Navigation, GBAS

Navigation systems based on GNSS: GBAS

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Indra Navia AS

KEY FACTS & FIGURES

- Indra Sistemas, S.A.
  - Premier IT company in Spain
  - Leading IT multinational in Europe and Latam
  - 36 000 employees, 16 000 outside Spain
  - Revenues M€ 2,688, 44% outside Spain
  - R+D+i: 7-8 % of revenues

- Indra Navia AS
  - Wholly owned subsidiary of Indra Sistemas, S.A.
  - Located in Oslo and Horten
  - Air Traffic Management (ATM) Systems Supplier
    - **Communication**
    - **Navigation**
    - **Surveillance**
  - 170 employees
  - Revenues ~ MNOK 500, 98 % outside Norway

HISTORY

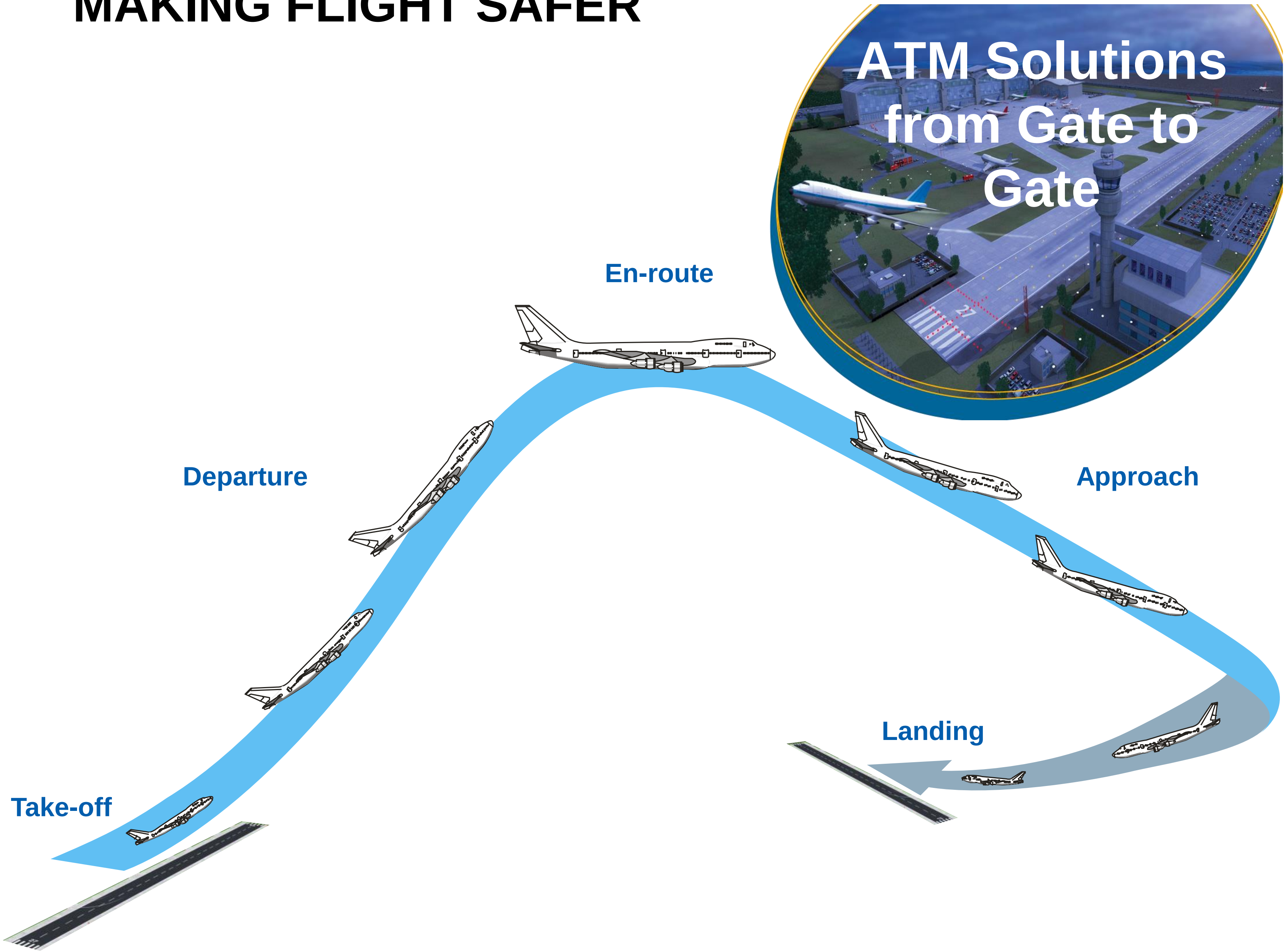
- Company origins
  - Gustav A. Ring (1916): **GAREX**, Communication
  - Norsk Marconikompani (1918): **NORMARC**, Navigation
  - Kongsberg Norcontrol: **NOVA**, Surveillance

- Previous names
  - Navia Aviation AS (1997-2000)
  - Northrop Grumman Park Air Systems (2000-2012)

- 18 April 2012:
  - Acquired by Indra
  - Name changed to **Indra Navia**

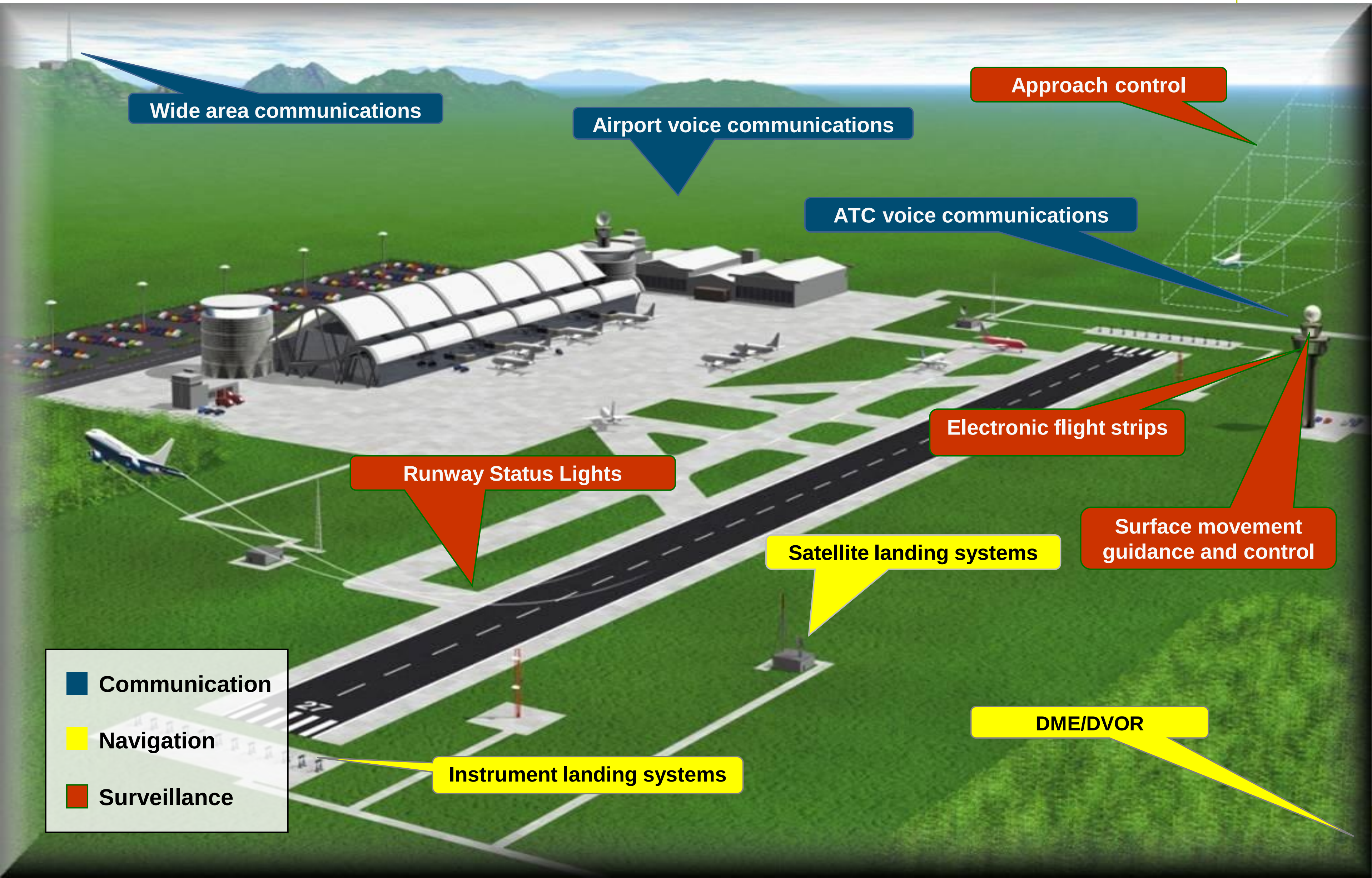
INDRA NAVIA

MAKING FLIGHT SAFER



INDRA NAVIA

WHAT WE DO

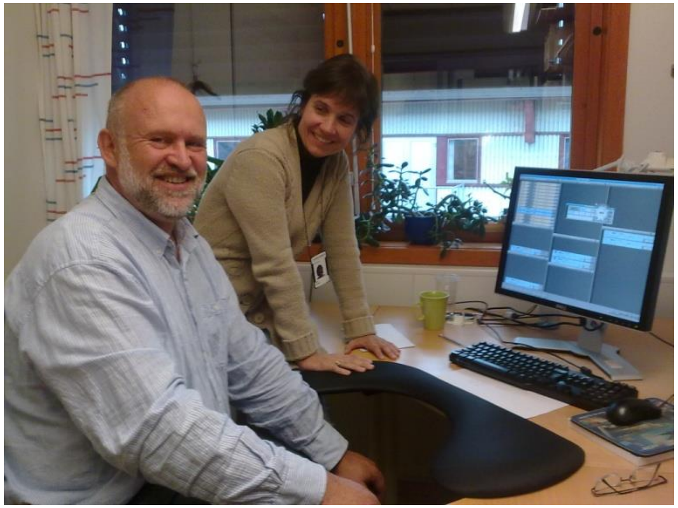


R&D

- 50 R&D/Systems Engineers
- All Core Competence in-house

- SESAR* Participation
  - Satellite Landing Systems (GBAS)
  - Airport Systems

- SESAR Objectives
  - Improved safety
  - Reduced ATM costs
  - Reduced emissions per flight
  - Increased air space capacity
  - in all weather conditions

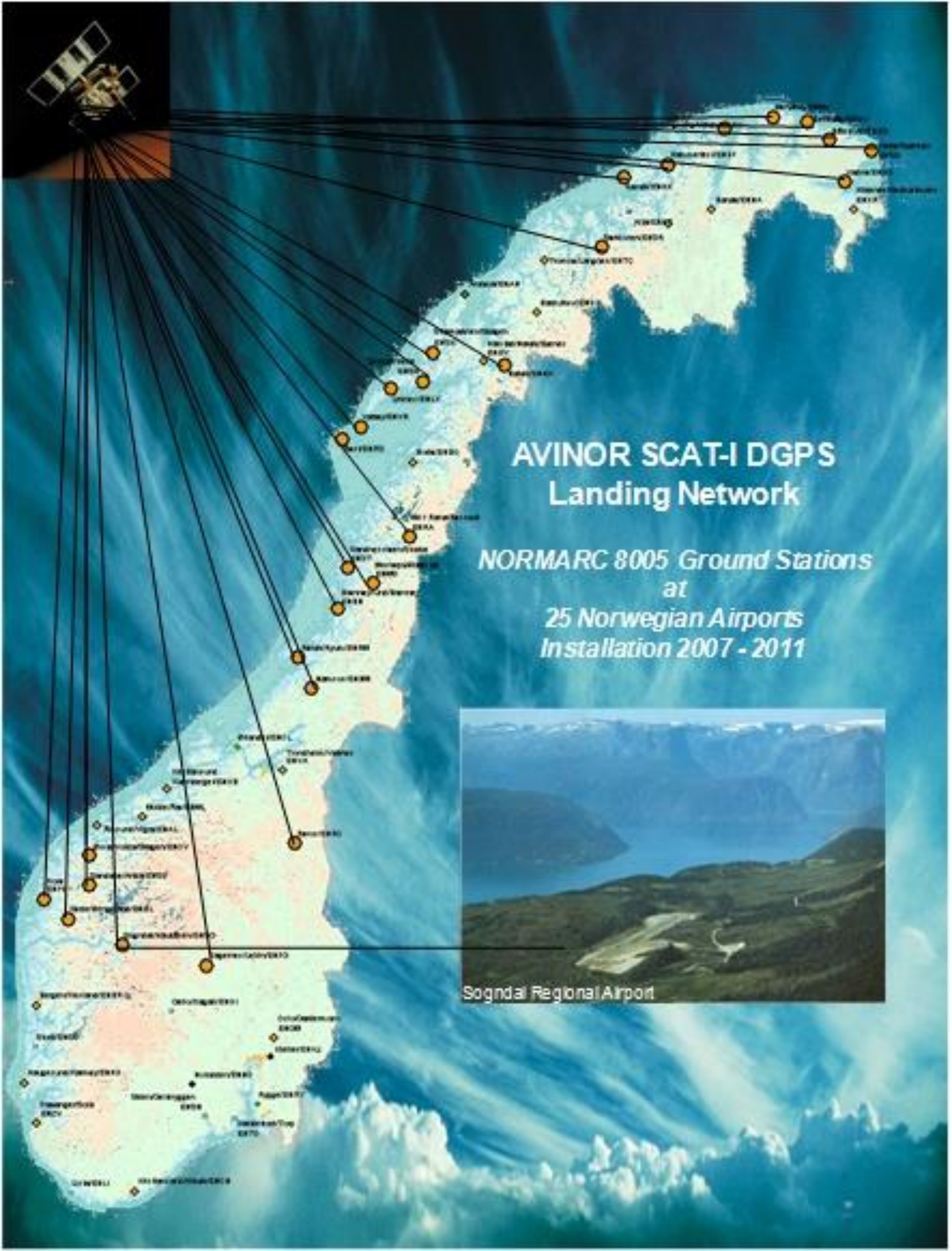


* SESAR: Single European Sky ATM Research

ILS in China – one of 150 installations

Countries with NORMARC ILS

- Abu Dhabi
- Angola
- Argentina
- Australia
- Bahrain
- Benin
- Bulgaria
- Burkina Faso
- Cameron
- Canada
- Cape Verde
- China
- Colombia
- Congo
- Croatia
- Cyprus
- Czech Republic
- Denmark
- Dominican Republic
- Dubai
- Ecuador
- Egypt
- Great Britain
- Greenland
- Equatorial Guinea
- Finland
- France
- Fujairah
- Gabon
- Germany
- Hungary
- Iceland
- India
- Indonesia
- Ireland
- Italy
- Ivory Coast
- Jamaica
- Jordan
- Kazakhstan
- Korea
- Kosovo
- Kyrgyzstan
- Latvia
- Liberia
- Lithuania
- Macao
- Madagascar
- Malaysia
- Mauritania
- Morocco
- Mozambique
- Netherlands
- Norway
- Pakistan
- Peru
- Philippines
- Portugal
- Romania
- Russia
- Serbia
- Seychelles
- Sharjah
- Shetlands
- Slovak Republic
- Slovenia
- South Africa
- Spain
- Sri Lanka
- Swaziland
- Sweden
- Switzerland
- Syria
- Taiwan
- Tajikistan
- Thailand
- Tunisia
- Turkey
- Vietnam



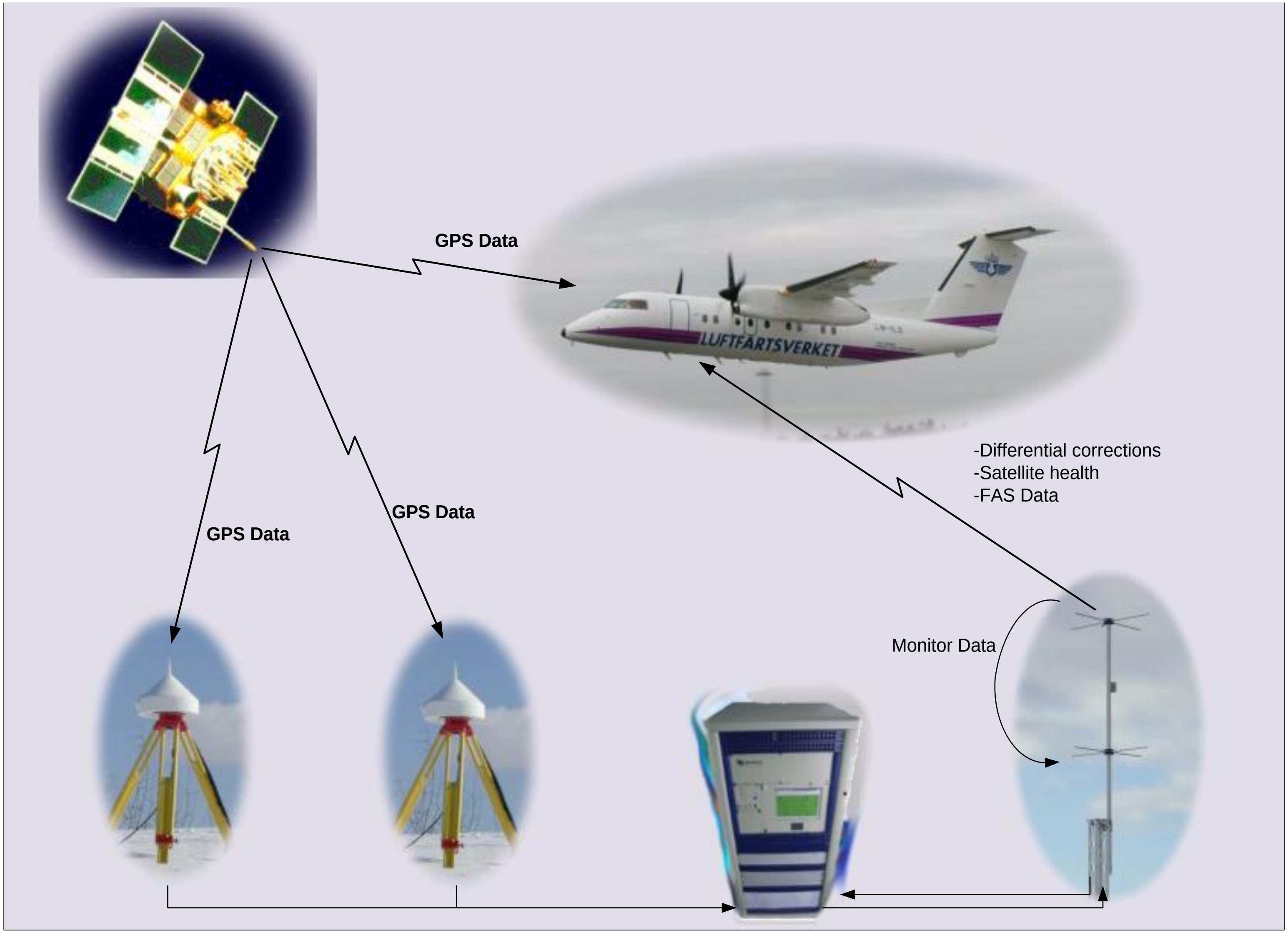
SCAT- I ground stations are being installed at up to 21 airports in Norway

Increasing the safety level on sites where ILS is difficult or infeasible to install

Providing CAT I integrity, continuity and availability on sites where CAT I has previously not been achievable due to terrain constraints

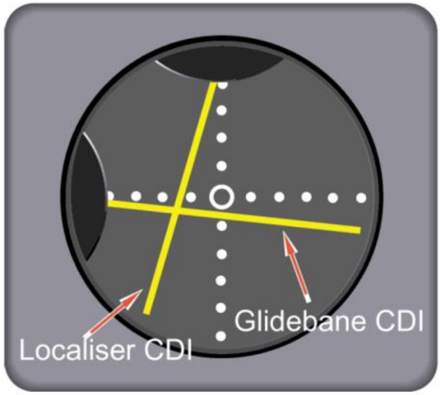
Indra Navia provides certified ground stations, services and assistance to aid the operation

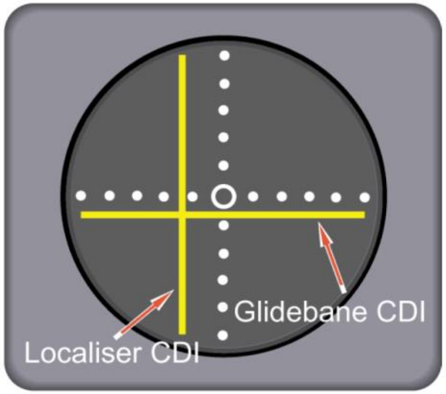
SCAT-I : Special Category I



Instrument Landing Systems

- ILS is the most widely used landing system today (but not the only, others are MLS, SCAT-I, SLS....)
- ILS requires two installations per runway, and may require substantial civil work in order to prepare the terrain in front of the antennas as required
- ILS is quite old, it is an analogue system from around WW2
- The advantages of ILS are mostly that it is a robust, simple, well proven, well known landing system.





There is a drive for renewing the landing systems, but not at any cost.

Why GBAS?

- One GBAS ground station can cover all runways on an airport
- A GBAS ground station (GS) can reduce time between approaches
- A GBAS GS can optimize curved approaches
- Several thresholds, several glide path angles
- Curved approaches and reduced time between approaches may reduce fuel consumption in the landing phase
- A GBAS GS is less dependent on civil works in front of the runways and on topography in general, but will also to some extent be dependent on topography and buildings as reception of the GNSS signals depends on Line Of Sight (LOS)

- One drawback is the investment necessary, and the change of system
- GBAS has to prove cost efficient and safe
- There are several “threat models” that have to be handled
- The documentation requirements are more stringent for GBAS (availability, continuity and integrity)

GBAS is a more efficient solution; less equipment, less maintenance, hence lower cost

Terms and abbreviations

GNSS: Global Navigation Satellite System

GPS: Global Positioning System, American GNSS

Galileo: European GNSS

GBAS: Ground Based Augmentation System

GBAS GS: GBAS Ground Station

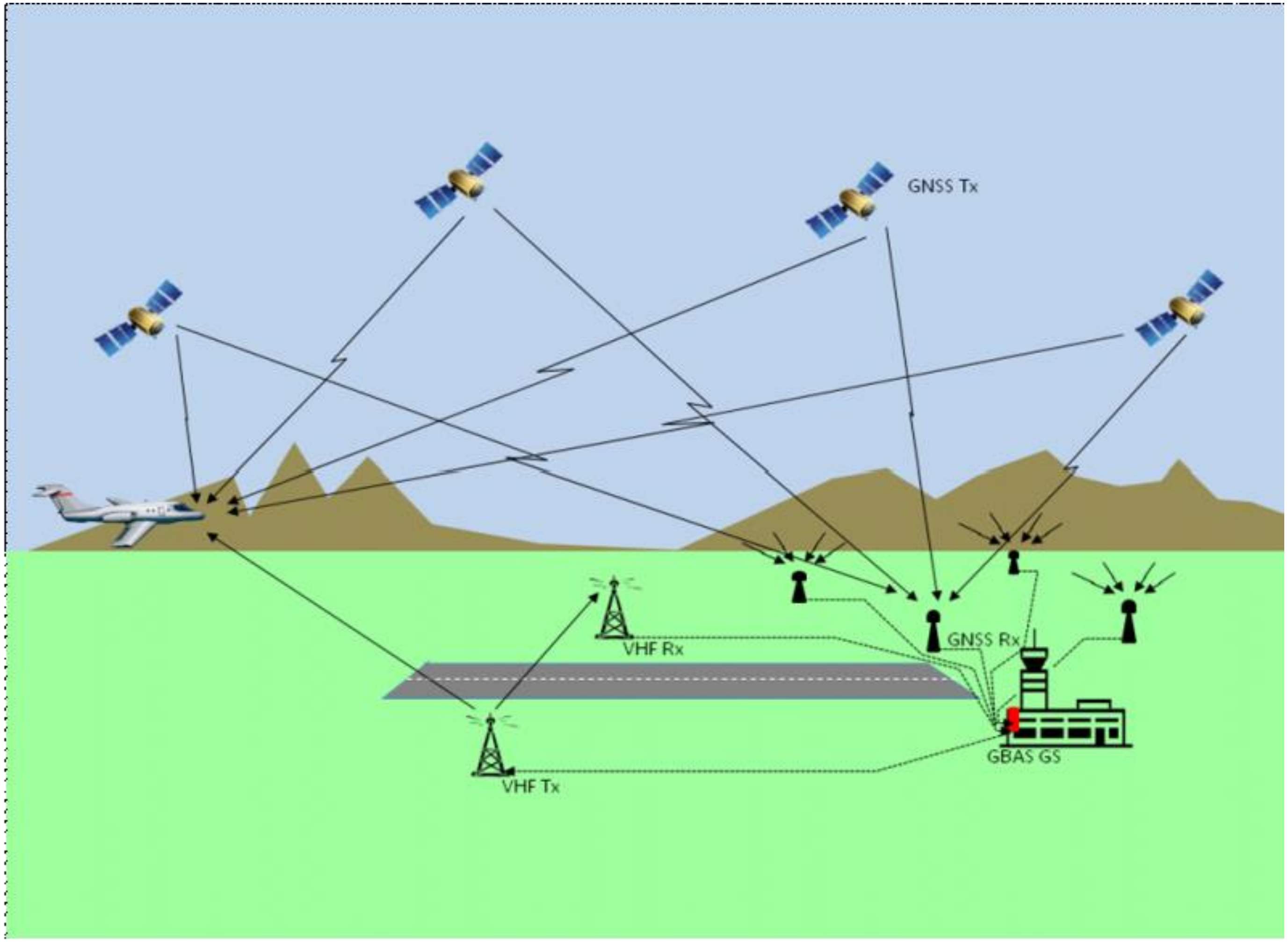
ILS: Instrument Landing System

GBAS is a differential GNSS system

Availability, Continuity and Integrity

- Availability: is the probability that the signal in space from the service provider will be available for any aircraft intending to conduct the approach. Must be better than 0.9992.
- Continuity: is the ability of the total system to perform its function without interruption during the intended operation. Failure rate must be better that 2.10^{-6} over 15s.
- Integrity: is a measure of trust which can be placed in the correctness of the information supplied by the total system. Failure, lasting more than 1.5s, rate must be better than 10^{-9} for internal faults and better than 10^{-7} for not detecting faults in the satellite for any one landing.

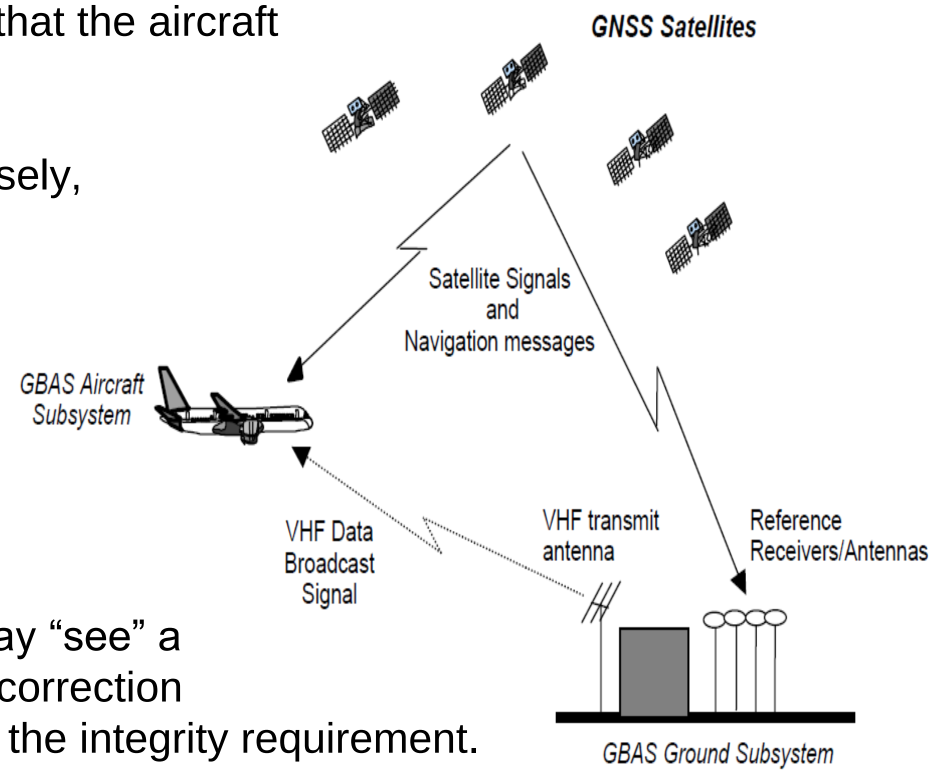
General GBAS architecture



What is GBAS?

A differential GNSS ground station, sending correction messages to the approaching aircraft, that the aircraft may choose to use or to ignore.

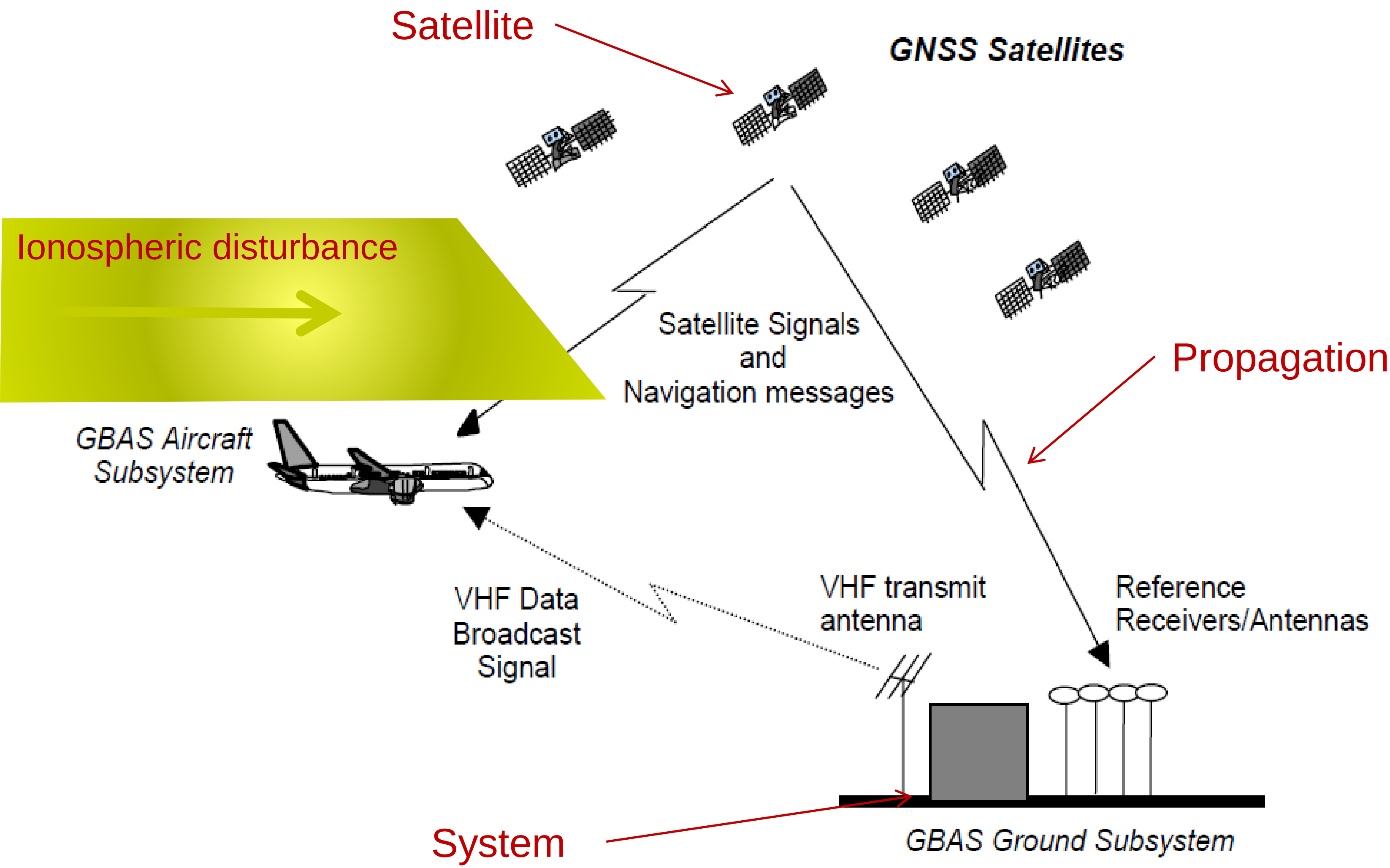
The GBAS GS knows its location precisely, and may therefore detect errors in the system, either in the satellites or due to the receiver conditions. This is true if the satellite and the GBAS GS are close enough to see the same satellites and to experience the same propagation environment.



When this is not true, the GBAS GS may “see” a different environment and send wrong correction messages to the aircraft, thus violating the integrity requirement.

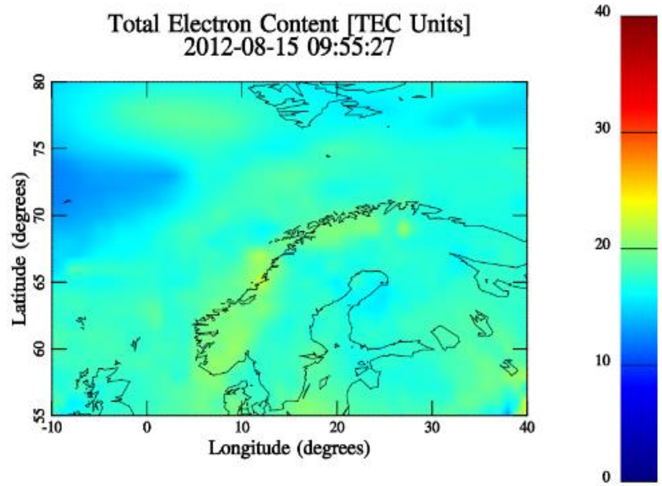
Such errors should therefore be detected by GBAS monitors. Different types of errors may result in different actions, but one possible action is to stop sending correction messages. Error sources may be Radio Frequency Interference (RFI), Ionospheric errors (plasma fronts or bubbles), Multipath, etc.

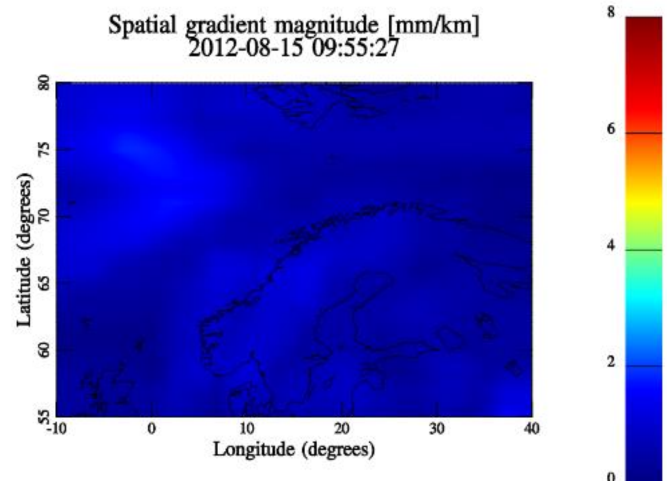
System architecture



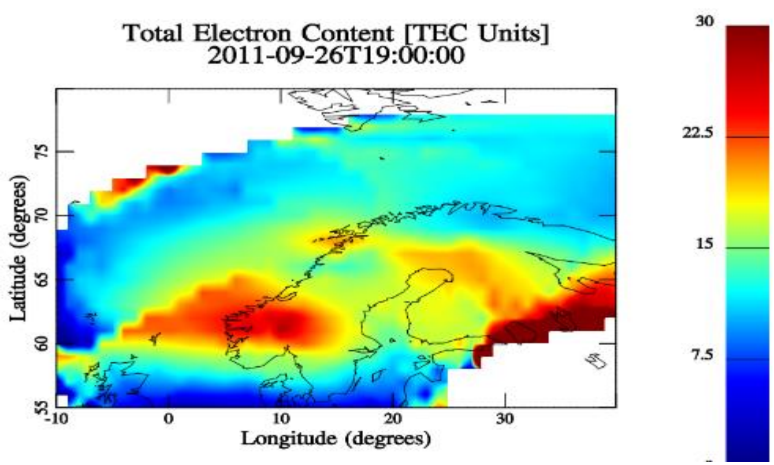
Identifying interesting points in time - gradients

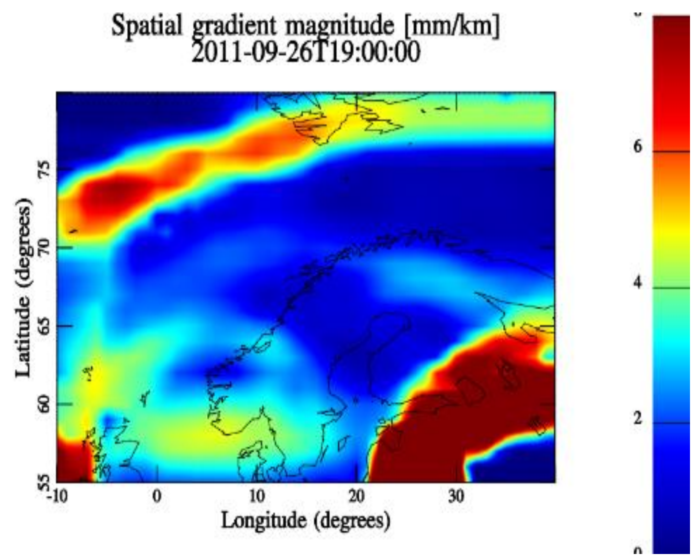
Quiet day, 15. August 2012

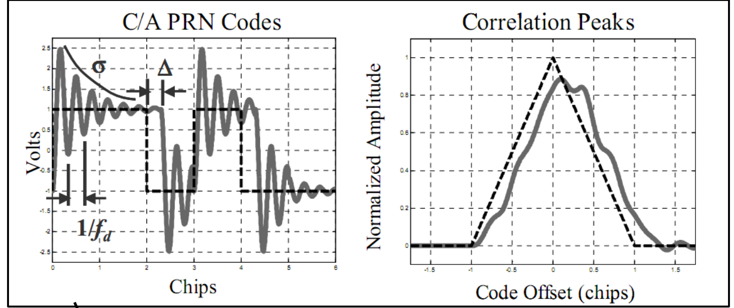




Active day, 26. September 2011







Must fulfill ICAO's requirements

GBAS ground station

GNSS signals

Correction sinals to the aircraft on VHF

EA monitor

CCD monitor

SD monitor

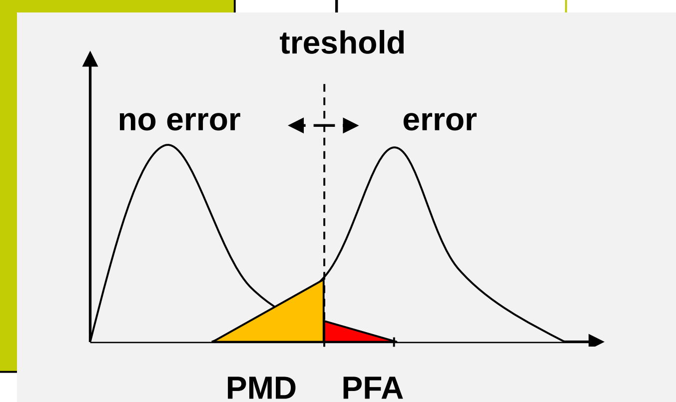
VHF monitor

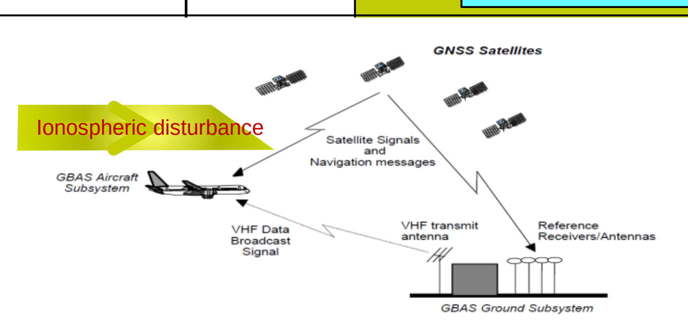
GS monitor

RFI monitor

MP monitor

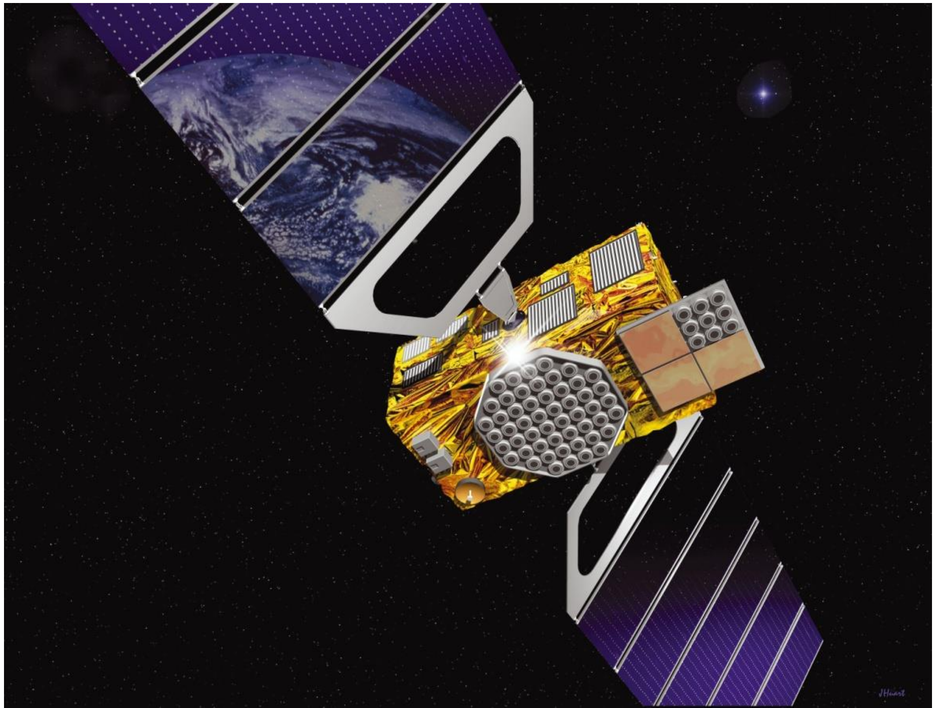
Ionosphere monitor





Why Galileo, not just GPS?

- GPS is controlled by USA
- For Europeans, it is evidently ”natural” to use the European system
- Galileo will provide two frequencies from start, solving some of the error estimation challenges, such as some of the ionospheric effects
- Other systems may also be used in principle; GLONASS (Russian), COMPASS/Beidou (Chinese) etc.
- Two operational Galileo satellites were successfully launched in October 2011, and two more in October 2012, and 28 other are to follow until the system is fully operational in 2019 (current expected date). Launch problems with the two last satellites launched on the 23rd of Aug. 2014.



GBAS status in a global setting

- ICAO (International Civil Aviation Organization) has drafted a set of requirements for GBAS in Annex 10
- Only a few airports are operational with GBAS Cat I in the world
- Airplanes must be equipped with the corresponding avionics
- In Europe, the SESAR project focuses on GBAS development and Annex 10 requirements validation. One project is focused on *GBAS Cat II/III L1* using GPS, while a follow-up project studies the transition to *GBAS Multi-frequency/Multi-constellation* aiming at using (also) Galileo

GBAS status at Indra Navia

- Indra Navia participates in the SESAR projects
- 15.3.6 (GBAS Cat II/III L1) with development of a GBAS GS prototype, installed at Frankfurt airport in May 2013. Airplanes equipped with Honeywell avionics are landing with guidance from this GBAS GS. Indra Navia budget about 7M€ over 6 years.
- Prototype installation at OSL/Gardermoen in September 2014. NRS and NFR financed projects.
- 15.3.7 (GBAS Multi-frequency/Multi-constellation) aiming at a transition towards Galileo.
  Indra Navia budget about
  400k€ over 3 years.
- The aim is to develop a commercial GBAS GS approaching 2018-2020

GBAS development at Indra Navia

GPS antenna installation at Gardermoen 10th of January 2013

Making Flight Safer

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