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Maritime Sense-Making and The Role of Big Data Analytics For Enhancing Maritime Security

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MARITIME SENSE-MAKING AND THE ROLE OF BIG DATA ANALYTICS FOR ENHANCING MARITIME SECURITY

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ABSTRACT

In this essay, the authors first examined the imperative of maritime sense-making in Singapore's context. Despite its importance, maritime sense-making is not a topic that has been discussed robustly before. Therefore, the authors sought to elaborate what maritime sense-making entails, and how it is conducted by the Singapore Maritime Crisis Centre today. The authors then examined what big data analytics is, and the possibilities and challenges in unlocking the potential that big data analytics offer for sense-making in the maritime domain.

Keywords: Big Data Analytics, Maritime Sense-making, Maritime Threats, Predictive Analytics, Ecosystem

INTRODUCTION

> *"Still doubtful about our capabilities? Good. Just wait and see. We will bring the war that you impose on us to your lands and seas... We will multiply the pain and suffering that you have inflicted on our people."*
>
> *- Abu Soliaman,*
> *Abu Sayyaf Group (ASG) spokesperson*[1]

The statement above was issued to the Philippines government in the aftermath of the SuperFerry 14 bombing, one of the worst maritime terror attacks in the world. The ferry was bound from Manila to Southern Philippines on 27th February, 2004, and as it was transiting just off El Fraile Island outside of Manila harbour, a bomb hidden on-board was detonated.[2] The resulting blast and an ensuing fire killed at least 116 people, including 15 children.[3]

Southeast Asia is no stranger to such terrorism-related incidents within the maritime domain. In 2003, it was discovered that Al-Qaeda had plans to attack Malaysian and United States (US) naval vessels on patrol in the Straits of Malacca.[4] The Malacca Strait again found itself in the crosshair of an unnamed terrorist group in 2010, this time with oil tankers as targets. The Republic of Singapore Navy's (RSN) Information Fusion Centre promulgated an advisory indicating that the terror group's intent was 'to achieve widespread publicity and showcase that it remains a viable group.'[5] Clearly, the terrorist threat in the maritime domain cannot be overemphasised. Although there has not been a successful attack on its soil, Singapore has been mentioned as a target on several instances.[6] In 2016, flyers and letters surfaced in Indonesia, warning of imminent bombing attacks at various sites across the Riau islands of Bintan and Batam, including the Batam Center Ferry Terminal and Bintan's Tanjung Pinang, reportedly targeted for the high concentration of Singaporean tourists at these locations.[7] Although the Katibah Gonggong Rebus (Boiled Snail) terror cell's foiled plot to launch a rocket attack on the Marina Bay Sands from Batam sounded incredulous on the onset, it is evident from the group's link to Islamic State of Iraq and Syria (ISIS), the 'routine firearms training' and robust command structure that the group poses a serious threat to Singapore's security.[8] These incidents illustrated above clearly demonstrates the intent of terrorist groups in targeting Singapore, and as the city-state continues to stave off potential attacks, its allure as a target will only grow.[9] In addition, the increasing numbers of self-radicalised individuals, including foreigners in Singapore, is a grave cause of concern.[10] Because these 'lone-wolves' are harder to detect and capture, enforcement agencies will continue to face mounting challenges in identifying these threats. As

such, the Ministry of Home Affairs' (MHA) Terrorism Threat Assessment Report has concluded that the threat of terrorism to Singapore is now higher than ever.[11]

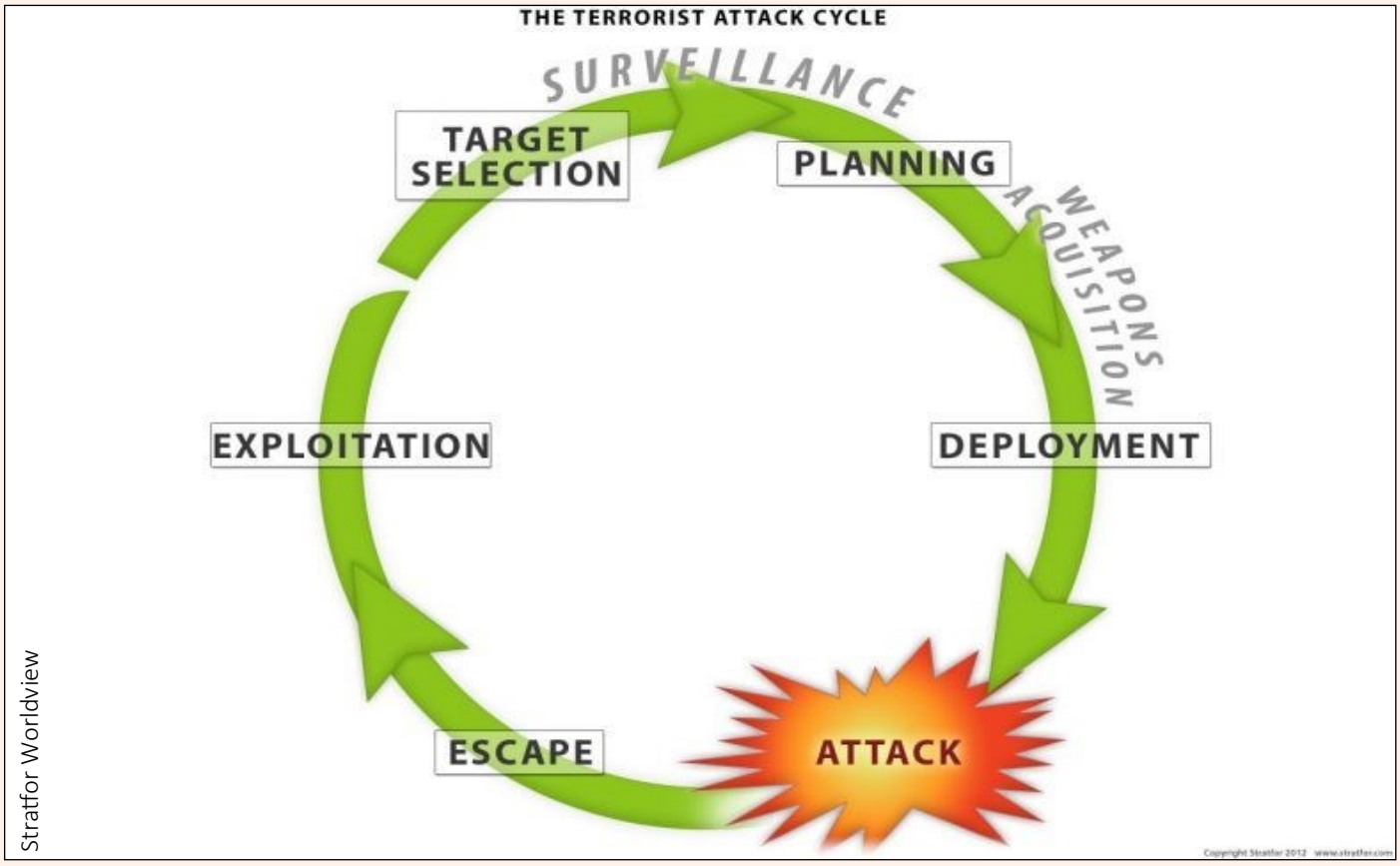
The abortive Marina Bay Sands rocket plot in 2016… clearly demonstrates the intent of terrorist groups in targeting Singapore, and as the city-state continues to stave off potential attacks, its allure as a target will only grow.

As a maritime nation, Singapore sits on the confluence of the strategic waterways of the South China Sea and the Straits of Malacca and Singapore. Together, these Sea Lines of Communication (SLOC) are of vital importance to global commerce: the United Nations (UN) Conference on Trade and Development (UNCTAD) estimates that one-third of global shipping passes through the South China Sea, much of it coming through the straits connecting the South China Sea to the Pacific and Indian Oceans.[12] Due to its strategic location, Singapore is currently the world's second-busiest port and the world's top trans-shipment hub, handling one-seventh of the world's transhipment containers.[13] There are on average 1,000 vessels in Singapore's waters at any one time, with a ship arriving or leaving every 2 to 3 minutes, which corresponds to almost 130,000 vessels calling into Singapore annually.[14] The maritime sector contributes to 7% of Singapore's Gross Domestic Product (GDP), supporting not only 170,000 jobs from over 5,000 maritime related enterprises and establishments, but also many Small and Medium Enterprises (SME) within the larger maritime ecosystem, in areas such as manufacturing and logistics.[15] Given the importance of its maritime domain and the ever-growing threat of maritime terrorism, Singapore places a strong emphasis on its ability to detect and respond to maritime threats. Hence, it has embarked on maritime sense-making to analyse and harness available information to obtain early warning indicators. This essay explores how maritime sense-making is done and evaluates the value it brings, and also the prospects and challenges of big data analytics in maritime sense-making.

WHAT IS MARITIME SENSE-MAKING AND HOW IS IT DONE?

Traditionally used in organisation studies and research on decision-making processes, the concept of sense-making generally refers to 'processes by which people seek to understand ambiguous, equivocal or confusing issues or events'.[16] As an extension, maritime sense-making thus describes the application of these processes in the maritime domain. An important component of maritime sense-making is that it seeks to identify the 'pattern-of-life', which involves a comprehensive understanding of the norms and habits of a particular subject. This situational awareness is built up by collating relevant information that can range from details of vessels, the quantities and types of cargo, the bio-data of crew members to a ship's voyage and tracks. From this information, any indicator of a potential maritime vulnerability will then be used for the identification of deviations from the norms and habits that have been established.

However, an anomaly does not necessarily mean that there is a maritime security threat. Maritime sense-making therefore fuses the anomaly detection process with 'traditional' security analysis. Research has shown that terrorist attacks involve a deliberate planning process in the form of a cycle. Known as the 'Terrorist Attack Cycle', it is typically divided into the different stages of planning, execution and aftermath of a terror attack.[17] Security agencies typically endeavour to intervene in the cycle as further upstream as possible, as it provides a margin for error and a longer timeline to effectively deploy necessary resources to neutralise the perceived threat. Another key impetus is that the stages within the cycle are elastic, and there may be drastically less time for authorities to intervene in the latter stages, depending on circumstances.[18] In the context of maritime security, it is by combining the analysis of the tactics, techniques and procedures of terrorist organisations and ascertaining the potential linkages with the maritime domain that allows the 'piecing together' and 'joining of the dots' in sense-making. For



Terrorist Attack Cycle

example, if it is ascertained that terrorists have developed a certain maritime strike capability or have shown interest in some particular class of vessels, the pattern of life of vessels transiting in and from that part of the world would be analysed to see if there are anomalies, and the bio-data of crew members will also be monitored. What maritime sense-making therefore brings about is a heightened situational awareness that allows for the earlier detection of potential maritime threats.

SINGAPORE'S MARITIME SENSE-MAKING

From the perspective of maritime sense-making, the dense traffic conditions and the multitude of activities in Singapore's maritime domain is a storehouse of extensive information. Evidently, not every piece of information will be relevant or accurate, and a researcher will need to sieve through the clutter to identify what is normal, and what constitutes an anomaly. In addition to the complicated information landscape, there are many different agencies and stakeholders involved in the security of Singapore's maritime domain. Recognising that the information flow between these agencies will be important in creating a shared situational awareness, the Singapore Maritime Crisis Centre (SMCC) was established in 2011.[19] The SMCC represents a Whole-of Government (WoG) approach to 'detect and deter' threats within the maritime domain 'as early and as far away from Singapore as possible'.[20] Since becoming fully operationalised in 2013, the SMCC has brought together the various maritime security agencies, creating tighter linkages to enhance mutual co-operation and understanding that sharpens operational responses and minimises any duplication of efforts.

A key component of the SMCC is the National Maritime Sense-making Group (NMSG), whose core business is to conduct sense-making and threat assessment.[21] The NMSG uses a system to 'integrate data, facilitate the sharing of information and provide insights to the agencies.'[22] Essentially, data from various sources are streamed and fused in a common database and made sense of through a process known as 'Entity Resolution' (ER).[23] ER applies real-life principles to ensure that the data being fused is of quality, and that data from different sources are mutually-intelligible. It essentially helps to identify when an entity is unique or if the same entity is using multiple identities to mask itself. Real-time analytic engines will then process these data streams and check for any anomalies. This allows

for the detection of 'weak links' and through machine processing, conduct pattern analysis which may be missed out by human analysts.[24] In essence, this provides for a more efficient means to find the proverbial needle in the haystack. The NMSG also uses an analytical test-bed as an 'enabler of continuous system improvement', to develop and test new threat models and analytical techniques. Being able to do so allows the NMSG and its systems to keep up with the changing security environment. The final outcome of what the system endeavours to deliver is 'actionable intelligence', which is shared with Singapore's maritime security agencies and to cue timely operational responses.[25]

Ultimately, by effectively detecting anomalies early, this allows for the cueing of timely operational responses by the relevant agencies. Using its systems, NMSG detected a possible ISIS supporter onboard a tanker in 2015, and that person was barred from disembarking in Singapore.[26] Similarly in 2016, a merchant vessel was flagged for suspicious activities, which subsequently led to the discovery of contraband items on-board and the arrest of a crew member.[27]

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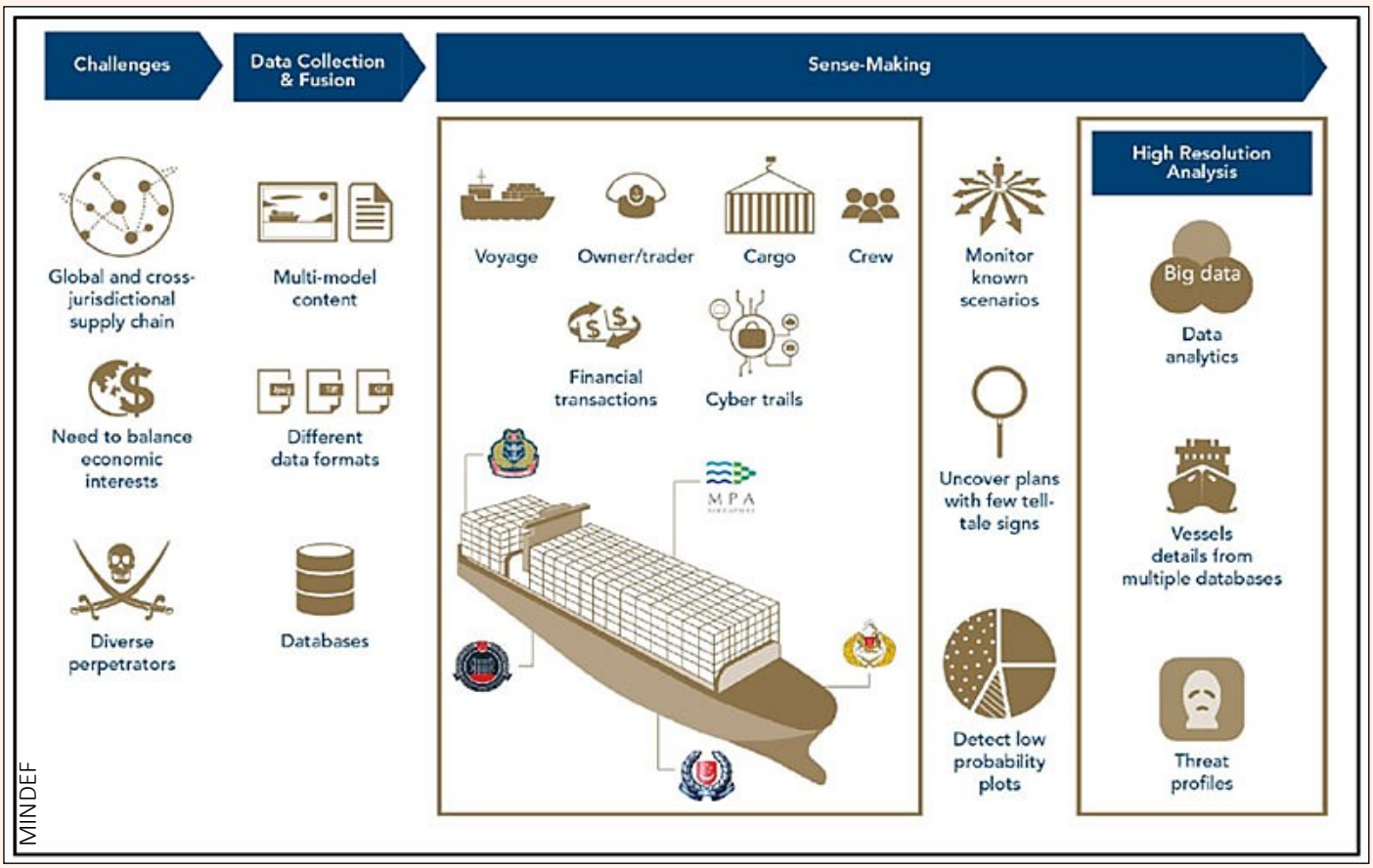
WHAT IS BIG DATA ANALYTICS?

Although there is no one, authoritative definition of big data, a widely quoted report by the McKinsey Global Institute describes it as 'data sets whose size is beyond the ability of typical database software tools to capture, store, manage, and analyse.'[28] Big data analytics thus refers to the ability to elicit trends and patterns from such extremely large quantities of information.



Factsheet: Safeguarding Singapore's Maritime Security

For the uninitiated, one of the first uses of big data analytics for security and crisis situations was first demonstrated in 2009. At the peak of the swine flu pandemic, the US Centre for Disease Control and Prevention (CDC) found that statistics from a national surveillance programme, which compiled new flu cases from 3000 clinics country wide, was always a week or two out-of-date, which was a crippling handicap when working against a rapidly spreading pandemic.[29] In its efforts to rectify the problem, the CDC found an unlikely ally in technology giant, Google. By analysing correlations between the frequency of search terms used on its popular search engine and the spread of the influenza virus over time and space, Google identified a combination of 45 search terms distilled from over 50 million, by processing it through an astounding 450 million mathematical models that allowed for predictions on the spread of the virus.[30] It was discovered that prior to visiting a clinic, many infected by the virus would first perform an online search to confirm their symptoms. By exploiting this information, Google was able to effectively build a map of the virus' spread, which uncannily corroborated with the CDC's data on the pandemic's prevalence, with the only difference being that Google's predictions were in near real-time, affording the CDC additional time to prepare for further outbreaks.[31] While the SMCC has embarked on the journey of maritime sense-making, it is still working towards its vision of unlocking the value of big data analytics.

UNLOCKING BIG DATA ANALYTICS

Harnessing The Full Potential Of Unstructured Data

The SMCC has been working with both structured and unstructured data in its efforts to secure Singapore's maritime domain. Structured data refers to information with a definitive length and format, such as crew lists, ship registries and cargo manifests. Given Singapore's status as a maritime hub, the SMCC has been able to work with partners to obtain a treasure trove of such data. Structured data reflects a high degree of organisation that allows for ready retrieval and easy storage, which allows the SMCC and its system to exploit such data to great effect. However, the real 'jackpot' is the wealth of information that can be leveraged from unstructured data. These refer to open source data available in a wide array of formats and media, such as emails, images, social media content, videos and podcasts. Unstructured data is important because it represents an estimated 95% of the world's total data in existence.[32] Because unstructured data represents such an overwhelming proportion of data, it offers a huge potential for exploitation. However, due to the complicated and wide-ranging forms of unstructured data, it presents numerous data management difficulties that complicate efforts to harness information from it. In addition, data has been continuously growing at unprecedented rates, which poses an additional level of difficulty for sense-making. The current global output of data in a single day stands at roughly 2.5 quintillion bytes, with 90% of the data in existence being generated in just the past 2 years alone.[33] The International Data Corporation (IDC) has forecasted that there will be 163 zettabytes (a trillion gigabytes) of data in existence by 2025, ten times of the total global data output of 16.1 zettabytes in 2016.[34] As such, systems wishing to harness the potential of unstructured data will need to be ready for exponentially larger data sets. In anticipation of this information revolution, the SMCC will look at the storage and processing of large datasets to exploit data more efficiently and effectively.

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However, a key challenge at present is that much of the SMCC's processes are still very much user-defined and processes are relatively 'conventional'. While mechanisms for machine-learning have been put in place, which allows the system to 'learn' and apply 'business rules' autonomously, these are still based on typical work patterns which are not the most advanced

as of yet. However, the SMCC has started to embark on new technological solutions, experimenting with the visualisation of unstructured data. This is a greenfield developmental area and the potential for growth and exploitation will be immense in the years ahead. In order to better harness unstructured data and combine it with the analysis of structured data, the NMSG is also working with experts to move towards 'Artificial Intelligence', constituting an important part of the 'continual system improvement' within the SMCC. The NMSG is also constantly seeking for new data sources; the ever-expanding database will provide a more vigorous buffer against any new threat scenarios, ensuring that the early-warning capabilities of the SMCC is maintained.

Predictive Analytics

The ultimate vision for the possibilities brought about by big data analytics will be to unlock the realm of predictive analytics, which allows for the detection of a potential threat even before it can occur. Predictive analytics will bring unprecedented early warning capabilities, allowing for interventions well within the 'target selection' and 'planning' stages in the Terrorist Attack Cycle. Since Google's success with big data analytics in 2009, the commercial application of big data analytics have grown by leaps and bound. Google has developed targeted marketing capabilities that allow companies to gather deep insights into customers' behaviour and spending trends.[35] The success of big data analytics within the commercial domain has also given inspiration to security practitioners. While similar success stories in the security domain are few and far-between, there have been some early pathfinders. BANDIT, a US Office of Naval Research Global (ONRG) funded project, is a programme designed to measure the impact of weapons and drug trafficking prior to the actual deployment of countermeasures efforts, and has demonstrated its usefulness in the seas off Central America, an area plagued by rampant drug trafficking.[36] BANDIT offers a platform that focuses on modelling 'different types of illegal behaviour' and 'interactions between agents' (smugglers, merchant vessels and security agencies).[37] By projecting the potential impact caused by trafficking activities, more effective countermeasures can be deployed, such as customised patrol routes and concentration of security assets in a high-risk area.[38] From this example, it is clearly possible to harness big data for security and crisis management purposes, unlocking its potential for predictive analytics through big data to improve maritime sense-making capabilities.

However, in the security domain, one of the challenges that need to be overcome is the lack of ground-truth data. Predictive analytics builds on existing trends and patterns, which in turn determines the accuracy of the system's predictions.[39] BANDIT is able to build up its system because there is a wealth of data concerning Central America's drug smuggling problem and the tactics used by traffickers.[40] Without a similarly extensive database with the relevant information, it would be difficult for a system to produce an adequate prediction, much less an accurate one. In the context of Singapore's maritime sense-making, there is unfortunately a lack of adequate security incidents (which is a good thing), but this also has some impact on the veracity of statistics.

Supporting Ecosystem For Big Data Analytics

Another key component in unlocking the potential of big data analytics is the need for adequate supporting infrastructure. This does not only refer to the need for funding for experimentation and the development of new analytical tools, but also the necessary training for new data analysts and data scientists. In 2017, it was announced that a grant of $45 million a year will be provided to the Defence Science and Technology Agency (DSTA) for the expansion of a new data analytics and artificial intelligence laboratory.[41] This is a concrete step in the right direction towards recognising the value of big data analytics. However, more needs to be done, so that the vision of unlocking big data analytics can be achieved. According to a study commissioned by the National Trade Union Congress (NTUC), there is a lack of such talent to support the growth of the industry, which poses a challenge to the SMCC's big data endeavours. It is therefore necessary for the SAF to support the manpower requirements and aspirations of data engineers, programmers and data scientists, so that the vision of unlocking big data analytics can be achieved. Indeed, the SAF and the defence industry would need to

be forward-looking and committed towards a strategy to realise the vision of harnessing big data analytics to its fullest potential.

CONCLUSION

In conclusion, the importance of the role of maritime sense-making in Singapore's maritime security cannot be overstated. Singapore faces numerous potential maritime threats, and given the porosity of the maritime domain, maritime sense-making is a natural step in enhancing the SMCC' situational awareness and to ensure prompt and ready operational responses. The importance of Singapore's maritime domain to its economy and social wellbeing is another imperative for the SMCC to ensure that its sense-making capabilities remain cutting-edge. Singapore has already started using maritime-sense making systems to better exploit data analytics, and the advent of big data and the possibilities brought about by big data analytics will be a key enabler for its maritime sense-making capabilities, as this will allow the SMCC to unlock the realm of predictive analytics and provide early warning of a potential threat even before it occurs. The SMCC has embarked on numerous initiatives to place itself in the driver's seat, to be in a position to accommodate future developments in big data and data analytics. While, there has been some developments to support the development of data analytics and artificial intelligence within the defence establishment, more needs to be done, and it is only with the continuation of such efforts, that SMCC will be able truly unlock the full potential of big data analytics and reap the rewards in the years to come.

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