

# Future of ATC surveillance

- Intro
- Current state (PSR, SSR, Mode S)
- Multilateration – WAM x MLAT
- ADS-B: GNSS overview (GPS, Glonass, Galileo)
- ADS-B: Link war
- ADS-B: SESAR ADS-B SurvSystem
- Conclusion

# Intro



# Current state - RADAR

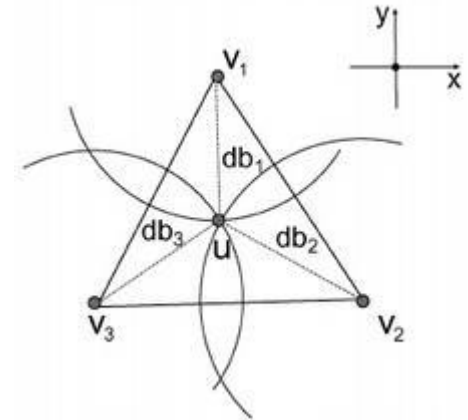
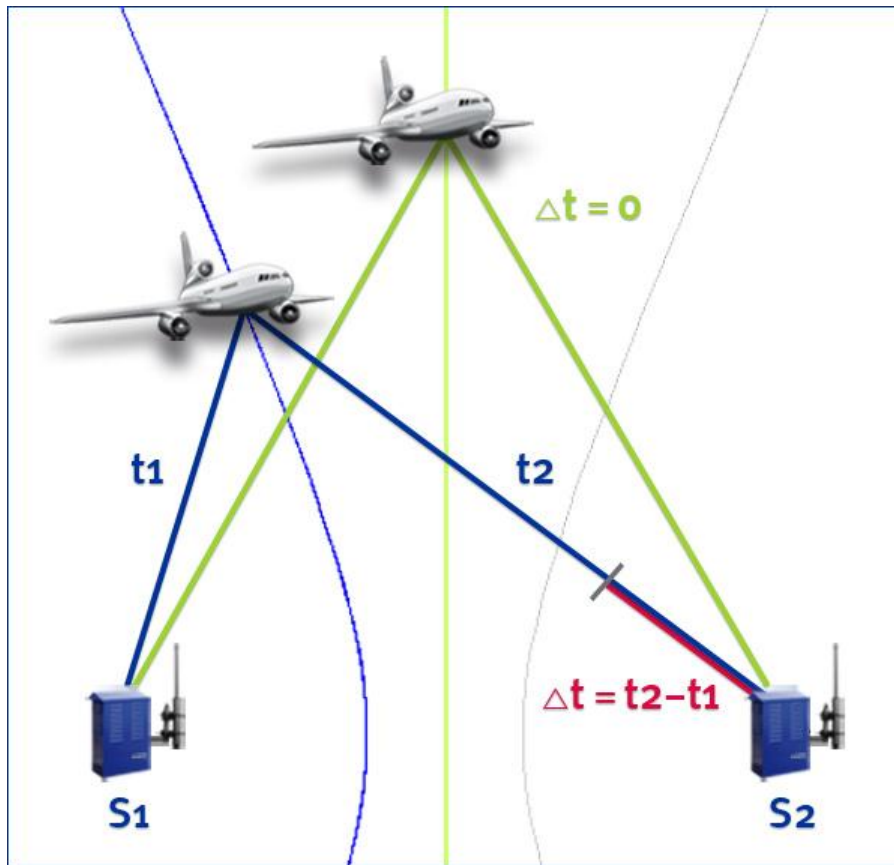
- PSR: Noncooperative, independent.
  - Noise, clutter, lack of ID, imprecise height, range
- SSR: Cooperative, less powering cost, range
  - Lifetime up to 15 years
- Or combined together for shared costs.
- Acquisition costs \$1-4 million
- Running costs \$20 ths / yr



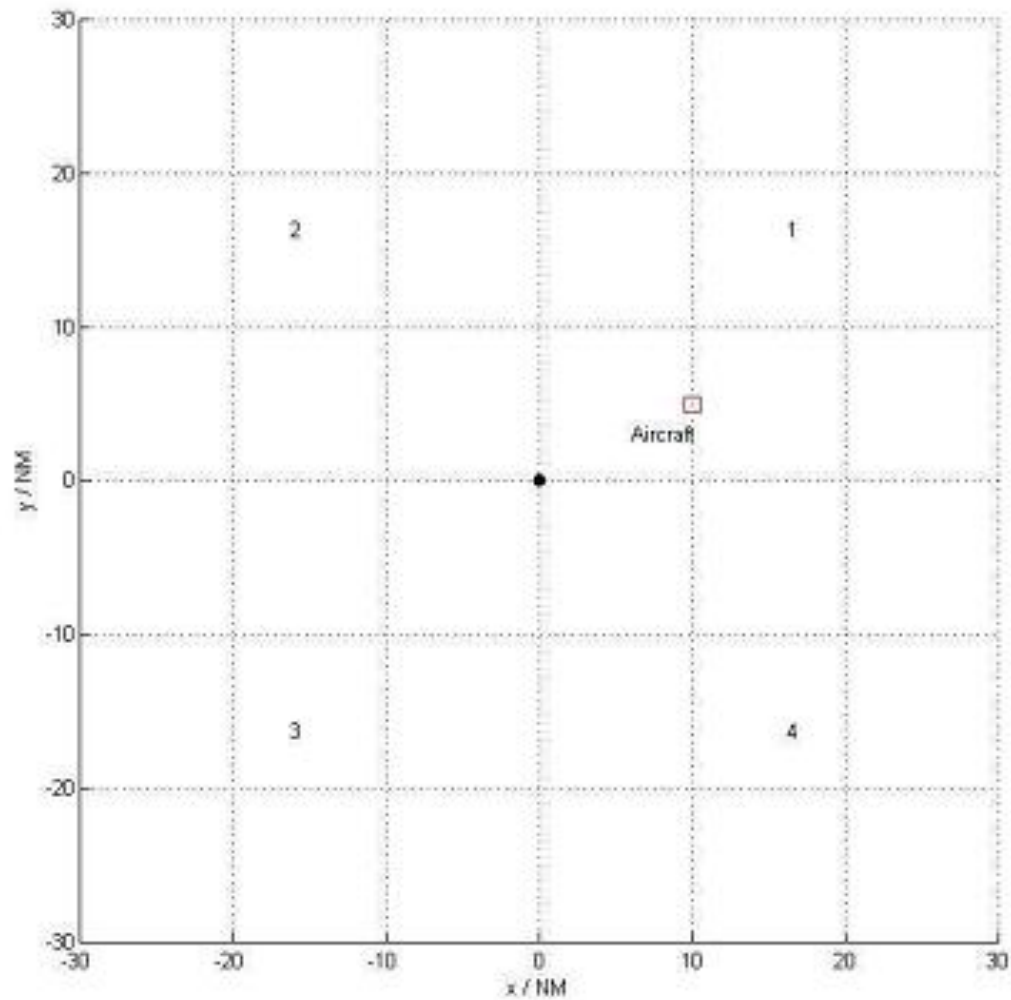
# Current state – Mode S

- Cooperative, independent. Eases up the frequency, interrogates with register requests.
- Still is a SSR – similar acquisition and running costs.
- Adds new parameters for improved ground system functionalities (nets, tools).

# MULTILATERATION

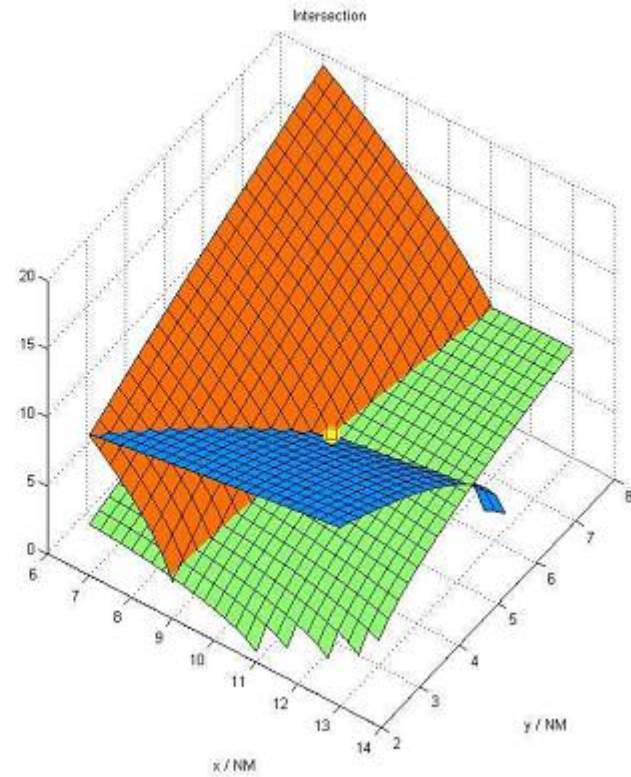
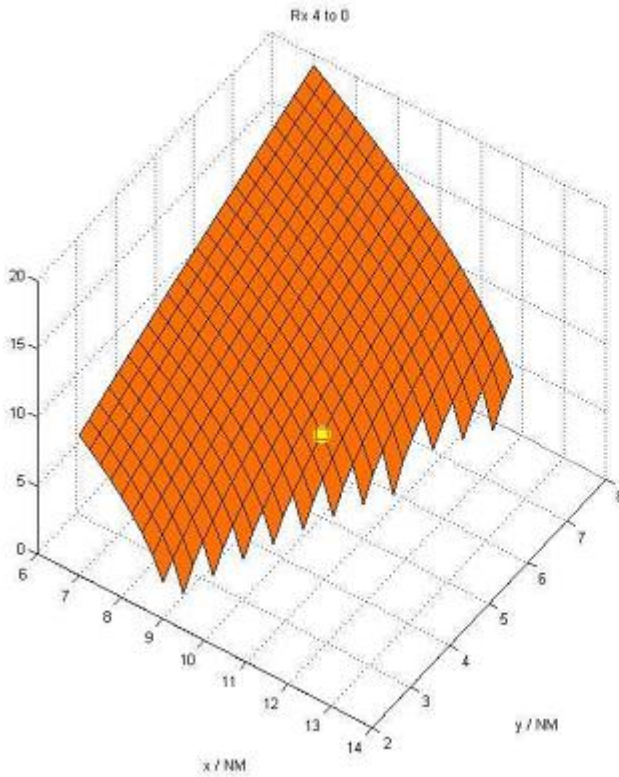


# MULTILATERATION

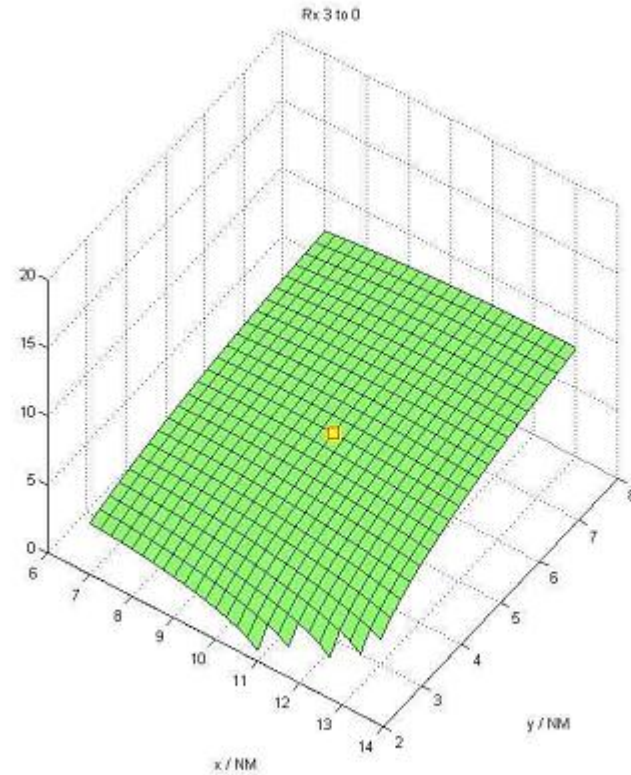
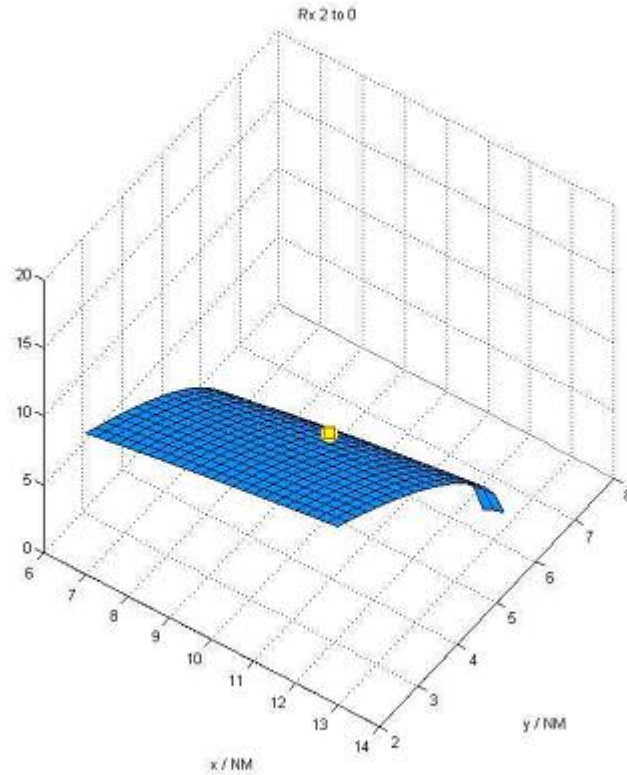




# MULTILATERATION



# MULTILATERATION



# MULTILATERATION

WAM for ENR/TMA Surveillance

or

MLAT for Approach/Airport Surveillance

usually combined into an A-SMGCS  
solution

Passive or Active (~'Multistatic MSSR')

# MULTILATERATION

+: Compact, passive, little power required. Concept easily scalable, no additional investment imposed on airspace users.

-: Not automatic; requires interrogator (MSSR or active node) and transponder. Line of sight to the entire configuration of the minimum receiver set. RF pollution kills range.

# MULTILATERATION Market Overview

Sensis (form. US, now SAAB, SWE)

Era (CZE-US)

Thales (FR), Qinetiq (UK), Comsoft (GER)

# ADS-B

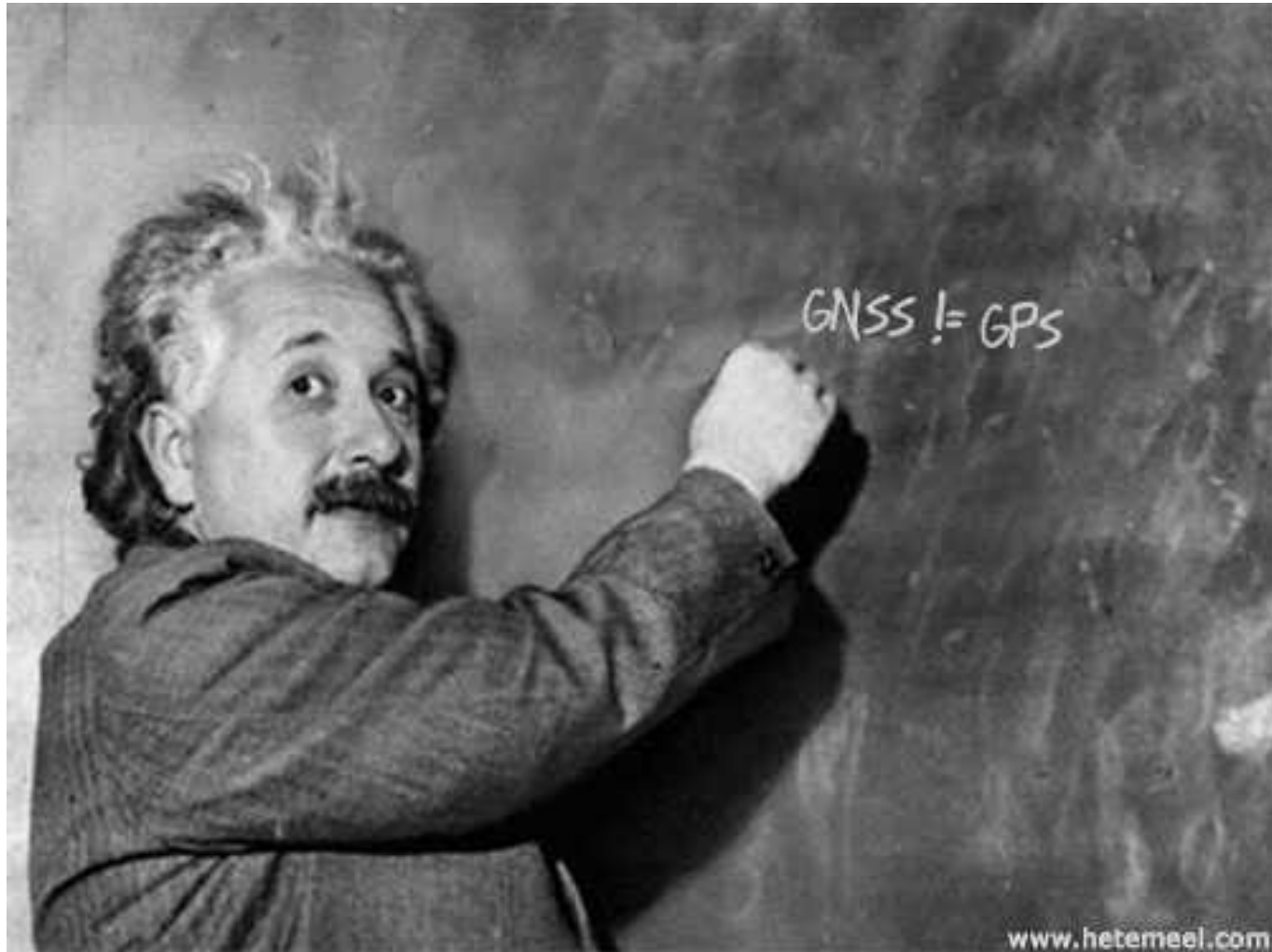


# ADS-B (not "Adds-bee")

- AUTOMATIC
  - No need to ask ("interrogate")
- DEPENDENT
  - Need help determining position (GNSS)
- SURVEILLANCE
  - Com and Nav related applications exist elsewhere
- BROADCAST
  - Everyone hears (+/- ?)



# GNSS





# GNSS: GPS

- GPS
  - 1973, DoD. Full ops 1994, SA turned off 2000
  - 31 satellites orbiting, 24 minimum cfg.
  - Each transmits time, ephemeris, system health and almanac (other satellites).
  - L1 (1575.42MHz) + L2 (1227.60 MHz)
  - L3 NUDET, L4 Ionospheric cor., L5 Safety of Life
  - Recent LightSquared affair

# GNSS: GPS

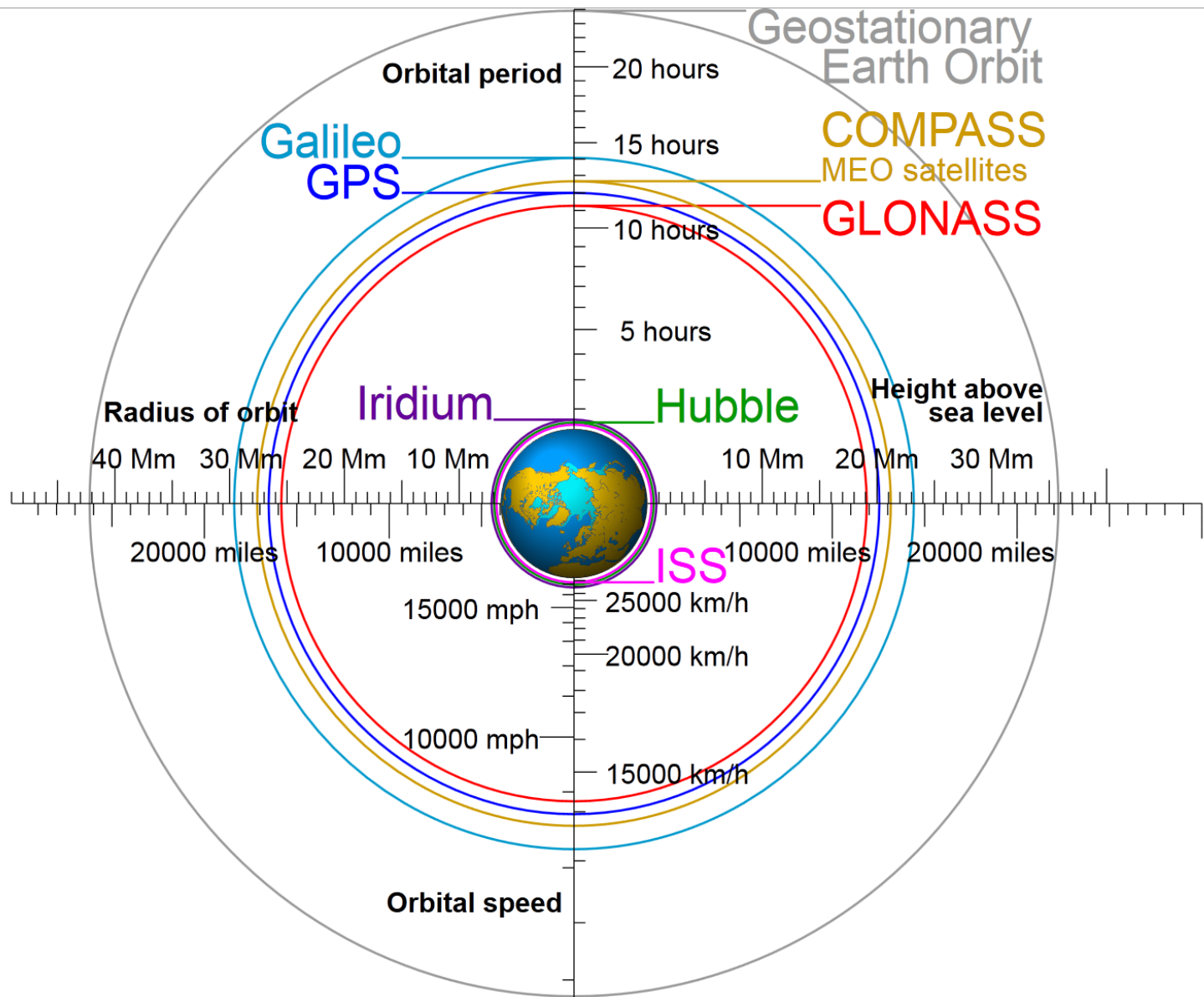


# GNSS: GLONASS

- Conceived in 1976, first uplift 1982, constellation complete 1995. Decline.
- Restored just 2 months ago (Oct 2011) to full constellation (24).
- 2006 open access to public, dual user units exist. Up to 10 m precision.
- 2 frequencies (1602, 1246 MHz)

# GNSS: Galileo

- 3,4bn EUR budgeted until 2013.
- Difficult history, nearly died several times.
- 2005 GIOVE-A, 2008 GIOVE B
- 21 Oct 2011, first two IOV lifted. Another two next year.
- FOC 2019, 27-3 elements. Lifetime 12 yr.
- SAR with feedback.



# ADS-B

- Position determined by aircraft using a GNSS receiver.
- What means to use to communicated the determined position to the ATC?
  - >>> ADS-B datalink

# ADS-B Link wars

- 1090ES
  - Builds on Mode S (1090 MHz, MHz wide)
  - Agreed for OAT globally, standardized
- UAT
  - US grown, ADS-B only, 1MHz channel (978Mhz)
  - Intended for GA
- VDLm4
  - AIS, STDMA, VHF band, need signalling channels
  - Full CNS link (to its own disservice)

# ADS-B pros / cons

+

- 1) Very cost effective (one GS of around 200 kUSD) + siting covers 200 NM
- 2) Accuracy to GNSS standard – 3m augmented

-

- 1) Integrity
- 2) Shifts cost onto operators -> resistance
- 3) Security



# ADS-B related terms and services

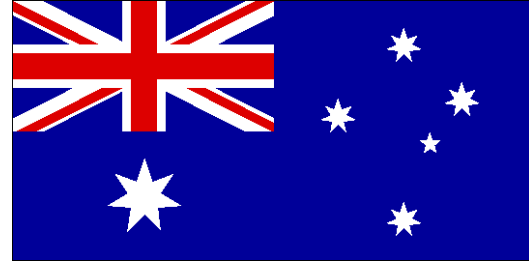
- ADS-B Out
- ADS-B In
- GNSS
- Link
- SBAS/GBAS/ABAS (WAAS x EGNOS)
- CDTI
- TIS-B, FIS-B, GNS-B

# ADS-B related terms and services

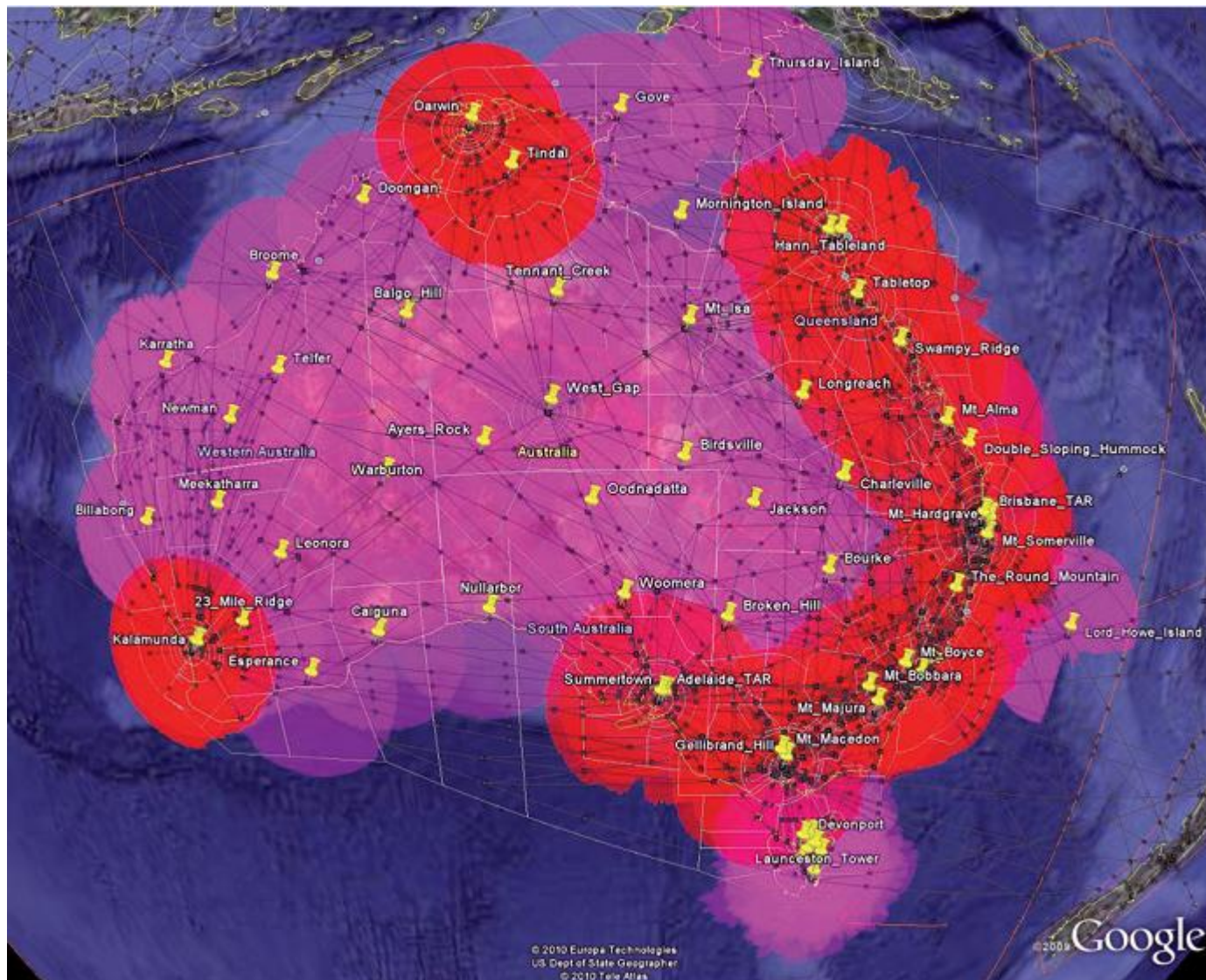
- ADS-B RAD
  - ADS-B NRA
  - ADS-B APT
  - ADS-B ADD
- 
- ATSA(W) (AIRB, ITP, VSA, SURF)
  - ASAS (?)

# ADS-B Implementation status

## AIRSERVICES AUSTRALIA



- World leader in deployment
- Optimum environment; vast landmass makes all else uneconomical
- Upper airspace covered by 57 GS (29 dual sites) by Thales (\$10 M)
- Equipage mandated by Dec 2013 for OPS above FL290
- What to do with Lower airspace? Lengthy wrangle with active GA base over mandate terms.



# ADS-B Implementation status

NAV Canada

- Hudson bay prime candidate
- Gone operational 15 Jan 2009
- Mandated at FL350-FL400
- Also whitelist, flight plan RMK/ADSB





## Phraseology

Existing 'Radar' Phraseology	New Generic 'Surveillance' Phraseology
RADAR SERVICE TERMINATED (non-radar routing if required).	SURVEILLANCE SERVICE TERMINATED (non-surveillance routing if required).
RADAR SERVICE TERMINATED DUE TO (reason).	SURVEILLANCE SERVICE TERMINATED DUE TO (reason).
SECONDARY RADAR OUT OF SERVICE.	ADS-B SURVEILLANCE OUT OF SERVICE DUE TO (reason).
* MODE CHARLIE NOT VALIDATED.	* PRESSURE ALTITUDE NOT VALIDATED.
* MODE CHARLIE IS INVALID.	* PRESSURE ALTITUDE IS INVALID.
RADAR SERVICE TERMINATED.	SURVEILLANCE SERVICE TERMINATED.
RESUME POSITION REPORTS.	RESUME POSITION REPORTS.
(aircraft ident) RADAR IDENTIFIED (position if required).	(aircraft ident) IDENTIFIED (position if required).
(aircraft ident) RADAR IDENTIFICATION LOST.	(aircraft ident) IDENTIFICATION LOST.
* POINT-OUT (position) (identification/SSR code) (track and altitude) (other information).	* POINT-OUT (position) (identification) (track and altitude) (other information).
* POINT-OUT APPROVED (Identification/SSR Code).	* POINT-OUT APPROVED (Identification).
	CONFIRM ADS-B ELIGIBLE? and if necessary — UNABLE TO ISSUE CLEARANCE INTO ADS-B EXCLUSIONARY AIRSPACE, MAINTAIN (altitude).
	NEGATIVE ADS-B DUE TO EQUIPMENT FAILURE.
	IF ABLE, CHANGE YOUR FLIGHT ID TO (FLIGHT ID).
IF YOU READ, (appropriate instructions). then — (Action) OBSERVED, WILL CONTINUE RADAR CONTROL.	IF YOU READ, (appropriate instructions). then — (Action) OBSERVED, WILL CONTINUE SURVEILLANCE CONTROL.
	(ACID) READING YOU ON 7700.
	CONFIRM THE NATURE OF YOUR EMERGENCY.





# ADS-B Implementation status

FAA

- Under NEXTGEN
- Dual deployment, 1090 for OAT, UAT for GAT
- Pioneer participation of UPS since 2006
- Implementation Key sites:
  - Juneau, Louisville, Houston, Philadelphia
  - Workgroup to test fusion algorithm. Found better than MSSR and approved for Terminal.
- ADS-B Rule: ADS-B Out by 2020 (declared airspace)



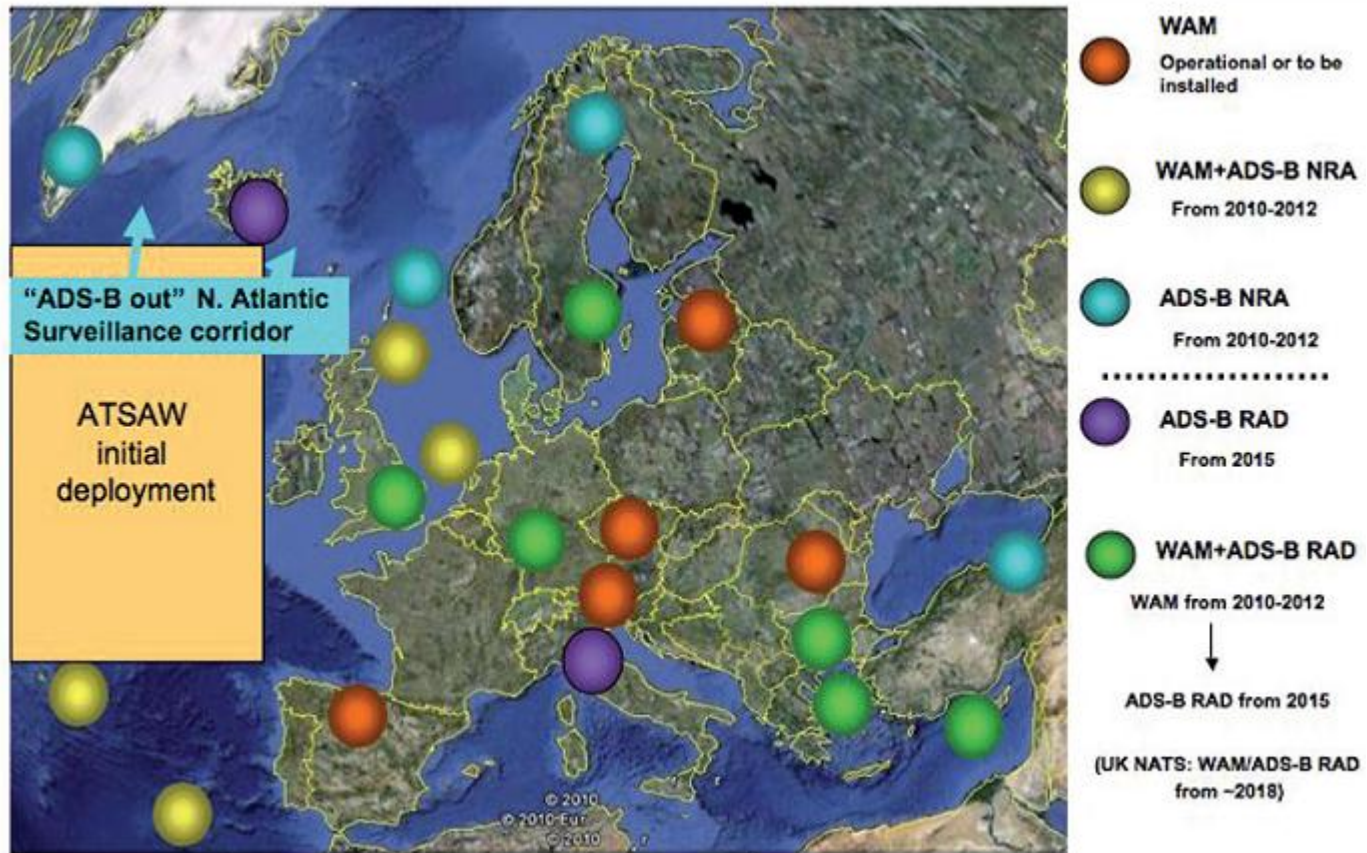


# ADS-B Implementation status

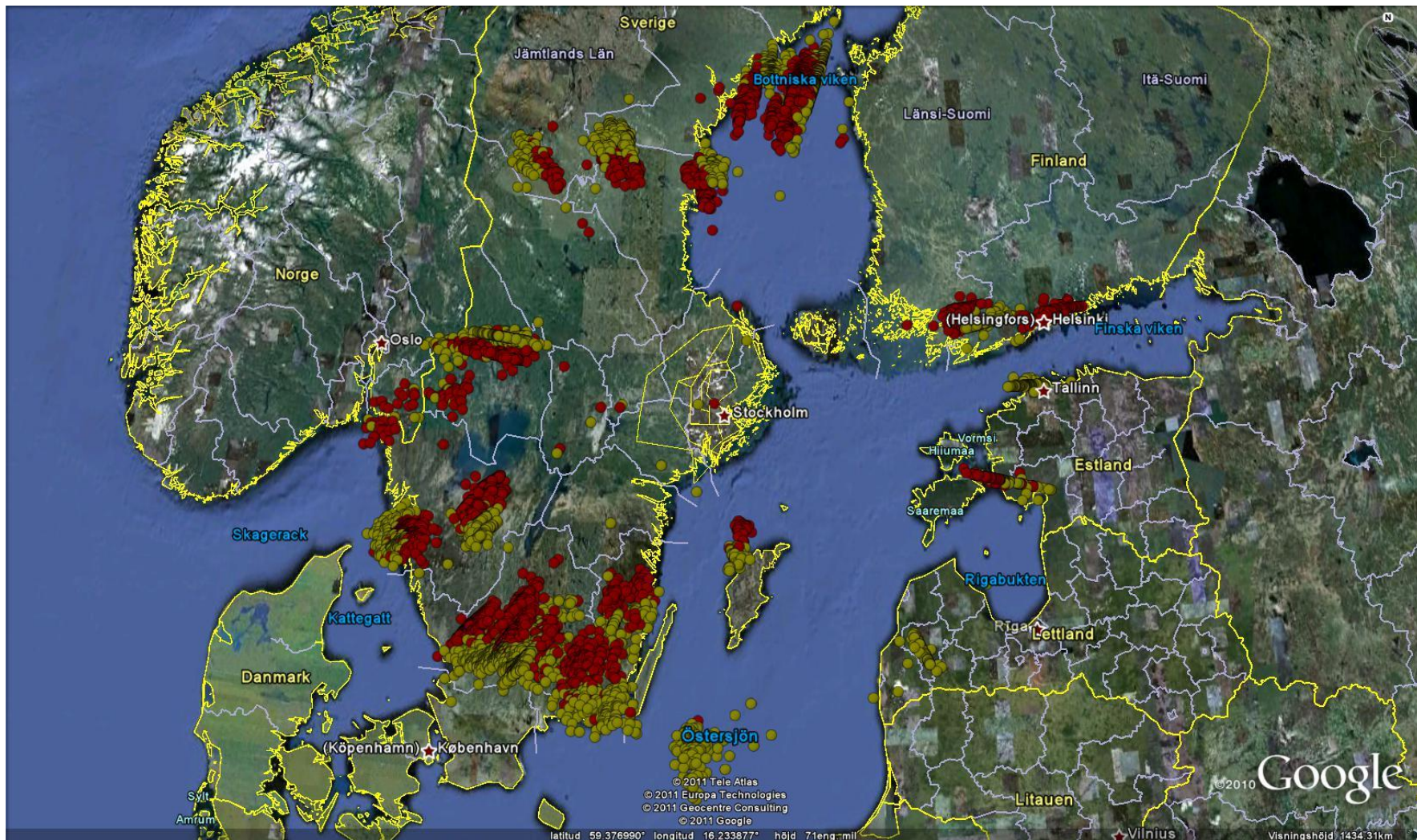


## Eurocontrol CASCADE

- Cristal ADS-B Out
- Cristal RAD HD (NATS)
  - Validation of ADS-B + WAM in London TC
- Cristal DLI Sweden
  - Dual link VDLm4 + 1090ES
  - Kiruna for NRA, Stockholm for RAD
- ATSAW studies









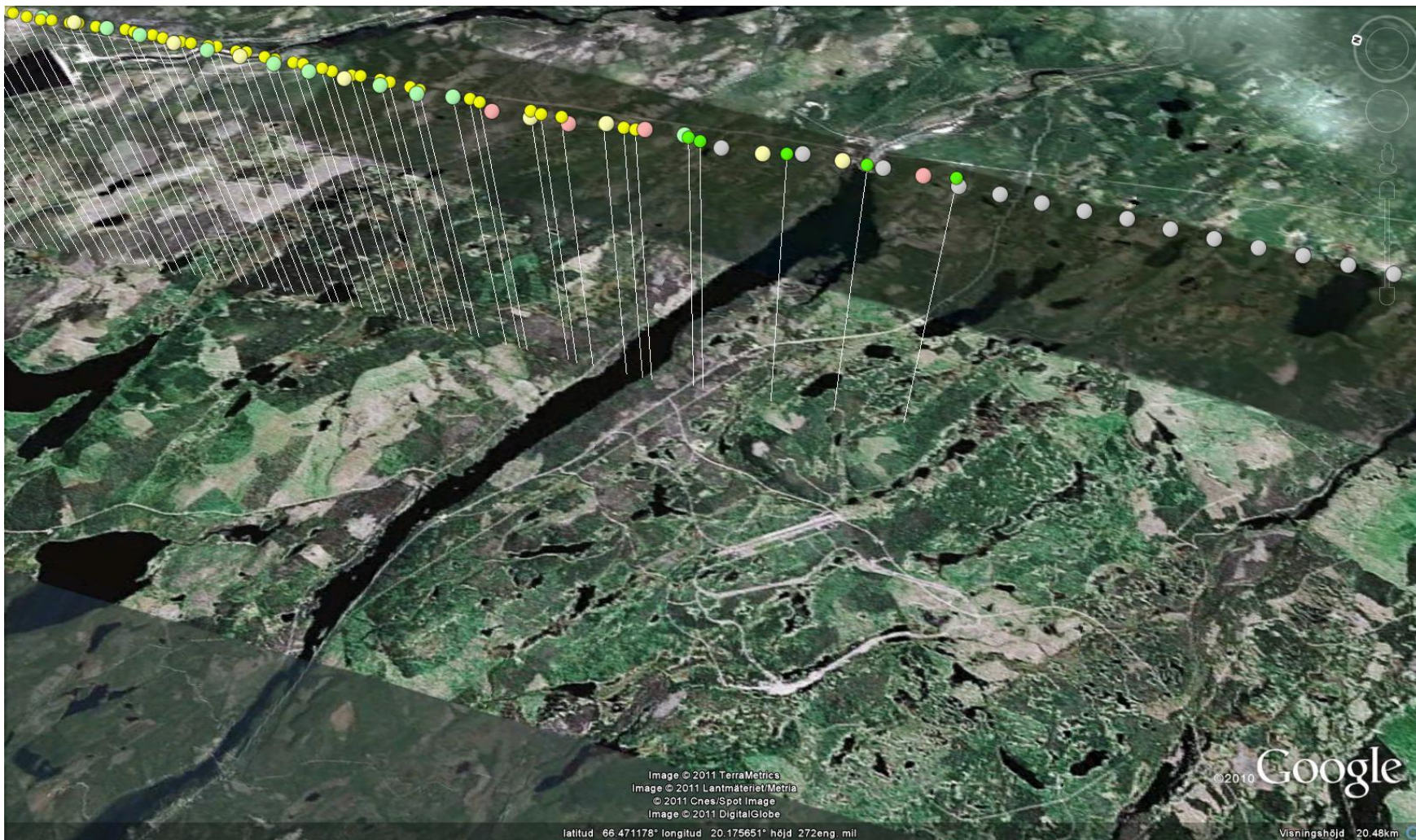


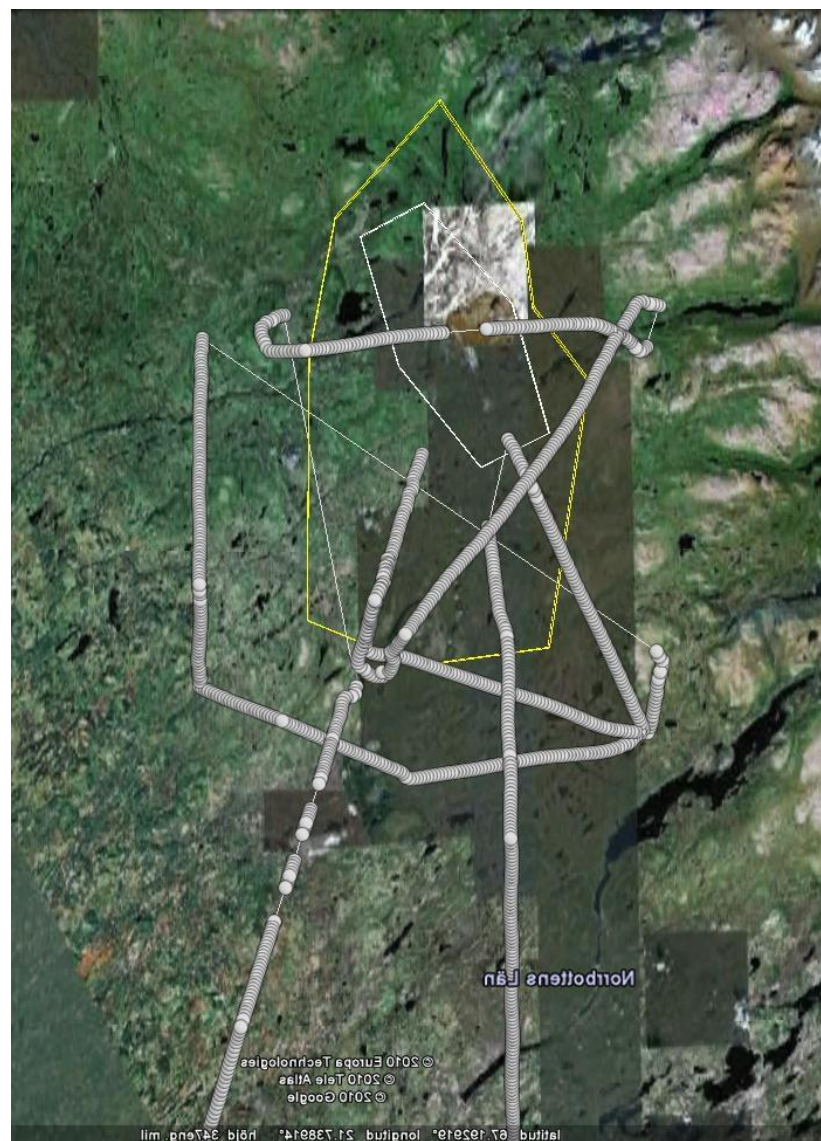
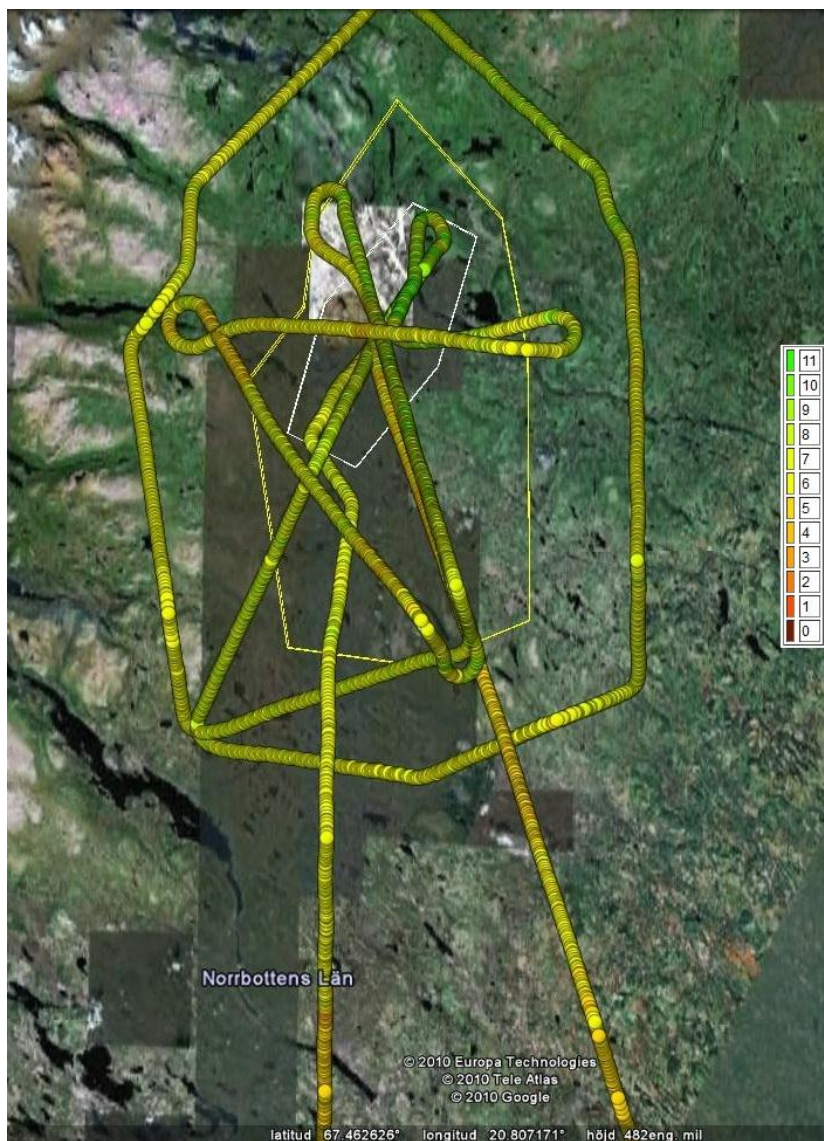
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latitud 66.471178° longitud 20.175651° höjd 272eng. mil

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Visningshöjd 20.48km

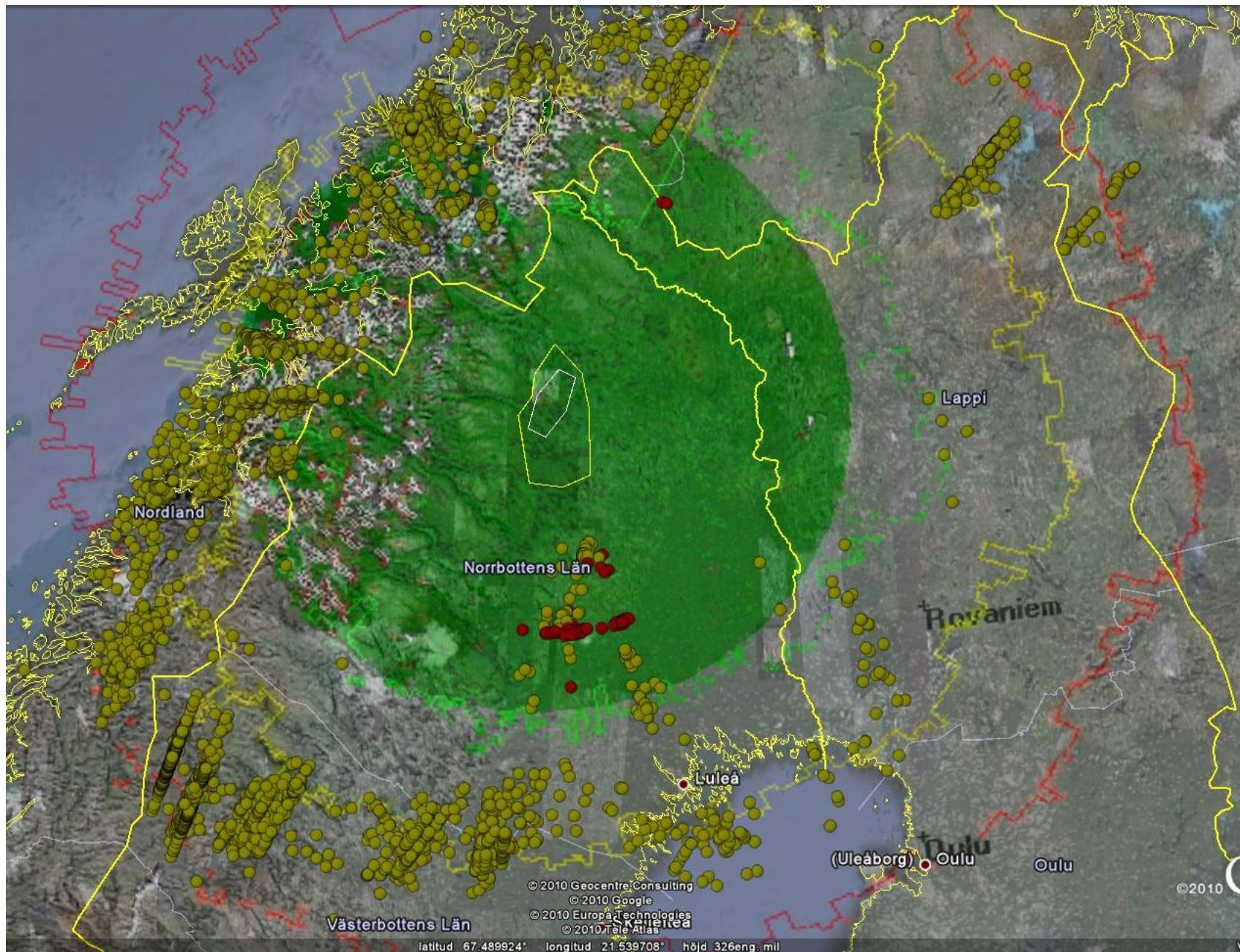












# ADS-B Market Overview

ADS-B Ground station \$100-400 ths

Avionics: depends on functions

- Cheapest ADS-B Out only sets at 2000 USD
- Top end with ADS-B In, CDTI interface, multilink and separate Differential channel at 10000 USD.
- Operators wary to equip before mandate



# ??ADS-B or WAM??

ADS-B: Large coverage, infrastructure at 10% cost of radar. No independent means of verification.

WAM (MLAT): Cost at ca 50% of radar, similar coverage but much less dependent.

Answer -> integrate together

# Future ADS-B Surv System

- SESAR WP15.4.5
- Defines System Requirements on ADS-B ground station, interface and tracker.
- Cross-correlation to full WAM integration
- "Security enhancements"
- Prototypes under development
- Suitable standalone surveillance for remote and regional environments?

# Remember PBN?

- Regulatory level moving towards PBS
- No need to bug the ATCO with source type
- Instead, requirements in Accuracy, Integrity, Reliability, Latency, Update probability imposed on system, whatever its nature.
- So far 3NM and 5NM mulled in a replacement standard to the obsolescent Eurocontrol RADAR paper. Further service types in pipeline.

# Questions

# NIC

NIC	Horizontal Containment	Comment
0	Unknown	No containment
1	$R_c < 20$ nmi	RNP-10 containment
2	$R_c < 8$ nmi	RNP-4 containment
3	$R_c < 4$ nmi	RNP-2 containment
4	$R_c < 2$ nmi	RNP-1 containment
5	$R_c < 1$ nmi	RNP-0.5 containment
6	$R_c < 0.6$ nmi	RNP-0.3 containment
7	$R_c < 0.2$ nmi	RNP-0.1 containment
8	$R_c < 0.1$ nmi	e.g. RAIM - GPS
9	$R_c < 75$ m	Future system
10	$R_c < 25$ m	e.g. WAAS HPL
11	$R_c < 7.5$ m	e.g. LAAS HPL
12-15	future expansion	

# NACp

NACp	Horizontal Error (95%)	Vertical Error (95%)	Comment
0	EPU > 10 nmi	-	Accuracy Unknown
1	EPU < 10 nmi	-	RNP-10 Accuracy
2	EPU < 4 nmi	-	RNP-4 Accuracy
3	EPU < 2 nmi	-	RNP-2 Accuracy
4	EPU < 1 nmi	-	RNP-1 Accuracy
5	EPU < 0.5 nmi	-	RNP-0.5 Accuracy
6	EPU < 0.3 nmi	-	RNP-0.3 Accuracy
7	EPU < 0.1 nmi	-	RNP-0.1 Accuracy
8	EPU < .05 nmi	-	e.g. GPS
9	EPU < 30 m	-	e.g. GPS (No SA)
10	HFOM < 10 m	VFOM < 15 m	e.g. WAAS
11	HFOM < 3 m	VFOM < 4 m	e.g. LAAS