection in 2D and 3D

• All required data for maintenance and repair works are online accessible for the team by cloud, i.e. descriptions, pictures, repair instructions, technical data, etc.

• The adaptive track maintenance is reducing the noise emissions and expands the life time of the tracks by many times

• Description, registration, assessment and documentation of all repairs / modification immediately with the ongoing operation.

• Assessments by using archived data allows an ongoing, condition-based and advanced maintenance rather than facing urgent and expensive ad-hoc repairs which might even stop the railway services

• Integration of all information into the business processes of railway operator

• Secures the availability of the infrastructure
Mobility - Project EFTEC

- Mobile Traffic Detection and Management –
  (GCS Innovation Project)
Mobile Traffic Detection and Management

EFTEC Highlights

- Entire system is absolute mobile: Detection and Management
- Temporarily operational at international hotspots, events, accidents and road work areas
- Quick & effective set-up for operation
- Individually available on demand
- Cheaper and more flexible as traditional fixed installed traffic management stems.
- Fully integrated in higher levels of traffic management

Project partners:

- momatec GmbH, Aachen, Germany
- Automotive & Rail Innovation Center of AGIT mbH., Aachen, Germany
- Campus Automobile de Spa -Francorchamps ASBL, Stavelot, Belgium
- Chudosznik Sunergia VOG, Eupen, Belgium
- Global Design Technology, Angleur, Belgium
- Terlamen VZW (Circuit Zolder), Heusden-Zolder, Belgium
- AutomotiveNL, Helmond, The Netherlands
ANCHOR - Captain’s Pilot Assist

The Captain Assistant System for Navigation and Routing
during Operations in Harbour
ANCHOR

• Captain’s Pilot Assist
• Navigation at harbour
  o current data on fairways
  o current data on pier
• Collision warning
• Environment (wind, current, …)
The ANCHOR Project

• Captain’s Pilot Assist
  Guidance through the harbour based on accurate and most updated data from harbour authority, for reliable, safe and energy & time efficient routing to the destination pier; warnings & alerts.

• Navigations-Trajectory
  Projection of trajectory and speed for the most efficient way through the harbour to the pier

• Collision Warning
  on impending collision with other ship or obstacles

• Environment Sensors
  Indication of environmental influences (wind, current, drift) inside harbour.
The ANCHOR Project: General Concept

The system consists of three main parts:
- Pilot Assistent Sub-system (PAS)
- Communication sub-system (CS)
- Harbour infrastructure (HI)
ANCHOR - Harbour Infrastructure

Harbour subsystem consists of two main parts: the server and the measurement network.

- Webcam
- Ground measurement network
- Environment observations services
- Long Range Communication to Pilot Terminal
- Local Network
- Internet
- Harbour server
ANCHOR – Pilot Assist – Ship Module

The PAS comprises two device:

**a) Ship Modules** – will be installed on the two sides of captain bridge

- GNSS + INS (with EGNOS and Galileo ready)
- Wi-Fi modem
- Battery pack (should assure 4-6h of work)
- Easy to install
- Special design cover
- Control Unit (Embedded system)
b) **Pilot Terminal** – control unit (laptop, tablet) with Wi-Fi, long range modem and dedicated software:

- Actual precise digital maps
- Actual weather information
- Harbour situation updates
- Real time navigation data
- Visualization of docking path
- Alarms and warnings
Main parameters of the „harbour” subsystem

- Communication between ship and the harbour
- Visualization of the measured data
- Archive of previous maneuvers in harbour
- Comparison and training tools
- Newest GIS data server
- Weather server
- Located in harbour
- Connected to internet (static public IP)
- Collect and make useful data from Measurements Networks and Global Monitoring and Observations Data Systems
ANCHOR – System testing

On 1\textsuperscript{st} & 2\textsuperscript{nd} October 2015 at ARIC’s test center at Wegberg-Wildenrath (Germany) (incl. GALILEO test-field railGATE & REDUS facility)

- Positioning: accuracy, dynamical behaviour
- Communication links
  - Driving along geodetic reference track
  - Proof of concept
ANCHOR – System testing

On May 2016, the ANCHOR system was successfully tested in real live situation at the harbour of Rostock/Warnemünde, Germany
ANCHOR – Demonstration Gdynia

On Dec. 2015, the ANCHOR system was successfully introduced to marine stakeholders by a real live demonstration at Gdynia, Poland
FP7-Project DETECTOR

- Detection and Recognition of GNSS Jammers –
  (an EU-FP7 Project)
GNSS Interference

Unintentional interference through
- De-tuned or faulty equipment
- Natural phenomenons in space and in the atmosphere

Intentional
- **Jamming**, Spoofing, Meaconing

Impact of Jamming
- To the receiver
  - Deviating, incorrect position
  - No position
- To Services
  - Small deviations
  - Economic effects
  - Impact on safety

Personal Privacy Device (PPD)
Project DETECTOR

- Detection of interferences on GNSS-Signals
- Recognition and classification on Jammers
- High accuracy on classification possible even with low cost device
- Collection of „Fingerprints“ of Jammer at data base
Field-Test at automotiveGATE

Jammer detection and recognition in real-life environment
Long Time Study of GNSS Jammers at A1

➢ 60 intentionally operated jammers within one month!
DETECTOR Sensor-Positioning

Gantry

Roadside

Recorded with different speeds
Thank you very much!

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ARIC – Complete Solutions out of one Hand

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