

# EIGHTH MEETING OF THE ICAO ASIA/PACIFIC GBAS/SBAS IMPLEMENTATION TASK FORCE (GBAS/SBAS ITF/8)

Australia's Ground Based Augmentation System (GBAS) Implementation and  
Operational Experience

Melbourne, Australia

12 to 14 May 2026

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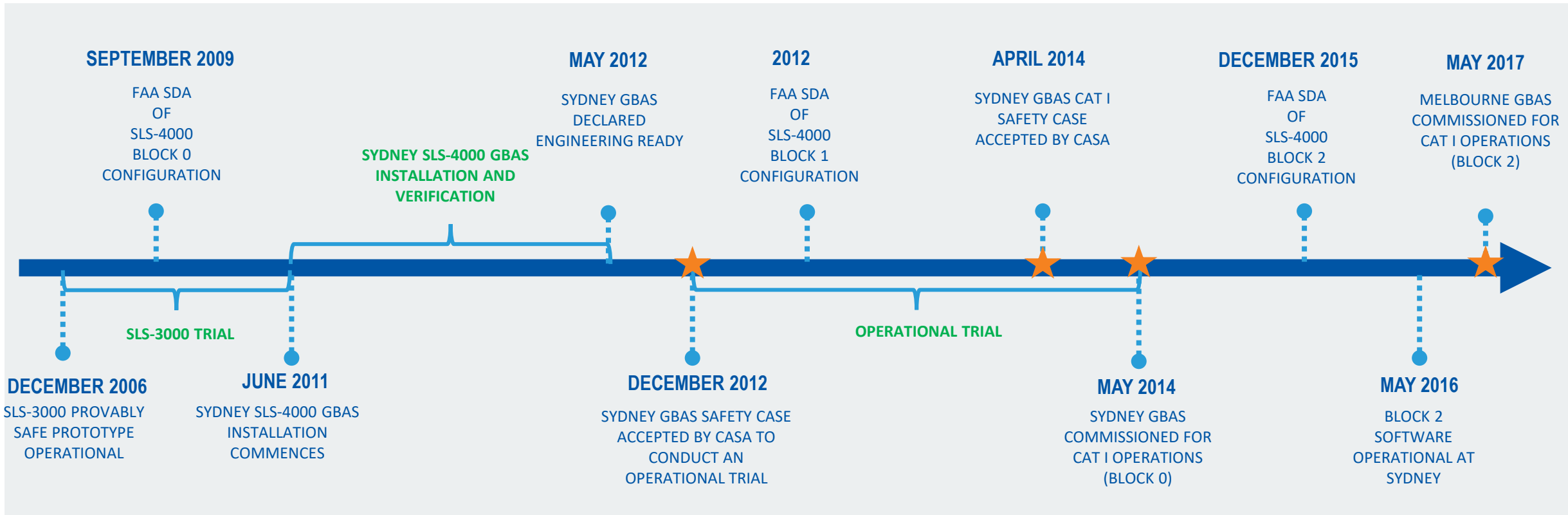
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# 1. AUSTRALIA'S GBAS JOURNEY

# 1. AUSTRALIA'S GBAS JOURNEY (1 OF 1)



NOTE: TIMELINE NOT TO SCALE

## ACRONYMS

FAA – Federal Aviation Administration  
 SDA – System Design Approval  
 CASA – Civil Aviation Safety Authority

## 2. OPERATIONAL IMPLEMENTATION APPROACH

# 2. OPERATIONAL IMPLEMENTATION APPROACH (1 of 3)

*Demonstrate that the Air Traffic Management System will be acceptably safe during and after the implementation of the Ground Based Augmentation System to support CAT-I landing operations*

## CONCEPT DEFINED

Demonstration that the concept of operations has been adequately defined and documented. Address the question how will the GBAS integrate and operate within the existing Air Traffic Management System.



## SAFETY ASSURANCE

Demonstration that safety assurance activities have been conducted for the system as a whole and that identified hazard controls have been incorporated into the design and implementation.



## DESIGN AND IMPLEMENTATION

Demonstration that the system has gone through adequate system design and implementation process. Demonstration that the design and implementation meets legislative requirements and conforms with ICAO SARPs.



### Key Elements

## SUPPORT SYSTEMS

Demonstration that the necessary sustainment systems are in place, which are adequately defined with acceptable controls in place.



## OPERATIONAL TESTING

Demonstration that Operational Testing has been adequately defined, completed and that any lessons learnt from Operational Testing have been integrated into CAT-I operations.



## CAT-I OPERATIONS

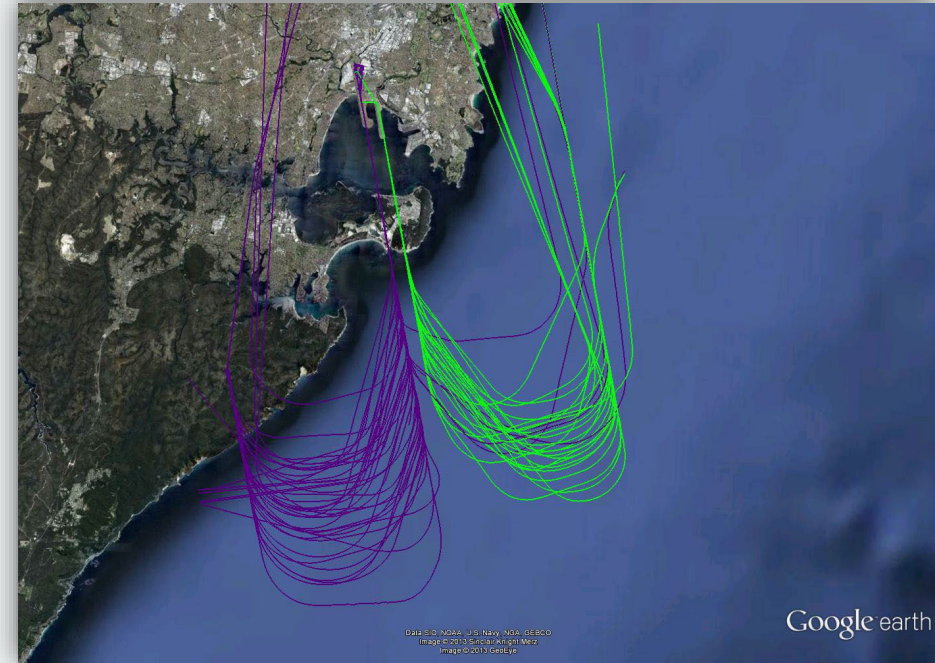
Demonstration that CAT-I landing operations are defined, Support Systems updated and the level of risk acceptable.



## 2. OPERATIONAL IMPLEMENTATION APPROACH (2 of 3)

### TESTING IN A REAL-WORLD ENVIRONMENT

- Safety Case (for Operational Testing) submitted and accepted by the Civil Aviation Safety Authority
- Objectives
  - Validate GBAS is meeting designed System Performance parameters
  - Validate that the service is operating as intended through aircraft using the GLS service
- Open to “Authorised Operators” only. Visual conditions only.
- Temporary Local Instruction in place for ATC
- No change to Service Provider Certificate. Operational Evaluation was conducted under test transmissions clause of the regulations.



### Pilot Feedback:

***“Very good intercept and approach was flawless”***

# 2. OPERATIONAL IMPLEMENTATION APPROACH (3 of 3)

## OPERATIONALISING THE CHANGE

- Hazards reviewed and updated to reflect CAT-I operations
- ATC instructions integrated into procedures and Aeronautical Information Publication documents were updated
- All evidence collated during the Operational Testing consolidated into Safety Case for CAT-I operations and accepted by CASA
- Future GBAS deployments managed as any other Navigation Aid deployment
- GBAS available for use by all operators authorised to conduct GLS approaches by their National Aviation Authority

CASR-171 Service Classifications (Chapter 2 MOS Part 171)	Coverage	ICAO Defined Services	Airways Systems	Support Services (External)
AERONAUTICAL RADIO NAVIGATION	National	Aeronautical Radio Navigation	<ul style="list-style-type: none"> <li>• Distance Measuring Equipment</li> <li>• Instrument Landing System – Localiser, Glide Path and Marker</li> <li>• Non Directional Beacon</li> <li>• Very High Frequency Omni-Range</li> <li>• <b>Ground Based Augmentation System</b></li> </ul> <p><b>Common Systems</b></p> <ul style="list-style-type: none"> <li>• Communications systems                             <ul style="list-style-type: none"> <li>- Microwave radio links</li> <li>- Satellite ground stations</li> <li>- Terrestrial cabling</li> <li>- Multiplexers</li> <li>- Data networking systems</li> </ul> </li> <li>• Voice Communication and Control System</li> <li>• Audio and Control Systems</li> <li>• ATC Consoles</li> </ul>	<ul style="list-style-type: none"> <li>• Public Telecommunication Networks</li> <li>• Copper and Fibre cables(Airport Owner)</li> </ul>



## 3. ENGINEERING AND MAINTENANCE

### 3. ENGINEERING AND MAINTENANCE (1 of 6)

#### ENGINEERING AND MAINTENANCE EXPERIENCE

01

GBAS scheduled maintenance is straightforward with minimal disruption to Service Delivery (average of four hours to complete annual maintenance)

02

Majority of corrective maintenance on the system is in response to Lightning strikes.

03

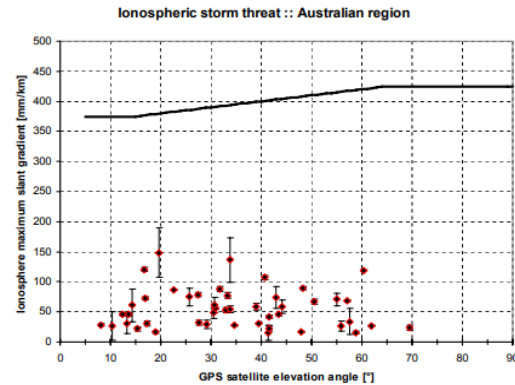
GBAS performance is constantly changing due to natural changes in satellite geometry (Unlike conventional navigation aids which are static and have repeatable performance characteristics).

# 3. ENGINEERING AND MAINTENANCE (2 of 6)

## KEY ENGINEERING ACTIVITIES DURING INSTALLATION

### IONOSPHERE THREAT MODEL VALIDATION

- Validate that the magnitude of ionosphere gradients within the mid-latitude region of Australia falls within the bounds of the Ionosphere Threat Model
- Largest ionosphere gradients fell well within bounds of the model



### SITE SELECTION

- Identify preliminary sites based on manufacturer Siting Process
- Set up a GPS antenna/receiver to evaluate GPS environment
- VHF coverage modelling using available software tools



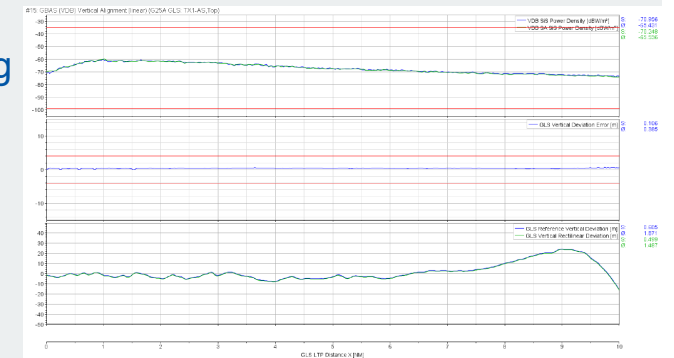
### INSTALLATION & INTEGRATION

- Site Design
- Civil Works
- Shelter & Tower Installation
- RSMU Installation
- VDB Installation
- Integration into ATM Systems



### VERIFICATION ACTIVITIES

- Factory Acceptance Testing
- Installation checks
- Site Acceptance Testing
- Flight Inspection



# 3. ENGINEERING AND MAINTENANCE (3 of 6)

## KEY ENGINEERING ACTIVITIES IN-SERVICE

### SYSTEM PERFORMANCE MONITORING

Perform annual system performance reviews of the GBAS to verify that performance requirements (Availability and Continuity of Service) continue to be met and support arrangements continue to remain effective.



### SATELLITE CONSTELLATION MONITORING

Evaluate notifications of satellite outage, assess their effect on the availability of GBAS Landing System approaches and request NOTAMs to be raised if any effects are identified.



### TECHNICAL SUPPORT

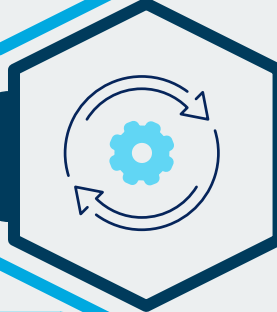
Undertake complex fault investigation (in collaboration with the manufacturer if required) and investigate any GBAS related pilot anomaly reports.



### Key Activities

### CONTINUOUS IMPROVEMENT

Undertake formal technology change management in accordance with internal policies identify and implement opportunities to optimise existing maintenance regimes.



### TECHNICAL DOCUMENTATION MANAGEMENT

Development, maintenance and authorisation of all technical documentation related to the ongoing support and maintenance of the GBAS including System Management Plans, Performance Inspection, Technical Certification criteria, Engineering instructions, supplier documentation and change proposals.



### TECHNICAL RISK MANAGEMENT

Monitor for new technical risks (e.g. increase in lightning strikes, satellite changes) or changes to existing technical risk profiles, develop appropriate controls, implement and monitor the effectiveness of controls.

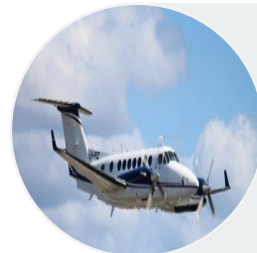


# 3. ENGINEERING AND MAINTENANCE (4 of 6)


## PLANNED MAINTENANCE ACTIVITIES



**GBAS EQUIPMENT (TOWER, VHF DATA BROADCAST AND REFERENCE RECEIVERS)**



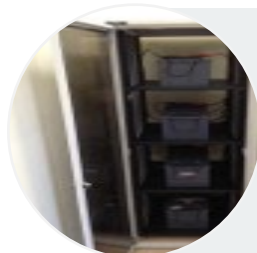
**ROUTINE FLIGHT INSPECTION**



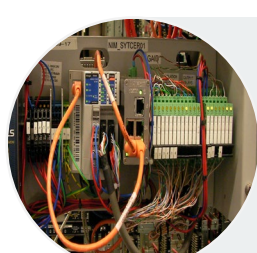
**SHELTER AND ANTENNA STRUCTURES**



**SHELTER AIR CONDITIONER**



**POWER, BATTERY AND EARTHING AND LIGHTNING PROTECTION SYSTEMS**

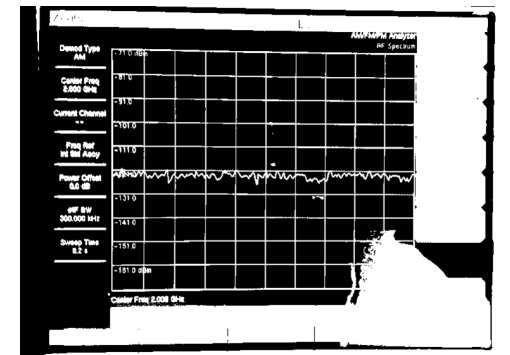
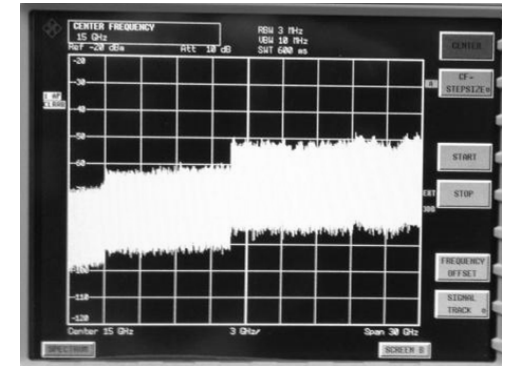
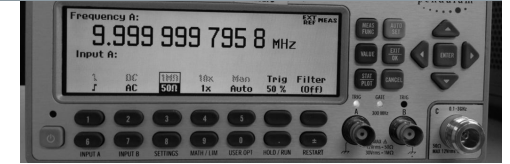


**GBAS STATUS MONITORING SYSTEM**

# 3. ENGINEERING AND MAINTENANCE (5 of 6)

## GBAS EQUIPMENT SPECIFIC MAINTENANCE TASKS

Monthly	GBAS Event Log Review
Bi-Monthly	Site inspection for any new intrusions and excess vegetation
Annually	VHF Data Broadcast (VDB) Transmitter checks (Frequency, Power, Spurious Emissions, Adjacent Channel)
	VDB Receiver (Frequency, Power) checks
	VDB and Reference Receiver condition check
	Redundant Power check
	Cooling fan control and condition checks
	Voltage Standing Wave Ratio (VSWR) and monitor check
	Surge Protection Device checks
Five Yearly	Site configuration check
	Remote Status Monitoring checks
	Flight Inspection (Single approach on each procedure supported by the GBAS)

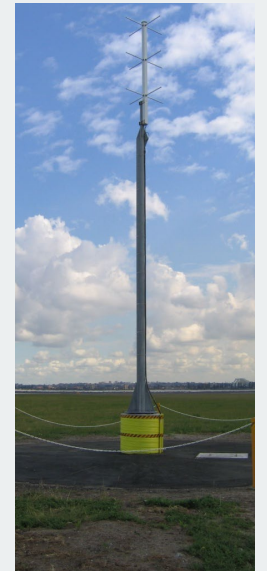
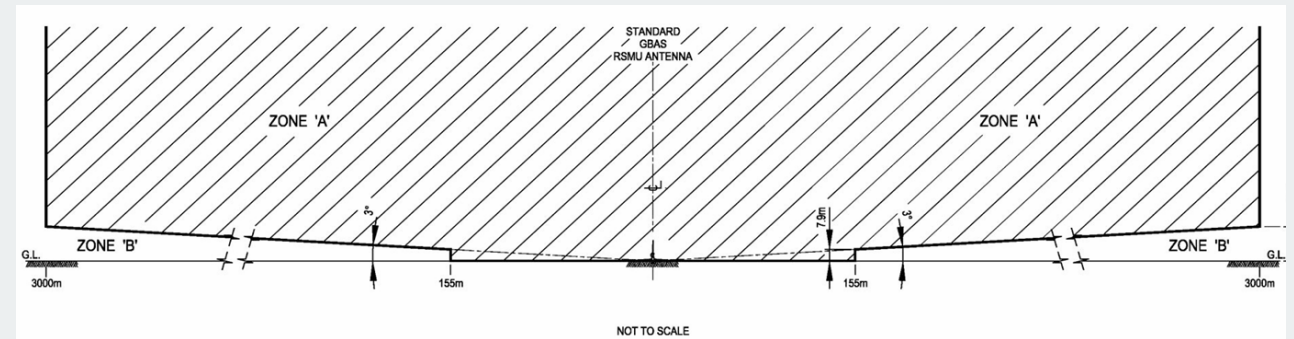


**GBAS Maintenance staff required to have undertaken manufacturer training and Technical Certification**

# 3. ENGINEERING AND MAINTENANCE (6 of 6)

## GBAS BUILDING RESTRICTED AREAS

- Developments or activities that may infringe protected airspace are sent to the Air Navigation Service Provider for assessment
- Building Restricted Area (BRA) established around the Reference Receiver and VHF Data Broadcast (VDB) antennas
- BRA is intended to identify activities that may require further specialist engineering analysis for effects on GBAS performance
- GBAS Engineering specialists undertake further detailed assessment if any activity intrudes into the BRA. This may involve the use of specialised software tools.
- Any material effects that new developments have on Reference Receivers may require configuration changes (e.g. new sector masking) to the system.
- Reference Receiver BRA
  - Protect the Reference Receivers from activities that may increase the multipath environment and/or effect line of sight to satellites
- VHF Data Broadcast BRA
  - Protect the VHF Data Broadcast signal for an aircraft that is located within the GBAS approach service volume



## 4. AIR TRAFFIC CONTROL

## 4. AIR TRAFFIC CONTROL (1 OF 4)

### BENEFITS OF GBAS

01

Expect no equivalent ILS Critical or Sensitive areas to protect allowing greater operational flexibility.

02

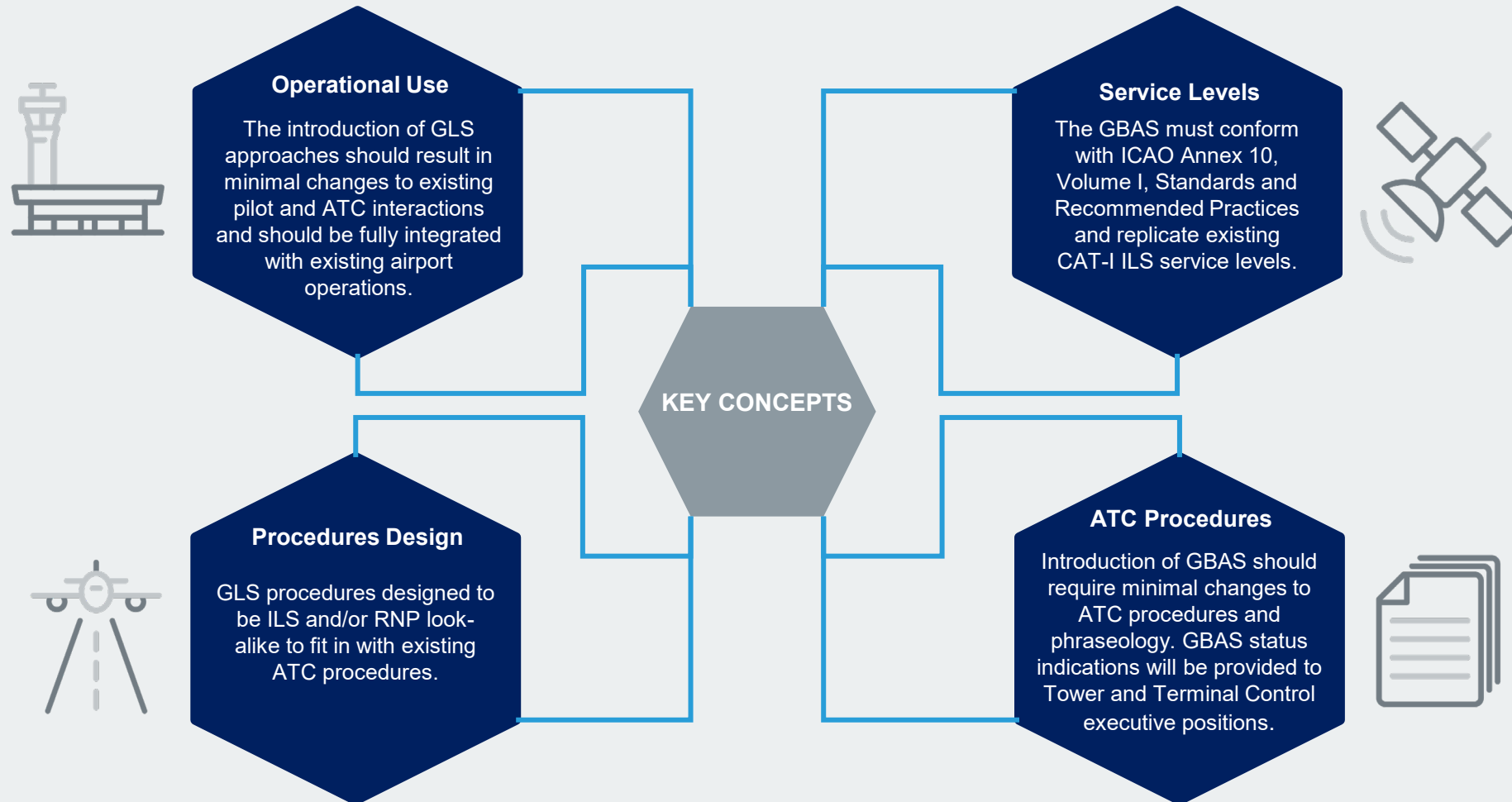
No loss of service during periodic flight calibration activities allowing the facility to remain in service.

03

Seamless transition from the ILS to GLS with minimal changes to existing practices.

# 4. AIR TRAFFIC CONTROL (2 OF 4)

## GBAS CONCEPT OF OPERATIONS



# 4. AIR TRAFFIC CONTROL (3 OF 4)

## ATC TRAINING NEEDS ANALYSIS AND CHANGE MANAGEMENT

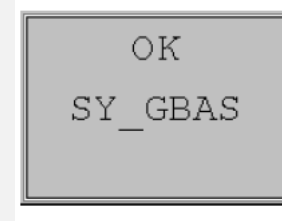
- An ATC Training Needs Analysis (TNA) was completed in accordance with existing practices. This included:
  - GAP analysis – Impact of changes and determination of training required
  - GAP learning – Analysis of knowledge and skills required
  - Training resources, methods and delivery requirements
- Briefings provided to ATC on the changes introduced by GBAS
- Local instructions updated and a group circular developed. Briefings conducted internally within ATC
- ATC provided with a briefing package on GPS satellite constellation monitoring practices
- Practical skills consolidated through ongoing On The Job training for ATC

Sectorisation/Airspace	No change
Traffic Processing	No change
Phraseologies	Additional phraseology (e.g. “Cleared GLS”)
Separation	No change
Information provided to pilots	Additional information on ATIS (e.g. “Expect GLS”)
Documents	Local instructions and training documentation updated
Workstation operation	New GBAS monitoring indication on Controllers screen
Equipment	New laptop used for supplementary GBAS information
HMI	Indication of aircraft GLS capability on Controllers screen
Abnormal/Emergency Operations	No change
Handover/takeover	Inclusion of GBAS information in Handover/Takeover
Degraded Modes	No change

# 4. AIR TRAFFIC CONTROL (4 OF 4)

## ATC STATUS MONITORING AND NOTAM

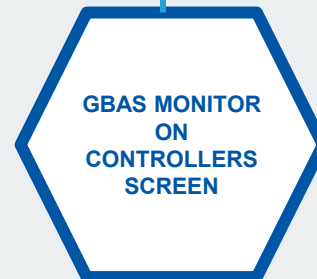
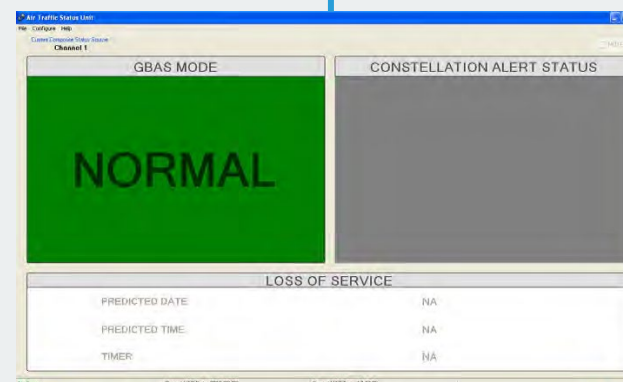
- GBAS OK/NOT OK status monitoring provided directly to the local Tower and responsible approach control unit
- GBAS technical monitoring provided to the Technical Operations Centre including:
  - GBAS Fail, GBAS Service Alert, GBAS on Battery, Loss of monitoring
- Dedicated laptop in the responsible approach control unit providing supplementary GBAS information
- Pilots notified of GBAS outages through a NOTAM
- ATC will inform pilots directly if their monitor indicates GBAS NOT OK
- GLS is not available during periods the VPL is predicted to exceed the VAL
- Example NOTAMs
  - GROUND BASED AUGMENTATION SYSTEM (GBAS) U/S
  - GROUND BASED AUGMENTATION SYSTEM (GBAS) U/S DUE CONSTELLATION AVAILABILITY
  - GROUND BASED AUGMENTATION SYSTEM (GBAS) ON TEST, DO NOT USE, FALSE INDICATIONS POSSIBLE, NOT TO BE USED FOR NAVIGATION



**GBAS OK**



**GBAS NOT OK**



# 5. PROCEDURES DESIGN

# 5. PROCEDURES DESIGN (1 OF 5)

## HIGH LEVEL DESIGN PROCESS

RUNWAY THRESHOLD AND OBSTACLE SURVEY DATA

REF	TYPE	DESCRIPTION	HEIGHT	ASPH	WID	THRES	ASPH	WID	THRES
1	OBSTACLE	...	...	...	...	...	...	...	...
2	OBSTACLE	...	...	...	...	...	...	...	...

GLS INSTRUMENT APPROACH PROCEDURE DESIGN

Software interface showing various parameters for GLS instrument approach procedure design, including approach category, glide path, and obstacle data.

GENERATE FAS DATA BLOCK FILE

Software interface for generating FAS data block files, showing fields for operation type, service provider, approach ID, runway number, and various performance and reference data.

LOAD FAS DATA BLOCK ONTO THE GBAS

PUBLISH INSTRUMENT APPROACH PROCEDURE

Published instrument approach procedure chart showing runway layout, glide path, and obstacle data.

PERFORM FLIGHT VALIDATION

Procedure Validation Certificate form with fields for organization, procedure name, location, and a table for validation results.

PROCEDURE	SAISFACTORY	UNSAISFACTORY
...	...	...

PERFORM FLIGHT INSPECTION

Software interface for flight inspection, showing a table of flight data and various performance metrics.

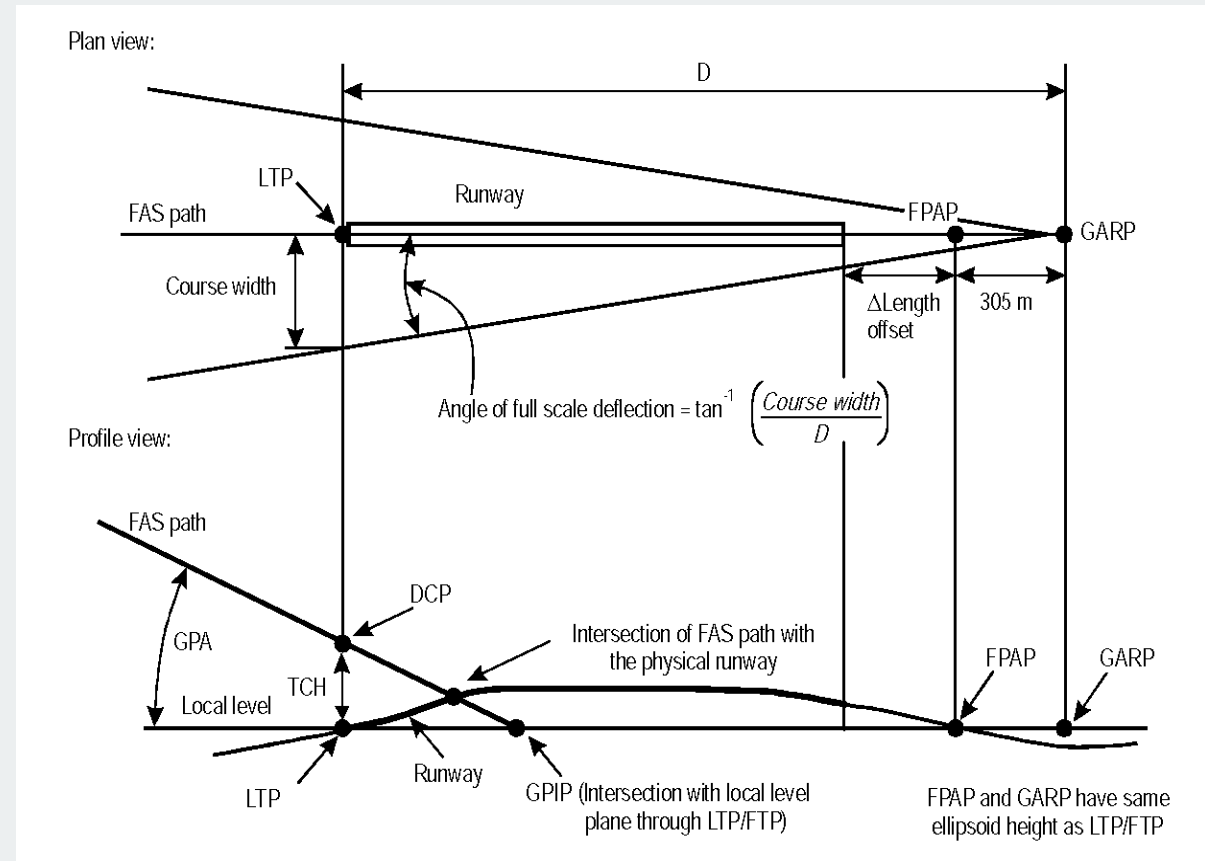
TYPE	STATUS	YSSD	SSC	LENGTH	TIME
...	...	...	...	...	...

- Notes:
- Coordinates of the Runway Threshold must be in the same datum and at the same epoch used for the Reference Receivers.
  - Three independent cross-checks by Engineering staff to assure the data has been coded correctly.
  - Maintenance staff will cross-check the values displayed through the local Maintenance Data Terminal with those provided by Procedures Design.
  - Flight Inspection will verify the broadcast FAS data matches that provided by Procedures Design, Verify VDB coverage and confirm lateral and vertical navigation errors are within tolerances.
  - Flight Validation will provide assurance that the GBAS ground subsystem can support the Instrument approach procedure (IAP), that the IAP ensures obstacle clearance and assess the flyability of the IAP.

# 5. PROCEDURES DESIGN (2 OF 5)

## GLS INSTRUMENT APPROACH PROCEDURE DESIGN CONSIDERATIONS

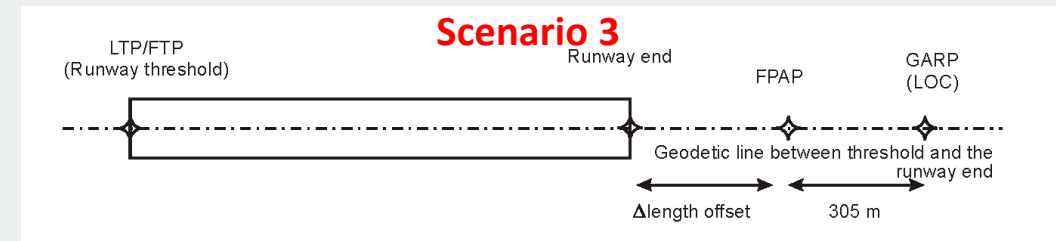
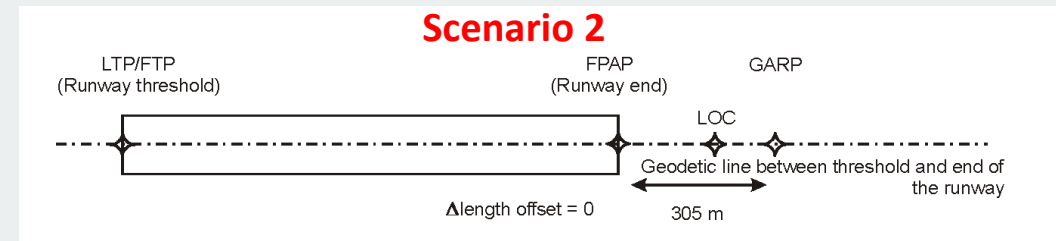
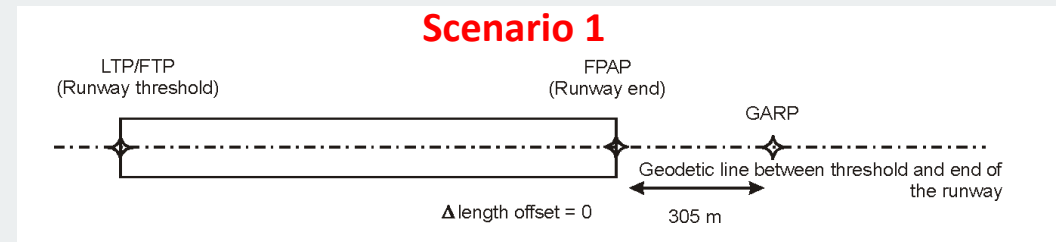
- GLS procedure design is based on an ILS equivalency method
- Glide Path Angle (GPA)
  - where ILS exists, match the GPA to the ILS GPA to the same runway end
  - consistent with PAPI or VASI
  - nominally 3°, unless obstacle clearance or airspace restrictions require a higher GPA
- Threshold Crossing Height (TCH)
  - nominally 15 metres (50 feet) or match existing ILS TCH
  - nominally 12 metres (40 feet) for Code 1 and 2 runways
- GLS instrument approach procedure must be wholly contained within the minimum service volume in ICAO Annex 10, Volume I, Attachment D, Figure D-5
  - GBAS integrity is only assured within 23 NM from the GBAS site
- There may be restrictions on the allowable GPA and TCH combination
  - constraint to mitigate the risk imposed by anomalous ionospheric conditions (Geometry Screening)



# 5. PROCEDURES DESIGN (3 OF 5)

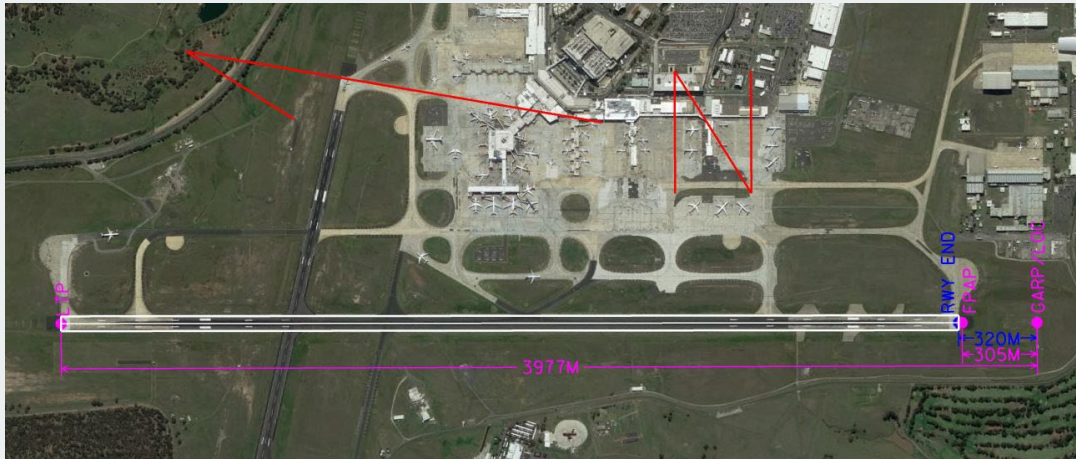
## GLS INSTRUMENT APPROACH PROCEDURE DESIGN CONSIDERATIONS

- Flight Path Alignment Point (FPAP)
  - Scenario 1: No ILS exists**
    - FPAP is coincident with the runway end
    - GNSS Azimuth Reference Point (GARP) is located 305 m from the FPAP in the direction of the approach
  - Scenario 2: ILS Localizer is less than 305 m from the runway end**
    - FPAP is coincident with the runway end
    - GARP is located 305 m from the FPAP in the direction of the approach
  - Scenario 3: ILS Localizer is greater than 305 m from the runway end**
    - GARP is coincident with the ILS Localizer position
    - FPAP is located 305 m from the GARP in the direction of the LTP
    - $\Delta$  length offset is the distance between the runway end and FPAP
- Course Width at Threshold
  - equivalency with Localizer guidance is achieved by matching the GBAS course width abeam the landing threshold with the Localizer course width at the same point
  - nominally 105 m for Scenario 1 and Scenario 2
  - matches the ILS Localizer Course half-width for Scenario 3



# 5. PROCEDURES DESIGN (4 OF 5)

## GLS INSTRUMENT APPROACH PROCEDURE DESIGN EXAMPLE – YMML RUNWAY 16 (SCENARIO 3)



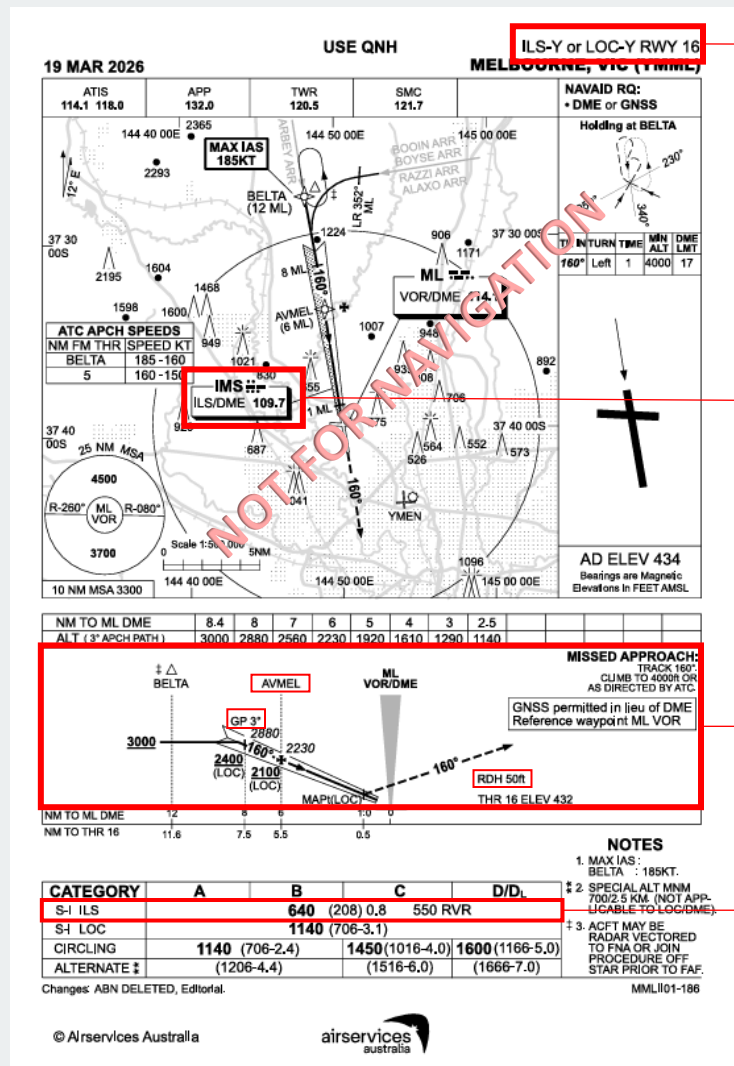
ILS		GBAS	
RWY end to LOC distance	320 m	GARP	LOC position (320 m from runway end)
		FPAP	305 m from GARP
		Δ length offset	15 m*
LOC course half-width	107 m	Course Width	107 m
GPA	3.00°	GPA	3.00°
TCH	50 feet	TCH	50 feet

\* Configured as 16 m in the FAS Data Block as the resolution of the Δ length offset is 8 m.

Item	Units	Range of Values	Resolution	Value
Operation Type	-	0 = Straight in Approach 1 to 15 = Spare	1	0
SBAS Service Provider	-	0 to 13 = Not used in Australia 14 = FAS Data Block is to be used with GBAS only 15 = FAS Data Block can be used with any SBAS service provider	1	14
Airport ID	-	AAAA to ZZZZ	-	YMML
Runway Number	-	1 to 36	1	16
Runway Letter	-	0 = no letter 1 = R (right) 2 = C (centre) 3 = L (left)	1	0
Approach Performance Designator	-	0 = GAST A 1 = GAST C (Category I) 2 = GAST C and GAST D 3 = GAST C, GAST D and an additional approach service type to be defined in the future 4 = GAST C, GAST D and two additional approach service types to be defined in the future 5 to 7 = Spare	1	1
Route Indicator	-	A to Z	-	W
Reference Path Data Selector (RPDS)	-	0 to 48	1	4
Reference Path Identifier (RPI)	-	3 or 4 letter alphanumeric characters (IDENT)	-	G16A
LTP/FTP Latitude	degrees	± 90.0°	0.0005 arcsec	-37°39'11.4570"
LTP/FTP Longitude	degrees	± 180.0°	0.0005 arcsec	144°50'05.6925"
LTP/FTP Height	metres	-512.0 to 6041.5 m	0.1 m	137.0 m
Δ FPAP Latitude	degrees	± 1.0°	0.0005 arcsec	-0°01'57.8290"
Δ FPAP Longitude	degrees	± 1.0°	0.0005 arcsec	0°00'21.9940"
Approach Threshold Crossing Height (TCH)	metres or feet	0 to 3276.7 feet or 0 to 1638.35 m	0.1 feet or 0.05 m	50.0 ft
Approach TCH Units Selector	-	0 = Feet 1 = Metres	-	0
Glide Path Angle (GPA)	degrees	0 to 90.0°	0.01°	3.00°
Course Width	metres	80 to 143.75 m	0.25 m	107.00 m
Δ Length Offset	metres	0 to 2032 m	8 m	16 m

# 5. PROCEDURES DESIGN (5 OF 5)

## GLS INSTRUMENT APPROACH PROCEDURE DESIGN EXAMPLE – YMML RUNWAY 16 (SCENARIO 3)



ILS

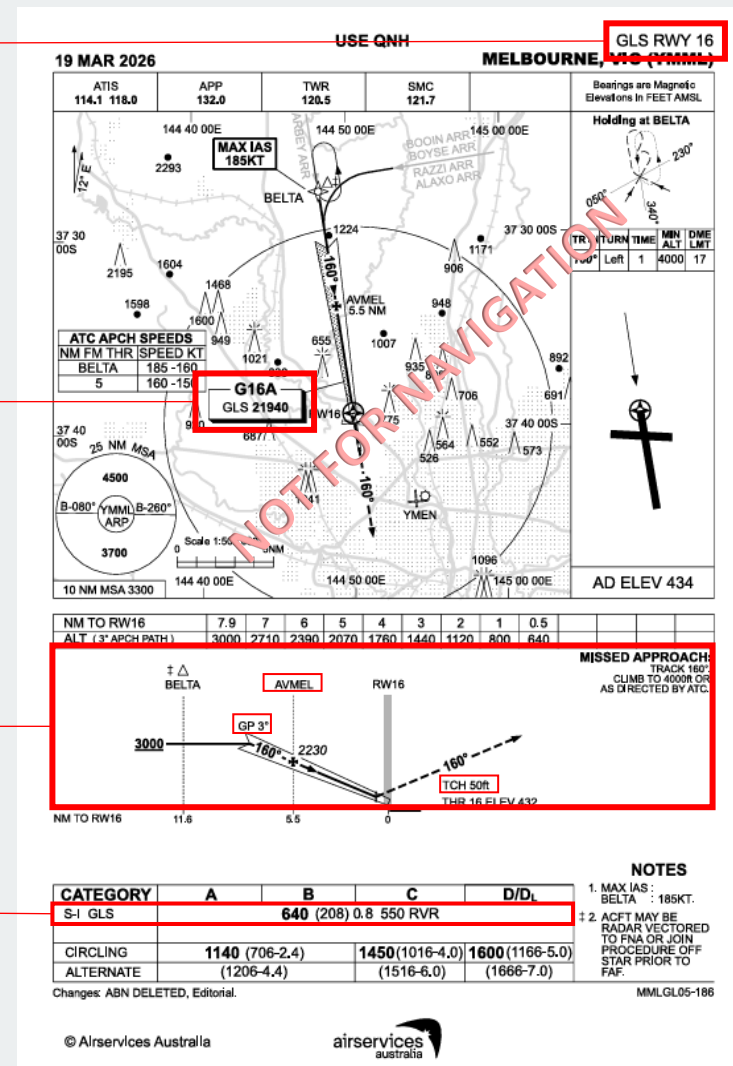
GLS

ILS IDENT and Frequency

RPI (G16A) and Channel Number

Same approach profile

Same minima

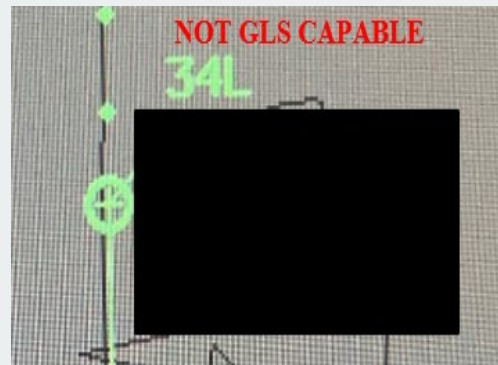


## 6.OPERATIONAL EXPERIENCE

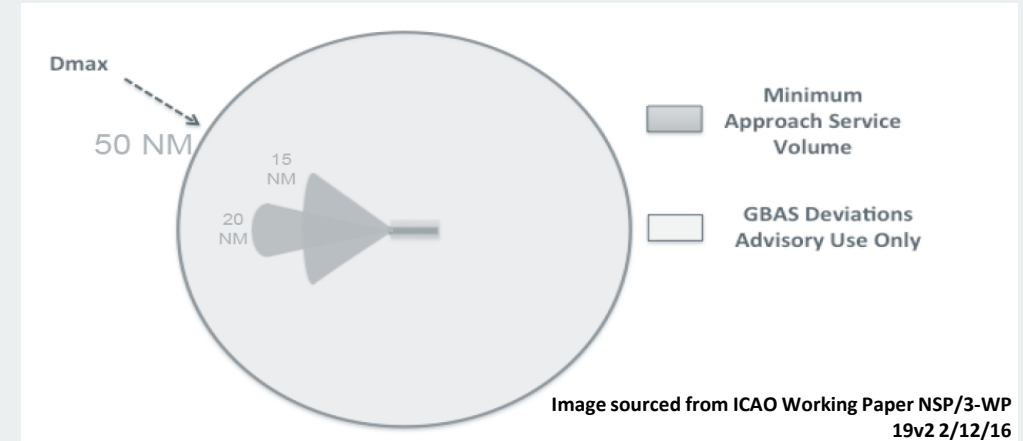
## 6. OPERATIONAL EXPERIENCE (1 OF 5)

### GLS EXPECTED APPROACH METHOD

- Based on industry feedback, GLS became the expected approach method from 2018.
- To support GLS as the expected approach method, a key update was made to the ATM system.
- This allows ATC to identify GLS-equipped aircraft by automatically scanning flight plans for GLS capability.
- GLS capability detected based on Flight Plan Field 10A, "A".
- If GLS capability is detected the arrival runway is highlighted in a distinct colour for Approach Controllers.



### MAXIMUM USE DISTANCE EXTENSION (Dmax)



- Based on industry feedback, GBAS Maximum Use Distance extended from 23NM to 50 NM.
- Enabled through a change to the definition of Dmax in ICAO Annex 10, Volume I, Amendment 91.
- Between 23 NM to 50 NM from the GBAS site, the GBAS guidance information is advisory only.
- Enhances pilot situational awareness, provides an indication of GBAS station health and improves GBAS course capture.

## 6. OPERATIONAL EXPERIENCE (2 OF 5)

### LOSS OF GLS GUIDANCE EVENTS

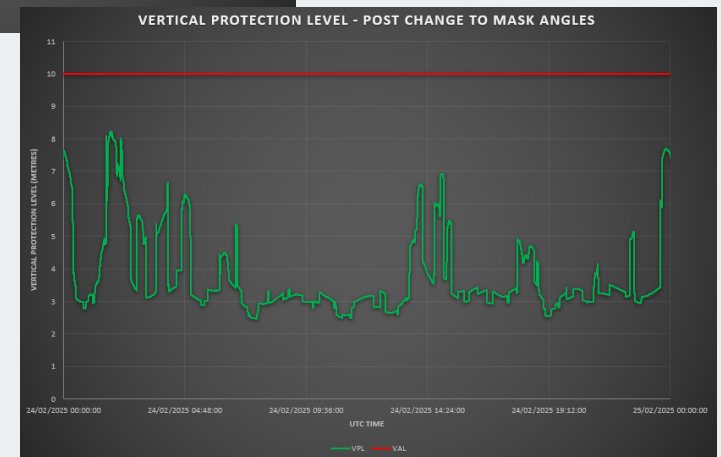
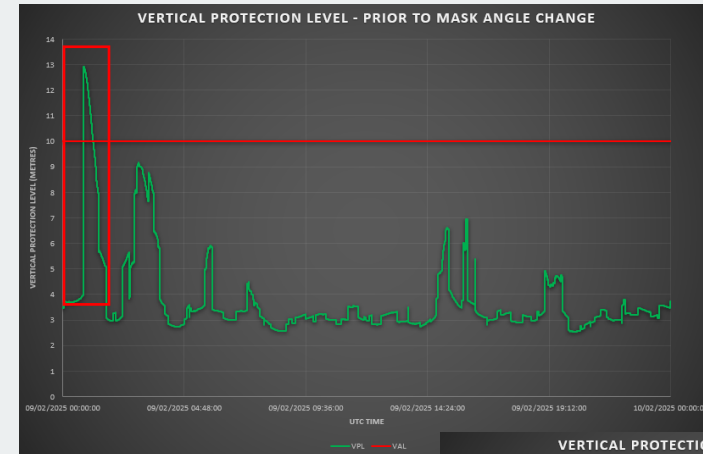
- Limited number of pilots experienced a loss of vertical deviation indications whilst performing a GLS approach
- In all instances, pilot had visual reference of the runway and continued the approach
- Attributed to Vertical Protection Level (VPL) exceeding the Vertical Alert Limit (VAL) due to integrity monitor exclusions of satellite
- Australia actively monitors predicted changes to the GPS satellite constellation configuration and will remove the GBAS from service (through a NOTAM) during periods the VPL is predicted to exceed VAL
- Continuity of Service requirements continue to be met at both GBAS installations



## 6. OPERATIONAL EXPERIENCE (3 OF 5)

### SATELLITE CROSS-CORRELATION EVENTS

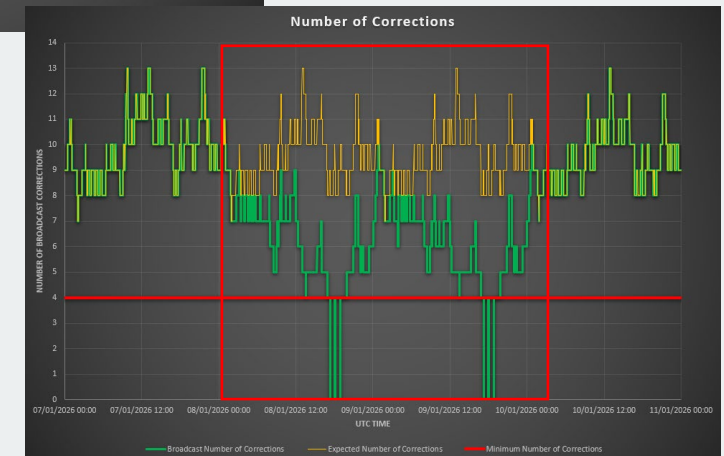
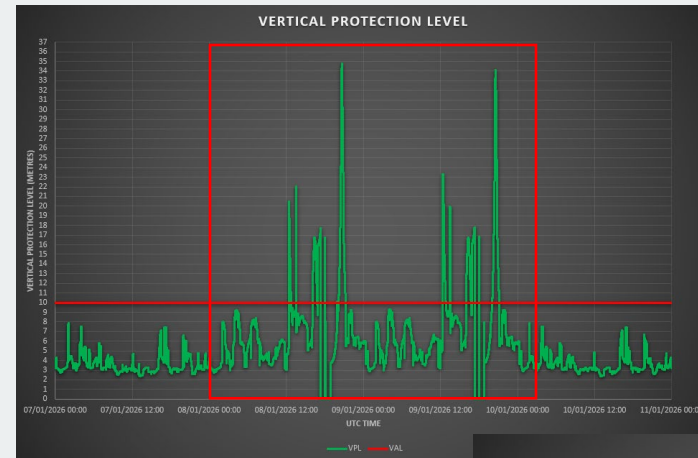
- At one site in Australia, pseudo-range corrections were not being broadcast for satellite PRN08.
- Loss of satellite PRN08 resulted in the VPL exceeding the VAL for a short period each day.
- The loss of pseudo-range was subsequently attributed to a satellite cross-correlation event with satellite PRN32.
- The satellite cross-correlation event was occurring when PRN08 was at low elevation angles (below  $5^\circ$ ).
- Mask angle at which the GBAS tracks a satellite was increased by two degrees (from  $3^\circ$  to  $5^\circ$ ) through a dataset change.
- This means the GBAS will not use any data from satellite PRN08 at the angle at which the satellite cross-correlation event occurs.
- The GBAS continues to broadcast pseudo-range corrections for satellite PRN08 with improvements in Availability.



## 6. OPERATIONAL EXPERIENCE (4 OF 5)

### JANUARY 2026 EVENT

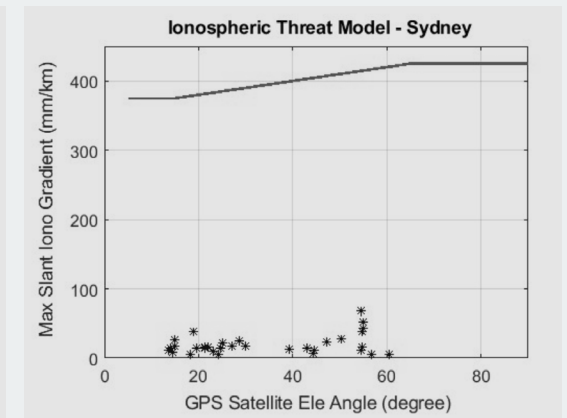
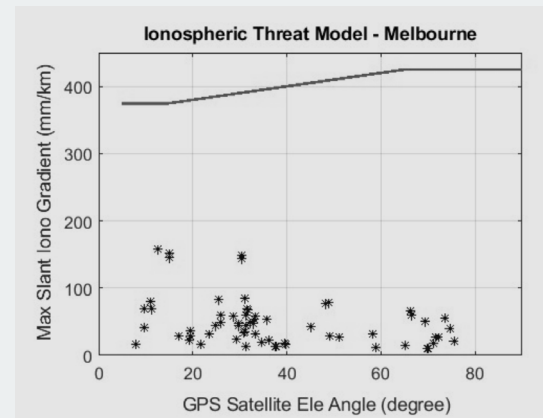
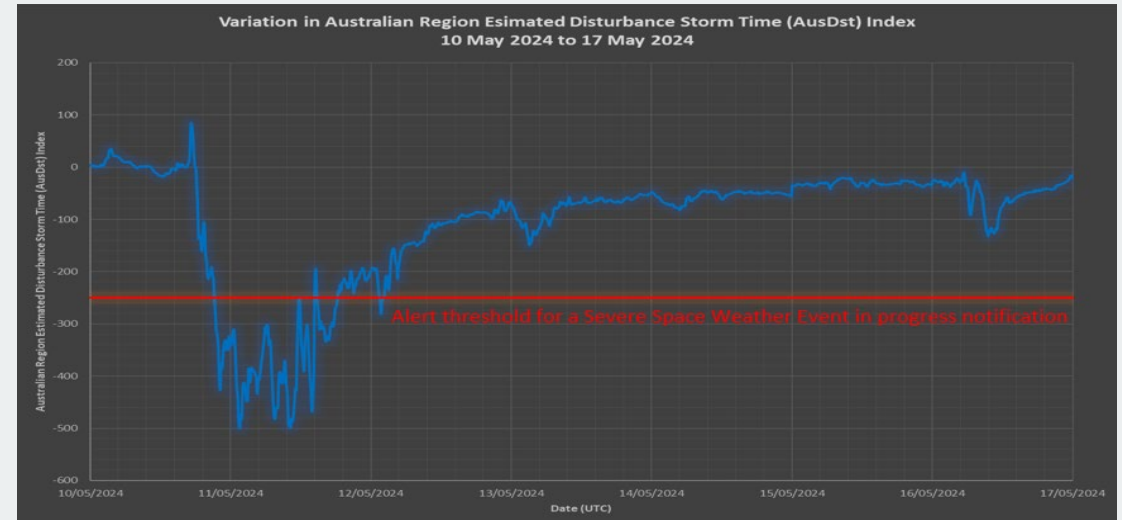
- On 8 and 9 January 2026, both GBAS sites in Australia raised a series of Constellation Alerts.
- Constellation Alerts are raised when the GBAS ground station detects that the current constellation geometry cannot support a precision approach service.
- Pseudo-range corrections not being broadcast for several satellites that were in view at the time.
- Resulted in significant inflation to the VPL above the VAL, over multiple time periods. As Continuity of Service could not be assured, the GBAS at both sites were removed from service.
- Both GBAS sites re-commenced broadcasting pseudo-range corrections for all satellites in view from 10 January with a corresponding reduction in the VPL.
- Both GBAS sites were returned to service after a 24 hour period of no VPL exceeding VAL events.
- Currently under investigation with the manufacturer.



# 6. OPERATIONAL EXPERIENCE (5 OF 5)

## SEVERE SPACE WEATHER EVENTS

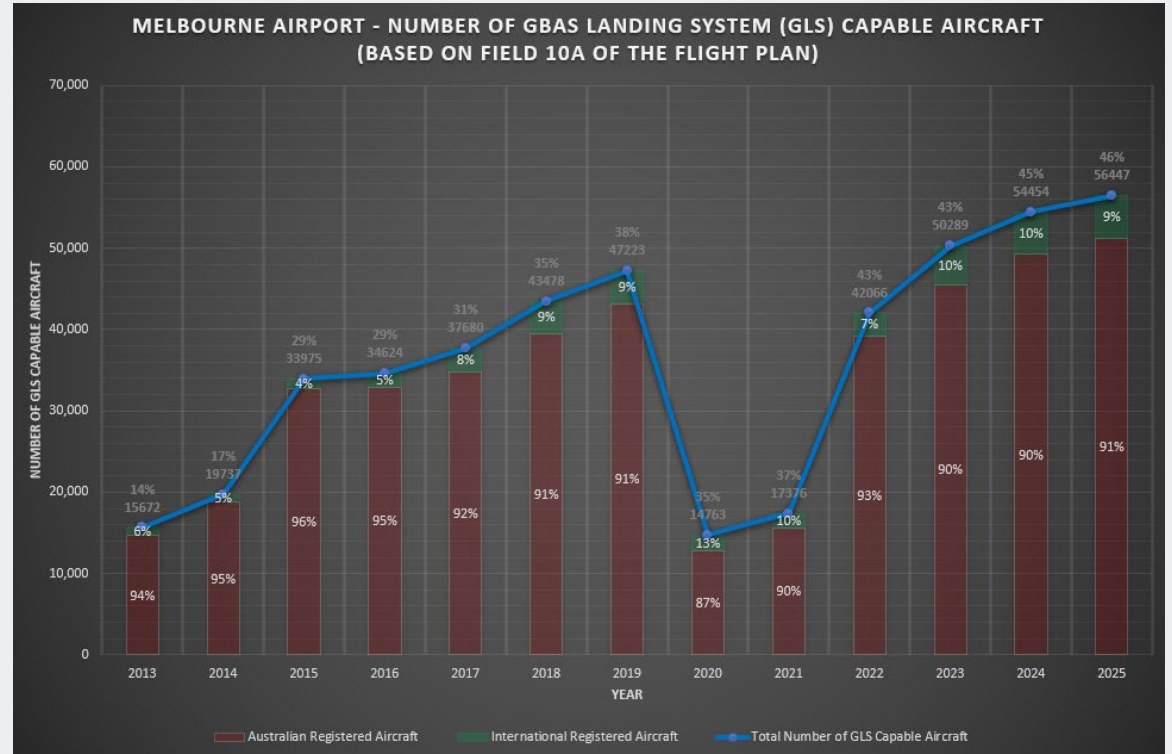
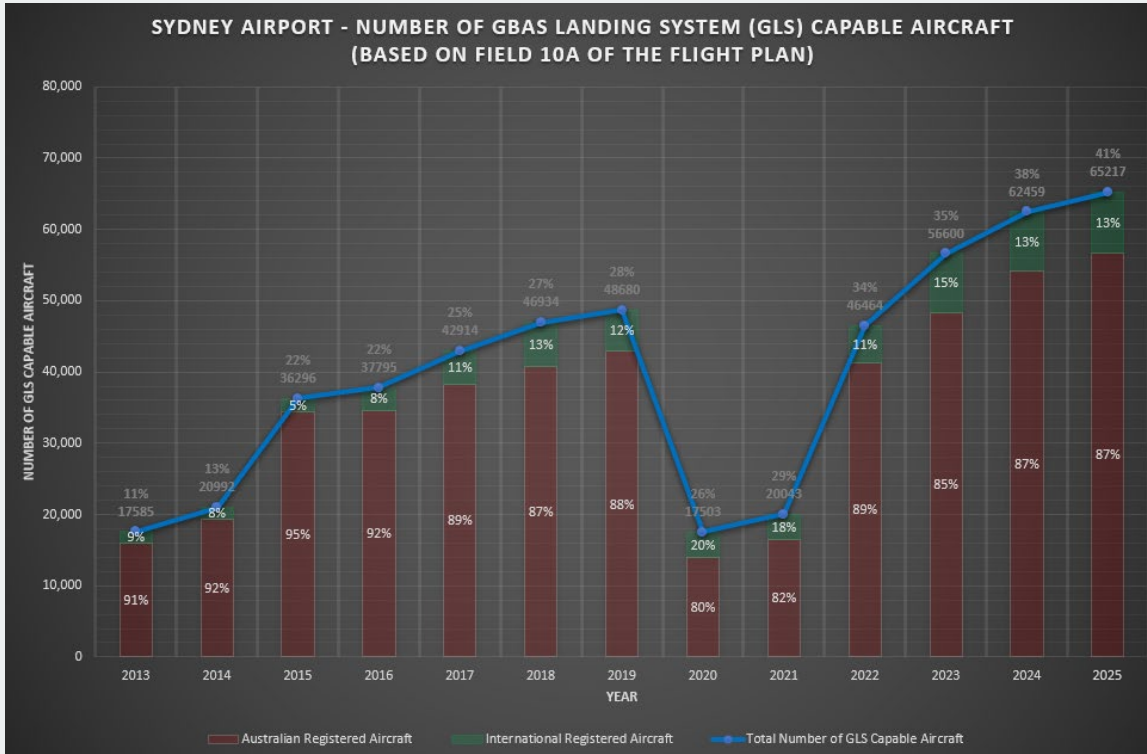
- Increased number of severe space weather events in the preceding two-year period
- During all these severe space weather events, the GBAS ground station continued to operate normally
- Observable increase in the number of code-carrier divergence events on the GBAS ground station resulting in the short-term exclusion of a satellite
- In most instances the VPL did not exceed the VAL even with the short-term exclusion of a satellite
- With the increase in severe space weather events, Australia undertook a study to validate that the existing Ionosphere Threat Model continues to bound the worst-case anomalous ionosphere gradients
- Study concluded magnitude of anomalous ionosphere gradients continues to fall well within the bounds of the Ionosphere Threat Model
- Continuous ionosphere gradient monitoring



## 7. FLEET EQUIPAGE

# 7. FLEET EQUIPAGE (1 OF 1)

## FLIGHT PLAN ANALYSIS



# Questions