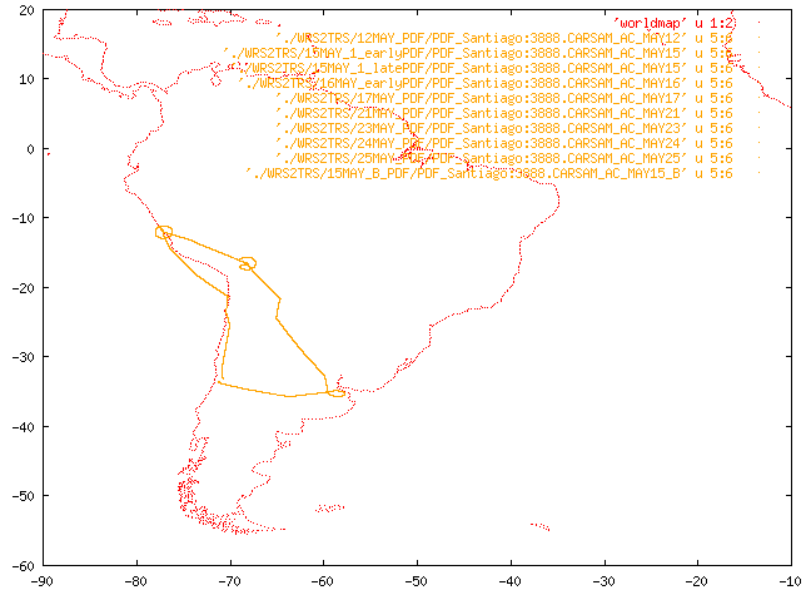


# CARSAM MAY 2002 FLIGHT TEST DATA



Thomas Dehel, NSTB  
FAA Technical Center  
August, 2002

# CARSAM May 2002 Flight Test Data Outline

- DATA COLLECTION SUMMARY
- DATA PROCESSING STEPS
- LIMITATIONS
- DATA PLOTS
  - AIRCRAFT POSITION and ALTITUDE (All)
  - LA PAZ Approaches
    - Accuracy
    - Availability
    - Integrity
  - US WAAS in CARSAM NPA Examples
  - IONOSPHERIC DATA
- CONCLUSIONS

# CARSAM May 2002 Flight Test Data Data Collection Summary

- Data Collected by Chilean aircraft
  - Flights 12 May, 2002 – 25 May 2002
  - Primarily enroute, some approaches at La Paz
  - Data consisted of Novatel Millennium:
    - RGEA logs (1 per second)
    - FRMA logs
- L1-only data from aircraft
- Some ground data from La Paz (L1/L2)
- Multiple TRS data from CARSAM sites

# CARSAM May 2002 Flight Test Data

## Data Processing Steps

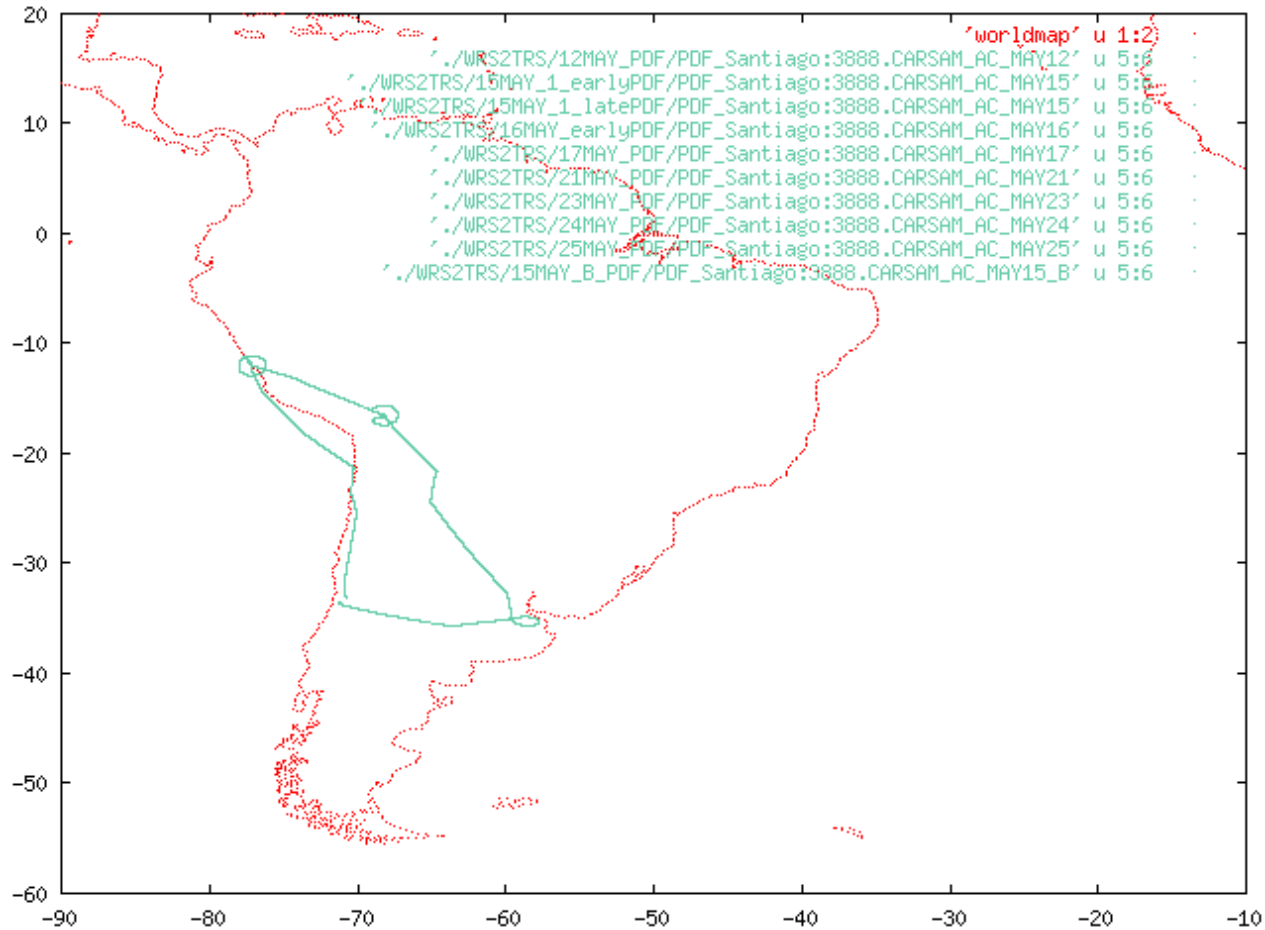
- 1: Convert ASCII to Binary with WINSAT (Novatel tool)
- 2: Convert Binary to TRS ICD format with “trsmill”
  - Written by JC Geffard, SUN compatible, available at FAATC
- 3: Process ICD format thru “Gpssolution”
  - Written by D. Nelthropp (SUN compatible, at FAATC)
  - \*Required additional TRS data since no ephemeris collected\*
  - Produces either position (WGS or ENU) or ENU error if truth is known (for static collection)
  - Also produces VPL and HPL using real or simulated UDRE/GIVEs
- 4: Process Iono data by using “unpackICD”
  - Written by K. Pham, (SUN compatible, at FAATC)
- 5: Use GNUplot to graph results
  - Public available software

# CARSAM May 2002 Flight Test Data Limitations

- No ephemeris collected
  - involved some additional effort
  - prevented attempt at example flight “truth” data
- No independent truth data collected
  - eg. Ashtec/TSPI
- No GPS/SBAS steering for aircraft
- No SBAS corrections available from CSTB
  - Small impact to accuracy since SA is off
- No L1/L2 collected on aircraft
  - L1 code-carrier still useful for Iono change measurements
- TRS outages on several days

# CARSAM May 2002 Flight Test Data

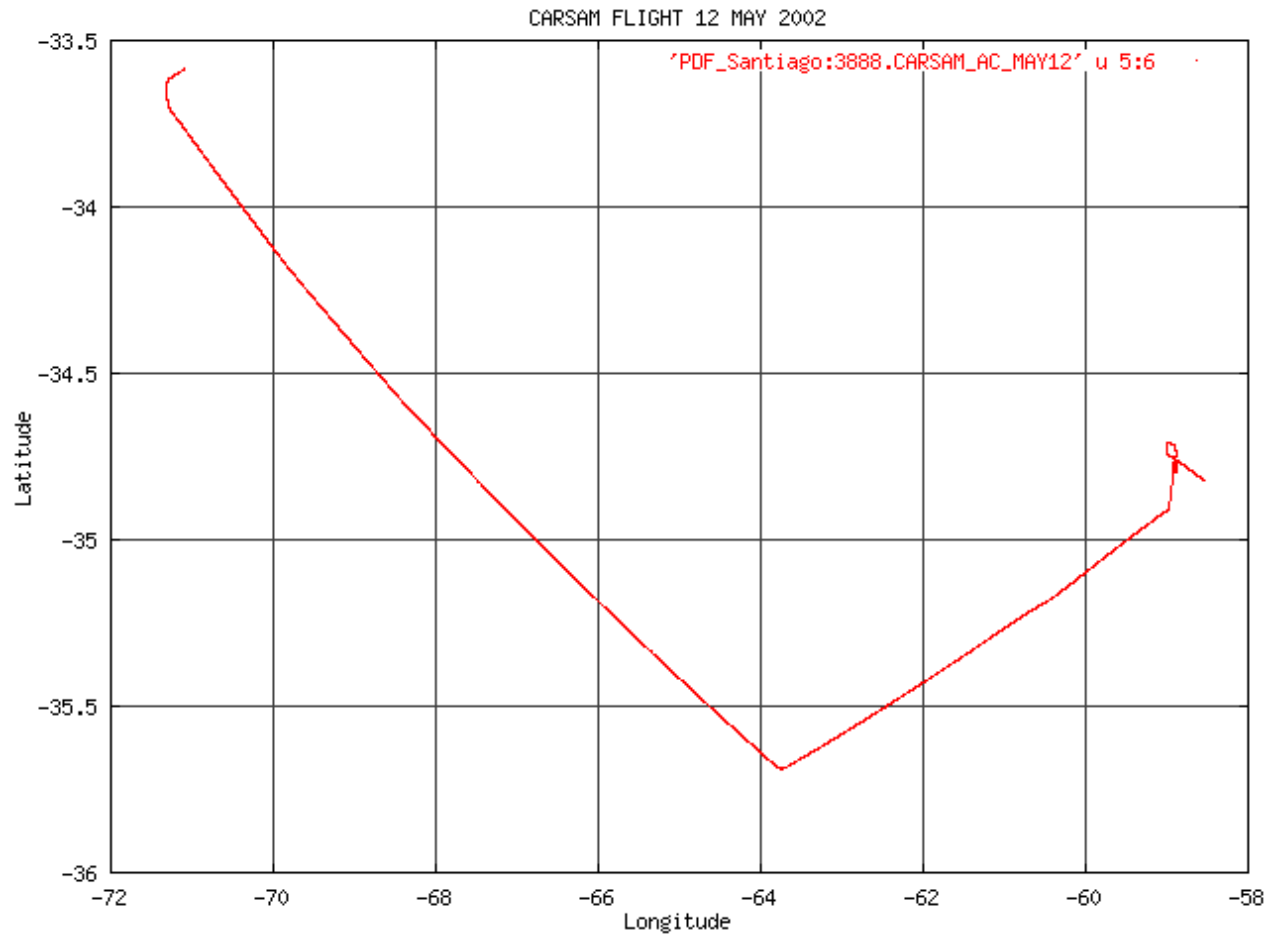
## AIRCRAFT POSITION (ALL FLIGHTS)



# CARSAM May 2002 Flight Test Data

## AIRCRAFT POSITION and ALTITUDE

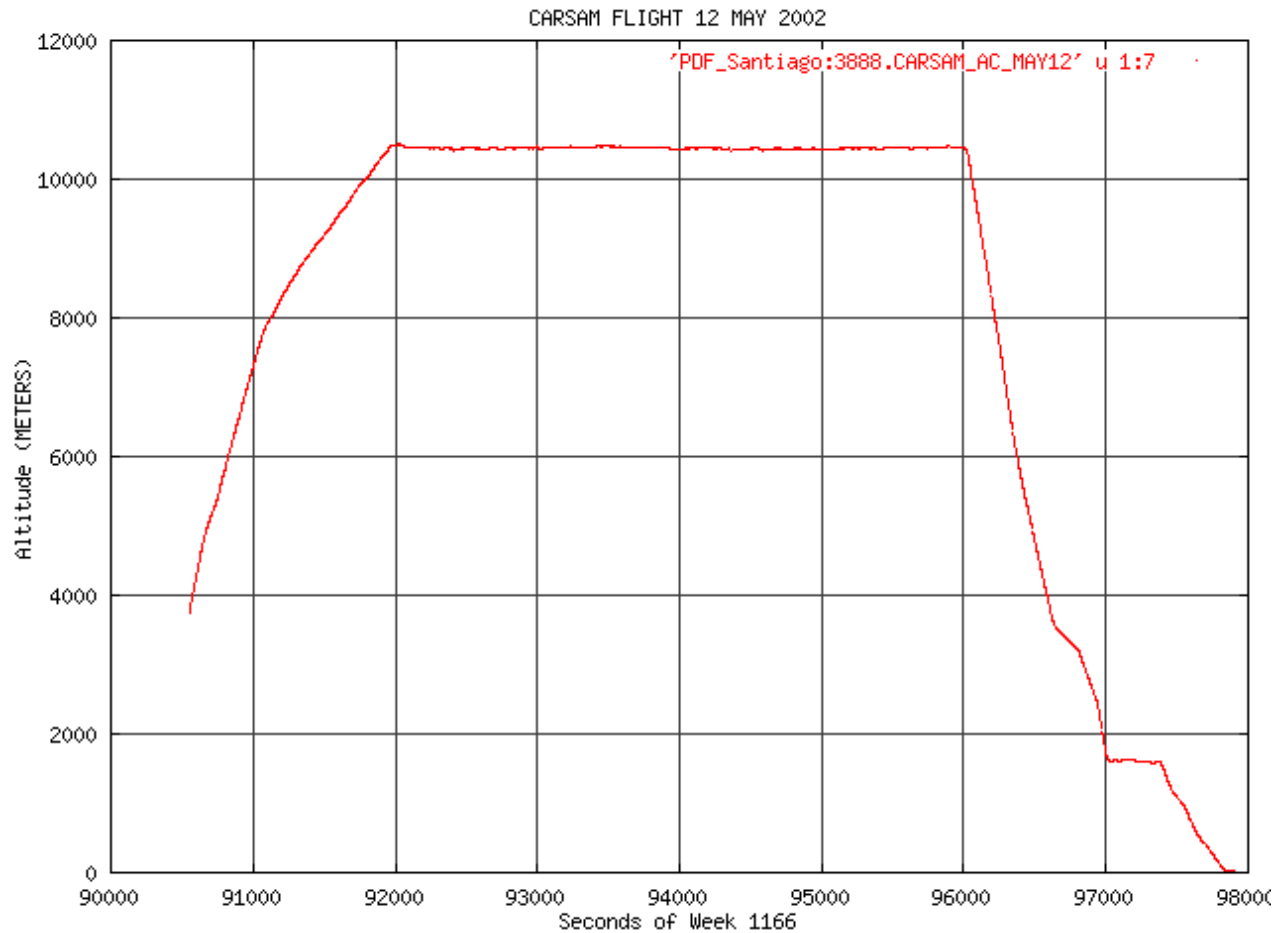
### 12 MAY 2002



# CARSAM May 2002 Flight Test Data

## AIRCRAFT POSITION and ALTITUDE

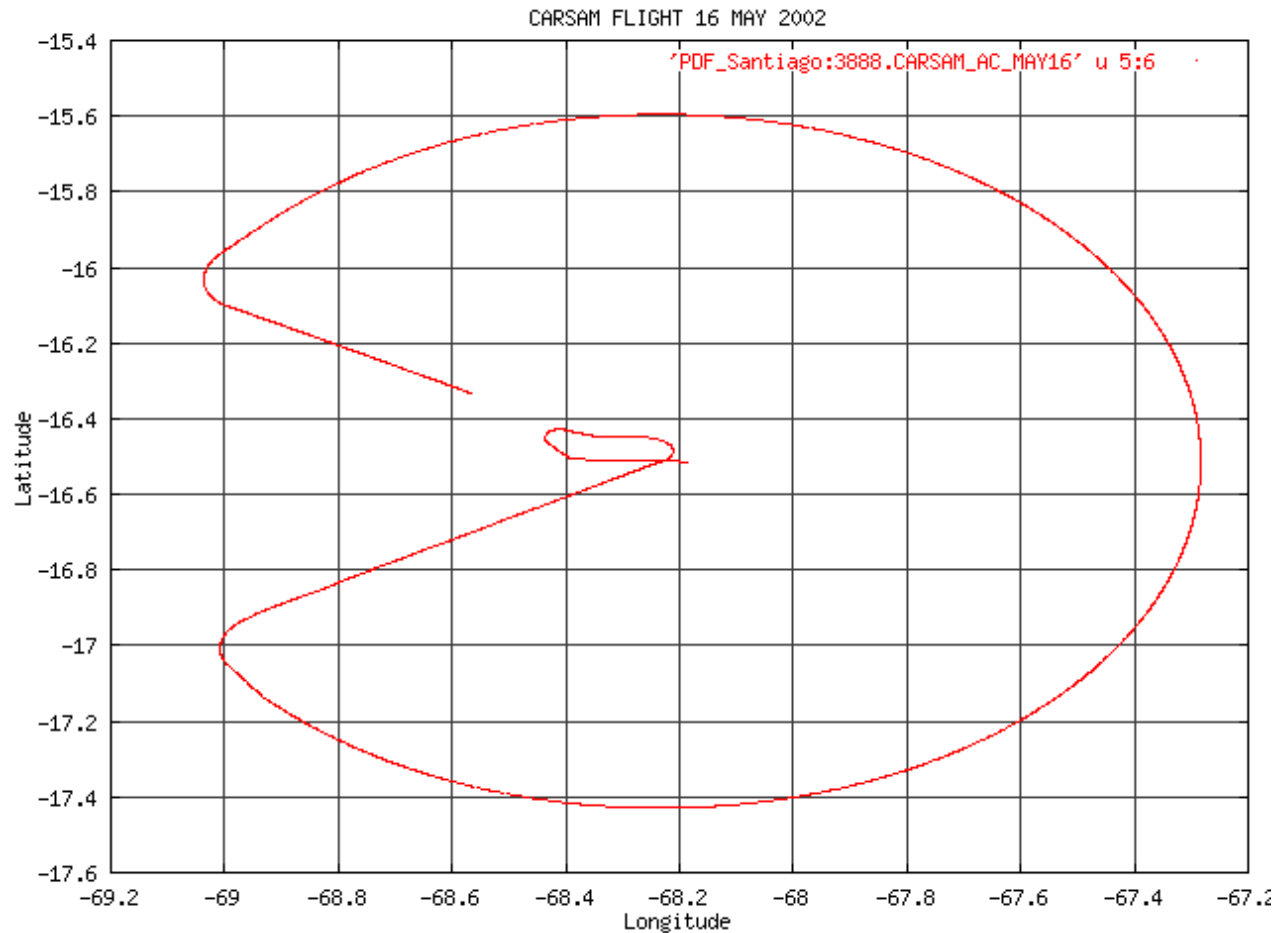
### 12 MAY 2002



# CARSAM May 2002 Flight Test Data

## AIRCRAFT POSITION and ALTITUDE

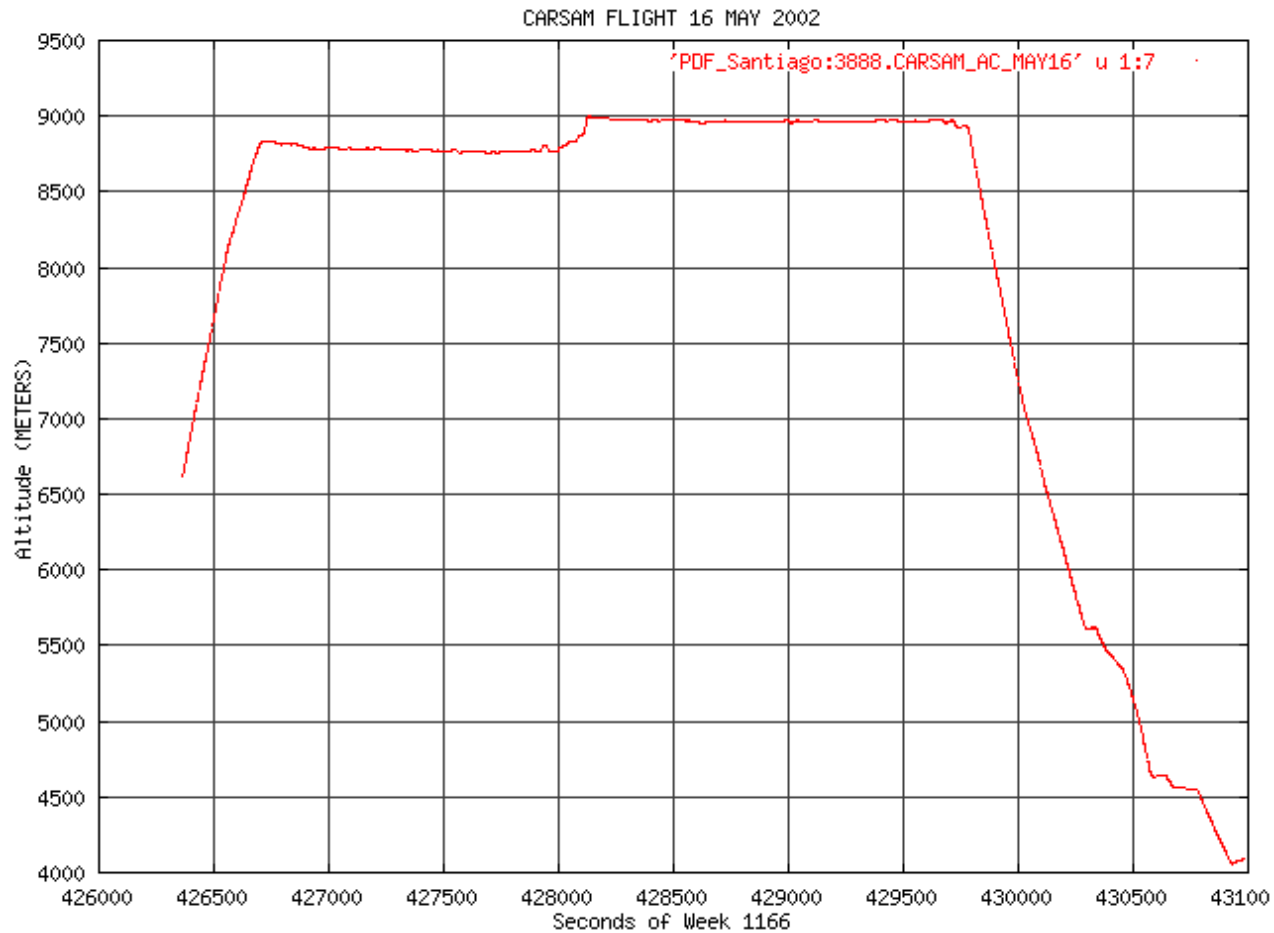
### 16 MAY 2002



# CARSAM May 2002 Flight Test Data

## AIRCRAFT POSITION and ALTITUDE

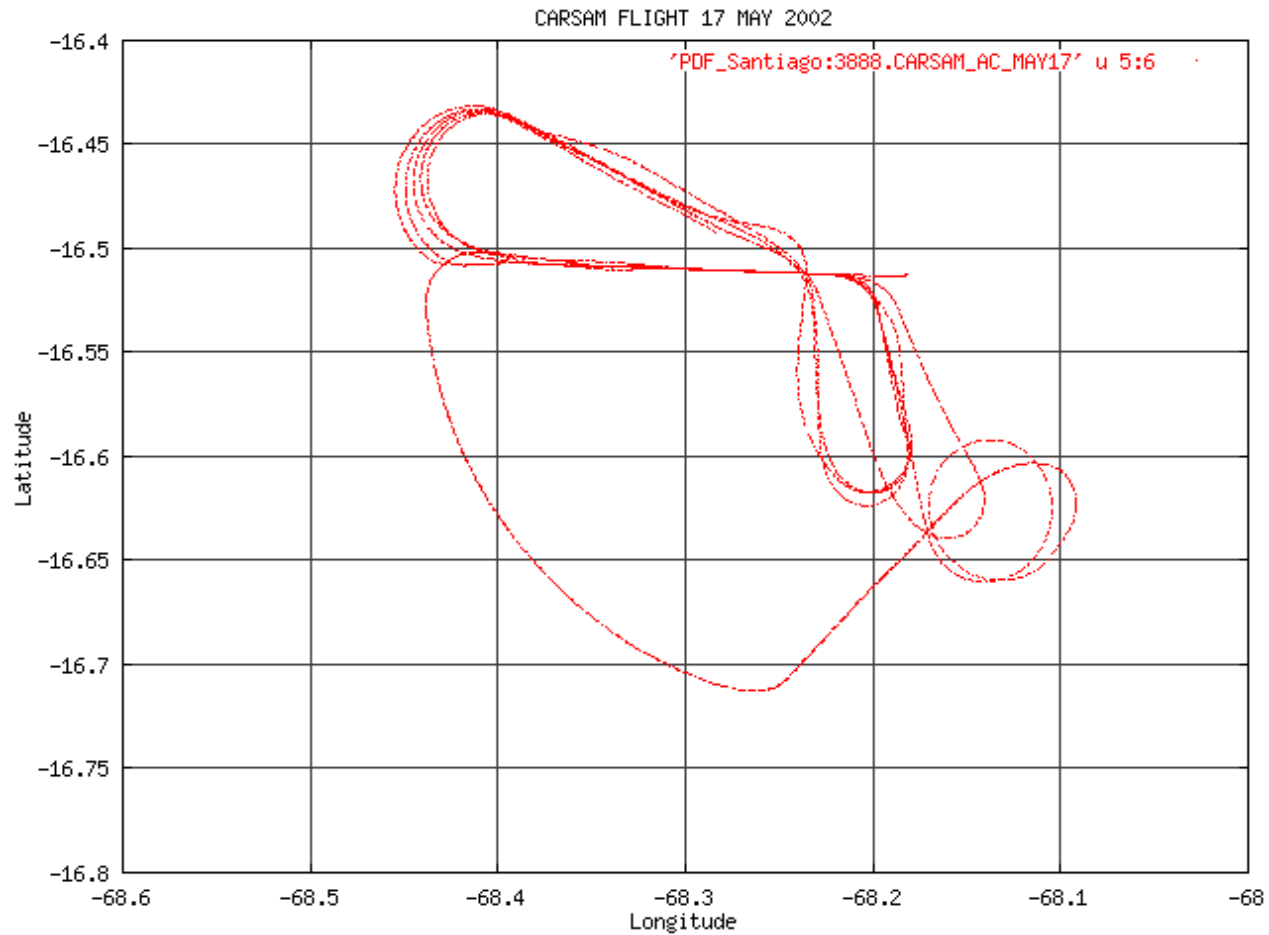
### 16 MAY 2002



# CARSAM May 2002 Flight Test Data

## AIRCRAFT POSITION and ALTITUDE

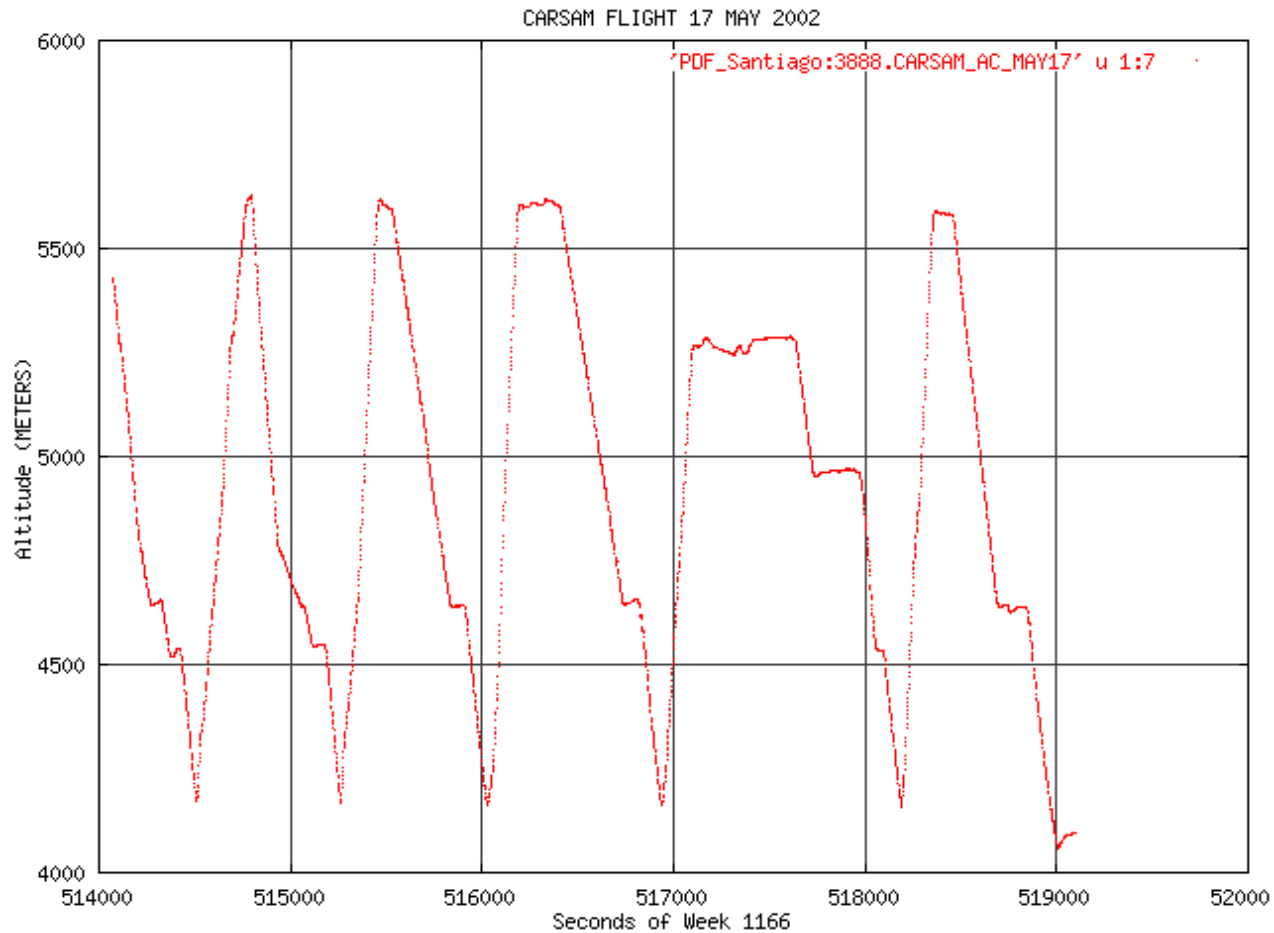
### 17 MAY 2002



# CARSAM May 2002 Flight Test Data

## AIRCRAFT POSITION and ALTITUDE

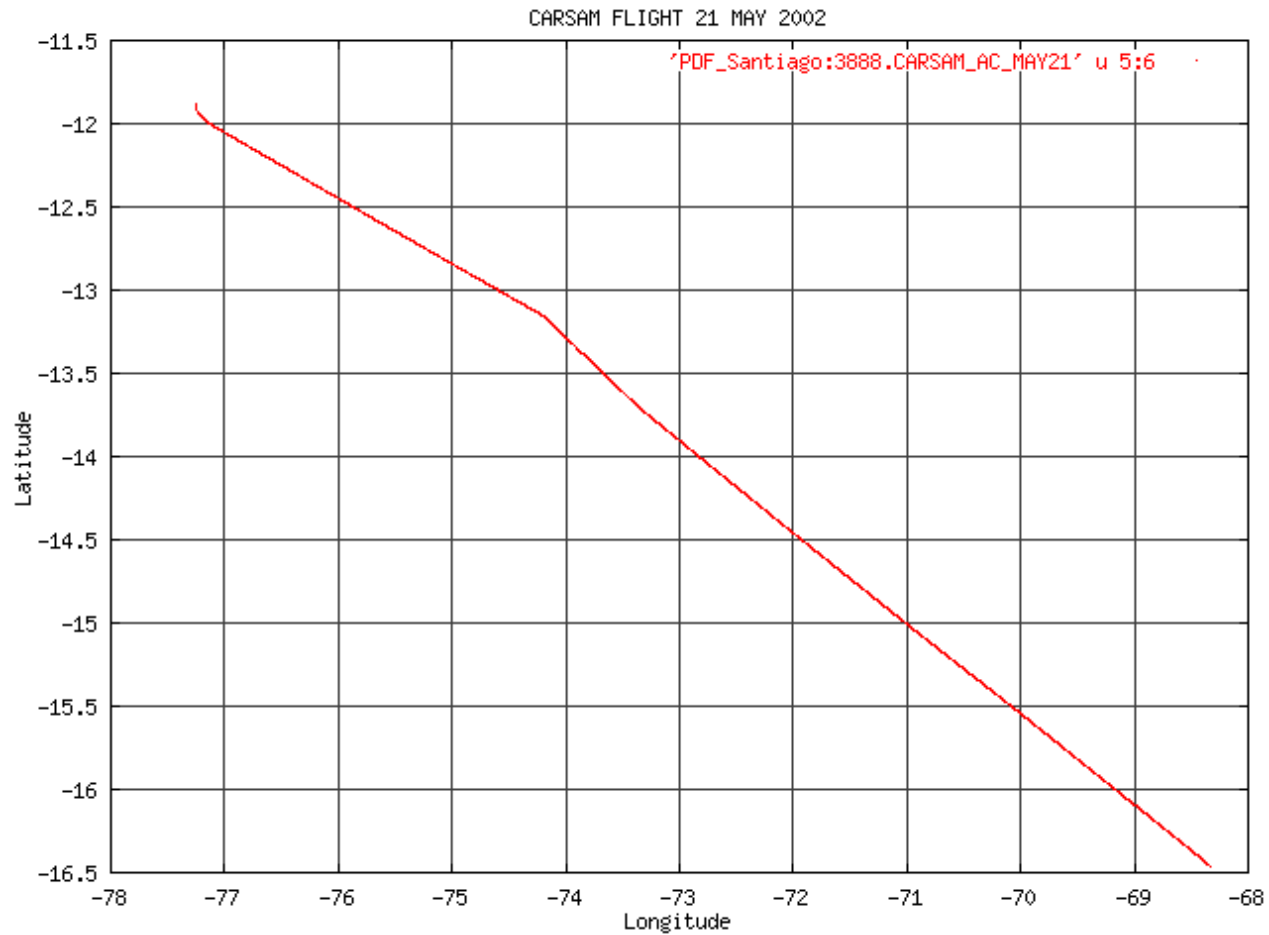
### 17 MAY 2002



# CARSAM May 2002 Flight Test Data

## AIRCRAFT POSITION and ALTITUDE

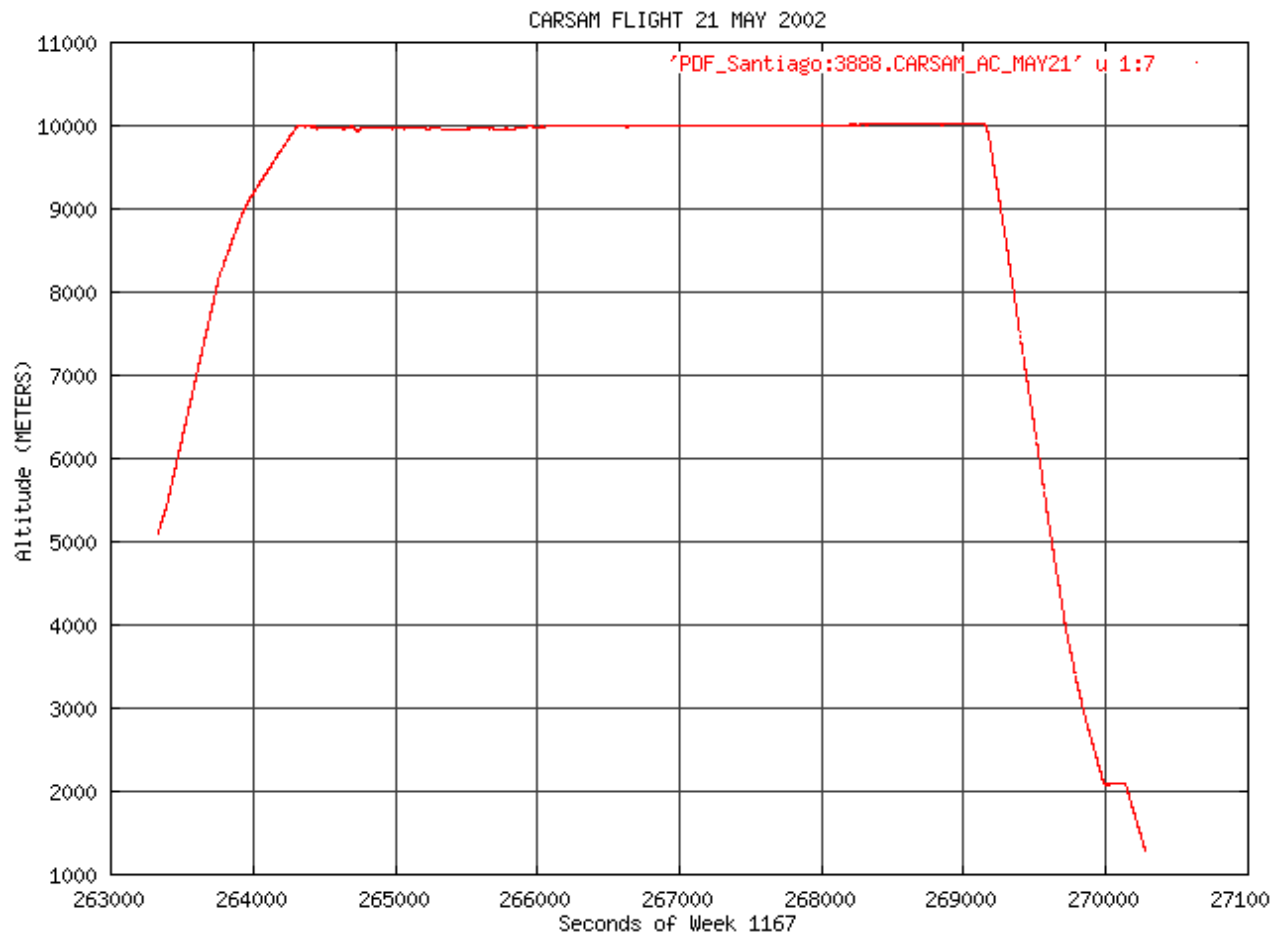
### 21 MAY 2002



# CARSAM May 2002 Flight Test Data

## AIRCRAFT POSITION and ALTITUDE

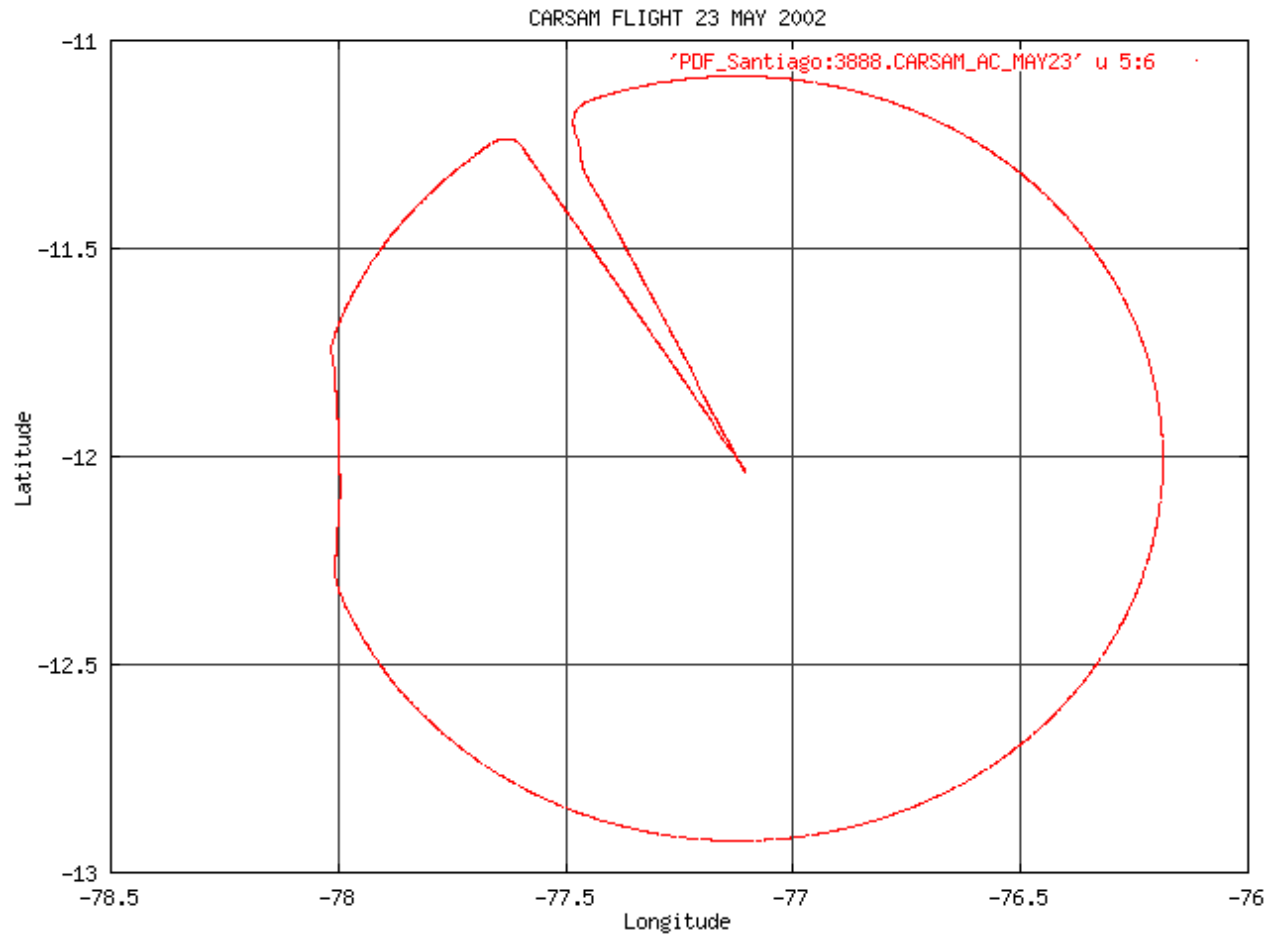
### 21 MAY 2002



# CARSAM May 2002 Flight Test Data

## AIRCRAFT POSITION and ALTITUDE

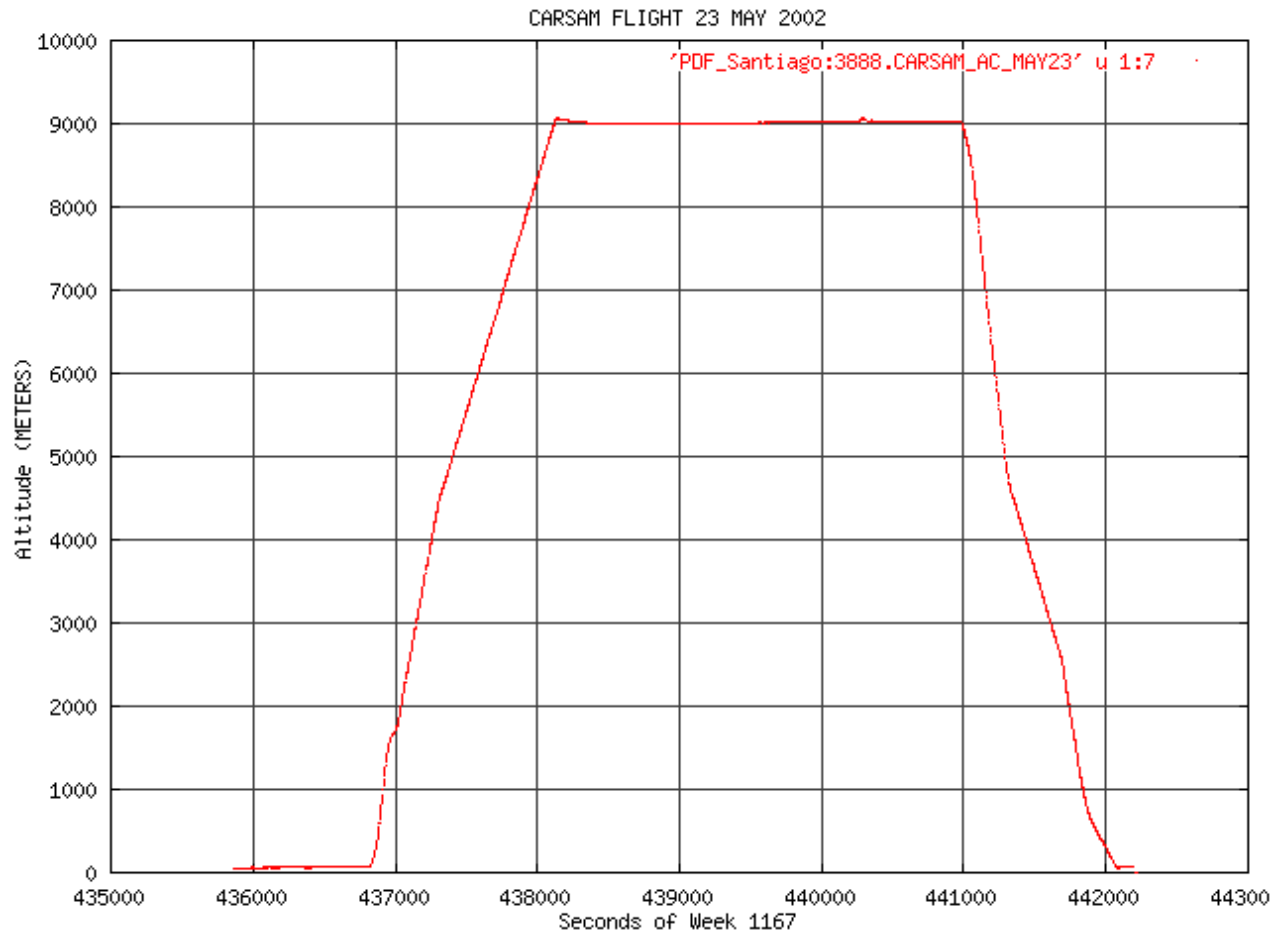
### 23 MAY 2002



# CARSAM May 2002 Flight Test Data

## AIRCRAFT POSITION and ALTITUDE

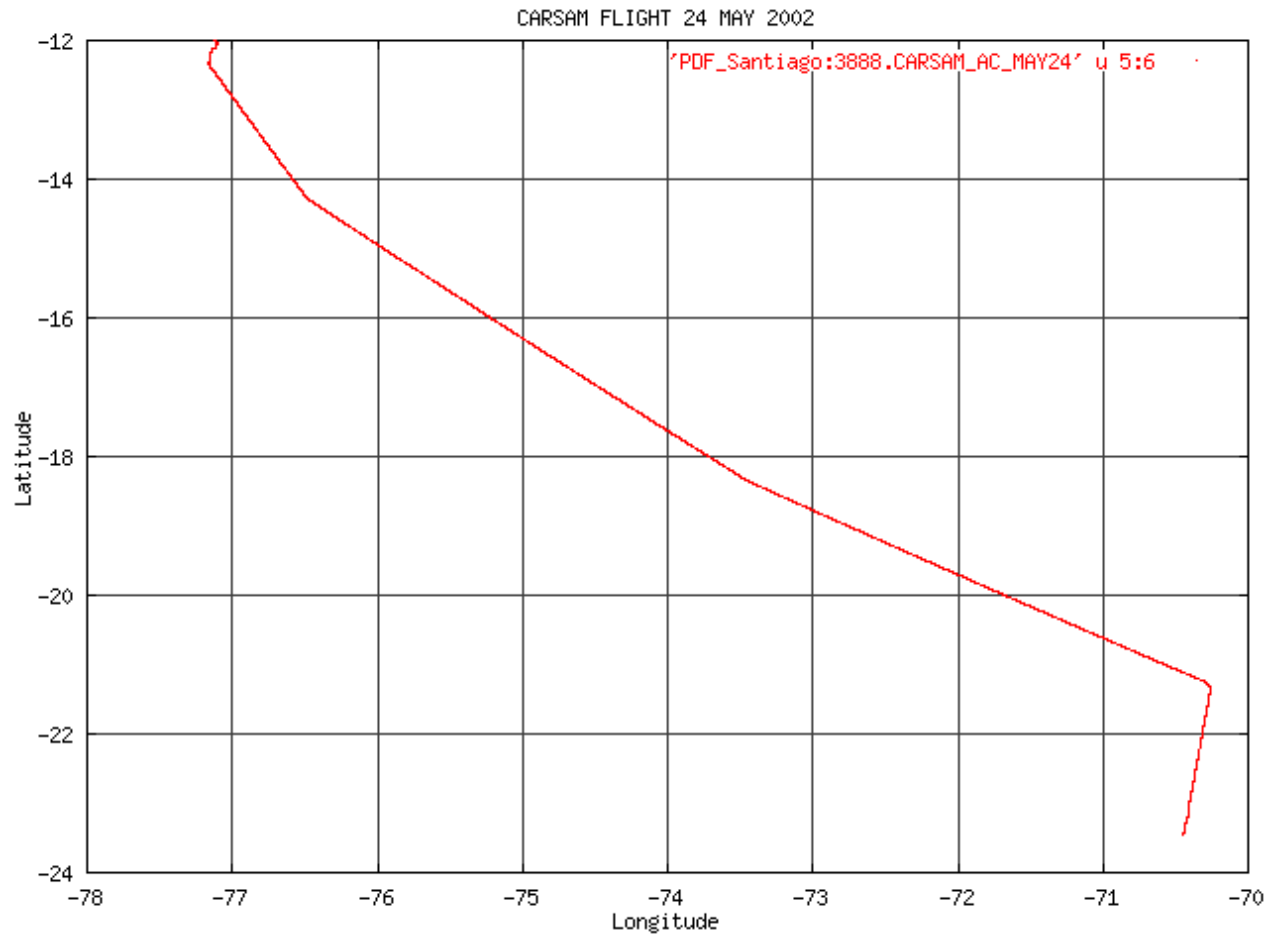
### 23 MAY 2002



# CARSAM May 2002 Flight Test Data

## AIRCRAFT POSITION and ALTITUDE

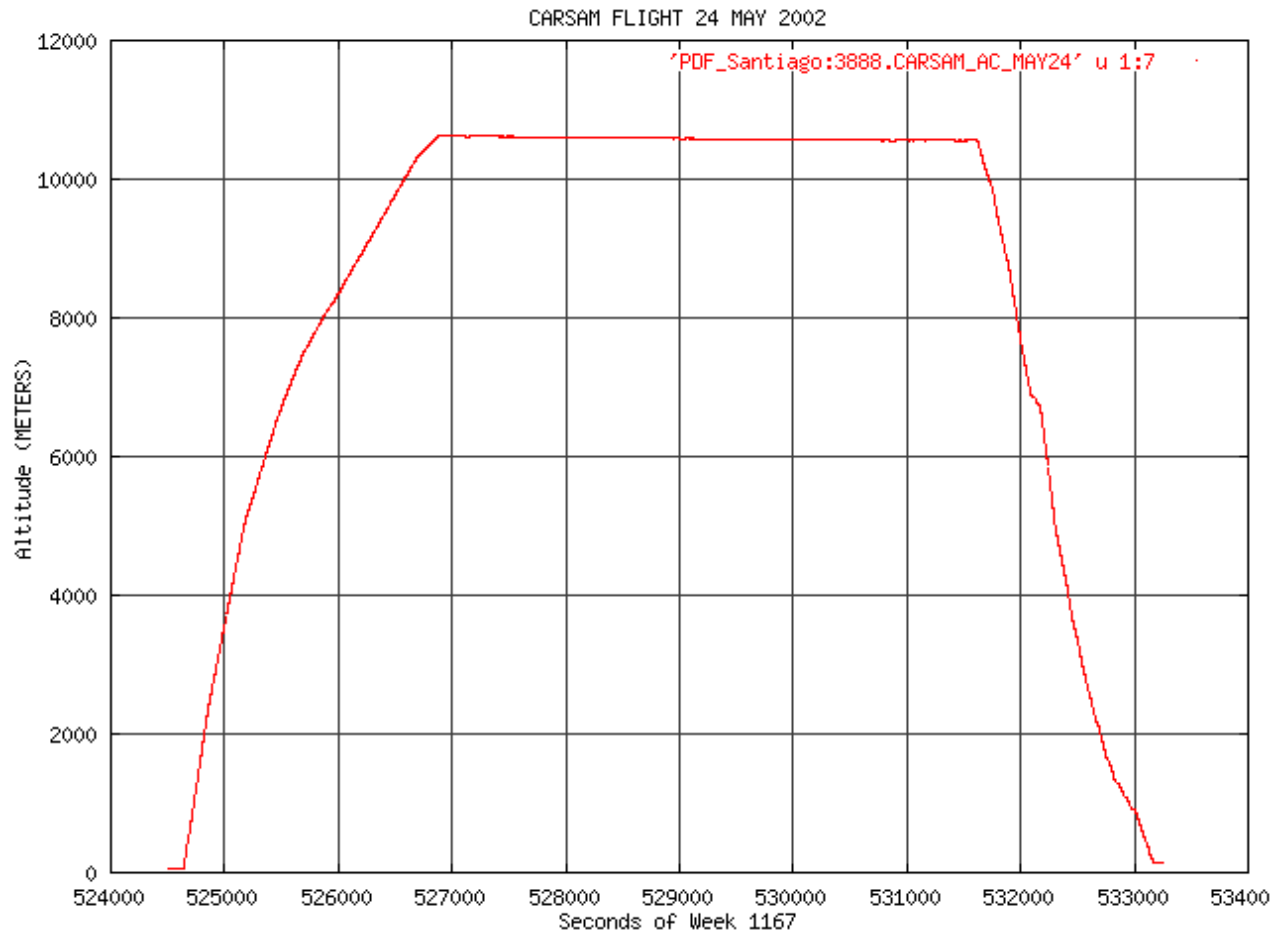
### 24 MAY 2002



# CARSAM May 2002 Flight Test Data

## AIRCRAFT POSITION and ALTITUDE

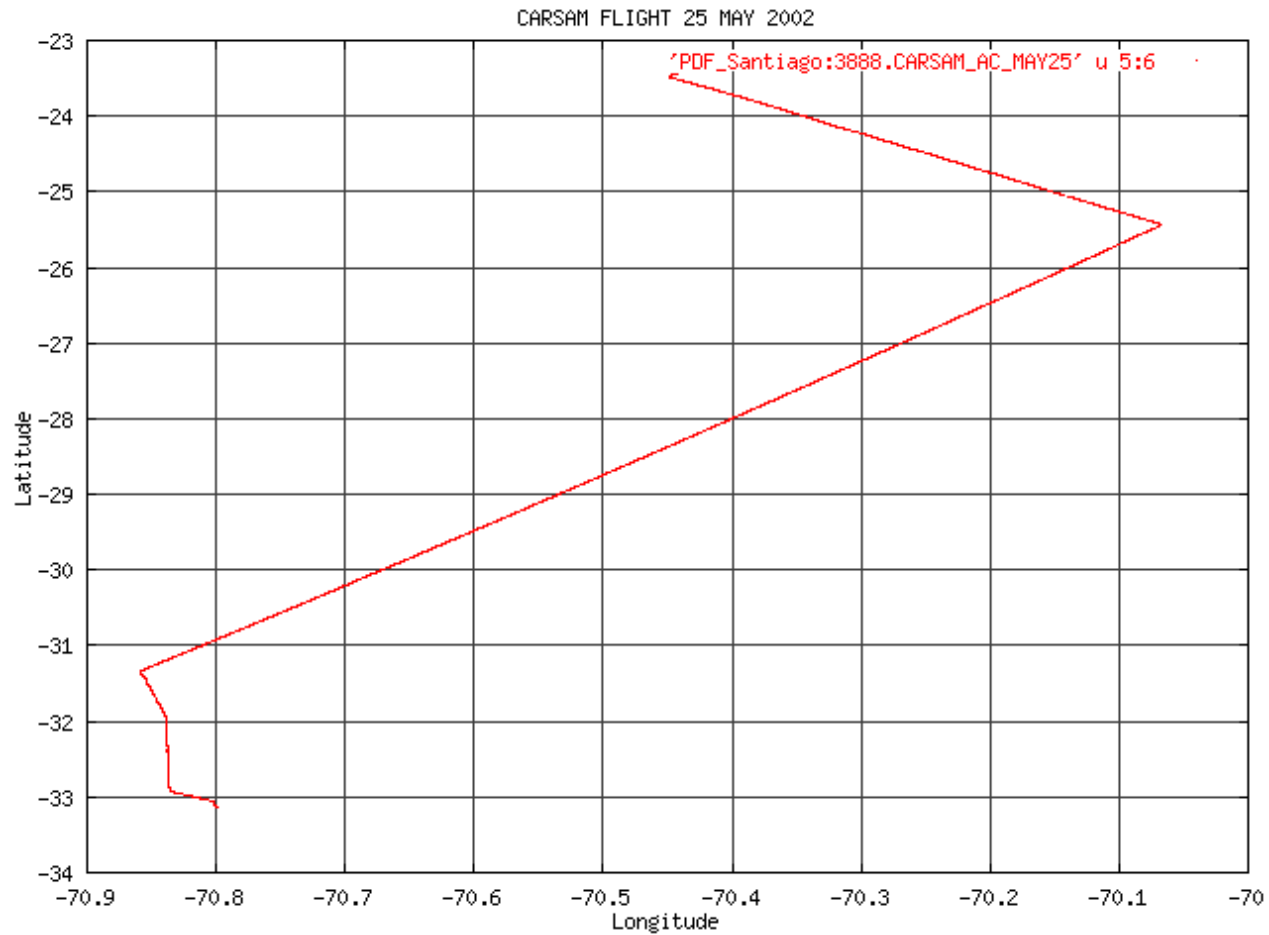
### 24 MAY 2002



# CARSAM May 2002 Flight Test Data

## AIRCRAFT POSITION and ALTITUDE

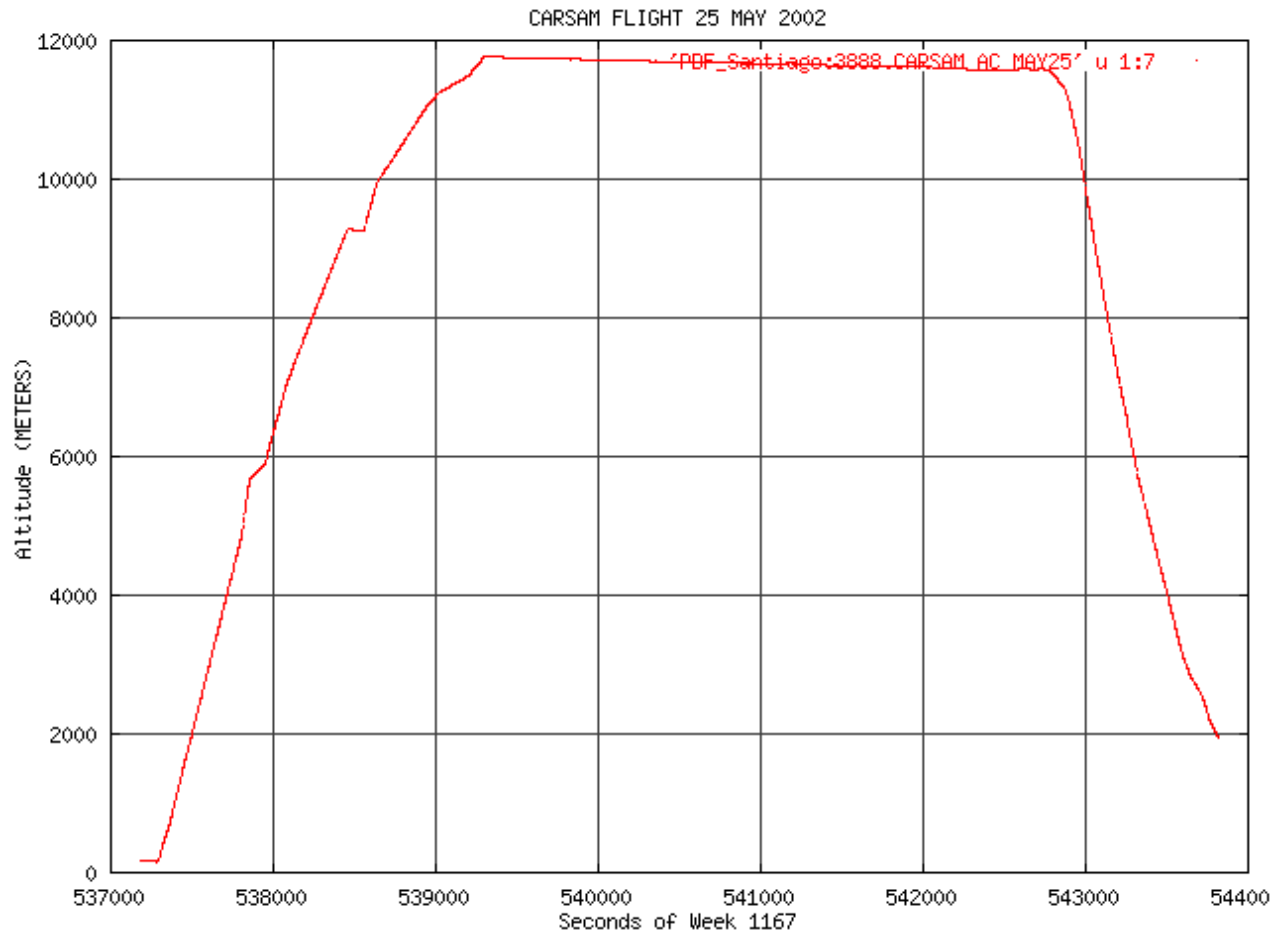
### 25 MAY 2002



# CARSAM May 2002 Flight Test Data

## AIRCRAFT POSITION and ALTITUDE

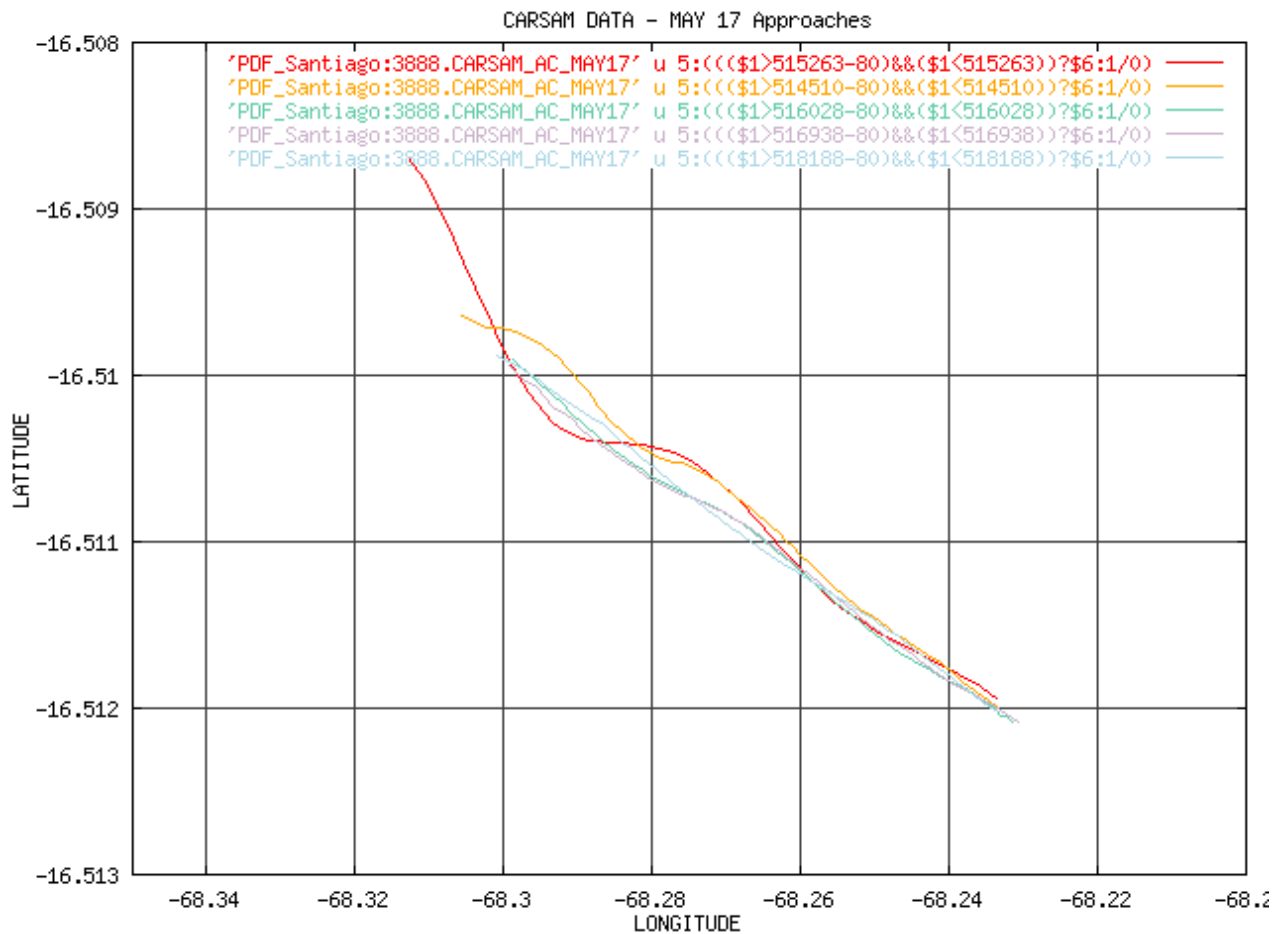
### 25 MAY 2002



# CARSAM May 2002 Flight Test Data

## LA PAZ Approaches – 17 MAY

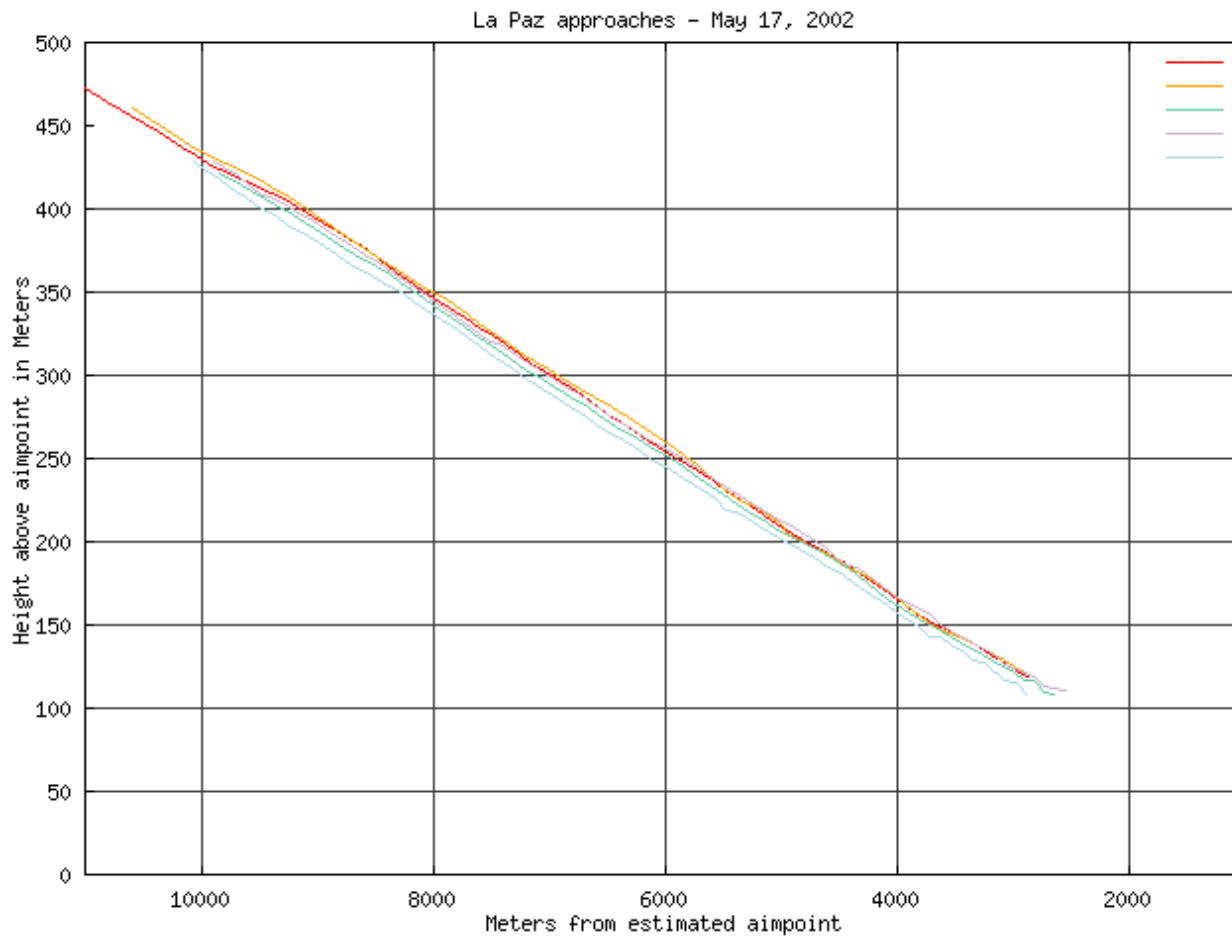
### Accuracy - Horizontal



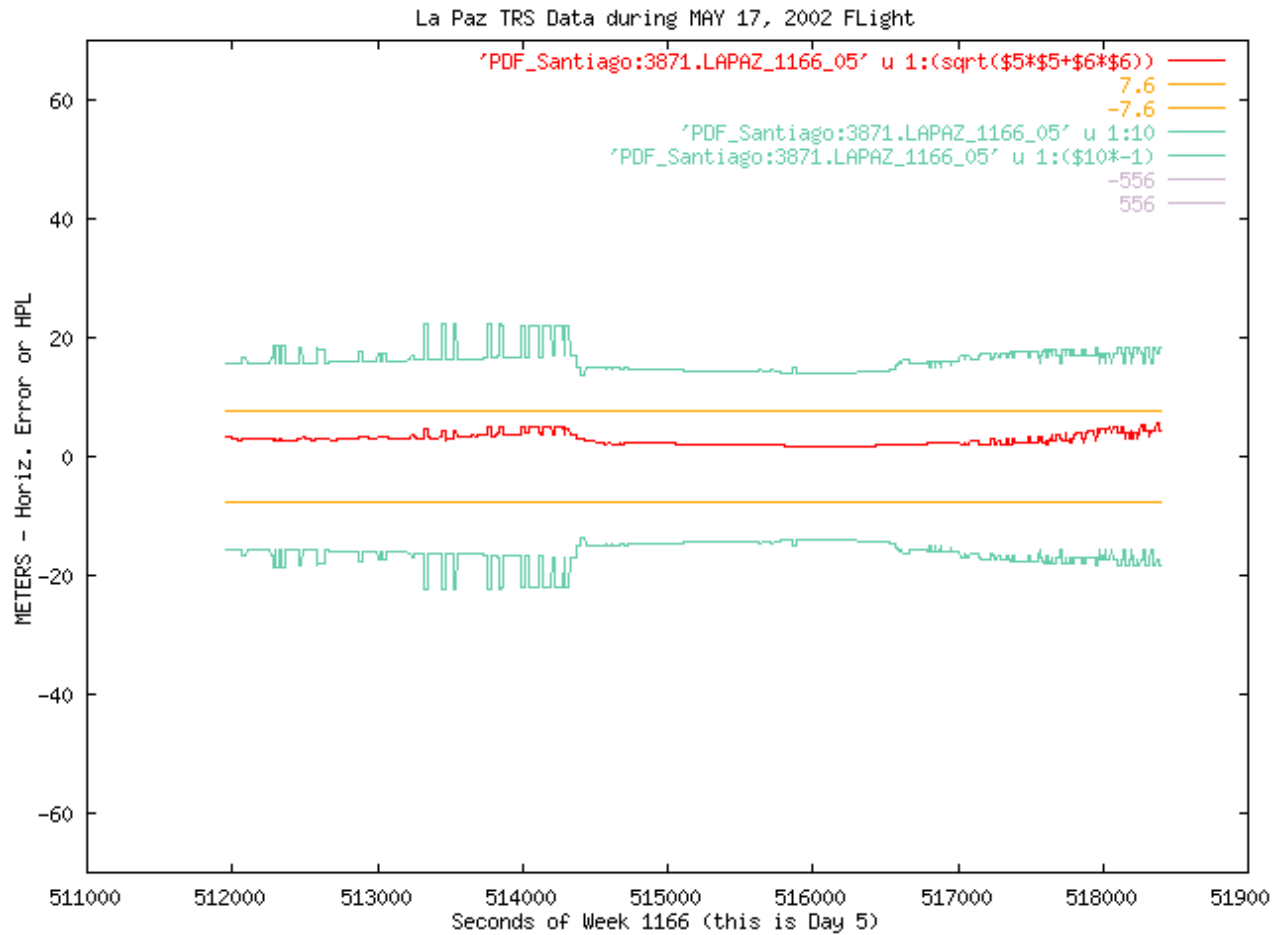
# CARSAM May 2002 Flight Test Data

## LA PAZ Approaches – 17 MAY

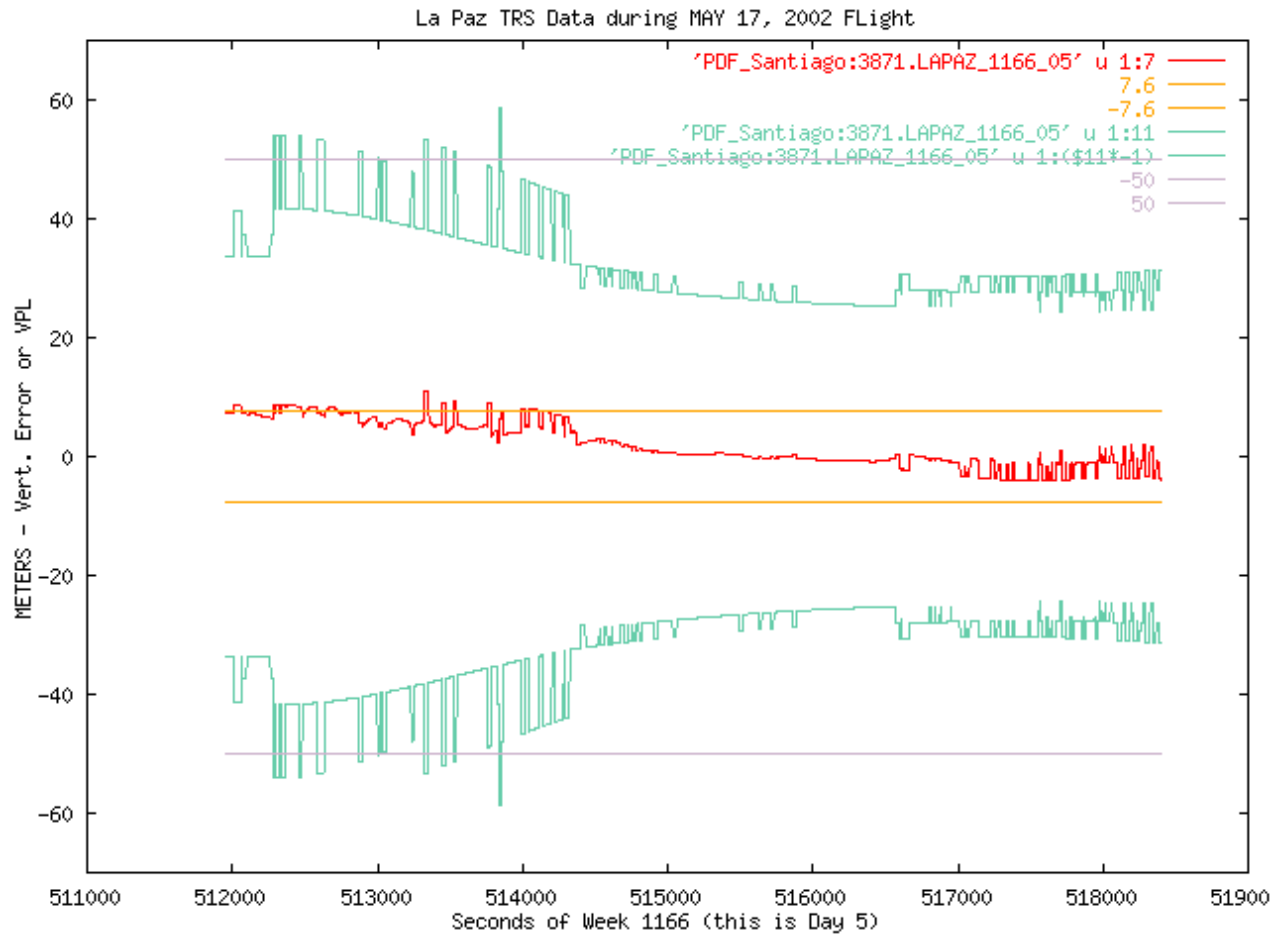
### Accuracy - Vertical



# CARSAM May 2002 Flight Test Data LA PAZ TRS Receiver (static)– 17 MAY Accuracy - Horizontal

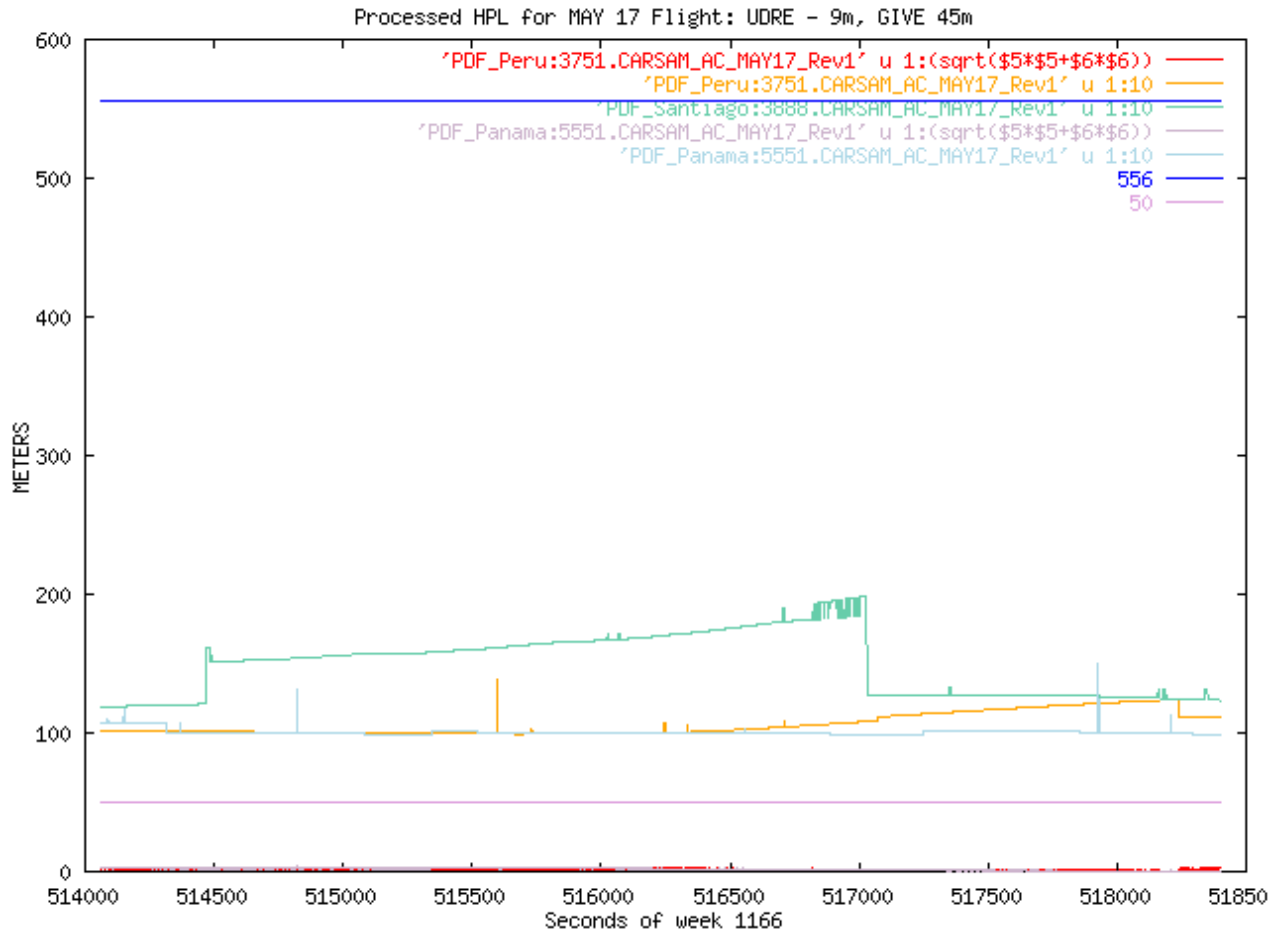


# CARSAM May 2002 Flight Test Data LA PAZ TRS Receiver (static)– 17 MAY Accuracy - Vertical



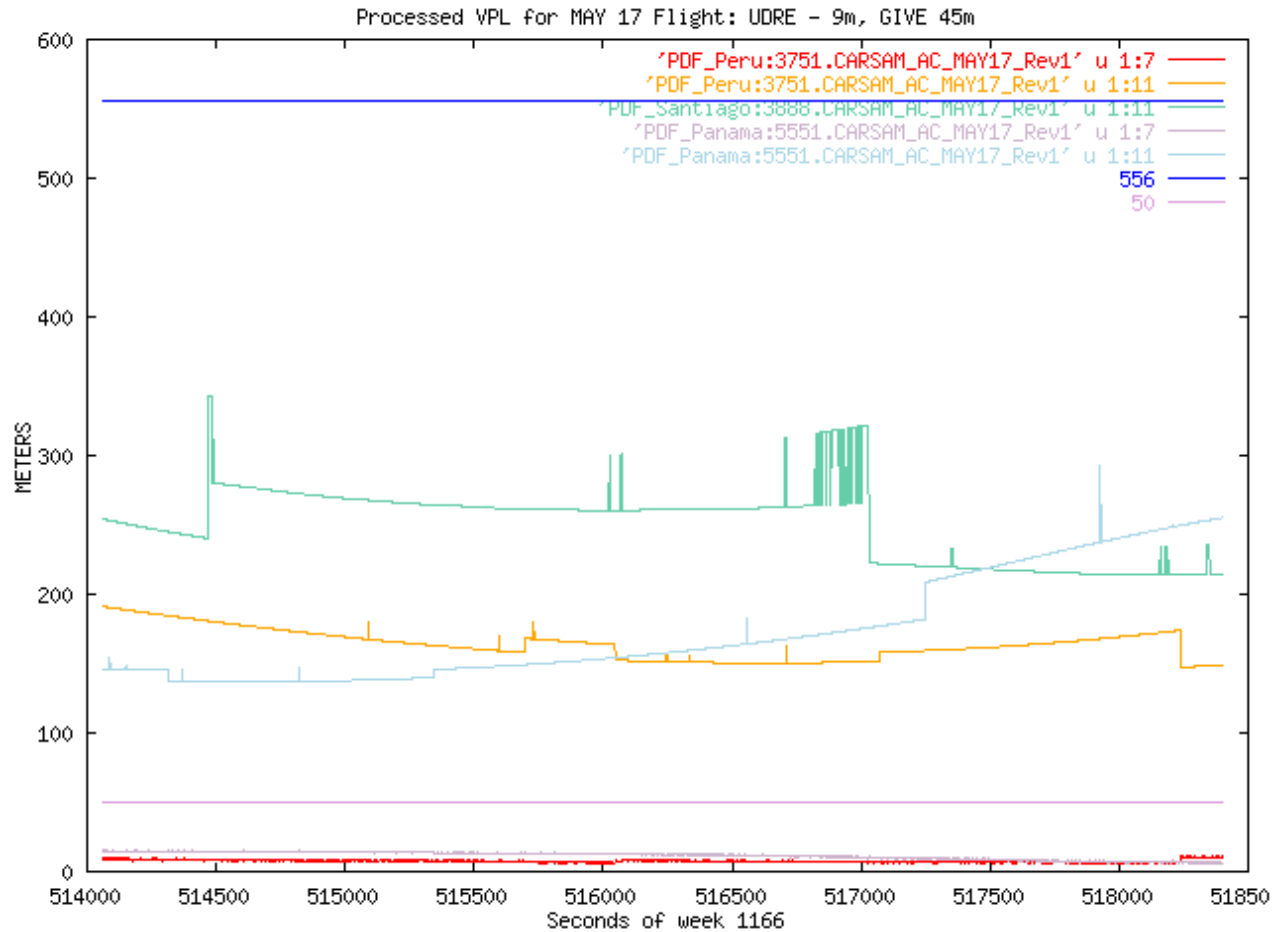
# CARSAM May 2002 Flight Test Data

## 17 MAY Data – Simulated 45 meter GIVES Availability/Integrity – Horizontal (NPA)



# CARSAM May 2002 Flight Test Data

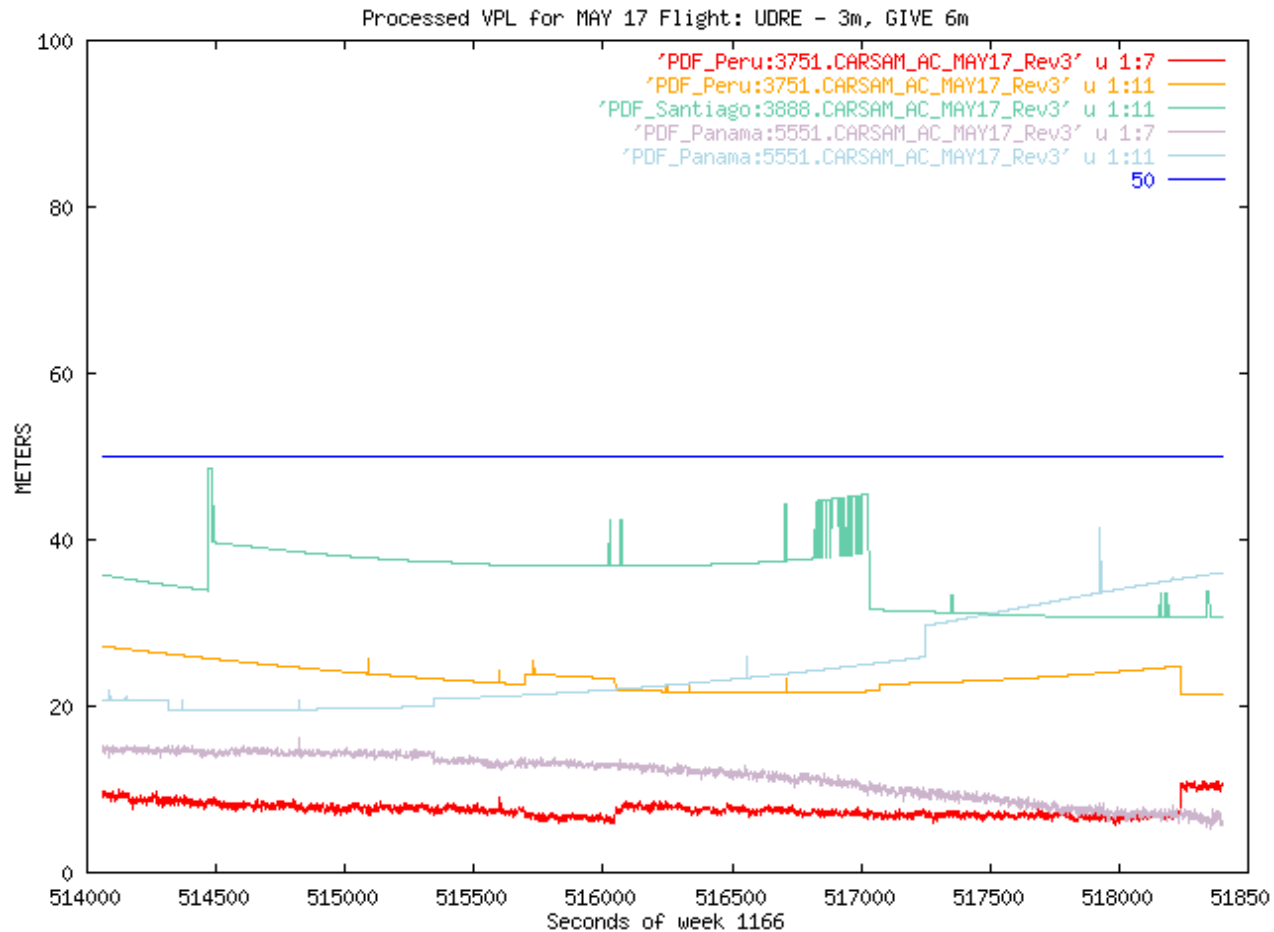
## 17 MAY Data – Simulated 45 meter GIVES Availability/Integrity – Vertical (LNAV/VNAV)



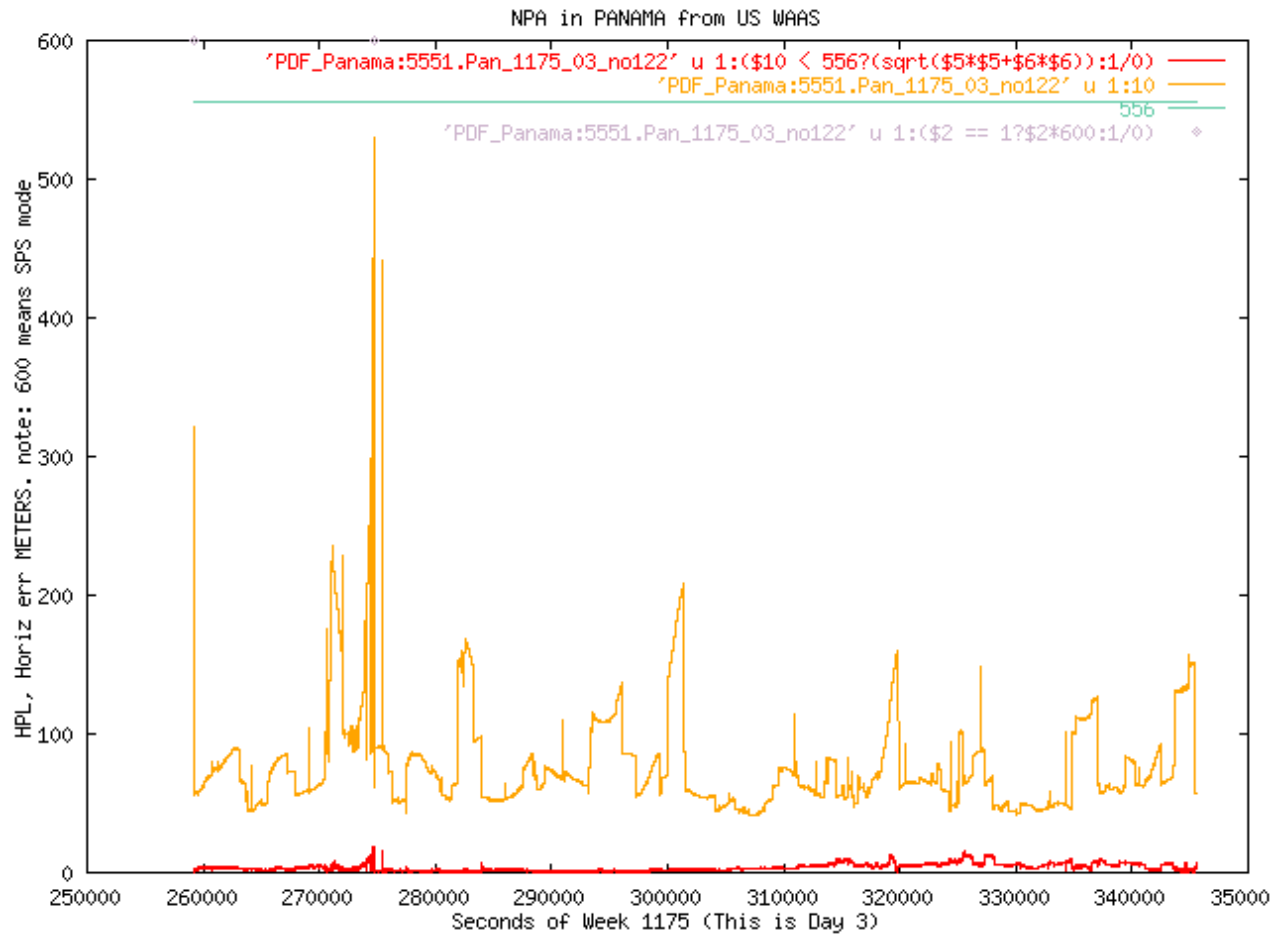


# CARSAM May 2002 Flight Test Data

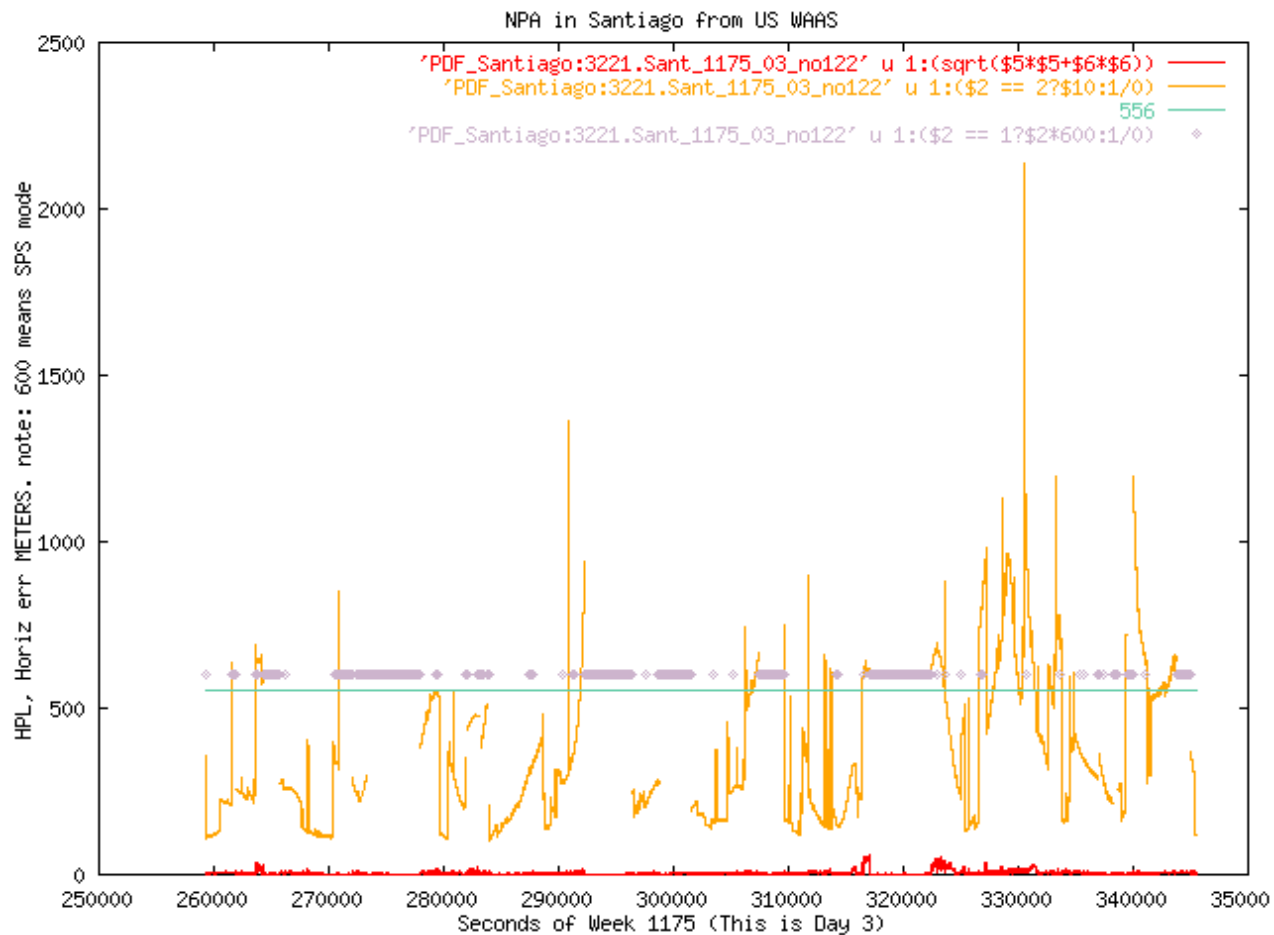
## 17 MAY Data – Simulated 6 meter GIVES Availability/Integrity – Vertical (LNAV/VNAV)



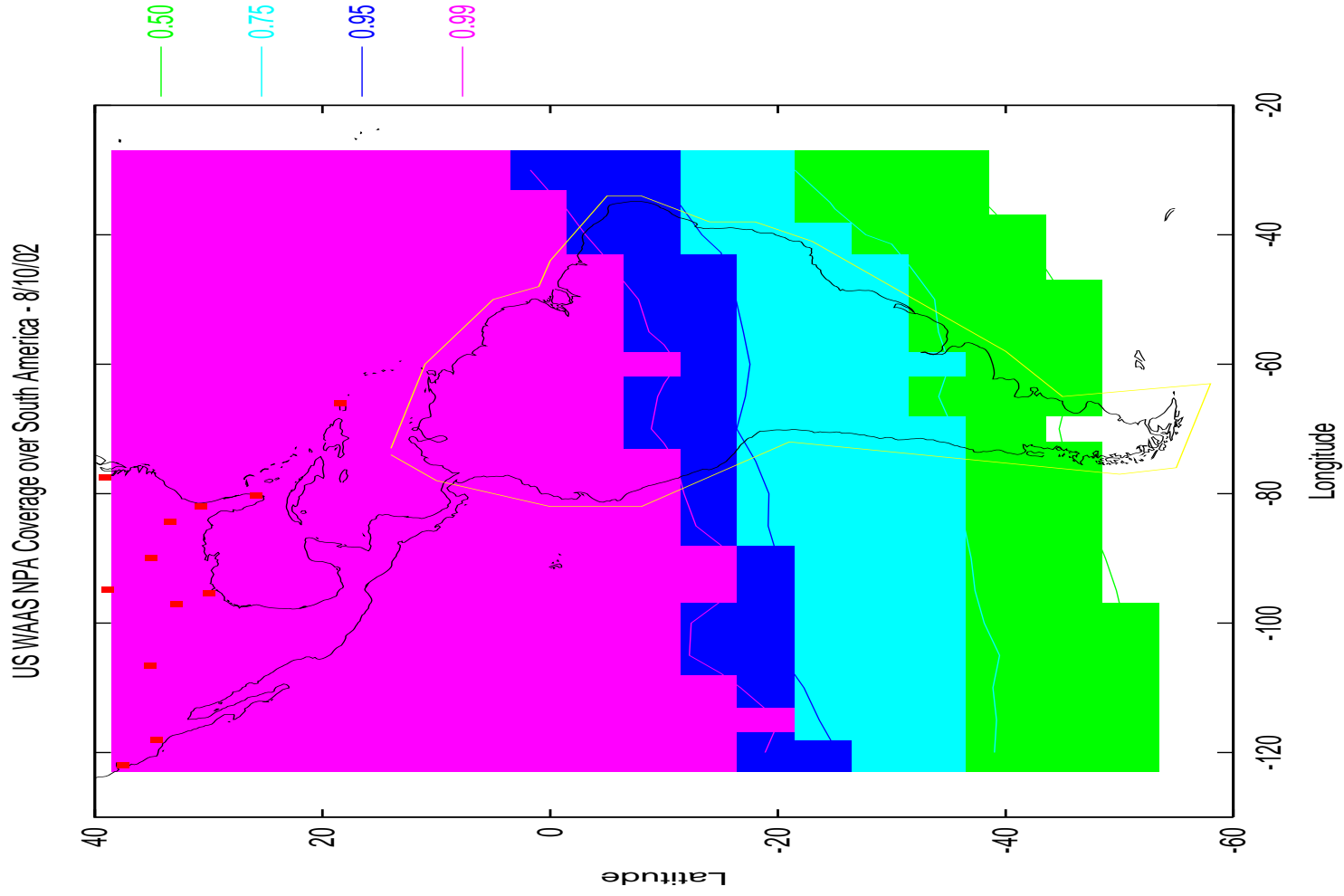
# US WAAS in CARSAM NPA Examples



# US WAAS in CARSAM NPA Examples



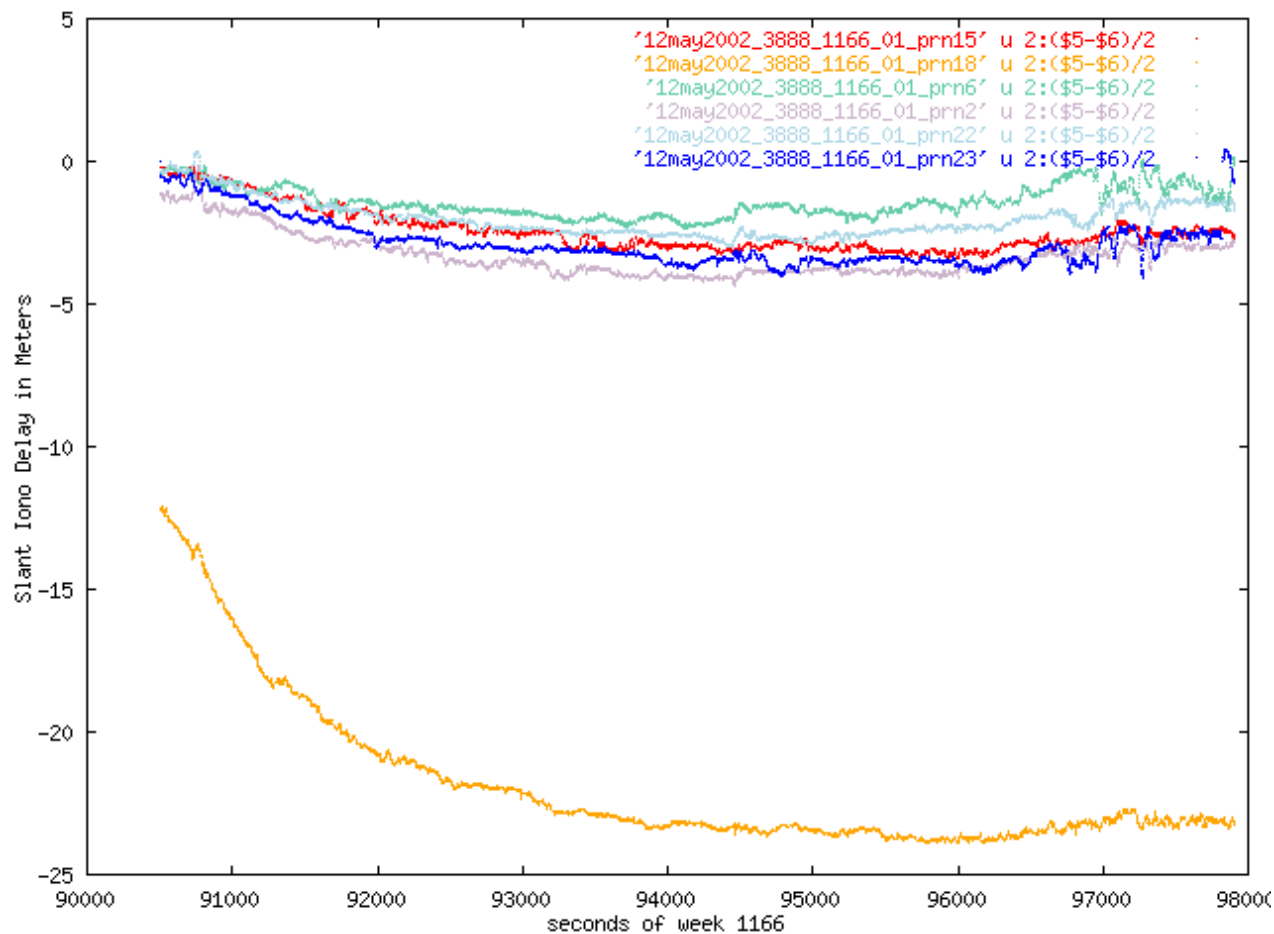
# US WAAS in GARSAM NPA Examples (NPA Availability on typical day)



# CARSAM May 2002 Flight Test Data

## 12 MAY 2002

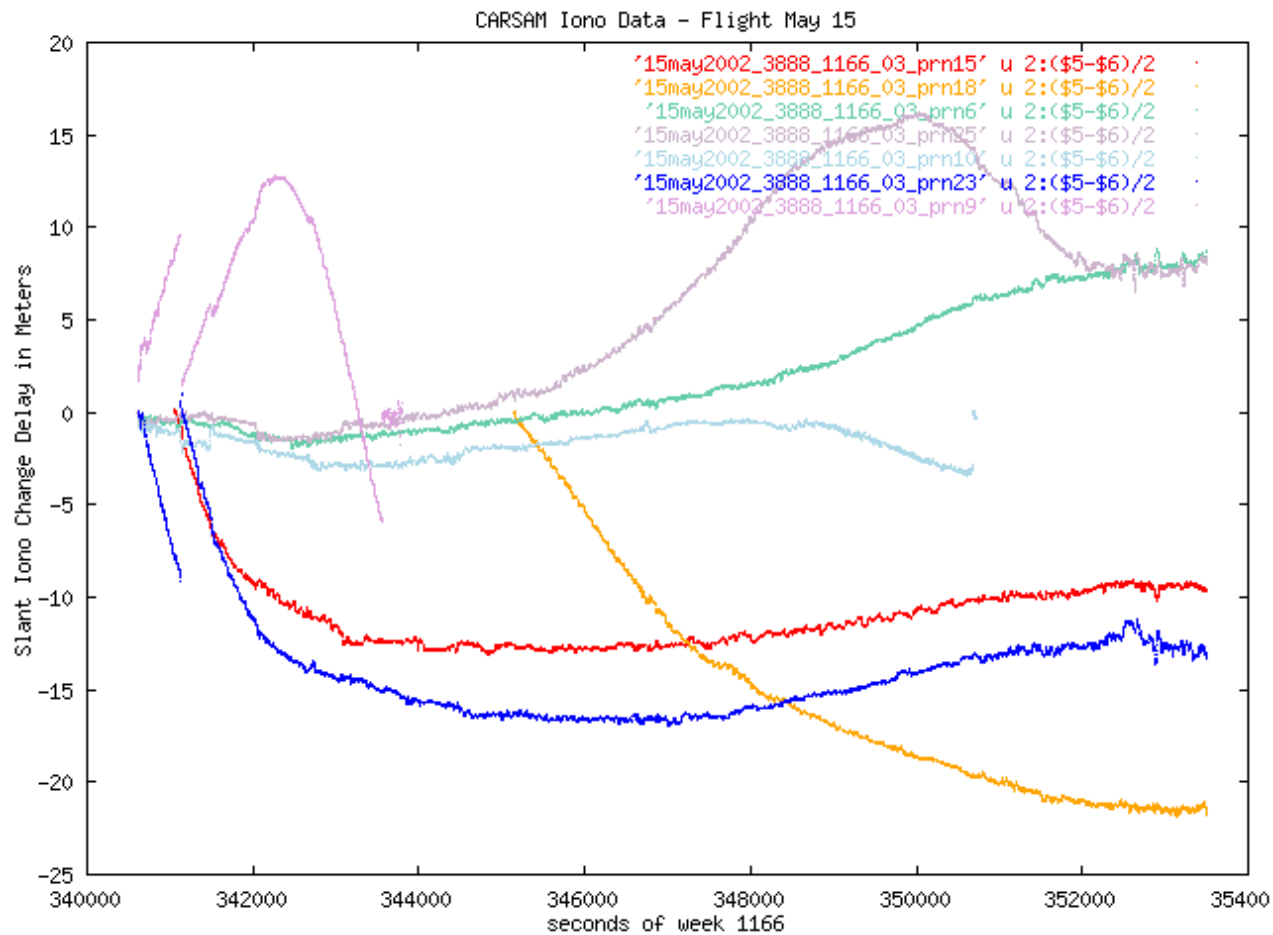
### Ionospheric Data: Aircraft (code-carrier)/2



# CARSAM May 2002 Flight Test Data

## 15 MAY 2002

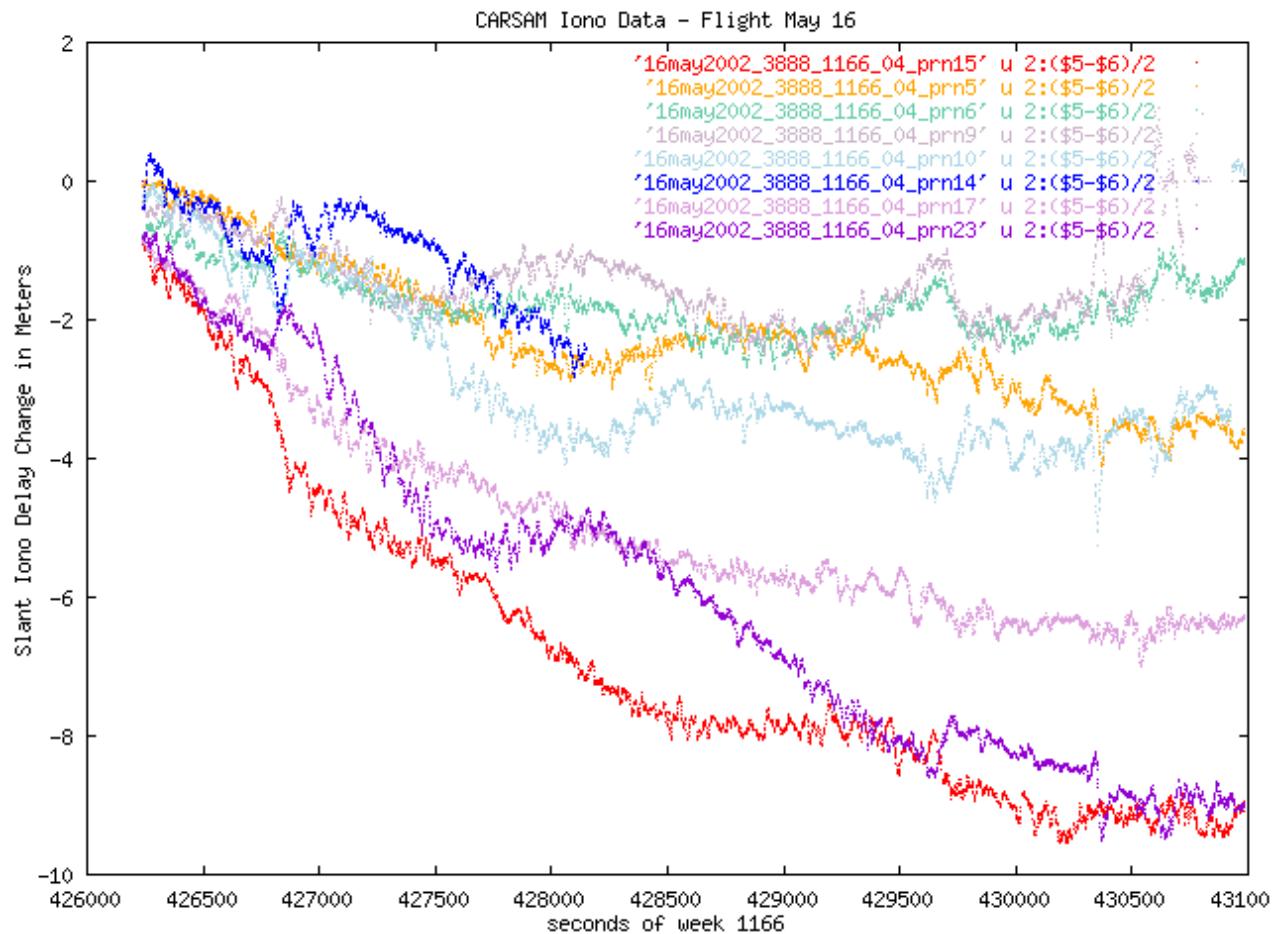
### Ionospheric Data: Aircraft (code-carrier)/2



# CARSAM May 2002 Flight Test Data

## 16 MAY 2002

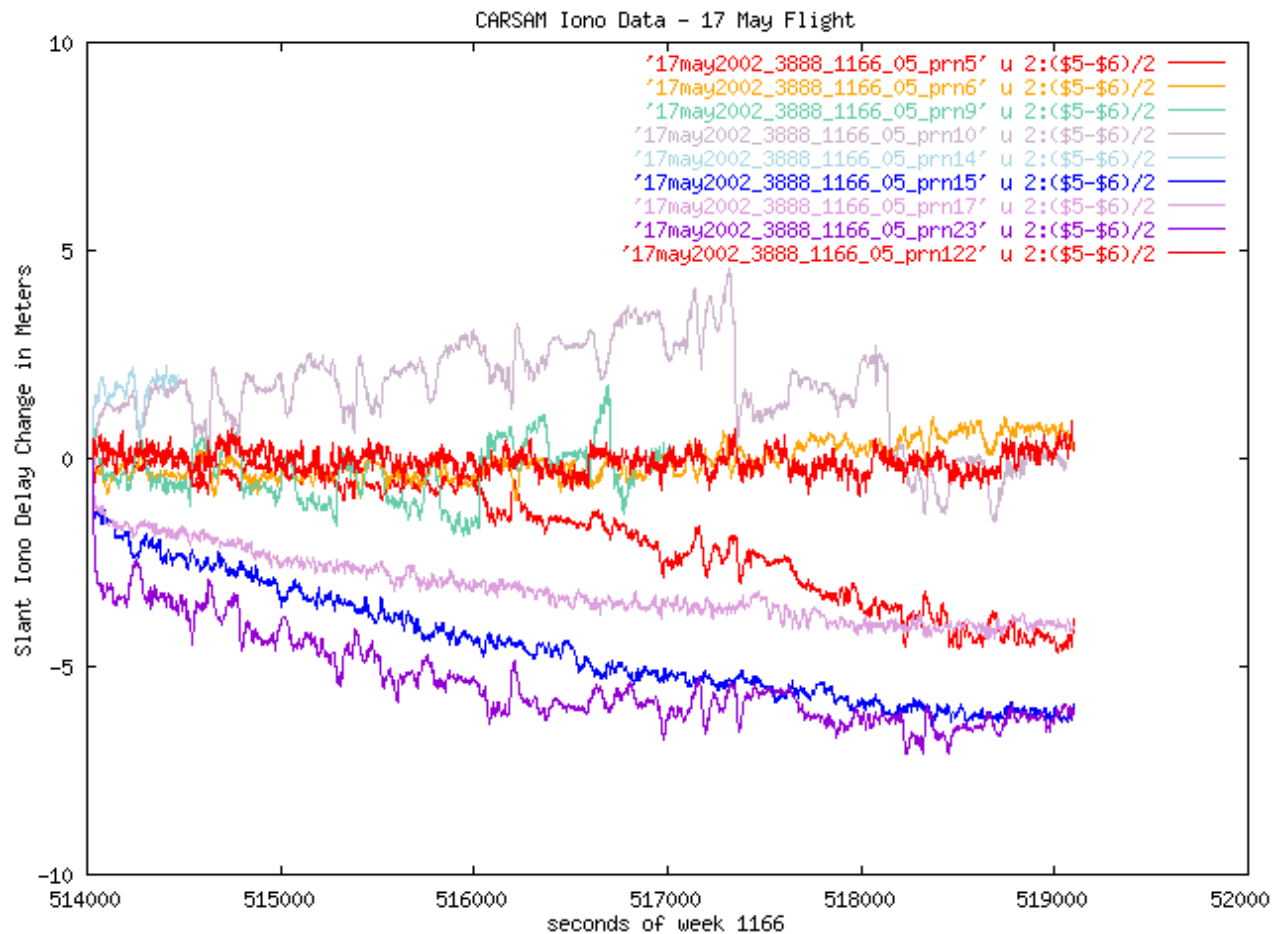
### Ionospheric Data: Aircraft (code-carrier)/2



# CARSAM May 2002 Flight Test Data

## 17 MAY 2002

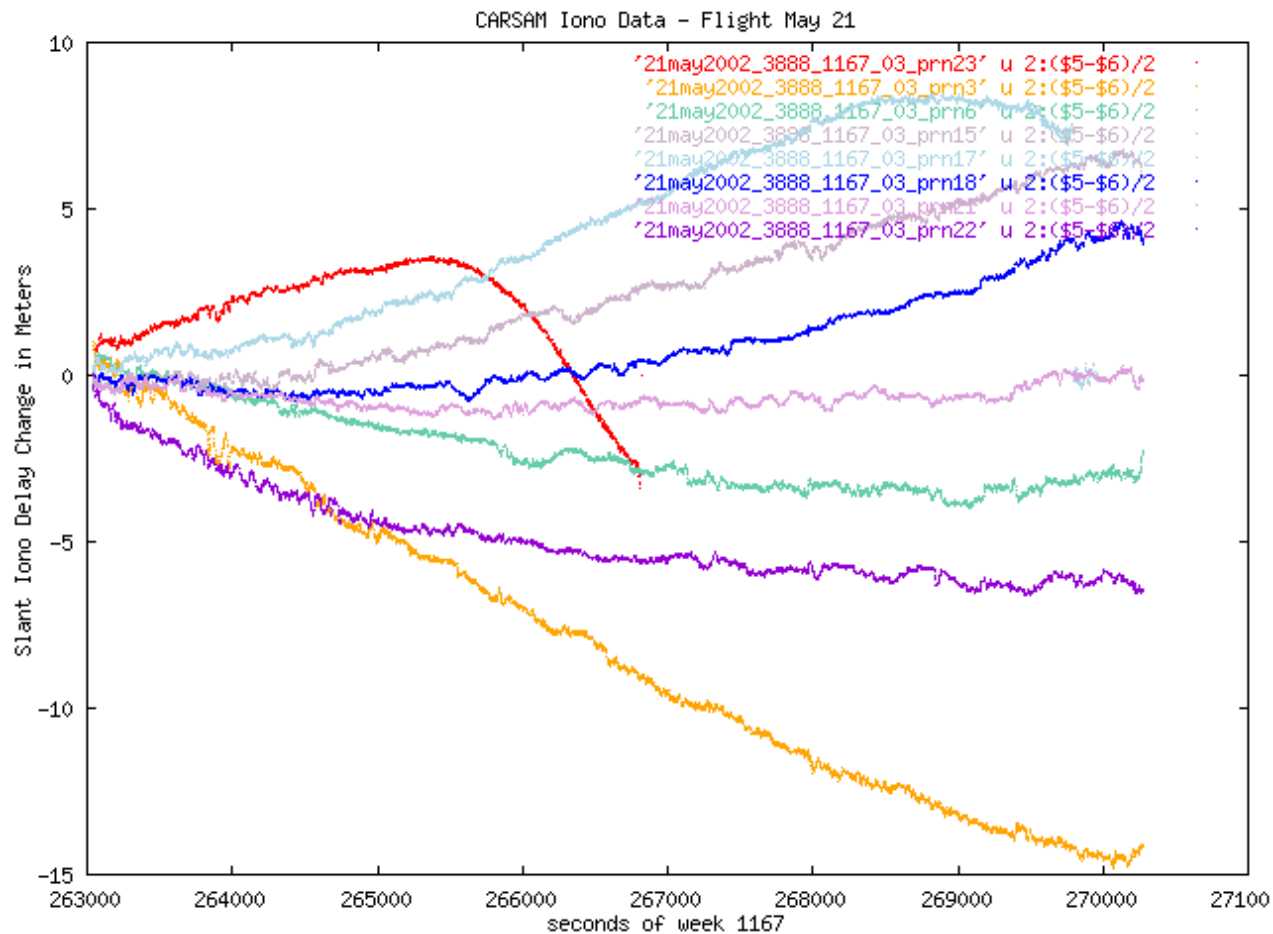
### Ionospheric Data: Aircraft (code-carrier)/2



# CARSAM May 2002 Flight Test Data

## 21 MAY 2002

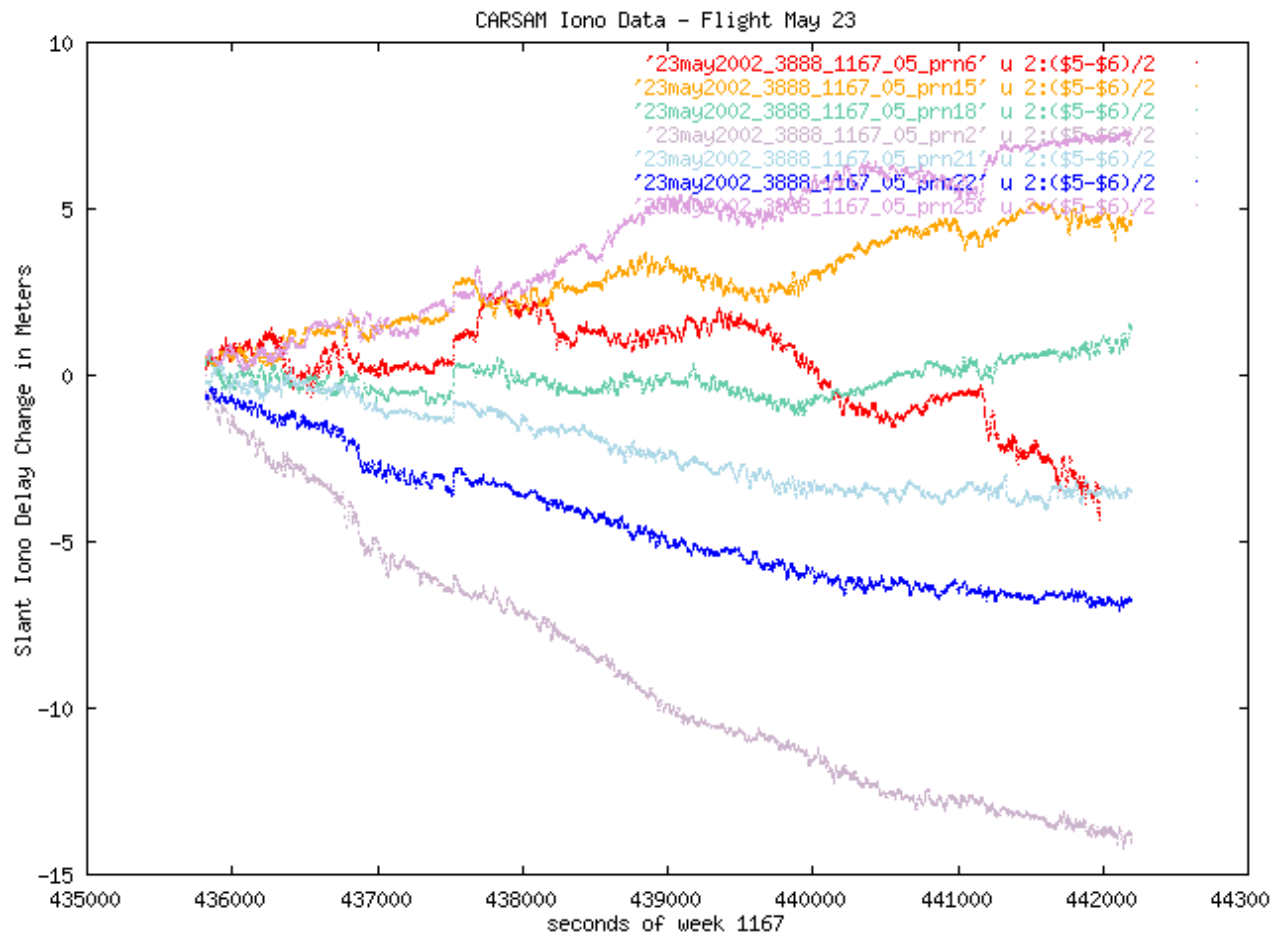
### Ionospheric Data: Aircraft (code-carrier)/2



# CARSAM May 2002 Flight Test Data

## 23 MAY 2002

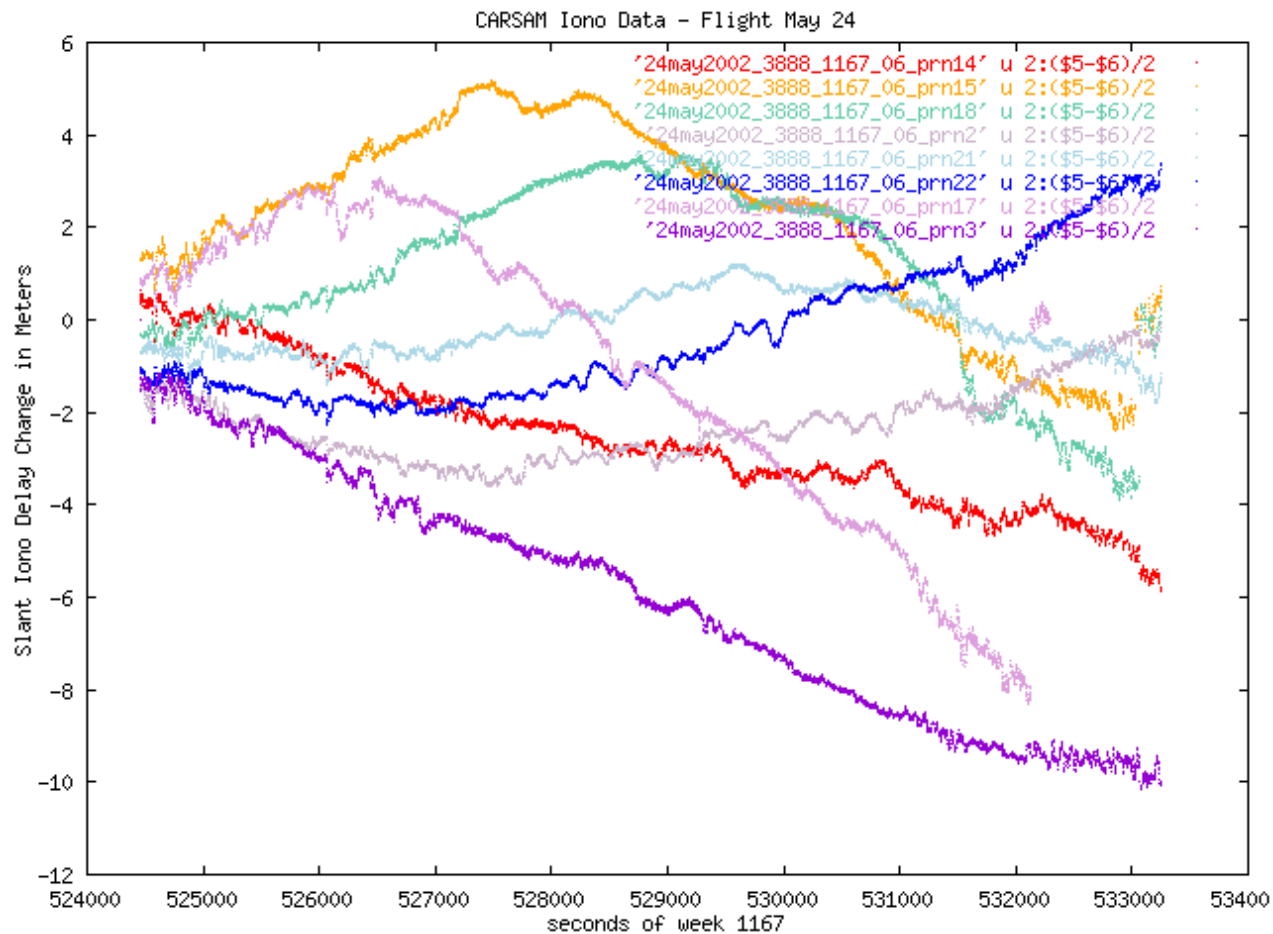
### Ionospheric Data: Aircraft (code-carrier)/2



# CARSAM May 2002 Flight Test Data

## 24 MAY 2002

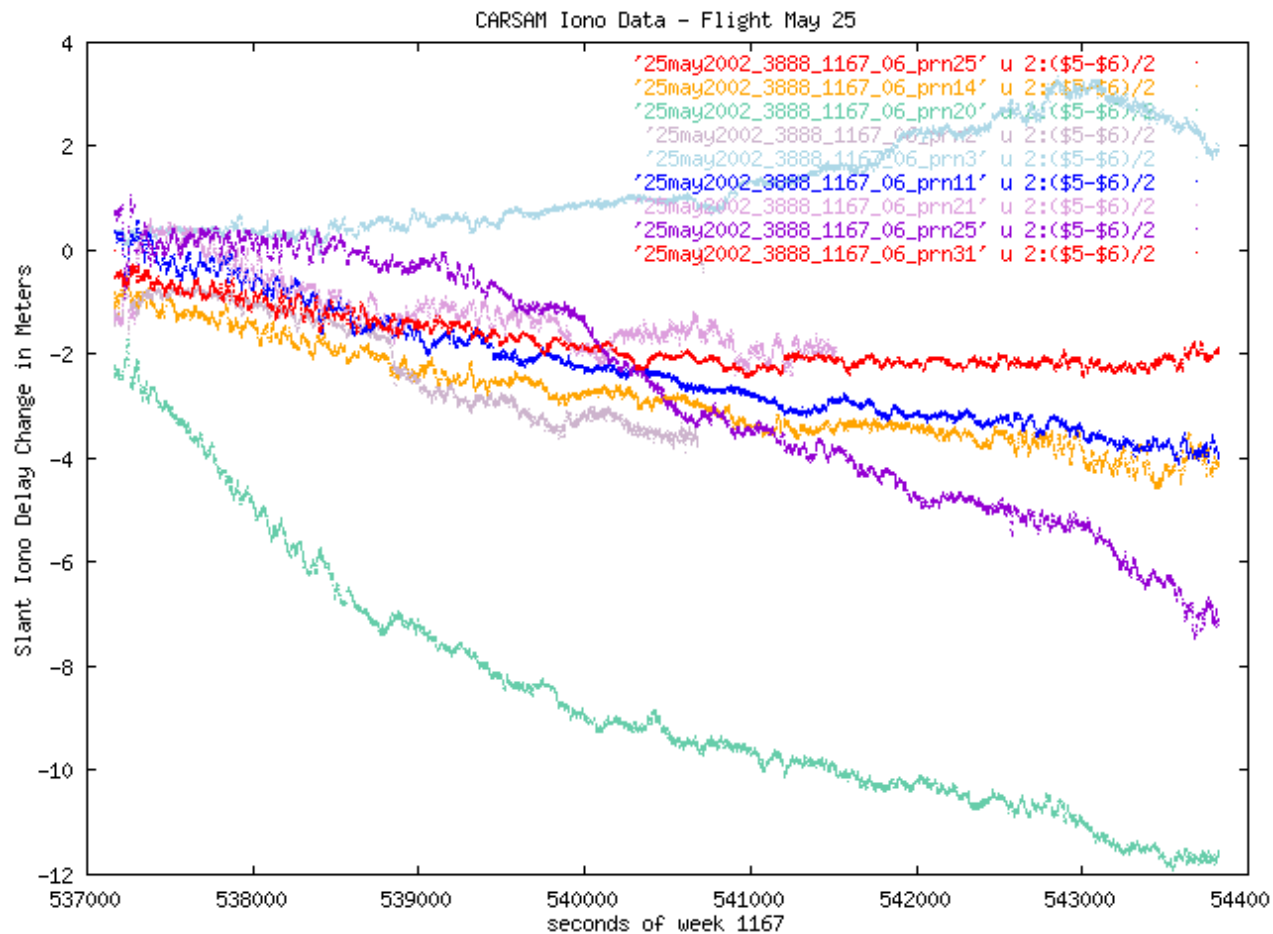
### Ionospheric Data: Aircraft (code-carrier)/2



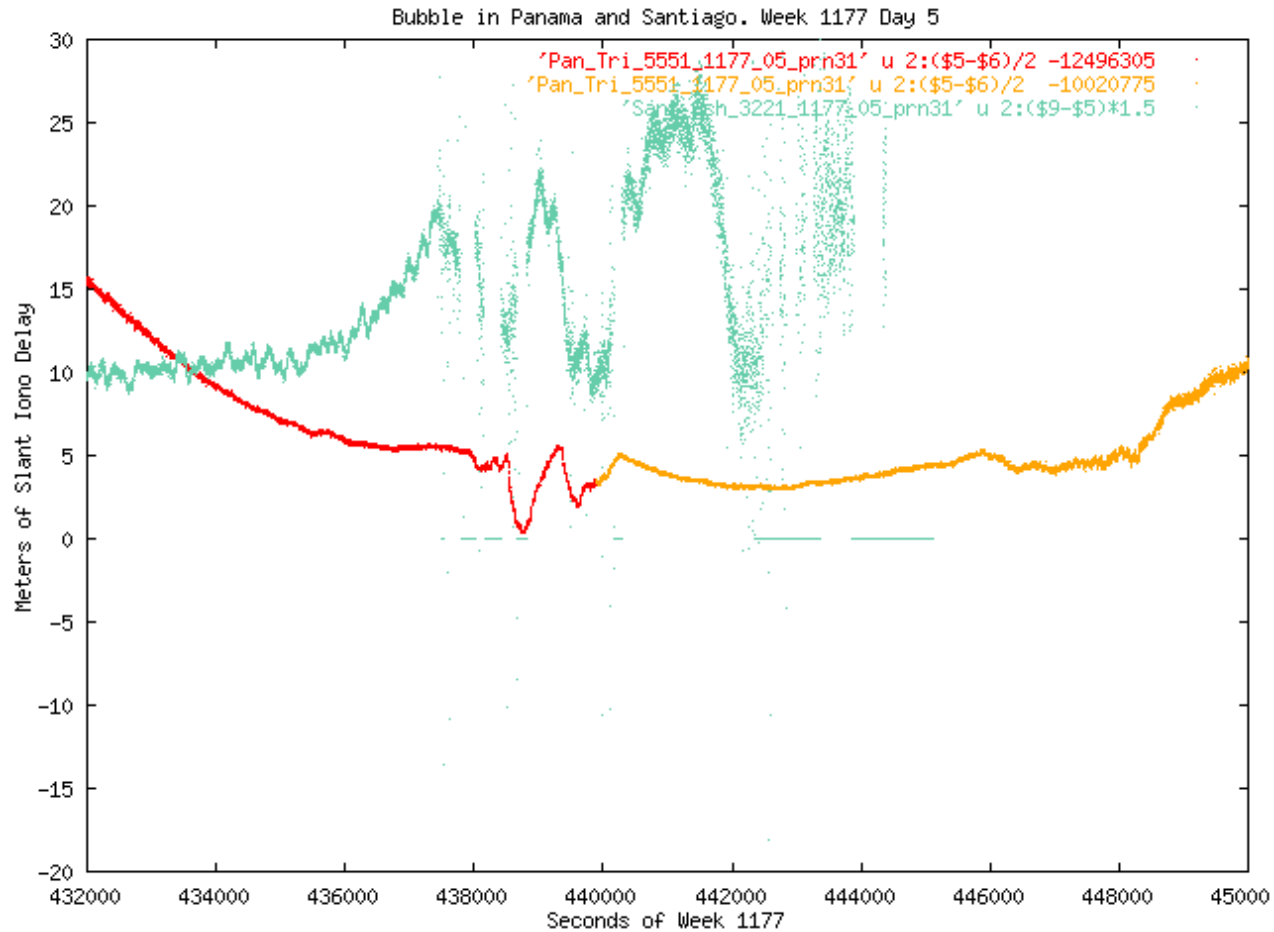
# CARSAM May 2002 Flight Test Data

## 25 MAY 2002

### Ionospheric Data: Aircraft (code-carrier)/2

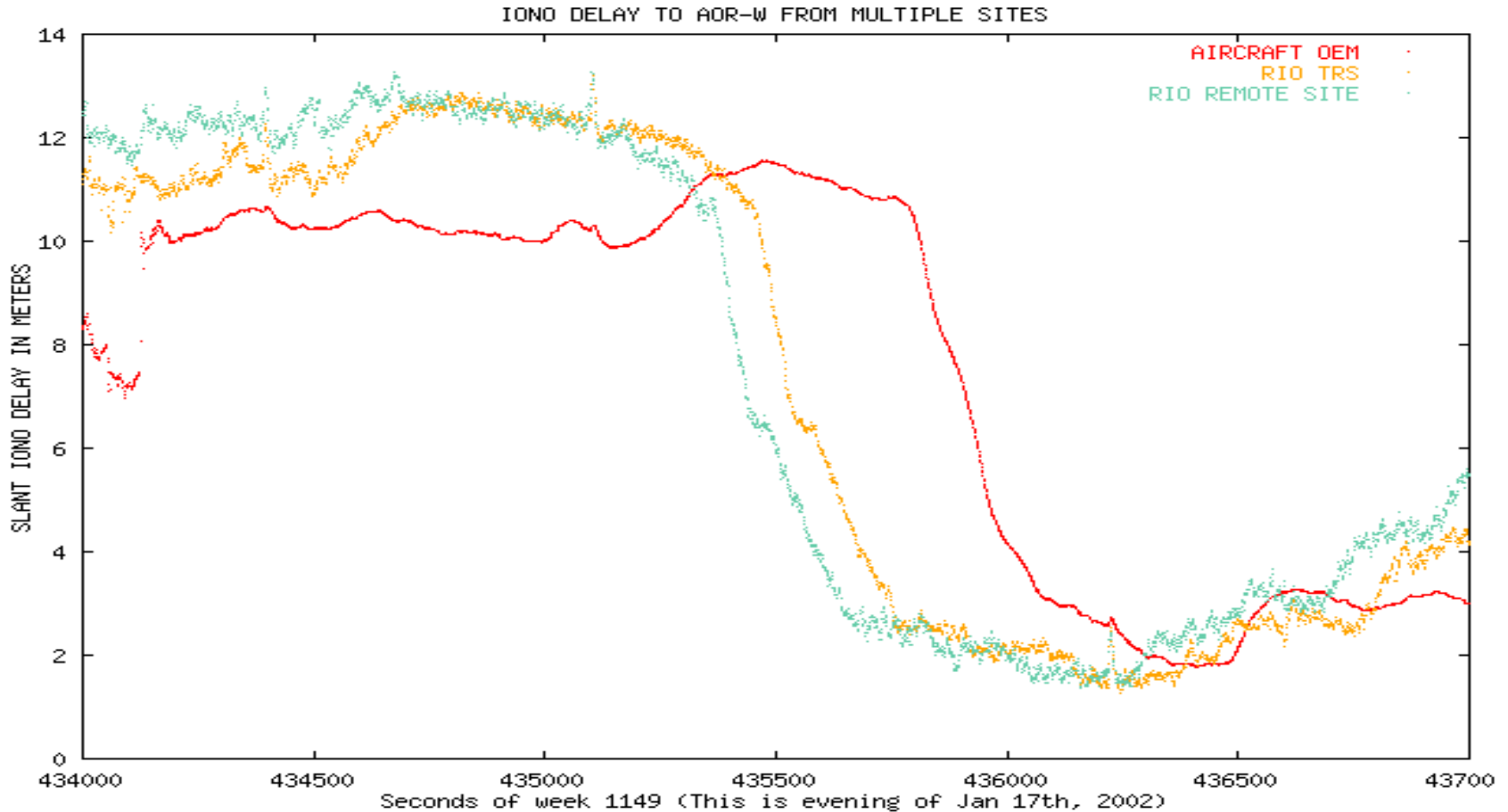


# Ionospheric Data: Bubble Examples



# Ionospheric Data: Bubble Examples

(Plots shows motion of bubble wall passing 2 ground receivers 15 km apart, then US aircraft receiver during flight test in Brazil, January, 2002)



# CARSAM May 2002 Flight Test Data

## Conclusions

- Aircraft receiver demonstrated successful data collection
- NPA:
  - Accuracy of GPS (even without CSTB corrections) demonstrated to be sufficient
    - Also demonstrated by US WAAS in Panama
  - Availability demonstrated by simulating UDREs of 9 and GIVES of 45
  - Integrity demonstrated in that HPL easily bound horizontal position error during tests
- LNAV/VNAV:
  - Master Station needs to have “safety approved” algorithm which can set GIVEs to 6 or less at most IGPs
  - Further tests required to demonstrate accuracy, availability, and integrity while operating a Master Station implementing the (undefined) GIVE algorithm
- Ionosphere: No severe ionospheric conditions, including satellite carrier loss due to scintillation or large gradient bubbles were observed during this test

***Thanks to all from the FAA!***

