Air Traffic Management

A Strategic Plan for Australia

VOLUME 3: Communication, Navigation and Surveillance

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Australian ATM Strategic Plan

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Executive Summary

The third volume of the Australian ATM Strategic Plan addresses the Communication, Navigation and Surveillance (CNS) infrastructure plans required to support the future ATM system. It sets out the agreed requirements of the ATM system upon the infrastructure, explores candidate technologies, identifies the appropriate mix of systems, and describes a transitional strategy for the evolution of the infrastructure over the next fifteen years. The CNS plan includes all the civil and joint civil-military CNS systems used on Australian territory, in airspace administered by Australia and onboard Australian aircraft.

An increasing expectation of system performance, and particularly safety, encourages the evolution of the infrastructure towards new technology. Australian ATM currently makes extensive use of ground based direction finding technology for navigation and voice position reports for surveillance, which significantly limit the performance of the system. Balancing the demand for new systems is the considerable investment in the current ground and airborne infrastructure.

The future infrastructure will need to employ a mix of cooperative technologies and for this reason the communication, navigation and surveillance systems should not be considered in isolation. As an example, Automatic Dependent Surveillance relies heavily upon the navigation infrastructure. In selecting CNS systems, Australia must also note global and regional trends, and be cautious of adopting unique technologies or retaining legacy systems that will not be supported by manufacturers or other States in the longer term.

Major changes detailed in this plan include an increased use of satellite and datalink technologies and the decommissioning of some of Australia's older systems. The plan also addresses the need for research and development programs to foster the introduction of the new technologies to the Australian ATM system.

The CNS Plan is critical to the ATM Mission of ensuring a safe, economic and efficient ATM system that accommodates demand, is globally interoperable, environmentally sustainable and satisfies national interests including defence and security. It will also provide ATM stakeholders with timely notification of expected changes to Australia's CNS infrastructure.

'Intentionally Blank'

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CHAPTER 1:
Introduction

Australian ATM Strategic Plan

1.1 Introduction

1.1.1 Background

The underlying Communication, Navigation and Surveillance (CNS) infrastructure is an essential pre-requisite for the introduction of any new ATM initiative, and forward CNS planning is necessary to ensure that the ATM system can deliver services when they are required. CNS provides the capability options for ATM and it is the technological developments of the mid 20th Century, such as radio-telephony, radar, and the radio-compass that have set many of the requirements for airspace design, operational procedure and service provision around the world.

Australia's CNS infrastructure for aviation has evolved gradually as new technology enables new applications to meet new demands. The last decade has seen major changes to our navigational infrastructure, with VLF Omega and domestic DME(A) being decommissioned, and various GNSS technologies being introduced. At the same time, new datalink communication and surveillance technologies such as CPDLC, ADS and ACAS have become increasingly integral to the safety, economy and efficiency of operations.

In recent years CNS/ATM planning between service providers and airspace users has seen a variety of technologies and niche services introduced that are not necessarily beneficial or available to all stakeholders. The need to identify harmonised outcomes for the wider ATM community has been recognised and the collaborative nature of the ATM planning undertaken by the Australian Strategic ATM Group (ASTRA) contrasts starkly with past approaches.

This is the first CNS Plan to be published by ASTRA and has been produced by the combined efforts of the civil and military representatives from a variety of Australian airspace user, service provider and regulatory organisations. This process and the resultant plan represent a major milestone in defining Australia's future CNS/ATM system.

1.1.2 Purpose

The CNS Plan is intended to coordinate the future implementation of communication, navigation and surveillance systems across government, industry and the wider ATM community. It sets out the agreed strategic direction of the signatory stakeholders and will be reviewed and updated on a biennial basis.

1.1.3 Scope

The nature of technology development limits the accuracy of any implementation schedule. For this reason the plan, while nominally looking forward fifteen years, attempts to identify the changes to CNS infrastructure that will occur in the near-term, medium-term and far-term.

Near-term changes can be expected to be accurate as they represent changes currently being implemented or at an advanced stage of planning. Conversely, far-term changes may be based on identified trends or developmental technology and may be considered more speculative in nature, but still providing guidance as to the return of service that might be expected from new technology. While some ATM planning extends out to a 30-year horizon, it is considered impractical to attempt to define the technological base far beyond a 15-year time frame.

This plan covers the civil and joint civil-military communication, navigation and surveillance systems used on Australian territory, in airspace administered by Australia and onboard Australian aircraft. It does not cover systems that are used exclusively for military purposes.

1.1.4 Objectives

Specific objectives of the CNS Plan are to:

- Identify the CNS systems required to ensure a safe, economic and efficient ATM system that accommodates demand, is globally interoperable, environmentally sustainable and satisfies national interests including defence and security.
- Provide ATM stakeholders with timely notification of expected changes to CNS infrastructure.
- Provide guidance in the selection and introduction of new CNS ground and airborne systems.
- Provide guidance in the retention or removal of existing CNS systems.

1.1.5 Provision of Services

Under the Civil Aviation Act 1988, the Civil Aviation Safety Authority (CASA) has the responsibility to regulate air traffic, aeronautical telecommunication and aeronautical radionavigation services and facilities. Parts 171 and 172 of the Civil Aviation Safety Regulations 1998 regulate the provision, operation and maintenance of these services when provided by a person or organisation other than the Australian Defence Force.

Under the Air Services Act 1995, Airservices Australia is responsible for providing facilities to permit safe navigation of aircraft within Australian administered airspace, and for the provision of air traffic, aeronautical telecommunication and aeronautical radionavigation services for the purpose of giving effect to the Chicago Convention or otherwise for purposes relating to the safety, regularity or efficiency of air navigation.

While some CNS systems are used in Australia for applications other than air traffic, aeronautical telecommunications or radionavigation services, Airservices Australia and the Department of Defence manage the great majority of Australia's ground-based CNS infrastructure.

CHAPTER 2:
Communication

2.1 Communication Requirements

2.1.1 Operational

ASTRA has developed the following operational goals for future communication infrastructure capability to assist with identifying any need for change:

- Allow aircraft to operate within Australian airspace, at least to that level of individual system performance currently possible;
- Be capable of providing communication services, such that present levels of safety are maintained or exceeded;
- Enable operations at lesser individual system performance, without penalty, to those operators defined by CASA, Airservices Australia, or other authority;
- Harmonise operations through integration of systems and regional CNS infrastructure;
- Provide aeronautical information to all airspace users;
- Be capable of supporting future Air Traffic Services (ATS):
  - providing clear, timely air-air and air-ground voice communications with coverage commensurate with the operations conducted in the area;
  - meeting en-route terminal and specialist communication requirements, such as long haul flexible routes and Precision Runway Monitoring (PRM) operations;
- Be capable of supporting non-ATS communication services:
  - dissemination of operational information such as Weather;
  - air-air communications outside controlled airspace;
  - unicom and company communication; and
  - airport Services – Fuel etc.

2.1.2 Technical

It is useful to characterise Communication technical performance using a number of measures. Coverage is the prime characteristic but service availability, continuity and integrity are also important characteristics. The required level of performance from a system is determined by the service the system is supporting. For example, a loss of voice communication continuity for two minutes would have little consequence to oceanic operations but the same two minutes loss in a terminal area could easily impact safety.

Coverage

Coverage is the volume of airspace in which the communications service can be expected to provide communication.

Availability

Availability may be defined as the proportion of time the services of a communication system are accessible. It is a function of both the physical characteristics of the environment and the technical capabilities of the transmitter and receiver facilities.

Continuity

Continuity of service is the ability of the communication system to continue to perform its function for the duration of an intended operation. Continuity is critical whenever reliance on a particular system is high, such as during an ATC monitored Precision Approach operation.

Integrity

Integrity is a measure of the communications systems ability to correctly detect and notify when a message passed through the system has not been delivered free of corruption. Voice communication systems do not have any integrity check mechanism. The check is performed by the humans that use the communication link in the form of read-back. An integrity check is not always required and many non-critical messages are passed without read-back; in this case the risk of communication error is accepted.

Interference

Interference, both intentional and unintentional, is an increasing problem to the communication systems. Consideration of communications performance in the face of interference is of increasing importance.

2.1.3 Economic

When infrastructure changes are required, the timing and number of transitions must be balanced to gain the greatest economic benefit from new technology without undue economic burden from overly frequent upgrading and retraining. The support of dual systems during transition is a considerable cost and the duration of transition must be managed to ensure that this cost is minimised.

Economic requirements for planning future infrastructure include the need to conduct cost-benefit analysis from both individual stakeholder and whole of industry perspectives.

2.1.4 Institutional

The institutional arrangements governing air navigation services in Australia involve several government agencies. The Department of Transport and Regional Services provides the governmental policy framework for Civil Aviation. Air Traffic Services provided by Airservices Australia are regulated by CASA. Defence communication issues are strongly coordinated with the civil framework but are dealt with separately by the Department of Defence, a provider and user of communication services in its own right. Radio spectrum policy is defined within the government through the Australian Communications Authority.

Coordination of these organisations is critical to the provision of air traffic services in Australia. It is intended that this CNS Plan will provide a basis for the future coordination of the stakeholders responsible for the provision of the infrastructure.

2.1.5 International

As a signatory to the Chicago Convention, Australia has agreed to abide by ICAO Standards and Recommended Practices. The various systems will need to meet the Australian operational requirement and be consistent with and have a performance not less than the ICAO technical standard.

Global and regional interoperability is a key component of Australia's strategic mission for ATM. As such, Australia will continue to plan and deploy systems consistent with the ICAO Global and Regional plans.

2.2 Selection of Communication Systems

Communication infrastructure, both voice and datalink, is used for air-ground, air-air and ground-ground communication. Communication systems are also used as a bearer to support navigation, surveillance and datalinks. As such, the selection of communication systems cannot be made in the absence of defined navigation and surveillance requirements.

2.2.1 Candidate Systems

Various candidate communication technologies have been considered in determining the future composition of the Australian CNS infrastructure. A short description of the various voice and datalink technologies follows.

2.2.1.1 Voice Communications Systems

Voice communication has been the mainstay of aviation communications. This will continue along side a rapidly growing use of datalink communications.

Very High Frequency (VHF) Voice

VHF voice communication is the most common radio communications system and is fitted to almost all aircraft. VHF communication provides clear, high quality, line of sight communication and is the prime voice communication medium for ATS and many other services. Modern VHF radios are small, inexpensive and reliable. VHF coverage for ATS purposes is provided down to 10,000ft over most of the Australian mainland, down to lower levels in higher traffic density airspace and down to the ground at regional and major aerodromes.

Ultra High Frequency (UHF) Voice

UHF communications has similar characteristics to VHF and is considered a variant specific to military and other specialised operations. UHF voice is not commonly used in civil ATM and is therefore not included in this CNS Plan.

High Frequency (HF) Voice

HF voice communication is employed where aircraft operations are conducted outside VHF coverage; typically oceanic and low level transcontinental. HF communications are more susceptible to signal propagation variation, interference and noise than VHF. Communication by HF is often operator intensive and hence controllers usually use radio operators to pass messages to and from aircraft. This limits the timeliness of HF communication.

Satellite Telephone

Satellite Telephone has the potential to offer low cost, high quality communications. The need to dial and establish the telephone connection limits the timeliness of access. The probability of establishing a call needs to be considered when considering using this technology to support a service. Satellite telephone holds promise as an alternative to HF voice in certain applications.

2.2.1.2 Datalink Communications Systems

The use of datalink communication in aviation is rapidly growing. Initial use was for specialised applications such as:

- aircraft operations management and engineering support purposes;
- ATM Separation Services with Controller/Pilot communications (CPDLC), Surveillance (ADS-C);
- Clearance Delivery (PDC); and
- TCAS co-ordination – Mode S datalink.

FANS-1/A

FANS-1/A systems are currently in service with a number of airspace users and ATM service providers. CPDLC and ADS-C applications in the Brisbane and Melbourne FIRS are based on FANS-1/A protocols using satellite and VHF datalinks.

Aeronautical Telecommunications Network (ATN)

The ATN is the ICAO generalised datalink network. ATN is envisaged to be a general-purpose network connecting ground and airborne nodes. The ATN would route messages between any nodes using underlying datalinks. ATN will support carriage of a wide variety of ground-air communications (such as CPDLC) and ground-ground communications (AMHS).

The underlying communications link used to deliver any given data packet will vary and is not necessarily know to the user. Currently, VHF and Satellite links are used; VHF is preferred when available due to lower cost and satellite is used outside VHF coverage.

ATN will not meet the requirements of some highly tactical applications, such as TCAS co-ordination, ADS-B and GNSS augmentation

Service Provider Datalink Communications (SPDL)

There are a number of third-party service provider organisations that offer worldwide datalink communication services to the aviation industry. These services can be used to support datalink communication between any two subscribers.

VHF Datalink

VHF is a line of sight system that can support the exchange of digital data air to air and air to ground. VHF datalink can be used to support specialised applications such as GNSS augmentation and generalised datalink as a bearer of the ATN.

Satellite Datalink

Satellite datalink communication has global coverage with the exception of the far polar regions. Polar orbiting satellites are being developed to address the polar coverage issue. Although satellite datalink is more expensive than VHF datalink, the introduction of spot-beams on satellites can reduce the cost of satellite communications.

Mode S Datalink

Mode S provides high bandwidth, line-of-sight datalink communications. Typical uses include the read-out of aircraft parameters, tactical datalink to support applications such as TCAS, and generalised datalink communications as a bearer of the ATN. Mode S is traditionally associated with classical rotating radar antennas although it can also be used with omni-directional antennas, for example ADS-B.

HF Datalink

HF can provide datalink communications, although the bandwidth and timeliness of message delivery make HF datalink viable only for specialist applications where other datalinks are not suitable. For example, HF is used in far polar regions where satellite and VHF coverage is poor.

2.2.2 Considerations

Technical Audit and Cost-Benefit Analysis

The ATM Strategic plan indicates that the following services will be required over the next fifteen years:

- ATC separation service – En-route, Terminal Area, Aerodrome and Surface;
- Precision Runway Monitor service;
- ATS directed traffic information;
- Airways Clearance Delivery;
- Air-air self separation communications;
- Broadcast of automatic information systems – ATIS, AERIS, VOLMET;
- In-flight Emergency Response;
- Search and Rescue communications;
- Hazard alerting services;
- Intra Company communications; and
- Ancillary services – fuel service.

This does not represent a significant change from the existing communication requirements. Changes to voice communication infrastructure are therefore likely to be based on service improvements.

The need for civil HF voice communications will decline as automated datalink communications become more widespread. Datalink communication can be expected to grow rapidly to provide improvement to existing communication services and support new surveillance services.

Stakeholder Plans

The CNS Plan will provide timely notification of agreed changes to infrastructure, allowing stakeholders to align their own plans with those of the Australian ATM community.

However, existing infrastructure and current stakeholder plans must be harmonised with this CNS Plan to minimise the impact of short-term change. Time to equip and return of service considerations dictate that a reasonable period of overlap between the introduction of new systems and decommissioning of legacy systems should be included in the transition strategy.

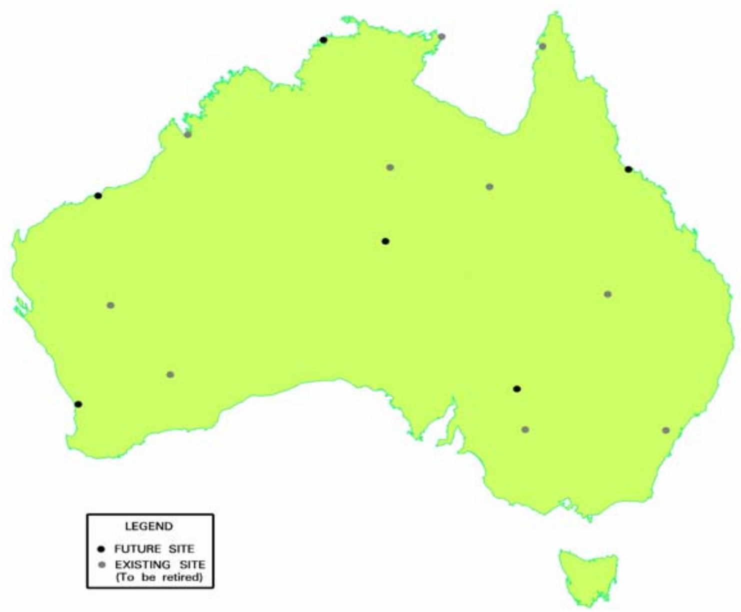
2.3 Communication Plan

2.3.1 The Present

The current Australian communication infrastructure provides VHF voice coverage down to 10,000 feet over the bulk of the country, extensive coverage at lower levels in the higher traffic density areas and coverage to the ground at regional and capital city airports. HF is used for oceanic and continental communications outside VHF coverage. CPDLC is used on oceanic and trans-continental routes by FANS-1/A equipped aircraft. Third party datalink communications are provided with VHF and satellite links

Figure 2.1: VHF coverage across Australia

Figure 2.2: Deployment of HF stations across Australia



2.3.2 The Future

Relatively few changes to the communications infrastructure are required in the next fifteen years. The voice communications system will continue to be predominately based on VHF in continental airspace, with 25KHz channel spacing to accommodate traffic density. HF voice will continue to be used in areas outside VHF voice coverage and in certain areas UHF will be used to support specialised military operations.

There will be increasing use of datalink communications such as CPDLC and PDC, AMHS and ATM datalink communication services will be introduced to eventually replace the existing FANS-1/A and AFTN systems.

Near-term changes

In the near term much of the existing VHF and HF terrestrial infrastructure will be upgraded. AMHS will be introduced as a replacement for AFTN and there will be a limited introduction of ATN on the ground to support AMHS.

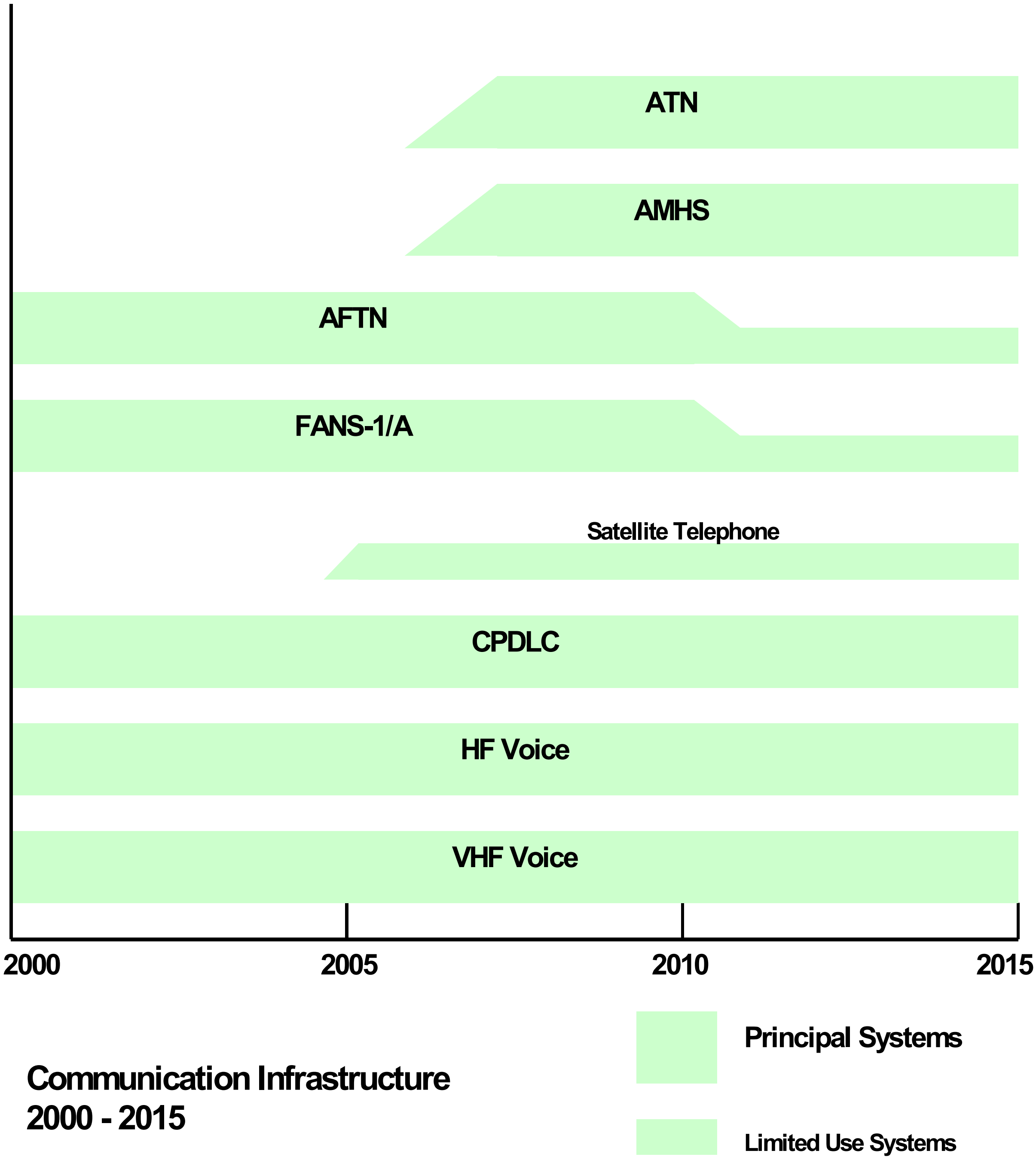
Medium-term changes

Medium Term changes include the widespread introduction of ATN and the introduction of Satellite Telephone in limited applications, such as SARwatch.

Far-term changes

Far Term changes may include the automatic datalink of weather to and from suitably equipped aircraft.

Figure 2.3: Indicative Transition Schedule for Communication Infrastructure



CHAPTER 3:
Navigation

3.1 Navigation Requirements

3.1.1 Operational

In order to analyse the potential of the various navigation systems available, it is necessary to define Australia's operational requirements for the future. Through stakeholder consultation, ASTRA has developed the following goals for future navigation infrastructure capability:

- Allow aircraft to operate within Australian airspace, at least to that level of individual system performance currently possible;
- Be capable of providing navigation services, such that present levels of safety are maintained or exceeded;
- Enable operations at lesser individual system performance, without penalty, to those operators defined by CASA, Airservices Australia, or other authority;
- Harmonise operations through integration of systems and regional CNS infrastructure;
- Be capable of supporting en-route and terminal area navigation requirements;
- Be capable of providing approach navigation guidance, to non-precision minima, at any location within Australian airspace and dependent Australian territories; and
- Be capable of providing or supporting approach navigation guidance, to precision minima, at any major aerodrome within Australian airspace and dependent Australian territories.

Apart from purely navigational purposes, position determination is also critical to the surveillance requirements of Air Traffic Services, Operator Flight Following, Search and Rescue (SAR) and other aircraft equipment such as Enhanced Ground Proximity Warning System (EGPWS). Operational demands will differ between operators and the rules that apply to the particular application.

3.1.2 Technical

Navigation technical performance may be measured in a number of ways. While accuracy is the most obvious quality of a navigation system, other measures such as data integrity, continuity of service, system availability and vulnerability to interference are also important.

Australia has adopted ICAO standards and recommended practices for navigation system performance. The actual accuracy, integrity, availability and continuity required of each system will therefore be that needed to meet the operational requirement, but not less than the relevant ICAO technical standard.

Accuracy

Accuracy is the measure of the precision of the navigation solution. ICAO Standards specify the accuracy requirements for each navigation system and according to the phase of flight (en-route, terminal, approach or departure).

Integrity

The concept of integrity includes both a failure to alarm and a false alarm. In general, integrity is the ability of a system to provide correct timely warnings to the user when the equipment is unreliable for navigation purposes. For some systems the term 'integrity' has a more specific definition.

Availability

Availability may be defined as the percentage of time the services of a navigation system are accessible. It is a function of both the physical characteristics of the environment and the technical capabilities of the transmitter facilities.

Continuity

Continuity of service is the ability of the total navigation system to continue to perform its function during the intended operation. Continuity is critical whenever reliance on a particular system is high, such as during an instrument approach procedure.

Vulnerability

Vulnerability is a qualitative measure of the susceptibility of a navigation system to both unintentional and deliberate interference. All radio-navigation systems have vulnerabilities and the effect of thunderstorms on ADF equipment is a well-known example.

3.1.3 Economic

Economic requirements for planning future infrastructure include the need to conduct cost-benefit analysis from both individual stakeholder and whole of industry perspectives.

Transition scheduling must be balanced to gain the greatest economic benefit from new technology without undue economic burden from upgrading and retraining. The need for a period of overlap of both old and new systems constitutes a considerable cost and transition must be managed to ensure that the cost of legacy infrastructure is minimised.

3.1.4 Institutional

The institutional arrangements governing air navigation services in Australia follow a three-tier model. Overall policy is defined within the government through the Department of Transport and Regional Services, safety regulation is the responsibility of CASA and the services themselves are provided by Airservices Australia. Defence navigation issues are strongly coordinated with the civil framework but are dealt with separately by the Department of Defence under the authority of the Defence *Act*. Coordination of these four organisations is critical to the provision of air navigation services in Australia.

Many satellite navigation systems are provided by organisations outside of Australia. In using these systems, appropriate consideration must be given to legal and sovereignty issues as well as those of a technical nature.

Other institutional issues pertinent to the navigation infrastructure include the management of the signal spectrum and the role of the private sector in the provision of navigation aids. This CNS Plan is the basis for the future coordination of the stakeholders responsible for the provision of the navigation infrastructure.

3.1.5 International

Global and regional interoperability is a key component of Australia's strategic mission for ATM. As such, Australia will continue to use ICAO standards and recommended practices for navigation systems and harmonise wherever possible with global and regional planning.

In the past Australia has been a leader in the development and adoption of new navigation systems and procedures, both domestically and through the ICAO standards development processes. This approach has resulted in considerable early and ongoing benefits to Australian and international stakeholders. While there is a need to identify trends and follow international plans, the lack of established international standards alone should not be reason to abandon the benefits of a new technology. Rather, Australia should continue to develop its CNS infrastructure in parallel with its participation in ICAO.

3.2 Selection of Navigation Systems

3.2.1 General

The selection of navigation systems for the future is based not only on the suitability of candidate systems in terms of operational, technical, economic, institutional and international requirements, but also on implementation factors such as cost-benefit analysis of change from the present infrastructure and specific stakeholder goals.

3.2.2 Candidate Systems

A number of candidate navigation technologies have been considered in determining the future composition of the Australian CNS infrastructure. A short description of each system follows.

Non-Directional Beacon (NDB)

NDBs are non-directional radio transmitting stations that operate in the low and medium frequency bands to provide ground wave signals to a receiver. Typical operational ranges are between 15NM and 200NM. The system comprises a simple ground beacon (the NDB) that radiates an omni-directional continuous signal coded with an identification sequence. The signal can be detected with Automatic Direction Finding (ADF) equipment, carried onboard the aircraft. The ADF indicates to the pilot the direction of the beacon relative to the aircraft's longitudinal axis. A low powered NDB, known as a Locator, is sometimes sited on the extended centreline of a runway to assist with approach navigation.

Very High Frequency Omni-Directional Radio Range (VOR)

VOR provides continuous measurement of the beacon bearing in degrees. The system comprises a ground beacon that transmits two signals: one is a reference signal and the other is a signal that varies signal phase with azimuth. The reference phase is frequency modulated while the variable phase is amplitude modulated. The receiver detects the two signals and computes the azimuth from the relative phase difference. VORs are characterised by unlimited capacity (in terms of the number of aircraft that can use the system at the same time) and moderate range, from 60NM below 5,000ft up to 180NM above 20,000ft.

Distance Measuring Equipment (DME)

DME is an interrogator-transponder system, the aircraft carrying the interrogator and the transponder being part of the ground installation. The airborne receiver determines the range to the DME beacon (slant range) by measuring the time between transmission and reception of a pulse pair. Some aircraft equipment can also compute ground speed and time-to-station. DME ground stations can only handle a limited number of aircraft interrogations at one time, but ICAO standards require a capability of at least 100 aircraft per ground station. Like VOR,

DME is a line-of-sight system and it is usual but not exclusive practice to co-locate DMEs and VORs to form a combined VOR/DME station.

Tactical Aid to Navigation (TACAN)

TACAN is a military system that provides both bearing and distance from the ground station, in a similar manner to a combined VOR/DME station. TACAN is interoperable with civilian DME equipment for distance measuring applications, but azimuth information can only be received by TACAN-equipped aircraft.

Instrument Landing System (ILS)

ILS is a precision approach navigation system. It comprises a Localizer (LLZ), which provides a track aligned with the runway centreline, a Glidepath which provides vertical path guidance for descent to the runway, and means to determine the distance along the approach, either by marker beacons, Locators, DME or GPS. ILS installations may have different capability levels governing the category of weather in which aircraft may continue to operate. While some of the existing equipment is capable of meeting Category II requirements, there are no ILS installations in Australia authorised for use below Category I minima.

Microwave Landing System (MLS)

MLS is a precision approach navigation system that uses a time-referenced scanning beam to provide azimuth and elevation data. Intended as a replacement to ILS, the MLS overcomes many of the limitations of the older system and introduces new capability, such as the potential for curved approach paths.

Transponder Landing System (TLS)

TLS, and its transportable variant TTLS, are precision approach navigation systems that use a discrete transponder code transmitted by an aircraft to provide path guidance. The ground station interrogates the standard ATC transponder to determine the position and altitude of the aircraft. The TLS then transmits a signal via an ILS channel to provide horizontal and vertical guidance to touchdown.

Loran-C

Loran-C transmitters are organised into chains of 3 to 5 stations and the sequence of signal transmissions consists of a pulse group from the Master station followed at precise time intervals by pulse groups from the secondary stations. The Loran-C navigation signal is a sequence of brief radio frequency pulses on a carrier wave and the basic measurements made by Loran-C receivers are to determine the difference in time-of-arrival between the master signal and the signals from each of the secondary stations of a chain. Loran-C is used in the USA as an en-route supplemental air navigation system for both Instrument Flight Rules (IFR) and Visual Flight Rules (VFR) operations although current Loran-C receivers do not support instrument approach operations.

Inertial Navigation System (INS) and Inertial Reference System (IRS)

Inertial navigation is a technique for determining the host aircraft's position, orientation and velocity by measuring and integrating acceleration and angular rotation. Early inertial systems used gimbal gyroscopes and accelerometers to measure linear acceleration and angular rate, while later systems used ring laser gyroscopes and large dynamic range accelerometers in conjunction with a computer system. A new technology known as Micro Electro-Mechanical Systems (MEMS) shows promise as an inertial navigation alternative for aircraft that are unable to accommodate the weight and bulk of the gyro-based systems. While inertial systems have some accuracy limitations, improvements are possible using a feedback voting system with multiple systems and GPS or DME updating. Because inertial systems are not dependent upon radio signals they have a high resistance to interference.

Global Navigation Satellite Systems (GNSS)

GNSS is a generic term used to identify all satellite navigation systems where the user performs onboard position determination from satellite information. GNSS is a core component of ICAO's global plans for CNS/ATM systems and Australia has been a leader in the operational approval of GNSS.

The issue of GNSS vulnerability has become prominent because of early proposals to replace multiple terrestrial navigation systems with a single system (GPS). A variety of mitigation strategies have been proposed to the vulnerability risks of transitioning to a GNSS-dependent navigation infrastructure. These include augmentation systems, alternative constellations, multiple frequencies, integrated GNSS/INS receivers and retention of a backup terrestrial network. After an extensive review, ICAO's GNSS Panel has found that there are no vulnerability issues that would preclude the global transition to GNSS.

Global Positioning System (GPS)

The US Government's GPS was the first GNSS to be introduced to air navigation. GPS operation is based on the concept of ranging and triangulation from a group of satellites, which act as precise reference points. The GPS receiver mathematically determines its position using the calculated pseudo-range and position information supplied by the satellite. At least four satellites are required to produce a three-dimensional position (latitude, longitude, and altitude) and time solution. The receiver computes navigational values, such as distance and bearing to a waypoint or ground speed, by using the aircraft's known position and referencing these to a database, providing an Area Navigation (RNAV) capability.

GLONASS

GLONASS is another GNSS constellation system and is operated by the Russian Federation. It shares the same principles of data transmission and positioning methods that are used in GPS and is also based on a constellation of orbiting satellites and a ground control segment. The fully deployed constellation is composed of 24 satellites, although it is currently operating in a degraded mode with only eight satellites fully operational. Work is underway to modernize the system and launch additional satellites.

Galileo

Galileo is likely to be the third GNSS constellation approved for aviation use and is an initiative of the European Union. It is based on a constellation of 30 satellites supported by ground stations and will provide positioning data in a similar way to GPS and GLONASS. Presently in its development phase, Galileo is planned to achieve initial operating capability in 2008.

Aircraft Based Augmentation Systems (ABAS)

A number of augmentation systems have been developed to overcome performance limitations of the GNSS constellations. Aircraft-based augmentation is achieved by features of the onboard equipment designed to resolve integrity deficiencies. Operational approvals for the use of GPS in IFR navigation require aircraft based augmentation, such as Receiver Autonomous Integrity Monitoring (RAIM) and inertial aiding, to ensure adequate performance.

Satellite Based Augmentation System (SBAS)

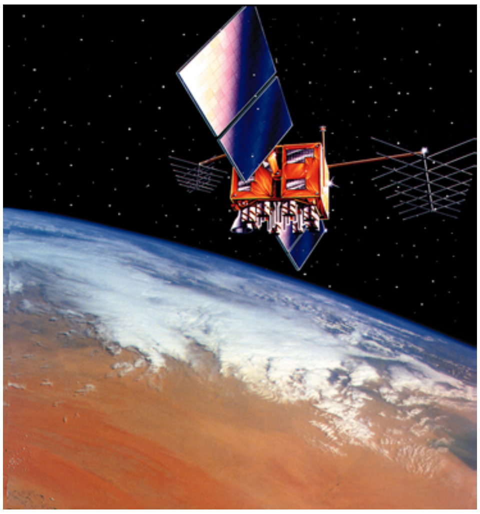
Satellite-based augmentation seeks to provide comprehensive performance improvements through the provision of ranging, integrity and differential correction signals to aircraft GNSS receivers from geostationary satellites. These geostationary satellites are not part of the constellations and are owned and operated by civilian organisations for civil air navigation. There are several SBAS programs in their development phases, including the Indian ‘Gagan’ programme, the European Geostationary Navigation Overlay Service (EGNOS), the Japanese MTSAT Satellite-based Augmentation System (MSAS) and the US Wide Area Augmentation System (WAAS). Each system uses a ground network of monitoring stations to measure the performance of the GPS constellation in their respective coverage areas. Present planning has these four systems being fully interoperable.

Ground Based Augmentation System (GBAS)

GBAS provides a precision approach service and provides deviation guidance for final approach and a positioning service of horizontal position, velocity and time information to support RNAV operations in terminal areas. A GBAS installation will typically provide GNSS corrections that support precision approaches to multiple runways at a single airport. In some cases, the data may be used for nearby airports and heliports as well. A number of systems are in development to provide differential corrections to the three GNSS constellations and it is likely that the US Local Area Augmentation System (LAAS) will be the first deployed operationally, with certification expected in 2005. Australia has commissioned an interim Special Category I (SCAT-1) ground station on Norfolk Island to gain some early benefits from the GBAS technology while it is in development.

Ground-based Regional Augmentation System (GRAS)

GRAS is a blending of SBAS and GBAS concepts to enhance GNSS performance. This concept is SBAS-like in using a distributed network of reference stations for monitoring GPS (or other constellations), and a central processing facility for computing integrity and differential correction information. Instead of transmitting this information to users via dedicated geostationary satellites, GRAS delivers SBAS message data to a network of terrestrial stations for a local check and reformatting. Each site broadcasts a GBAS-like data signal that can be received by the aircraft to obtain augmentation data for both en route as well as terminal area approach and departure operations. Airservices Australia is currently running a GRAS research and development project.



3.2.3 Considerations

Technical Audit and Cost-Benefit Analysis

In 1996, Airservices Australia commissioned a comprehensive technical audit and cost-benefit analysis of evolving Global Navigation Satellite System (GNSS) technology in response to ICAO's drive toward a CNS/ATM concept that was highly dependent upon satellite systems. The study also focused on the need to improve the effectiveness and efficiency of air navigation in Australia. The report of the study, released in 1997, recommended as its preferred option a combination of satellite and ground based GNSS augmentation. For a number of reasons, including risks relating to the maturity of emerging technologies at the time, the recommendations of the study were not implemented.

In early 2002, in response to maturing technologies and the identified need to produce a CNS plan as part of the Australian ATM Strategic Plan, a project to update the study was undertaken by ASTRA. Through a collaborative process, stakeholders produced an updated set of navigation requirements and amended the terms of reference to include a review of non-GNSS solutions and a 'whole-of-industry' approach to the cost-benefit analysis. The review sought to identify a preferred future air navigation/surveillance model for Australia that is technologically sound, costed, achievable, consistent with the ATM Strategic Plan, and will be supported by the Australian ATM community.

The study, undertaken on behalf of ASTRA by Booz Allen Hamilton included extensive consultation with stakeholders to identify candidate systems and the operational benefits of each. Some candidate systems were eliminated quickly from further consideration due to operational limitations and the nature of the existing Australian ground and airborne infrastructure. Others were grouped into complementary groups of systems and analysed against the requirements. The report was released in November 2002 and key findings included:

- The current infrastructure does not satisfy future requirements.
- The current system is not easily upgradeable to meet future requirements.
- The technical audit showed that no single system fully met the whole set of requirements.
- The high order cost-benefit analysis, supported by a top-level risk analysis, suggested that scenarios based on GPS in combination with other systems were the most favourable.

Positioning for the Future

In August 2002, the Deputy Prime Minister released a National Strategic Policy for GNSS, which had been developed by the Australian GNSS Coordination Committee (AGCC). Entitled *Positioning for the Future*, the policy sets out a vision for Australia to be a world leader in the multimodal application of satellite navigation. The strategic principles on which work towards this vision will be based are:

- National Coverage;
- Safety;
- Efficiency, Economic and Social Benefits;
- Industry Development;
- Flexibility of Policy and Strategy;
- Standards;
- Environmental Benefits; and
- National Security.

The policy states that the Commonwealth Government will work cooperatively with the private sector to maximise the economic, social and environmental benefits of an integrated GNSS-related infrastructure that will:

- Enhance public safety;
- Facilitate the development and use of present and future applications of GNSS;
- Facilitate the use of GNSS services across multiple modes and applications and its integration with other technologies;
- Accommodate present and future demand for GNSS-related functionality;
- Be domestically and globally interoperable;
- Contribute to environmentally sustainable outcomes; and
- Be compatible with national security requirements.

This CNS Plan is aligned with the Government's policy and details how that policy will be implemented in the future ATM system.

Stakeholder Plans

Existing stakeholder infrastructure and plans must be harmonised with this CNS Plan to minimise the impact of short-term change. Time to equip and return of service considerations dictate that a reasonable period of overlap between the introduction of new systems and decommissioning of legacy systems should be included in the transition strategy.

Area Navigation (RNAV) and Required Navigation Performance (RNP)

Area Navigation (RNAV) is a method of navigation that permits aircraft operation on any desired course. RNAV does not require a track directly to or from any specific radio navigation aid, and was developed to provide more lateral freedom and more efficient use of available airspace. VOR/DME, DME/DME, Loran-C, GNSS, INS or IRS equipment can provide RNAV capabilities.

RNAV allows a route structure to be organized between any two locations to reduce flight distance and the tolerances used for traffic separation. It permits aircraft to be flown in terminal areas on structured paths that expedite traffic flow and, depending upon the capability of the navigation system, to conduct instrument approaches at aerodromes without ground landing aids. RNAV is used widely around the world, particularly in areas without an extensive network of ground aids. RNAV is a pre-requisite to the implementation of User-Preferred Trajectory (UPT).

Very few aircraft are fitted with just one navigation system and manufacturers often choose systems that complement each other to provide the best navigation solution for a range of applications. DME updating of INS has been standard equipment for many years and a number of products are now available that integrate GNSS and inertial reference data. In the past these systems have been practical only for long-haul aircraft, but technological advances mean that similar products will become available for light aircraft during the 15-year horizon of this plan.

In developing the application of RNAV, ICAO has introduced the concept of Required Navigation Performance (RNP), which focuses upon the navigation performance of the aircraft at the time of the operation in addition to the certificated performance of the component systems. Australia has introduced non-exclusive RNP airspace throughout the Australian FIRs. RNP10 is currently used in oceanic areas for reduced separation minima and it is expected that RNP4 and lower RNP types will be introduced in coming years to accommodate demand in continental en-route and approach operations.

Circling Approaches

Visual circling approaches are often used to align an aircraft with the landing runway and are commonly used with Non-precision Approaches (NPA) based on terrestrial navigation aids. Controlled Flight into Terrain (CFIT) during this procedure is a recognised hazard due to the proximity of terrain, manoeuvring requirements and associated weather conditions. Indications are that a straight-in approach to the runway from the instrument procedure is up to 25 times safer than a circling approach.

The location of terrestrial navaids is based upon a number of factors and the ability to provide runway-aligned approaches may be sacrificed in the interests of signal coverage, site accessibility or other demands. Even when a terrestrial azimuth-based installation is able to provide a runway-aligned approach, it is unlikely to serve all runways. Because they are not dependent upon a track to a navaid, RNAV-based approaches offer much greater flexibility and Australia has published more than 300 runway aligned GPS NPAs to date.

3.3 Navigation Plan

3.3.1 The Present

The current Australian Navigation infrastructure makes extensive use of terrestrial navaids. There are currently 282 NDB, 93 VOR, 75 DME, 10 TACAN and 35 ILS installations in Australia.

Much of Australia's current air navigation infrastructure has been developed over a long period to support requirements that were in some cases established up to 40 years ago. This infrastructure has a limited capacity to support current and future performance requirements. A specific conclusion reached by Booz Allen Hamilton on the limited performance of the current air navigation system was related to the great reliance currently placed on NDB, an aid that cannot support area navigation.

IFR operations, while now using GNSS extensively, still rely upon the provision of a terrestrial network to provide the necessary alternate aerodromes in the event of a satellite fault. This is largely due to the design of TSO-C129 generation GPS receivers that are unable to exclude a detected faulty satellite from the navigation solution.

Figure 3.1: Deployment of NDB across Australia

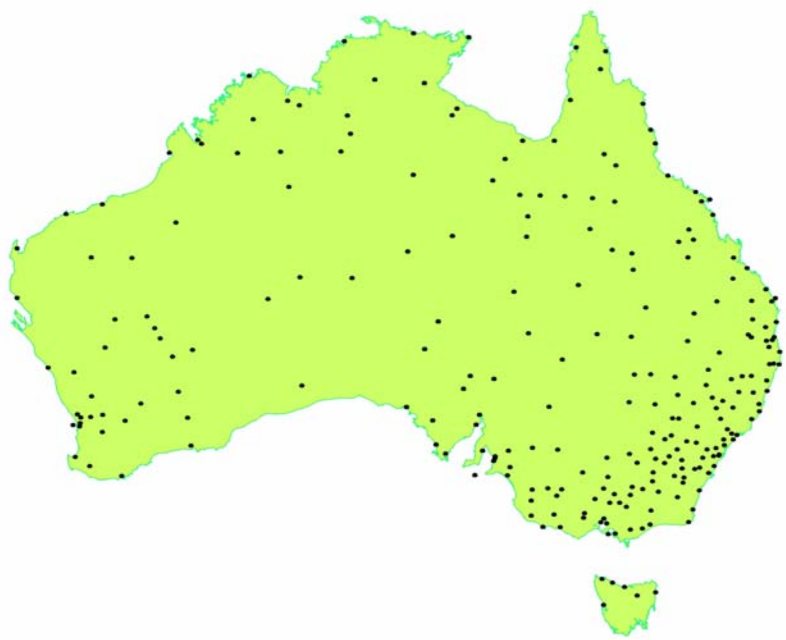


Figure 3.2 - Deployment of VOR and ILS across Australia

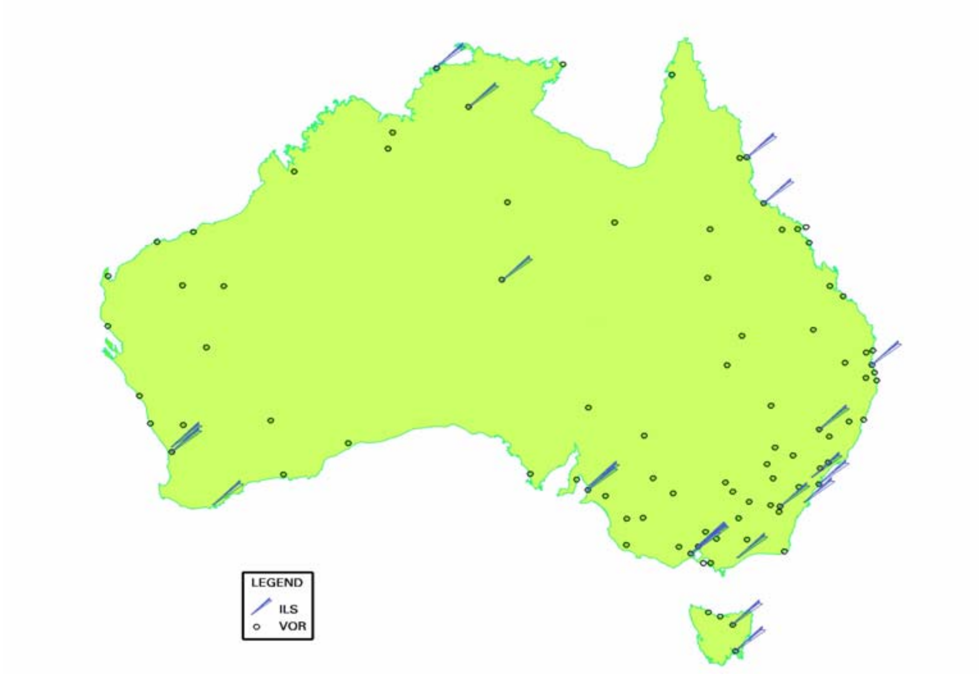
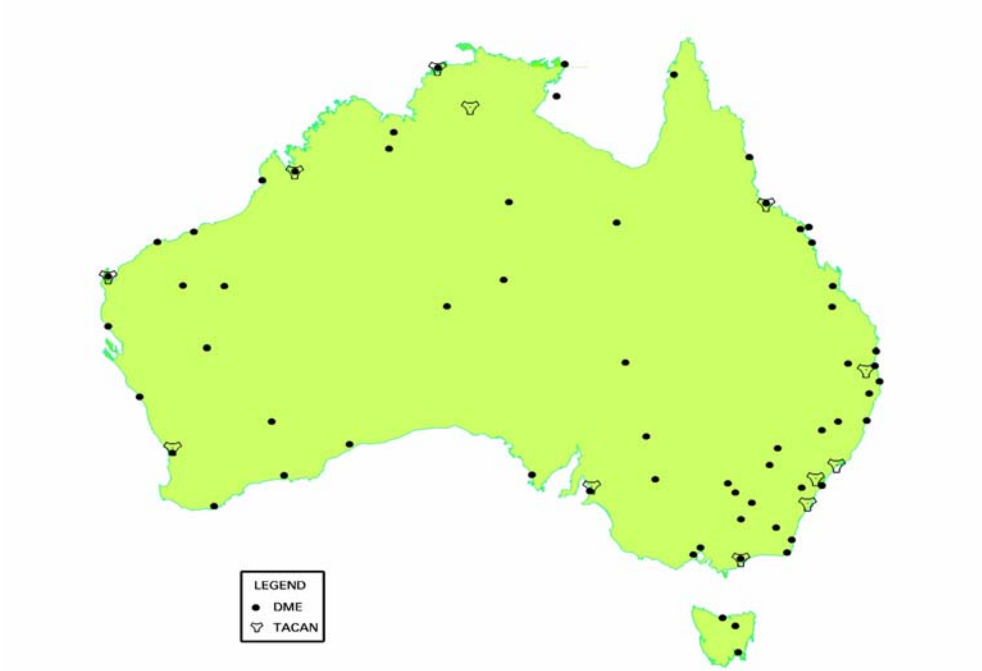


Figure 3.3 - Deployment of DME and TACAN across Australia



3.3.2 The Future

In ten to fifteen years time the Australian navigation infrastructure will be based upon GNSS, Inertial and the ILS navigation systems, with a backup network of terrestrial navaids to meet contingency requirements. This approach is similar to the direction taken by the US and consistent with ICAO plans for the Asia Pacific Region.

Near-term changes

The new TSO-C145 and C146 generation of GPS receiver is likely to provide a solution to the present dependence upon the terrestrial network. Studies conducted by CASA point to its suitability for use as an 'only means' system that does not require a terrestrial alternate. ASTRA is presently conducting a test programme on the new receiver to validate the earlier studies under failure and operational conditions. Approval as an 'only means' system would place the GPS (using TSO-C145 or C146 equipment) on an equal footing with the other en-route and NPA navigation systems presently used in Australia.

The other significant change in the short term will be the introduction of GPS precision approaches. Initially using the SCAT-1 system, GBAS will start to provide GNSS precision approaches in Australia.

Medium-term changes

New GNSS technology in the form of SBAS, GRAS, and Galileo systems will have developed to the point where Australia can introduce them to the operational infrastructure.

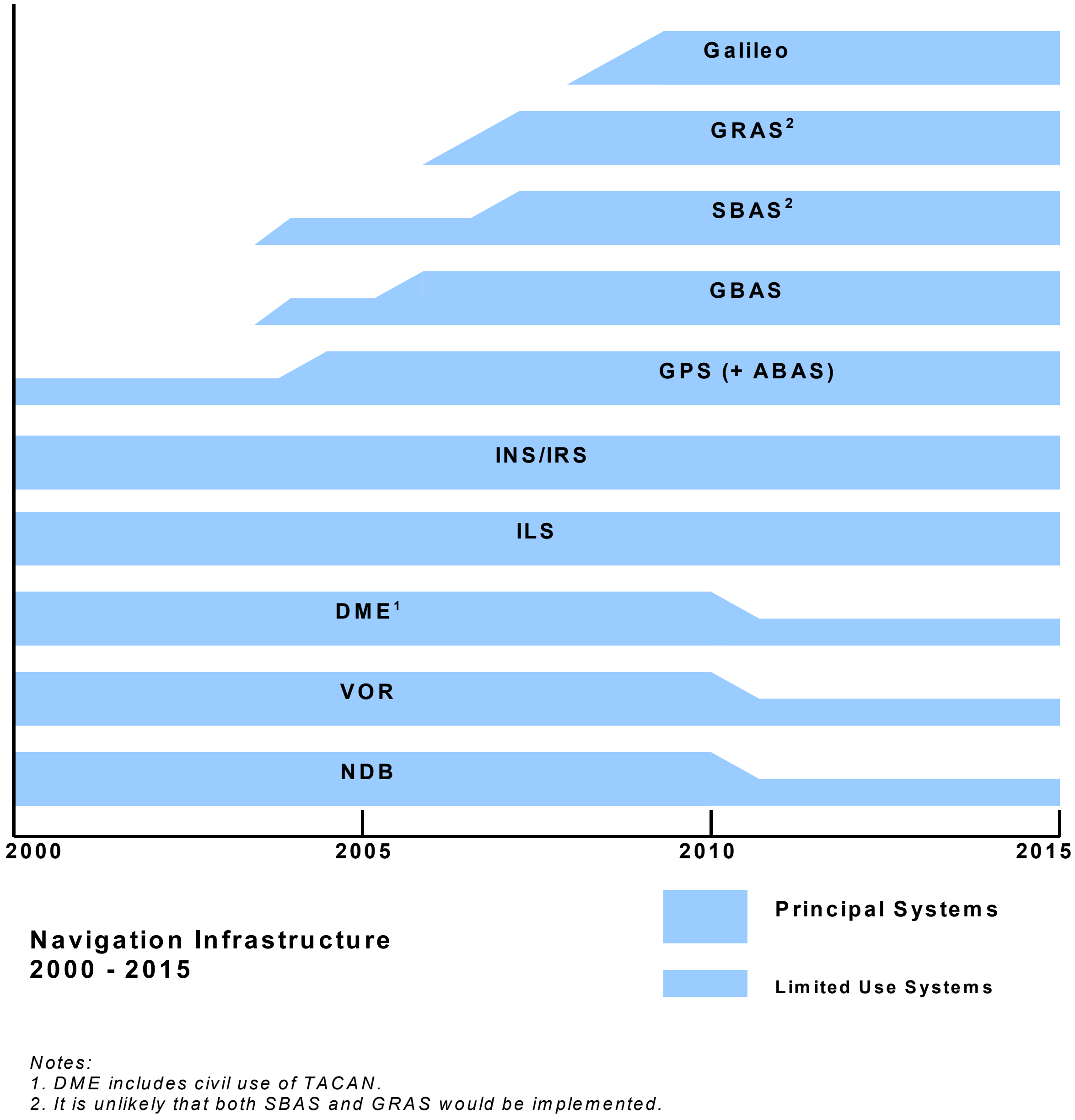
While it is expected that some limited SBAS benefits can be derived from the WAAS and MSAS geostationary satellites in the short term at no cost, a ground-monitoring infrastructure will be needed to realise the full benefit of those systems. The Australian GRAS will also require deployment of a ground network and either (full) SBAS or GRAS would constitute a major investment. Galileo is scheduled to become operational in 2008, providing another full GNSS constellation and allowing considerable redundancy protection without reliance on terrestrial systems.

It is also expected that during this time the development of MEMS technology will enable the use of inertial navigation in aircraft of any size.

Far-term changes

With GNSS and Inertial systems established as viable alternatives and demonstrated operational benefits, the dependence on the terrestrial networks will be largely eliminated. The majority of NDB, VOR and DME sites will be decommissioned from 2010, with a backup network of key facilities retained to provide contingency navigation services. The seven years between the publication of this CNS Plan and 2010 is considered a reasonable period of time for aircraft operators to transition to the future infrastructure and allows at least seven years return of service from equipment installed prior to the release of this plan. ILS will be retained until at least 2015 to provide services to aircraft not equipped for GNSS precision approach and to enhance the contingency capability provided by the backup network.

Figure 3.4 – Indicative Transition Schedule for Navigation Infrastructure



CHAPTER 4:
Surveillance

4.1 Surveillance Requirements

4.1.1 Operational

Surveillance is used in aviation for a variety of purposes, including operator (company) flight following, SAR and ATM. ASTRA has identified the following operational requirements for the future Australian surveillance infrastructure:

- Allow aircraft to operate within Australian airspace, at least to that level of individual system performance currently possible;
- Be capable of providing surveillance services, such that present levels of safety are maintained or exceeded;
- Enable operations at lesser individual system performance, without penalty, to those operators defined by CASA, Airservices Australia, or other authority;
- Harmonise operations through integration of systems and regional CNS infrastructure;
- Be capable of supporting air traffic services throughout Australian airspace;
- Be capable of providing ground-based independent surveillance at designated controlled aerodromes;
- Be capable of providing or supporting ground-based automatic dependent surveillance at major aerodromes and in controlled airspace, throughout Australian airspace;
- Be capable of supporting airborne automatic dependent surveillance throughout Australian airspace; and
- Be capable of integration with national defence and security agencies.

4.1.2 Technical

As with the technical requirements for navigation systems, ICAO standards of Accuracy, Integrity, Availability and Continuity will constitute the minimum technical requirement for surveillance systems. Where operational demands specify a different level of performance then the technical standard will be the higher of the two requirements.

4.1.3 Economic

Nation-wide radar surveillance is economically impractical for Australia due to the high cost of radar and the relatively low traffic flows over much of the continent. Furthermore, radar surveillance is physically impractical in most of the oceanic airspace managed by Australia. In seeking alternatives to a radar-based surveillance infrastructure, the principal economic requirement is that the benefits outweigh the costs. When conducting cost-benefit studies, it is important to consider the infrastructure as a whole as well as the individual components, and to take both industry-wide and individual stakeholder analysis into account.

Transition scheduling must ensure the greatest benefit from new technology without undue economic burden. A radar network constitutes a very large ongoing investment and is generally replaced as a whole under one contract when the existing system reaches end-of-life. For this reason, economic considerations are likely to dictate that major changes to the ground-based surveillance infrastructure should be timed to co-incide with the replacement of the existing hardware.

4.1.4 Institutional

As with navigation infrastructure, both Airservices Australia and the Department of Defence control the Australian ground-based surveillance infrastructure. The surveillance data gathered from individual sites is shared between the two organisations for ATS, SAR and other purposes. A co-ordinated approach to the management of the surveillance infrastructure benefits the two organisations and the airspace users.

Many new surveillance technologies require the co-operation of the airspace user to be fully effective. As the Australian surveillance infrastructure evolves to incorporate the benefits of new systems, ASTRA will become increasingly important as a forum for airspace users and ATM service providers to produce collaborative plans for the future.

4.1.5 International

Australia has been quick to adopt new surveillance technologies in recent years and is actively involved in the process of producing ICAO standards and recommended practices to use them. Harmonisation with global and regional plans is a high priority in the development of the surveillance infrastructure.

4.2 Selection of Surveillance Systems

4.2.1 Candidate Systems

In developing the Australian surveillance infrastructure plan, ASTRA has considered the use of the following technologies:

Pilot Position Reports

Pilot position reports are the basis of procedural separation techniques and until recently were the only means of conducting en-route surveillance outside radar coverage. These reports have traditionally been passed by voice communication although some reports are passed by CPDLC. Voice reports are used for both ground-based and airborne surveillance while only ATS receives CPDLC reports.

Primary Surveillance Radar

Primary radar surveillance is based on pulses of ultrahigh frequency radio waves transmitted by a rotating aerial. Any aircraft that reflect the pulse are illuminated and the return signals can be used to determine the position of the aircraft. This is achieved without any co-operative response from the aircraft, but as only a small percentage of the transmitted energy is reflected back, very large amounts of power are required to achieve even limited coverage.

Secondary Surveillance Radar (SSR)

SSR is one of the earliest aviation applications of an automatic datalink and uses a transponder onboard the aircraft in addition to the ground-based equipment. Mode A surveillance requires the aircraft to reply to interrogation with an identification code for determination of range and azimuth, while SSR Mode C replies include barometric altitude data. SSR Mode S augments the mode A/C information further with aircraft address, bank angle, selected altitude and other parameters.

Traffic Alert and Collision Avoidance System (TCAS)

TCAS is an instrument integrated into other systems in an aircraft cockpit and TCAS II was the first product to meet the ICAO standards for an Airborne Collision Avoidance System (ACAS). It consists of hardware and software to display the traffic situation in the vicinity of the aircraft and provide both traffic advisories and, if necessary, resolution advisories to the crew. ACAS relies upon the interrogation of aircraft SSR transponders and provides a backup to the air traffic control system's regular separation processes. A TCAS II display provides only safety-critical information about nearby traffic to the crew and must be supplemented by other means of surveillance.

Automatic Dependent Surveillance – Contract (ADS-C)

ADS-C is a technique whereby the aircraft automatically reports present position, altitude, next waypoint and other parameters to the ground ATS system via VHF or satellite datalink. ADS-C reports are made in accordance with a contract between ATS and the aircraft that dictates the reporting frequency and any specific events, such as altitude deviations, that will trigger another report. ADS-C reports are 'addressed' to the relevant ground station and, like transponder replies, are not received by other aircraft. ADS-C is well suited to surveillance of air transport category aircraft in oceanic and remote areas.

Automatic Dependent Surveillance – Broadcast (ADS-B)

ADS-B reports are similar in content to those of ADS-C, but are broadcast at very close (<1 second) intervals on a line-of-sight datalink. This high rate of update provides a radar-like surveillance capability to ATS and has a major advantage over SSR alone with the ability to convey 'intent' data. Because the reports are broadcast, other aircraft can also receive and display them on a Cockpit Display of Traffic Information (CDTI). A CDTI is a graphical display that can provide the crew with a situational awareness similar to a combination of TCAS display, directed traffic information and 'party-line' monitoring of ATS voice communications.

Multi-Lateration

Multi-Lateration is a surveillance technique based on the reception of an aircraft transmission at multiple locations. By accurate measurement of the slightly different time that the signal arrives at each of the multiple receivers, triangulation can be used to determine the position of the aircraft. The aircraft's transponder is a convenient source of the signal as Mode S transponders spontaneously transmit a 'squit' of data every second and a deployed system could include interrogators to elicit 'squawks' from Mode A/C transponders. Multi-Lateration systems have been deployed at a number of foreign airports for surface surveillance and the technology shows promise as a surveillance system to support PRM operations.

4.2.2 Considerations

Cost-Benefit Analysis

As with any change to CNS Infrastructure, a cost-benefit analysis is required to justify the required investment. For many years the only alternative to procedural separation has been radar and both service providers and airspace users have accepted the costs of the associated infrastructure. Now, as ADS-B emerges as a low cost alternative for service providers, careful analysis must be directed to the equipage of aircraft.

There are a number of ADS-B implementation scenarios that could be cost-beneficial for Australia and the ATM community as a whole. However, the most beneficial options are likely to require the carriage of ADS-B technology by the great majority of aircraft, including those receiving the least economic benefit. Options for subsidising the fitment of ADS-B across the Australian fleet need to be considered so that costs are shared fairly.

Stakeholder Plans

Existing stakeholder infrastructure and plans must be harmonised with this CNS Plan to minimise the impact of change and to ensure a reasonable return of service from new equipment. Much of the existing civil radar network will be reaching the end of its service life in 2008 and this presents a rare opportunity to change the capability of both the ground-based and airborne infrastructure at minimum cost. It seems likely that Mode S capability would be a standard feature of any modern SSR system tendered and there is also an opportunity to replace en-route radar coverage in the 'J-curve' with ADS-B coverage of the entire continent.

The Co-operative Nature of Surveillance

A variety of techniques are used to provide data for both ground-based and airborne surveillance, but only two are fully independent of the surveilled targets (which may include aircraft, vehicles and a variety of other 'traffic'). These independent techniques are visual acquisition and primary surveillance radar.

All other techniques require varying degrees of cooperation from the traffic and the carriage of serviceable equipment to facilitate the exchange of surveillance data. Both Voice and CPDLC position reporting mandate the use of specific communication equipment and are 'dependent' on the 4-Dimensional navigation data reported by the flight crew. SSR uses an automatic response to the interrogation of the aircraft's transponder to provide identification and aircraft derived data to the ground system. As the name implies, Automatic Dependent Surveillance (ADS) could be considered a hybrid of the traditional' surveillance techniques, combining a dependence on position reports with automation typical of SSR replies.

A common mode of failure may exist for both Navigation and Surveillance when CPDLC, Voice, ADS-B or ADS-C position reporting techniques are used. While visual acquisition and radar can provide a contingency navigation service to aircraft, other techniques cannot, and other risk mitigators (such as redundancy of navigation or surveillance systems) must be considered, according to operational requirements. The fact that a surveillance system may not be able to provide navigation services under certain circumstances should not exclude it from consideration.

The ADS-B Datalink Debate

Until recently there has been considerable uncertainty as to which, if any, datalink would become the global standard for ADS-B. Two datalinks, VDL Mode 4 and Mode S Extended Squitter, have technical standards produced by ICAO panels, while a third link, known as UAT, is used in Alaska's pioneering 'Capstone' program.

Interoperability is a major concern in strategic ATM planning and Australia has therefore been cautious about deploying ADS-B until a globally accepted standard has emerged. During 2002 and 2003 announcements from various manufacturers, service providers and regulators around the world indicated a growing consensus for Mode S datalink in air transport operations. In March 2003, a Task Force established by ICAO's Asia-Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) unanimously supported the use of Mode S Extended Squitter datalink for ADS-B in the Asia Pacific Region for air transport category aircraft.

Crew Situational Awareness

One of the criticisms of the introduction of datalink technology is that crews are no longer able to monitor communications of other aircraft with ATS. Position, tracking, traffic and weather reports, when transmitted on a common voice frequency, all contribute to a crew's situational awareness and their ability to make informed decisions for their own flight. Although TCAS displays provide a critical defence between aircraft in close proximity, they are quite limited in range and cannot convey traffic identification or intent data to the crew as 'party line' monitoring of voice reports can. A CDTI has the capability to supply much of this extra information in a datalink environment and thereby enhance both the efficiency and safety of operations.

4.3 Surveillance Plan

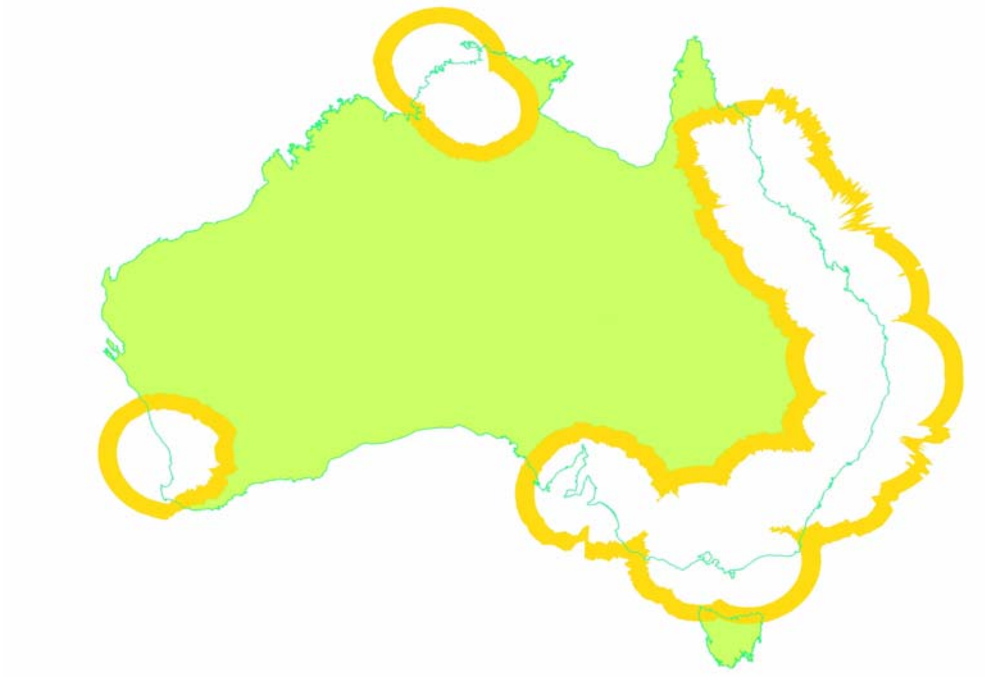
4.3.1 The Present

Australia's radar infrastructure is deployed mainly in the high traffic density areas of the mainland. Airservices Australia presently operates a network of eleven SSR Mode A/C en-route ATC radars down the east coast 'J curve', each with a nominal range of 250 nautical miles. The major aerodromes are served by eight terminal area ATC radars, each capable of primary surveillance to 50 nautical miles and Mode A/C secondary surveillance to 250 nautical miles, and Airservices also operates one Surface Movement Radar at Sydney Airport. The Department of Defence provides primary and secondary ATC surveillance with radars located at nine additional aerodromes.

ADS-C and CPDLC are used in both the Brisbane and Melbourne FIRs although the number of aircraft equipped with the necessary avionics is still quite limited. Airservices has initiated a 'pilot' or trial deployment of ADS-B in the Burnett Basin near Bundaberg, using the Mode S Extended Squitter datalink. All other ground-based surveillance is achieved through pilot position reports using the voice communication infrastructure.

The majority of airborne surveillance is also achieved with voice communications, although there is some limited augmentation achieved through the use of TCAS and similar products. The carriage and use of ACAS is mandated in Australia in accordance with ICAO Annex 6 standards.

Figure 4.1 - Radar coverage across Australia



4.3.2 The Future

The next fifteen years will see an increase in the use of automatic surveillance techniques and a corresponding decline in pilot position reports. Both primary and secondary surveillance radar will continue to be used in busy terminal environments and it is likely that Mode S capability will be a feature of the future ground-based surveillance infrastructure. ADS-C will remain a core component of Australia's oceanic surveillance infrastructure. ADS-B will be used widely to provide both ground and airborne surveillance and its introduction will enable the introduction of significant changes to ATM in Australia.

Near-term

Pending the outcome of the current Burnett Basin trial as proof of the 'radar-like' benefits of ADS-B, Airservices is proposing to deploy an initial deployment of 20 ADS-B ground stations across Australia. The next few years will also see the increased use of ADS-C and RNP 4 to support reduced separation standards and the introduction of UPRs.

Medium-term

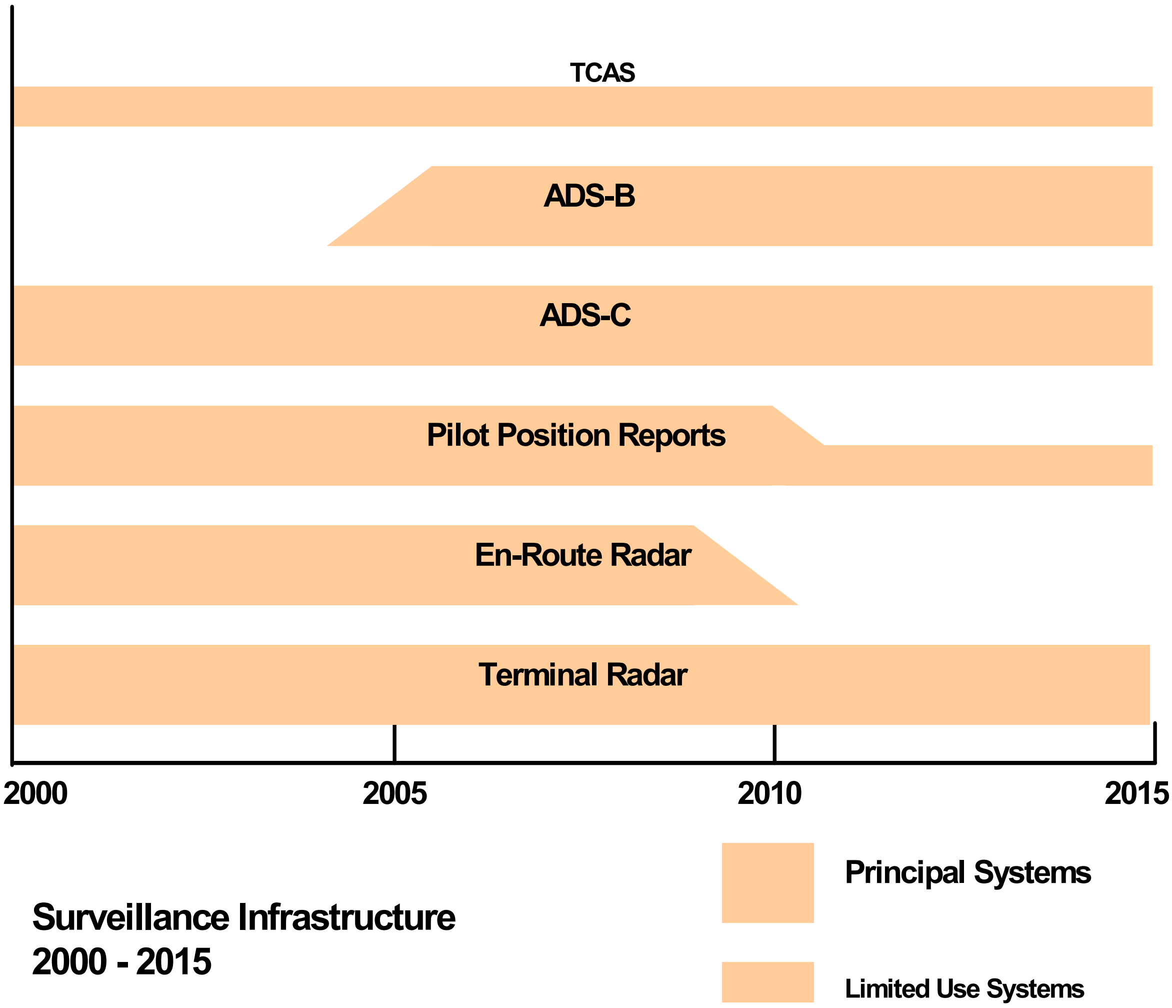
Airservices' existing radar network will reach the end of its service life in 2008. Likely medium term changes to the surveillance infrastructure will therefore include the commissioning of a new Mode S terminal area radar network and wide scale deployment of Mode S ADS-B ground stations for en-route continental surveillance. Apart from en-route applications, the introduction of Mode S ADS-B technology will also enable new surveillance capabilities at FIR boundaries, in terminal areas of smaller aerodromes and on aerodrome surfaces.

In the medium term, a range of CDTI products will become commercially available and will initially be used for enhanced situational awareness applications. Enhanced situational awareness is the first application of the Airborne Separation Assistance System (ASAS) currently being developed by ICAO.

Far-term

Once the new radar and ADS-B networks have been commissioned there will be little change to the ground infrastructure for some years. However, in ten years time the CDTI and ASAS technology will have developed to a point where the more demanding ASAS applications can be introduced. Airborne Spacing, Airborne Separation (from designated traffic) and Airborne Self-separation (from all traffic) are likely to become responsibilities able to be delegated by ATS to a flightcrew. While these responsibilities are held by pilots flying outside controlled airspace today, the evolution of CDTI is expected to enable similar operations in higher density traffic environments in the interests of efficiency, economy and safety. It must be stressed that these concepts are still being developed and that changes to the traditional relationship between controllers and pilots will need to be carefully managed.

Figure 4.2 – Indicative Transition Schedule for Surveillance Infrastructure



CHAPTER 5:
CNS Infrastructure Transition

5.1 Research and Development

CNS Infrastructure represents a considerable investment and its performance is critical to aviation safety. For these and other reasons, the importance of Research and Development (R&D) projects for new systems cannot be overstated. Even 'off-the-shelf' products already being used operationally overseas must be tested under local conditions and have suitable procedures and training developed for their use. ASTRA has identified the need for R&D projects in the following areas as being critical to implementing the near term and medium term changes identified in this CNS Plan:

- GNSS Only Means Navigation;
- RNP/RNAV and APV Approaches;
- Backup Navaid Network;
- CNS Infrastructure Cost-Benefit Analysis;
- ADS-B Ground Station Deployment; and
- CDTI and ASAS Applications.

5.2 Planning

There is a range of activity required to introduce a change to CNS Infrastructure and coordinated implementation requires effective planning. Perhaps the most critical element in planning for changes to a system is the collaborative approach to decision making by all affected participants in the system.

This process requires not just representation of the organisations involved in a particular project, but wider consultation with the ATM community and the inclusion of individuals with operational expertise in the various aviation disciplines. ASTRA has been established to provide a national strategic planning forum and Australia is an active participant in ICAO's regional and global planning fora.

5.3 Implementation

In accordance with the planning strategy outlined above, implementation of the required CNS infrastructure changes to realise the benefits will require a collaborative approach within the stakeholder group. This implies that each stakeholder commits to providing the necessary detail that is required to develop the justifying cost benefit cases. Following (and in some cases in parallel with), the R&D initiatives described in section 5.1, one or a number of ‘transition projects’ would be developed. It is envisaged that, with the explicit agreement of all stakeholders, that a lead stakeholder group would be chosen to manage the transition project(s).

The increased integration of CNS functions in equipment may introduce common failure modes. Risk mitigation strategies, including procedural technical solutions, must be developed.

When implementing change, stakeholders will be cognisant of the strategic plan and ensure that pre-requisites will be achieved before a change is implemented.

Because technological advances cannot be precisely predicted in the longer term, the allocation of operational, engineering, regulatory and training resources to introduce new systems may be difficult. The CNS Plan will be updated on a regular basis to provide all stakeholders with the latest guidance.

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Australian ATM Strategic Plan

Glossary of Acronyms

A

ABAS	Aircraft Based Augmentation System
ACAS	Airborne Collision Avoidance System
ADF	Automatic Direction Finder
ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
AERIS	Automatic En-Route Information Service
AFTN	Aeronautical Fixed Telecommunication Network
AGCC	The Australian GNSS Coordination Committee
AMHS	Aeronautical Message Handling System
APANPIRG	Asia-Pacific Air Navigation Planning and Implementation Regional Group
APV	Approach with Vertical Guidance
ASAS	Airborne Separation Assistance System
ASTRA	The Australian Strategic ATM Group
ATC	Air Traffic Control
ATIS	Automatic Terminal Information System
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Services

C

CASA	Civil Aviation Safety Authority
CDTI	Cockpit Display of Traffic Information
CNS	Communication, Navigation & Surveillance
CPDLC	Controller - Pilot Data Link Communication

D

DME	Distance Measuring Equipment
DME(A)	Distance Measuring Equipment (Australia)

E

EGNOS	European Geostationary Navigation Overlay Service
EGPWS	Enhanced Ground Proximity Warning System

F

FIR	Flight Information Region

G

GBAS	Ground Based Augmentation System
GLONASS	Global Navigation Satellite System (Russian Federation)
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GRAS	Ground-Based Regional Augmentation System

H

HF	High Frequency

I

ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
ILS	Instrument Landing System

INS	Inertial Navigation System
IRS	Inertial Reference System
L	
LAAS	Local Area Augmentation System
LLZ	Localiser
M	
MEMS	Mirco Electro-Mechanical Systems
MLS	Mircowave Landing System
MSAS	MTSAT Satellite-based Augmentation System
N	
NDB	Non-Directional Beacon
NM	Nautical Miles
NPA	Non-precision Approach
P	
PDC	Pre-Departure Clearance
PRM	Precision Runway Monitor
R	
R&D	Research & Development
RAIM	Receiver Autonomous Integrity Monitoring
RNAV	Area Navigation
RNP	Required Navigation Performance
S	
SAR	Search and Rescue
SBAS	Satellite Based Augmentation System
SCAT-1	Special Category 1 Landing System
SPDL	Service Provider Data Link
SSR	Secondary Surveillance Radar
T	
TACAN	Tactical Aid to Navigation
TCAS	Traffic Alert and Collision Avoidance System
TLS	Transponder Landing System
TSO	Technical Standard Order
TTLS	Transportable Transponder Landing System
U	
UAT	Universal Access Transceiver
UHF	Ultra High Frequency
UPR	User Preferred Route
UPT	User Preferred Trajectory
V	
VDL	VHF Data Link
VFR	Visual Flight Rules
VHF	Very High Frequency
VLF	Very Low Frequency
VOR	VHF Omni-Directional Radio Range
W	
WAAS	Wide Area Augmentation System