Smart Ports: Is SADC positioned for Transition?

Leticia A Grimett‡

ABSTRACT

Whereas international trade was previously the preserve of organised business, the digital revolution and the increased popularity of online purchases on the internet has meant that international trade is now easily accessible at an individual level. At both a domestic and international level, the Covid-19 crisis amplified the pressure placed on businesses and consumers to adopt digital technologies, and this has been catalytic in moving the public towards greater reliance on online transactions and a movement away from traditional purchasing practices. Increased global trade at an individual level has put greater pressure on global supply chains, with every link in the supply chain being called upon to perform more effectively and efficiently. Ports, as gates of entry into domestic markets and transshipment routes, have been under increased pressure to conform to the needs of the international trading community.

Greater trading volumes have put ports at risk of higher levels of crime by international and domestic criminal syndicates. The changing environmental landscape has meant that ships are being transformed for compliance purposes. Increased concern about water quality and impacts on sensitive habitats has put additional pressure on port authorities. These pressures have led to the creation of smart ports, which are fully automated, taking advantage of the latest technologies, blockchain and artificial intelligence (AI), and state of the art monitoring software and processes, while adhering to and promoting compliance with both the latest environmental protocols and the United Nations (UN) 2030 Sustainable Development Goals (SDGs).

In this contribution to the conference, the discussion centres on the challenges facing ports in the Southern African Development Community (SADC) region, in the light of the latest global developments. Smart ports and the drivers towards greater changes are discussed and analysed. Finally, the state of ports in the SADC region are evaluated in the light of the latest global developments in order to determine whether our ports are prepared to transition and changes that can be made to facilitate the process.

Keywords: port development, smart ports, transformation, generations of ports

‡ Honorary Research Fellow at the University of KwaZulu-Natal School of Law, South African International Maritime Institute.

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I INTRODUCTION

Change is often driven by need and inescapable circumstances, and the movement towards the establishment of smart ports is no exception. Global trade has been both a catalyst for and a beneficiary of increased technological breakthroughs. It has also, unfortunately, been a major contributor to the climate change crisis. Shipping companies are known to contribute towards increased carbon dioxide (CO_2), nitric oxide and greenhouse gas (GHG) emissions, spillage of fossil fuels and hazardous waste, as well as waste matter, thus polluting the marine environment.[1] Ships at port are also responsible for air pollution, which affects both the surrounding communities and the sensitive marine ecosystems surrounding the ports.[2] The needs of multinational companies have facilitated the speedy development of both the supply chain sector, risk management policies and legislation, as well as information technology (IT) and data management breakthroughs, and the use of artificial intelligence to expedite manufacturing processes and secure data management systems, amongst others.

Increased trade volumes have placed greater pressure on ports to perform more efficiently and effectively.[3] In addition to their gateway function, ports are also customs access and exit points, with government agencies facing additional pressures to their normal customs functions. As the 9/11 terrorist attack clearly indicated, increased global trade has provided more opportunities for criminal syndicates and terrorist cells to move contraband, weapons and illegal animal and human cargoes.[4] The endogenous and exogenous pressures placed on ports and the competition faced by governments, with the fast-changing balance of power between western and eastern ship owners, together with more stringent trade, shipping and supply chain regulations, has led to the rise of the smart port.[5] In this paper, smart ports will be defined and the many elements influencing their adoption will be explained. Against this backdrop, the development of the ports of Maputo in Mozambique, Walvis Bay in Namibia and Durban in South Africa will be discussed and analysed to determine whether they are positioned to take the next step to transition successfully as smart ports.

II THE TRANSFORMATION OF PORTS

The Collins Dictionary defines a 'port'[6] as a harbour where goods or passengers are loaded or unloaded. Although this definition describes the basic activities at a port, it can hardly be relied upon to adequately describe the many aspects of modern ports. With time, the functions of ports have changed and evolved, with each successive generation fulfilling a new role.

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1 A Chircop, M Doelle & R Gauvin *Shipping and Climate Change: International Law and Policy Considerations Special Report (Waterloo: Centre for International Governance Innovation 2018)* (available from: https://www.cigionline.org/sites/default/files/documents/Shipping%27s%20contribution%20to%20climate%20change%202018web_0.pdf>) at 5.

2 N Braathen (ed) *Environmental Impacts of International Shipping: The Role of Ports (Paris: OECD Publishing 2011)* cited in OECD Environmental Impacts of Ports (2022) (available from: <https://www.oecd.org/greengrowth/greening-transport/environmental-impacts-of-ports.htm>).

3 ZH Munim & H Schramm 'The Impacts of Port Infrastructure and Logistics Performance on Economic Growth: The Mediating Role of Seaborne Trade (2018) 3(1) *Journal of Shipping and Trade* (available from: <https://jshippingandtrade.springeropen.com/track/pdf/10.1186/s41072-018-0027-0.pdf>).

4 J Peterson & A Treat 'The Post-9/11 Global Framework for Cargo Security' (2006) 2 *Journal of International Commerce and Economics* (available from: <https://www.usitc.gov/publications/332/journals/cargo_security.pdf>) at 2.

5 Public–Private Infrastructure Advisory Facility (PPIA) *Port Reform Toolkit* Modules 1 and 2 2 ed (Washington, DC: World Bank 2007) (available from <https://ppiaf.org/sites/ppiaf.org/files/documents/toolkits/Portoolkit/Toolkit>) at 5.

6 'port' Collins Dictionary [online] (available from: < https://www.collinsdictionary.com/dictionary/english/port>).

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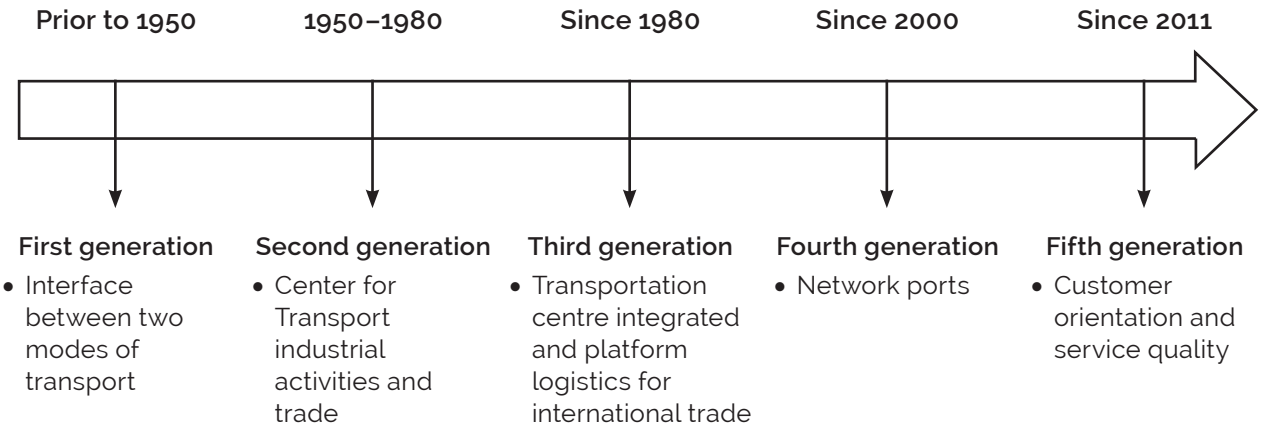

Figure 1: The Five Generations of Ports[7]

The Public-Private Infrastructure Advisory Facility (PPIA) and World Bank Toolkit[8] refers to three main forces driving port reform. These are:

- External forces of competition and technology from the shipping industry
- The acknowledged financial and operational benefits of private participation in infrastructure development and service delivery
- The diversification and globalisation of investors and operators in the port industry.

The first force has driven the need to restructure port operations to deal with the external factors affecting port viability. These include national competition for global markets, changes in port and transport technology, and increased competition among ports.[9] The impact of technology on ports has become a powerful differentiating force between ports and radically increased the ability of ports to perform. The fourth industrial revolution (4IR) technologies, such as AI, the Internet of Things (IoT), cloud, big data and blockchain, are common modern smart port technologies.[10]

According to an ALG newsletter,[11] the following elements are the basis for smart ports:

Industrial IOT and blockchain:

- Blockchain integration
- Private LTE networks
- Wireless control
- Integrated sensors

Automation:

- Self-driving vehicles
- Automated cranes
- Interrmodal transfers
- Autonomous vessels
- Drones for prearrival inspection

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7 A Hlali & S Hammami 'Seaport Concept and Services Characteristics: Theoretical Test' (2017) 11(1) *The Open Transportation Journal* (available from: <https://benthamopen.com/FULLTEXT/TOTJ-11-120/>).

8 PPIA op cit note 5 at 4–8.

9 Ibid at 5.

10 Transport Connectivity and Logistics Section, Transport Division *Smart Port Development Policies in Asia and the Pacific* (Bangkok: United Nations Economic and Social Commission for Asia and Pacific (UNESCAP) 2021) (available from: <https://www.unescap.org/sites/default/d8files/event-documents/SmartPortDevelopment_Feb2021.pdf>) at 15.

11 ALG 'The Future of Ports: How to Stay Competitive' *ALG Newsletter, Shaping the Future* (n.d.).

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Artificial intelligence:

- Real-time berth planning
- Predictive maintenance
- Automated yard planning
- Demand planning at the gates

Sustainability:

- Integrated renewable resources
- E-mobility market
- Quay to vessel power
- LNG/electric vessels

The costs of these technologies have increased the cost of efficient performance, rapidly altering the competitive landscape. Port models developed in the 19th and early 20th century were simpler and had many drawbacks.[12] However, these models significantly constrained ports from competing effectively on a service quality basis, limited their agility and market responsiveness in mobilising resources, and constrained their ability to share risks with private sector partners. As many of the challenges facing modern ports had not been envisaged, the models for port development were appropriate for the period in which they were developed. In planning how responsibility for future port development and operations will be divided, policy makers now have the option of both public sector and private sector participation. In deciding on desired levels of investment to be funded or guaranteed from public sources, policymakers must increasingly weigh the competitiveness of their port(s) in relation to other ports in their region and, in comparison, to the supply chain alternatives available to their users. These alternatives are now more abundant than they were 15-plus years ago. The port business is therefore more competitive now than it was prior to the 4IR. New institutional models are therefore needed for this new era of increased competition.[13]

The second force generating momentum for reform is private sector participation in infrastructure and superstructure development. In this era of decentralisation, many sectors that were protected by governments have been outsourced to the private sector. Governments and lending agencies have come to acknowledge that private sector participation can be a powerful force for enhancing the performance of port assets, as with other infrastructure assets. National and regional seaports have accepted that they cannot compete effectively without the efficiencies offered by private operators and without access to capital provided by private investors. There has thus been a steady increase of private sector participation in port operations around the world. Countries with recent experience of port reform include Argentina, Brazil, Canada, Chile, China, Colombia, Egypt, Estonia, Germany, India, Indonesia, Japan, the Republic of Korea, Latvia, Lithuania, Malaysia, Mexico, Mozambique, Nigeria, Oman, Panama, the Philippines, Poland, Russia, Tanzania, Thailand and the United Kingdom. In addition, the pace of private investment in the sector is accelerating.[14]

The third force affecting reform is the development of a global market for port development services. Each specialised niche contains several international companies that offer specialised service capabilities. The sector contains four groups of operators:

1) The first wave comprising of 'global stevedores', the first to have expanded their operations internationally from a strong home base.
2) The second wave comprising regional operators now entering the international market following the success of their predecessors.
3) Shipping lines investing in terminals.
4) Niche investors looking more specifically at small- to medium-scale facilities.[15]

In addition to providing core port services, ports are increasingly delivering nontraditional services to their

[12] PPIA op cit note 5 at 6.
[13] Ibid.
[14] Ibid.
[15] Ibid at 7.

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customers. These nontraditional services have expanded the role of port service providers in the supply chains of shippers and create value for shippers by expanding the scope of markets they can economically access by reducing the delivery cost of products they sell, or by reducing the cost to complete buy/sell transactions. Ports can now participate in specialised port service niches and differentiate themselves from other more traditional ports.[16]

In addition to the changes afforded to the operational port functions, modern ports are under pressure to conform to global operational standards on risk management, supply chain management and environmental standards. The level of pressure depends on the stringency of the regional laws and the level of development of the countries involved, as well as their level of commitment to the net zero targets of the Paris Agreement on Climate Change. Countries within the European Union are moving at a rapid pace to ensure that both their ports and their ships are environmentally compliant.[17] Where ports are extremely busy or situated close to cities, fishing waters, ecologically protected areas or within rivers, there would be greater pressure for them to conform to standards as the risks and pressures facing the ports, rivers and cities are greater.

The development of ports would therefore, to some extent, be related to the pressures which they face and their commitment to change, as well as the access to capital required to ensure that these changes are made and maintained. In addition to regional challenges, there are the global commitments by governments to the UN SDGs to which 185 UN member states bound themselves to implement and uphold in 2015.[18] These 17 SDGs aim to support environmental preservation, economic development and social integration, and to improve the quality of life for the present and future generations. The International Association of Ports and Harbors (IAPH) launched the World Ports Sustainability Programme (WPSP) in February 2019 to integrate the SDGs into the business strategies of and governance by port authorities, and help align them with global sustainability standards. The five WSPS themes are climate and energy, community outreach and port—city dialogue, resilient infrastructure, governance and ethics, and safety and security. With the inclusion of the SGDs, the development of ports cannot be rejected by any forward-thinking government, as all global players are affected by change and committed to being part of the change.[19]

In addition, the World Bank's Port Reform Toolkit[20] provides five factors that are expected to affect future ports:

- Intensifying global competition: Trade and the growing trend towards globalization of production, expanding the geographical scale or logistics reach
- Changing technology: The need for container port productivity improvements, and the growing role of information technology
- Changing distribution patterns: Looking for strategic hub locations. Generating income of a transshipment hub by the double handling of containers. Inland container terminals replace activities from the port to enhance intermodal efficiency
- Increasing importance of environment, safety and security concerns
- Change in the bargaining power of stakeholders due to port changes – consolidation among ocean carriers, and the emergence of a global logistics service provider environment.[21]

Furthermore, a rapidly changing global trading environment, including increasing vessel sizes and cargo volumes, has made it necessary to revise the business

[16] Ibid.
[17] Ministry of Environment (Finland) *EU Climate Change Policy* (European Union 2022) (available from: <https://ym.fi/en/eu-climate-policy>).
[18] UNESCAP op cit note 10 at 13.
[19] Ibid at 14.
[20] PPIA op cit note 5 at 21.
[21] UNESCAP op cit note 10 at 15.

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model (service) and introduce the technological innovation needed to strengthen port competitiveness. Most ports should therefore try to move towards becoming smart ports in order to maintain productivity, customer-friendliness, efficiency and competitiveness.

While it is tempting to see the smart port model as complete, it is important to realise that, together with changing technologies, smart port development is in its infancy and is likely to face even more challenges. The latest 2022 DNV report, *Maritime Forecast to 2050*, looks at the efficiency of alternative fuels and the movement to the use of ammonia as a ship propulsion fuel post 2035.[22] According to this report, the efficiency of these non-fossil fuels is much less than that of fossil fuel. Ships will therefore need to refuel more often. In addition, ammonia needs more storage space than traditional fossil fuels. This will impact both the ships that are running on these fuels and the ports receiving them. Greater refuelling needs will mean greater opportunities for ports to make themselves available.[23] Ports along global shipping routes that would not normally receive ships in transit may now be within the refuelling path of these ships and, if they are equipped, have opportunities to trade afforded them. Because alternative fuel technology is still in its infancy, however, no one can accurately predict the potency of alternative fuels come 2035. Additional to the issue of alternative fuels is the issue of the technology needed to launch and receive automated ships. This will require the technology, resources and appropriate skills. The movement to smart port status is therefore one of continual change and improvement.

III SMART PORTS DEFINED

The fifth-generation smart port has the following five distinguishing characteristics:[24]

(a) smart port services and applications such as vessel and container management

(b) technologies such as data centre, networking and communication, and automation

(c) use of sustainable technology to increase energy efficiency and reduce greenhouse gas emission

(d) cluster management such as a shipping cluster that consists of geographically proximate companies and stakeholders with their main activity being shipping

(e) development of hub infrastructures to foster collaboration among different ports.

In their definition of smart ports, Molavi et al[25] have identified the following domains and subdomains as being attributed to smart ports:

According to Molavi et al,[26] smart ports have the following four domains:

1. Operational domain
2. Environmental domain
3. Energy domain
4. Safety and security domain

The key sub-domains for operational efficiency:

- Productivity: are operations timeous, within budget and according to available space and facilities?
- Automation: Do the control systems (set of devices that manages the behaviour of other devices or systems) for operating equipment with minimal or reduced human intervention operate efficiently?
- Intelligent infrastructure: Is technology, including hardware and software operate efficiently?

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[22] Det Norske Veritas (DNV) 'Energy Transition Outlook 2022: Transport in Transition' (2022) (available from: <https://eto.dnv.com/2018/maritime>) at 55.

[23] Ibid at 57.

[24] K-LA Yau, S Peng, J Qadir, YC Low & MH Ling 'Towards Smart Port Infrastructures: Enhancing Port Activities using Information and Communications Technology' (2020) 8 *IEEE Access* (available from: <https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9079821>) at 1–2.

[25] A Molavi, G Lim & B Race 'A Framework for Building a Smart Port and Smart Port Index' (2020) 14(9) *International Journal of Sustainable Transportation* (available from: <https://www.tandfonline.com/doi/abs/10.1080/15568318.2019.1610919?journalCode=ujst20>) at 9.

[26] Ibid at 10.

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The key sub-domains for environmental efficiency:

- Environment management systems (EMSs): is there an EMS to improve their environmental performance and environmental impacts.
- Emissions and pollution control: is there a system in place?
- Waste management: is there a system in place?
- Water management: is here a system in place?

The key sub-domains for energy efficiency:

- Efficient energy consumption: is it possible for direct and indirect energy users to reduce their energy consumption?
- Production and use of renewable energy generated from natural processes: do these resources partially or totally address the port's energy demand and significantly reduce pollution?
- Energy management: are there strategies and systems to make efficient use of the available energy?

The key sub-domains for safety and security:

- Safety management systems: is there a system to administer safety principles in the workplace?
- Security management systems: is there a system to identify potential threats to the port and to develop procedures and then initiate, monitor, review, and maintain them to deal with security risks.
- Integrated monitoring and optimisation systems: are there integrated software and hardware systems to guarantee the port's safety and security?

Using all the elements attributed to smart ports, Molavi et al.[27] subsequently defined a smart port as 'a port having all the elements of a digital port, knowledge port, intelligent port and humane port'. In addition, 'a smart port gathers better-educated individuals, skilled workforces, intelligent infrastructures, and automation to facilitate knowledge development and sharing, optimize the port operations, enhance the port resiliency, lead a sustainable development, and guarantee safe and secure activities'.

The UNESCAP article [28] referred to the Korean Maritime Institute's definition of a smart port. This definition defines a smart port as a comprehensive concept, aiming at automation, logistics optimisation, energy efficiency, eco-friendliness and reinforcement of connectivity with hinter cities by means of process innovation and the introduction of information technologies (IT) such as IoT, AI, robotics etc. This definition aligns with the definition of Molavi et al. We can see from these definitions and descriptions that for a port to qualify as a smart port it needs to be more than technologically proficient and contain elements relating to all four domains listed.

In addition, there are levels of technological proficiency or stages which a port has to pass through before it can be considered to have reached the level of technological proficiency required of smart ports.

Below are the four phases of technological progress which ports pass through before they attain smart port status.[29]

1. Phase 1 – port information:
   - use of paper documents, manual processing
   - less systematic port procedures
   - willingness to transform to a computerised port.
2. Phase 2 – automatic port:
   - paperless transactions by e-documents
   - use of an information system, such as port-EDI (electronic data interchange) and terminal operating systems (TOS) to handle port operations
   - willingness to change semi-automated port operations to fully automated.

[27] Molavi et al. op cit note 25 at 7.
[28] UNESCAP op cit note 10 at 18.
[29] Ibid at 86.

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3. Phase 3 – digital port:
    - construct an automated port using radio frequency identification (RFID), sensors, cameras etc
    - use of port collaboration models such as Single Window, port community system PCS etc
    - willingness to interconnect with other organizations or countries for information sharing
    - Prepare a nationwide logistics masterplan or roadmap for smart ports.
4. Phase 4 – smart port:
    - a fully automated port that uses nascent, automation and innovative technologies
    - digital transformation with the 4IR technologies.
    - the objective is an optimised, unmanned and autonomous port
    - comply with international regulations and/or standards.

IV SMARTPORT DEVELOPMENT IN SUBSAHARAN AFRICA

The development of smart ports is not a phenomenon limited to the biggest, busiest global ports. The changes brought about by global trade and the technological adaptations made throughout global supply chains have meant that all ports must adapt or be left behind. In light of these requirements and developments, the question of transition of the ports within the SADC region is raised. More specifically, the readiness of the ports of Durban, Maputo and Walvis Bay to participate in the global smart port movement is questioned. The answer to this question lies not with the three main ports under discussion, but with an understanding of the dynamics behind the top ten global smart ports, the majority of which are in Europe. According to the Sinay,[30] the world's top ten ports, in progressive order, are the ports of Rotterdam, Hamburg, Antwerp, Singapore, Shanghai, le Havre, Los Angeles, Copenhagen, Valencia and Barcelona. From the list, we can see that Europe is at the forefront of smart port development. What has made these ports unique is their commitment to the SDGs and their incorporation into all aspects of port operations.[31] Be it the Digital Twin at the Port of Rotterdam, complete automation, as in the Singapore Tuas mega port project, or digital sensors and intelligent use of 5G technology and digital systems, the relevant ports have fully integrated environmental and ecological goals into their daily operating systems, ensuring that the cities in which they operate are not negatively affected by port operations.

Commitment to change does not happen in a vacuum, however. The top ten smart ports are among the busiest ports in the world and, with increased global trade, have been pushed beyond their normal capacity. They have had to find methods to improve port operations, increase productivity, decrease port congestion and satisfy all their stakeholders, all of whom are operating under tremendous pressure. The proximity of European ports to each other has meant that shippers have many alternatives to choose from, thus increasing the level of inter-port competition. These ports, as portals to global trade within the region, must answer to their customers, many of whom depend on just-in-time processes to manufacture goods. As vital supply chain partners, port operators have had to align with European and other global multinationals that are already using the most advanced technology to streamline manufacturing, service and administrative processes. The culture of business within these countries has transferred to the port authorities. In addition, the level of skills development and the prevalence of highly skilled labour has assisted the transition and progress of these ports towards their smart port status.

In addition, there are structural efficiencies working in the favour of these ports. Rather than playing the traditional landlord role, these port authorities have long worked in partnership with the private sector to ensure efficient port functions. Not only do ship owners and shipping companies own their own berths at these

[30] Sinay 'Top 10 Smart Ports around the World' *Sinay* 29 June 2021 (available from: <https://sinay.ai/en/top-10-smart-ports-around-the-world/>).
[31] Ibid.

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ports, but service providers work autonomously from and harmoniously with port authorities to ensure the smooth running of port operations and other services. This arrangement assists with the raising of finances, as port authorities have not had to bear the burden of raising finances alone. The fact that these ports are among the busiest ports in Europe, the USA and Asia has meant that they are able to maximise their income and raise funds needed to finance change through port operations. This, in turn, does not put a tremendous burden on governments to invest in port development, even though the port authorities work hand-in-hand with government. At the Antwerp port, the port house, a unique residence for the governing port authorities, is found on the port premises.

The dynamics of the SADC ports are very different. In the South African context, the Transnet Port Authority (TNPA) is the government entity in charge of port operations. In addition, the South African port system still works on the landlord system. The ports of Maputo and Walvis Bay have been assisted by their cooperation agreements between DP World (an international terminal operator) and the national ports administration. This has enabled these countries to leverage international private sector resources for their domestic port development programmes. In preparation for this paper, the port websites for Namibia, Mozambique and South Africa were visited. Much of the information on these websites is for publicity purposes and does not provide in-depth insights into the port processes. More accurate information was sourced during interviews with port officials, SADC officials and private sector port-related bodies in Namibia, Mozambique and South Africa. In the Durban port, the digitalisation of processes has already begun, as the port authorities seek to align themselves with the needs of their global customers and global legislative requirements. Despite these advances, the ports suffer from delays due to old machinery and the lack of resources, both human and financial, required to develop the port. The ports of Walvis Bay and Maputo have also expanded and begun to use more advanced technology, according to their country's standards. While these developments are encouraging, the ports of Maputo and Mozambique are not currently working at maximum capacity. They are, instead, in the process of positioning themselves for greater trade, competing among themselves for trade from South America, China and Europe. We have seen from the European and Asian examples that increased competition is a driver of development and that smart port development was largely driven by inter-European and inter-Asian competition, in addition to the needs of businesses within the regions. Three factors were highlighted during discussions with industry and port authorities:

1. The first factor was the difficulty in adopting a Single Window approach in South Africa, Mozambique and Namibia. Because of the fragmentation of government and private sector processes, where processes often overlap without the relevant transparency, creating a dedicated and secure trade portal is difficult. This relates to other monitoring and evaluating functions as well.
2. The second factor relates to the processing hubs, which are directly linked to international supply chain just-in-time manufacturing goals. While most of the products assembled in these processing hubs are for export purposes, there is still a percentage of the product that needs to be absorbed by the local economies by way of domestic trade. Without the assurance that this product can be absorbed by developing countries like Namibia, Mozambique or South Africa, it is unlikely that investors would choose them, thus removing a vital step in smart port creation.
3. The third factor is linked to the infrastructure required for smart port development, like reliable, dedicated and cheap internet, reliable, cheap and clean energy, an enabling legislative environment as well as highly skilled tech-savvy individuals. These requirements are lacking in South Africa, Namibia and Mozambique.

While our governments have been proactive in transforming our ports, port development cannot happen in a vacuum. Smart port development is dependent on the goodwill of major stakeholders within the international trade value-chain. From the data provided relating to smart port development, as global trade has developed, so ports have become important connectors for the global supply chain

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development. The port of the future is fully integrated into the global supply chain and the city in which it operates, working with city authorities, global industry, shipping lines and international terminal operators, global police structures, governments and end users. Whereas most undeveloped ports are separate bodies, with little impact on their environment and under the control of their individual governments, the loss of complete sovereignty and control, and a commitment to transparency, international cooperation and the adherence to increasingly stringent environmental, supply chain, trade and risk compliance legislation, and policies will be the price of inclusion into global supply chains for ports and governments. Shipping companies have already begun to collaborate and merge, forming extremely powerful lobby groups, with the ability to choose compliant ports or boycott ports that are not deemed suitable. Besides the goodwill of governments to comply with the needs of global supply chain administrators and shipping lines, is the fact that countries should have a suitable environment for port development. Development of the ports will therefore be dependent upon the following:

- The development of the South African business sector and the speedy change to a 4IR-enabled economy. Smart port development must be linked to a stable and growing economy that can support the demands of a developing smart port environment and ancillary requirements. Problems with the supply of energy, the reduction in the cost of airtime and data, fibre and fibre speeds, and other basic energy and communication infrastructure will need to be addressed if these economies are to grow and integrate into an increasingly fluid global trading system. Currently, the urban areas are beneficiaries, but the rural areas are still dead zones. To ensure that digital technologies become mainstream, the movement towards alternative fuels and energy sources will have to be prioritised by government.
- Alignment to global supply chain trends and legislative requirements will require more education of the business community about these requirements and the importance of alignment for the development of the South African economy and ports. More importantly, the Southern African economies will need to adopt procedures and legislation that allow complete compliance with global supply chain procedures, risk compliance and environmental measures, being fully committed to increasing transparency in administrative and business processes. As integrated supply chains are dependent on honesty and ethical processes, these countries will need to commit to a culture of ethical business and governance.
- Alignment with the greening of global trade initiatives will have a serious impact on the readiness of the SADC ports to receive and service new-generation ships. As global shipping moves to full automation, this is a priority area because smart port development is been driven by the greening of Europe and climate change undertakings. From a development perspective, environmental initiatives have been viewed with suspicion because they are often seen as conflicting with development goals. With the adoption of the UN SDGs, there will need to be a shift in the culture and the business mindset.
- A major impediment to change is government employment goals and the need for skills development. Traditionally, state-owned enterprises were used to absorb labour, especially unskilled labour, where there are activities that require more physical labour. In the ports, automation will require a complete restructuring of labour, with a movement towards more skilled labour. Given that the largest pool of unemployed labour is young and unskilled, the movement towards automation and digitalisation of the port and business will create a short- or medium-term skills shortage. There will therefore be a need for rapid upskilling initiatives. The speed at which the labour force and the school system can be transformed and repurposed will therefore affect the speed at which the ports in the region can transition. What is apparent, however, is that, without a suitably skilled labour force with emphasis being placed on technology and science, the ability to grow and develop these ports will be hampered. These skills development initiatives are urgent and require rapid intervention by

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governments. The 4IR and technological era requires a skilled labour force able to meet the changing global work environment needs. As ports, the international trading system and the shipping environment all adopt technology for more efficient business processes, the core and support maritime systems will need multi-skilled individuals. In the maritime education and training context, several interventions will be required:

- Conduct an audit of the current training systems, institutions and processes to determine their suitability and ability to address changing global employment needs and norms.
- Because the maritime sector is a niche sector, it has requirements that are not easily understood. As the sector becomes more advanced and reliant on technology, there will be an even greater need for training institutions to understand the sector's requirements, anticipate the needs of the global maritime players and prepare the workforce with the skills and the mindset required to address these employment needs.
- Where institutions had previously worked in isolation, there will be a need for greater cooperation with industry. As the industry has both core and support roles, the way general functions can be modified to meet maritime industry needs must be understood and met. Training institutions must adapt their approach to imparting practical and theoretical understanding.
- Institutions and schools should also adapt their curriculums to ensure that learners are more equipped for the changing working environment by providing learning programs that enable learners to choose more skilled career paths.
- Understand the stumbling blocks in rural education and devise strategies that facilitate the introduction of rural populations to more advanced learning systems, so that the gap between skilled and unskilled employees can be closed.

Another major issue is that of sourcing finances. The current landlord system in South Africa does not serve the country and there must be a complete rethink of the governance structures of ports in the SADC area. Going forward, a greater commitment by government to public–private partnerships and the way in which partners and service providers are chosen will be required. Given the power held by the shipping sector and sector requirements, financing of smart ports through public–private partnerships will require that governments demonstrate their goodwill and commitment by relinquishing their commitment to absolute control of their ports and adopting real partnership commitments.

All these factors, taken together, are required to create the foundation of an enabling environment.

V CONCLUSION

The adoption of the smart port methodology cannot be avoided and is required if ports are to survive. The speed at which change occurs is dependent on the current status of the business community, the policies of the various governments and their willingness to align with current and future global business and administrative legislative requirements and processes, as well as their willingness to relinquish administrative power to the private sector, where required, for funding of port development initiatives. At present, within the context of the transition of ports, our governments are still dealing with the major structural issues that affect the rapid transition of domestic economies and, hence, the development of the ports. The transition of our ports towards smart port status will therefore depend on the speed at which both the public and the private sector can adapt to the new global trading climate, and make the required internal changes. With new technologies comes new opportunities and, while transition will require changes within the labour force, a radical repurposing and skills development programme can assist with the transition and create job opportunities within new sectors. There is therefore a need to rethink

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the current approach to skills development throughout the education value chain. A skilled labour force is critical for advanced business growth and will enhance the region's ability to align with global developments. This is a very important fact, as port development occurs together with the business community and adjusts to the needs of the business community. The speed at which the business community develops will therefore impact on the demands made on the port authorities. Without these demands, transition will be much slower.

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Leticia A Grimett

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