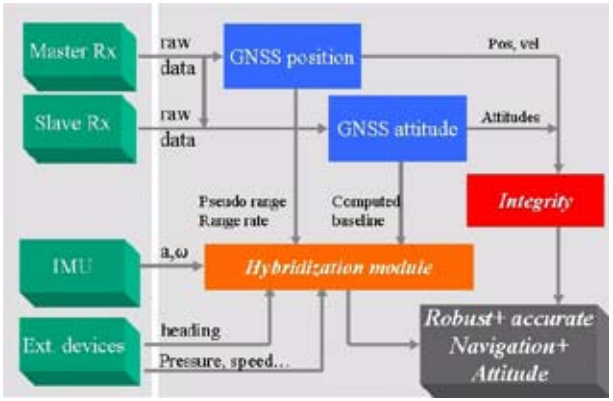
Multi-Sensor Fusion for High Dynamic Applications

A way to improve the robustness of GNSS is to hybridize it with inertial sensors. Different strategies of hybridization are investigated depending on the level of coupling envisaged, characteristic of sensors and dynamics of the user. Standard Kalman filters provide a high level of coupling efficiency, but extended Kalman or particle filters are better suited since they take into account the nonlinear nature of the inertial sensors. For high dynamics applications, it is necessary to use deeply coupled INS-GNSS receivers with multifrequency carrier phase solutions.



Automatic landing under all weather conditions using GBAS

A drawback of very precise inertial sensors is their extensive pricing. Thus, hybridization with low cost Micro-Electro-Mechanical Systems (MEMS) sensors for civil aviation is par-ticularly investigated by DLR's department of Navigation. Additionally, GNSS receivers can provide attitude information by using additional antennas separated by constant baselines. This attitude solution can be combined with the attitude given by an inertial measurement unit to improve robustness. A novel concept, Airborne Autonomous Integrity Monitoring (AAIM) provides a measure of integrity for the INS-GNSS solution. Currently, DLR investigates also new AAIM concepts in the frame of the FAGI project.

DLR at a glance

DLR is Germany´s national research center for aeronautics and space. Its extensive research and development work in Aeronautics, Space, Transportation and Energy is integrated into national and international cooperative ventures. As Germany´s space agency, DLR has been given responsibility for the forward planning and the implementation of the German space program by the German federal government as well as for the international representation of German interests. Furthermore, Germany's largest project-management agency is also part of DLR.

Approximately 5,700 people are employed at thirteen locations in Germany: Koeln (headquarters), Berlin, Bonn, Braunschweig, Bremen, Goettingen, Hamburg, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Stuttgart, Trauen and Weilheim. DLR also operates offices in Brussels, Paris, and Washington D.C.

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Information

Integrity and Performance Oriented Navigation

Robust navigation for high demanding applications

DLR

Advanced Integrated Navigation

The state of the art of satellite based navigation solutions for civil aviation is not sufficient to achieve the stringent requirements of category II/III precision landing. At this point, even GNSS (Global Satellite Navigation Systems) with robust ground based augmentation systems (GBAS) shows its limitations.
To overcome these difficulties, it is necessary to define new concepts of navigation, where the satellite based navigation receivers are integrated with other systems. At present it is thought to combine satellite based navigation with inertial navigation and to deeply merge them in the flight manage-ment systems of aircraft. A field of our activity is the com-bined architecture of an autoland system with both single and dual frequency GBAS. This integrated approach provides a high level of robustness and accuracy for complex applica-tions. With novel algorithm architectures emerges adapted performance determination based not any more on navigation performance alone but on "total" system efficiency (naviga-tion performance for integrated systems).
An induced activity is relative navigation. Here, the problem is not anymore to provide a PVT (Position, Velocity and Time) solution in an absolute way, but to perform relative position-ing with a moving reference object. Several applications like formation flying of satellites, self contained docking of an automatic transfer vehicle onto the international space station or for shipboard landing of a helicopter will profit from this technique. A challenge is to provide a robust navigation solu-tion for high dynamic reference and rover receiver.

Integrity in GNSS

Applications for Integrity in GNSS

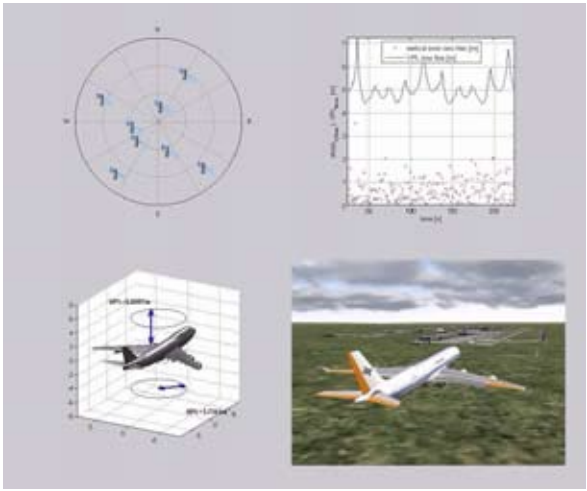
The key performance parameter in Safety of Life applications is the integ-rity, i.e. the trust one can have in the function of the system. In its activities, the Institute of Communication and Navigation investigates the robustness of the navigation solution, develops techniques to monitor threats, investi-gate and develops methods to detect, mitigate or exclude a faulty element of the system wich may lead to an unac-ceptable error in the navigation solu-tion.
The GNSS integrity activity is subdivided into 4 sub-activities:
- Combined GPS + Galileo RAIM
- Satellite Based Augmentation Systems (SBAS) and Galileo/GPS Integ-rity Channel (GIC)
- Ground Based Augmentation Systems (GBAS)
- Aircraft Based Augmentation Systems (ABAS)

RAIM

Receiver Autonomous Integrity Monitoring is a technique that provides integrity information using a set of observed satellites. It allows to detect and to exclude a faulty satellite based on a self consistency check of observables. Modern RAIM algorithms combine the onboard detection and exclusion techniques with additional integrity information from SBAS or GBAS. One important improvement is the significantly re-duced time to alarm which can theoretically fulfill stringent precision approach requirements. Present acitivites of the Institute in the field of RAIM concern RAIM for the multi constellation (Galileo, GPS) and multifrequency scenarios as well as carrier phase (C-) RAIM for high precision applications.

Automatic landing with GBAS

Together with the DLR Institute of Robotics and Mechatronics, a GBAS landing demonstrator has been developed and is used to investigate and verify new GBAS algorithms, e.g. dual frequency smoothing techniques to protect against severe ionosphere gradients. In this demonstrator, an automatic landing control system can be coupled with "live" GNSS data and an experimental GBAS station at Braunschweig airport trough DLR's experimentation and validation network (EVnet) or a simulated GBAS/GPS/Galileo multi constellation navigation system, which lets the aircraft land under CAT III conditions using satellite based navigation only.



Automatic landing in a simulated Galileo+GBAS scenario