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International Civil Aviation Organization
CAR/SAM REGIONAL PLANNING AND EXECUTION GROUP (GREPECAS)
Sixth CNS Committee Meeting of the GREPECAS ATM/CNS Subgroup (CNS/COMM/6)
Santo Domingo, Dominican Republic, 30 June to 4 July 2008

Agenda Item 2 **Navigation systems developments**
2.2 Follow up on the planning/implementation activities of the SBAS and GBAS augmentation systems in the CAR/SAM Regions

Status of GNSS elements and signals

(Presented by Unidted States)

Summary

The FAA commissioned the first SBAS on July 10, 2003. The system is called the Wide Area Augmentation System (WAAS). During the past year, there have been significant systematic enhancements made to WAAS. These systematic enhancements have resulted in improved WAAS service that has led to several operational enhancements.

This Information Paper reviews the systematic and operational enhancements that have occurred with WAAS over the past year. With the increasing use of SBAS, it is essential that operational requirements and procedure design criteria be globally harmonized.

1. INTRODUCTION

1.1 The FAA commissioned the first SBAS on July 10, 2003. The system is called the Wide Area Augmentation System (WAAS). During the past year, there have been significant systematic enhancements made to WAAS. These systematic enhancements have resulted in improved WAAS service that has led to several operational enhancements.

1.2 This Information Paper reviews the systematic and operational enhancements that have occurred with WAAS over the past year. With the increasing use of SBAS, it is essential that operational requirements and procedure design criteria be globally harmonized.

2. DISCUSSION

2.1 **Systematic Enhancements.** Since commissioning in July 2003, several enhancements to WAAS have been made. In the past year, the upgrades have resulted in improvements in WAAS service. Major elements of the systematic enhancements over the past year are discussed below.

2.1.1 **New Wide Area Reference Stations (WRS's).** A total of thirteen new WRS's have been installed and are now operational. Four new WRS's were commissioned in Alaska at Barrow, Kotzebue, Fairbanks and Bethel. Five new WRS's became operational in Mexico at San Jose Del Cabo, Puerto Vallarta, Mexico City, Tapachula and Merida. Finally, four new WRS's were commissioned in Canada and are located at Winnipeg, Goose Bay, Gander and Iqualuit. These new WRS's along with the other enhancements have significantly expanded WAAS Localizer Performance with Vertical Guidance (LPV) service beyond continental US (CONUS) to throughout much of the North American continent.

Various levels of WAAS service are now available throughout most of the western hemisphere.

2.1.2 **Ionospheric Grid Point (IGP) Mask.** The IGP mask has been upgraded resulting in more accurate measurement of ionospheric delays in the region that matches the coverage area provided by the two new WAAS geostationary satellites. This upgrade has resulted in expanded WAAS service in North America.

2.1.3 **WAAS Geostationary (GEO) Satellites.** Two new WAAS GEO satellites were made operational, providing improved coverage and service enhancements. One enhancement is the broadcast of a second frequency (L5). At present, information contained on this frequency is identical to what is broadcast on the GEO's L1 frequency. Future system enhancements will look to take full advantage of this second frequency. The new WAAS GEO satellites are located at 133° W longitude and 107° W longitude. These locations provide dual coverage throughout CONUS, much of Alaska, most of North America and the eastern half of South America. This coverage is depicted in figure 1. The solid line identifies 5°-elevation coverage and the dashed line 7.5°-elevation coverage.

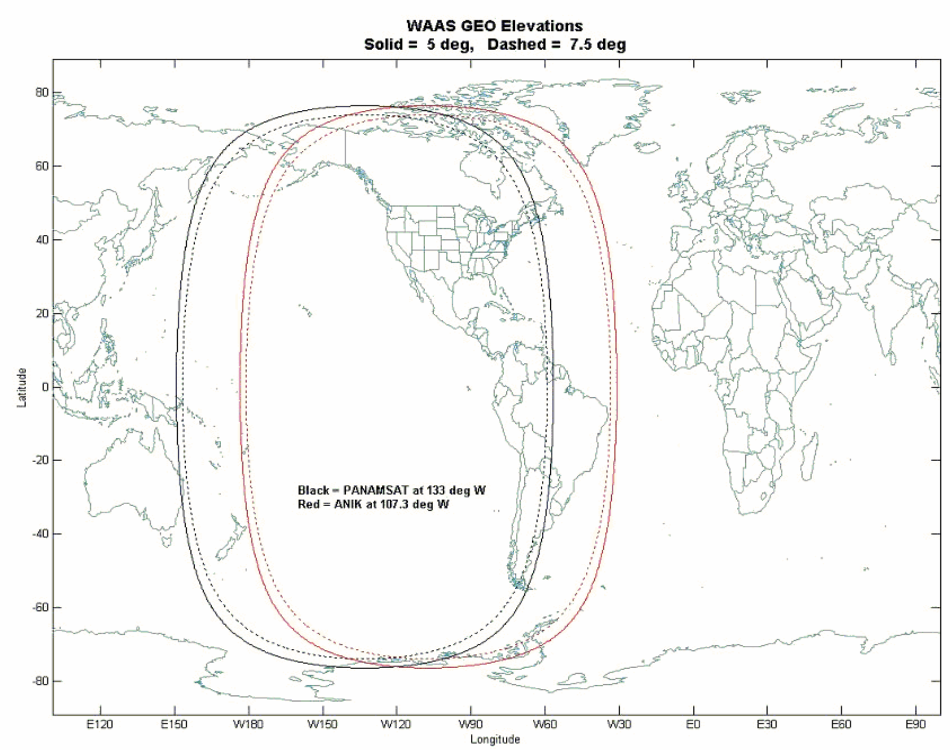

Figure 1. WAAS Geostationary Satellite Footprints.

2.1.4 **Geostationary Satellite Ranging.** The two new WAAS GEOs (Intelsat and ANIK) provide a ranging signal similar to a GPS satellite. These provide additional ranging sources to support en route, terminal and non-precision approach operations resulting in increased availability for GPS non-precision approach operations.

2.1.5 **System Robustness.** Recent upgrades have also enhanced system robustness and include a more robust integrity function. An example is the extreme storm detector. WAAS differentiates between extreme and moderate ionospheric storms. When an extreme ionospheric storm is detected WAAS vertical service is discontinued, system wide, for a period of time. Note that en route through NPA service is still available.

2.1.6 **Operations and Maintenance.** The most recent WAAS upgrade included upgrades to improve the human computer interface and to provide better situational awareness of status of WAAS components.

2.2 **Near Term Additional Enhancement.** The final WAAS service enhancements will include implementation of a Signal Quality Monitor (SQM) that meets the full ICAO threat model. The SQM monitor will become operational in September 2008. The SQM will cover the full WAAS service volume.

2.3 **Operational Benefits.** The systematic enhancements, discussed above, have led to WAAS operational benefits discussed below.

2.3.1 **Benefits with the Use of ILS Equivalent Surfaces.** The FAA is developing WAAS LPV procedures using obstacle clearance surfaces equivalent to ILS surfaces. This results in the following benefits.

a) The survey methods associated with the use of ILS surfaces are much less complex survey methods than those needed to survey the existing PANS OPS two segment SBAS final approach obstacle clearance surface.

b) ILS obstacle clearance surfaces do not lay below the Annex 14 precision runway surfaces to near the extent the existing PANS OPS SBAS final approach surfaces lay below the Annex 14 precision runway surfaces.

c) The ILS surfaces will support decision altitudes/heights (DA/H's) as low as 60 m (200 ft) where obstacles and infrastructure permit, even when vertical alert limits (VAL) exceed 24 m to 28 m. Existing PANS OPS SBAS criteria limit DA/H's to heights above 60 m (200') when VAL exceeds 24 m to 28 m.

d) The procedure designer's familiarity with the ILS surfaces enhances the simplicity of SBAS operational implementation.

e) Procedure design criteria are more consistent with SBAS avionics functionality.

f) Procedure design tools, such as the Collision Risk Model, can be readily applied.

There is no need to develop new criteria. The criteria describing these surfaces already exist.

2.3.2 **System Safety Analysis.** In March 2007, the FAA completed a safety study that demonstrated that with a WAAS vertical alert limit (VAL) of 35 m or less LPV procedures could be designed with operating minima as low as 60 m (200') height above threshold (HAT) DA/H's. In order to operate to DA/H's below 250' HAT:

a) The location must have availability of vertical protection level (VPL) of 35 m or less, exceeding 99% of the time,

b) The obstacle environment must permit the lower minima; and,

c) Runway infrastructure must support the lower minima.

2.3.3 **WAAS LPV Service Contour.** A twenty-four hour roll-up for WAAS LPV service on 3/17/2008 is depicted in figure 2. The figure shows 100% availability of LPV service over 95.55% of CONUS. As can be seen, high levels of LPV service are available over much of Canada and about 75% of Mexico. Service contours for LPV-200 availability along with a real time depiction of the current LPV service contour can be obtained at http://www.nstb.tc.faa.gov/.

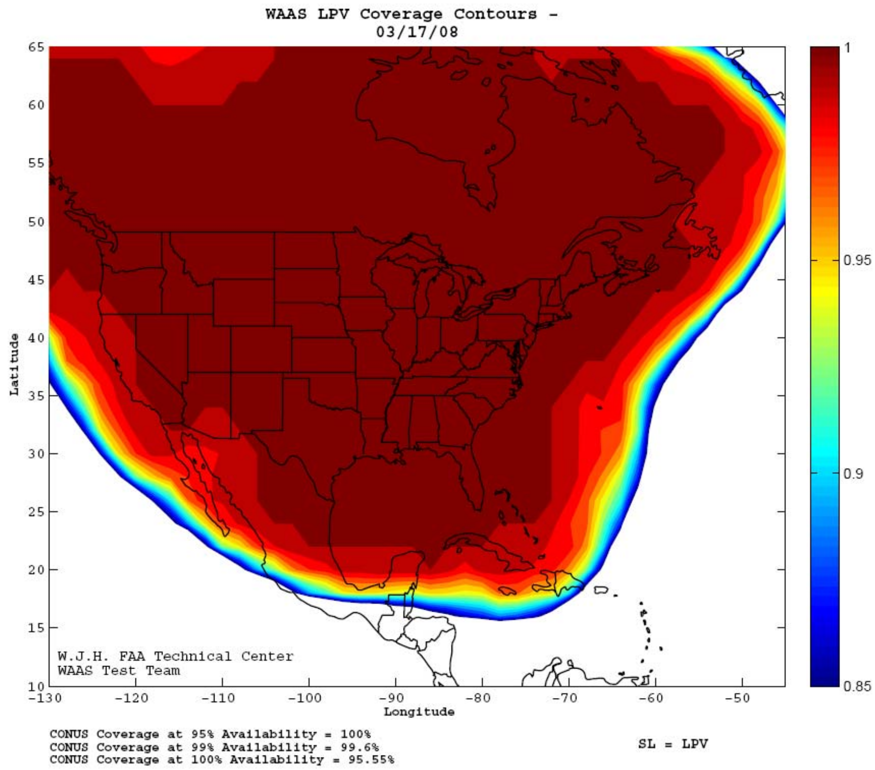

Figure 2. WAAS Vertical Operations Service Contour.

2.3.4 **WAAS Supports Required Navigation Performance (RNP).** WAAS service availability of RNP 0.3 service is depicted in figure 3. RNP 0.3 is defined as where the HPL is less or equal to 556 m. An availability of 99% for RNP 0.3 service extends southward, covering approximately 50% of South America. WAAS provides for higher RNP availability when compared to GNSS. A real-time depiction of service contours for RNP 0.1 and 0.3 can be obtained at http://www.nstb.tc.faa.gov/.

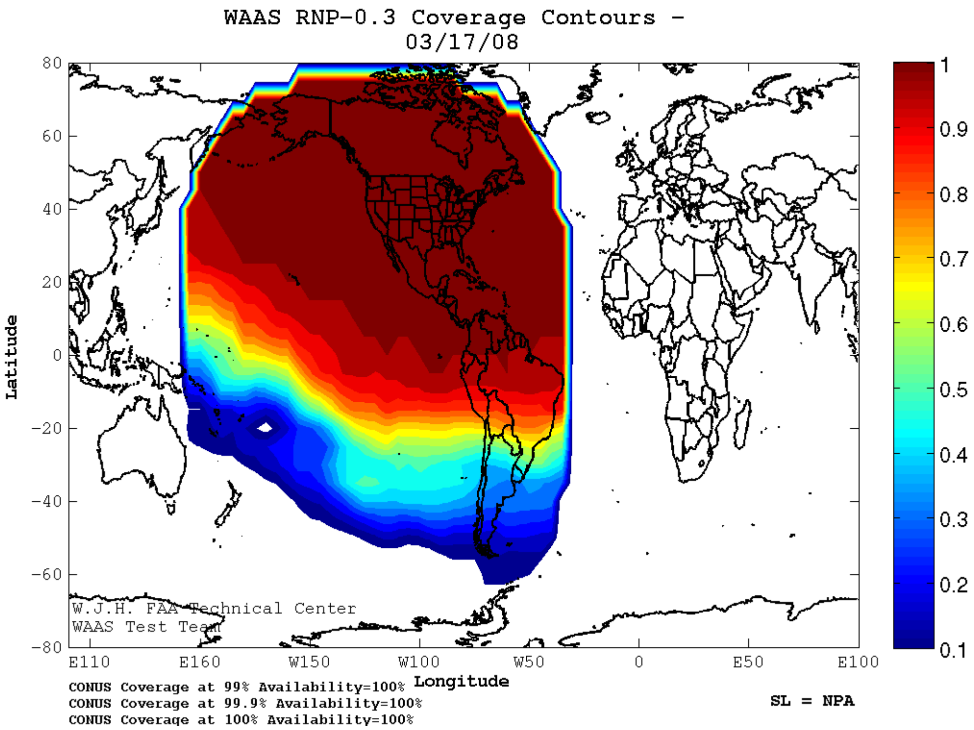

Figure 3. WAAS RNP Service Volume.

2.3.5 **SBAS Avionics Standard.** During the past year, the SBAS avionics standard, RTCA DO-229 has been updated to RTCA DO-229D and is fully backward compatible with previous editions of DO-229.

2.3.5.1 Avionics manufacturers continue to certify SBAS avionics in accordance with US Technical Standard Order C145B/146B. These equipment certifications involve several different avionics architectures including:

a) “Stand alone” avionics with the sensor, navigation and database functions in one single unit. This architecture, termed Gamma, is presented in figure 4.

b) A flight management computer employing, as input, a WAAS sensor and outputting WAAS navigation and display information consistent with the TSO. This architecture, called Beta, is depicted in figure 5.

c) A multi-mode receiver (MMR) meeting ARINC-755/756 characteristics that includes WAAS functionality. This is the Delta IV architecture and is depicted in figure 6.

2.3.5.2 More than 30,000 WAAS sensors, of the various types, have been produced by different manufacturers for civil applications.

2.3.6 **LPV Procedures.** As of the last AIRAC cycle, the FAA has published 1028 LPV procedures. Fourteen of these procedures are to DA’s of less than 250’ HAT. Within the next year, the number of published LPV procedures, in the US, will exceed the number of Category I ILS procedures published in the US.

2.3.6.1 One example of an LPV procedure to a DA less than 250’ HAT is depicted in figure 7. For this particular runway, the LPV minimum is 124’ lower than the LNAV/VNAV procedure to the same runway. This operational benefit would not result with the use of existing PANS OPS SBAS criteria.

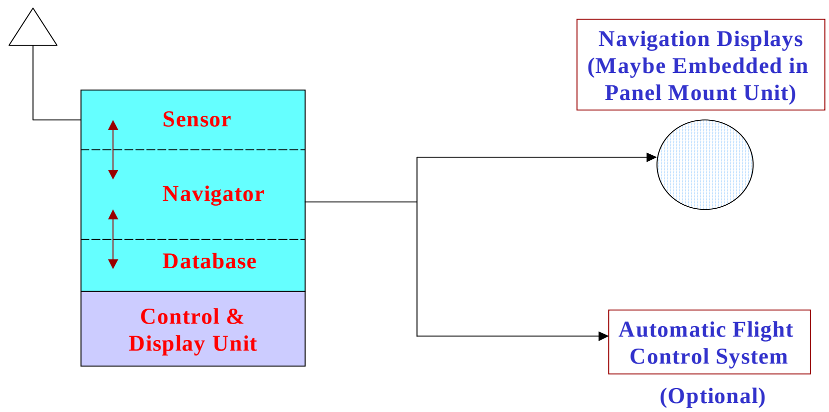

Figure 4. Gamma WAAS Architecture.

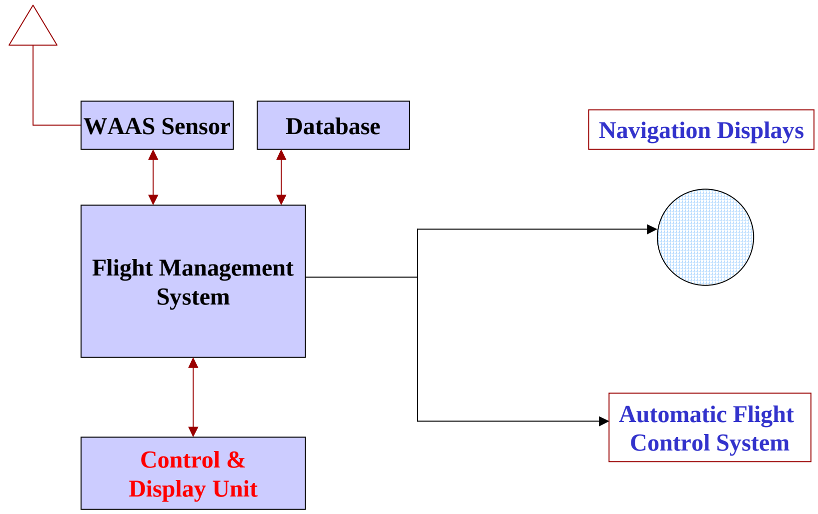

Figure 5. Beta WAAS Architecture.

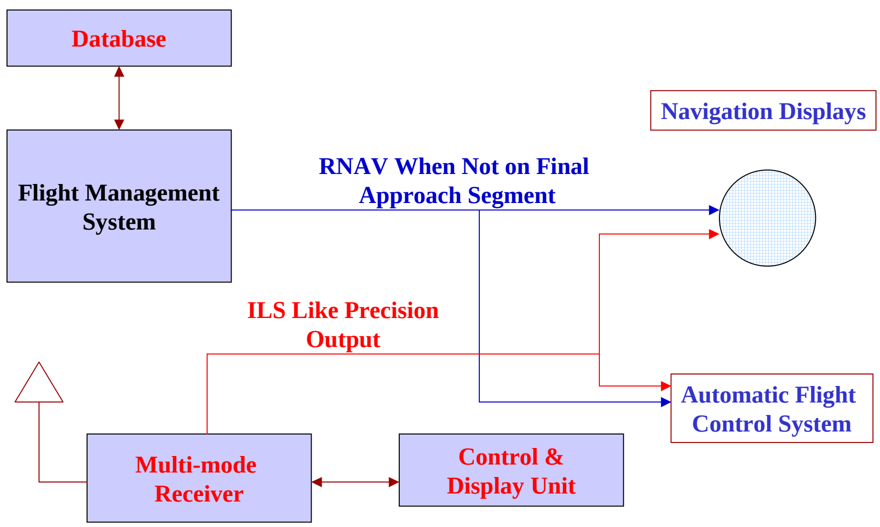

Figure 6. Delta-IV WAAS Architecture.

2.3.7 **New Procedure Design Criteria.** The FAA has published FAA Order 8260.54A. This Order includes new criteria for WAAS. These new criteria address:

a) Construction of localizer performance (LP) procedures. These procedures are equivalent of localizer only procedures utilizing only lateral guidance. These procedures can be implemented where vertically guided procedures can not be developed because of glide slope qualification (GQS) surface penetrations.

b) Construction of offset VNAV procedures. These criteria apply to WAAS but not to barometric VNAV procedures.

2.3.7.1 The FAA is about to publish FAA Order 826.42B. This order addresses helicopter operations. The Order includes procedure construction criteria for procedures that may be flown using WAAS avionics. These criteria include:

a) Point-in-Space (PinS) LP criteria.

b) Reverse PinS Route Departure criteria

c) Special helicopter en route criteria which utilizes reduced area semi-widths.

3. SUMMARY

3.1 The current phase of the WAAS program completes in September 2008. The next phase will include some additional system enhancements of which status will be provided at future meetings of the NSP.

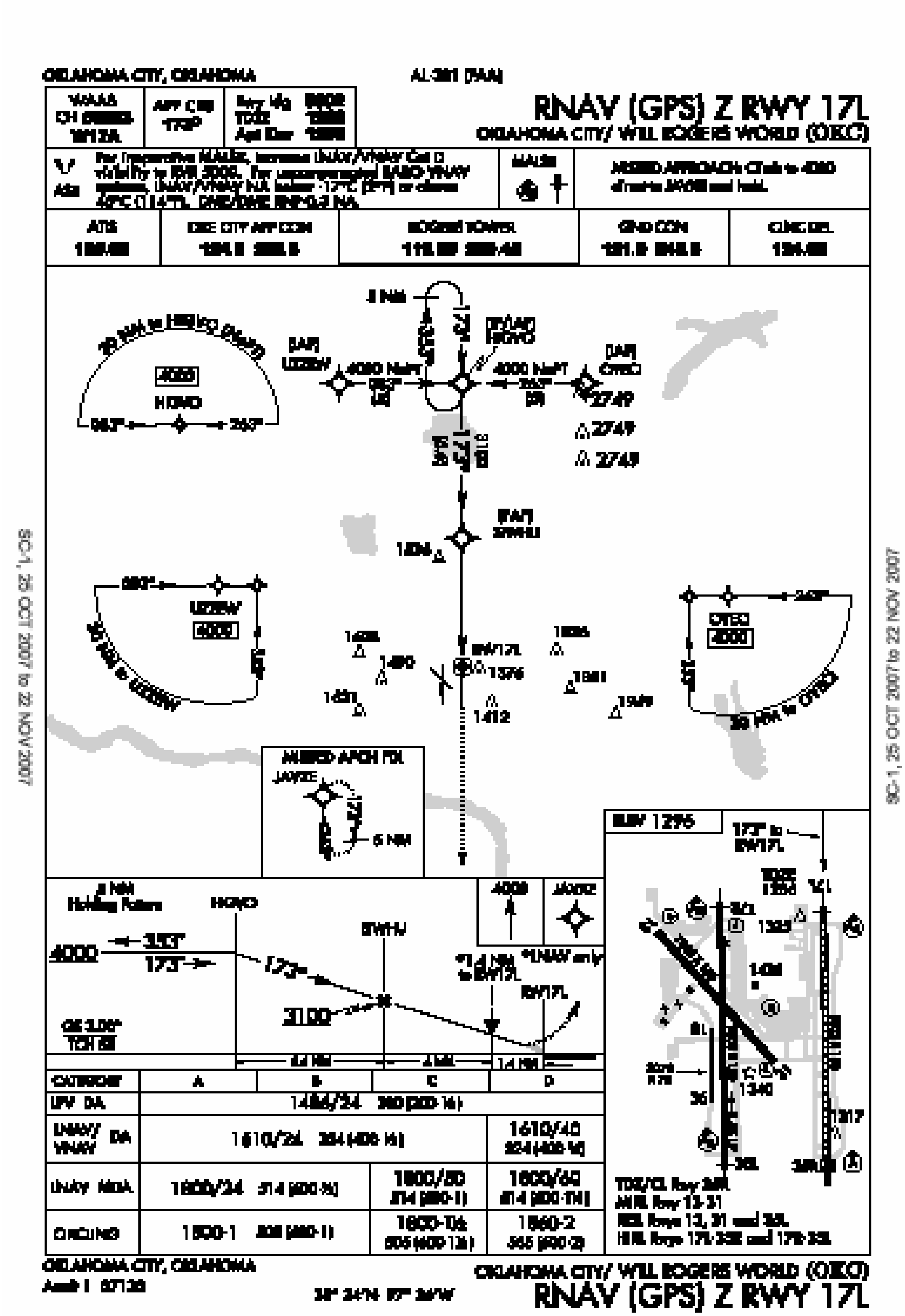

Figure 7. LPV Procedure with 200’ HAT DA/H.

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