Analysis of Changes in the Islands of the South China Sea PoC

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NEW SPACE INTELLIGENCE

October 7, 2024

Takeaways

- Successfully detected changes due to land reclamation and facility construction on Pearson Reef and Fiery Cross Reef—situated in the Spratly Islands of the South China Sea—using optical and radar satellite imagery[1]
- Combined analysis of satellite images and vessel movement data for monitoring land reclamation and facility construction on the islands
- We will continue to develop our services based on the results and challenges gained from this proof-of-concept project (PoC)

1. Background and Positioning

1.1 Background of the PoC

In a world full of uncertainty and opacity, intelligence based on objective evidence is indispensable for decision-making. The demand for intelligence based on spatial information, such as satellite data, is growing, with the market expected to reach a scale of ¥10 trillion globally. Currently, Mitsubishi Research Institute, Inc. and New Space Intelligence, Inc. are leveraging their respective strengths to develop intelligence services using satellite data for both domestic and international markets. As part of this effort, we conducted a PoC to analyze changes in the islands of the South China Sea.

1.2 Positioning of the PoC

The purpose of this PoC was to assess the business potential of providing change monitoring services for the islands, which are of strategic importance to Japan. Specifically, we first developed a hypothesis regarding how land reclamation and facility construction would progress in the islands of the South China Sea (hereafter referred to as the “land reclamation and facility construction hypothesis”). This hypothesis was then verified using satellite imagery and vessel movement data.

1.3 Reasons for Selecting the Analysis Area

The islands of the South China Sea were chosen as the area for change monitoring analysis in this PoC. The South China Sea is an important sea lane for Japan, and changes in the islands within this region could impact various fields, including Japan’s security and economy. As a result, there is strong interest in this region from both public and private sectors. Additionally, the South China Sea is an area where the coastal nations are in conflict over territorial claims to the islands. Therefore,

[1] Optical satellite images (resolution: 10m) and radar satellite images (resolution: 3m) were used.

Southeast Asian countries and other coastal nations in the South China Sea are also paying close attention to developments in this area.

2. PoC Methodology

2.1 Hypothesis Formulation

Based on publicly available information, we independently developed a hypothesis regarding land reclamation and facility construction in the islands of the South China Sea. This hypothesis considers the entire process, from the beginning of land reclamation to the completion of various facilities, as a sequence of phases, which we have identified as follows:

① Land reclamation is carried out, followed by dredging of waterways around the island to enable ship navigation.
② A wharf is constructed to facilitate the transportation of construction materials via ships.
③ Facilities, such as residential or commercial buildings, radar and communication facilities, as well as solar panels for power generation, are built on the island using the transported materials.

In this hypothesis, specific types of ships are assumed to be involved in each phase of activity related to land reclamation, wharf construction, and other phases. For example, dredgers and sand carriers are involved in the reclamation phase, while cement tankers travel between the mainland and the island during the wharf construction phase, contributing to each stage of the process.

2.2 Hypothesis Verification

2.2.1 Detection of Changes in Land Reclamation and Facility Construction Using Satellite Imagery

We used satellite imagery to verify whether changes occurring during each phase of the land reclamation and facility construction hypothesis could be detected, and to what extent specific changes could be confirmed using low-resolution (10m) optical satellite images. As shown in Table 1, Pearson Reef, where Vietnam is conducting land reclamation and facility construction, and Fiery Cross Reef, where China is carrying out similar activities, were selected as the islands for change detection. On Pearson Reef, we attempted to detect changes related to land reclamation, the construction of wharves and residential/commercial facilities, and the installation of radomes and

solar panels using optical satellite imagery. Meanwhile, at Fiery Cross Reef, we used both optical and radar satellite imagery to detect changes on the island between January and August 2022.

Table 1: Islands selected for change detection using satellite imagery

Island Name	Target/Subject	Period	Image Type
Pearson Reef (Reclamation and Facility Construction by Vietnam)	Reclamation	Sep 2023 – Jun 2024	Optical
	Wharf	Oct 2022 – Oct 2023	
	Residential/ Commercial Facilities	Jun 2018 – Jun 2020	
	Radome	May 2017 – Jun 2018	
	Solar Panel	Jun 2020 – Oct 2022	
Fiery Cross Reef (Reclamation and Facility Construction by China)	—	Jan 2022 – Aug 2022	Optical, Radar

2．2．2 Analysis of Ships Involved in Land Reclamation and Facility Construction Using Vessel Movement Data

In addition to satellite imagery, vessel movement data was used to analyze ships involved in activities at each phase of the land reclamation and facility construction hypothesis. Specifically, we obtained vessel movement data for ships located near the newly reclaimed areas of Pearson Reef between October 2023 and June 2024, analyzing which types of ships were involved in reclamation work. Furthermore, vessel movement data from ships located around Fiery Cross Reef between May 2016 and February 2017 was obtained to analyze which ships were involved in the construction of residential/commercial facilities and aircraft hangars.

3. PoC Results

3.1 Detection of Changes in Land Reclamation and Facility Construction Using Satellite Imagery

3.1.1 Achievements

(1) Change Detection Using Optical Satellite Imagery

As shown in Table 2, we successfully detected most of the targeted changes at Pearson Reef, excluding the solar panels, using optical satellite images. Specifically, as shown in Figure 1, we were able to detect changes related to land reclamation activities carried out at Pearson Reef between October 2023 and February 2024, and the construction of a wharf at Pearson Reef between May and August 2023. The success of this change detection suggests the potential to estimate the start,

continuation, and completion of many phases within the land reclamation and facility construction hypothesis using optical satellite imagery with a certain level of resolution.

Table 2: Results of change detection using satellite imagery

Island Name	Target/Subject	Period	Image Type	Change Detection Results
Pearson Reef (Reclamation and Facility Construction by Vietnam)	Reclamation	Sep 2023 – Jun 2024	Optical	Successful change detection
	Wharf	Oct 2022 – Oct 2023		
	Residential/ Commercial Facilities	Jun 2018 – Jun 2020		
	Radome	May 2017 – Jun 2018		
	Solar Panel	Jun 2020 – Oct 2022		Change detection unsuccessful ⇒ Higher resolution images are required
Fiery Cross Reef (Reclamation and Facility Construction by China)	—	Jan 2022 – Aug 2022	Optical, SAR	Successful change detection

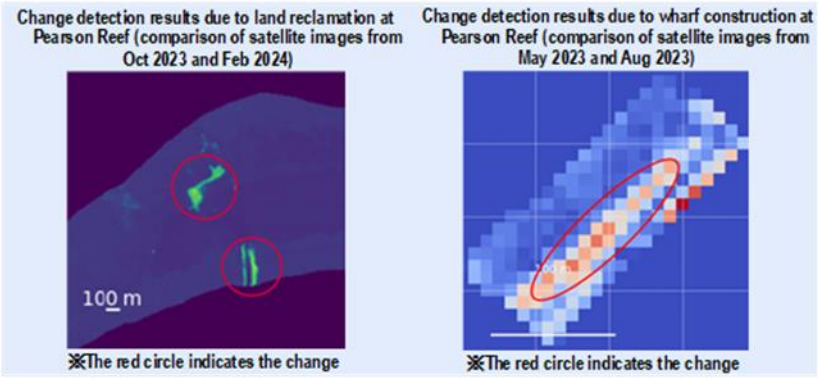


Figure 1: Detection results of changes due to land reclamation and wharf construction on Pearson Reef using optical satellite images

(2) Change Detection Using Radar Satellite Imagery

We successfully detected changes at Fiery Cross Reef using radar satellite imagery between January and August 2022. For example, Figure 2 shows the results of analyzing changes in radar satellite images from August 3 and August 31, 2022. The red dots indicate areas where the reflection intensity was higher on August 31 compared to August 3, while the blue dots show areas where the reflection intensity decreased. Most of these changes could not be confirmed with low-resolution (10m) optical satellite images. However, the changes highlighted in red squares, due to their location (next to a wharf) and size (approximately 120m), were identified as a vessel (about 120m in length) using low-resolution optical satellite imagery (resolution: 10m).

This successful change detection demonstrates that radar satellite imagery can be used to detect changes on islands, even in situations where it is difficult to acquire optical satellite images, such as at night or during adverse weather conditions.

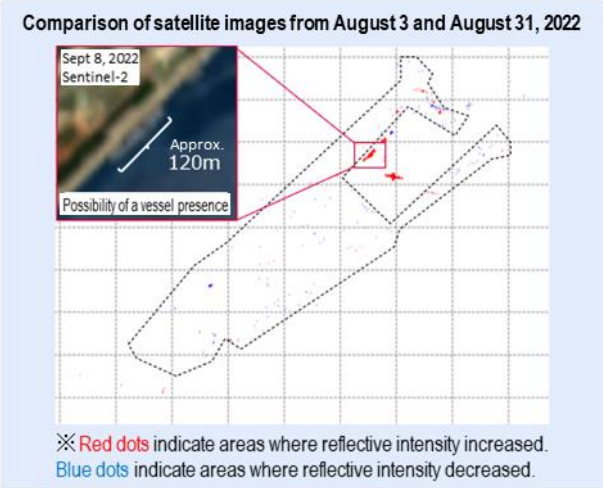


Figure 2: Detection results of changes at Fiery Cross Reef using radar satellite images

3.1.2 Challenges

While we succeeded in detecting many of the target changes, several challenges became apparent. For example, due to the small amount of change in the construction of wharves, residential/commercial facilities, and radome installations at Pearson Reef, it was difficult to accurately confirm the nature of the detected changes using low-resolution optical satellite images (resolution: 10m). Additionally, except for a few cases (such as the detection of the vessel near the wharf mentioned earlier), the contents of changes detected with radar satellite images could not be confirmed using low-resolution optical satellite imagery.

3.2 Results of the Analysis of Ships Involved in Land Reclamation and Facility Construction Using Vessel Movement Data

3.2.1 Ships Involved in Land Reclamation at Pearson Reef[2]

It was revealed that the ships potentially involved in the new land reclamation at Pearson Reef between October 2023 and June 2024 did not transmit vessel movement signals. For example, optical satellite images from June 4, 2024, showed several ships located near the new reclamation area at Pearson Reef, indicating their

[2] Vessel movement data provided by Spire, Inc.

potential involvement in land reclamation activities. However, no vessel movement signals were detected in that area on the same day.

3. 2. 2 Ships Involved in Facility Construction at Fiery Cross Reef[3]

(1) Achievements

By analyzing vessel movement data for ships located around Fiery Cross Reef between May 2016 and February 2017, we were able to identify approximately 10 cargo ships that were potentially involved in the construction of residential/commercial facilities and aircraft hangars at the reef. These cargo ships were present in the port at Fiery Cross Reef during the period when the construction of these facilities took place, suggesting they may have been transporting materials used in the construction. If these 10 ships were indeed involved in the construction of residential/commercial facilities and aircraft hangars at Fiery Cross Reef, it may be possible in the future to estimate the start, continuation, and completion of similar phases at other islands by monitoring the activities of such cargo ships using real-time vessel movement data.

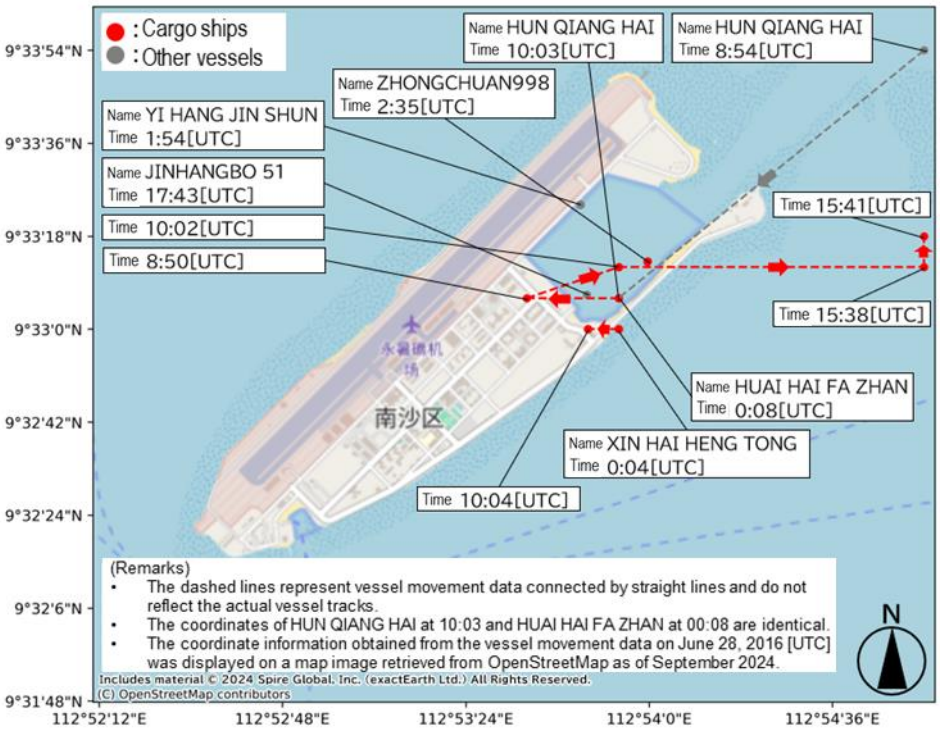


Figure 3: Vessel tracks of cargo ships and others located around Fiery Cross Reef (June 28, 2016 [UTC])[4]

[3] Includes material © 2024 Spire Global, Inc. (exactEarth Ltd.) All Rights Reserved.
[4] Map images are subject to the Creative Commons Attribution-ShareAlike 2.0 license.

(2) Challenges

While we were able to identify cargo ships that were likely involved in the facility construction at Fiery Cross Reef, several challenges were also revealed. For example, vessel movement data alone cannot confirm what materials these cargo ships were transporting. Therefore, it is necessary to explore methods to verify the cargo (such as identifying and monitoring departure ports). Additionally, we were unable to confirm whether ships that did not transmit vessel movement signals, but were present in the port during the construction of residential/commercial facilities and aircraft hangars at Fiery Cross Reef, were involved in the construction. A method to track the activities of ships not transmitting vessel movement signals (such as using satellite-based radio signal collection to gather vessel position data) will need to be considered.

4. Future Plans

Through the detection of changes related to land reclamation and facility construction using optical and radar satellite images, as well as the analysis of vessels involved in these activities using vessel movement data, we have identified both achievements and challenges. Moving forward, we will continue to develop our services, taking these results and challenges into account.

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