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NAVAL DEFENCE

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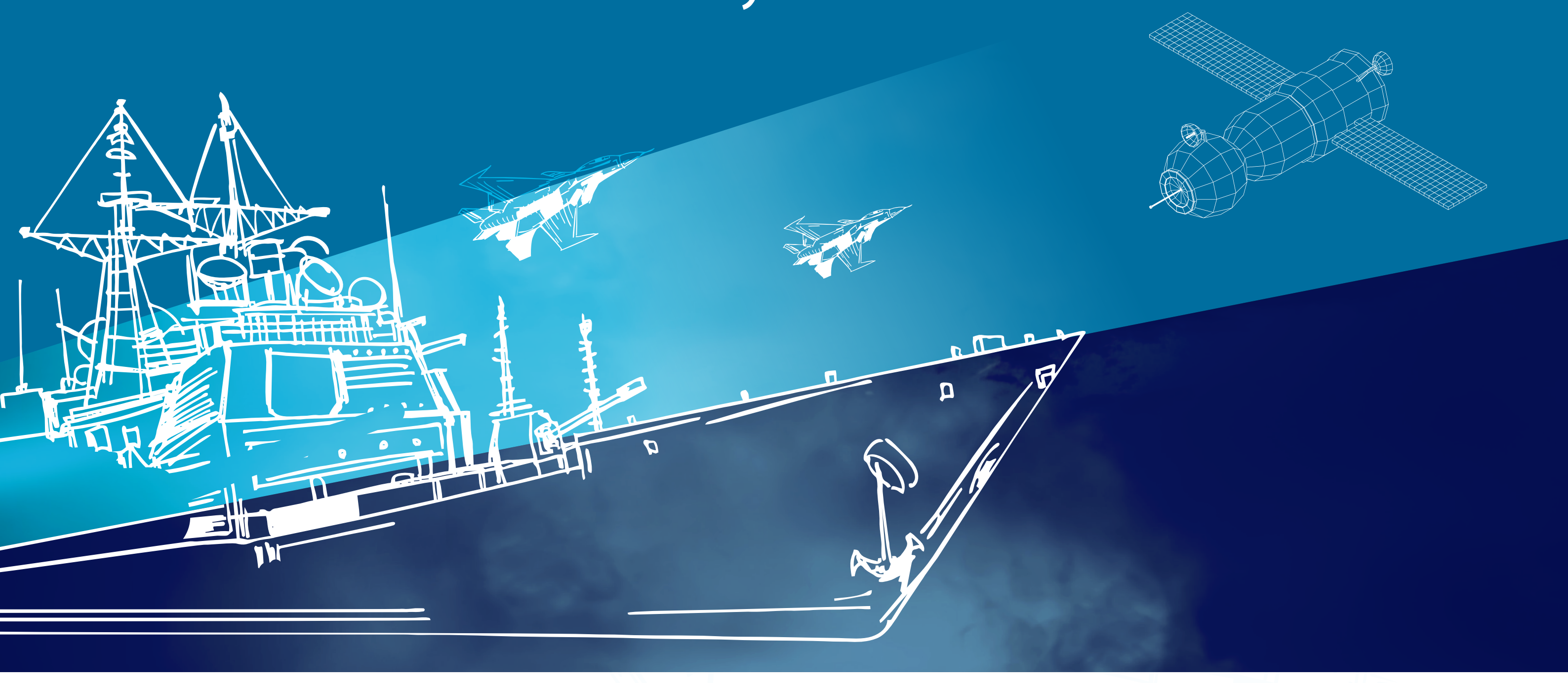
Innovative unmanned and remote solutions for improved maritime security in the Arabian Gulf

May 2023



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INTRODUCTION

The importance of the Arabian Gulf and the Red Sea for global trade and energy security is undisputed. These waters also have three of the most vital choke points in the world– the Straits of Hormuz, Bab el-Mandeb, and the Suez Canal. Ensuring maritime security in these waters is therefore vital. Towards this, regional and extra-regional navies operate in these waters. Regional navies enable maritime security with patrol forces that provide persistence and there is growing realization that these regional capabilities need to be strengthened. Such realization has led to increased investments in maritime security by countries such as Saudi Arabia and the Gulf Cooperation Council (GCC) countries. There is also growing interest in local manufacture of maritime capabilities with a focus on technology-based solutions. Local manufacture of incrementally larger and more capable naval platforms is ongoing but would take some time maturing, and yet the maritime security requirement is immediate. Gulf countries already have increasing capability in manufacturing unmanned aerial systems (UAS) which could be leveraged to develop similar capabilities in unmanned maritime systems (UMS). Given these conditions, **what solutions do unmanned and remote systems provide to bolster maritime security and what are the opportunities and challenges therein? Will increasing investment in unmanned and remote maritime systems by Gulf countries improve maritime security in the waters adjoining the Arabian Peninsula?**

Figure 1:Waters & choke points around the Arabian Peninsula

I (Arun Mannath) was joined by Adam Watters, Programme Manager for MDA and ISR at Saildrone, Aymeric Moullart de Torcy Senior Manager Unmanned Systems at Naval Group, Fabien Sire, Managing Director of Maritime Systems at Airbus, Mark Exeter Managing Director of Maritime, ASVs at L3 Harris Technologies, Matthew Hunt Product Line Director of Mine Warfare, Autonomous Systems at Thales, and Steve Vaillancourt Head of Unmanned Systems and Communication Integration at Al Seer Marine on a Think Tank Discussion at IDEX/NAVDEX 2023 in Abu Dhabi to debate and examine 'Innovative Unmanned and Remote Solutions for Improved Maritime Security in the Arabian Gulf'. I thank the panellists for their erudite thoughts and engaging discussions on the yet to be fully revealed or realised world of unmanned and remote maritime systems. My research at Frost & Sullivan on the subject together with insights from the think tank discussion inform this paper.

UNMANNED MARITIME SYSTEMS

Since Nicola Tesla first demonstrated remote controlled boats in 1898 with the 'Teleautomaton', steady progress has been made in this area, but developments in unmanned maritime systems have gained speed in recent times and many nations have already developed or are currently developing such systems. This trend can be attributed to the following:

- **Operational Need.** Increasing and more capable Anti-Access/Area Denial (A2/AD) strategies being adopted by nations have made the cost of operations in littoral waters and securing objectives in such littorals using manned craft an expensive and difficult task. With unmanned maritime systems, many missions that would be considered too risky for manned platforms earlier, may now be considered acceptable.

- **Improvements in Technology.** Advances in technologies for unmanned vessels (UVs) in areas such as propulsion systems, power systems, sensors, communications, datalinks, autonomous systems, navigation systems, artificial intelligence (AI), machine learning (ML), swarm computing, Big Data analytics and also networked operations have allowed for improved unmanned, manned-unmanned teaming (MUM-T), and autonomous capabilities.

Figure 2: Saildrone Voyager, Source - Saildrone

- **Affordability.** UMS are expected to be a less expensive option for maritime security compared to an equivalent conventional manned naval capability.

- **Work Force Availability.** It is becoming increasingly challenging to find the trained workforce required to man vessels at sea–commercial or military. UMS could be a solution to overcome some of these challenges.

- **Social Value.** Increased attention is being given to the social value of investments, and contribution of such investments to lower carbon footprints, net zero solutions. Unmanned systems with lower carbon footprints are expected to find greater support as long as they meet maritime security requirements. OEMs of unmanned maritime systems could support the net zero goals and strategies of nations and militaries.

Unmanned surface vehicles (USVs). autonomous surface vehicles (ASVs), and unmanned underwater vehicles (UUVs) allow for **distributed maritime operations** and **distributed lethality.** These systems are cost-effective, reduce risk and vulnerability, persistent and increase the effectiveness of manned platforms. They have utility particularly in 3D missions which are **'Dull, Difficult**, and **Dangerous'.** Significant developments in recent years, with new technologies and capabilities being introduced have improved their performance and expanded their applications. Some important developments in UMS are given below:

- **Increased Endurance and Range.** New battery technologies, solar power and improved propulsion systems are allowing USVs to operate for longer periods and cover greater distances. Saildrone's USVs have reportedly been deployed at sea continuously for 220 days.

- **Advanced Sensors and Communication Systems.** High-resolution cameras, radar, sonar, other sensors and instruments are being integrated into unmanned and autonomous vehicles to provide real-time situational awareness and communications capabilities.

- **Swarm Capabilities.** Groups of USVs can now coordinate in swarms for more efficient and effective operations. Many global companies are currently experimenting and developing these capabilities.

- **Quantum Technologies.** Highly accurate quantum sensors are revolutionizing navigation capabilities in the maritime industry. Unmanned and autonomous vessels using quantum sensors will be able to navigate with unprecedented precision. Quantum sensors will also be able to measure physical properties such as temperature and pressure with much higher accuracy than was hitherto possible.

Figure 3: L3 Harris Autonomous Systems, Source - L3 Harris

- **Payloads.** Newer USVs and ASVs being built are designed to carry larger payloads of weapons, sensors, and communication systems.

- **Size.** While the size of USVs under development is as large as 300 ft. However, what was more important than size was the effect desired from the unmanned platform, and so the focus should be on the effect and on whether the system has the desired seakeeping capability, sensors, weapons, communication and network capabilities to deliver the effect desired.

The think tank discussion identified that unmanned platforms are designed to deliver effects. Therefore, the focus must be on the effect and on whether the system has the desired seakeeping capability, sensors, weapons, communication and network capabilities to deliver the effect desired.

Key Technology Enablers

Key technologies that would allow for improved unmanned and autonomous maritime systems are:

- **Sensors.** USVs and UUVs use various sensors such as radar, sonar, lidar, cameras, bathy, and oceanographic sensors to navigate and collect data, for collision avoidance, to map their environment, and to detect objects of interest.

- **Communication & Mesh Networks.** Communication technologies are critical for USVs and UUVs to transmit data back to their operators or to other vehicles in a swarm. This may include satellite, radio, or acoustic communication, depending on the operating environment. The ability to operate in communication denied environments would be important for military requirements. Mesh networks enable communication in such communication denied environments.

- **Autonomous Navigation.** To operate autonomously, USVs, ASVs, and UUVs need advanced algorithms and software for them to navigate, detect, and avoid obstacles, map their environment, and achieve mission objectives.

- **Power Systems.** USVs and UUVs require to operate for extended periods of time without refuelling or recharging and use a variety of power sources, including batteries, fuel cells, or solar panels.

- **Materials and Design.** USVs and UUVs need to be suitably built and designed to withstand the harsh operating conditions at sea, including high-sea states, saltwater corrosion, and extreme temperatures. 3D printing, additive manufacturing technologies would be important for scaling.

The think tank discussions highlighted that the technologies needed to provide viable UMS were now available and the important requirement in future would be to make them more reliable, more effective, and more maintainable.

Key Challenges to be Addressed

The Think Tank discussions revealed that while much progress had been made, there were important areas that remain to be addressed for the wide adoption of UMS:

- **Trust.** Trust is the most important element for the growth of UMS and for the degree of autonomy that would be possible. Operators and developers will have to build trust with customers, requiring long-term engagements by manufacturers. Building trust in the ability of these unmanned maritime systems to comply with COLREGs (International Regulations for Preventing Collisions at Sea) and their ability to operate safely in the company of other manned and unmanned vessels would also determine the level of autonomy that would be acceptable. Also, trust in the decisions of robotic autonomous systems will have to be built through operations, simulations, and will be an incremental process.

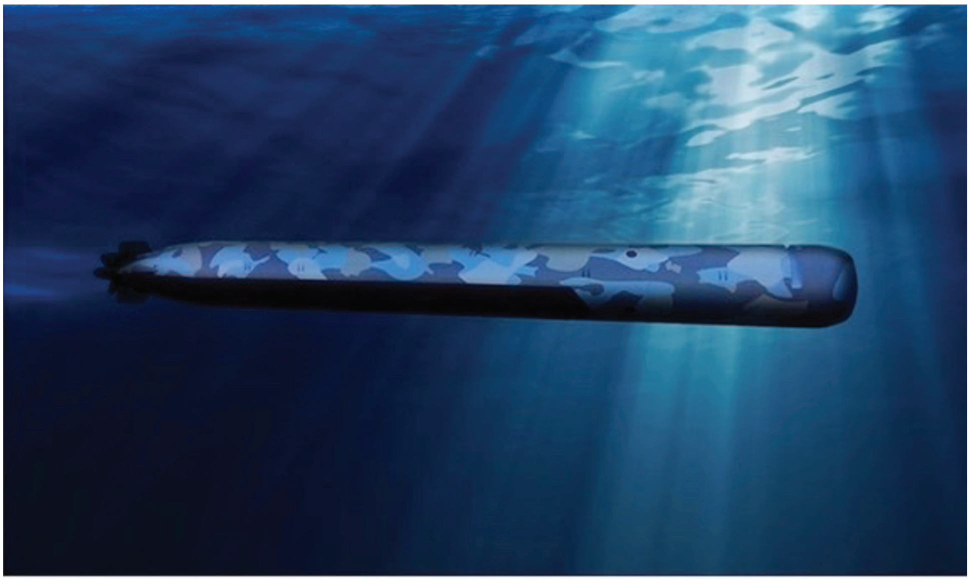

Figure 4: Naval Group UUV, Source - Naval Group

- **Regulations.** For unmanned/autonomous maritime systems technology to progress, there is a need to have regulations in place. Regulations for safe navigation including COLREGS, UNCLOS (United Nations Convention on the Law of the Sea) 1982, various IMO (International Maritime Organization) regulations, and shipping laws are premised on objective rules requiring human interpretation or based on subjective standards. Are these maritime regulations adequate for UMS and acceptable globally as to allow for safe unmanned/autonomous operations and safe interactions between manned and unmanned vessels at sea? If not, appropriate regulations need to be in place for unmanned and autonomous operations at sea to grow fully.

- **COLREGs Compliance.** Unmanned maritime systems are currently COLREGs aware but have a long way to go before they become COLREGs compliant. This journey from awareness to compliance would need to be bridged by promulgating and complying with regulations for unmanned systems, training of these systems in actual conditions at sea or on simulators and building greater confidence in their safe operations in increasingly challenging maritime environments.

- **Explainability.** The challenge of being able to explain to operators the actions taken by the AI of unmanned systems remains because AI does not often think like humans. Explainability of the actions of autonomous systems will be important for improving confidence in such systems.

- **Risk.** While unmanned systems de-risk humans by their not having to be present on the scene, it introduces other elements of risk. To an extent, across the spectrum of conflict, the presence/actions of unmanned systems in a given scenario is considered less threatening than if the same scenario involved manned vessels. However, there is also a risk of an authority acting more ambitiously in a given situation because there are no humans involved. Yet another aspect of operational risk is the need to accept that we will break some hardware in the process of adoption of these systems and while establishing CONOPs (concept of operations), failing which we may limit the speed and scale of adoption and progress of UMS. The degree of risk the operators are willing to assume will therefore be important for the development of UMS.

Figure 5:Thales Autonomous Unmanned Systems for Mine Countermeasures, Source - Thales

- **Interoperability.** The ability of different software, hardware systems to integrate and operate together would be important for creating a common/minimum surface picture or for other common objectives. Customers would desire to operate multiple unmanned systems from different suppliers and would want to select the sensor and weapons suites on their UMS. In addition, technologies are changing rapidly. In these circumstances, it would be desirable for unmanned systems to have open architecture systems that allow interoperability, create options and allow for multiple missions. Trust would be important for such partnerships and cooperation.

- **Mothership.** Currently, a mothership is being assigned as an operational control platform for a fleet of unmanned systems, and many navies have started designating and preparing such motherships. While such motherships enable controlled autonomy, it is not without a few tactical disadvantages. Current unmanned maritime systems still require a lot of teaming at the tactical and operational level.

- **Data.** Given the persistence of such unmanned systems and the large numbers in which they can be deployed, such systems will generate large volumes of data (which would feed maritime data centres) which AI and ML algorithms will then use for improved autonomy, decision support, and overall improved unmanned operations. Data and interoperability of data between nations and operators would be critical for the success of integrated unmanned operations and adoption of such systems. Sovereign requirements and interoperability will need to be factored for the success of unmanned maritime systems. The volume of data generated by such systems also proves to be a significant challenge and the bandwidth of communication systems and satellites will also have a key role to play in how much of this data can be transferred in real time. The key then will be for the customers/operators of such unmanned systems to be able to reveal what data is key to them and what isn't, so that the transfer of such data can be prioritized. To reduce the burden on customers, UMS capabilities can also be provided by OEMs on a Data-as-a-Service (DaaS) model that would also reduce training requirements for customers.

- **Safety & Security.** Ensuring the physical security of unmanned vehicles from capture, and cybersecurity would of course be vital. Some of the ways of securing them passively could involve designing the platform shape in such a way that they can't be boarded or easily handled. Deploying them in large numbers at very low cost could take away the tactical advantage of anyone inimical capturing a few of them. In addition, storing data generated by UMS on clouds or servers ashore and not on the unmanned platform would also mean that data collected by the platform cannot be retrieved by others. Making such systems consumables, numerous, and cost-effective, to the point of customers being willing to lose some of them can also be considered. In terms of more aggressive security measures, options to self-destruct or scuttle the unmanned vessels if they are captured or compromised could be considered. Regulations on the sovereignty of the flag state over such vessels, if promulgated in future, would also be helpful.

Figure 6: Naval Group USV, Source - Naval Group

- **Training.** Training on these systems would be important to be able to exploit them fully. However, if navies are going to have multiple unmanned maritime systems, then the challenge of training personnel on such multiple systems may be a barrier to interoperability of unmanned systems and make for high switching costs. An alternative could be to have Design–Build–Operate–Maintain (DBOM)/Contractor Owned–Contractor Operated with Navy Oversight (COCONO) models for non-tactical systems or missions, taking some of the burden of training and switching costs away from customers/operators. The degree to which this is possible will again depend on trust. Military and commercial teams will need to decide how to work together with these commercial models.

- **Current Level of Autonomy.** The unmanned maritime systems currently available are remote controlled, providing augmented capabilities and it would be some time before regulations, trust, reliability, training, and confidence in these systems allow for more autonomous or fully autonomous unmanned maritime operations at sea. Autonomous underwater systems are a more challenging domain given the limitations of communication underwater. AI in unmanned/ autonomous maritime operations is currently at an early stage and much more system training would be required to achieve semi-autonomous and fully autonomous mission capability.

- **Vehicle Health Monitoring & Maintenance.** All unmanned and autonomous vehicles would need to have vehicle health monitoring systems. Depending on the effect desired, the mission for which unmanned maritime systems are designed, redundancy of critical systems (propulsion, power, and sensors) based on MTBF (mean time between failures) may also be needed. Compatible, easy to use launch and recovery systems for those unmanned systems that are meant to be integrated with manned vessels will be necessary together with maintenance facilities onboard the manned vessels.

Use of UMS in the Gulf Region for Maritime Security

Unmanned maritime systems have a wide range of potential applications in various fields. The roles UMS can play and the payloads they carry would be dependent on the specific mission requirements. These systems could offer a cost-effective and efficient solution to the challenges of monitoring and controlling the vast maritime borders of the gulf region, ensuring safety and security in the waters of the region. The applications of UMS in the gulf region can be:

- **ISR.** Unmanned systems can be used for intelligence, surveillance and reconnaissance (ISR), patrolling and monitoring using cameras, radar, sonar, and other sensors to provide real-time situational awareness. These systems can be deployed for long periods and can cover large areas, providing real-time information about any suspicious activities, helping to identify and track potential threats such as piracy, smuggling, gun-running, IUU (illegal, unreported, and unregulated) fishing.

Figure 7: Arabian Gulf Need to insert below the image.

- **Border Control/ Coastal Security.** The Arabian peninsula is the largest peninsula in the world with long coastlines, making it challenging to monitor and control borders. UMS can be used for border control and monitoring activities to augment capacities to prevent illegal immigration, human trafficking, smuggling, and other illicit activities.

- **Port and Harbour Security.** Unmanned Systems can be used for monitoring and securing ports and harbours, using cameras, sensors, and communication systems.

- **Oil & Gas Industry.** Autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs) can be used for inspection and monitoring of subsea structures of offshore platforms.

- **Mine Countermeasures.** Unmanned systems can be used for detecting and neutralizing underwater mines, using sonar and specialized equipment for mine sweeping and hunting.

- **Anti-submarine warfare.** Unmanned systems equipped with sonar can be used to detect and track submarines.

- **Surface Warfare.** USVs can also be used for targeting ships and targets ashore. Globally, USVs and ASVs that would carry multiple weapon payloads in VLSs are being built to provide distributed maritime operations and distributed lethality.

- **Electronic Warfare.** UMS can effectively support electronic warfare, ESM (Electronic Support Measures), SIGINT (Signal Intelligence), and ELINT (Electronic Intelligence) missions given the persistence of such systems.

- **Environmental Monitoring.** Significant maritime activity in the Gulf region comes with risks of oil spills and marine pollution. Unmanned systems can be used for monitoring marine environments, tracking oil spills, and monitoring water quality using sensors for measuring temperature, salinity, and other environmental parameters.

- **Hydrographic Surveys.** Unmanned systems can be used for hydrographic surveys, generating bathy profiles, change profiles that help secure trade and ensure safety of maritime operations.

- **Search and Rescue.** Unmanned systems can also be used for search and rescue operations using sensors and cameras for the purpose.

Progress of Unmanned Maritime Operations in the Arabian Gulf

There is increasing activity and adoption of unmanned maritime systems in the Arabian Peninsula. Al Seer Marine, Abu Dhabi, supplies unmanned systems to Gulf countries. It also revealed a 5m Hydra USV at IDEX 2023, reportedly built in 5 days using additive manufacturing. This is possibly the world's first 3D printed USV. ADSB also unveiled a new unmanned vessel at NAVDEX 2023, the 170 M-detector USV, for MCM (Mine Countermeasures) and ASW (Anti-Submarine Warfare) missions. ADASI, Abu Dhabi, also offers a remote-controlled Jet-Ski for coastal surveillance.

Set up in September 2021, USN Task Force 59 project initiatives undertaken by the USN Naval Forces Central Command (NAVCENT) together with navies of Gulf countries have seen trials of unmanned maritime systems being undertaken in the Arabian Gulf over a period of two years. Towards this project, 11 bilateral maritime exercises, three major international exercises, and over 30,000 hours of safe operations of USVs have been undertaken in waters around the Arabian Peninsula this far.

According to Vice Admiral Brad Cooper, the NAVCENT and US Navy 5th Fleet Commander during IDEX 2023, by the summer of 2023 nearly 100 of these unmanned vehicles will be operated in waters around the Arabian peninsula in partnership with navies of Gulf countries. A majority of these systems will be based on the "COCONO" model.

Figure 8: Al Seer Marine USV, Source - Al Seer Marine

Figure 9: Bahrain Navy Ship exercising with Mantas T-12 USV in the Arabian Gulf in October 2022, Source - USN

Future of Unmanned Maritime Systems

The technologies required for UMS are already available and the focus in future would be to make them more available, more reliable, and more maintainable. In the next 5 years, sub-30m systems with some autonomous capability working within regulatory limitations is expected, augmenting existing fleets. Simplicity of such operations with little training required would also be highly desirable.

Unmanned maritime systems are not planned to replace Navies but will augment their capacities and capabilities. Such UMS are likely to follow a pattern similar to UAVs where they progress from manned to MUM-T (Manned Unmanned Teaming) to fully autonomous unmanned systems capable of undertaking missions of increasing autonomy and complexity

Satellite-based Maritime Surveillance

Figure 10: Satellite image of Louvre Abu Dhabi, Source - Airbus

The increasing use of space for earth observation, communication, surveillance; the miniaturizing of satellites and payloads; and the reducing costs and time required for deploying or replacing such satellites is an opportunity to provide effective, efficient, and low cost maritime surveillance. Also, advancements in ML, AI, and data analytics enable more on-demand and real-time space-based solutions being provided. All these developments will enable increasing use of satellite-based maritime surveillance for maritime domain awareness (MDA), decision support and accelerate responses.

Technologies Used for Satellite-based Maritime Surveillance

Space-based maritime surveillance is enabled by mostly terrestrial and marine technologies that are deployed on satellites. Details of a few such technologies are provided in subsequent paragraphs:

- **SAT-AIS.** Automatic Identification System (AIS) fitted on ships is limited in range as it operates in the VHF band and can also be switched off or spoofed. This means AIS info is only available near coasts or in the vicinity of other vessels. A low earth orbit (LEO) satellite-based AIS on the other hand provides a larger swath of coverage and suffers only from the disadvantage of degradation of signals caused by simultaneous arrival of multiple AIS signals from within the same coverage area. AIS is usually a payload on satellites in sun-synchronous orbits, which results in longer revisit times and gaps unless constellations of satellites are used. With detection ranges of as much as 1500 miles, these systems cover wide swaths of the ocean but require cooperative ships.

- **SAR.** Synthetic Aperture Radar (SAR) is a high-resolution imaging system that uses microwave signals to provide accurate geolocation and imaging by day and night regardless of weather. These systems fitted on satellites can cover as much as 450 km in swath.

- **Optical Sensors.** Multispectral (MSP) and Hyperspectral (HSP) optical sensors, covering the entire optical region between microwaves and X-rays, wavelengths between 0.3μm to 15.5μm, provide accurate detail at high resolution upto 30 cm.

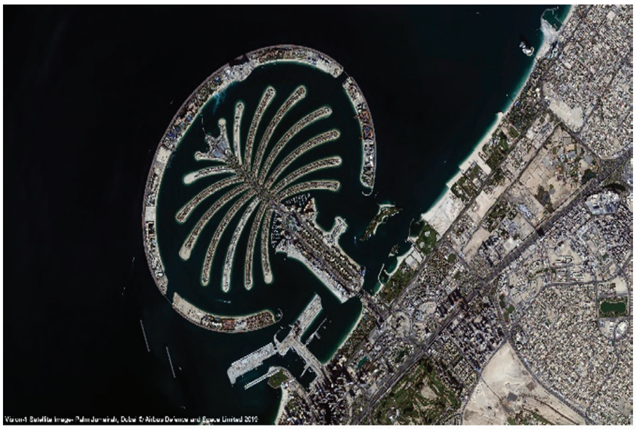

Figure 11: Satellite image of Dubai Palm Jumeirah, Source - Airbus

- **GNSS-R.** Global Navigation Satellite System Reflectometry (GNSS-R) is a passive bistatic radar (PBR) system where navigation signals emitted by GNSS satellites including GPS, GLONASS, Galileo, Beidou-2, IRNSS/NavIC and QZSS are received by space-based GNSS-R receivers. Since they are passive systems, they can be carried by small satellites such as nanosats and cubesats.

Key Challenges to be Addressed

- **Realtime and On-demand Solutions.** Current systems can revisit any place on earth atleast once a day, providing capability to monitor large areas, and provide historical event maps. But to provide real time and on demand solutions, larger constellations of dedicated satellites will be needed where unbroken and continuous coverage is needed.

- **Geopolitics and Export Control.** Given the expansive capabilities of satellite-based systems, the decision to provide such services is often not purely commercial. Geopolitics and export control, as with any other Defence acquisition, will play a key role in the type and nature of satellite-based maritime services that can be contracted.

- **Data.** Very large volumes of data are generated by satellite-based solutions each day and effectively managing and interpreting this data for it to be coherent and relevant at the right time as required by customers will be key to the utility of satellites for maritime security. In addition, willingness to share the data from multiple constellations of satellites would also be important to provide continuous surveillance.

Partnerships and Collaboration

Figure 12: Satellite image of MV Ever Given Blocking Suez Canal, Source – Airbus

The waters immediately surrounding the Arabian Peninsula extend from the Arabian Gulf to the Suez Canal and extend more than 3500 nm. Ensuring maritime security in this large area is consequently no small challenge. No one entity, state, industry, or military can hope to unilaterally find all solutions. In fact, each solution will need a coming together of many to find acceptable and best solutions relevant to the case. Partnerships,collaborations,cooperation, and shared responsibility between Gulf countries will help optimise investment in suitable unmanned systems towards developing a common maritime picture in the Gulf region and for other common purposes. Collaboration and partnerships will then be key to wider acceptability of common solutions.

Conclusion

Unmanned vessels will indeed be valuable for augmenting maritime capacities and capabilities in the waters around the Arabia Peninsula. Initially, these UMS are expected to be remote controlled, tethered systems capable of limited missions whilst acting either independently or with motherships before more capable, autonomous, and independent systems are developed that can handle complex multi-mission operations in constrained waters where manned and unmanned platforms operate together in close proximity.

The Arabian Gulf is already witnessing the earliest deployment of unmanned vessels by the USN together with other regional navies to enhance regional capabilities and capacities. The early roles planned for such deployments are for Maritime Domain Awareness. With growing confidence in UMS operations, more time training with such systems and better technology, more challenging roles would be possible using unmanned and autonomous maritime systems to augment current regional maritime capacities and capabilities. The opportunities for such systems to strengthen maritime security in the Gulf region are many if the challenges mentioned above can be overcome.

The use of satellites for maritime surveillance is already being undertaken in the Arabian Peninsula and will bolster maritime security. However, greater coordination and partnerships to have a larger constellation of satellites would be required to reduce revisit times and provide more real-time and on-demand solutions that are relevant.

Traditional naval forces, unmanned and autonomous vessels, and satellites will all have an important part to play in enabling maritime security in the waters around the Arabian Peninsula. The advantages of using innovative unmanned and remote solutions are plenty and worth pursuing to enhance maritime security in the gulf region. The increased use of unmanned systems and satellites will also free up major naval combatants for tasks for which they alone are best suited

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