



# Satellite Based Augmentation Systems and the Leap Second

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# The Problem

## Inter-operability

### Automatic Dependent Surveillance – Broadcast (ADS-B)

**Interoperability and ADS-B are highly dependent upon all systems having the same geodetic and time basis.**

**Timekeeping “Thought” has not kept pace with the development of modern navigation and communications systems**



# ADS-B

## ADS-B (Broadcast)



Typically  
broadcast 1/second



### Automatic

no pilot input required

### Dependent

extremely accurate position  
and velocity vector from  
aircraft (eg GPS)

### Surveillance

aircraft position, altitude,  
velocity vector, + . . .

### Broadcast

any ground station or  
aircraft can monitor



# Time Basis for GPS and SBAS's

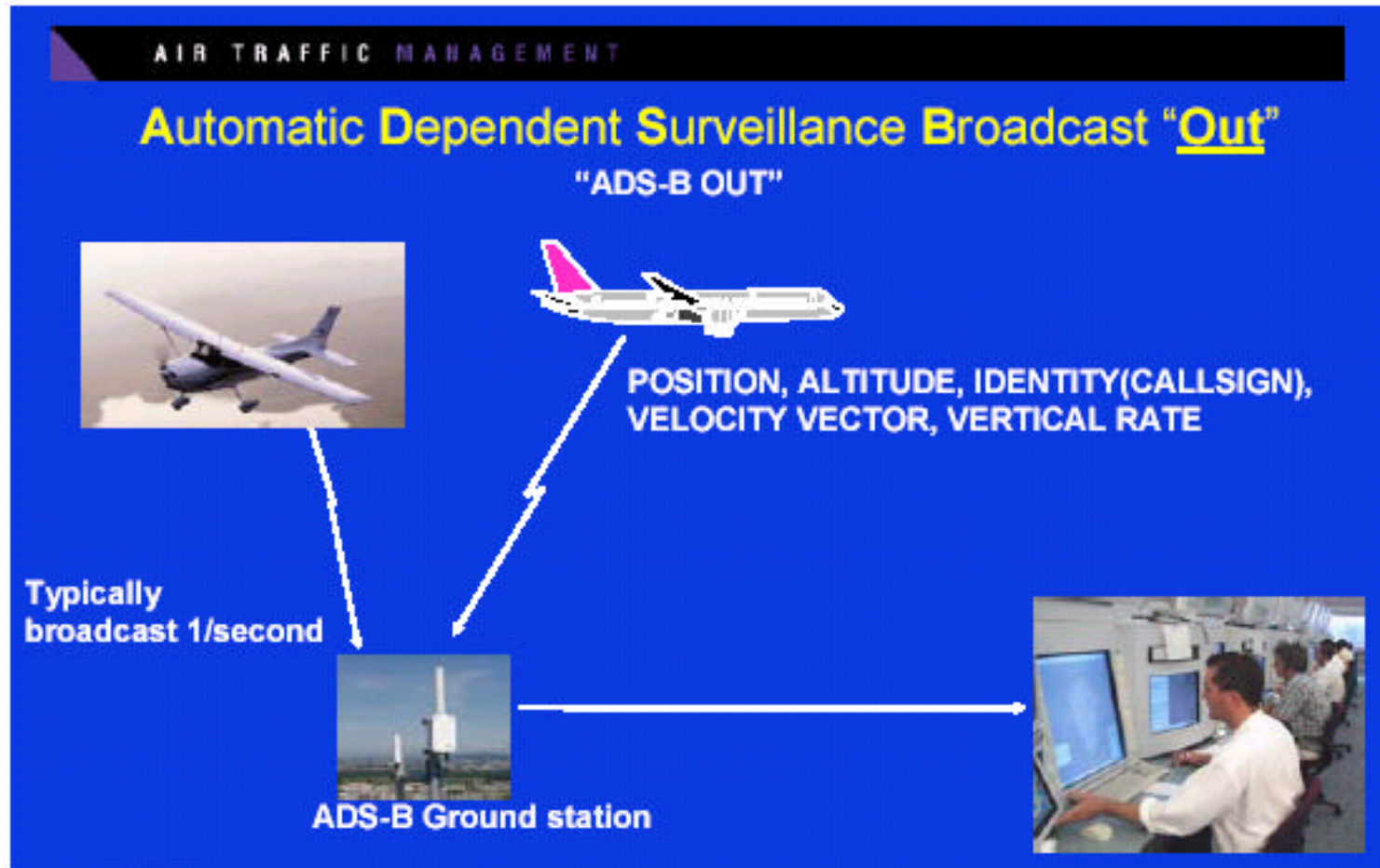
## Satellite Navigation Systems:

1. GPS = GPS Time (a continuous uniform time scale)
2. WAAS = WNT = GPS Time (Geo used for navigation)
3. EGNOS = ENT = GPS Time (Geo used for navigation)
4. MSAS = MNT = GPS Time (Geo used for navigation)
5. Galileo = GST = TAI (a continuous uniform time scale)
6. GLONASS = UTC

**All systems will give offsets from UTC.**



# ADS-B





# The Future

## Increased Capacity in Air Lanes

**In North Atlantic Corridor separation distances become smaller where planes operate using different navigation systems**

## Runway Incursion

**Multiple Parallel Runways and increasing ground traffic**



# The Future Problem

**Different time basis for different systems**

**GPS Time, UTC and TAI**

**Virtual Radar through ADS-B**

**Plot position as function of TIME**

**No Radar over Atlantic**



# The Mathematics of the Problem

**Relative Velocity between 2 Aircraft =**

**1000 miles/hr      1609 km/hour**

**0.278 miles/sec      0.447 km/sec**

**Offset between UTC and GPS Time & TAI will  
continue to grow**

**It is not a matter of cost, but of saving lives!**





## Concerns

- **All SBAS's do not have the same time basis.**
- **Aircraft traveling eastward (WAAS) will have a different time basis from those traveling westward (Galileo).**
- **Air Traffic Controllers have clocks keeping UTC while navigation systems have a different time basis.**
- **Aircraft moving on ground between different runways can not occupy the same space at the same time.**
- **Frequency of Leap Seconds will increase**
- **Insertion of Leap Seconds may not be uniform!**

**Safety of Life is an Issue!**



## More Concerns

- **System designers do not understand TIME!**
- **Air Traffic Controllers are in a STRESSFUL Environment!**
- **GLONASS was unusable for 20 hours once during the occurrence of a Leap Second.**

**Safety of Life is an Issue!**



# Recommendations

**A uniform and continuous reference time will go a long way towards preventing catastrophes.**

## **Several Step Process:**

- **Stop Leap Seconds**
- **Set SBAS and GTPS Time = TAI**
- **Set UTC = TAI**

**Safety of Life is an Issue!**