IPIF 2019

WP6

Kinematic Road Survey

IPIF 2019 - WP6

Topics:

- What is Integrated Navigation?
- Why do we need lever arms?

- Introduction to Applanix POS LV420 (PCS, IMU, DMI, GAMS,...)
- Introduction to GNSS reference concept

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What needs to be done at the field(work)?

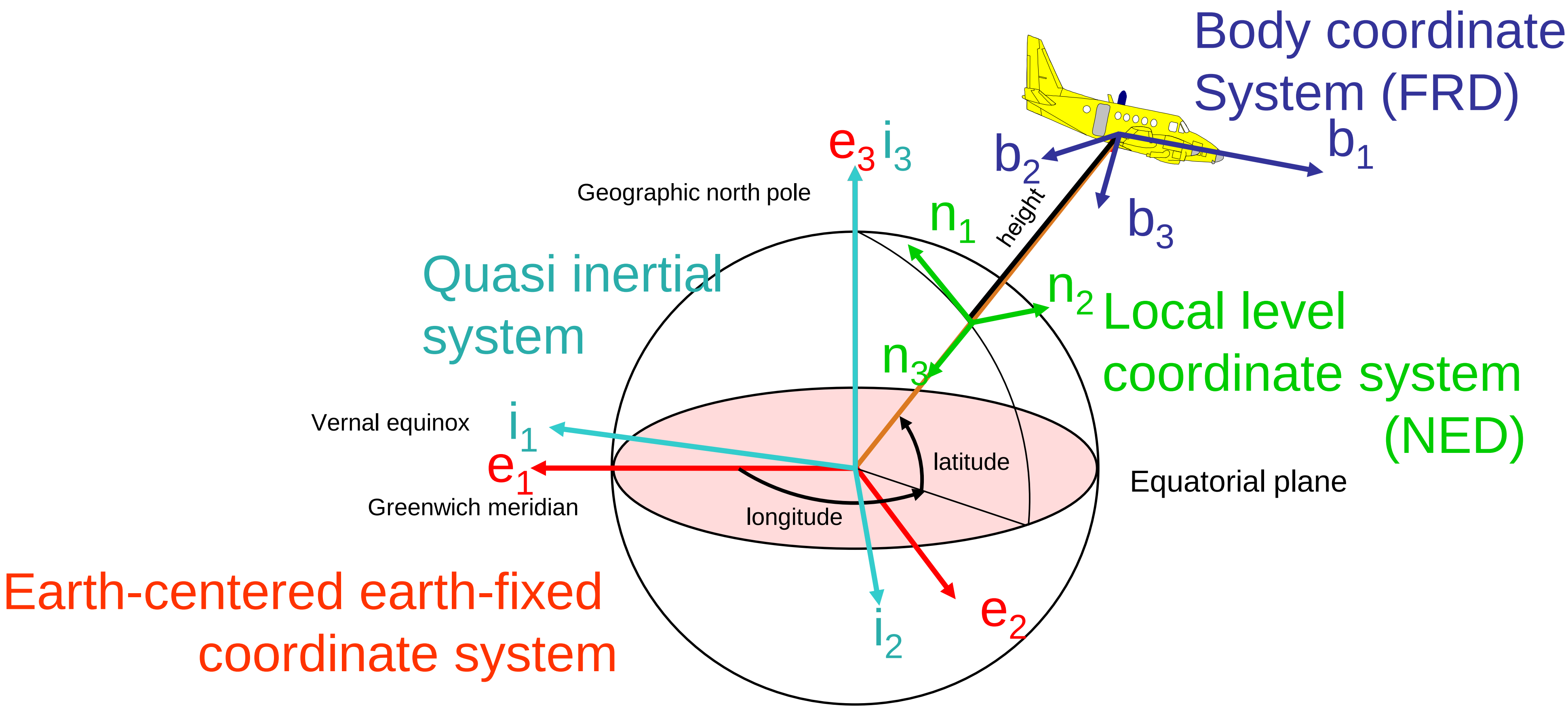
- Setup of Applanix POS LV420
  - leverarms, init drive, GAMS measurement
- (Setup of GNSS base) => Virtual Reference Station

- Drive the routes according to the road book and record data

- Data management
  - Applanix raw data, download and convert GNSS raw to RINEX,...
- Postprocessing using POSPac MMS
- Converting results into UTM frame

- Interpretation of results/delivering results to other WPs

Coordinate Systems



Integrated Navigation Systems, loosely coupled

<u>INS</u>

- Position, Velocity and Attitude
- High data rates
- Errors are potentially unbounded
- provides high-bandwidth attitude, position and velocity for vehicle guidance and control

<u>GPS</u> (one receiver)

- Position and Velocity
- Errors are bounded
- provides high-fidelity positions and velocities to calibrate the INS

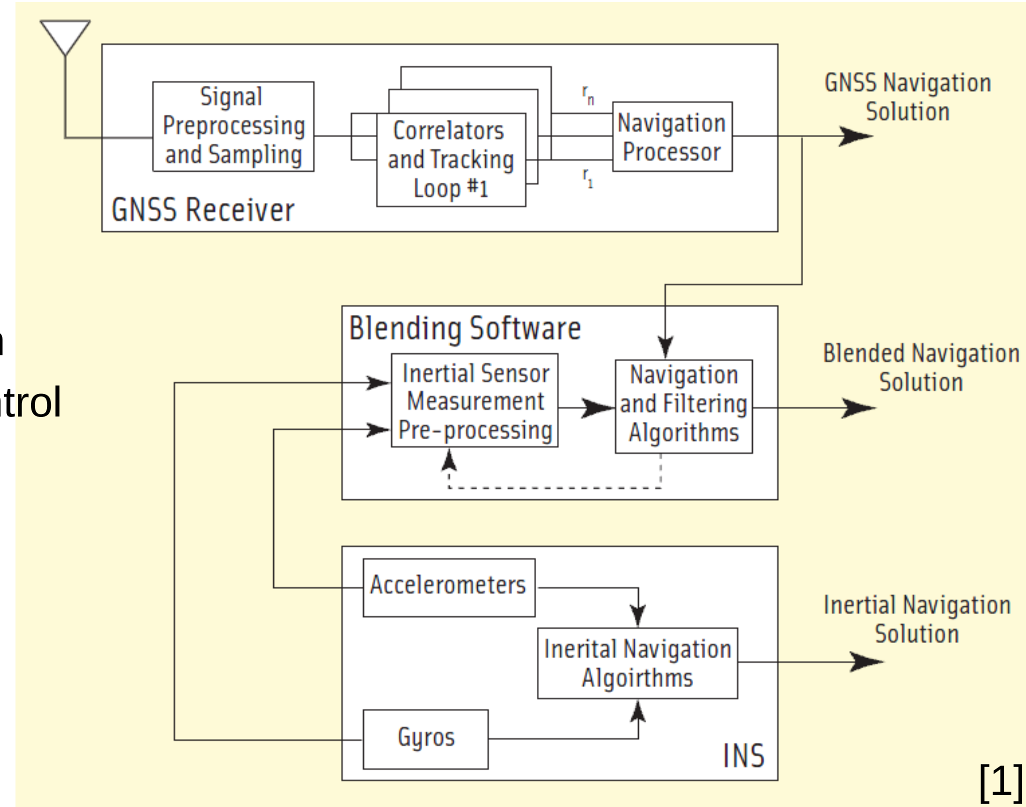


FIGURE 1 INS/GNSS Loose Integration

- two independent navigators
- combination of the advantages
- high redundancy

www.nav.uni-stuttgart.de

tight integration

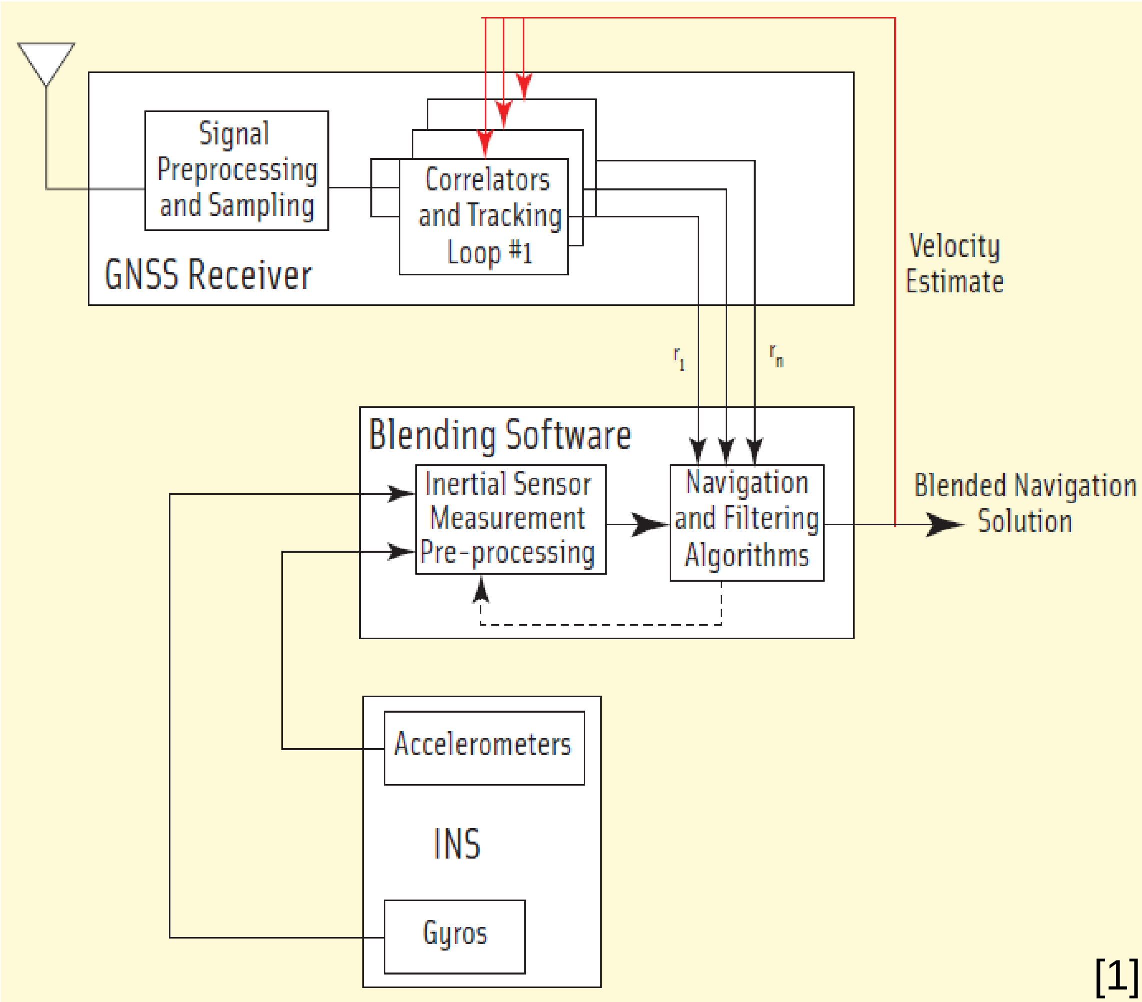


FIGURE 3 INS/GNSS Tight Integration (Alternate Definition)

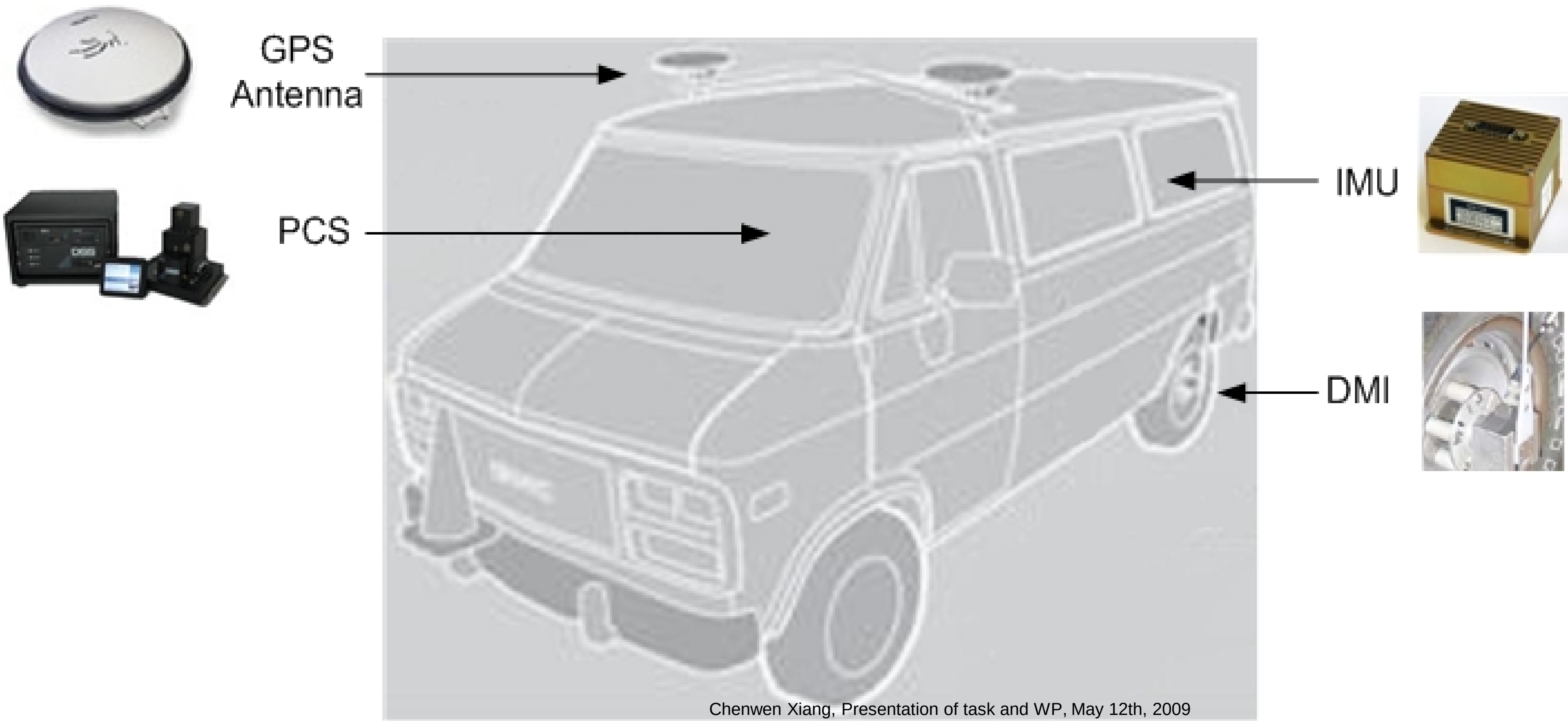
classic:

- INS and GNSS reduced to their sensor functions
  - pseudorange r
  - pseudorange rate
  - acceleration
  - rotational rate
- less redundancy

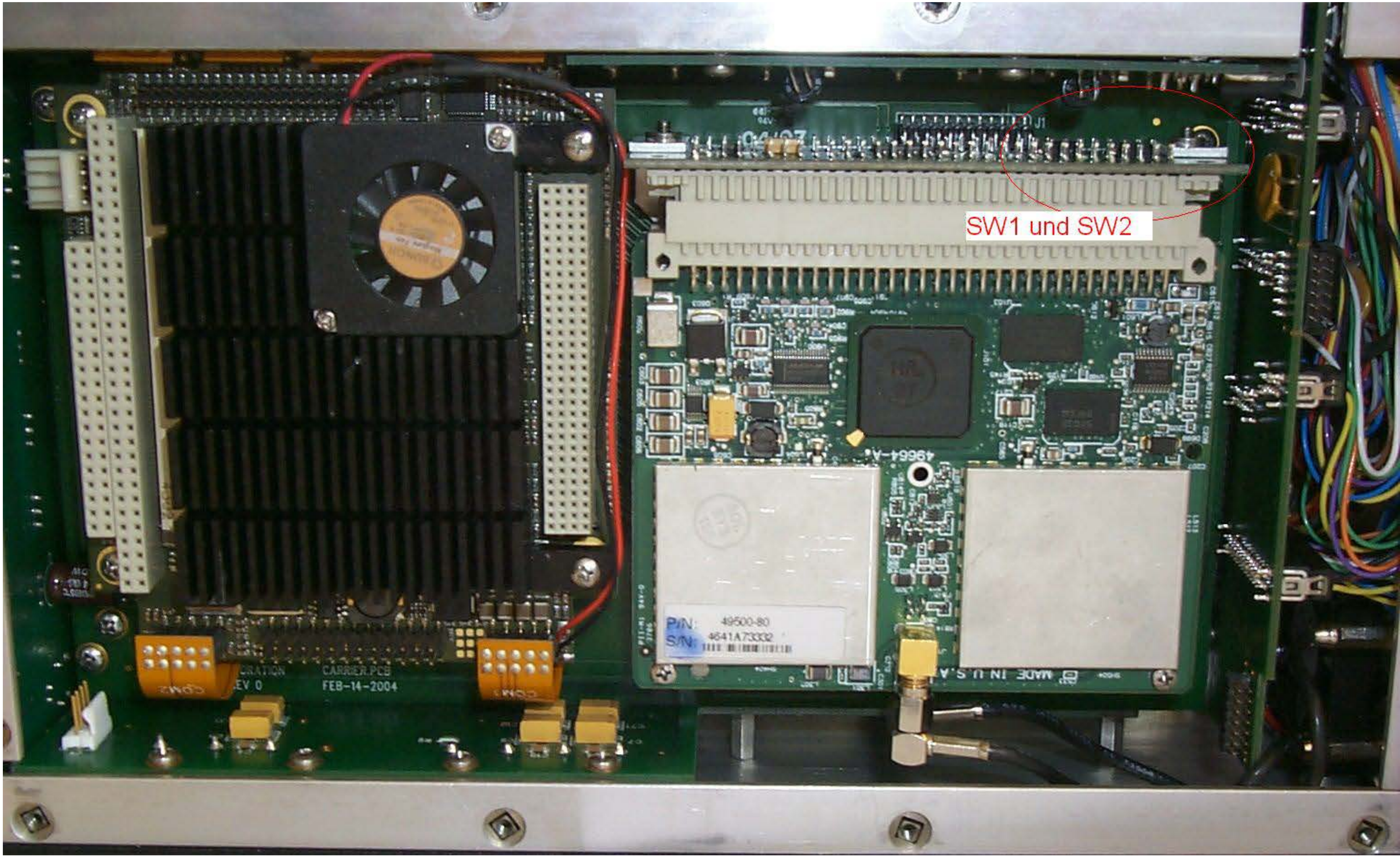
alternative:

- GNSS receiver performance improved by feed back information from the filter
- high dynamic maneuvers → better GNSS tracking
- less redundancy and independence

Applanix LV420 System



LV420 System (PCS open)



LN 200: Fiber Optic Gyroscope (FOG) IMU

Manufacturer: Northrop Grumman / Litton

3 gyroscopes
3 accelerometers

http://www.es.northropgrumman.com/solutions/ln200/assets/Inertial_Measurement_Unit_LN-2.pdf

Heritage:

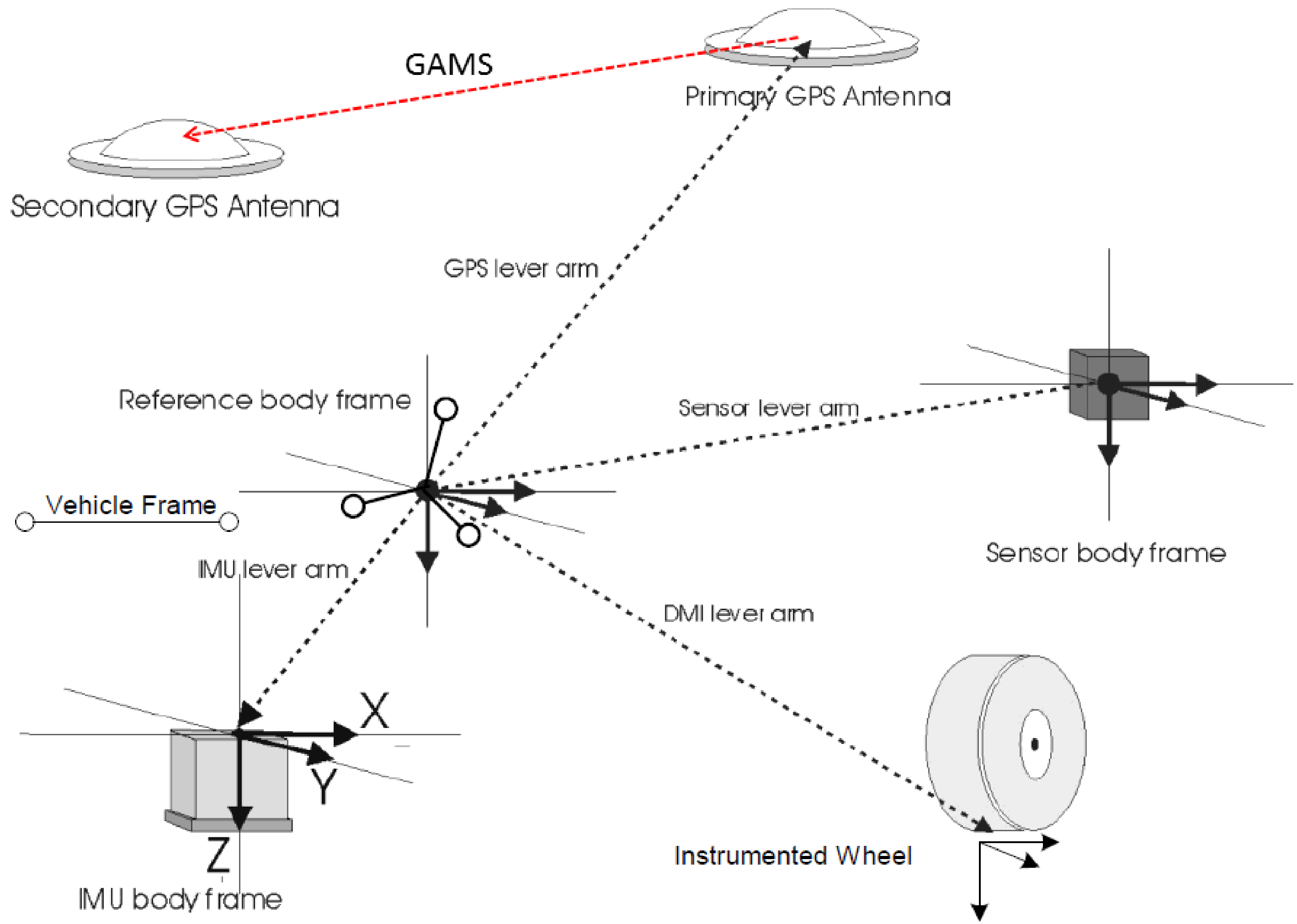
on the following platforms:

- Satellites
- UAV (Predator, …)
- INS Van

Applications:

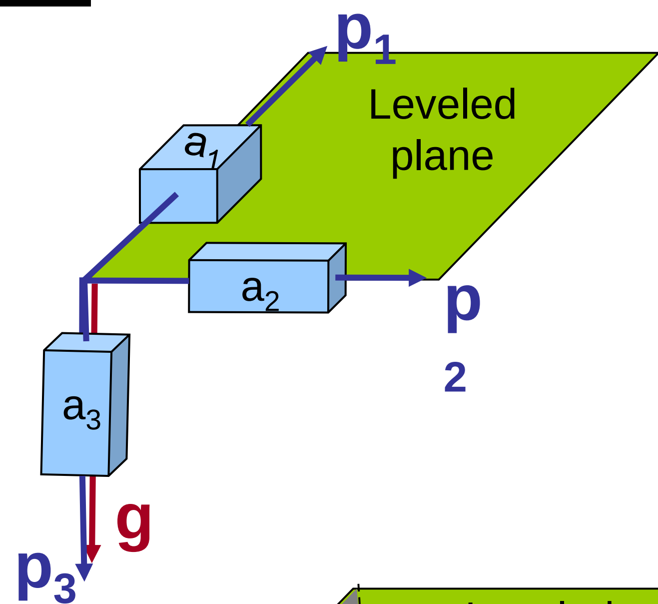
- camera/mapping
- space stabilization
- missile guidance
- radar/EO/FLIR stabilization
- motion compensation
- UUV/UAV guidance and control
- IMUs for higher order integrated systems

Applanix LV420 System lever arms



Theoretical Measurements of a <u>stationary</u> Accelerometer triad

Stationary Leveled Accelerometer Triad



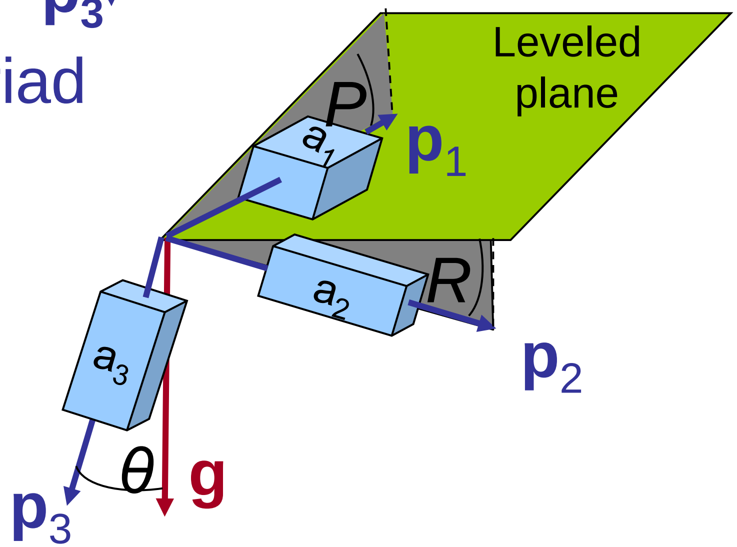
- Nominal Measurements:

$$a_1^p = 0$$

$$a_2^p = 0$$

$$a_3^p = g$$

Stationary Mis-Leveled Accelerometer Triad



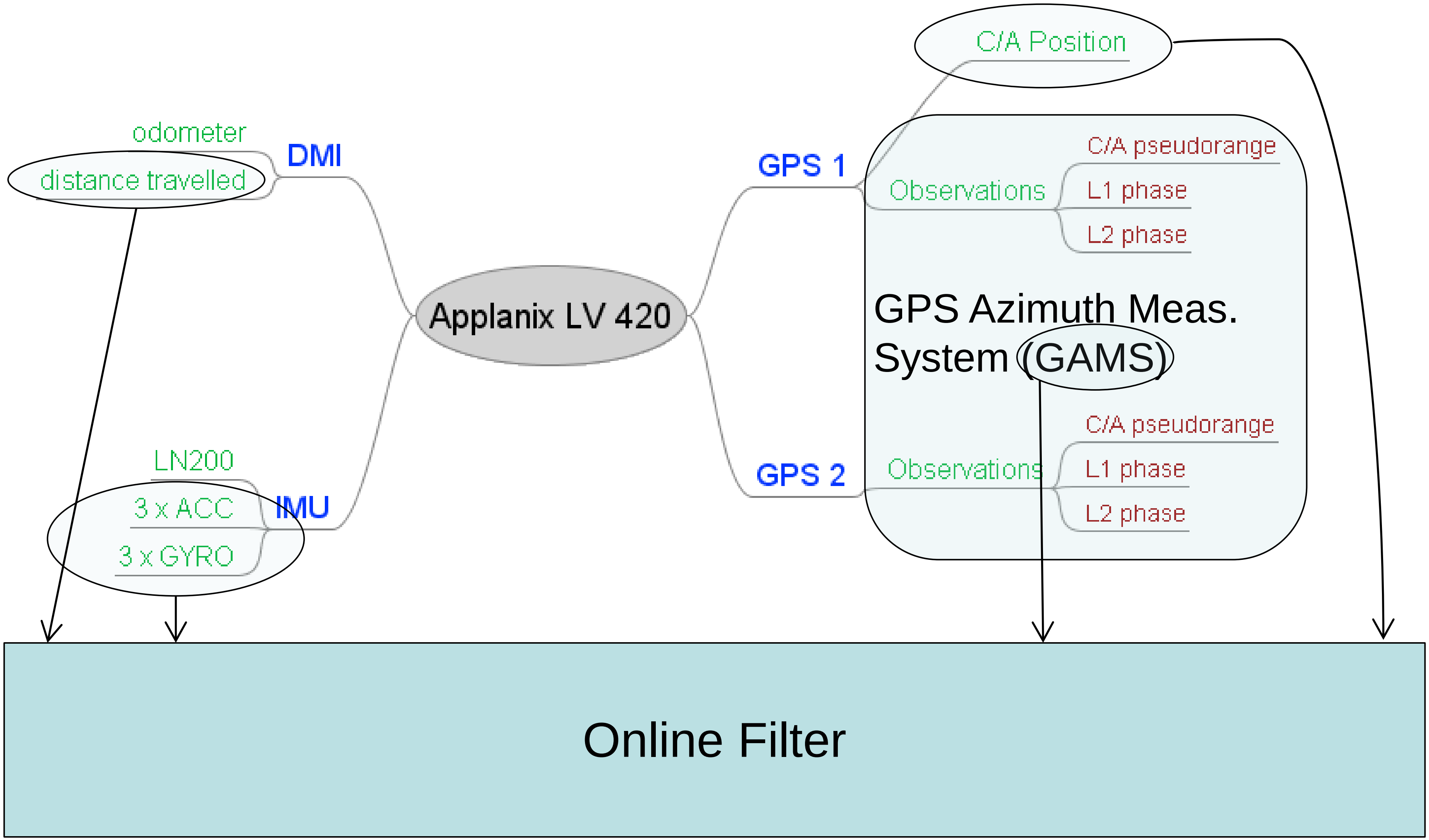
- Nominal measurements:

$$a_1^p = \pm g \sin P$$

$$a_2^p = \pm g \sin R$$

$$a_3^p = \quad g \cos\theta \quad \text{with} \quad \theta = \sqrt{R^2 + P^2}$$

Actual measurements = Nominal measurements + Errors


C/A Position
odometer
DMI
distance travelled
GPS 1
C/A pseudorange
Observations
L1 phase
L2 phase
Applanix LV 420
GPS Azimuth Meas. System (GAMS)
C/A pseudorange
LN200
Observations
L1 phase
GPS 2
3 x ACC
IMU
L2 phase
3 x GYRO
Online Filter

Post-processing

- Additional GNSS reference station
  - DGPS (Code&Carrier Phase) or RTK solution (Carrier Phase)
  - network solution possible (only with software PosPAC MMS)

- Processing steps
  - forward
  - backward
  - smoothing

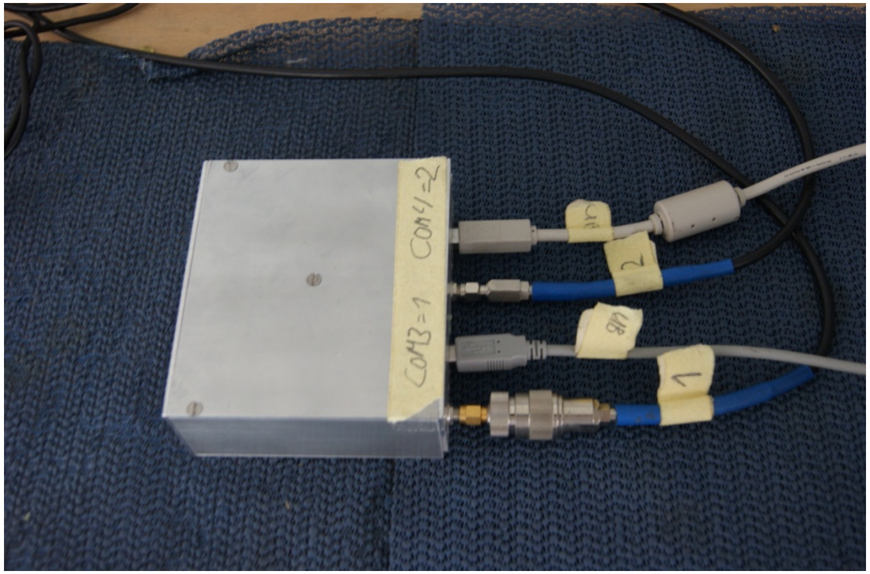
- Output
  - Time, 3D position, 3D velocity, 3D attitude
  - Output estimated lever arm / alignment
  - coordinate transformation (-> UTM)

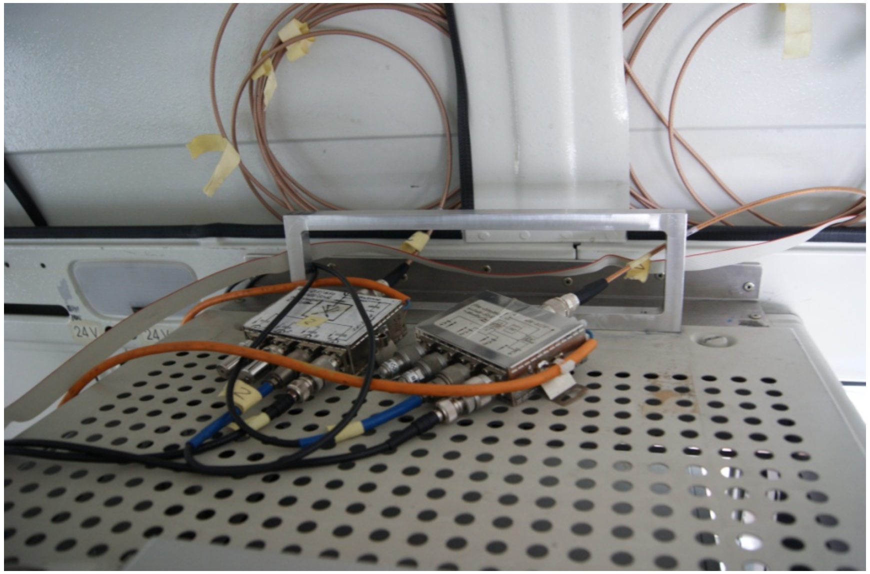
Van outside (LB20090812)

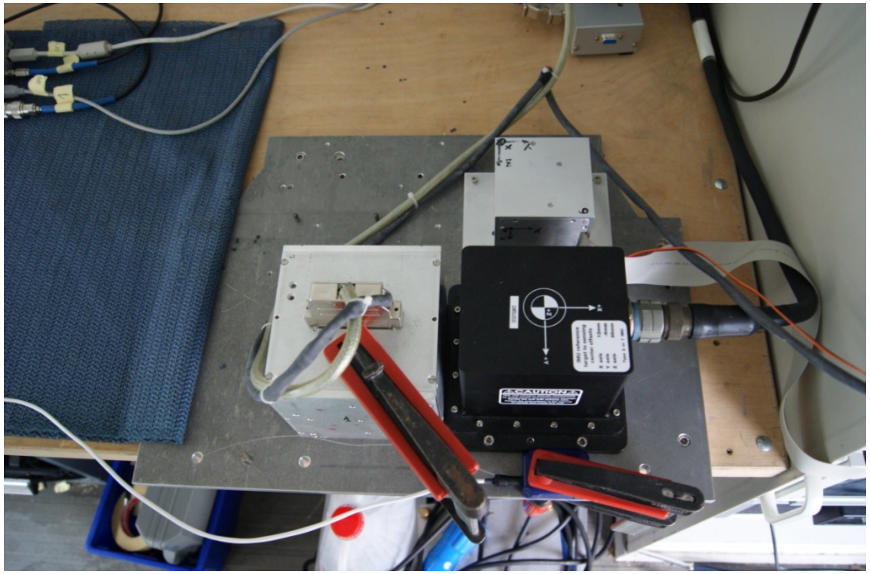
Distance Measurement Indicator (DMI), antenna 2 und 1

Van inside (LB20090812)

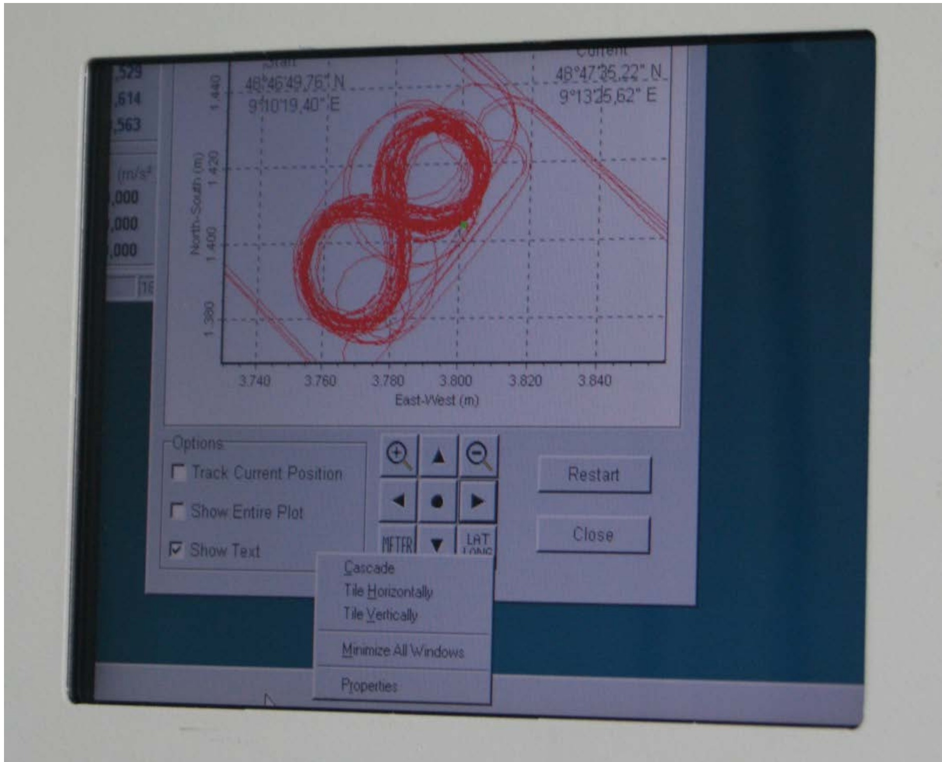
Van inside, Wasen20100729

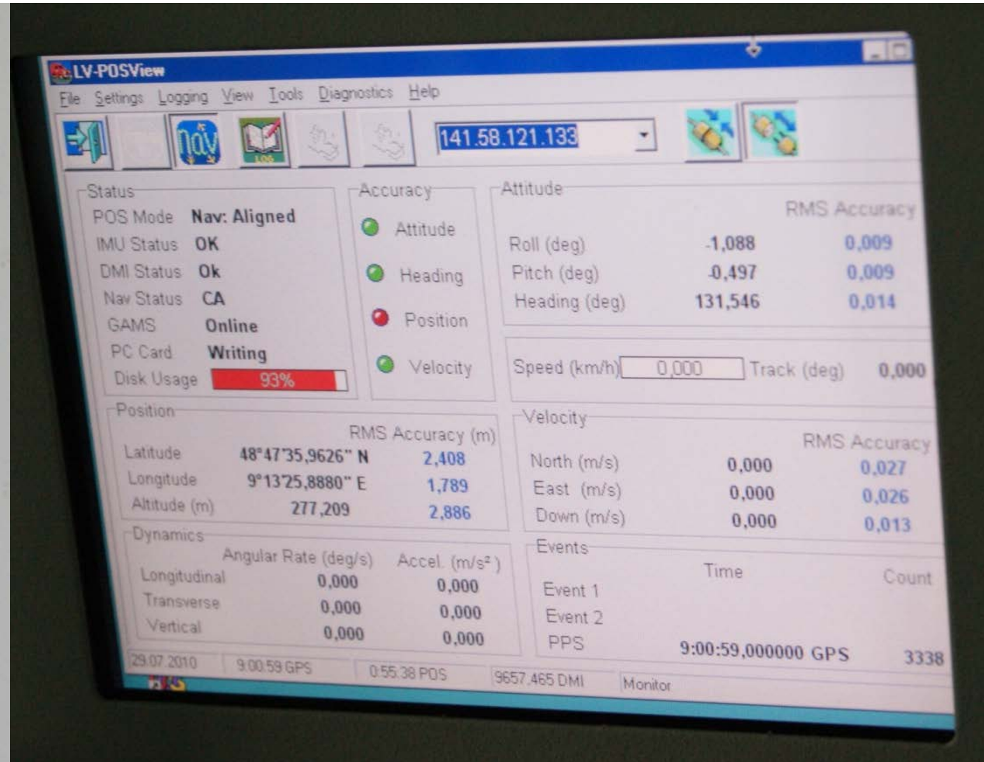




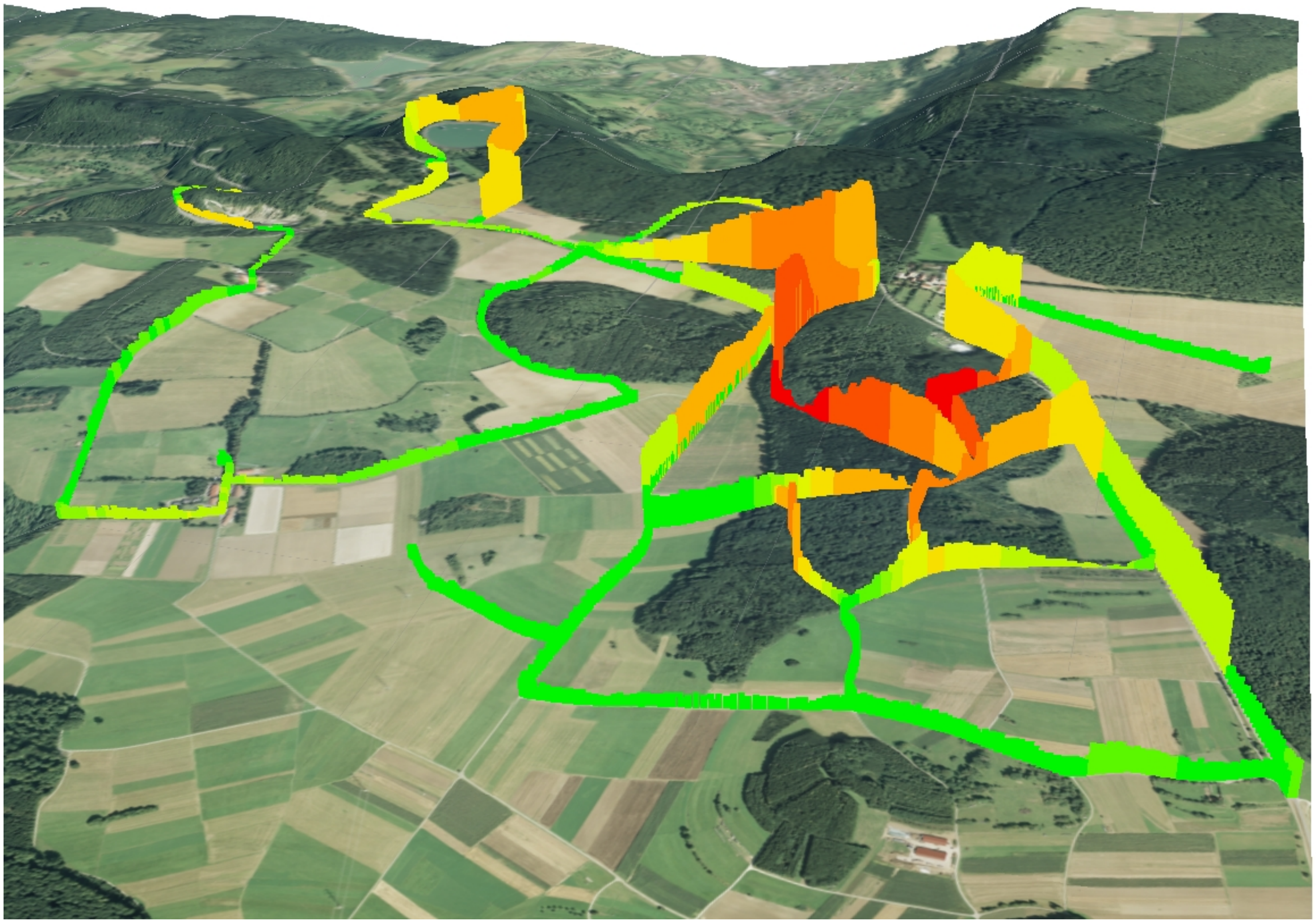


Applanix LV420 *online*





IPIF2009



Literature

[1] Gebre-Egziabher, Demoz; 2007: What is the difference between 'loose', 'tight','ultra-tight' and 'deep' integration strategies for INS and GNSS? In: InsideGNSS (2007), No. 1, page 28-33. http://www.insidegnss.com/auto/JanFeb07GNSSolutions (secured).pdf

recommended books:

[D] **Wendel 2007** Wendel, Jan: *Integrierte Navigationssysteme : Sensordatenfusion, GPS und Inertiale Navigation / von Jan Wendel /// Sensordatenfusion, GPS und Inertiale Navigation.* München [u.a.] /// München : Oldenbourg, 2007. – ISBN 3-486-58160-0

[E] **Farrell 2008** Farrell, J.: *Aided navigation: GPS with high rate sensors.* McGraw-Hill, 2008

[E] **Aggarwal 2010** Aggarwal, Priyanka: *MEMS-based integrated navigation.* Artech House, 2010

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- What needs to be prepared for the fieldwork?

- What needs to be done for the brief description and presentation?

Work Flow (from previous project)

- **Hardware installation:** POS Computer System, inertial measurement unit, distance measurement indicator and two GPS antennas have to be installed properly to the vehicle.
- **Lever arm survey and parameters installation:** Lever arms describe the position relationship of every sensor in Cartesian coordinates. Those parameters mainly come from an old work package and have to be re-survey and checked. They need to be put into LV-POSView before measurements.
- **Kinematic survey:** Drive in the route which was previously planned and attention should be paid about the front panel of LV-POSView, a red light indicates that correspond sensors are not working properly.
- **Data post-processing:** Combine all the available data in software POSPac MMS and transform all the results in UTM coordinates using the 7 parameters from work package x.
- **Results entry to a GIS database:** Input all the results into ArcGIS? or QGIS, then results can be conveniently represented and analysed.

- Results should be
  - Route survey with accuracy discussion
  - Height profile of the routes
  - Height profile of the landing strips (comparision with DTM)