



International Civil Aviation Organisation

Sixth Meeting of CNS/MET Sub Group of APANPIRG

Bangkok, Thailand, 15 -19 July 2002

Agenda Item 6: Review:

- a) Strategy for the provision of Precision Approach and Landing Guidance Systems
- b) GNSS strategy
- c) GNSS implementation
- d) GPS measurement campaign

NEW TEST RESULTS WITH A GROUND-BASED REGIONAL AUGMENTATION SYSTEM (GRAS) IN AUSTRALIA

(Presented by Australia)

SUMMARY

Australia continues to test the Ground-based Regional Augmentation System (GRAS) in support of the ICAO GRAS SARPs. Recent tests have concentrated on the crossover between VHF broadcast stations. It is evident that there is no interference because of the fast rise and fast decay of the signal in each time slot used.

1. INTRODUCTION

An overview of the GRAS elements and functions is shown in Figure 1.^[1] GRAS uses ICAO based SBAS Standards and Recommended Practices (SARPs) for the data collection network and central processing facility.^[2] The correction information and integrity information are delivered to each GRAS VHF Station (GVS) in the network as SBAS message data. Each GVS performs a local verification check of the data, formats a GBAS-like (local area) message and transmits it at 1 sec. intervals in a TDMA-managed 1/16th sec time slot compatible with the GBAS VDB protocol.^[3] GRAS uses test prototype GBAS user equipment in the aircraft with a minor software change to enable reception and use of the GRAS message in the GBAS software.

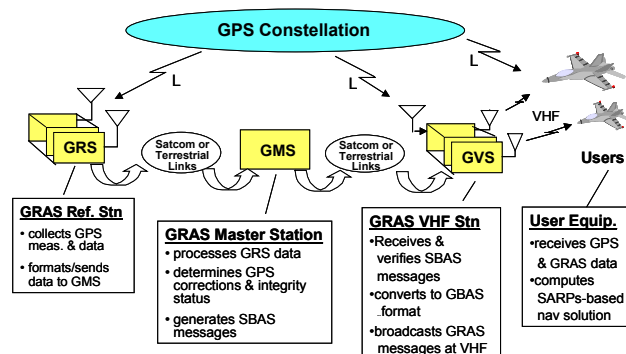


Figure 1: GRAS Concept Overview [1]

2. DATA LINK TESTS

VHF data broadcast transmitters were installed at the International Airport in Melbourne Victoria (VIC) and in Cooma New South Wales (NSW). A third transmitter is also being established at Albury NSW. The aim of the testing was to determine if one VHF frequency using judicious TDMA slot management could be used for GRAS. The flight paths included a segment that bisected the distance between Melbourne and Cooma to provide nominal equi-power signals from the two GVS transmitters. Direct flight segments between these two points were also flown to establish direct to/from power levels. In addition, flight segments that deliberately required flying out of the range of one transmitter before entering the range of the second transmitter were also flown to assess the reacquisition capabilities. Approaches were made into Cooma using straight-in, right hand curved and left hand curved approaches. The nominal flight tracks are shown in Figure 2.

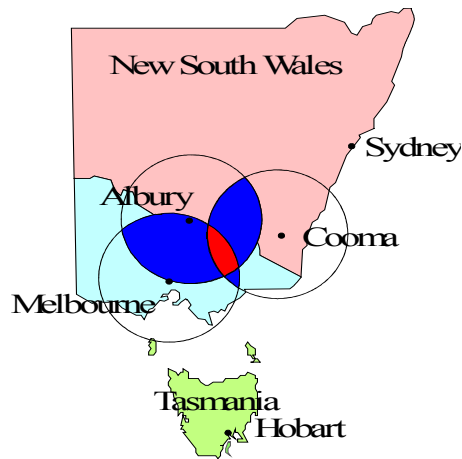


Figure 2: VHF Test Coverage Area

The blue area is the common coverage between two VHF transmitters while the red area is the coverage between the three VHF stations. Only the coverage between two adjacent VHF sites was used for the flight tests. The frequency employed was 113.575 MHz.

3. TEST RESULTS

There were clean transitions between the signals received from two GVS sites and no interference was detected. The fast rise and decay times of the signals contribute to the ability to stay within the allotted time slot.

Figure 3 shows the time slots with GRAS data that was received by the test aircraft at the equi-power point between the Cooma and Melbourne GVSs. These correspond to the B Odd and A Even time slots assigned for receiving the Cooma and Melbourne GVS signals, respectively.

- 3 -



Figure 3: Equi-power point Melbourne-Cooma

Figure 4 shows the time slots with GRAS data when the test aircraft was 10 NM closer to Melbourne with B Odd and C Odd time slots assigned for receiving the Cooma and Melbourne GVS signals, respectively.



Figure 4: Cooma-Melbourne (closer to Melbourne)

Figure 5 shows the same situation as in Figure 4, except at the equi-power position between the Cooma and Melbourne GVSs.



Figure 5: Equi-power point Melbourne-Cooma

Figure 6 shows a GRAS User Platform data recording, in particular the VHF slot field strength that resulted during the flight trials from Melbourne to Cooma and return. The GRAS avionics equipment automatically switches to the new slot when it has tracked a new signal that is greater than the one being tracked, for 60 seconds without error. It can be seen that there is a clean swap over well within the GBAS tolerance of -87dBm. The peaks and troughs during the Cooma reception (blue) correspond to approaches (peak) and departures (troughs) made while in that area.

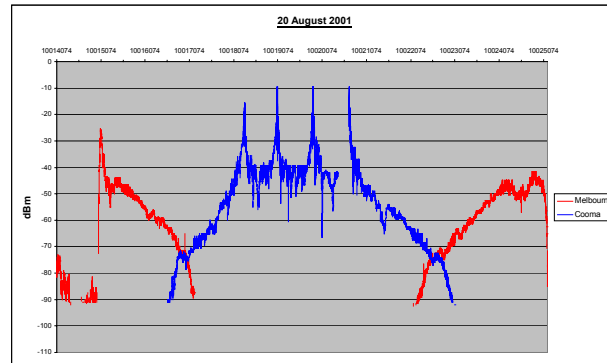
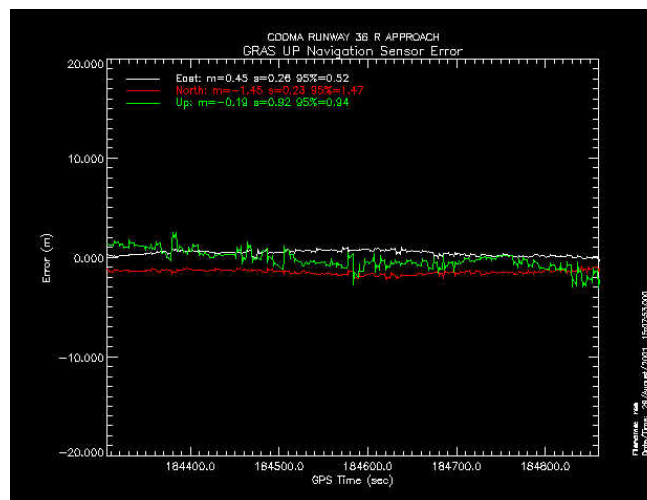


Figure 6: User Platform VHF Signal Strength

The Navigation Sensor Error (NSE) results of the enroute through a right hand turn onto finals at Cooma Runway 36 are detailed in Figure 7.



**Figure 7: GRAS Navigation Sensor Errors
- Cooma Runway 36 Right Hand Turn to Finals**

The east, north, up errors are listed in Table 1. The reference stations being used were located in Adelaide, Alice Springs, Hobart, Canberra and Brisbane. The errors are low as the aircraft was operating in a benign ionospheric area and stable conditions. No less than six satellites were being tracked at any given time. The Navigation Sensor Error performance is more than adequate for enroute/non-precision approach operations and even potentially appropriate for approaches requiring vertical guidance. More work needs to be done to assess integrity and availability/continuity aspects of the GRAS concept.

Table 1: Navigation Sensor Error Statistics for Cooma Runway 36 Right Hand Turn to Finals

Component	Mean (m)	σ (m)
East	0.45	0.28
North	-1.45	0.23
Up	-0.19	0.92

Other trials showed similar results. Approaches using left hand turns onto finals produced the results in Figure 8 and Table 2.

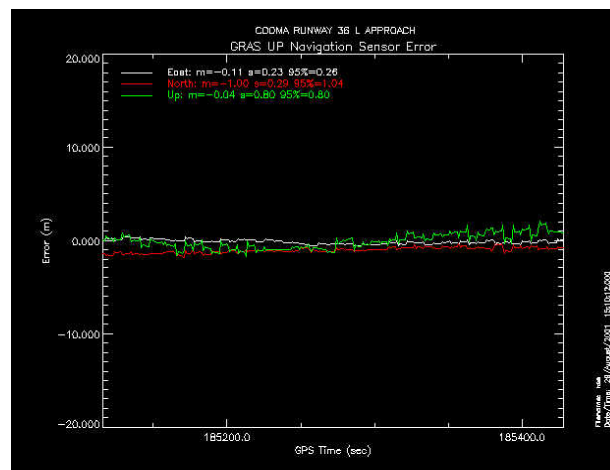


Figure 8: GRAS Navigation Sensor Errors - Cooma Runway 36 Left Hand Turn to Finals

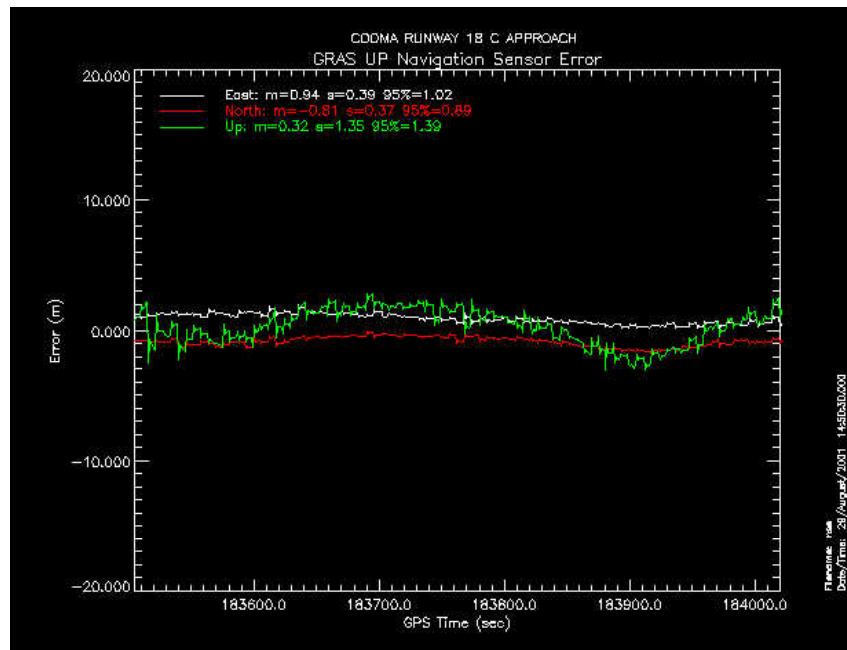
Table 2: Navigation Sensor Error Statistics for Cooma Runway 36 Left Hand Turn to Finals

Component	Mean (m)	σ (m)
East	-0.11	0.23
North	-1.00	0.29
Up	-0.04	0.80

Approaches onto finals from the extended centreline produced the results in Figure 9 and Table 3.

**Table 3: Navigation Sensor Error Statistics for
Cooma Runway 36 Centreline Finals**

Component	Mean (m)	σ (m)
East	0.94	0.39
North	-0.81	0.37
Up	0.32	1.35



**Figure 9: GRAS Navigation Sensor Errors
- Cooma Runway 36 Centreline Finals**

From these initial test results, GRAS has the potential to provide vertical guidance for both enroute and approaches, using a single frequency with good TDMA slot management. Such slot management is expected to provide the capability to honeycomb the slots to provide national coverage on one frequency. The final architecture will be decided through the International Civil Aviation Organisation GNSS Panel.

RECOMMENDATION

The meeting is invited to note the continued testing of GRAS in Australia.

REFERENCES

1. Graeme Crosby, William Ely, Keith McPherson, Joy Stewart, Donna Kraus, Tim Cashin Kevin Bean, Dr. Bryant Elrod, "A Ground-based Regional Augmentation System (GRAS) – The Australian Proposal" ION GPS-2000, September 2000
2. "International Standards and Required Practices (SARPs) for GNSS," Draft Amendment to Aeronautical Telecommunications, Annex 10 to the Convention on International Civil Aviation (ICAO), Vol. I (as submitted to GNSS Panel, Montreal, November 1999 and amended by working group meeting, Seattle, June 2000).
3. Minimum Operational Performance Standards for Global Positioning System / Local Area Augmentation System Airborne Equipment (LAAS MOPS), RTCA Document No. DO-253, January 11, 2000.

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