FACT SHEET
Jindalee Operational Radar Network

What do the terms OTHR and JORN mean, and how do they differ?

A. *OTHR refers to Over-the-Horizon Radar, a term applied to high frequency (HF) radars which operate using sky-wave or surface-wave principles. JORN is the Jindalee Operational Radar Network and this is the name given to the Australian Defence Force's (ADF's) network of HF sky-wave over-the-horizon radars and the Jindalee Coordination Centre acquired under Defence's Project Air 2025 (Air 2025).*

Jindalee Operational Radar Network (JORN) – A Vision for a Layered Surveillance Network?

A. *Australia's JORN comprises three Over-the-Horizon Radar (OTHR) systems and forms part of a layered surveillance network providing coverage of Australia's northern approaches. The network is designed to detect objects of military significance that might present a threat to Australia.*

In February 1985 the then Minister for Defence, Kim Beazley, commissioned Paul Dibb, who was an external consultant and former member of the Department of Defence, to analyse Australia's defence planning and make recommendations for future developments. Dibb's report was published in March 1986. The report recommended that Australia abandon the remaining elements of the forward defence policy and concentrate its military resources on the geographic areas relevant to defending the country and its economic interests from direct attack. Dibb recommended that Australia's military posture be based on a strategy of denying aggressors the ability to attack the country. This was to be achieved through using a layered defence of OTHR, patrol aircraft and maritime strike aircraft to protect Australia's approaches. Dibb's report recommended that additional resources be applied to further exploit this promising technology and added that there was a strong case for considering at least two further OTHRs.

Why Over-the-Horizon Radar (OTHR)?

A. *Conventional microwave radar detection performance against low-level aircraft is limited to the radar's line-of-sight and impacted by the natural curvature of the Earth. In essence, the radar cannot see low flying aircraft much beyond the visual horizon. This physical limitation allows a low flying aircraft to approach close to the radar without being detected. An aircraft flying at 1000 feet, for example, is unlikely to be detected by a microwave radar until about 40 nm (or 70 km) from the radar.*

OTHR utilises the refractive properties of the ionosphere to refract or bend transmitted high frequency (HF) electromagnetic waves back to Earth well beyond a conventional radar's radar horizon. This concept negates curvature of the Earth *effects and the resulting blind zones, making it difficult for low flying aircraft or ships to approach undetected.*

This basic difference facilitates surveillance down to sea-level at far greater ranges than what can be achieved using a microwave radar. For a country the size of Australia OTHR therefore provides a cost effective solution to the problem of monitoring Australia's air and sea approaches and increases the probability of detecting an approaching threat at longer range.

How did the Jindalee Operational Radar Network (JORN) become a Defence asset?

A. *The decision to acquire JORN as a Defence asset began after the publication of Paul Dibb's report in March 1986, and Dibb's recommendation that Australia adopt a layered defence of Over-the-Horizon Radar (OTHR), patrol aircraft and maritime strike aircraft to protect Australia's approaches.*

Dibb's recommendation to invest in OTHR research and acquire an operational system was adopted in the 1987 Department of Defence White Paper, 'The Defence of Australia', which stated that 'the Government has given high priority to the design and development of this [OTHR] network, based on the Australian designed Jindalee experimental radar. The OTHR network will be a basic element of a national system for air defence and airspace control.' The paper identified the Government's intention to acquire three OTHRs. Based on the 1987 Defence White Paper, Joint Project 2025 (JP2025) was initiated to build a further two OTHRs in addition to the experimental OTHR at Alice Springs.

In 1991, a contract was awarded to Telstra, in cooperation with GEC-Marconi, to build two operational OTHRs that would form JORN. After considerable project difficulties, responsibility for the project moved to Lockheed Martin and Tenix (who formed the RLM Group) in 1997, and in 1999, No 1 Radar Surveillance Unit moved from Alice Springs to RAAF Base Edinburgh to remotely operate the Alice Springs OTHR from the JORN Coordination Centre. In 2003, RLM Group delivered two JORN OTHRs to the Australian Defence Force. These radars, along with the Alice Springs radar, comprise JORN in its current form. In May 2015 No 1 Radar Surveillance Unit was renamed No 1 Remote Sensor Unit to incorporate the operation of other surveillance assets in addition to OTHR at the unit.

Where are the Australian Over-the-Horizon Radars (OTHRs) located?

A. *The ADF currently operates three OTHRs. These radars are dispersed across Australia—Longreach in Queensland; Laverton in Western Australia; and Alice Springs in the Northern Territory—to provide surveillance coverage of Australia's northern approaches.*

What is the current status of the Australian Over-the-Horizon Radar (OTHR) capability?

A. *JORN underwent a capability upgrade under Joint Project 2025 (JP2025.) Phase 5 of JP2025 achieved Final Operational Capability in December 2013. The project delivered a number of capability enhancements to the Longreach and Laverton OTHRs, and integrated the Alice Springs radar into the network.*

What is the nominal surveillance area covered by the Jindalee Operational Radar Network (JORN)?

A. *The JORN has a nominal operating range of 1000–3000km, as measured from the individual radar sites. The Alice Springs and Longreach OTHRs cover an arc of 90 degrees each, whereas the Laverton OTHR coverage area extends through 180 degrees.*

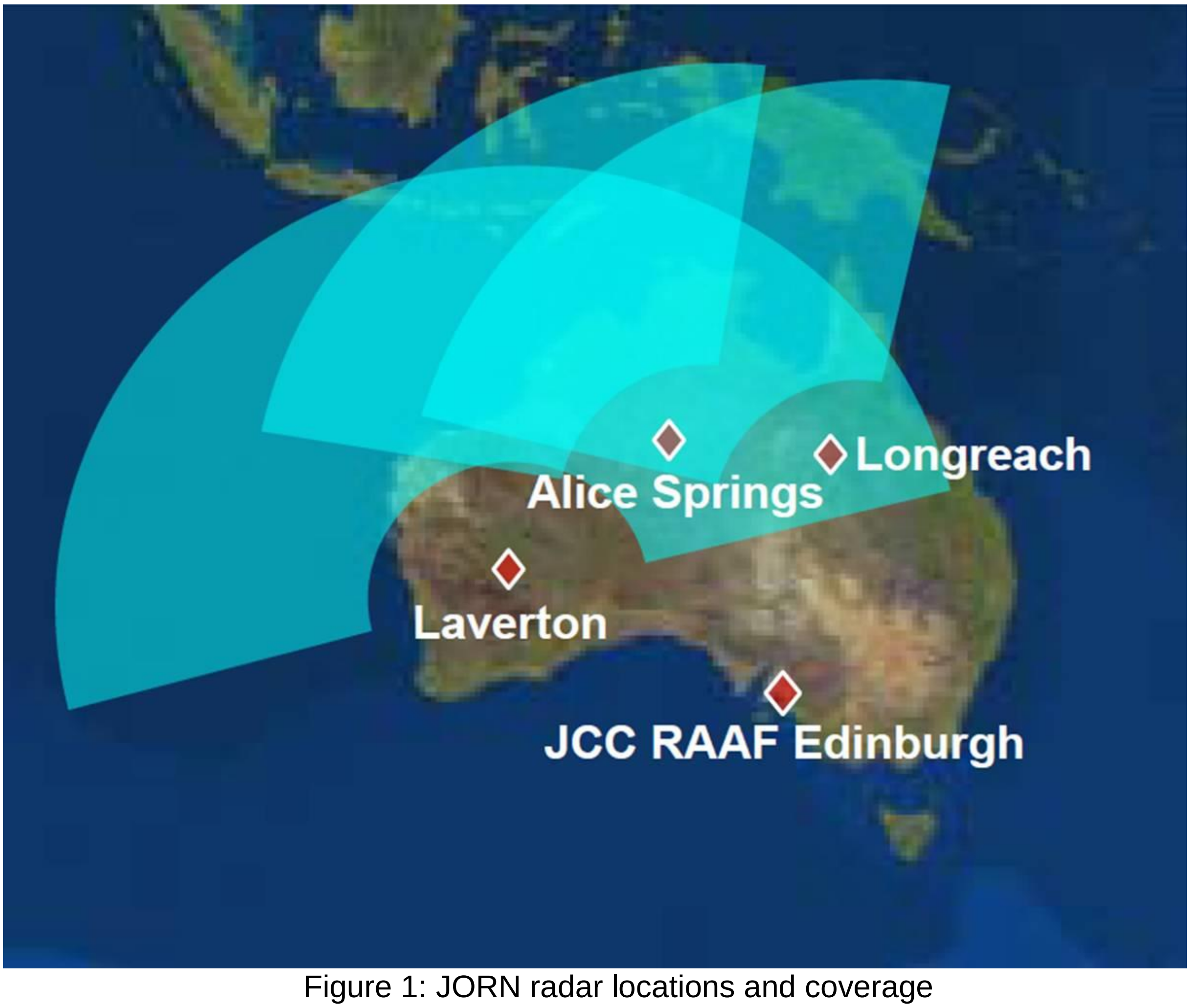

Figure 1: JORN radar locations and coverage

Does the Jindalee Operational Radar Network (JORN) operate 24 hours per day?

A. *JORN was designed and acquired for the defence of Australia. In the context of the defence of Australia and peacetime military operations, the operating hours of JORN are managed to meet Defence's surveillance priorities.*

How is peacetime tasking optimised for the Jindalee Operational Radar Network (JORN)?

A. *Defence has biased JORN's peacetime use towards maximising the probability of detecting aircraft and ships while ensuring efficient employment of JORN's fiscal and staff resources. In this context, JORN peacetime tasking is governed primarily by two major considerations:*

1. The likelihood of JORN being able to detect an object of interest; the probability of detecting a particular object being a function of the prevailing ionospheric and environmental conditions, and of the object's size, construction and behaviour.

2. Ionospheric limitations that bias OTHR surveillance operations towards daylight hours, when solar radiation emitted by the sun increases the level of ionisation within the ionosphere.

What role does the Jindalee Operational Radar Network (JORN) play in Australia's border protection effort?

A. *JORN is tasked to provide surveillance support to Border Protection Command's broader surveillance operations.*

Can the Jindalee Operational Radar Network (JORN) detect wooden boats?

A. *The detection of wooden vessels by JORN is highly improbable. JORN was designed and funded for the defence of Australia, with specifications to detect surface vessels of the size and design of an Armidale class patrol boat. JORN was neither designed, nor is it suitable, as a persistent, broad-area surveillance tool for wooden vessels.*

For an object to be detected by an Over-the-Horizon Radar (OTHR) it needs to possess a radar reflective (metal) surface of suitable size so that sufficient radar energy is reflected back to the radar receiver. Wooden vessels do not generally satisfy this requirement.

Will Over-the-Horizon Radar (OTHR) detect an engine in a wooden boat?

A. *For an object to be detected it needs to possess a radar reflective (metal) surface of suitable size so that sufficient radar energy will be reflected back to the OTHR receiver. Therefore, it is highly improbable that an OTHR would detect an engine in a wooden vessel.*

Did the Jindalee Operational Radar Network (JORN) detect flight MH370?

A. *Malaysia Airlines flight MH370, a Boeing 777-200, was classified as missing at 0240h on 08 Mar 14 whilst enroute from Kuala Lumpur to Beijing. On 24 Mar 14, the Malaysian Prime Minister announced that MH370 had probably ended its flight in the middle of the Indian Ocean to the west of Perth, far from any possible landing sites. The aircraft was carrying 227 passengers and 12 crew, including six Australians.*

Based on the time of day that MH370 disappeared, and in the context of peacetime tasking, JORN was not operational at the time of the aircraft's disappearance. Given range from individual OTHRs, the ionospheric conditions and a lack of information on MH370's possible flight path towards Australia, it is unlikely that MH370 would have been detected if the system had been operational.

Are there any future upgrades planned for the Jindalee

Operational Radar Network (JORN)?

A*. To keep pace with technological advancements, and to ensure that JORN remains at the leading edge of Defence capability, future upgrades are planned under Project Air 2025 Phase 6. Phase 6 will take advantage of Australia's world class OTHR research and development to address OTHR sustainability issues and incorporate new and emerging technologies. Initial Operational Capability for Phase 6 is planned to occur between FY2018-19 to FY2020-21.*

Who operates the Jindalee Operational Radar Network (JORN)?

A. *JORN is operated by the Royal Australian Air Force's No 1 Remote Sensor Unit (1RSU) at RAAF Base Edinburgh in South Australia.*

What is the Jindalee Operational Radar Network (JORN) designed to detect?

A. *JORN was designed and acquired for the defence of Australia. As such, JORN is designed to detect air targets equivalent in size to a military BAE Hawk-127 jet-trainer aircraft or larger, and objects on the surface of the water equivalent in size to an Armidale Class Patrol Boat or larger.*

Does an Over-the-Horizon Radar (OTHR) work like a conventional radar by constantly sweeping across its surveillance area?

A. *An OTHR is designed and operated specifically to see 'over the horizon'. Conventional microwave radars such as those commonly seen at airports propagate in a straight line and cannot detect objects beyond their line of sight i.e. beyond the visual horizon. OTHRs overcome this limitation by 'bouncing' (through a process of refraction) high frequency (HF) radio waves off the ionosphere.*

OTHRs do not continually 'sweep' an area like a conventional radar but rather 'dwell' by focusing discrete radar energy on a particular area – referred to as a 'tile'. The transmitted HF energy can be electronically steered to illuminate other 'tiles' within the OTHRs coverage as required to satisfy operational tasking or in response to intelligence cueing. When an OTHR dwells on an area, it is configured to either detect maritime vessels or aircraft.

How does an Over-the-Horizon Radar (OTHR) work?

A*. OTHRs comprise fixed transmitter and receiver antenna arrays of substantial size which are geographically separated. High frequency (HF) radio waves are generated at the transmitter site and propagate through the atmosphere at an angle until they meet the ionosphere. OTHR utilises the refractive properties of the ionosphere to refract or bend the transmitted HF waves back to Earth. When these refracted HF waves hit a radar reflective (metal) surface of sufficient size, either airborne or maritime, some of the energy is reflected back along the transmission path to the OTHR receiver. Sophisticated computer systems then process the received energy to discern objects within the radar's footprint.*

OTHR systems can be characterised as follows:

1. OTHRs operate on the Doppler principle, whereby an object can only be detected if its motion toward or away from the radar is distinct from its surroundings.

2 The location and orientation of an OTHR's transmitter and receiver arrays determines the lateral limits of the radar's coverage. The extent of OTHR coverage in range is variable and principally dependent on the state of the ionosphere.

3. OTHRs do not continually 'sweep' an area like conventional radars but rather 'dwell' by focusing the radar's energy on a particular area – referred to as a 'tile'.. The transmitted HF energy can be electronically steered to illuminate other 'tiles' within the OTHR's coverage as required to satisfy operational tasking or in response to intelligence cueing.

What role does the ionosphere play in Over-the-Horizon Radar (OTHR) operations?

A. OTHR performance on any given day may be affected by the following conditions:

*1. **State of the ionosphere.** The ionosphere is the upper part of the atmosphere extending from 75 to 450 km above the Earth's surface that consists of particles that have been ionised by solar radiation emitted by the Sun. As such, the level of ionisation, and hence the structure of the ionosphere, is dependant upon the amount and type of incident radiation and this varies markedly depending on the level of solar activity. Other more localised phenomena also affect the stability and/or structure of the ionosphere. It is the combination of these phenomena and solar events which determines the quality of refractive support provided by the ionosphere. The most significant factors affecting ionospheric support for OTHR operations include:*

- *the 11 year solar cycle;*
- *solar disturbances (i.e. flares and coronal mass ejections);*
- *meteors;*
- *geomagnetic activity;*
- *ionospheric disturbances; and*
- *ionospheric variations throughout the day and night.*

*2. **Environmental conditions.** The natural environment can also limit the effectiveness of OTHR in detecting specific objects, namely:*

- *rough seas and winds can cause increased radar clutter making the detection of maritime vessels very difficult; and*
- *lightning associated with thunderstorms can cause localised ionospheric changes.*