Investigación y desarrollo en el más allá

I Congreso en Ingeniería Geomática
Valencia
2017-07-05/06

GeoNumerics
Av. Carl Friedrich Gauss, 11
Parc Mediterrani de la Tecnologia
E-08860 Castelldefels
Spain

I. Colomina

2017-07-05, v. 1.0

Investigación y desarrollo [en geomática y navegación] en el más allá [de la Universidad]

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Me

The company

GeoNumerics is a small team with a long experience dedicated to geomatics and navigation.

Awarded the “Innovative SME” seal by the Spanish Ministry of Economy and Knowledge (2015-12) for the period 2016-2018.

About our people

- age range 27 y
- age average 44 y
- gender balance 40/60
- PhD 60%
- international 20%
- telework 25%
- Students + 20%

Our mission & values

MISSION

GeoNumerics primary goal is to develop state-of-the-art geomatic software and deliver outstanding services to the geomatic community.

WE VALUE

scientific and technical excellence,
consistency and detail,
reliability and commitment,
creativity and innovation,
honesty,
teamwork,
trust and respect.

About our people

Men Wanted for Hazardous Journey

Men wanted for hazardous journey. Low wages, bitter cold, long hours of complete darkness. Safe return doubtful. Honour and recognition in event of success

29 December 1913, The Times

Attributed to Ernest H. Shackleton
Watkins, Julian 1959. The 100 Greatest Advertisements 1852-1958

About us and the world

- XXI century & the economy of knowledge
- knowledge companies (“R&D intensive”) and knowledge workers
- … technological excellence is a necessary condition for welfare
- … though not sufficient

- R&D system (public & private)
  - universities
  - research centres
  - technology & technology-transfer centres
  - **R&D intensive companies**

Our attitude

Simple can be harder than complex: you have to work hard to get your thinking clean to make it simple. But it's worth it in the end because once you get there, you can move mountains.

— Steve Jobs

There is nothing more practical than a good theory.

— James C. Maxwell

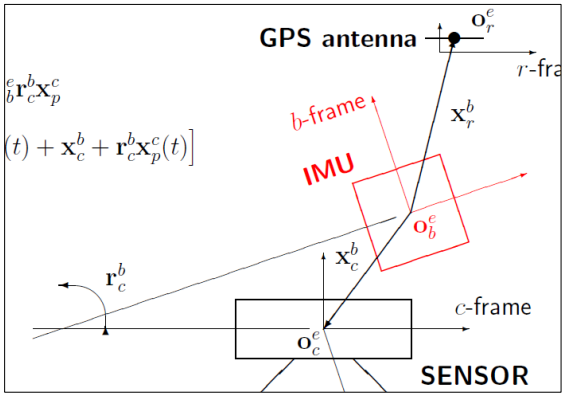
Less is more.

— Minimalist movement

ABOUT GEOMATICS & US - 1

- geodesy & navigation
- remote sensing [geometric] & photogrammetry
- cartography (modelling & visualization)

SENSOR ORIENTATION

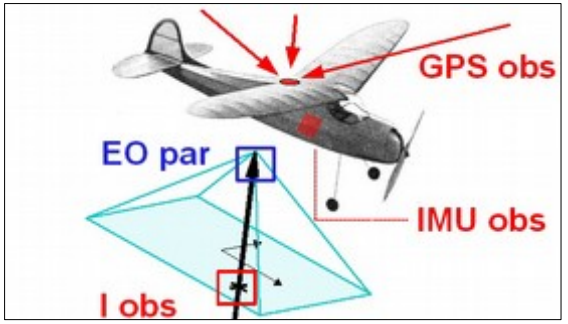


SENSOR CALIBRATION

$$\delta x = \hat{x}\left[k_1 r^2 + k_2 r^4 + k_3 r^{\prime} \right. \\ + b_1 \hat{x} + b_2 \hat{y} - 2 b_3 k + b^{\prime}$$

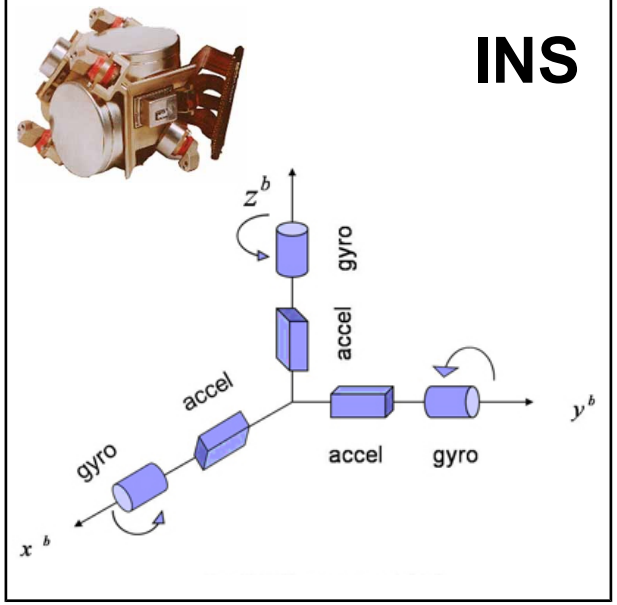
$$\delta y = \hat{y}\left[k_1 r^2 + k_2 r^4 + k_3 r^{\prime} \right. \\ - b_1 \hat{y} + b_2 \hat{x} + b_3 \hat{x}\hat{y} - b^{\prime}$$

INTEGRATED SENSOR ORIENTATION



GNSS

INS



UAS

since 2004

ABOUT US & GEOMATICS

- kinematic geodesy: trajectory determination tPVAG
- geometric remote sensing and photogrammetry
- graph navigation & system design

GAL COREGAL

ATENEA

mapKITE

Knowledge base

From our recordd

2004	dynamic networks: geodetic processing of inertial, odometer, ...	
2005	first photogrammetric project with unmanned aircraft	
2008	relative aerial control [INS/GNSS] no need for boresight matrix	
2011	**mapKITE**: tandem TMM + AMM (unmanned) + KGCPs (US, ES patent)	
2012	4D space-time calibration: use of [INS/GNSS-derived] tP**V**A	
2012	Fast AT: **accurate quasi-direct** sensor orientation with INS/GNSS	
2015	Use of Galileo E5 AltBOC codes for surveying and mapping	

Knowledge base

- years experience in **SW development of geomatic** kernels/engines,
- **fundamental geomatics technology (geodesy)**,
- **numerical algorithms (mathematical background)**,
- network modelling & adjustment **(post-mission methods)**,
- **precise geodetic positioning** with GPS and INS/GPS **(INS/GNSS).**
- **mono-sensor orientation** & **calibration**, **(modelling)**
- **multi-sensor system calibration** & **orientation**: frame cameras, line cameras, airborne LiDAR, mobile LiDAR, … **(estimation)**
- precise, accurate & reliable **navigation (real-time methods).**
- **drone-based remote-sensing**

TRAJECTORY DETERMINATION

- **real-time (navigation) theoretical basis**
  - IEKF: Iterative non-linear Extended Kalman filtering (classical)
  - ILS: Iterative non-linear Least-Squares filtering (innovative)
- **post-processing (orientation) theoretical basis**
  - IEKFS: IEKF and Smoothing (classical)
  - Dynamic Networks: DN, solution of Stochastic Differential Equations (SDE) with finite element-like approach
- **software is available for transfer or reference**
  - C/C++ (various compilers and processor architectures)
  - tested, verified & validated (ESA standards)
  - proven in various projects (private, public, institutional partners/clients)

Drone applications

- **design & development of**
  data acquisition, time tagging & navigation HW**/SW systems**
  (for research and transfer to industrial partners)
  - Linux & uC/OS (RTOS)
  - for autopilot systems, for remote sensing payloads
- **applications to**
  - Search-and-Rescue (SAR) with unmanned systems
  - close-range aerial photogrammetry and remote sensing
  - Smart-City surveillance & monitoring tasks (e.g.: thermal efficiency)
  - precision agriculture and environmental monitoring
  - planetary/asteroid navigation

PRODUCTS - R&D SERVICES - ADVANCED R&D

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PRODUCTS

SW engines & SW applications

R&D SERVICES

Feasibility analysis, tailored development

ADVANCED R&D

H2020-funded R&D projects, ...

PRODUCTS

SW engines

itavera.**GENA - G**eneric **E**xtensible **N**etwork **A**pproach

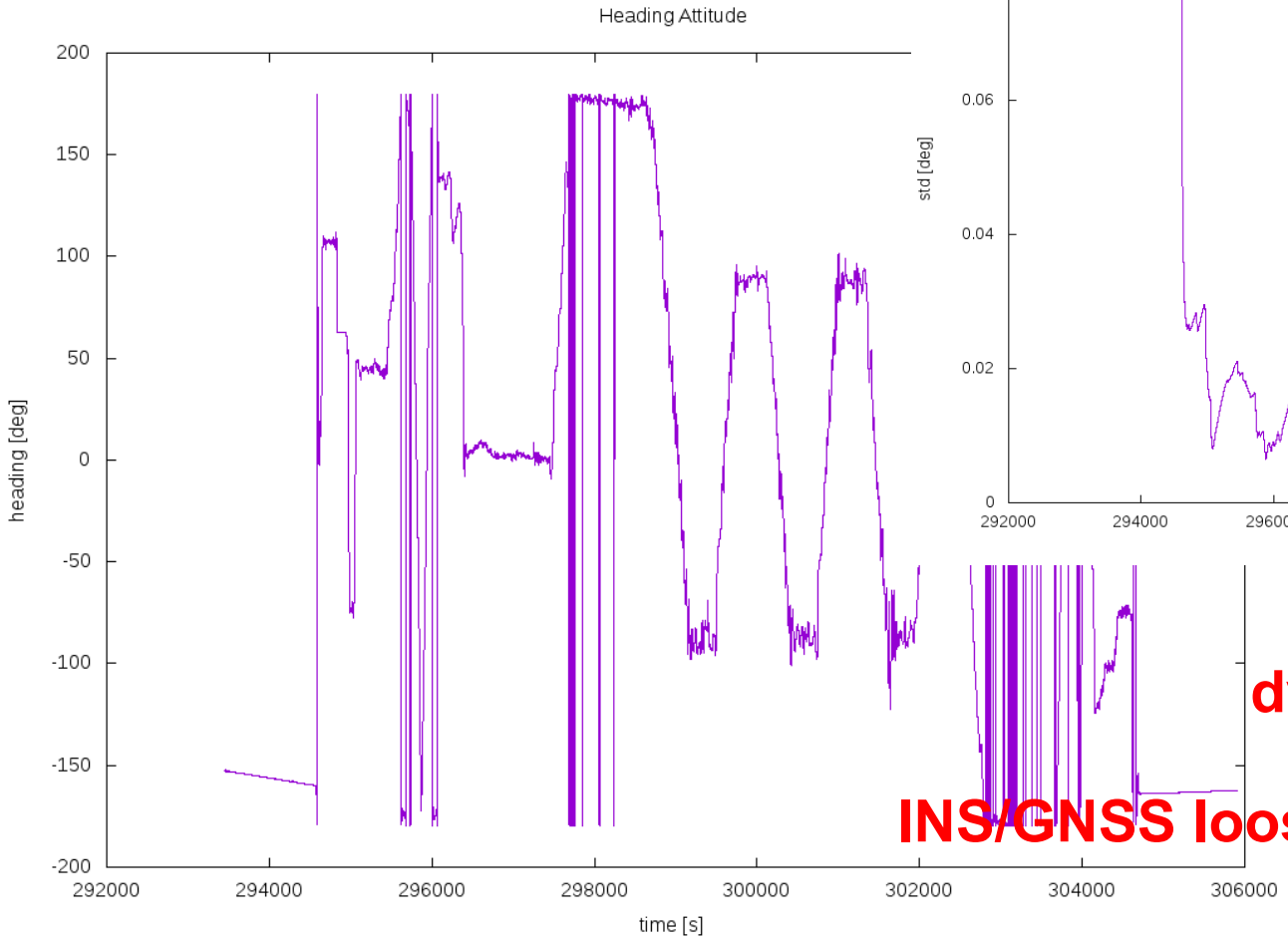
itavera.**NEXA - N**ew **E**xtensible **S**tate-**S**pace **A**pproach

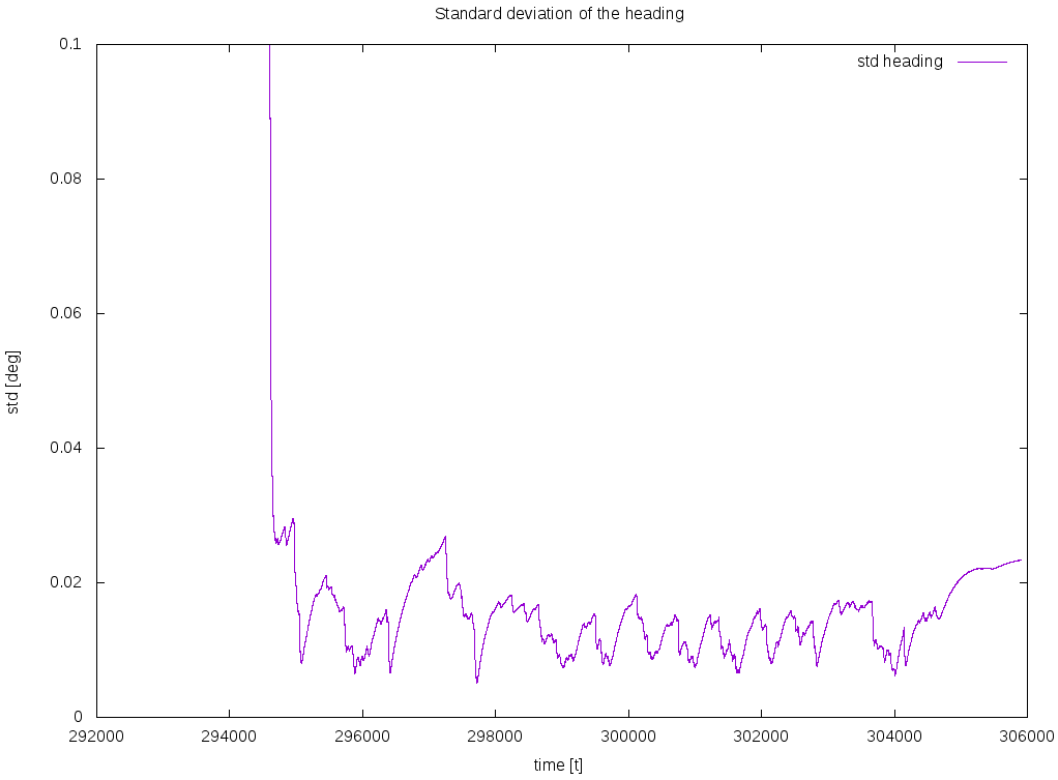
SW applications

gausbert.**CALIBRA -** Pre-calibration of sensors and sensor systems

gausbert.**ORIENTA -** Orientation/self-calibration of images, sensors and sensor systems

THE NEXA PLATFORM





dynamicSURVEY toolbox

INS/GNSS loosely coupled integration

THE NEXA PLATFORM

NEXA

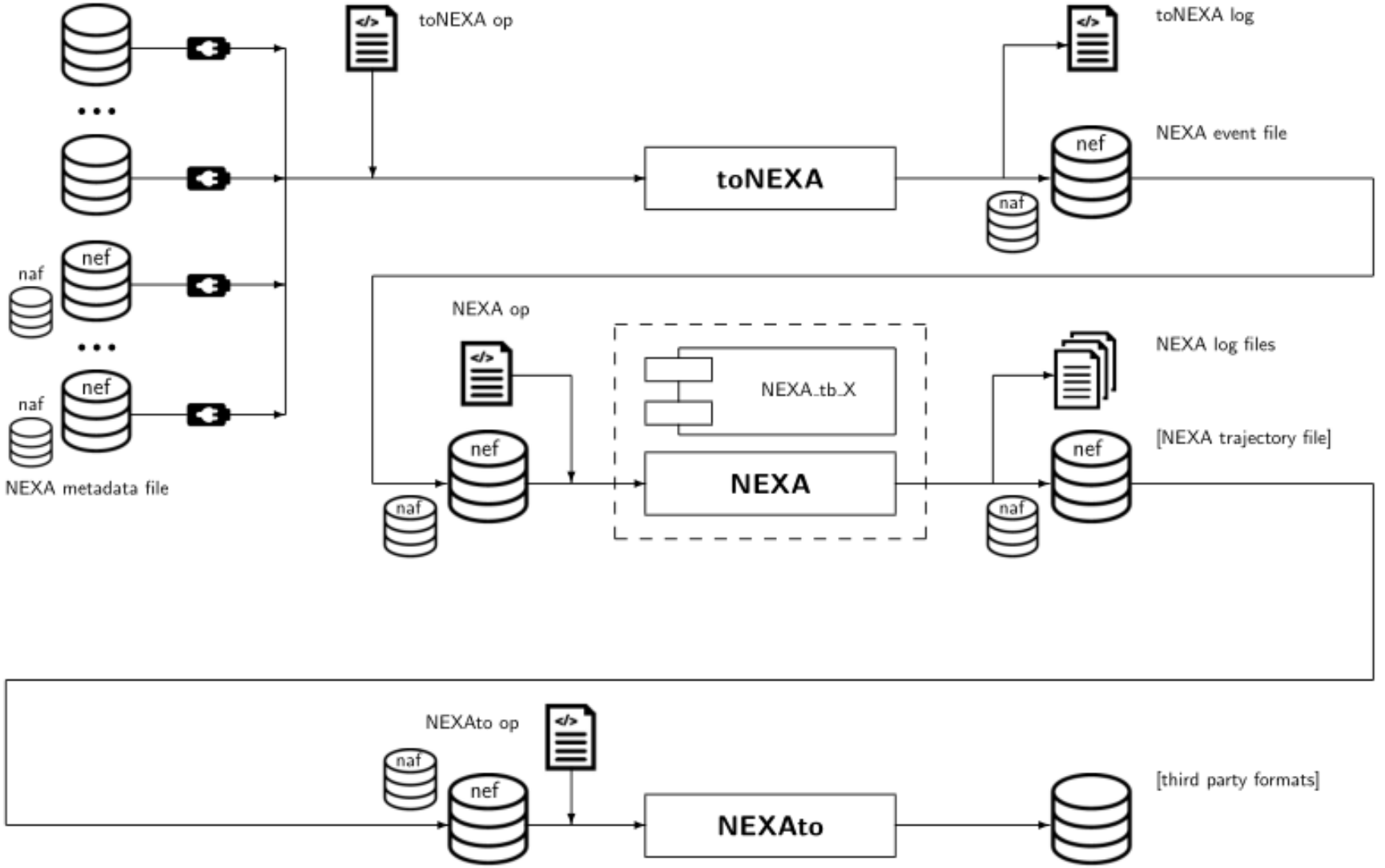
NEXA - New Extensible State-Space Approach

NEXA is a trajectory estimation SW platform, that delivers real-time and post-mission trajectories for applications in:

- geodetic and geophysical kinematic surveying,
- drone, plane, spacecraft photogrammetry, remote-sensing & geodesy,
  - INS/GNSS for airborne sensor orientation,
  - INS/GNSS for airborne kinematic gravimetry,
- terrestrial mobile mapping systems,
- high-precision structural vibration determination.

THE NEXA PLATFORM

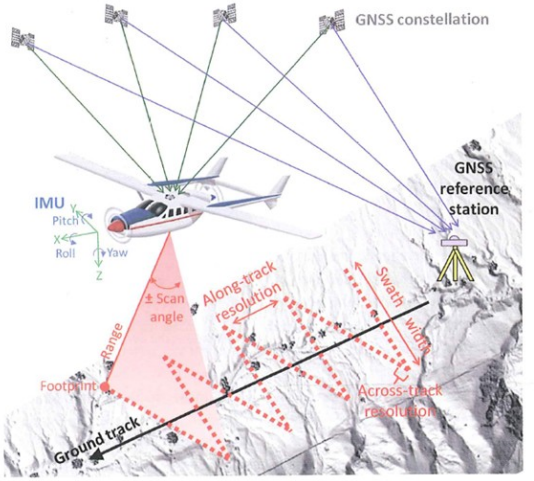
NEXA



THE GENA PLATFORM

GENA

$$
\begin{aligned}
g_1(\ell_1 + v_1\,, x_1, \ldots, x_p) &= 0 \\
\ldots & \\
g_n(\ell_m + v_m, x_q, \ldots, x_r) &= 0
\end{aligned}
$$



			latest record
n	number &/or type of models		
m	number &/or type of observations	$\approx$	**800.000.000**
r	number &/or type of unknowns	$\approx$	**650.000**

THE GENA PLATFORM

GENA

GENA - Generic Extensible Network Approach

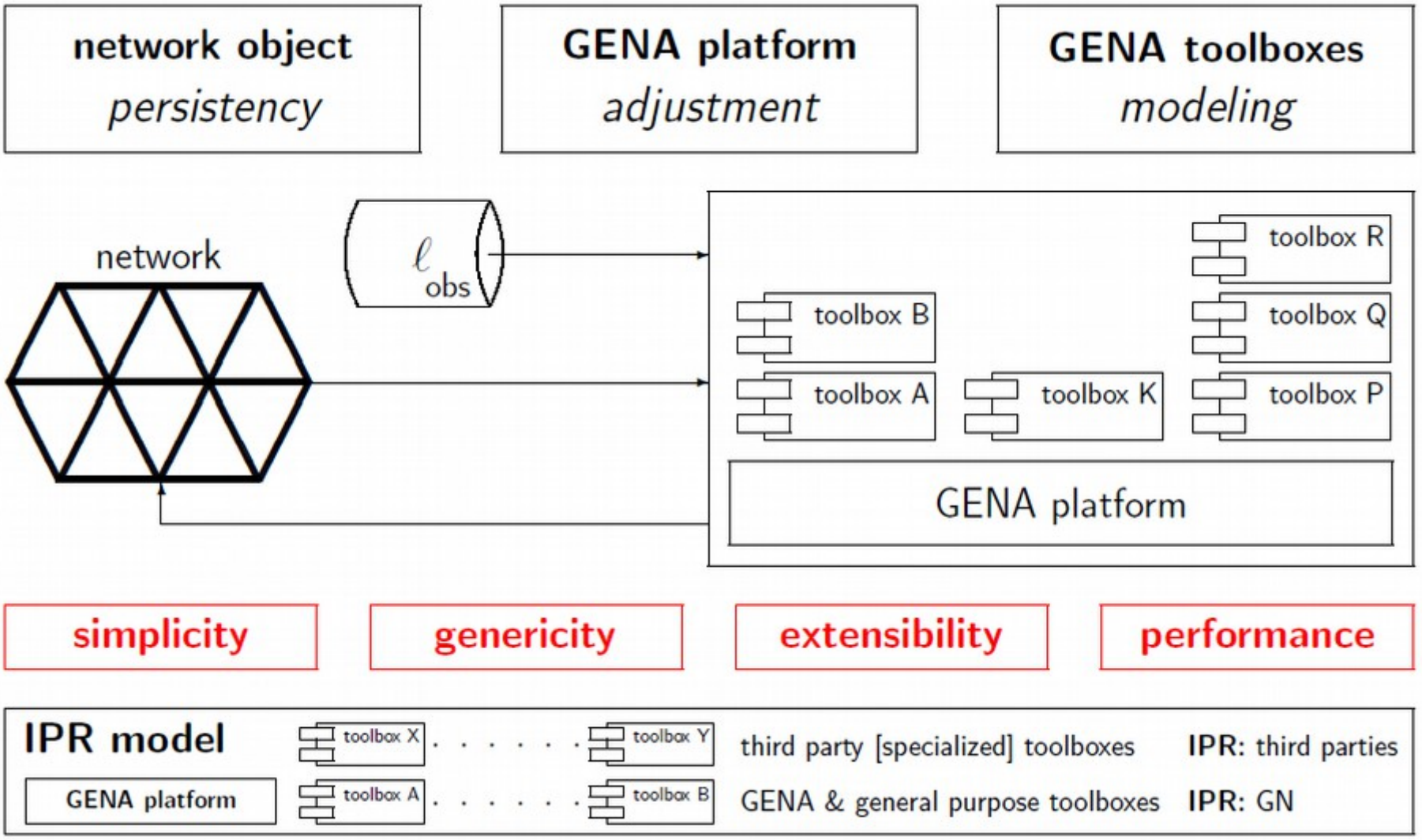
GENA is a network adjustment SW platform, that

enables network modeling and adjustment for applications in:

- geodetic surveying (geoSURVEY toolbox),
- airborne photogrammetry and remote-sensing (airVISION toolbox),
  - GPS/INS supported aerial triangulation,
  - integrated sensor orientation and calibration,
  - airborne LiDAR block adjustment,
- space remote-sensing (spaceVISION toolbox),
- high-precision static/dynamic surveying (dynamicSURVEY toolbox).

GENA SYSTEM CONCEPT

GENA



A RECORD OF APPLICATIONS

GENA

positioning	GNSS	GPS, Galileo	COREGAL, mapKITE
orientation	INS/GNSS/PARS	integrated sensor orientation (based on bundle adjustment)	mapKITE
kinematic gravimetry	INS/GNSS	dynamic networks	GAL
sensor calibration system calibration	cameras LiDAR	single, multi-head, aerial, ter-restrial, self-calibration	own research
sensor orientation	cameras, LiDAR INS/GNSS	synchronised, un-synchronised FAST-AT, KGCPs	mapKITE own research
sensor orientation spatio-temporal	INS/GNSS/PARS	simultaneous system time & space calibration & orientation	own research
trajectory repair	INS/GNSS/PARS	visual aiding for reconstruction of distorted trajectories	ATENEA
radar-antenna orientation	INS	IMU orientation & calibration, antenna pointing & orientation	own research

R&D SERVICES

OrbiSTAR

OrbiSTAR

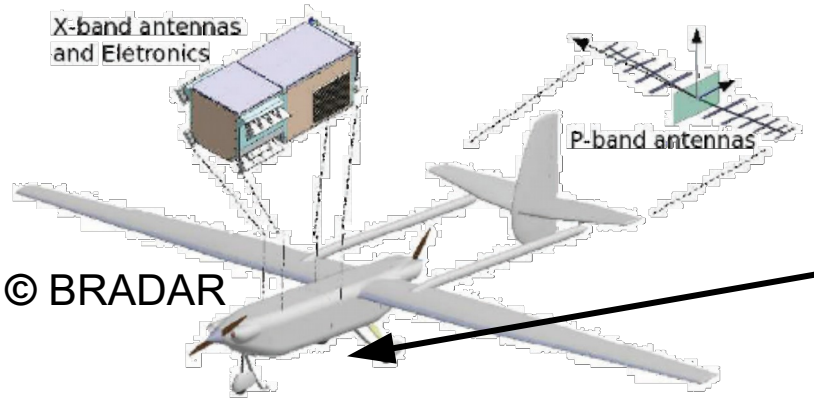
- Multispectral lightweight payload for the SARVANT remote sensing unmanned aerial system
- Geometric calibration of low-cost cameras
- ms-level synchronization of low-cost cameras
- Orientation with the FAST-AT method

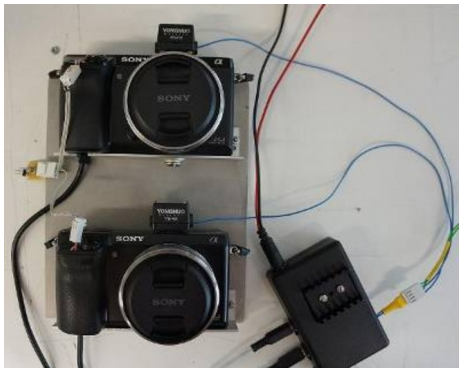
BRADAR

EMBRAER DEFESA & SEGURANÇA

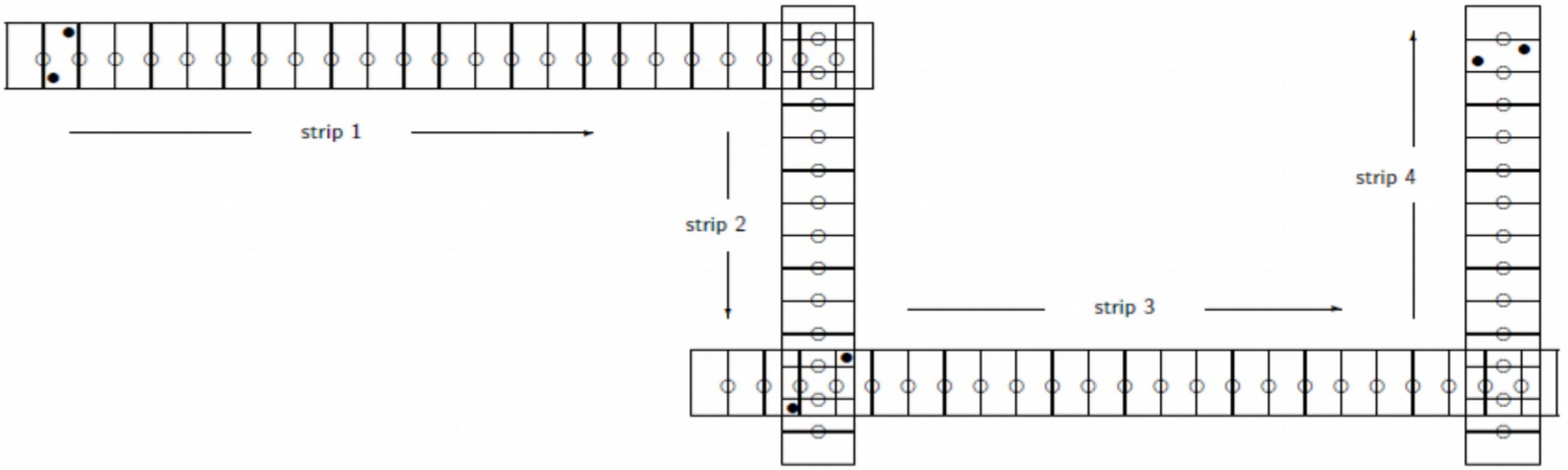
OrbiSTAR

Lightweight & low-cost multispectral remote sensing payload





FAST AT orientation method with GENA



M200-TONS

Timing, Orientation and Navigation System (SABER M200 radar)

- Static high-accuracy radar attitude determination
- General geometric calibration or radar panels

BRADAR

EMBRAER DEFESA & SEGURANÇA

ADVANCED R&D

GAL – Galileo for Gravity

- INS/Galileo/GOCE kinematic airborne gravimetry (KAG)
- SiPF KAG with INS/Galileo [INS/GNSS] (IG contribution)
- **Dynamic Network (DN) KAG** with INS/Galileo [INS/GNSS]
- **PPP GNSS integrated in** SiPF (IG contribution) **& DN**

GAL – AIRBORNE [SINS] GRAVIMETRY

airborne gravimetry: kinematic gravimetry from aircraft.

SINS gravimetry: kinematic gravimetry with strapdown IMUs.

$$\ddot{x}^e = R_b^e f^b - 2\Omega_{ie}^e v^e + g^e(x)^e + \delta g^e(x^e)$$
$$\dot{R}_b^e = R_b^e \left(\Omega_{ei}^b + \Omega_{ib}^b\right)$$

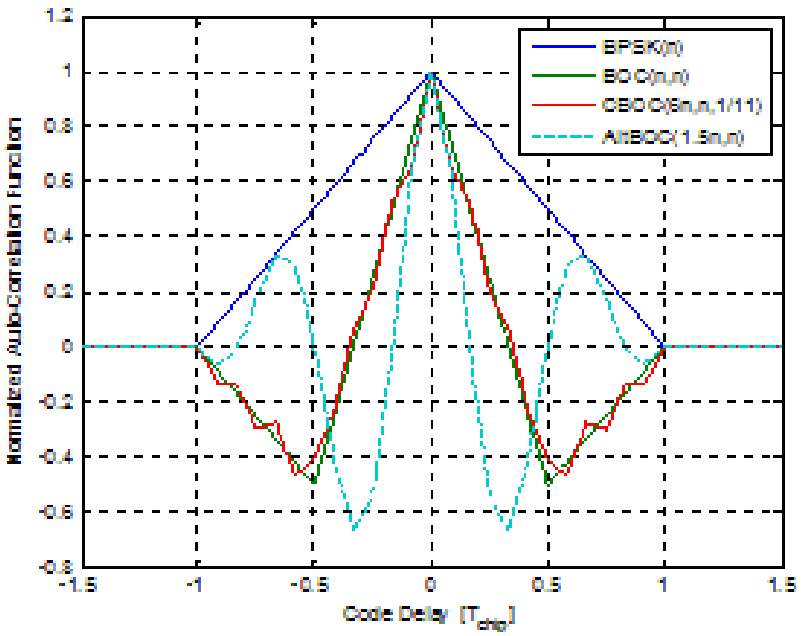
COREGAL

Combined Positioning-Reflectometry Galileo code Receiver for Forest Management

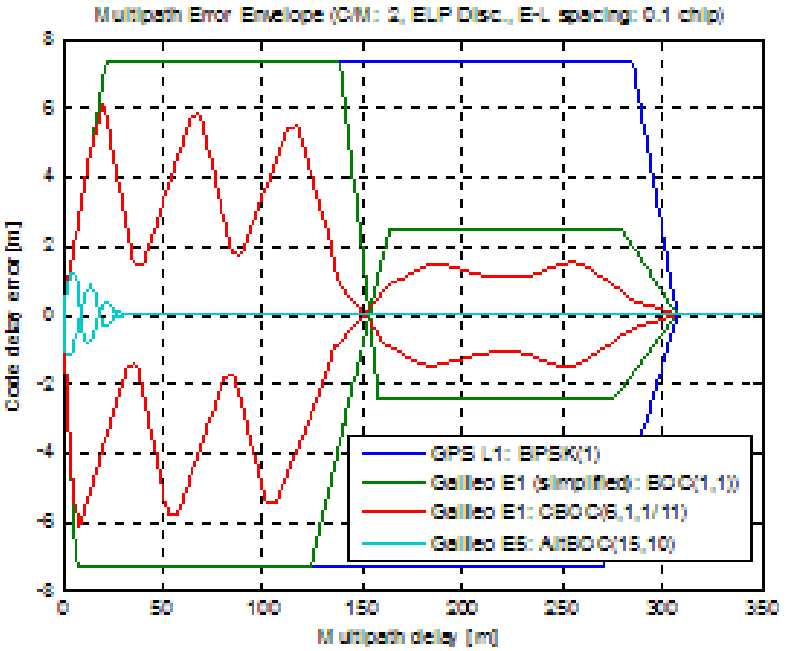
R&D H2020 Galileo project lead by DEIMOS Engenharia

COREGAL: Galileo E5 AltBOC PERFORMANCE

AUTO-CORRELATION FUNCTION



MULTIPATH ERROR ENVELOP



TRACKING ACCURACY AND RANGING PRECISION

		open sky	multipath-fading
E5 AltBOC (15,10)	–	**0.02 m** (44 dB-Hz)	**0.08 m** (40 dB-Hz)
E1 CBOC (6,1,1/11)	–	0.25 m (40 dB-Hz)	2.00 m (36 dB-Hz)

mapKITE – combined kinematic terrestrial and unmanned aerial corridor mapping

- new combined kinematic geodata acquisition from manned terrestrial and unmanned aircraft (follow-me, virtual-tether approach)
- EGNOS/GPS/Galileo ultra-safe [real-time] navigation
- GPS/Galileo/vision/kinematic-ground-control [post-mission] orientation
- application to 3D corridor mapping (roads, railways, waterways)

ALTAIS S.L. Cartografía & Urbanismo

CAT UAV

deimos ENGENHARIA

EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

GRID-IT

unesp

Presidente Prudente, SP

engemap geoinformação

Assis, SP

TopScan Gesellschaft zur Erfassung topographischer Information mbH

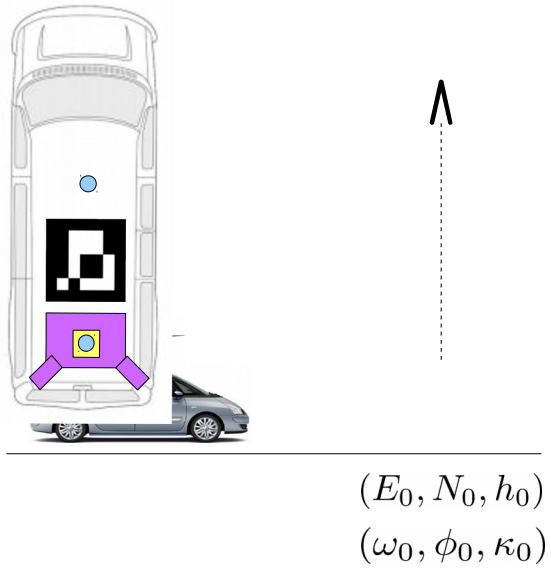
uavision

GSA

TANDEM AERIAL-TERRESTRIAL

mapKITE

- a tandem terrestrial-aerial mobile mapping system, consisting on an Unmanned Aircraft (UA) and a Terrestrial Vehicle (TV)
- UA and TV carry remote sensing and navigation payloads to perform simultaneous geodata acquisition.
- a virtual TV-to-UA tether (real-time waypoint supply) to guide the UA.
- an optical target mounted on the TV roof.



H2020 PROJECT RESULTS

mapKITE

- mapKITE operation demonstration:
  - Virtual tether + Pilot-in-motion
  - Early-bird adoption by ENGEMAP

- Early mapping potential

H2020 COORDINATION & PATENTS

mapKITE

- 2-year project (*Galileo-2-2014: SME based EGNSS applications*)
  - Ten companies, six countries
- Follow-up: *MapKITE-to-market* (SME instrument – phase I)
- GeoNumerics holds mapKITE patents in Spain, US, (Europe to come, Brazil...)

https://vimeo.com/181634599
https://vimeo.com/214011604

ALTAIS S.L. Cartografía & Urbanismo · CAT UAV · deimos ENGENHARIA · EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE · GRID-IT

unesp · engemap geoinformação · TopScan Gesellschaft zur Erfassung topographischer Information mbH · uavision · geonumerics

MORE INFORMATION…?

mapKITE

www.mapKITE.com
www.gsa.europa.eu/egnos-gpsgalileo-based-high-resolution-terrestrial-aerial-sensing-system

What do we expect from University?

- research results of essential nature
- research results available in open access journals
- publication of research, not research for publication
- potential for cooperation, not unfair competition

- graduates with a solid, general background
- we will teach them the specific knowledge of the company
  (0.5 to 2 years to “productivity”)
- PhD graduates are welcome (60% of GN staff holds a PhD degree)

TWO FUNDAMENTAL BELIEFS

Modern companies shall make a profit, but profit from work that benefits their customers and humanity.

— Anonymous

Men and women want to do a good job, a creative job, and if they are provided the proper environment, they will do so.

— William R. Hewlett

THANK YOU FOR YOUR ATTENTION!

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