Annex A

About Tuas Terminal Phase 2

The Tuas Terminal development is a testament to Singapore's commitment to sustain its lead as a global maritime nation. Continuing the investment in port infrastructure, Tuas Terminal has now entered the second phase of its development.

The Tuas Terminal will be developed in four phases over the span of some 30 years, with the Phase 1 reclamation works scheduled to be completed by the early 2020s and Phase 2 in the mid-2020s. Work is already ongoing for Tuas Terminal Phase 1, which started in Feb 2015. As of Mar 2018, more than 70 per cent of the 221 caissons were installed to form the wharves of Phase 1.

Profile of Tuas Terminal Phases 1 & 2

MPA has awarded the reclamation project worth SGD1.46 billion for Tuas Terminal Phase 2 to Penta-Ocean Construction Company Limited/ Hyundai Engineering & Construction Co Ltd/ Boskalis International BV (PHB) Joint Venture. The project includes the dredging of Tuas basin, construction of wharf structures and reclamation of 387 hectares of land. When completed, the 21 deep-water berths in Phase 2 of Tuas Terminal development will be able to handle about 21 million twenty-foot equivalent units (TEUs) per annum. When completed, the entire Tuas terminal will have a total capacity of up to 65 million TEUs.

The scale and complexity of the project presents opportunities for the team of MPA, local and international engineers and contractors to challenge themselves and find innovative solutions to optimise productivity and efficiency. One such challenge is the construction of the wharf structure, which will see the engineering teams use an

innovative caisson design to fabricate some of the largest caissons in the world on site.

The use of caisson is a more efficient method of construction than other methods such as piling, and affords site personnel a safer work environment. As the caissons are of standard sizes and pre-fabricated in a factory-like environment on-site, productivity and quality of the wharf structures will be improved. State-of-the-art technology will be applied to control thermal cracking of concrete after casting of caisson base, to achieve better durability.

For construction of foundations to caisson quay walls and capital dredging of basins and fairway, PHB Joint Venture will mobilise the biggest and most powerful cutter suction dredger and back hoe dredger to maximise efficiency.

Furthermore, PHB Joint Venture's reclamation design will overcome the challenge of traditional reclamation filling using hopper barges, which restrict filling to just below sea level. Through the use of special purpose bulk material handling equipment such as E-crane and reclaimer barge, the use of dredged material for filling above sea level would be maximised.

Within the reclaimed land, the use of soil improvement techniques will allow dredged materials as well as surplus excavated earth from construction sites to be reused as reclamation fill materials for the project. Reusing such materials, which would otherwise be disposed of, reduces the quantity of sand fill required for reclamation.

"We appreciate MPA's decision to entrust PHB Joint Venture with this major port land development project. PHB Joint Venture will bring leading-edge equipment, advanced construction technologies, and innovative techniques to maximise efficiency and productivity. Given our combined technical capabilities and strong track record of completing similar projects, we are confident that we can meet this project's challenges for successful development of Singapore's next generation port." said a spokesperson for the consortium, which comprises Penta-Ocean Construction Company Ltd, Hyundai Engineering & Construction Company Ltd, and Boskalis International BV.

About Penta-Ocean Construction Company Limited/ Hyundai Engineering & Construction Co Ltd/ Boskalis International BV Joint Venture

The three companies have a wealth of experience in collaborative execution of major marine infrastructure projects in Singapore and internationally. Penta-Ocean Construction Company is Japan's leading contractor in coastal and waterfront development. Hyundai Engineering and Construction Company is Korea's foremost contractor in building and civil engineering. Boskalis International, headquartered in the Netherlands, operates one of the largest and most modern dredging fleets worldwide. All three companies have had a continuous presence in Singapore for

many years and are proud to be continuing their contributions to national development through land reclamation and infrastructure development.

Annex B

MPA-Research Council of Norway MOU

Singapore and Norway collaborate closely in maritime research and development, education and training (RDET). MPA has a Memorandum of Understanding (MoU) on Maritime RDET with the Research Council of Norway (RCN) since 2000. MPA is renewing its MOU with the RCN for the 7th term for three years till 2021.

The MOU R&D areas include maritime environment, sustainable energy technology, offshore and marine engineering, maritime operations and info-communications.

A second Joint Call for Proposals in Norway and Singapore will be launched by RCN and MPA (through the Singapore Maritime Institute) in 2018. This Joint Call for Proposals will focus on Maritime Digitalisation, Advanced Technologies, Autonomous Vessels and Systems, and Green Shipping.

Mr John-Arne Røttingen said, "It is important that this MOU has been renewed. It has already had a large impact. It is also particularly important that Norway and Singapore will launch a second joint call. The first joint call was very successful and enabled scientists from two of the world's leading maritime nations to work jointly on improving the environmental footprint of shipping. With a new joint call in important emerging areas such as digitalisation and autonomous shipping, this call will address tomorrow's challenges for the maritime industry, and the results will be of major significance for both parties as well as for the industry at large."

Besides the Norway-Singapore Joint Call for Proposals, the many joint activities carried out under the MOU include the International Maritime and Port Technology Conference (MTEC) and e-navigation Forum held in April 2017 together with Singapore Maritime Technology Conference. These activities and platforms help develop the capabilities of Norway and Singapore in maritime R&D and technology, and provide opportunities for maritime professionals to share industry challenges and experiences, and technology developers, research community to share their expertise and technological solutions.

Annex C

Kongsberg Norcontrol- ST Electronics-MPA Next Generation Vessel Traffic Management System (NGVTMS) Innovation Programme

About NGVTMS Innovation Programme

The vessel traffic information system (VTIS) is a mission critical system that supports MPA's strategic role in ensuring the navigation safety of Singapore port waters and the Singapore Strait. In ensuring that our VTIS continues to remain at the fore-front of what is available in the market today, the NGVTMS Innovation Programme was set up to focus on research, discovery, conceptualisation and validation of new operating concepts, processes, business rules and technology relating to vessel traffic management.

ST Electronics-Kongsberg Norcontrol NGVTMS Innovation Programme Award

MPA has awarded the consortium of ST Electronics and Kongsberg Norcontrol the Maritime Innovation And Technology (MINT) Fund to develop the NGVTMS Innovation programme. Under the programme, ST Electronics and Kongsberg Norcontrol will jointly invest up to $9.9 million over three years to develop NGVTMS capabilities, including new decision-support tools such as analysis of vessels routes, traffic hotspots prediction, and detection of potential collision situations that provide accurate and comprehensive maritime situational awareness.

ST Electronics and Kongsberg Norcontrol will also jointly develop and test digital technology and advanced data communications system for information exchange between ships and port authorities, in support of the e-Navigation initiatives by the International Maritime Organization to enhance operational efficiency and safety.

In addition, the consortium will adopt an open system architecture to facilitate wider collaboration and inter-operability with other technology partners, as well as the flexibility to introduce software/hardware enhancements on a regular basis.

Annex D

MPA-Wärtsilä MOU on Maritime R&D and Innovation

Wärtsilä Corp and MPA signed a memorandum of understanding (MOU) today, to promote maritime R&D and innovation in the areas of digital acceleration, cyber-physical security, and intelligent vessel and port operations.

The MOU was signed between Mr Marco Ryan, Chief Digital Officer, Wärtsilä Corp and Mr Andrew Tan, MPA Chief Executive. The signing ceremony took place at the opening of the Singapore Maritime Technology Conference, observed by the Finnish Ambassador Ms Paula Parviainen and Senior Minister of State Mr Lam Pin Min.

The inaugural MOU will see both organisations cooperating to initiate, co-create and promote research, innovation development and test-bedding projects with the maritime industry, research institutes and institutes of higher learning (IHLs), and to build up a pool of small and medium enterprises in Singapore in the following areas:

a) Digital Acceleration
Participation in Singapore Smart Port Acceleration Challenge - build local venturing activities through co-creation and mentorship with start-ups and support co-creation and test-bedding of activities that contribute to the development of maritime technologies;

b) Effective Cyber-Physical Security
Work with IHLs and the maritime community on cyber-physical systems onboard vessel for enhanced operational resilience, including aggregating cyber incidents reported by ships to facilitate coordinated incident response and management;

c) Intelligent Vessels Operations and Connectivity with Smart Port
Develop and field testing of intelligent vessels capabilities with local operators and develop pathways to safe and sustainable autonomous operations, enabled by regulatory sandboxing. Explore reliable, secured and cost-effective data exchange between port and vessel to enable efficient operations, digital twin modelling and simulations to generate value adding applications; and

d) Education, awareness
Synergise activities from both organisations, participate in awareness generation and education through forums and showcasing across MPA Living Lab and Wärtsilä Digital Acceleration Centre.

Annex E

NUS Enterprise-PortXL MOU to develop the Maritime Innovation Eco-system of Singapore

NUS Enterprise, the entrepreneurial arm of the National University of Singapore (NUS), and a partner of MPA for the Maritime Technology Acceleration Programme, named PIER71 (Port Innovation and Ecosystem Reimagined at BLOCK71), signed a MOU with PortXL to develop the Maritime Innovation Ecosystem of Singapore. The MOU was signed between Mr Mare Straetmans, Managing Director of PortXL and the CEO of NUS Enterprise, Dr Lily Chan. The signing ceremony took place during the opening of the Singapore Maritime Technology Conference and was observed by both the Dutch Ambassador and Senior Minister of State Mr Lam Pin Min.

The MOU will see both organisations collaborate to promote the Singapore Maritime Innovation Ecosystem globally such as cross-marketing of events. Both will seek to nurture promising technology start-ups in the maritime industry by providing market access to maritime companies, and for start-ups to develop pilot projects for test-bedding.

“With emerging technologies beginning to disrupt Singapore’s traditional flagship industry, corporates and the start-up community need to seize opportunities to create innovation-driven growth,” said Dr Lily Chan, CEO of NUS Enterprise. “The collaboration with Port-XL is the first of many fruitful partnerships to follow as part of our efforts to help build a vibrant and innovative maritime ecosystem as well as grow links to leading innovation hubs in the world.”

“The maritime, logistics and energy sectors are in big need for creating new business value. As the first and only maritime startup program in the world, PortXL is very proud to partner with the number one University in Asia to make this step in Singapore. This means leveraging eco-systems in Singapore and Rotterdam in supporting startups with their engagement with corporates and growth in Asia and Europe,” said Mr Mare Straetmans, Managing Director of PortXL.

To further support the cause, MPA will be also launching the Maritime Innovation & Technology (MINT) Fund Call for Proposals and Smart Port Challenge (SPC) to seek innovation from the research and technology community in June 2018. Further details about the events will be published on MPA’s website.

Annex F

MPA-Keppel O&M-TCOMS MOU to jointly develop autonomous vessels

MPA, Keppel Offshore & Marine (Keppel O&M) and the Technology Centre for Offshore and Marine, Singapore (TCOMS) will be signing a Memorandum of Understanding (MOU) on 25 April 2018 to jointly develop autonomous vessels for a variety of applications including undertaking harbour operations such as channelling, berthing, mooring and towing operations.

It will be undertaken in various phases starting from remote controlled vessels leading to completely autonomous vessels and will see Keppel O&M using its remote vessel monitoring and analytics programme, VesselCare™, as the base platform in the initial phase to develop autonomous vessels. VesselCare™ is able to perform data consolidation, condition based monitoring and maintenance, mining and analytics of vessels.

Mr Chris Ong, CEO of Keppel O&M said, “As a leader in the design and construction of specialised vessels, we have been developing advanced remote monitoring and analytics systems for vessels. We are pleased to partner MPA and TCOMS to take the next step in developing fully autonomous vessels. The industry is keen for the commercial use of autonomous vessels as there are multiple safety, efficiency and cost benefits. This partnership demonstrates Keppel O&M’s commitment to be at the forefront of research and provide the latest cutting-edge technologies to our customers.”

During the advanced stages of monitoring & controlling a vessel, the project will develop a Digital Twin of the tug which will simulate vessel behaviour to help optimise the vessel operations using data analytics and visualisation tools. TCOMS will provide expertise in coupled physical-numerical modelling and simulation to evolve solutions that improve on the predictability and control of the behaviour and response of the vessel.

Prof. Chan Eng Soon, CEO of TCOMS, added, “As a national research & development centre for the marine and offshore industry, TCOMS is glad to collaborate with leading organisations such as Keppel and MPA to develop innovative concepts such as autonomous vessels for marine and maritime operations. The behaviour of marine vessels in challenging operating conditions is complex and to some extent still poorly understood. This is one key technical challenge that we seek to address, to ensure that autonomous vessels could operate safely and reliably while enhancing efficiency and productivity.”

As the maritime industry moves towards leveraging technology to produce more autonomous vessels & operations that is safer, faster, and more cost-effective, one potential application is the regional harbour fleet of crafts including tug boats, pilot boats and ferries, among others.

Annex G

Memorandum of Intent with Eight Classification Societies to support Singapore Maritime Datahub

As part of supporting Maritime Singapore's ongoing digital transformation, the Maritime and Port Authority of Singapore (MPA) will be establishing the Singapore Maritime Data Hub (SG-MDH) under the MPA Living Lab to promote data sharing and innovation.

2 The SG-MDH aims to be developed into a one-stop centralised data repository and collaborative platform for the maritime community. It will enhance and facilitate data sharing by the various stakeholders of the maritime community and encourage the co-development and test-bedding of innovative digital applications and data-driven services with sectorial or industry-wide impact.

3 MPA has signed a Memorandum of Intent with eight classification societies to collaborate on the development of the SG-MDH.

4 The scope of collaboration to be explored under the MOI includes the possibility of contributing maritime datasets to the SG-MDH data platform that could be accessed by the maritime community, as well as partnering with stakeholders in the maritime innovation ecosystem such as shipping companies, maritime start-ups, and technology providers to leverage SG-MDH for co-development of solutions that could enhance navigational safety, operations efficiency, and overall port productivity among other potential areas of collaboration.