The Indian Ocean and Smart Ports[1]

Vijay Sakhuja[*]

The Review of Maritime Transport (RMT) 2019, published by the United Nations Conference on Trade and Development (*UNCTAD*), has projected a positive outlook for global shipping which is expected to grow at an annual average growth rate of 3.4 percent for the next five years.[2] The RMT urges states to 'adopt a multipronged approach'[3] to address shortcomings in port operations, and notes that 'digitalization and automation are transforming the shipping sector and requiring new skills'.[4] Furthermore, new technologies and innovations are offering 'new opportunities to achieve greater sustainability in shipping and ports, as well as enhanced performance and efficiency.'[5]

There are visible trends in the use of digital technologies in maritime trading eco-system to enhance efficiency and productivity, particularly in port operations. The port-digital ecosystem is built around the Cyber-Physical System (CPS): that is, physical infrastructure and cyber facilities to augment efficiency at various levels along the ship-shore-ship supply chain - ships, ports, and associated supply chains that connect the production hubs in the heartland back to the ocean. The CPS is enabled by a host of Fourth Industrial Revolution (4IR) technologies, also referred to as Industry 4.0, such as Artificial Intelligence Machine Learning, Blockchain, Big Data, Autonomous Systems, etc. These are up-scaling the efficiency of the maritime connectivity eco-system.

In early 2019, the global fleet comprised of 92,294 seagoing ships, accounting for nearly 1.97 billion dead-weight tonnage (DWT).[6] There are several thousand ports (big, medium, and small) across the globe; but 99 per cent of world's mercantile trade moves through only 835 sea ports and inland ports.[7]

[*]**The Author,** Dr. Vijay Sakhuja is a former Director, National Maritime Foundation, New Delhi. He is currently Visiting Senior Fellow, Cambodian Institute for Cooperation and Peace, (CICP) Phnom Penh, as also Consultant with Vivekananda International Foundation, the Indian Council of World affairs, and the Kalinga International Foundation, all in New Delhi.

India is a maritime nation, and its external trade (90% by volume and 70% by value) is handled by 12 major ports and approximately 200 non-major ports which dot the 7516 kilometres long coastline. There are 1719 vessels under Indian register (1.83 of the world's total) and, in 2017, 1011 vessels were engaged in India's sea borne trade, and 885 vessels were under national flag and 126 foreign flagged vessels.[8] The maritime trade has been expanding, and the focus is on infrastructure development and the capacity enhancement of ports. India's Sagarmala Programme features port led development,[9] and there are 574 projects to be implemented during 2015–2035. Moreover, as of 30 September 2019, as many as 121 projects have been completed and 201 projects are under various stages of implementation, development, and completion. Some ports have begun data related transformations at the organisational and operations levels.

In the above contexts, this paper is an attempt to understand the impact of 4IR technologies in the port sector. It identifies three ports in the Indian Ocean that have assimilated, or are at various levels, of using 4IR technologies in operations. The paper also highlights the role of 4IR in the Chinese Belt Road Initiative through the Digital Silk Route, and briefly focuses on the status of the digitalization of Indian ports.

The Definition of Smart Port

A 'connectivity eco-system' is a process which facilitates the movement of goods that are transported on board carriers which move on the road, on the rails, in the air, over the seas through sea ports and dry ports, and through services that are delivered through digital platforms, including fibre optic cables in support of port operations. It is dynamic in nature, and lies at the heart of globalization which is the highpoint of the global economy marked by economic prosperity and maritime trade. In this eco-system, ports are the important nodes which connect the land to the sea, and it is here that bulk of the trans-shipment of goods takes place. There are numerous port development projects mushrooming across the globe, including expansion programmes for existing infrastructure, and are attracting 'Smart Port' thinking.

It is useful to define a Smart Port to obtain a clearer understanding of the term as also to identify the various technologies that go into making a port smart. Numerous definitions have been propounded to define the term; but a simpler version is "Smart Port uses automation and innovative technologies including Artificial Intelligence (AI), big data, Internet of Things (IoT) and Blockchain to improve its performance."[10]

At the heart of this definition are two important issues: first, 4IR technologies enable 'efficient data-driven decision making';[11] and second, enhancing the efficiency of the supply chain. This is not to suggest that it is only the ports that require 4IR technologies; instead, these technologies are now embedded in every facet, and the operation of the supply chain in which the port is one of the many stakeholders.

Many seaports across the globe have begun using 4IR technologies, and the major players are in Europe and the USA, barring one in Asia.[12] The future global market for the smart port segment is very encouraging, and is projected to touch US$ 5.3 billion by 2024 from an estimated US$ 1.7 billion in 2019, at a CAGR of 25 percent. In this, the Blockchain segment (control over information, the privacy of the user, and the prevention of the manipulation of data) is expected to be the fastest-growing market during this period.[13] Some industry experts believe that "smart ports are the only ports that will survive."[14]

4IR Technologies in Port Operations

4IR technologies provide unique opportunities, and can potentially revolutionise the entire supply chain ecosystem built around multiple stakeholders, such as shippers, freight forwarders, terminal operators, carriers (trucks, rail, and ships), other connected service providers such as port customs, security agencies, and emergency services, all of which are connected to each other in real time.

It has been noted that,

introducing IoT techniques into container terminal operations enables port terminal operators and other port related entities to collect, process, and store bulky digitalized data from daily terminal operations on a 24 hours and 365 days per year basis no terminal staff intervention.[15]

Moreover, Artificial Intelligence will "learn port operation skills and practices by analyzing the big data", and the automatised container terminal yard "will assist the terminal staff in all over daily operations and management works". Some of the important functions would be assisting terminal planners about stowage and yard plans, crane time optimisation, and the control and processing of container cargo traffic, etc.[16]

Blockchain technology is critical for enhancing operations in business, governance, management, security, and defence, as also in human-social engagements. The use of Blockchain technology is well known in crypto

currencies, such as the Bitcoin's gold, Ethereum, Zcash, Litecoin, Dash, Ripple, Monero, etc. These are now accepted as legal forms of payment and tools of financial exchange.

A Blockchain platform enables the exchange of information on the

provenance of goods, tariff codes, classification data, import/export data and certificates, manifests and loading lists, customs values, status information, and all other information about goods within the supply chain ecosystem was available for all parties involved at any time and everywhere. [17]

What emerges is a protected and paperless supply chain which contributes to not only transparency but also enables track-and-trace. For example, before entering a port to discharge its cargo, a ship transmits a variety of data to port operators, the customs department, security agencies, and other service providers which can be authenticated and approved through artificial intelligence tools and speed up pre-arrival requirements, thereby adding to efficiency, reducing the turnaround time of ships, and the delivery of cargo to the end-users.

A Hong Kong-based company '300cubits' has put out an expression of interest to " partially replace US dollars in the container shipping industry with a token soon to be launched on Ethereum".[18] It plans to sell tokens to industry practitioners which will be "used as booking deposits for container shipping where value could be lost if a customer does not turn up with a cargo or a container liner does not load a cargo according to a confirmed booking". This is consequent to the company's belief that trust between liners and customers is critical given that "customers in container shipping do not bear any consequences for not showing up for bookings".

The commercial maritime world has already embraced Blockchain technology in a few sectors; but its use in other marine related activities will potentially change the industry, making it more transparent, efficient, and secure.

Ports in the Indian Ocean

There are a number of important ports that dot the Indian Ocean littoral, but there are only few major ports.[19] These include: East Africa: (Durban (South Africa), Maputo (Mozambique) and Djibouti (Djibouti); West Asia and Persian Gulf: (Aden (Yemen) and Jebel Ali, Dubai; South Asia: Karachi (Pakistan), JNPT, (India), Kolkata and Haldia (India), Chennai (India) Colombo (Sri Lanka),

Hambantota (Sri Lanka); Southeast Asia: Singapore (Singapore) and Port Kelang (Malaysia); and Australia: Port Freemantle and Melbourne Port. However, only two major ports (Jebel Ali, Dubai, UAE, and Singapore) in the Indian Ocean figure in the top 20 container ports; however, there are at least 10 ports listed in the top fifty container ports of the world.[20]

Lloyd's List, a major maritime conglomerate, is of the view that there would be trade expansion through port infrastructure investment in the South Asia, Middle East, and Africa (SAMEA) region, and the smaller ports would

Rank	Port	2018	2017
		(in **Million TEU**)	
1	Shanghai, China	41.02	40.23
2	Singapore	36.60	33.67
3	Ningbo-Zhoushan, China	26.35	24.61
4	Shenzhen, China	25.73	25.21
5	Guangzhou Harbour, China	21.92	20.37
6	Busan, South Korea	21.66	20.47
7	Hong Kong, China	19.60	20.76
8	Qingdao, China	19.31	18.30
9	Tianjin, China	16.0	15.07
10	Jebel Ali, Dubai, UAE	14.95	15.37
12	Port Klang, Malaysia	12.32	11.98
18	Tanjung Pelepas, Malaysia	8.96	8.38
25	Colombo, Sri Lanka	7.05	6.21
32	JNPT, India	5.05	4.71
37	Mundra	4.44	3.98
35	Jeddah, Saudi Arabia	4.12	4.15
48	Salalah, Oman	3.39	3.95

be the 'game-changer' for ports and trade.[21] Further, new global Blockchain initiatives by major shipping companies necessitate data synchronisation between maritime ecosystems across the value chain. This is becoming critical. All stakeholders, including customs and port authorities, would be able to share a database which would not only be secure but also add to transparency and efficiency. In the succeeding sections, this essay discusses three major trans-shipment hubs in the Indian Ocean: the Port of Singapore; Abu Dhabi Ports (ADP), UAE; and the Port of Colombo, Sri Lanka.

The Port of Singapore

Singapore began using mobile devices and 4G wireless connectivity for communications and improving productivity as early as 2015, and mobile Apps were introduced to 'passenger experience and business operations at the terminals'. For instance, the Maritime and Port Authority of Singapore's (MPA) App, 'myMaritime@SG', is available on the iTunes App Store and Google Play, and can be operated by both iOS and Android mobile devices. The App enables the maritime community and the public to obtain maritime information on related issues and services.[22]

The MPA has been the catalyst to make Singapore a Smart Port through a number of initiatives. The Smart Port Challenge, started in 2017, is a platform which offers opportunities for start-ups to embrace 4IR technologies to transform the maritime sector and deliver solutions.[23]

After an eighteen month study of the performance and capabilities of the 5G network for port applications, the MPA and the Infocomm Media Development Authority (IMDA) are all set to work on 5G network infrastructure development, and catapult port operations for future applications across the various verticals of the industry.[24]

Similarly, the Singapore port is preparing to dock Maritime Autonomous Surface *Ships* (*MASS*) - that is, autonomous ships. In that context, a Centre of Excellence for Autonomous and Remotely Operated Vessels (CEAOPS) was announced.[25] The chief executive of MPA remarked that,

> Digitalisation and new technologies will disrupt the future of the maritime industry, and the evolution of MASS could potentially enhance global maritime trade more efficiently and safely in how we ship goods around the world. We're pleased to support the establishment of CEAOPS as it will enhance MPA's efforts in establishing Singapore as a MASS ready port and a leading technology cluster for MASS technologies.[26]

In March this year, *PSA Polaris,* a 27 meters long MASS, a jointly funded 'IntelliTug' project of the MPA and the Maritime Innovation and Technology (MINT) Fund, successfully completed the first commercial trials in the port, and 'demonstrated its capability to avoid a variety of obstacles, including virtual and real-life moving vessels'.[27]

Abu Dhabi Ports, UAE

Like Singapore, the UAE has been at the forefront of building 'Smart Ports'. As early as 2013, DP World had promoted the idea, and one of its top

functionaries for the UAE region noted that the company had

> created our smart port concept, one that offers traders mobile applications and round the clock electronic transaction facilities giving them real-time information, 365 days a year, through their smartphones and from any location.[28]

The UAE is also developing infrastructure to operate autonomous ships to add to safety as also to lower the cost of operations. The Abu Dhabi Ports (ADP) has signed a deal with Robert Allan Ltd. to develop fully unmanned autonomous marine tugs.[29] The tugs will support towing and manoeuvring operations within ports for autonomous container ships. The leadership of ADP believes that for it to lead the charge towards digitalising the region's maritime operations, "adopting digital solutions and keeping up with the changing demands of global trade have proven to be key drivers for economic growth, and are integral towards achieving our goal of being a smart port".[30] ADP is also working with Dell Technologies to integrate advanced technologies into maritime operations and solutions.[31]

Interestingly, ADP has now diversified from not being just a recipient of technology; it is now joining port projects overseas. For instance, it is now a partner 'for an online port community system India has been developing into a single-window logistics experience'.[32]

The Port of Colombo

Unlike Singapore and ADP, the Colombo Port's plan to turn into a Smart port is just beginning. In 2019, the Sri Lankan government announced that steps have been taken to introduce automated functions in the port, and transform it into a Smart Port to improve efficiency over the next 12 to 18 months. Further, the government has allocated US$ 5.18 million for the project which includes 'IT upgrades to streamline terminal management and cargo systems' as also to use satellite-based systems to improve productivity.[33] The Ports and Shipping Minister, Sagala Ratnayaka, is upbeat about the transforming Colombo into a Smart Port which will add to "efficiency and handle a greater volume of activities within a shorter period of time with the use of advanced IT and information systems."[34]

The Digital Silk Route and Smart Ports

Among many contemporary economic issues concerning the Indian Ocean, connectivity infrastructure, economic corridors, shipping routes, and port

related infrastructure have been high on the agenda. The majority of Indian Ocean littorals do not possess technological expertise and the requisite financial capital and, therefore, need support for the development of maritime infrastructure. This has been a significant catalyst for China to aggressively pursue its political, economic, and strategic agenda through the 21st century Maritime Silk Road (MSR), which is a part of the ambitious and overarching Belt Road Initiative (BRI).

The MSR is focused on connectivity infrastructure involving the development of ports, harbours, roads, and rail network as well as energy related infrastructure. China has obtained long term leasing rights to a number of ports and maritime spaces in the Indian Ocean and the Mediterranean Sea through 'lend and lease' agreements.

In 2019, two major Chinese State-owned maritime enterprises - COSCO and China Merchants - run as many as 42 major ports in 34 countries across the Eurasian and African coastlines.[35] Many countries in the region are quite sanguine about Chinese support, notwithstanding the fear of a debt trap (Sri Lanka, Pakistan, Maldives, Ethiopia, Kenya and Malaysia) partly due to its ability to deliver quality products.

China also has other Silk Road plans and these cut across domains, including the Arctic Silk Road, the Digital Silk Road, and the Health Silk Road. In 2016, China also announced the Digital Silk Road (DSR) an invisible silk road,[36] involving fibre optic cables and satellites network to "improve international communications connectivity" as also "foster the internationalization of China's rapidly growing tech companies".[37] The 2015 'Vision and Actions on Jointly Building Silk Road Economic Belt and 21st-Century Maritime Silk Road' notes that China should

> jointly advance the construction of cross-border optical cables and other communications trunk line networks, improve international communications connectivity, and create an Information Silk Road. We should build bilateral cross-border optical cable networks at a quicker pace, plan transcontinental submarine optical cable projects, and improve spatial (satellite) information passageways to expand information exchanges and cooperation.[38]

Further, in 2017, speaking at the opening ceremony of the Belt and Road Forum for International Cooperation, President Xi Jinping reiterated the critical necessity to

> pursue innovation-driven development and intensify cooperation in frontier areas such as digital economy, artificial intelligence, nanotechnology and

quantum computing, and advance the development of big data, cloud computing, and smart cities so as to turn them into a digital silk road of the 21st century.[39]

The DSR comprises of three pillars: first, telecommunication infrastructure, which includes the development of fibre optic cables network, both on land and under the sea, high-speed broadband network including 5G connections, and the safety of industrial data; the second is E-commerce; and, the third pertains to smart city projects under which advanced information and communication technologies - such as the internet of things - would control and drive a number of services, including utility, medical, traffic, and safety.[40]

It is the first pillar of the DSR that has direct relevance to the MSR, and helps China consolidate its position in the Indian Ocean strategic calculus. For instance, Huawei Technologies, a world leader in telephony, particularly the 5G, is also engaged in the undersea cable business. It has planned a 12,000 kilometres Peace Cable project for laying an underwater high-speed internet cable system to link Pakistan (Gwadar), South Africa, Kenya, Somalia, Djibouti, Egypt, and France.[41] The USA has asked its treaty allies and close partners, including India, to "refrain from using Huawei in the setting up of their 5G wireless telecommunication systems due to serious security concerns".[42]

Another important element of the DSR is the BeiDou Navigation Satellite System (BDS) comprising 40 satellites which would provide services to the "entire globe by the year 2020", with "100 times more accuracy." Currently, BDS provides service to nearly 30 BRI countries, and there are plans to add more satellites into the constellation, and expand services to all 64 BRI countries.[43]

China has developed a sophisticated Big Data Risk Monitoring Platform (BDRMP) under the 'Smart Customs' initiative. The BDRMP has been set up at the Customs office at Nanning, and links cross-border trade across 26 ports in Southeast Asian nations.[44] It is envisaged that the platform would allow "custom agencies to manage and monitor in real-time complex operational and regulatory risks relating to cross-border customs declarations as well as optimize operations in trade logistics and trade compliance."[45] It has been noted that BDRMP is also a way to impose unofficial sanction to "target the goods of nations (or even individuals) that the PRC wishes to influence", and was used to 'restricted Philippine banana exports from entering Asian markets between 2016 and 2018 over bilateral tensions related to the South China Sea.'[46]

Indian Ports and 4IR

The Indian Ministry of Shipping has taken a data related initiative in the port sector, both at the organisational and operational levels to enhance the 'Ease of Doing Business'.[47] Some of these include: Direct Port Delivery (DPD); Direct Port Entry (DPE); RFID, and the installation of scanners/container scanners which have reduced congestions at the entry gates of the ports. The upgraded Port Community System (PCS 1X version) has been set up in all ports, and "enables seamless data flow between the various stakeholders through common interface" which would result in a "complete paperless regime, E-DO (Electronic Delivery Order) through PCS made mandatory, along with e-invoicing and e-payment."[48]

As noted earlier, the Jawaharlal Nehru Port Trust (JNPT) ranks 32nd among the top 50 ports in the world, and has been continuously enhancing its efficiency through innovation and reform. It is using digital technologies for the automated management of cargo movements, and vessel-port-vehicle traffic management through data based analytics, GPS, and image-recognition technologies.[49] Similarly, there is a push towards "AI-led restructuring of the ports-logistics sector", and a good example is the "Nhava-Shewa and Bhiwandi, e-commerce led logistics" which has transformed warehouse and trucking operations in the sector, adding to efficiency.[50]

The above developments are good examples for many other Indian ports, and these will have to quickly adapt to the ongoing transformation in the port ecosystem that is rapidly absorbing 4IR technologies to enable them to remain competitive at the national and international levels. Likewise, human resources - workers, labour, truckers, and supply chain managers - will have to be part of the port-digital ecosystem.

The Indian government has promoted the idea of 'digital India', and Indian ports are pursuing this objective. Over the past few years, the incumbent government has shown interest in adopting new forms of technology. Ports are designing business innovative models not only to lower operational costs but also to add efficiency through real-time tracking and tracing of shipments using 4IR tools and technologies. A number of technological innovations are currently underway at both major and non-major ports in India, and "Blockchain, the Internet of Things (IoT), and artificial intelligence" have been introduced, making the entire port-logistic ecosystem function like a seamless entity, and support the national port led development plan under the Sagarmala Project.[51]

Concluding Thoughts

The concept of Smart Ports is yet to gather momentum among the Indian Ocean littorals, and only two ports - the Port of Singapore and the Abu Dhabi Ports, UAE - have made significant investments; the Port of Colombo, Sri Lanka has also taken some initiatives. Many other Indian Ocean countries, such as Australia, Bangladesh, India, Malaysia, and South Africa are considering Smart Ports, and the idea figures prominently in their Blue Economy plans.

At the strategic level, the appetite for new port projects among Indian Ocean littorals as well as China's deep pockets will help many countries, particularly the small island states, to pursue Smart Ports - and these may even take a lead over others, albeit with Chinese support. China's ability to craft cooperation under the Digital Silk Road and augment the connectivity infrastructure of the Indian Ocean states is a potential source for competition. Australia, India, Japan, and the USA are likely to add robustness to the Blue Dot Network, and build robust partnerships to challenge any economic and strategic 'hegemonic order' led by China in the Indian Ocean. This attracts a number of strategic concerns.

Notes :

[1] This article does not include the impact of COVID-19 which has disrupted global maritime supply chains, resulting in major shipping companies cancelling voyages, the closure of port operations due to the quarantine of port labour and stevedore service providers, and the shutting down of manufacturing hubs.

[2] "Review of Maritime Transport 2019", at https://unctad.org/en/PublicationsLibrary/rmt2019_en.pdf, accessed 2 April 2020.

[3] Port call optimization; trade and transport facilitation; and port operations.

[4] "Review of Maritime Transport 2019", at https://unctad.org/en/PublicationsLibrary/rmt2019_en.pdf, accessed 2 April 2020.

[5] Ibid.

[6] Ibid.

[7] "Seaports of the World by Country", at http://exportvirginia.org/wp-content/uploads/2014/04/Seaports-of-the-World.pdf, accessed 2 April 2020.

[8] See, https://unctad.org/en/PublicationsLibrary/rmt2018_en.pdf, p. 30.

[9] "Projects under Sagarmala", at http://sagarmala.gov.in/projects/projects-under-sagarmala, accessed 16 April 2020. Some important facets of the Sagarmala Project are: a   Port Modernization and New Port Development, including new Greenfield ports; b   Port Connectivity Enhancement with the hinterland to optimize cost and time of cargo movement through multi-modal logistics solutions, including inland water transport and

coastal shipping; c Port-linked Industrialization and the development of Coastal Economic Zones and industrial clusters to reduce the cost of logistics and the time taken by international and domestic seaborne trade; and Coastal Community Development, promoting sustainable development of coastal communities through skill development & livelihood generation activities, fisheries development, coastal tourism, etc.

[10] Matteo Natalucci, "What is a Smart Port?" at https://www.porttechnology.org/news/what-is-a-smart-port/, accessed 2 April 2020.

[11] "Smart Ports Market by Technology IoT, Blockchain, Process Automation, Artificial Intelligence AI, Elements Terminal Automation, PCS, Smart Port Infrastructure, and Others , Throughput Capacity, Port Type, and Region – Global Forecast to 2024", at https://www.marketsandmarkets.com/Market-Reports/smart-ports-market-165784113.html, accessed 2 April 2020.

[12] Ibid. 'Royal Haskoning The Netherlands , IBM USA , ABB Switzerland , Trelleborg AB Sweden , Port of Rotterdam The Netherlands , and Abu Dhabi Ports UAE '.

[13] "Worldwide Smart Ports Market Insights 2019–2024 : Big Data Analytics, IoT, and AI to Transform Port Operations", at https://www.globenewswire.com/news-release/2019/08/08/1899479/0/en/Worldwide-Smart-Ports-Market-Insights-2019-2024-Big-Data-Analytics-IoT-and-AI-to-Transform-Port-Operations.html, accessed 21 September 2019.

[14] "How the Fourth Industrial Revolution is Impacting Ports of the Future", https://www.boldbusiness.com/digital/fourth-industrial-revolution-impacting-ports-future/, accessed 21 September 2019.

[15] Kenji Ono1, Masayuki Tanemura and Yasuhiro Akakura, "AI Port Initiatives", at http://www.ysk.nilim.go.jp/kakubu/kouwan/system/2018_01.pdf, accessed 21 September 2019.

[16] Ibid.

[17] "Why blockchain should be global trade's next port of call", at https://www.weforum.org/agenda/2017/05/blockchain-ports-global-trades/, accessed 2 April 2020.

[18] "Blockchain Currency Ready for Container Shipping", at https://maritime-executive.com/article/blockchain-currency-ready-for-container-shipping, accessed 2 April 2020.

[19] "Indian Ocean Trade and Transportation", at https://www.britannica.com/place/Indian-Ocean/Trade-and-transportation, accessed 30 October 2019.

[20] "Top 50 World Container Ports", at http://www.worldshipping.org/about-the-industry/global-trade/top-50-world-container-ports, accessed 2 April 2020.

[21] "Why smart ports will be a game-changer for shipping", at https://lloydslist.maritimeintelligence.informa.com/articles/2019/lloyds-list-forums/why-smart-ports-will-be-a-gamechanger-for-shipping, accessed 2 April 2020.

[22] "Singapore MPA Unveils Smart Port Initiatives", at https://www.maritime-executive.com/article/singapore-mpa-unveils-smart-port-initiatives, accessed 2 April 2020.

[23] "Singapore's smart port initiative attracts more start-ups", at https://www.seatrade-maritime.com/asia/singapore-s-smart-port-initiative-attracts-more-start-ups, accessed 2 April 2020.

[24] Mark Johnston, "M1 to test 5G tech in Singapore smart port initiative", at https://sg.channelasia.tech/article/663429/m1-test-5g-tech-singapore-smart-port-initiative/, accessed 2 April 2020.

[25] "Singapore setting up research centre into autonomous ships", at https://www.seatrade-maritime.com/asia/singapore-setting-research-centre-autonomous-ships accessed 2 April 2020.

[26] "Singapore starts researching autonomous ships", at https://safetyatsea.net/news/2019/singapore-starts-researching-autonomous-ships/, accessed 2 April 2020.

[27] "Port of Singapore Mass Trials Successful", at https://www.portstrategy.com/news101/technology/port-of-singapore-mass-trials-successful, accessed 0 April 2020.

[28] "DP World highlights need for smart ports". at https://www.khaleejtimes.com/business/local/dp-world-highlights-need-for-smart-ports , accessed on 2 April 2020.

[29] "Abu Dhabi Ports inks deal to develop first autonomous tugboats", at https://www.arabianbusiness.com/technology/442161-abu-dhabi-ports-inks-deal-to-develop-first-autonomous-tugboats, accessed 2 March 2020.

[30] Ibid.

[31] "Abu Dhabi Ports Selects Dell Technologies to Accelerate its Digital Transformation Journey", at https://www.adports.ae/abu-dhabi-ports-selects-dell-technologies-to-accelerate-its-digital-transformation-journey/, accessed 5 March 2020.

[32] "Abu Dhabi Ports to link with India's digital freight portal", at https://www.joc.com/port-news/international-ports/abu-dhabi-ports-link-india%E2%80%99s-digital-freight-portal_20191114.html, accessed 2 April 2020.

[33] "Sri Lanka set to transform Colombo port into smart port", at http://www.xinhuanet.com/english/2019-02/25/c_137849478.htm, accessed 2 April 2020.

[34] "Sri Lanka's leading port to be transformed into smart port", at https://newsin.asia/sri-lankas-leading-port-to-be-transformed-into-smart-port/, accessed 2 April 2020.

[35] John Hemmings, "The Hidden Dangers of China's Digital Silk Road", at https://nationalinterest.org/feature/hidden-dangers-chinas-digital-silk-road-131887, accessed 15 March 2020.

[36] Grzegorz Stec, "The Invisible Silk Road: Enter the Digital Dragon", http://www.eias.org/wp-content/uploads/2016/03/EU_Asia_at_a_Glance_Stec_DSR_2018-1.pdf, accessed 15 April 2019.

[37] Ibid.

[38] See "Vision and Actions on Jointly Building Silk Road Economic Belt and 21st-Century Maritime Silk Road", http://en.ndrc.gov.cn/newsrelease/201503/t20150330_669367.html,

accessed 16 April 2019.

[39] http://en.people.cn/n3/2019/0424/c90000-9571418.html assessed on 2 April, 2020

[40] "Smart cities are taking over, and over 50% of them are in China", accessed 16 April 2019, at https://www.cnbc.com/advertorial/2018/03/28/smart-cities-are-taking-over-and-over-50-percent-of-them-are-in-china.html, accessed 16 April 2019.

[41] Dipanjan Roy Chaudhury, "Huawei under radar of many countries fearing espionage", at https://economictimes.indiatimes.com/news/international/business/huawei-under-radar-of-many-countries-fearing-espionage/articleshow/67782890.cms, accessed 17 March 2020.

[42] "Security suspect Huawei fights to contend for India's 5G procurement", at https://www.tibetanreview.net/security-suspect-huawei-fights-to-contend-for-indias-5g-procurement/, accessed 17 March 2020.

[43] Sabena Siddiqui, "BRI, BeiDou and the Digital Silk Road", at https://www.asiatimes.com/2019/04/opinion/bri-beidou-and-the-digital-silk-road/, accessed 17 March 2020.

[44] Max Schwerdtfeger, "Big Data Platform Launched in New Silk Road", at https://www.porttechnology.org/news/big-data-platform-launched-in-new-silk-road/, accessed 17 March 2020.

[45] Ibid.

[46] "Hidden dangers of China's Digital Silk Road", at https://www.beltandroad.news/2020/03/14/hidden-dangers-of-chinas-digital-silk-road/, accessed 3 April 2020.

[47] "Ministry of Shipping Year End Review, 2019", Press Information Bureau

Government of India, Ministry of Shipping, at https://pib.gov.in/newsite/PrintRelease.aspx?relid=196067, accessed 15 April 2020.

[48] Ibid.

[49] "Impact of Digitalization in the Ports Sector", https://itforchange.net/sites/default/files/1664/Impact-of-Digitalization-in-the-Ports-Sector.pdf, accessed 16 April 2020.

[50] Ibid.

[51] "Inducing Digitalization in Indian Maritime Sector", at http://sagarmala.gov.in/sites/default/files/INDUCING%20DIGITALISATION%20IN%20INDIAN%20MARITIME%20SECTOR%20%281%29-converted.pdf, accessed 16 April 2020.

✴ ✴ ✴