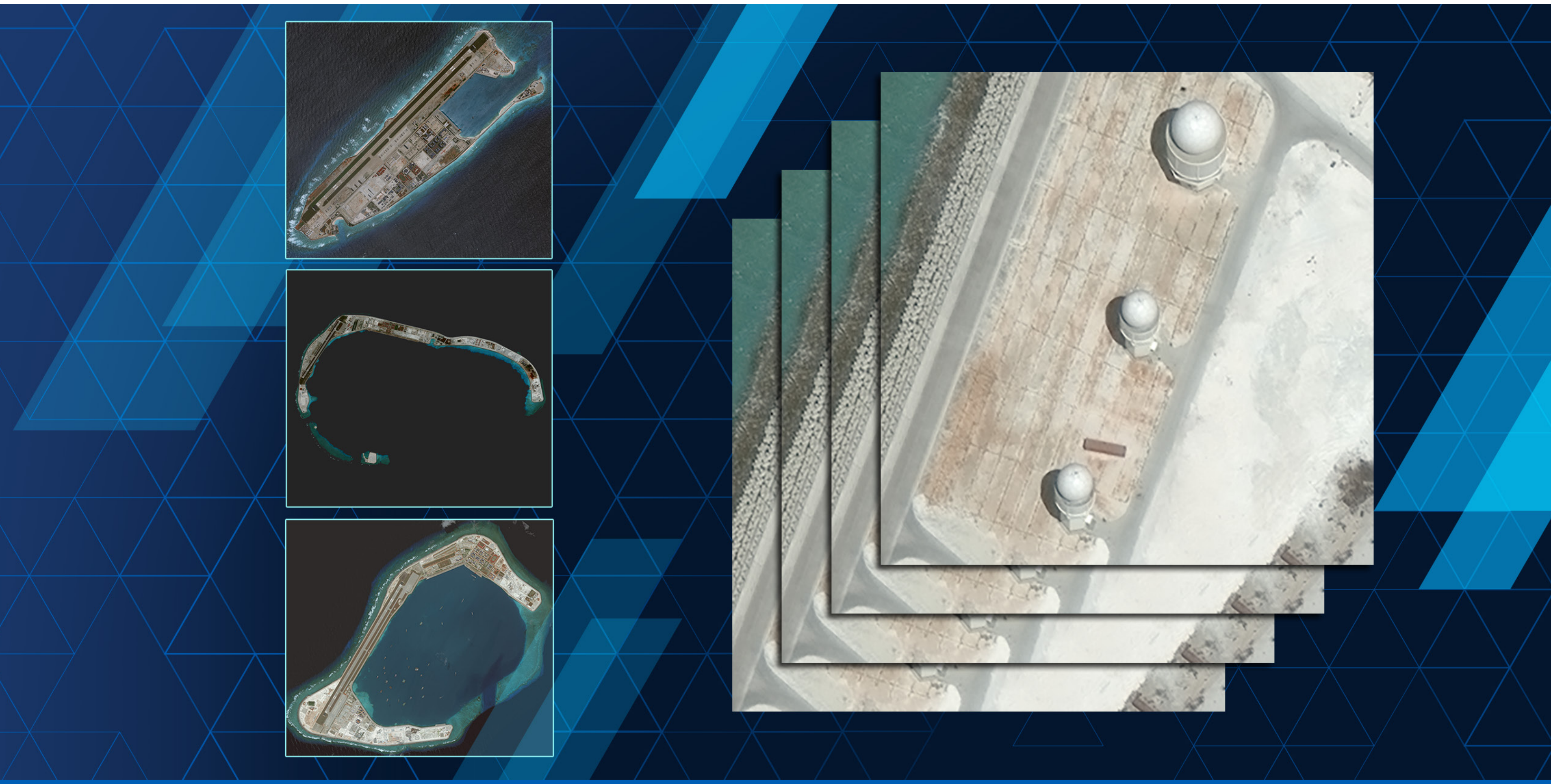
## SOUTH CHINA SEA MILITARY CAPABILITY SERIES

*A Survey of Technologies and Capabilities on China's Military Outposts in the South China Sea*



# AIR AND SURFACE RADAR

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## Introduction

This military capability (MILCAP) study focuses on air and surface radar capabilities on seven Chinese island-reef outposts in the South China Sea (SCS). These SCS MILCAP studies provide a survey of military technologies and systems on Chinese-claimed island-reefs in the Spratly Islands, approximately 1,300 kilometers (700 nautical miles) south of Hong Kong (see Figure 1). These Chinese outposts have become significant People's Liberation Army (PLA) bases that will enhance future Chinese military operations in the SCS, an area where Beijing has disputed territorial claims (see Appendix B). The SCS MILCAP series highlights a PLA informationized warfare strategy to gain and maintain information control in a military conflict.

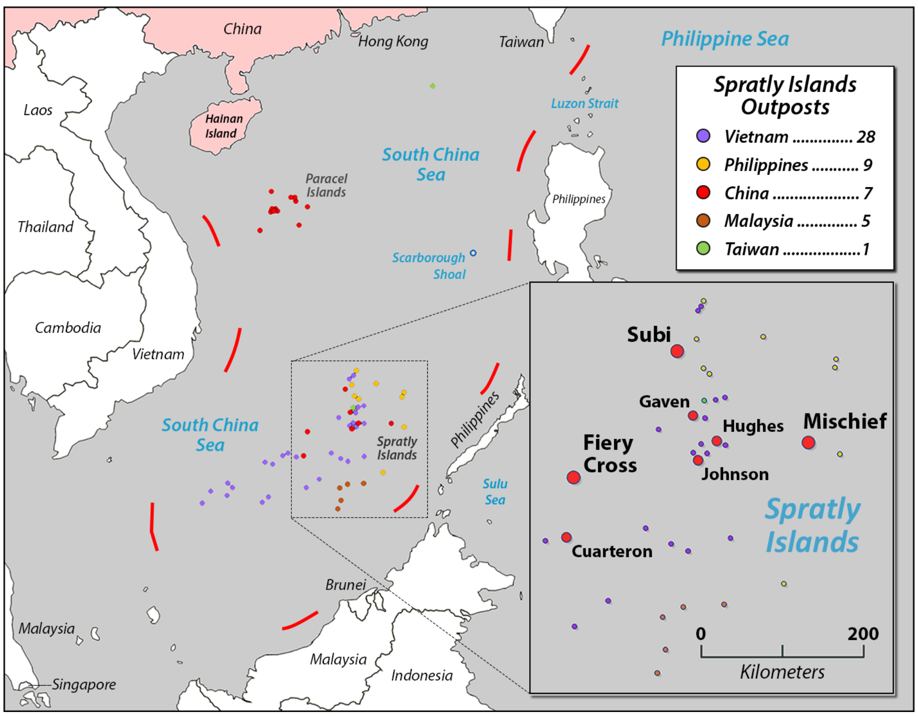



**Figure 1. SCS Occupied Features**

Radar systems on the Chinese island-reefs appear to be diverse and redundant covering a broad swath of the frequency spectrum, incorporating a range of sensor phenomenology. Over two dozen probable radars were noted on the island-reefs in total. These include likely air- and surface- search radar, target-tracking radar, microwave over-the-horizon radar that can track surface targets at long range, and a unique low-frequency radar on Subi Reef purported to have significant "counter-stealth" capabilities. Overview graphics of all capabilities noted on major outposts appear in Appendix C.

## Radar, 雷达

Radar systems arrayed on the Chinese outposts likely cover the frequency spectrum from very high frequency (VHF) (30 to 300 megahertz) up through X-band (8 to 12 gigahertz). Detection threats from the PLA radar network to foreign military ships and aircraft lie not in the strength of any one system. The radar threat on the Chinese outposts are found in the diversity, redundancy, and overlapping frequency coverage that are characteristic of Chinese capabilities focused on control of battlespace information.

Twenty-seven large radomes house radars that provide air and surface surveillance for the PLA outposts. Each major island-reef has seven large radars that are complemented by additional radars on each of the minor outposts (see Figure 2).

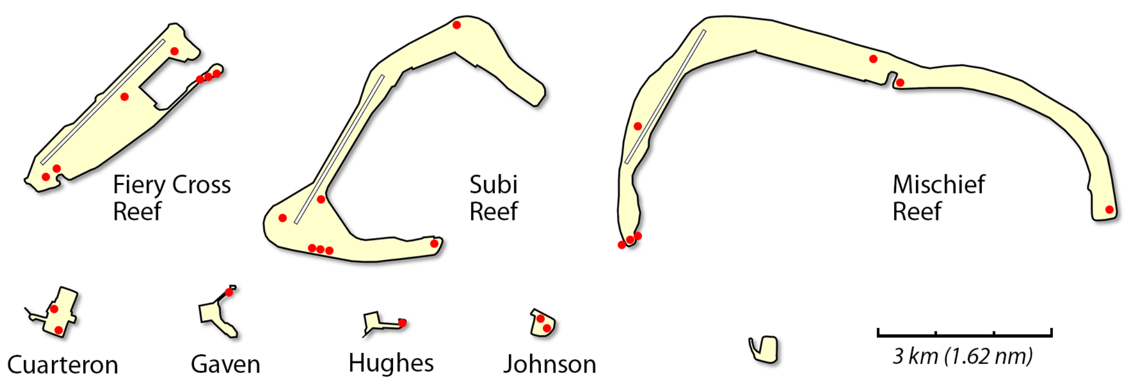



**Figure 2. Observed SCS Radar Locations, June 2018**

Tower-mounted radomes probably house large, powerful air surveillance radars operating in various frequency bands. A few may also be large multi-function or surface search radars. Many horizon-limited surface radars similar to a ship's navigation radar are relatively small and not easily identified in imagery.

Elevating a radar reduces ground clutter and extends the radar's horizon, especially against low-flying targets. The tallest Chinese island-reef tower is 36 meters (118 feet) with a 16-meter (52-foot) radome and is found on Fiery Cross, Mischief, and Cuarteron Reefs (see Figure 3).


(Image © 2020 Maxar/DigitalGlobe, Inc.)

**Figure 3. Probable Air Surveillance Radar, Fiery Cross Reef**

## Air and Surface Radar

A three-tower set of radomes ranging from 26 meters (85 feet) to 30 meters (98 feet) tall are found on each on the major island-reefs. These may be a mix of air and surface radars operating in different frequency bands (see Figure 4).


(Images © 2020 Maxar/DigitalGlobe, Inc. except upper right, courtesy of *Philippine Daily Inquirer*)

**Figure 4. Probable Air and Surface Surveillance Radar Three-Tower Sets, Subi Reef (Upper Left), Fiery Cross Reef (Lower Left), Mischief Reef (Upper Right; Satellite Image of Same—Lower Right)**

## Air Traffic Control Radar

Probable air traffic control radars are mounted on towers adjacent to air operations buildings at each of the airfields on Fiery Cross, Subi, and Mischief Reefs (see Figure 5). These radars may provide an air picture used to control military aircraft and may also contribute to China's broader air traffic control network that monitors foreign military aircraft or civilian airliners transiting the SCS.




**Figure 5. Air Traffic Control Radar, Subi Reef**

## Target Tracking Radar or Low-Altitude Air Surveillance Radar

Probable target tracking or low-altitude air surveillance radars are colocated with surface-to-air missile (SAM) facilities on each of the major Chinese outposts (see Figure 6). These tower-mounted radars may pass targeting data about low-altitude targets such as inbound cruise missiles, aircraft, and helicopters directly to SAM firing units. The radars could also be target-engagement radars used for SAM control, allowing the fire control radars normally in the SAM batteries to remain silent.

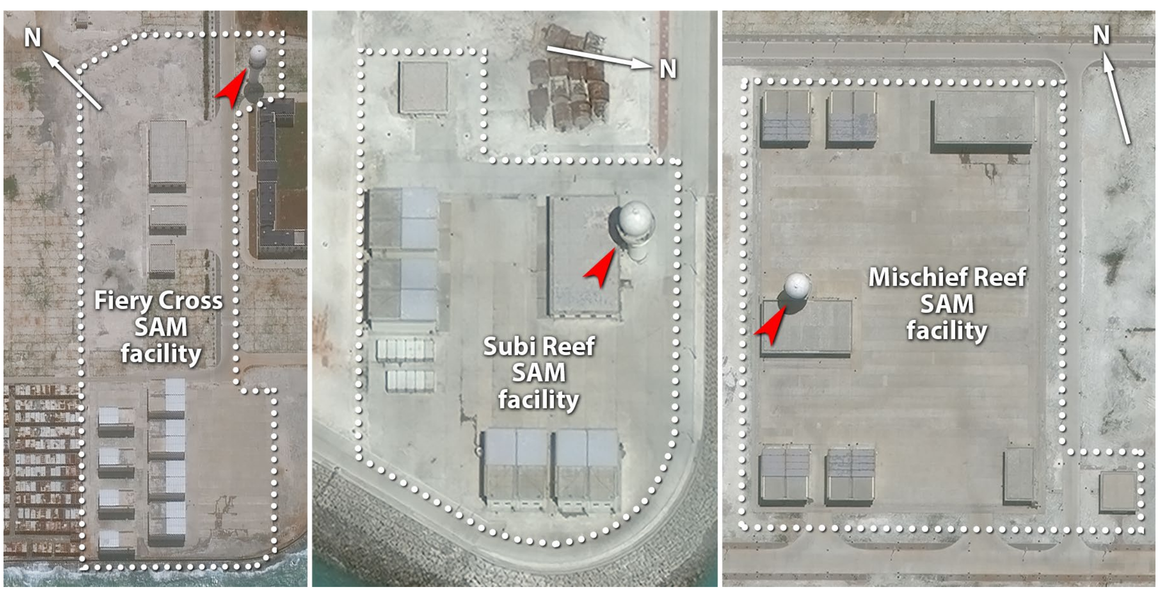


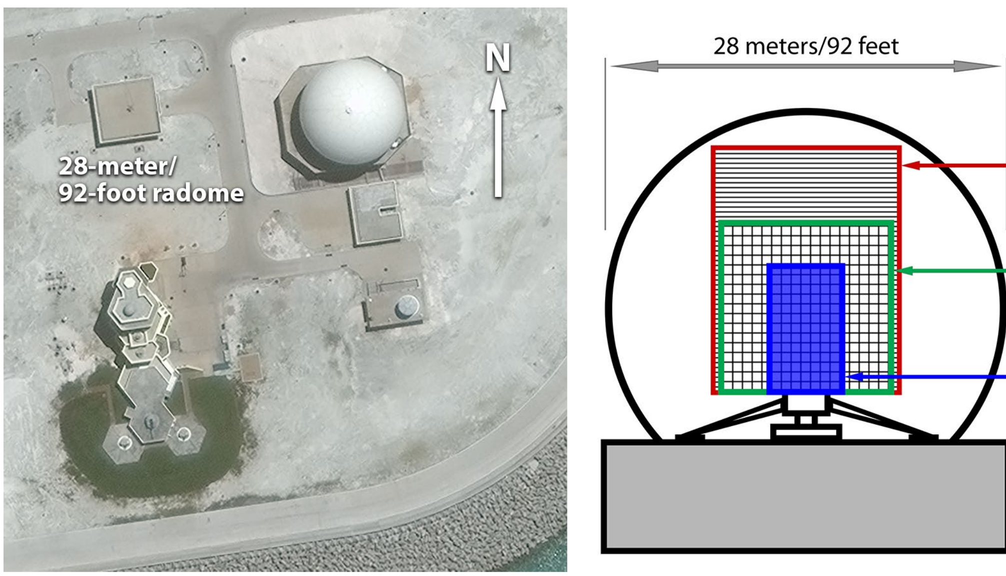



**Figure 6. SCS SAM Facility Radars**

For additional information on these SAM facilities, see the SCS MILCAP study titled "Offensive and Defensive Strike Capabilities."

## Mischief Reef Large Radome

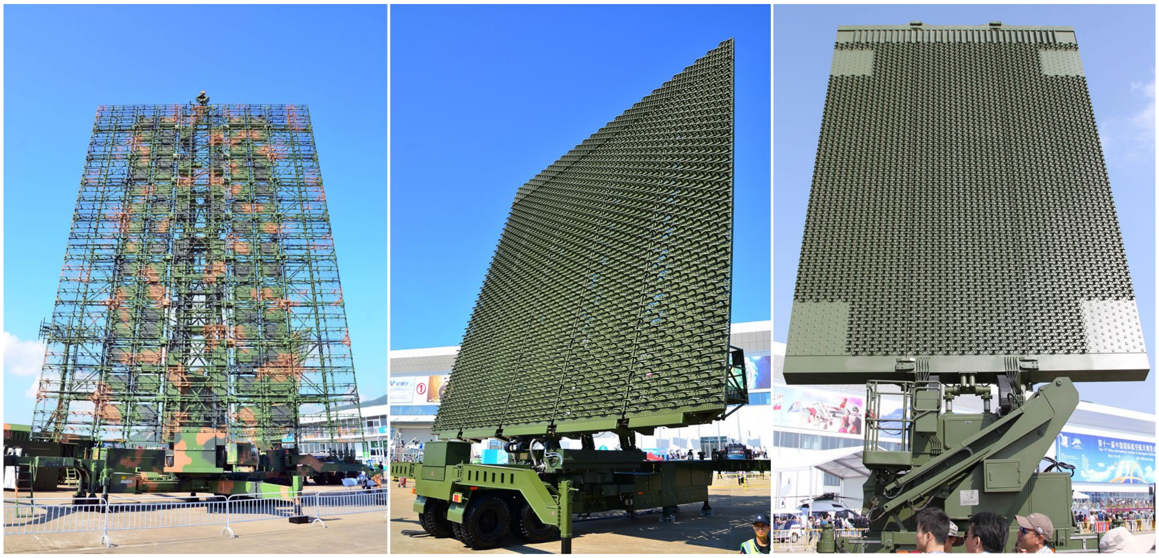
A 28-meter (92-foot) diameter radome is located on the far eastern end of Mischief Reef and may house an extremely large VHF- or ultra high frequency (UHF)-band radar. The massive covering is 11 meters (36 feet) larger in diameter than any other radar-associated radome on any other island-reef. Estimating the height of the rounded radome from overhead imagery is difficult, but the interior clearance is probably between 20 and 22 meters (66 and 72 feet) (see Figure 7).




(Image © 2020 Maxar/DigitalGlobe, Inc.)

**Figure 7. Mischief Reef Large Radome (Left) and Dimensions of Candidate Radars (Right)**

Chinese research institutes (RIs) produce a number of very large radars for the PLA that are designed to operate in lower frequency bands. Such low-frequency radars are likely candidates for the contents of the Mischief Reef large radome (see Figure 8). All of these arrays require space within the dome to spin. The largest of these radars is the JY-27A, produced by the 38$^{th}$ RI that operates in the VHF-band. Assuming a 2- to 3-meter base, the 20-meter JY-27A antenna is likely too tall for the housing. There are a number of radars similar in size to the L-band (1–2 gigahertz) SLC-7 radar, but these would be dwarfed by the massive 28-meter radome. The radar that is most likely housed in this radome is in the same class as the UHF-band (300–1,000 megahertz) YLC-8B radar, also known as the Type-609 "intelligence radar" (情报雷达), that appeared at the China Air Show in November 2018.




(JHU/APL Photos)

**Figure 8. Examples of Chinese Surveillance Radars JY-27A (Left), YLC-8B (Center), and SLC-7 (Right)**

The 14th RI promotes the YLC-8B as a radar optimized for early warning detection of airborne targets that also has sufficient resolution to perform target tracking functions. The YLC-8B reportedly has the capability to track stealth aircraft because of its low, UHF-band operating frequency.[1] Three-dimensional UHF radars in this class also have advertised capabilities to detect and track small-radar-cross-section missiles at long range as well as ballistic missiles and other near-space objects.

## Subi Reef Counter-Stealth Radar

A large, circular radar array identified by Chinese researchers as a synthetic impulse and aperture radar (SIAR) is located on Subi Reef (see Figure 9). This VHF-band radar is purported to have significant "counter-stealth" capabilities. For more information on this array, see the SCS MILCAP study, "In Depth: Chinese Counter-Stealth Radar."


**Figure 9. Subi Reef SIAR Array**
(Image © 2020 Maxar/DigitalGlobe, Inc.)

[1] "YLC-8B Medium/High Altitude Long Range 3D Surveillance Radar," data sheet, NRIET (Nanjing Research Institute of Electronics Technology aka 14th RI), 2016.

## Radar Detection Ranges

Figure 10 shows line-of-sight radar coverage from the Chinese-held SCS island-reefs. Radar coverage against airborne or surface targets is often simply expressed as the direct line of sight to a target limited only by the curve of the Earth (see Figure 11).[2] Determining actual radar detection ranges involves equations that must account for the frequency of the radar, the reflected radar cross section of the target at that frequency, radiated power of the radar, antenna gain, signal processing, atmospheric attenuation, and other factors. Operating many different types of radar with different waveforms in a variety of frequency bands may mitigate the effects of weather or countermeasures such as stealth or electronic jamming.

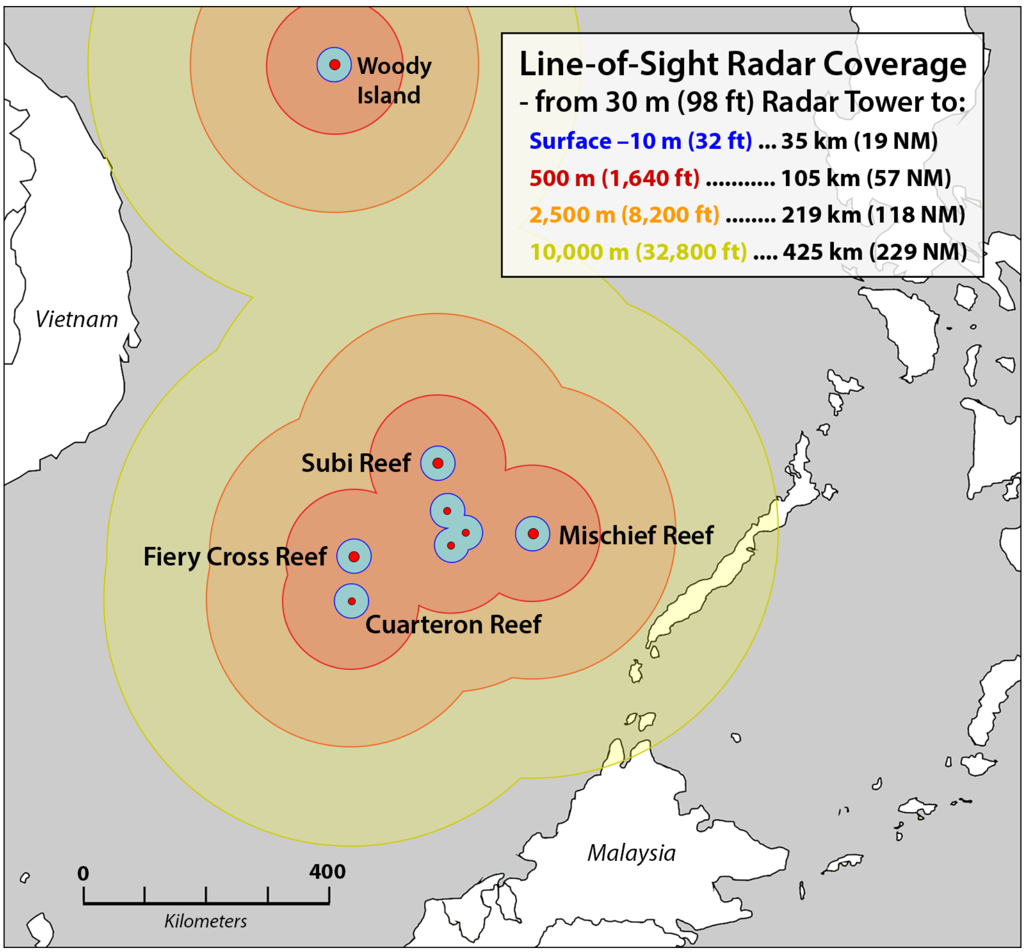



**Figure 10. Potential Radar Coverage from China's SCS Outposts**

[2] *Calculated radar line-of-sight is slightly farther than visual line-of-sight due to the refraction of radio waves in the atmosphere. See, for example, calculations at:* www.rfcafe.com/references/electrical/ew-radar-handbook/radar-horizon-line-of-sight.htm.

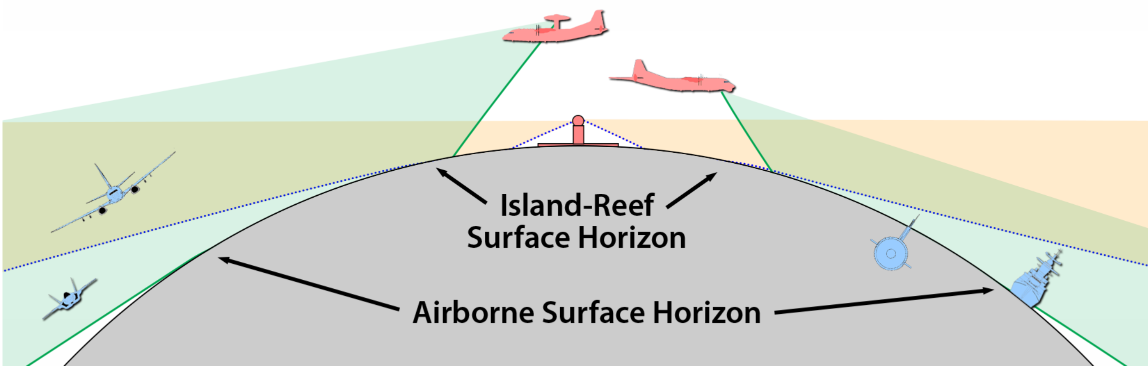



**Figure 11. Representation of Island-Reef and Airborne Surface Horizon**

Radars with sufficient power, antenna gain, and processing, like many of those probably housed within the outpost radomes, should have detection ranges of several hundred kilometers against a relatively small radar-cross-section target. This network will generate good situational awareness against larger targets, such as civilian airliners, or maritime patrol aircraft, such as the U.S. Navy P-8A *Poseidon*.

## Airborne Radar

This study focuses primarily on ground-based air- and surface-radar noted on the Chinese island-reefs. However, manned or unmanned aircraft flying from the island-reef airfields will also contribute to the radar picture generated by the PLA outposts. PLA aircraft with capable radars that can detect airborne or surface targets include the KJ-500 airborne early-warning and control (AEW&C) aircraft and the Y-9Q anti-submarine warfare/maritime patrol (ASW/MARPAT) aircraft (see Figure 12). Both of these aircraft were seen in commercial satellite imagery at the airfield on Fiery Cross Reef in April 2020.[3] For more information on these capabilities, see the SCS MILCAP study, "Special Mission Aircraft and Unmanned Systems."

(Japanese Ministry of Defense Photos)

**Figure 12. KJ-500 AEW&C Aircraft (Left) and Y-9Q ASW/MARPAT Aircraft (Right)**

[3] "Fiery Cross Reef: Permenant Base for ISR Aircraft in the South China Sea," *ImageSat International*, June 14, 2020. https://storymaps.arcgis.com/stories/476d0c84a9f84046b9866db8f9405f72

The detection range of airborne radar, like ground-based radar, may be limited by the radar cross section of targets or atmospheric attenuation. Potential airborne line-of-sight radar coverage from a KJ-500 AEW&C aircraft orbiting over the Spratly Islands and two Y-9Q ASW/MARPAT aircraft patrolling the SCS appears in Figure 13.

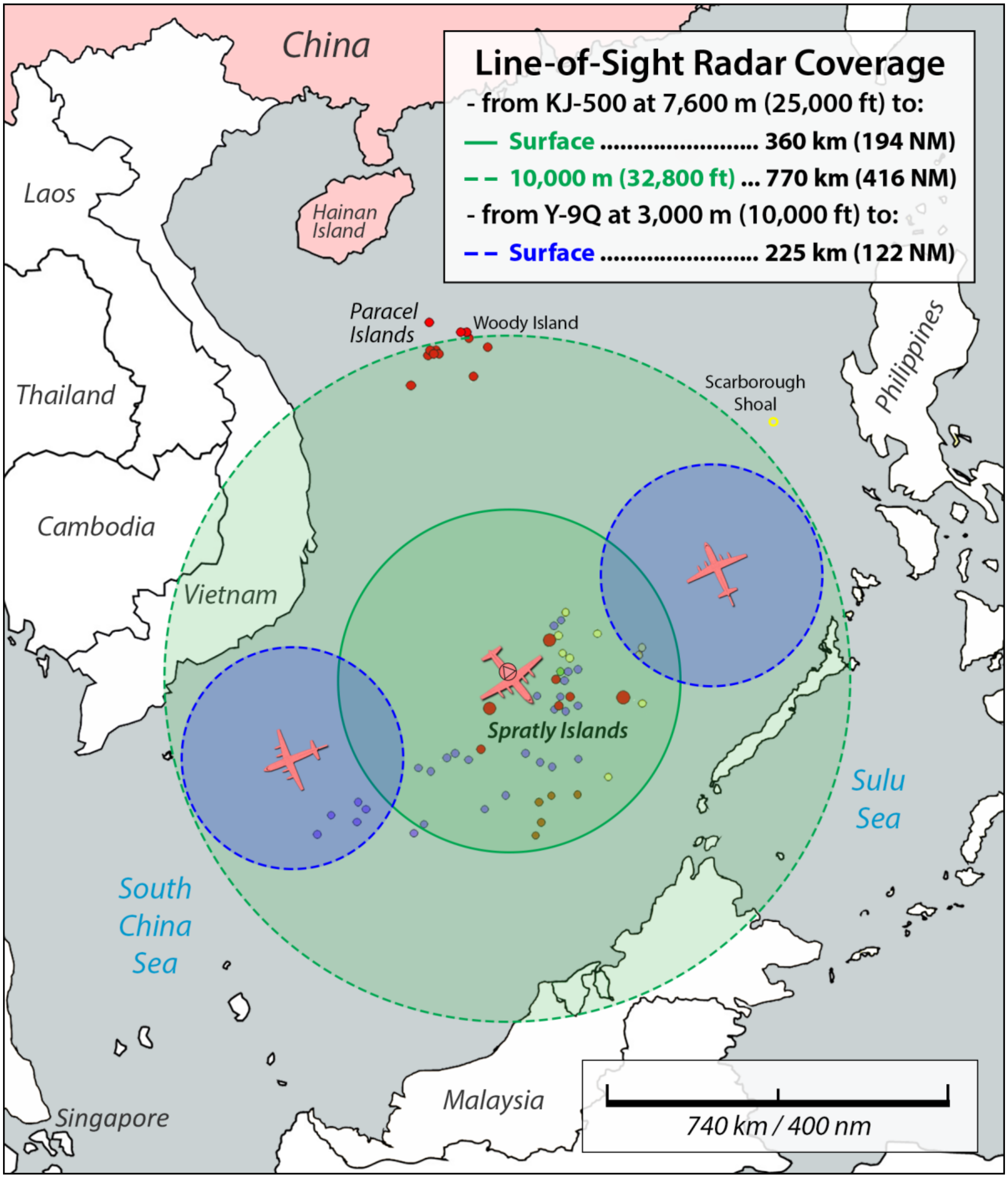



**Figure 13. Airborne Line-of-Sight Coverage from KJ-500 AEW&C and Y-9Q ASW/MARPAT**

## Over-the-Horizon Radar, 微波超视距雷达

Seven radomes arrayed throughout the island-reefs are probably over-the-horizon radars that may provide a detection capability against surface targets at ranges up to 450 kilometers (243 nautical miles). Figure 14 shows the locations of the probable over-the-horizon radars. Three pairs of identical structures, 9 by 15 meters (30 by 49 feet), topped with a single cylindrical radome, have been built at extreme ends of each major island-reef for maximum separation, which probably improves the pairs' ability to triangulate signals. Cuarteron Reef hosts a single structure of this type. The structures are all set close to shore with an unobstructed view of the water (see Figure 15). Given the appearance of the structures, their relative locations, field of view, and height above the water, these radomes probably house an active-passive over-the-horizon radar system similar in design and function to the Russian Mineral-ME or Monolit-B systems. Chinese engineers refer to these over-the-horizon radar as a "microwave over-the-horizon radar" (微波超视距雷达).[4]

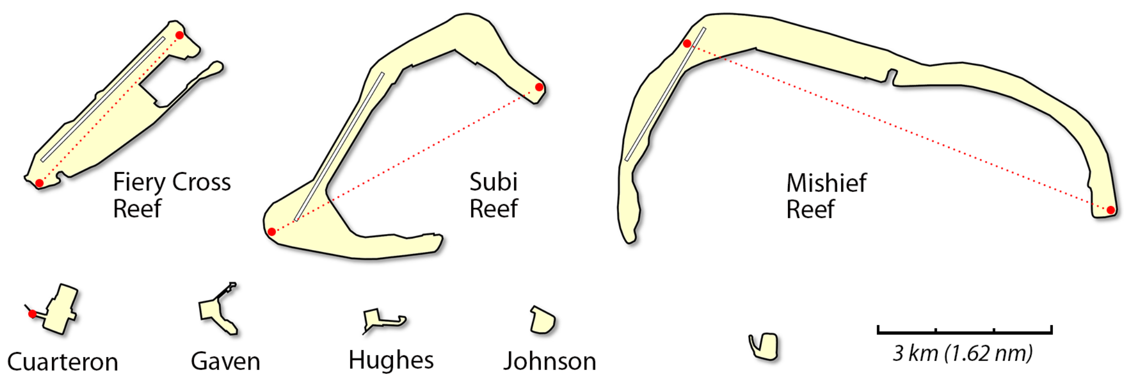



**Figure 14. Observed Probable Over-the-Horizon Radar Locations, June 2018**

China acquired Mineral-ME technology through its purchase of two Russian-export Sovremenny guided-missile destroyers in the 1990s. Since then, the Mineral-ME reportedly evolved into a Chinese-designed "fourth-generation" over-the-horizon radar called the H/LJQ-366 or Type-366 Radar.[5] Most ships in the PLA surface fleet are equipped with the H/LJQ-366 over-the-horizon radar system.

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[4] Kang Shifeng, Zhang Yusheng, and Wang Hongguang, "微波超视距雷达大气波导环境" [Atmospheric Ducting Environment for Microwave Over-the-Horizon Radar], 装备环境工程 [Equipment Environmental Engineering] 10, no. 5 (October 2013): 85.

[5] The H/LJQ-366 designator for this Chinese over-the-horizon radar is widely used in commercial sources such as IHS Jane's as well as PLA enthusiast websites and social media. See, for example, "'Mineral-ME'/H/ LJQ-366 型超视距雷达在中国海军舰艇的应用" [Use of "Mineral-ME"/H/LJQ-366 Over-the-Horizon Radar on Chinese Naval Vessels], 微博 [Weibo (Social Media)], October, 10, 2017, https://www.weibo.com/ttarticle/p/show?id=2309404157853186311011.


(Images © 2020 Maxar/DigitalGlobe, Inc., Philippine Daily Inquirer (Right))

**Figure 15. Probable Over-the-Horizon Radar, Northern Fiery Cross (Right), Southern Subi Reef (Center) and Cuarteron Reef (Left)**

The Russian over-the-horizon radar was designed as a shipborne (Mineral-ME) or coastal-based (Monolit-B) system for maritime surveillance and anti-ship missile targeting. It consists of three elements—an active radar that operates in lower X-band (8–10 gigahertz), a "passive radar" or electronic intelligence system that can detect signals between 1 and 12 gigahertz, and a targeting data link. The system has an advertised active detection range of 250 kilometers (135 nautical miles) and a passive detection range of 450 kilometers (243 nautical miles) (see Figure 16).[6]

The Chinese H/LJQ-366 is capable of detecting targets over such long distances by exploiting a phenomenon called atmospheric ducting. Specifically, these systems rely on detecting electromagnetic waves trapped in a marine evaporative duct formed by the large humidity gradient just above the sea surface. The active over-the-horizon radar is set within the height of the evaporative duct and its radar waves are super-refracted downward, essentially bending them with the curve of the Earth. Reflections of the active radar or electronic signals emitted by targets may also become trapped in a surface duct and will travel over long distances back to the radar's passive receiver.[7]

The data link associated with these over-the-horizon radars allows the island-reef stations as well as nearby PLA Navy ships equipped with the H/LJQ-366 to triangulate

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[6] "Mineral-ME," data sheet, Rosoboronexport (Russian Defence Export), 2018, http://roe.ru/pdfs/pdf_2266. pdf. See also, "Monolit-B Coastal System for Surface and Air Recommanssance," Typhoon Joint Stock Company, 2020, http://www.typhoon-jsc.ru/en/index.php.

[7] KangShifeng et al.,"海洋无线电装备电波环境信息保障技术"[MarineRadioEquipmentElectromagnetic Environment Information Protection Technology], 装备环境工程 [Equipment Environmental Engineering] 14, no. 7 (July 2017): 1.

and locate targets by exchanging radar returns and electronic signal detections.[8] The location and orientation of the seven structures noted on China's SCS outposts are ideal, achieving maximum separation to effectively cross-fix target lines of bearing. While the shipborne Mineral-ME data link is advertised as limited by the surface horizon (approximately 35 kilometers), the Chinese systems probably link target information among outpost radars using inter-island communications.

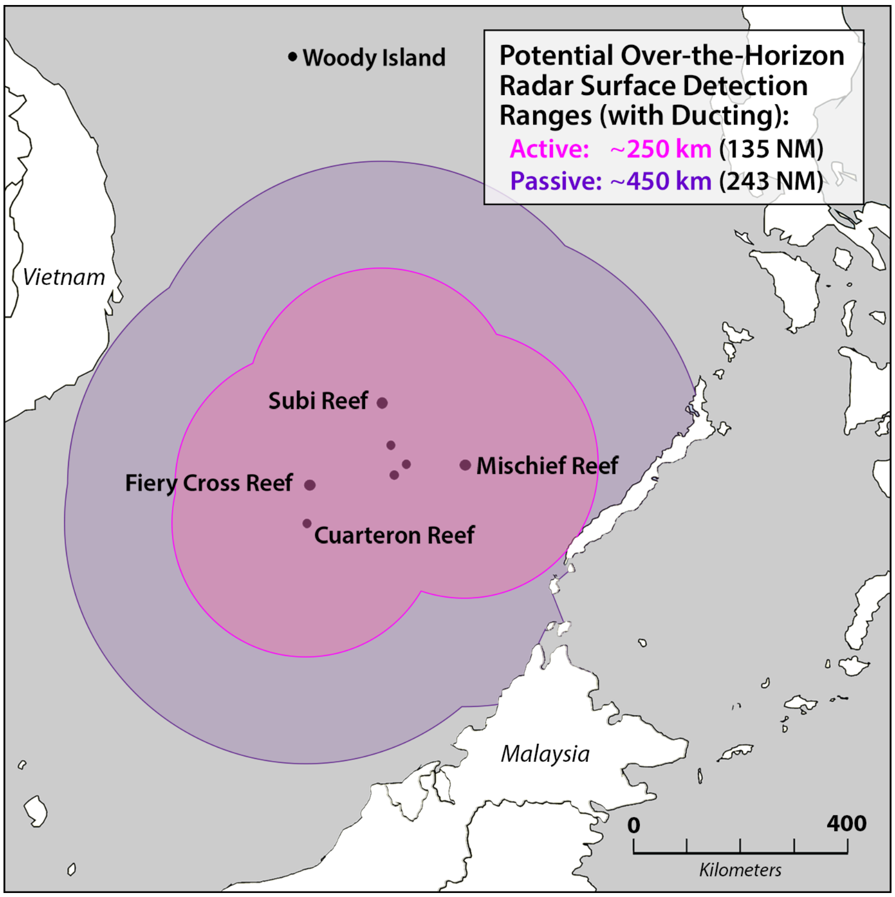


**Figure 16. Potential Over-the-Horizon Surface Target Detection Ranges**

High-fidelity weather and hydrology forecasting greatly enhances exploitation of atmospheric ducting by this type of over-the-horizon radar system. The SCS outposts' meteorological stations likely provide such data. For additional information on outpost meteorological facilities, see the SCS MILCAP study "Hardened Infrastructure, Battlespace Environmental Management and Counter-Reconnaissance."

[8] Hqy1228, "'Mineral-ME'/ H/LJQ-366 型超视距雷达在中国海军舰艇的应用" [Use of "Mineral-ME" / H/LJQ-366 Over-the-Horizon Radar in Chinese Naval Vessels], *Weibo* (blog), October 1, 2017, https://www.weibo.com/ttarticle/p/show?id=2309404157853186311011.

## Conclusions

Observations of the radar infrastructure on the China's SCS island-reefs indicates the PLA has a number of different types of radar operating across a broad swath of the frequency spectrum. The Subi Reef SIAR "counter-stealth radar" operates in the low VHF-band. The large radome on Mischief Reef almost certainly houses a VHF-band or, more likely, UHF-band radar. Radars operating in L- or S-band for surveillance up through X-band used for missile targeting are likely found throughout the seven island-reefs based on the size of radomes and their colocation with certain facilities. High-frequency (HF) sky-wave or surface-wave radar arrays were not seen in commercial satellite imagery. However, seven identical structures are likely X-band over-the-horizon radars. These radars are capable of actively and passively detecting and triangulating surface ship targets several hundred kilometers from the island-reefs. As of mid-2020, ISR aircraft were deployed to the Chinese SCS outposts. These aircraft provide significant improvements in PLA radar coverage, especially at low-altitude and against surface targets at long range.

Overlapping, redundant coverage from the PLA's radar system-of-systems creates a complex electromagnetic environment in the SCS. Potential radar coverage from island-reef-based radar systems and aircraft launched from outpost airfields is shown in Figure 17. A single PLA Navy surface ship equipped with a substantial air surveillance radar is also included in this graphic. Multiple ships and aircraft networking their air and surface pictures with outpost radars may significantly extend and enhance sensor coverage in the SCS. Again, radar detection ranges depicted in Figure 17 may be significantly limited by factors such as atmospheric attenuation or the small radar cross section of a radar's target.

The PLA commitment to diverse and redundant radar systems demonstrates an informationized warfare strategy that emphasizes battlespace information control. Radar diversity and redundancy with coverage across the frequency spectrum is consistent with the PLA's design approach to other complex system-of-systems such as island-reef communications. The detection threat to foreign militaries operating in the SCS is not from a single radar system but from the sum total of different radars operating in conjunction with other reconnaissance systems. These island-reef-based capabilities will ultimately network with space-, air-, surface-and underwater-based systems to create a diverse, distributed PLA sensor network. Simultaneous electromagnetic jamming against all frequency bands covered by the PLA is a difficult proposition. Countering complex Chinese sensor networks will require an integrated system-of-systems approach integrating kinetic and non-kinetic means to deny PLA designs to gain and maintain battlespace information advantage.

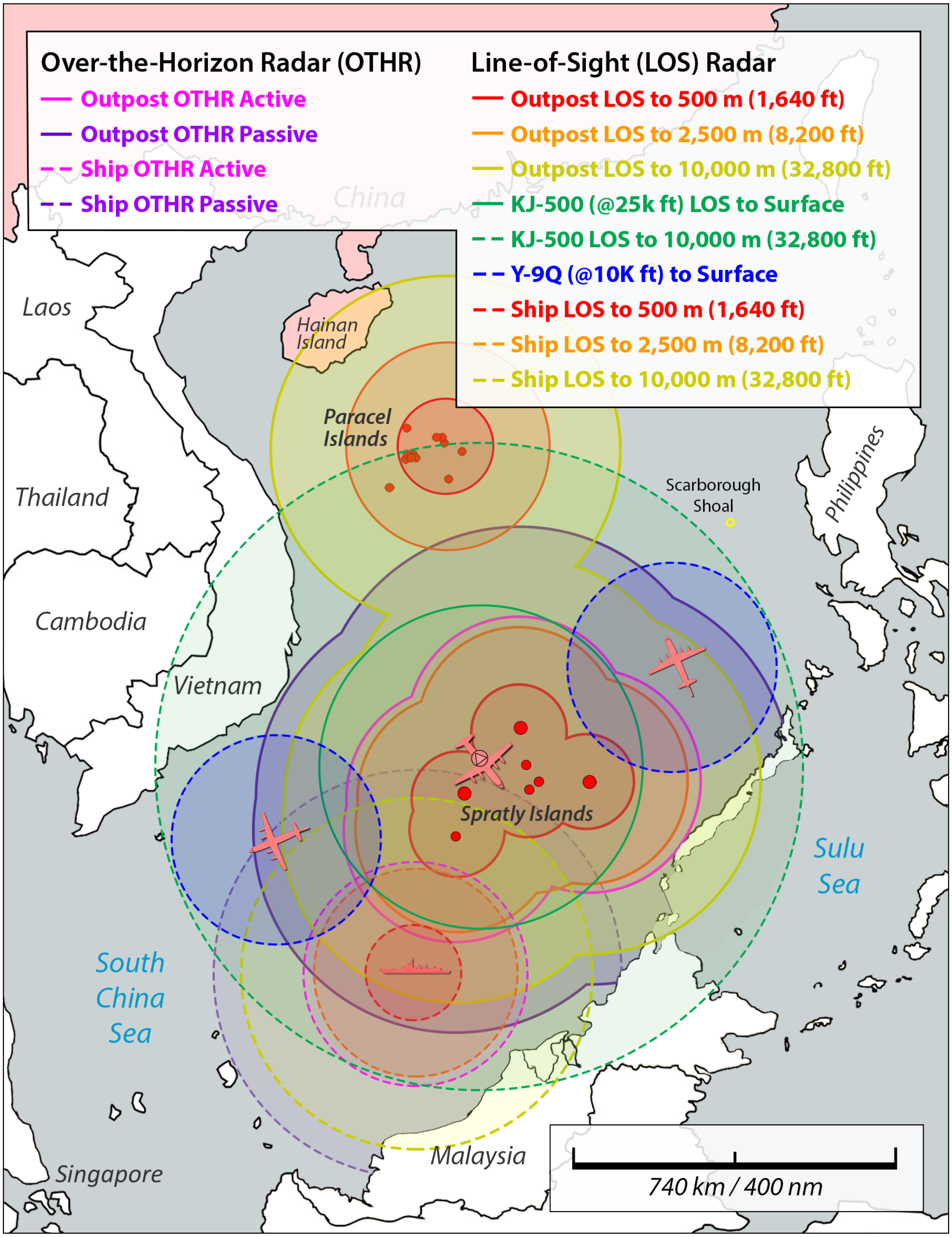


**Figure 17. Potential Island-Reef Generated Radar Coverage**

# Appendix A. Sources and Methods

Observations and analysis of the Chinese SCS outposts in these MILCAP studies rely on commercial satellite imagery licensed to JHU/APL and collected by the Maxar/DigitalGlobe Inc. WorldView-3 satellite (see Table 1). WorldView-3 can collect images up to 30-centimeters resolution, which translates to image quality between 5.0 and 6.0 on the National Imagery Interpretation Rating Scale (NIIRS).[9] For these studies, software like Google Earth Pro and Adobe Photoshop were used to interpret imagery, measure features, and adjust image color and balance. These images were not subject to any special processing or proprietary enhancements.

**Table 1. DigitalGlobe Inc. WorldView-3 Satellite Imagery Details**

| Island-Reef | Location | Date | DigitalGlobe Image ID |
|---|---|---|---|
| Fiery Cross Reef | 09°33′00″ N, 112°53′25″ E | June 14, 2018 | 104001003C49BB00 |
| Subi Reef | 10°55′22″ N, 114°05′04″ E | June 19, 2018 | 104001003E841300 |
| Mischief Reef | 09°54′10″ N, 115°32′13″ E | June 19, 2018 | 104001003D964F00 |

Reference images published in these studies cover hundreds of square meters, which necessarily obscures many specific features used in making assessments. Zoomed-in examples of details available in these satellite images are shown in Figure 18. The dots made up of only a few pixels in Figure 18(A) cannot be readily identified. However, their location on the basketball court leads to a conclusion that these may be personnel. As shown in Figure 18(B), observing shadows and other features may reveal structures such as a common HF dipole antennae, even if the fine-gauge wires cannot be seen in the image. Shadow length may be translated into object height using satellite image metadata and simple trigonometry. Figure 18(C) is an example that indicates the likely connection between two widely separated troposcatter terminals based on antenna pointing angles. Figure 18(D) demonstrates that positive identification of detailed features may be possible with a much higher quality reference image. The PLA Navy Type 056 corvette in the satellite image may be an anti-submarine warfare variant (Type 056A) based on the light colored feature seen where the door for a towed sonar array should be located.[10]

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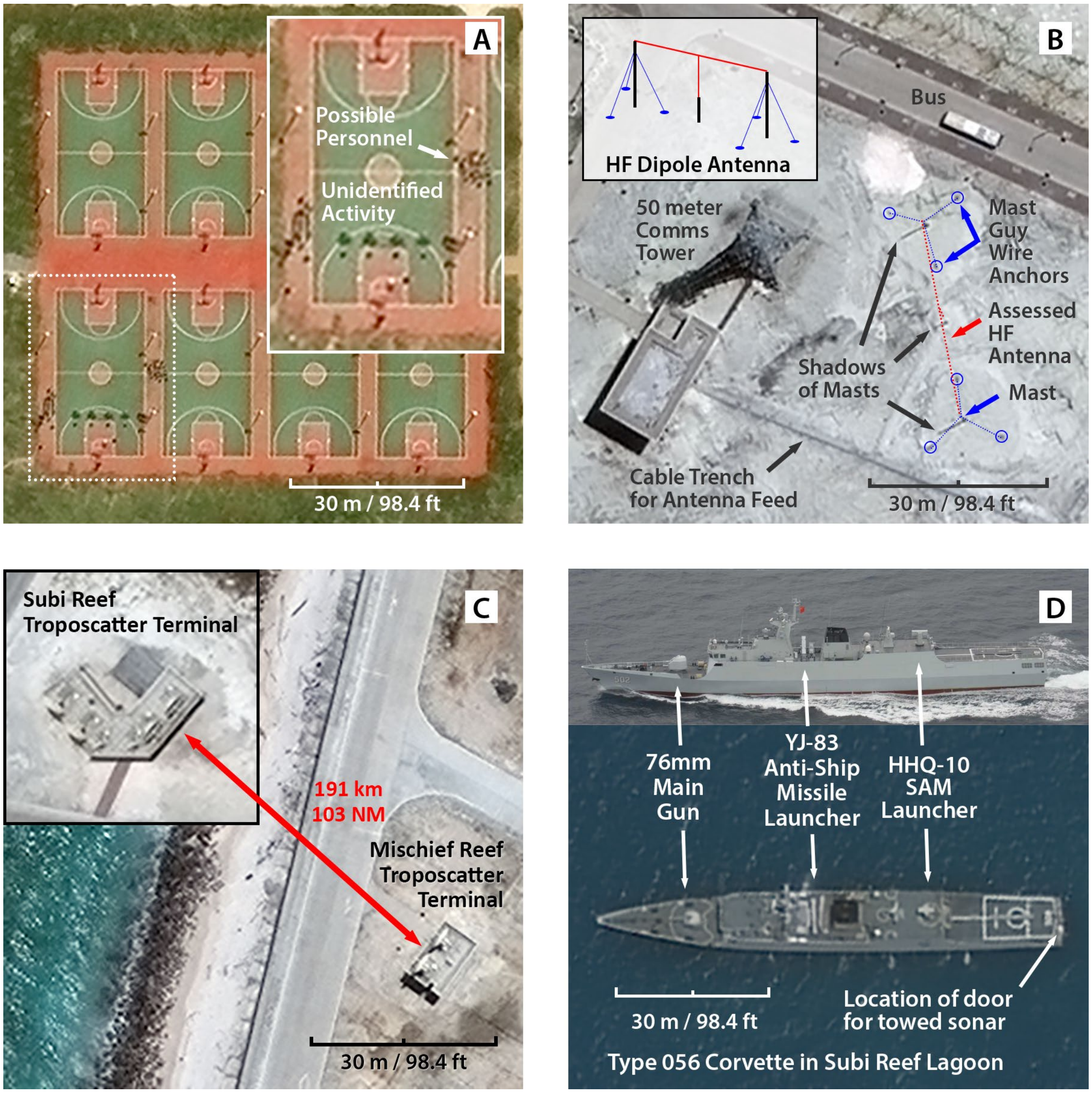
[9] Leigh Harrington, David Blanchard, James Salacain, Stephen Smith, and Philip Amanik, *General Image Quality Equation; GIQE version 5*, (Washington, DC: National Geospatial-Intelligence Agency (NGA), 2015), https://gwg.nga.mil/ntb/baseline/docs/GIQE-5_for_Public_Release.pdf.

[10] See close-up images of the towed array door in "'Sanmenxia,' First Type 056A ASW Corvette (Jiangdao Class), Commissioned in Chinese Navy (PLAN)," *Navy Recognition*, November 19, 2014, accessed July 1, 2020, http://navyrecognition.com/index.php?option=com_content&view= article&id=2189.




(Images © 2020 Maxar/DigitalGlobe, Inc. Photograph of ship courtesy of Japan Self Defense Force)

**Figure 18. Detailed Image Examples. (A) Mischief Reef Basketball Courts, (B) Mischief Reef HF Antenna, (C) Troposcatter Terminals, (D) Type 056 Frigate**

Publicly accessible satellite imagery, available on Google Earth or from organizations like the Asia Maritime Transparency Initiative, provides historical images that may show changes to island-reef features over time. Official or semi-official Chinese sources discussing military capabilities on the SCS outposts complement imagery analysis and help qualify imagery observations. Where appropriate, these studies also reference secondary sources such as credible media reporting on China's SCS island-reefs or public U.S. government statements about PLA capabilities in the SCS.

# Appendix B. South China Sea Maritime Territorial Claims

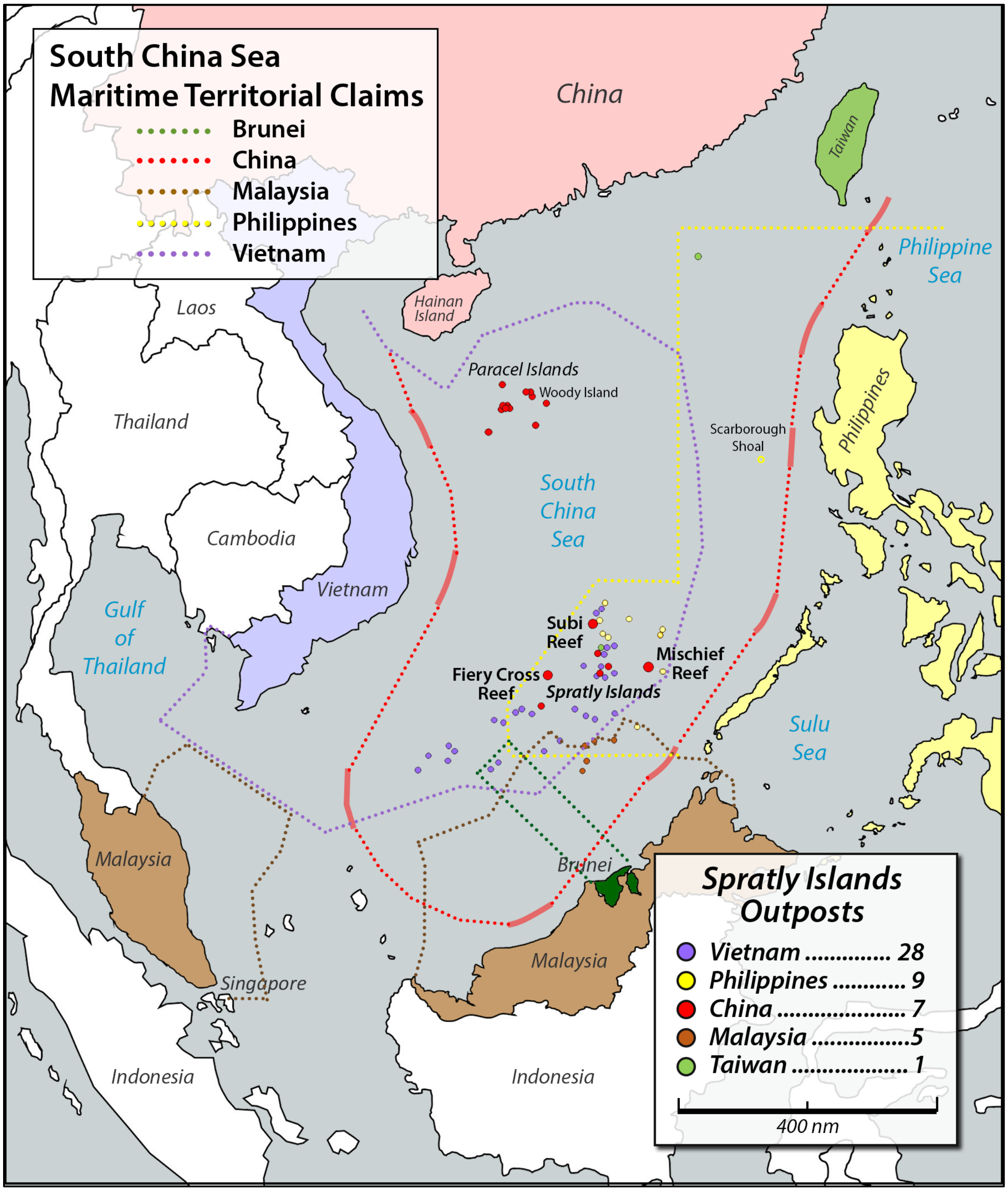



**Figure 19. South China Sea Maritime Territorial Claims**

## Appendix C. Island-Reef Capabilities Overview Graphics

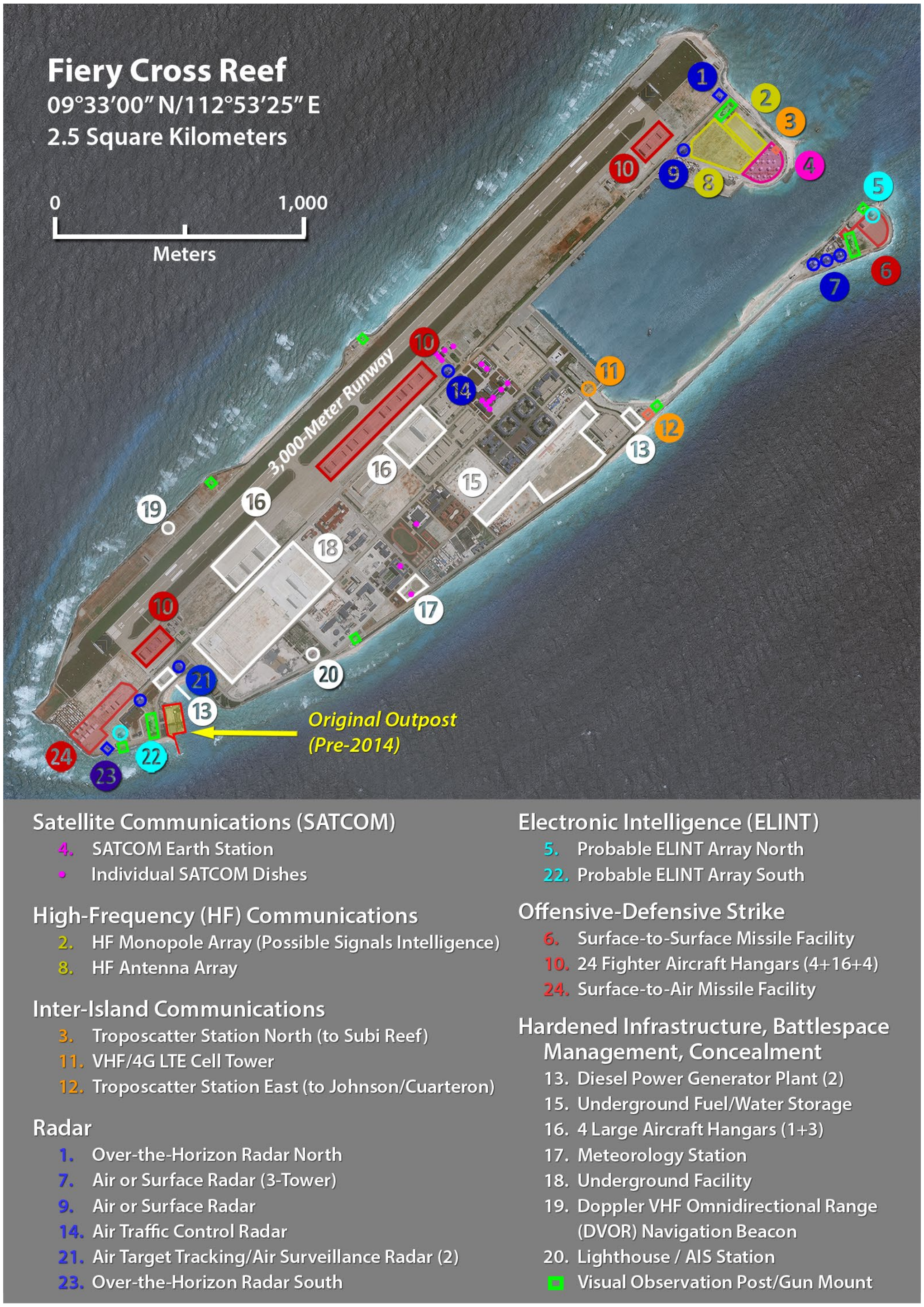
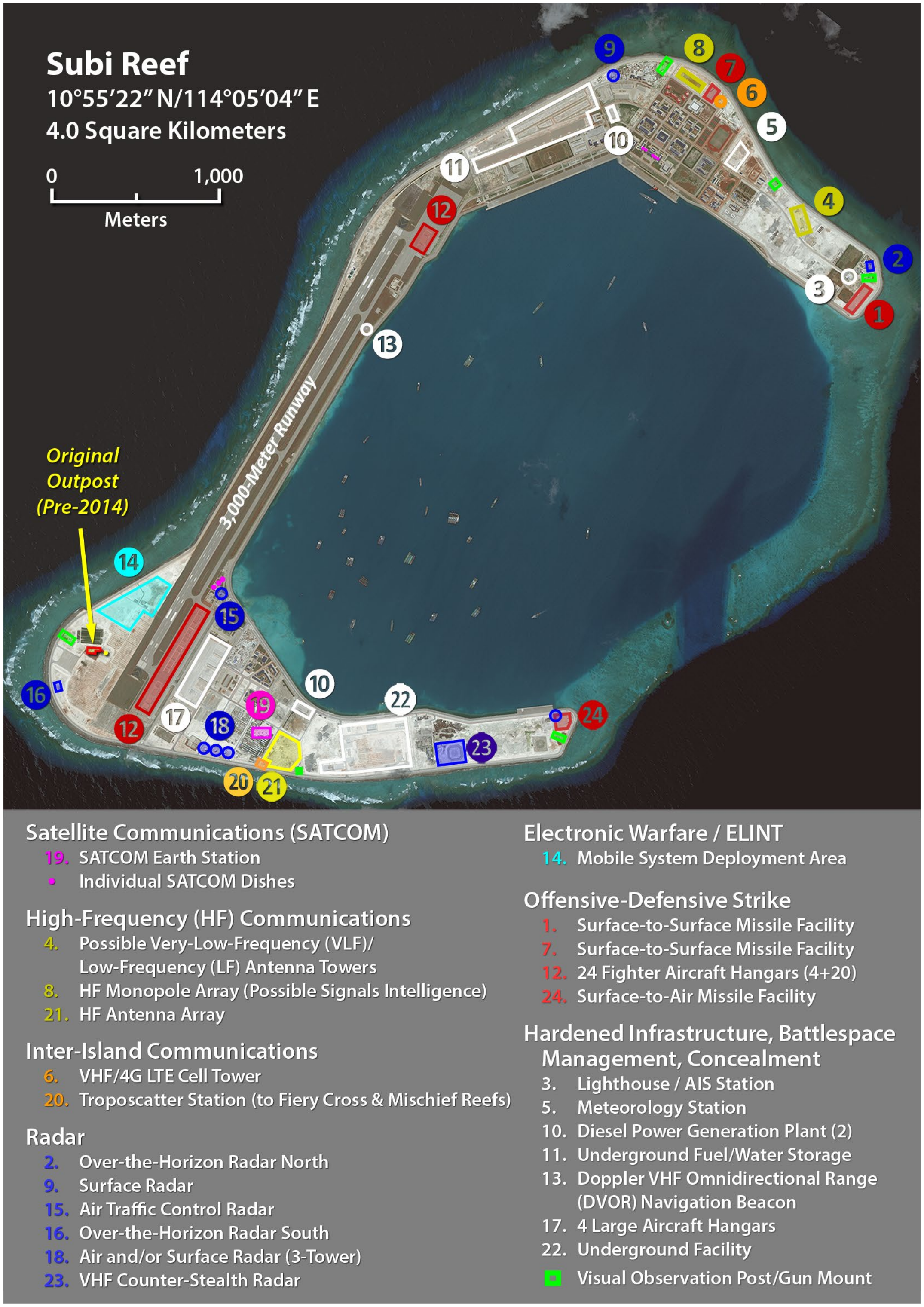


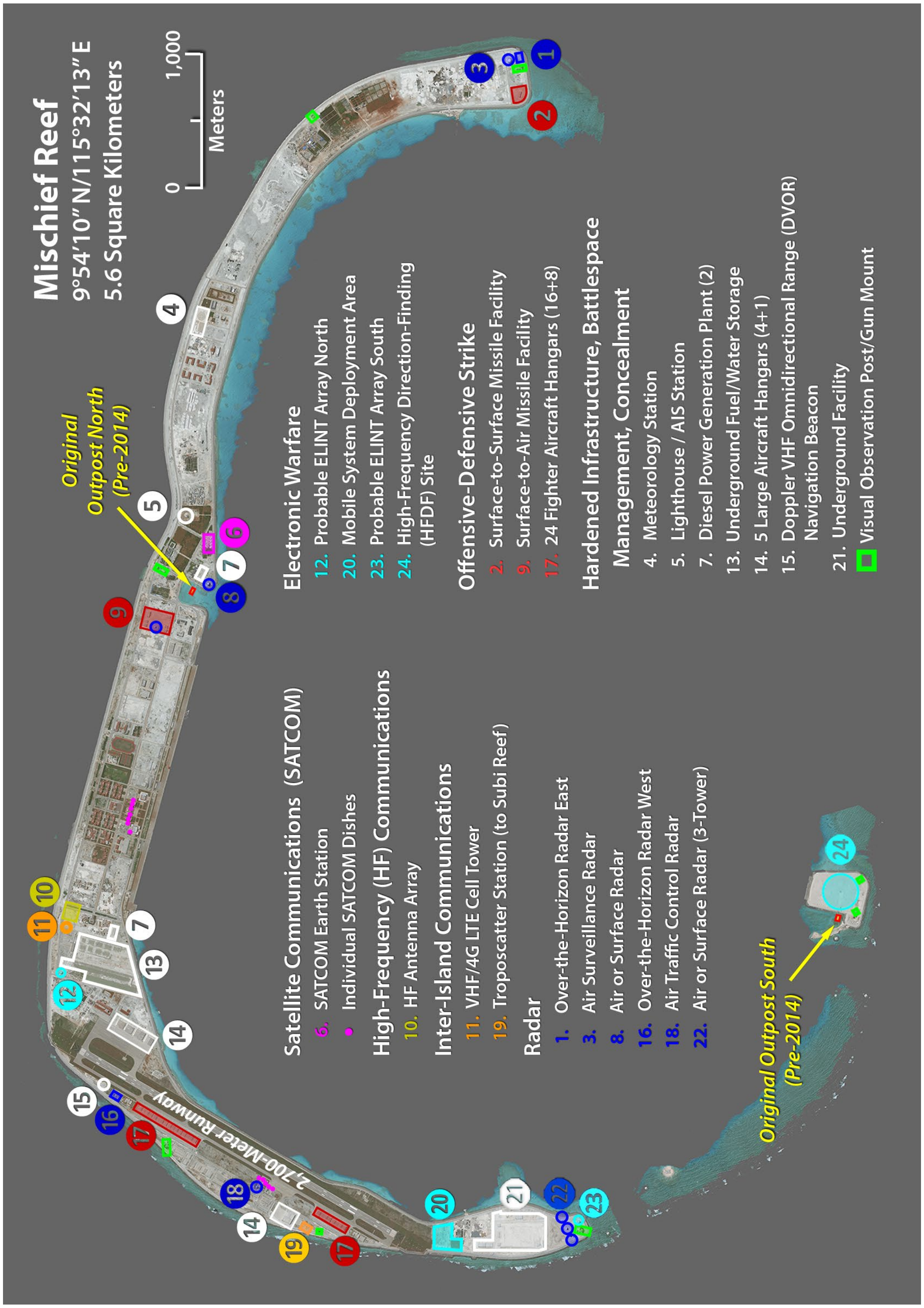



**Figure 20. Fiery Cross Reef Overview**




(Image © 2020 Maxar/DigitalGlobe, Inc.)

**Figure 21. Subi Reef Overview**




(Image © 2020 Maxar/DigitalGlobe, Inc.)

**Figure 22. Mischief Reef Overview**

# Appendix D. Definitions and Abbreviations

**AIS—**Automatic identification system; tracking system used by large ships

**4G LTE—**Fourth-generation long-term evolution; cellular communications

**ASCM—**Anti-ship cruise missile

**C4—**Command, control, communications, and computers. Sometimes rendered C3, dropping “computers” or C2, “command and control”

**C4ISR—**Command, control, communications, computers, intelligence, surveillance, and reconnaissance. Sometimes C5ISR or C5ISRT, including “cyber” and “targeting”

**CCD—**Camouflage, concealment, and deception

**ELINT—**Electronic intelligence

**EMS—**Electromagnetic spectrum; common frequency bands are shown in Table 2

**Table 2. Radio and Radar Frequency Bands**

<table>
<tr><th>ITU Radio Bands</th><th>Band Name</th><th>Frequency Range</th><th>IEEE Radar Bands</th><th>Frequency Range</th></tr>
<tr><td>VLF</td><td>Very-low frequency</td><td>3-30 kHz</td><td></td><td></td></tr>
<tr><td>LF</td><td>Low frequency</td><td>30-300 kHz</td><td></td><td></td></tr>
<tr><td>MF</td><td>Medium frequency</td><td>300-3000 kHz</td><td></td><td></td></tr>
<tr><td>HF</td><td>High frequency</td><td>3-30 MHz</td><td></td><td></td></tr>
<tr><td>VHF</td><td>Very-high frequency</td><td>30-300 MHz</td><td>VHF</td><td>30-300 MHz</td></tr>
<tr><td rowspan="2">UHF</td><td rowspan="2">Ultra-high frequency</td><td rowspan="2">300-3000 MHz</td><td>UHF</td><td>300-1000 MHz</td></tr>
<tr><td>L</td><td>1-2 GHz</td></tr>
<tr><td rowspan="6">SHF</td><td rowspan="6">Super-high frequency</td><td rowspan="6">3-30 GHz</td><td>S</td><td>2-4 GHz</td></tr>
<tr><td>C</td><td>4-8 GHz</td></tr>
<tr><td>X</td><td>8-12 GHz</td></tr>
<tr><td>Ku</td><td>12-18 GHz</td></tr>
<tr><td>K</td><td>18-27 GHz</td></tr>
<tr><td>Ka</td><td>27-40 GHz</td></tr>
<tr><td>EHF</td><td>Extremely-high frequency</td><td>30-300 GHz</td><td></td><td></td></tr>
</table>

**EW—**Electronic warfare

**HFDF—**High-frequency direction finding

**Information power—信息力** (*xìnxī lì*)—A Chinese term referring to the capability of a military force to achieve information superiority, ensuring the use of information for friendly operational forces while simultaneously denying adversary operational forces the use of information

**Informationized warfare—信息化作**战 (*xìnxī huà zuòzhàn*)**—**The prevailing "form of war" (战争形态, *zhànzhēng xíngtài*) in Chinese military theory.

**Island-reef—**岛礁 (*dǎo jiāo*)**—**A Chinese term for an islet or an island of sand that has built up on a reef. China's military outposts in the Spratly Island group were formerly rocks or high-tide features that do not have the international legal status of island that might otherwise define territorial waters or an exclusive economic zone

**ISR—**Intelligence, surveillance, and reconnaissance

**PLA—**People's Liberation Army; Refers to the entire Chinese military

**PLAN—**People's Liberation Army Navy

**PNT—**Positioning, navigation, and timing

**SATCOM—**Satellite communications

**SAM—**Surface-to-air missile

**SCS—**South China Sea

**SoS—**System-of-systems.

**Southern Theater—**One of five PLA theater commands created in 2016 Chinese military reorganization. Area of responsibility includes southern China, Hainan Island, the SCS, and Paracel and Spratly island-reef bases

**SSF—**PLA Strategic Support Force

**SSM—**Surface-to-surface missile

**Troposcatter—** Troposcatter or tropospheric communications are microwave signals, generally above five hundred megahertz, scattered by dust and water vapor in the atmosphere, allowing for over-the-horizon communication links

**UAV—**Unmanned aerial vehicle

**USV—**Unmanned surface vehicle

**UUV—**Unmanned underwater vehicle

## About the Author

J. Michael Dahm is a senior national security researcher at the Johns Hopkins University Applied Physics Laboratory where he focuses on foreign military capabilities, operational concepts, and technologies. Before joining JHU/APL, he served as a US naval intelligence officer for over 25 years. His most recent assignments included senior analyst in the USPACOM China Strategic Focus Group, assistant naval attaché at the US embassy in Beijing, China, and senior naval intelligence officer for China at the Office of Naval Intelligence.

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