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Agenda Item 4: Asia/Pacific and inter-regional SAR planning, coordination and cooperation

AIRCRAFT ELECTRONIC NIGHT SEARCH GUIDANCE

(Presented by AUSTRALIA)

SUMMARY

This paper presents guidance developed by Australia to assist RCC personnel when planning night searches by aircraft using Electro-Optic/Infrared (EO/IR) and Night Vision Imaging Systems (NVIS). The guidance is being considered for inclusion in the International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual by the ICAO/IMO Joint Working Group on Harmonization of Aeronautical and Maritime Search and Rescue (ICAO/IMO JWG-SAR).

The APSAR/WG is invited to note the guidance and provide any comments to Australia which may enhance or improve this guidance prior to its further consideration by the JWG-SAR at its next meeting later in 2023.

1. INTRODUCTION

1.1 At the Twenty-Fifth meeting of the ICAO/IMO Joint Working Group on Harmonization of Aeronautical and Maritime Search and Rescue (ICAO/IMO JWG 25) held in 2018, Australia presented information (WP.12) outlining an aircraft search technique that at the time was being developed and trialed in Australia for tasking of suitably equipped and capable fixed-wing aircraft during night searches over land using Electro-Optic/Infrared (EO/IR) and Night Vision Imaging Systems (NVIS). The JWG noted that this so called ‘circle search technique’, once developed, might supplement existing IAMSAR Manual night search guidance contained within Volume II, chapter 5, paragraph 5.7 Night search patterns. Australia provided an update on further development in this capability to JWG 26 (WP.29) in 2019.

1.2 Australia’s Bombardier CL604 SAR aircraft are now commonly deployed to conduct night searches using their EO/IR and NVIS capability with the ‘circle search technique’. The experience to date with using this capability for night searching has seen successes in locating search targets at night.

1.3 At JWG 29, 17 to 21 October 2022, Australia presented draft “Aircraft Electronic Night Search Guidance” (WP.5) which has been developed by Australia to update and supplement existing IAMSAR Manual night search guidance, not only for use of the “circle search technique” but also the wider use of EO/IR and NVIS sensors for night searching by aircraft. Australia proposed that this guidance, as provided in the Appendix A to this working paper, be incorporated into the IAMSAR Manual to assist RCC personnel when planning night searches by aircraft using EO/IR and NVIS. The JWG considered Australia’s proposal, together with comments by the United States (WP.24) and following further discussion, the JWG supported the inclusion of this guidance in the IAMSAR Manual but with further consideration by an ad hoc correspondence group under the coordination of Australia to further consider the matter and report to JWG 30 when it next meets in late 2023.

2. DISCUSSION

Aircraft Electronic Night Search Guidance

2.1 The Appendix A to this paper, titled *Aircraft Electronic Night Search Guidance*, is guidance developed by Australia’s national aeronautical and maritime SAR authority, the Australian Maritime Safety Authority (AMSA). Its purpose is to provide general guidance for SAR coordinators on electronic night searching by fixed-wing and rotary-wing aircraft using EO/IR and NVIS more broadly, not only for the ‘circle search technique’ noted in the Introduction.

2.2 This guidance has been developed with the inclusion of feedback following consultations with members of the Australian National SAR Council, which includes AMSA, Australian State and Territory SAR authorities (police) and the Australian Defence Force, feedback from Australian aviation SAR units experienced in the use of EO/IR and NVIS, and other reference sources.

2.3 The guidance has been developed to consolidate a range of information and inputs to create general guidance without being specific about individual capabilities, commercial products or equipment used. The guidance, being general in nature, is intended for RCC SAR coordinators and not aircraft operators who should have their own guidance, procedures and training tailored to their individual operation and capability.

2.4 The aim of the guidance is to provide RCC SAR coordinators with updated and improved general guidance to assist them with:

2.4.1 use of aircraft with EO/IR and NVIS capabilities,

2.4.2 appreciation of the many variables that apply to EO/IR and NVIS aircraft night search operations,

2.4.3 setting reasonable expectations of what can be achieved with appropriate regard to capability, effectiveness, limitations, and safety considerations, and

2.4.4 enabling well informed decisions and discussions with aircraft operators and aircrew with an emphasis that, when considering any night search operation, SAR coordinators should be guided by the aircrew’s expertise for best use of their aircraft and their individual sensor capability.

2.5 Noting that other Asia/Pacific States will have SAR subject matter experts within their State SAR systems with expertise and experience in electronic night searching by aircraft using EO/IR and NVIS such as aircrew, APSAR/WG participants are invited to share the guidance in the Appendix A with those personnel and provide any enhancements to the guidance for consideration by the ICAO/IMO JWG-SAR.

2.6 At the annual meeting of the Australian National SAR Council in October 2022, the Council endorsed the inclusion of the guidance in the Australian National SAR Manual which has since been published in the February 2023 edition of the Australian National SAR Manual, Appendix F – link [National Search and Rescue manual \(amsa.gov.au\)](https://amsa.gov.au). Any enhancements received to the guidance from the APSAR/WG will also be considered for improvements to the Australian National SAR Manual guidance.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

- a) note the information contained in this paper;
- b) share the guidance in the Appendix A with SAR subject matter experts within APSAR/WG participants' State SAR systems who have expertise and experience in electronic night searching by aircraft using EO/IR and NVIS, such as aircrew, and invite those personnel to provide comments and any enhancements to the proposed guidance for consideration by the ICAO/IMO JWG-SAR; and
- c) discuss any relevant matters as appropriate.

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Appendix A - Aircraft Electronic Night Search Guidance

Definitions

Term	Definition
EO/IR, or Electro-Optic/Infrared systems	Electronic imaging systems which include both visible and infrared sensors that can be used day and night and in low light conditions with the ability to view objects at long distance.
NVD, or night vision device	Night vision enhancement equipment fitted to, or mounted in or on, an aircraft, vessel or vehicle, or worn by a person, that can: <ol style="list-style-type: none"> 1. detect and amplify light in both the visual and near infrared bands of the electromagnetic spectrum; or 2. provide an artificial image representing topographical displays.
NVIS, or night vision imaging system	A self-contained binocular night vision enhancement device, usually including goggles, that: <ol style="list-style-type: none"> 1. is helmet mounted or otherwise worn by a person; and 2. can detect and amplify light in both the visual and near infrared bands of the electromagnetic spectrum. NVIS is a term used to incorporate all aspects associated with night vision, including NVD.

General Considerations

1. This information provides general guidance for search planners when considering night searches by aircraft using Electro-Optic/Infrared (EO/IR) equipment and/or Night Vision Imaging Systems (NVIS).

Note 1 - day searches using visual observation plus EO may be beneficial, but this guidance focuses on night search only.

Note 2 – NVIS is used in this guidance as a collective term incorporating all aspects associated with night vision such as Night Vision Devices (NVDs) and Night Vision Goggles (NVGs).

2. It is preferable, safer, and normally more effective to search in daylight. Of course, the timing of distress situations is not always optimal for a daylight search. Where suitably capable night search aircraft with aircrew trained and competent in safe night search operations are available, SMCs may consider a night search is necessary where the urgency of the situation may be critical to saving lives.
3. Factors generally common to selection of aircraft and the ability for pilots to safely accept any search task apply such as regulatory requirements, risk factors, aircraft performance and capability, equipment fitted, aircrew training and experience, weather, nature of search area (topography, vegetation, distance offshore, availability of forced landing areas, obstacles, and powerlines, etc), fuel endurance available, transit times, available time on scene, fatigue, etc.

4. Search planners and coordinators should have a good understanding of the capability and limitations of EO/IR and NVIS searching to be able to discuss and brief an effective search plan with the aircrew to establish reasonable expectations of possible outcomes and best use of the asset. Given the range of variables for these types of searches, search planners should be guided by the aircrew's expertise and plan the search accordingly with safety of the operation the priority.

Aircraft and equipment factors

5. Aircraft type and the type of EO/IR and NVIS equipment available on board provide different search options. Aircrew training and experience play a central role in night search effectiveness.
6. Ideally the use of a combination of EO/IR and NVIS is the most effective. NVIS can provide a wide viewing area with any sightings being able to be examined in more detail using IR which has a narrower field of view and greater acuity. EO/IR cameras with the ability to zoom in on sightings provides advantages over EO/IR systems without this capability. Aircraft lighting, both internal and external, needs to be compatible with NVIS.
7. It is possible that an object can be visible in the NVIS but not be visible in the EO/IR, or vice versa depending on the object's characteristics. This may present challenges where search aircraft equipped with only one of these two types of electronic night search capability needs to transfer sighting details to another search aircraft with the other means of detection for investigation.
8. Advanced systems integrated with navigation systems, moving map displays and recording capabilities provide additional benefits to assist operators to provide greater search integrity, efficiency, and effectiveness. For search aircraft suitably fitted, the ability for the RCC to send search patterns and search areas via data files (e.g., KML files) to be uploaded to aircraft mission management systems, GNSS units or aircrew portable electronic devices (if equipped) can provide efficiencies by reducing the need for complex conversations, relay of information and human error. Such aircraft if also fitted with a GNSS flight tracking system may also be able to provide the RCC with a debrief of the actual search tracks flown.
9. Visual and IR lasers are visible using NVIS. SAR coordinators should note that some aircraft operators may have visual or IR laser capability which may be used for the purpose of guiding other aircraft and surface SAR units to a distress location. IR lasers can also be used by crew members on the same aircraft operating with different sensors to help each other acquire a sighting, for example, the crew member operating the EO/IR is having difficulty acquiring a sighting detected on NVIS by another crew member. Depending on the laser type there may be hazards associated with their use. SAR units who intend to use lasers should be appropriately authorised and trained in their use. Other assets involved in a search operation, both aircraft and surface units, should be informed when lasers are being used by search assets so they can take their own precautions with respect to laser safety and prevent confusion as to the reason for the laser.
10. Aircraft fitted with an external public address or loudhailer system may assist with providing verbal directions to a person on the surface and may give comfort to a missing person not yet located that they are being looked for.
11. Safety and capability can be enhanced for aircraft fitted with a terrain warning system, weather, or ground mapping radar and, for helicopters, auto-hover.
12. Some Light Emitting Diode (LED) lighting systems, clearly visible to the naked eye, fall outside the combined visible and near-infrared spectrum of NVIS and therefore will not be visible to aircrew using NVIS. This may present a hazard where LED lighting is used for surface obstacles. Emergency or other equipment fitted with LED lighting used by survivors may also impact detectability using NVIS.

13. Poor visibility due to contaminants in the air such as dust or smoke may compromise EO/IR and NVIS effectiveness. In maritime areas, strong winds can blow salt spray across camera lenses and windows obscuring the electronic image or view through windows, potentially leading to missed detection. Rain in the area can help clear this residue away.
14. In maritime areas, detectability of unlit targets on the sea surface using NVIS will be degraded, particularly in calm conditions because of the low albedo (reflective properties) and contrast.

Survivor factors

15. Search success can be limited where people being searched for are not actively trying to be located or are not capable of actively aiding search crews, for example due to exposure or injury, or if they are hiding.
16. Ideally persons in distress will have a light source which can be easily seen by NVIS equipped crews, such as a torch, light from a mobile phone or signal fire. Reflective material may also assist. It is also possible that laser pointers may be used by persons in distress.
17. A person in the water without a light or reflective surface in broad scale searches where a specific splash point is not known is very difficult to locate at night. A known splash point with a short time frame between the splash point time and arrival of the search aircraft will increase the probability of locating the target.
18. To assist survivor awareness of the presence of the search aircraft and to elicit a survivor response signal, when the aircraft first arrives in the search area, if possible, the aircraft should be made as conspicuous as it can be by flying through the search area or orbiting at lowest safe altitude with as many external lights visible before commencing the search pattern.
19. A person in distress may see or hear the search aircraft and respond by activating a light or flare. Crews should be alert that it is possible the person in distress may not have had the opportunity to activate their light signal by the time their aircraft passes and where possible adjust their search technique accordingly, for example, by flying both directions along the same search leg or, if capable and practicable, directing their detection equipment to search both forward and behind the aircraft.
20. Survivor morale can be lifted when a search aircraft is sighted or heard during the night, even if the search aircraft does not find the survivor.

Search planning factors

21. The timeliness and accuracy of intelligence information for search area determination has a bearing on search effectiveness.
22. Search coordinators should also consider that a NVIS capable aircraft may not necessarily be capable of conducting a NVIS search. This is because:
 - a. NVIS may be used by pilots and aircrew solely for the purposes of safe air navigation and terrain avoidance functions in compliance with aviation regulations and may not have any capacity to conduct dedicated NVIS searching, whereas
 - b. other aircrew not directly involved in air navigation and terrain avoidance functions may use NVIS solely for the purposes of searching and observation.
23. Search planning should also take into account that search crews, when using EO/IR and NVIS equipment, will need periodic breaks to manage operator fatigue and provide an opportunity to view the search area with unaided electronic vision which may pick up lights that both EO/IR and NVIS cannot.

24. It is important to note that aircraft EO/IR equipment can normally only search one side of a search leg at a time, or only a forward or rear splay area at any time. Using NVIS to detect possible search targets, then using the EO/IR to investigate those sightings is generally the most effective search technique especially for small targets.
25. The target type will influence the type of night search to be conducted. Considerations include whether the primary target is to be a person, aircraft, vessel, or other object, its size, and its potential to provide a light source or light signal, and the amount of heat it may produce. The potential condition of the target should also be considered such as whether a survivor is likely to be capable of signalling or moving, a distressed aircraft has been damaged, or a vessel has capsized or is semi-submerged.
26. Night searches may be more effective in areas with reduced numbers of people to avoid false sightings. Wildlife and livestock can be a distraction.
27. Environmental conditions to consider include:
 - a. **Weather conditions** - both for search effectiveness and compliance with flight operations regulations, such as NVIS minima, ability to maintain visual meteorological conditions (VMC), risk of inadvertently entering instrument meteorological conditions (IMC), availability of optimal search altitude due to amount of cloud cover, precipitation, visibility, the action of wind over terrain and impacts of turbulence, freezing level, surface and air temperature, humidity, fog or mist, thunderstorms and sea conditions.
 - b. **Ambient light** - amount of moonlight and moon phase, position and elevation, effect of twilight and other ambient light sources. Nights with good ambient light enables more effective searching with NVIS.
 - c. **Thermal crossover** - the natural phenomenon that normally occurs twice daily when temperature conditions result in a loss of contrast between two adjacent objects on IR imagery which may have an adverse effect on IR detection.
 - d. **Bushfire/wildfire activity** - EO/IR detection capability will be affected by the heat from the fire(s). NVIS detection capability will be affected by the light from the fire(s) which can cause blooming (distortion or blotting out of the image) and smoke can reduce visibility.
 - e. **Thunderstorms** – search aircraft should avoid thunderstorms by a safe distance to avoid the hazardous effects of severe turbulence, lightning, icing, etc. Distances from thunderstorms may be difficult to estimate visually when using NVIS and the fitment of airborne weather radar or other electronic detection devices to the aircraft will assist. The NVIS image may be adversely affected by lightning flashes.
 - f. **For searches over land** - the topography including type of terrain, type and degree of vegetation, ground cover such as snow, and shadows from overhanging rocks and cliffs can impact search effectiveness. Different terrain can have positive and negative impacts on night searches. For EO/IR, a hot night may cause image wash out and a lack of obvious contrast between hot and cold and cause other structures and material to maintain heat for a longer period. Rocky terrain can be difficult to search by EO/IR where objects have the ability to retain heat during the day and provide ‘false positives’ during a night search. Time spent by ground crews checking these sightings can limit overall search effort.
 - g. **For searches over water** - sea conditions will determine search effectiveness. Rough water, waves, choppy surfaces, and whitecaps can impede identification of people in the water. Whitecaps splashing over the head of a survivor limits detectability.

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28. Searching over water presents different challenges to searching over land. Helicopter operations may be limited by the ability of the crew to maintain continuous visual contact using NVIS with land or a shoreline, including any illumination levels and potential hover references. Large areas of open water such as oceans can be difficult to comprehensively search. Operations in close proximity to coastline, islands or other obstacles can limit ability to search at optimum search altitude due to minimum safe altitude requirements.
 29. A more finite and smaller search area would benefit from a low altitude and slow speed search however a vast expansive search area such as in an open rural environment might require a higher altitude and faster search speed to cover. Higher probability locations may need smaller and repeated sweep widths or multiple orbits depending on field of view and to vary the slant ranges to potentially reveal previously unseen detail. Lower altitudes and low search speeds are most suitable for searching for a person in the water.
 30. For best use of available aircraft search time, the best search progression will generally be in order of firstly covering the Last Known Position, then the intended route, likely routes or locations based on local knowledge and intelligence, before a broad area search. For overwater searches, search planners will need to allow for drift of the target.
 31. Search pattern and sweep width choice and suitability will be dependent on the various factors described in this guidance and should be guided by aircrew expertise. Search patterns using parallel legs may be best in some cases while flying orbits/circular patterns may be better. Adjustments may be required when the aircraft arrives in the search area due to the conditions encountered and aircrews should be provided with flexibility to adjust their search parameters where possible.
 32. Search altitude variations may be applicable depending on the type of search, search aircraft type, its electronic night search capability and aviation regulatory requirements. The lowest safe search altitude at night over land is terrain and weather dependent but generally 1,500 – 2,000 feet above ground level (AGL) would be reasonable. For helicopters with NVIS capability and regulatory approval, lower altitudes may be possible where conditions allow, and it is safe to do so. Higher search altitudes may be optimal such as the those generally flown by high performance SAR aircraft using a circle search technique which would normally be flown between 5,000 – 10,000 feet AGL and typically not above 15,000 feet AGL. As different aircraft operators, both civil and military, may have different capabilities and regulatory authorisations, SAR coordinators should be guided by the operator/aircrew on a case-by-case basis when planning search altitudes.
 33. Searching areas of thick vegetation such as forested areas can be difficult. Searching over forested areas can be more effective at a higher altitude to allow for a higher viewing angle through the tree canopy. Circling an area of thick vegetation to provide a view from different angles may also assist.
 34. EO/IR and NVIS can fail to detect a person due to the limitations and variables outlined in this guidance, and depending on where and how they are situated, for example under thick vegetation, covered in mud, etc. Search planning decisions made regarding potentially discounting areas searched by EO/IR and NVIS need to be carefully considered and searching those areas again by different search methods are likely to be needed for better search integrity.
 35. Sector searches over a datum improve detectability through the cumulative effect of repeatedly covering the datum area. Circular patterns or orbits may also offer the same effect.

36. Most night search operations are likely to occur outside controlled airspace and where more than one aircraft is to be used for searching in the same area, as for day searches, those aircraft should be planned to allow aircrew to maintain deconflicted operations, both laterally and vertically, not only for safety purposes but also to maximise available search time while minimising the need for pilots to organise self-separation with other aircraft. Planning for such operations must be arranged and discussed between the RCC and the pilots in command of those aircraft before such flights begin to maintain safe operations. For operations within controlled airspace, Air Traffic Services (ATS) requirements will need to be factored into the planning in consultation with the responsible ATS unit.

Surface unit support

37. The success of night searches can be dependent on surface (land or marine) unit support to investigate sightings by search aircraft. The deployment of surface units in the search area in support of the aircraft night search may also assist the aircrew to establish suitable reference parameters for their sensor equipment for the search conditions.

38. Where aircraft and surface resources are to search concurrently, identification of high probability areas suitable for air search while surface resources search more easily accessible areas can provide more efficient search area coverage.

39. Where surface search personnel are likely to be present there should be a method for the aircraft search crew to easily identify them, for example, radio communications, identifying light signals, and IR strobes where aircraft NVIS are used. Surface units may be assisted by search aircraft to locate distress locations or identify a point of interest, for example by use of helicopter search lights to illuminate a search location or use of search aircraft laser systems

NOTE – see precautions regarding aircraft laser systems in *Aircraft and equipment factors* section above.

40. Helicopter night winching has limitations, especially overwater, where a suitable visual reference is required or an auto-hover capability. NVIS capability may assist to safely permit a night winching within regulatory requirements, however, using surface unit support to investigate sightings or perform a rescue presents a lower risk option.

Circle Search technique - General guidance

41. A circle search is based on the search aircraft having the capability to search using a combination of EO/IR and NVIS operating at a fixed distance around a datum. As the aircraft flies the circular search pattern, the aircraft's NVIS and EO/IR are used as search sensors. Observers are afforded a broad but less detailed view of the search area utilising NVIS while EO/IR may provide both a wide field of view for target acquisition and a detailed, narrow field of view for target investigation. Due to the nature of this search technique and aircraft bank angle, observers and search equipment only search from the one side of the aircraft, i.e., towards the inside of the circle.

42. The circle search flight profile depends on three key inputs:

- a. A datum to define the centre of the search area;
- b. A search radius, typically 3NM for faster fixed-wing aircraft, to balance search area coverage against the aircraft's NVIS and EO/IR capability, aircraft handling characteristics and search platform stability. The optimum radius will depend on the aircraft performance limitations; and
- c. An altitude, normally between 5,000-10,000ft AGL and typically not above 15,000ft for aircraft capable of higher altitudes.

43. Search planners need to be guided by the aircrew as to the optimum circle search radius, search altitude and speed.
44. The search area should be relatively confined and made up of terrain considered suitable for a circle search.
45. Before the search is initiated, the aircrew sensor operator breaks the search area into several smaller areas defined by human made or geographic boundaries such as roads, rivers, and property lines. Multiple orbits of the search area allow for each sub-area to be observed from multiple angles until the crew is confident the entire area has been searched as effectively as possible within the limits of the aircraft sensor capability and search conditions. For this reason, circle searches are ordinarily confined to land areas and are not normally appropriate for over water searches due to the lack of maritime surface features available. However, if multiple fixed points of reference are available overwater, like islands, reefs, and mud flats, then a circle search may be an option if the search area is geographically constrained to those areas.
46. For broader areas, several circle searches may be combined adjacent to each other to complete that area in stages, for example a search along a track. This is dependent, of course, on aircraft endurance, crew duty time and on-scene search time available.
47. The number of circle searches required will depend on the time taken to clear each individual search area and this will depend on the nature of the terrain, weather, light levels, and aircrew operator skill.
48. The nature of terrain will determine the ideal search altitude. For example, heavily wooded or mountainous terrain are best searched at higher altitudes to improve the look down capability of the EO/IR, but the ideal search height will always be secondary to the Lowest Safe Altitude.
49. Cloud and/or poor visibility may compromise a circle search; however, the EO/IR capability can be utilised to look through cloud breaks where they occur.
50. When search planners are considering tasking suitably capable aircraft for a sector or expanding square search, the use of a circle search should also be considered.