Fahrer-Assistenzsysteme für Lastkraftwägen mit Anhängern

Advanced Navigation Solutions – ANavS

Patrick Henkel

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1. Advanced Navigation Solutions - ANAVS

- Company founded as GmbH, spin-off of the Institute of Communications and Navigation, Technische Universität München, Germany
- ANAVS **Position and Attitude Determination (PAD) System**: GNSS / INS based software and hardware for automotive and maritime applications

- 1st Prize in Bavaria at the European Satellite Navigation Competition - Galileo Masters (2010)
- Dissertation award of Vodafone for Dr. Patrick Henkel (2011)
- VDI award for Jean Kiam (2013)
- Funding by ESA, German and Bavarian Ministries
- 50+ presentations at international conferences
- 10+ journal publications
- 4 international patents on relative carrier phase positioning by ANAVS

1. Advanced Navigation Solutions - ANAVS

- **Geodetic precision with low cost GNSS receivers**

Geodetic receivers

+ Precise and accurate position information (cm accuracy)
+ Reliable position information
– Expensive for many applications
– Geodetic antennas too large for many applications

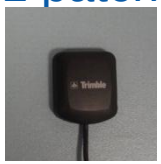
Low cost navigation chips and antennas

+ Available for a few euro
+ Small size of antennas and chips
+ Large scale production for mass market
– Position accuracy of only 1 m due to single frequency, code multipath (tens of meters), cycle slips and clock offsets (milliseconds)
– No reliable position information

- **ANAVS' PAD System** bridges the gap between both GNSS receiver types
- **Attitude determination** and **RTK positioning software** for low cost receivers and **integrated hardware solutions**
  - **heading** accuracy of **0.5° / baseline length** [m]
  - **RTK positioning** accuracy of **5 cm**

2. PAD System hardware

- **Attitude determination** main processing unit
  - PAD System software
  - 2 low cost GPS receivers (u-blox LEA 6T)
  - Intel I7 processor, WLAN, hard disk drive
  - Optional: INS (Invensense MPU 9150)
- Two external GPS L1 patch antennas



- Visualization on a tablet (position and attitude)
- Much lower cost, size and weight than geodetic receivers or high end INS
- Optional: implementation on ARM processor (Raspberry Pi)

2. PAD System hardware

- **RTK relative positioning** for up to 30 modules
  - PAD System software
  - Low cost GPS receiver (u-blox LEA 6T)
  - Microcontroller, Bluetooth, LiPo battery
  - External GPS L1 patch antenna
  - Optional: INS (Invensense MPU 9150)
- Reference station module for absolute positioning, connected to standard processor
- Visualization on a tablet (relative positions)
- Optional: implementation on ARM processor (Raspberry Pi) for two modules

2. PAD System hardware

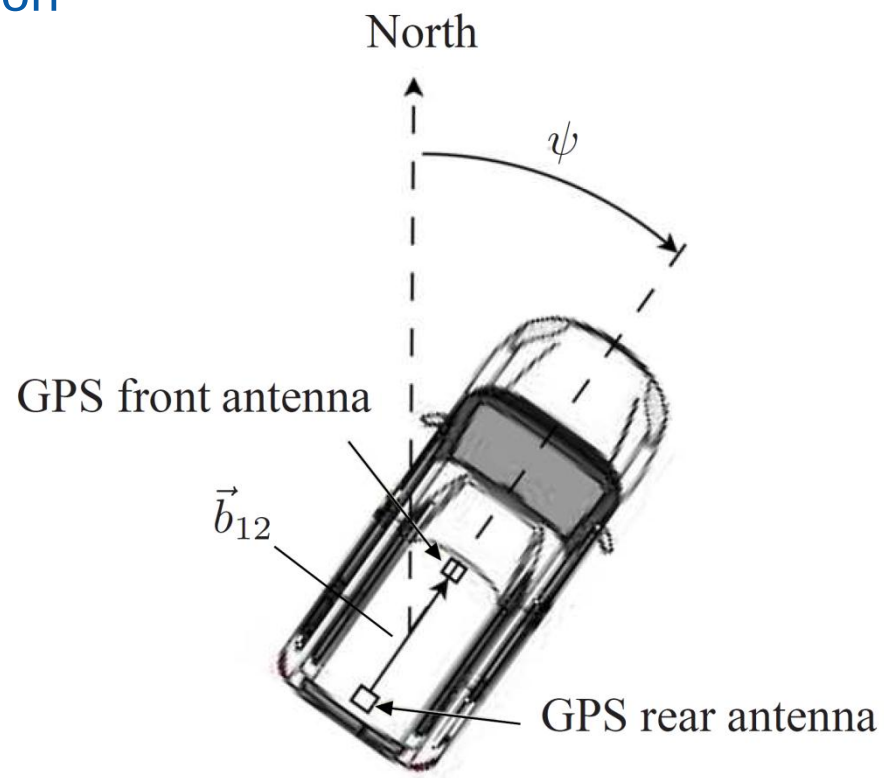
24.04.2013: ESA Director General, **Jean-Jacques Dordain** and ANAVS CEO, Dr. **Patrick Henkel** on a live demonstration of **ANAVS PAD System**

3. PAD System software

- Modularized software in C language
  - Synchronization for satellite movements in receivers differential clock offset ©
  - Soft-constrained float ambiguity estimation ©
  - Maximum a posteriori (MAP) estimator © for integer ambiguity fixing
  - Cycle slip detection and correction by MAP estimator
  - GNSS / INS sensor fusion (tight coupling)
- Input
  - Code / carrier phase measurements and navigation messages from low cost GPS receivers
- Output
  - **Absolute position** (sigma: **0.5 m**)
  - **Relative position** in local ENU coordinate frame (sigma: **1 cm**)
  - **Heading** (sigma: **0.5° / baseline** [m]) and rate of heading
  - Baseline length (sigma = 1 cm)
  - For more than 2 receivers: 3D attitude (roll, pitch, yaw)
  - Phase residuals
  - Supports NMEA standard
  - Update rate according to rate of measurements (5 Hz or better)

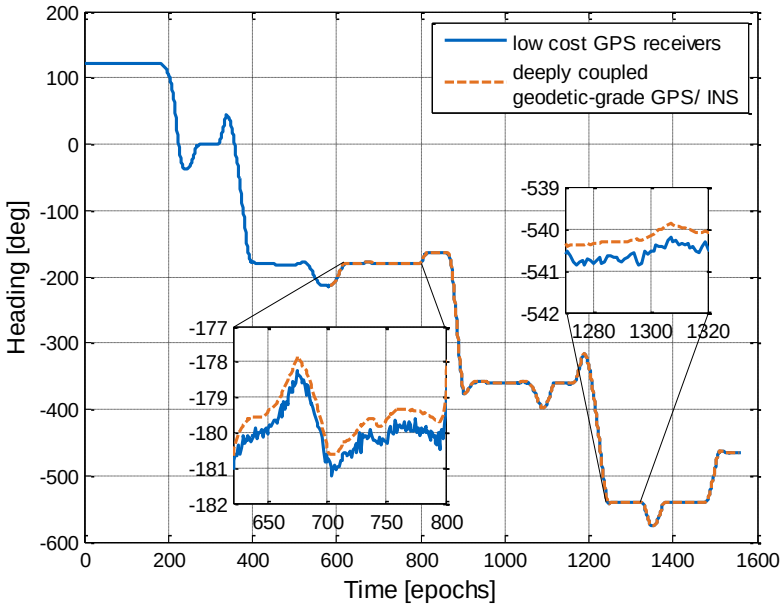
4. Driving assistance systems using two 2 low-cost u-blox GPS receivers

- Skidding detection / prevention
- A sensor for autonomous driving of cars
- Parking assistance
- Compass information for initial phase of driving



4. Driving assistance systems using two 2 low-cost GPS receivers

Heading determination with an accuracy of 0.5°/ baseline length [m]



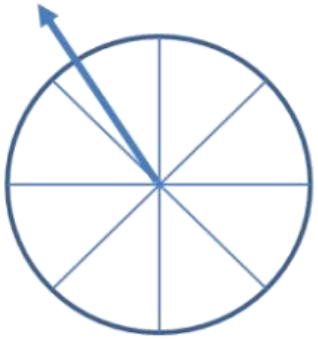
5. ESA-IAP project: driving assistance system for trucks

ASSISTANCE SYSTEM FOR TRUCK-TRAILER COMBINATIONS

Set drive mode to:

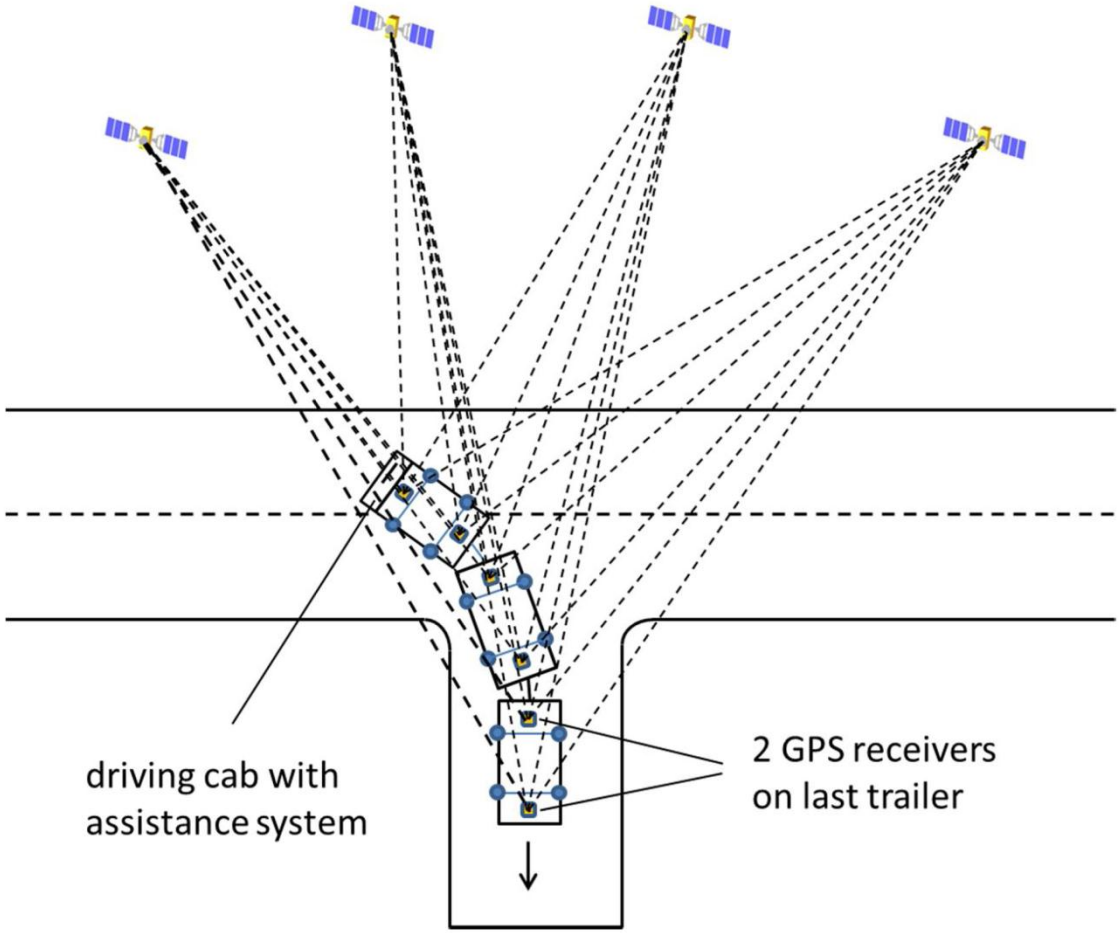
BACKWARDS

Turn driving wheel to position:

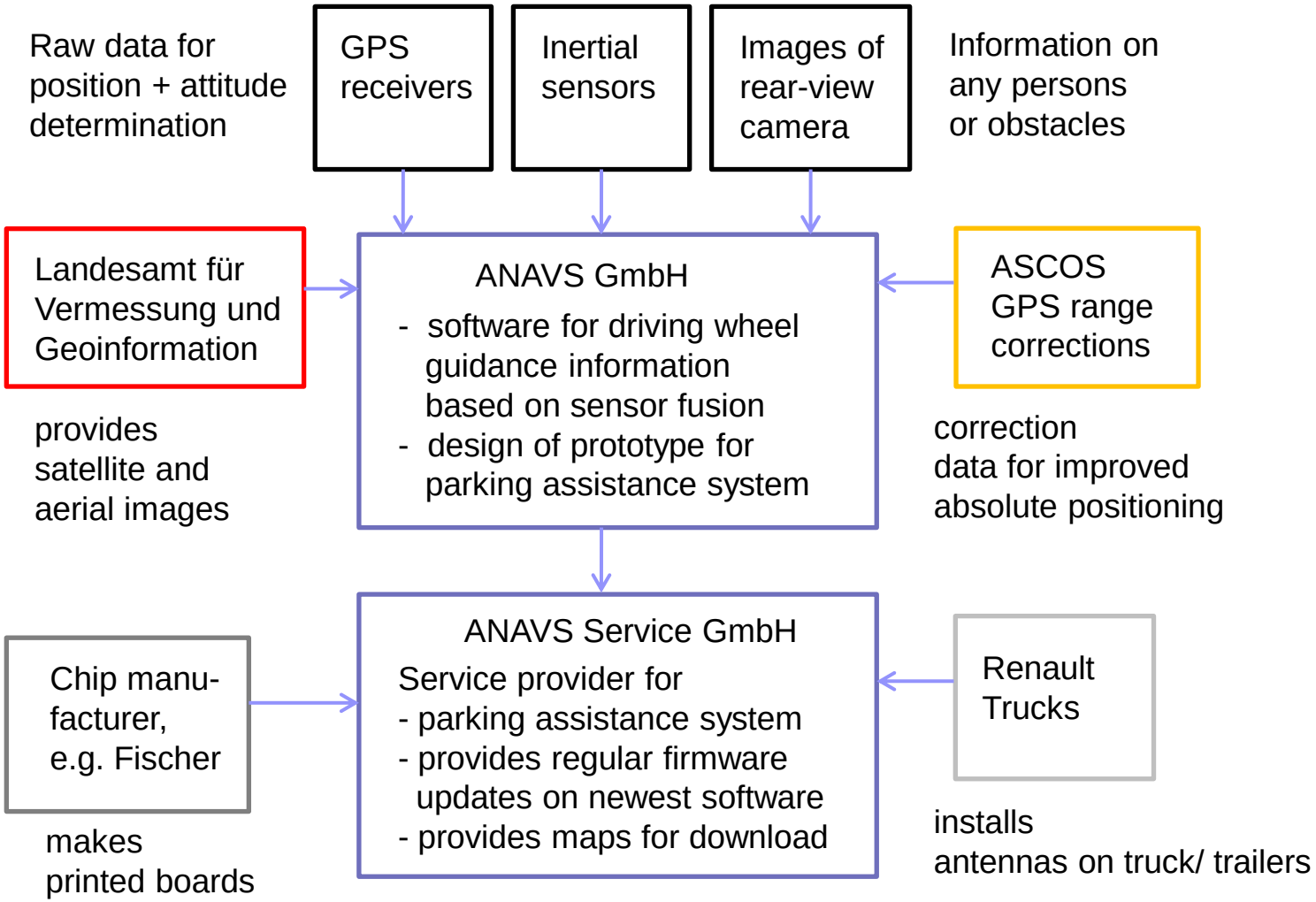


Distance to destination: **4.2 m**

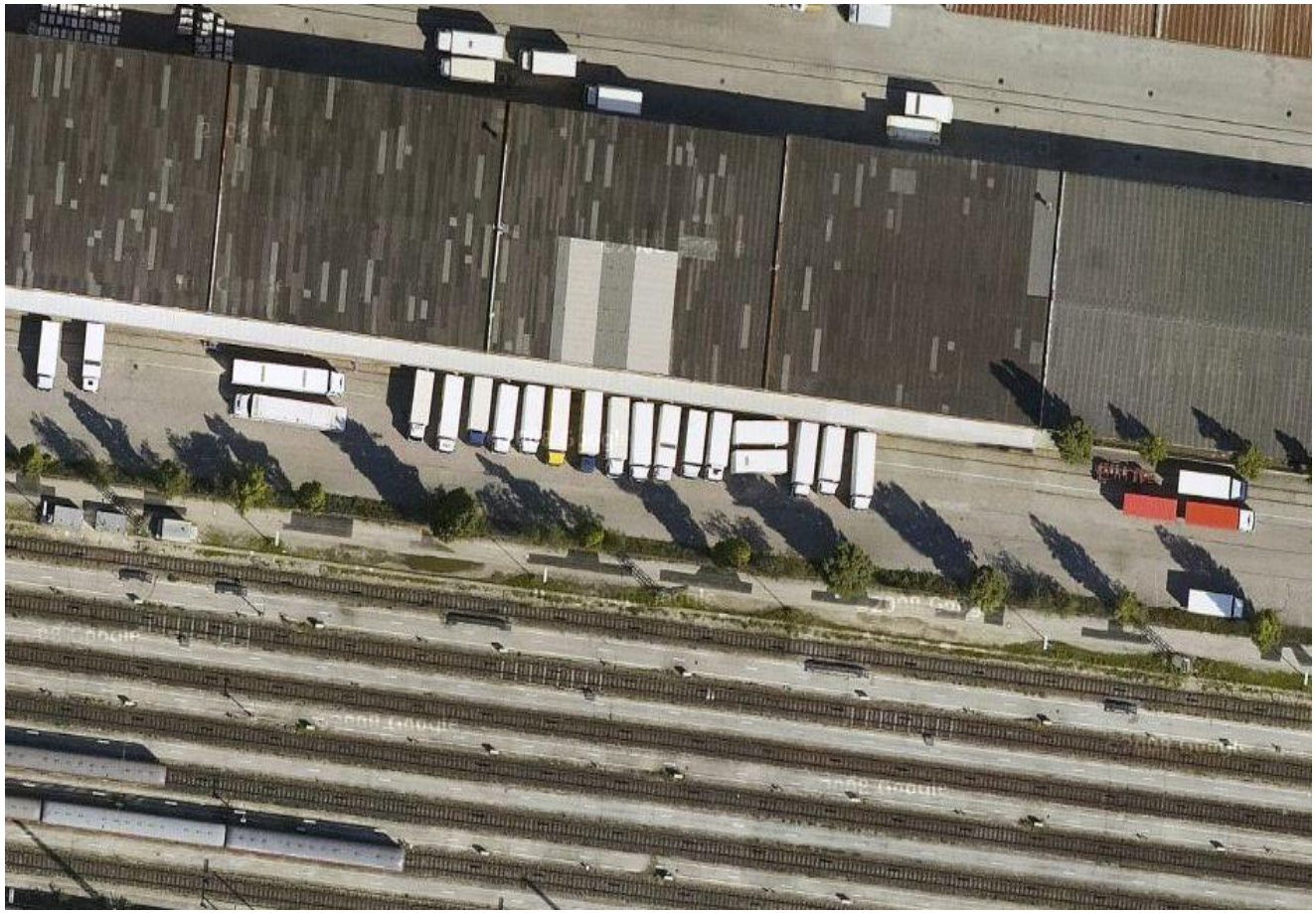
Driving assistance system for truck-trailer combinations



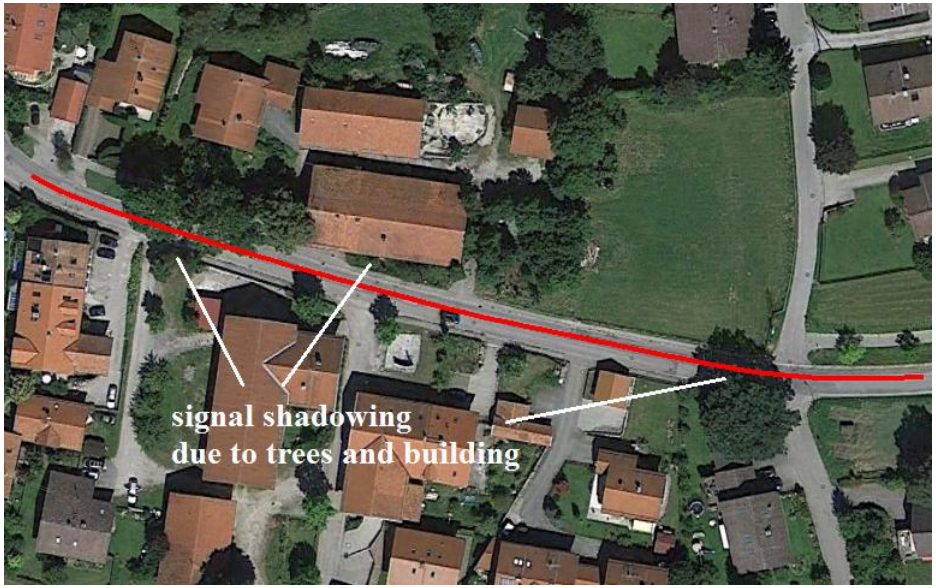
Driving assistance system for truck-trailer combinations

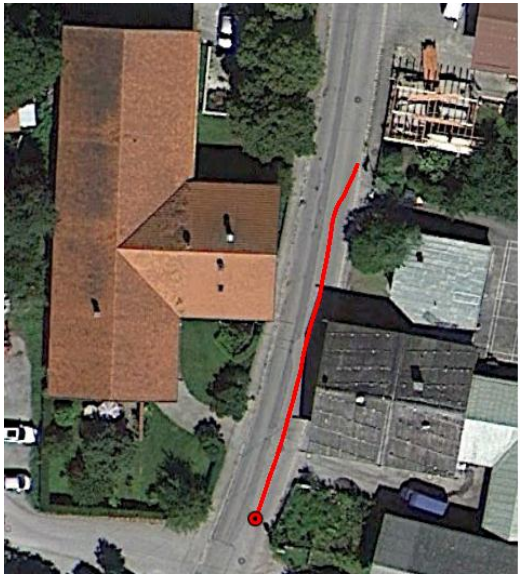


A potential user: Spedition Hillenbrand



GPS/ INS coupled heading determination with two u-blox LEA 6T GPS receivers





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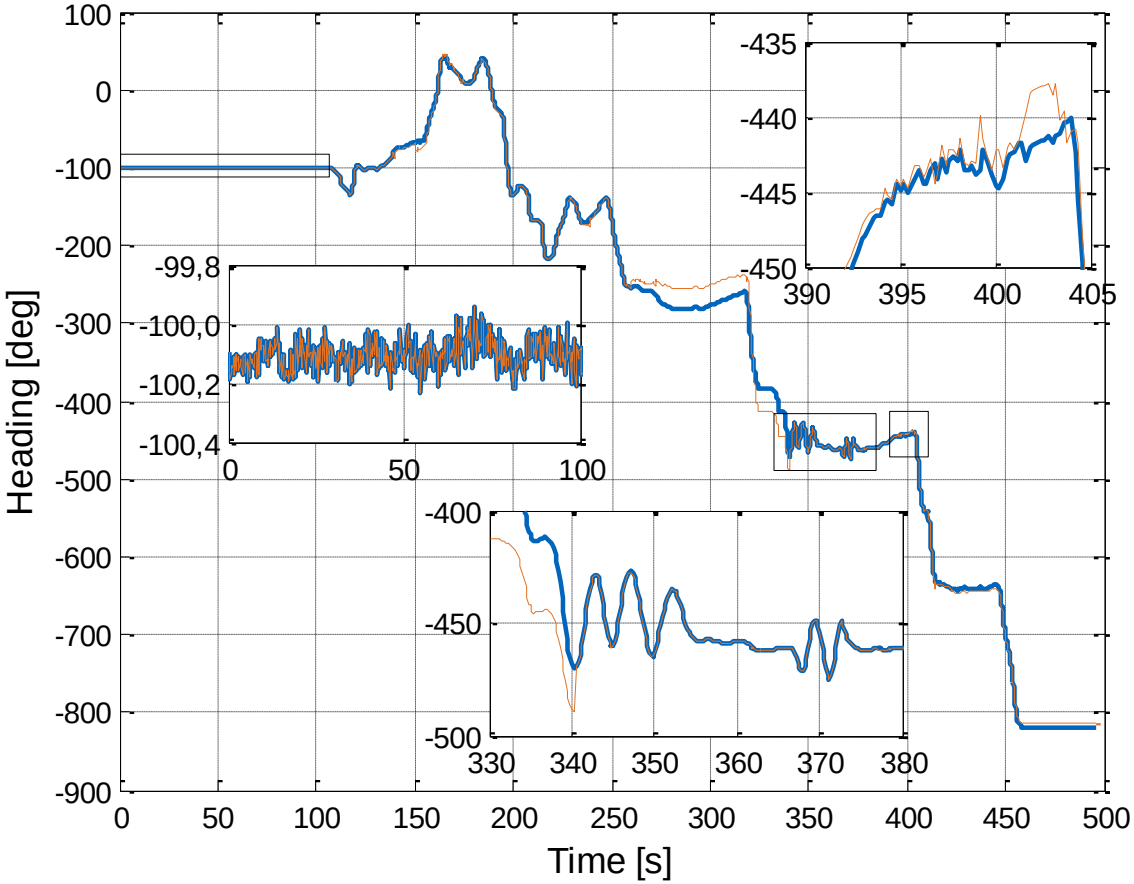
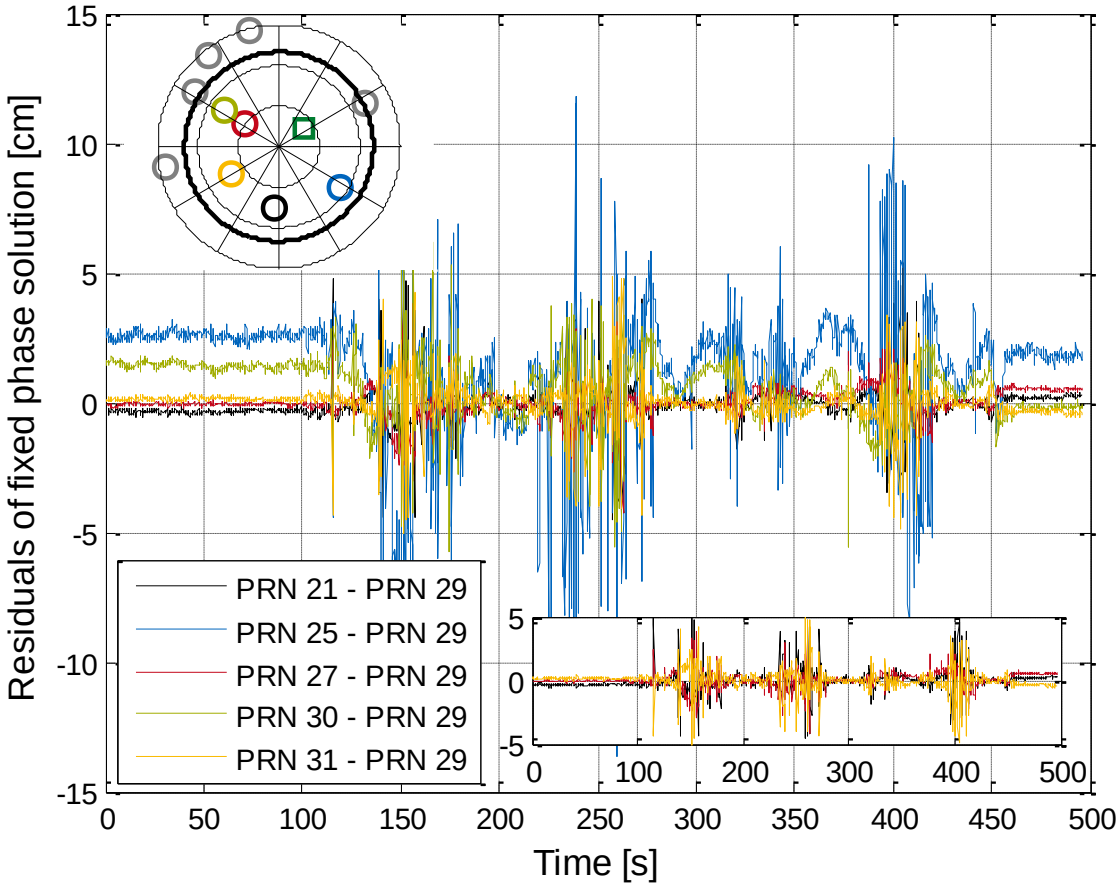
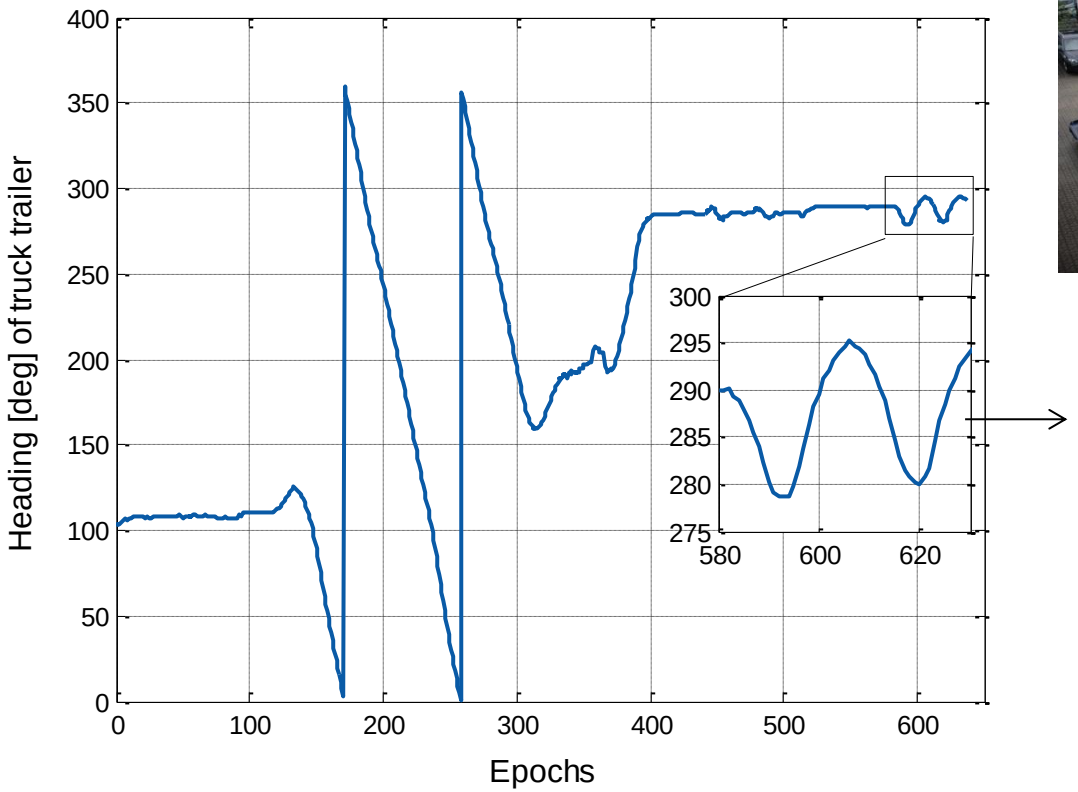


GPS/ INS coupled heading determination with two u-blox LEA 6T GPS receivers



Heading of trailer during test drive with Renault's Magnum truck

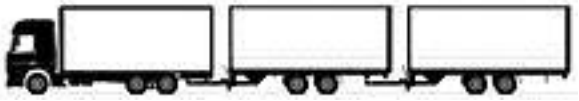


slalom drive

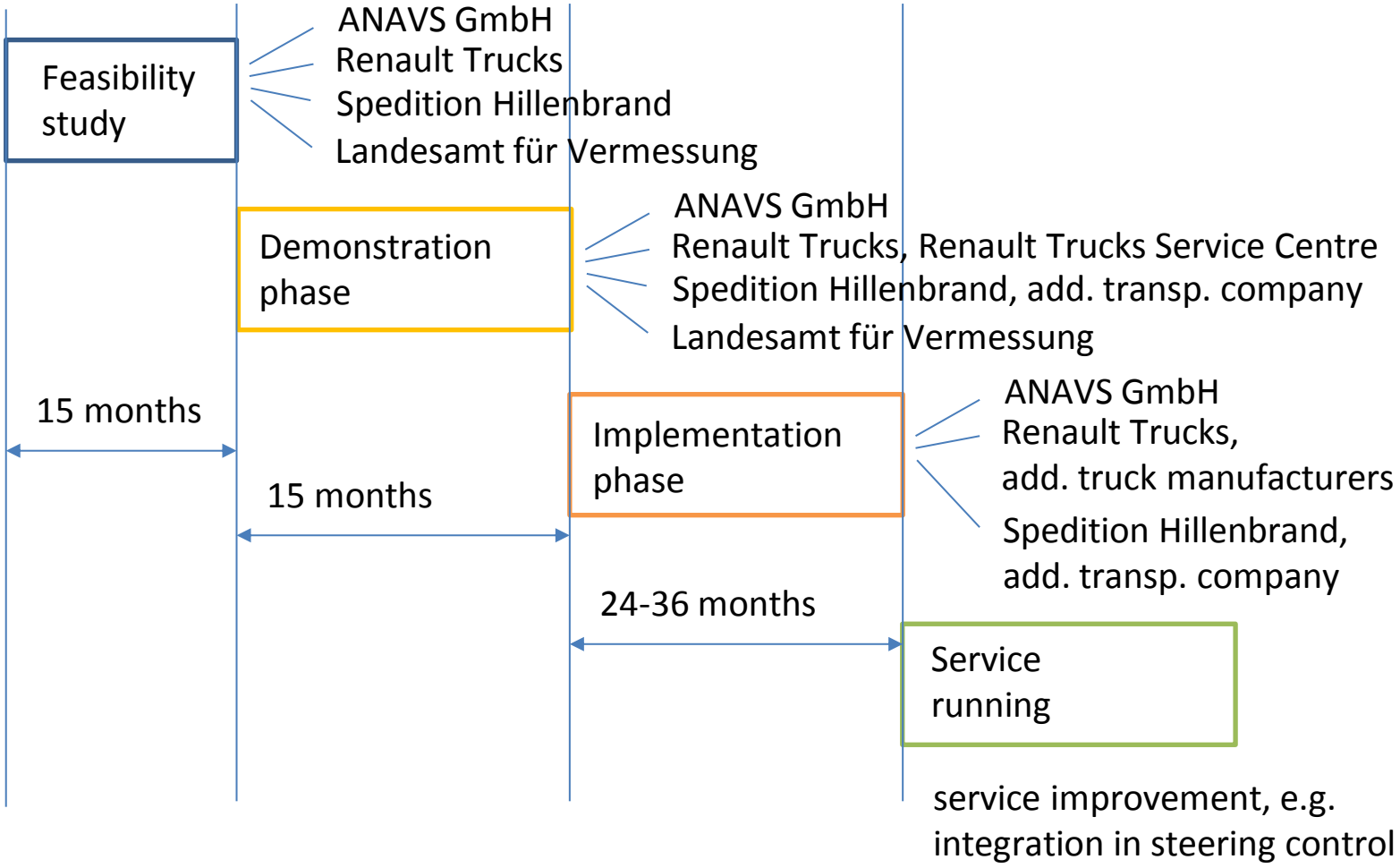
Some benefits of parking assistance systems for trucks

- enables wider use of long truck-trailer combinations and,
  thereby, a reduction of fuel and personnel costs for logistics/ transportation companies
- easy reverse driving on construction sites or other unpaved roads
- simplified reverse parking into narrow passages for unloading of freight
- no need of uncoupling of trailers and individually parking of each trailer
- enables reverse parking of single- and multi-trailer trucks in bad weather conditions (with rain drops or blinding lights on the truck mirrors)
- reduction of accidents and insurance costs

Truck-trailer systems

A train 	Motor tractor with swap body platform, dolly and semi-trailer - most frequently used EuroCombi/Gigaliner in the EU - high maneuverability and stability - dolly quite expensive
B train 	Semi-trailer tractor with semi-trailer and 2nd coupled trailer - frequently used EuroCombi/Gigaliner in the European Union - cheaper to realize than type A (no need for dolly) - maneuverability less good than in type A
C train 	Motor tractor with two coupled trailers, also called Road Train System (RTS) - very flexible solution, i.e. 2nd trailer can be easily decoupled - low number of axles limits cargo load to 48 tons

Roadmap to service provision



6. Advanced Navigation Solutions - ANAVS

- Partners and clients

Lehrstuhl für Kommunikation und Navigation
Technische Universität München

SWISS TIMING

esa

RENAULT TRUCKS

VOLVO

DLR

Precision in Inertial Navigation, Guidance, Surveying and Control
iMAR

AEVO

7. Patents

- **Patrick Henkel** and **Juan Manuel Cárdenas**, *Method for Determining a Baseline between Two Receivers*, European Patent Application, EP 12 199 772.0, application date: 28.12.2012.
- **Patrick Henkel** and **Patryk Jurkowski**, *Method for Determining the Heading of a Moving Object*, European Patent Application, EP 12 153 398.8, application date: 31.01.2012.
- **Patrick Henkel** and **Patryk Jurkowski**, *Maximum a posteriori probability ambiguity estimation with soft baseline length and orientation constraints*, European Patent Application, EP 2 479 588 A2, application date: 24.01.2011.
- **Patrick Henkel** and **Patryk Jurkowski**, *Verfahren und Vorrichtung zur Bestimmung der Relativposition zwischen zwei Empfängern und Verwendung der Vorrichtung zur Stabilisierung schwebender Lasten*, International Patent Application, PCT / EP2011 / 067554, 7.10.2011, priority date: 18.10.2010 based on application number 10 2010 038 257.4, publication date: 26.04.2012, WO 2012/052307.

8. Contact

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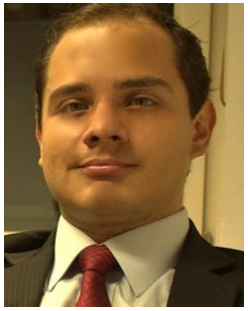

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Providing Orientation

Advanced Navigation Solutions