ABSTRACT

The consortium SPP MiG participated the NGCP challenge organised by Singapore Maritime Institute and the Maritime Port Authority of Singapore. The main idea of the concept is based on the condition of 80% transhipment cargo at the terminal. This kind of transhipment hub requires an immense sorting effort of all boxes discharged from vessels and to be loaded on other vessels. Thus the consortium decided to build a terminal around a sorting machine as the heart of all operation. The technology for this sorting area is based on the Linear Motor Transfer Technology, which is also used for the Transrapid airport connection in Shanghai. Simulation studies, executed with the CHESSCON suite, proved that this concept is able to achieve the targets given by the organisers. Within this paper the concept is presented with the technologies used for discharging/loading, horizontal transportation, stacking and sorting the containers on the terminal. Furthermore some ecological aspects will be discussed.

Keywords: NGCP, Terminal Planning, New Technologies, Transhipment Hub.

1. INTRODUCTION

As the amount of containerised cargo is expected to show a steady growth in the forthcoming years the requirement for large container ports will be unbroken in the near future. Typically the space for the enlargement of existing terminals or the construction of new container ports is restricted. The optimisation of existing terminal operations usually shows only incremental improvements.

Thus fundamentally new concepts with regard to the construction and operation of a future container port are necessary to attain a considerable progress in terminal design and to maximise container throughput, handling capacity and sustainability.
This is the basic design principle for the “Next Generation Container Port” (NGCP).

The Hamburg-based team SPP MIG (Singapore Power Port Made In Germany) which comprises approved experts in harbour construction and technology, harbour logistics, building services and architecture has taken up this challenge.

The NGCP will exceed every other currently operated container terminal in the world in terms of capacity, efficiency, productivity, reliability and sustainability.

The planning horizon is set for 10 years. Thus the NGCP will have to be innovative in technological, organisational and creative ways while at the same time technologies will have to be employed that are either already proven to work today or which will be fit for operation within the next ten years.

The following organisers’ parameters had the greatest impact on the proposed design:

- Annual throughput of no less than 20 million TEU;
- Transhipment rate: 80%;
- Terminal area: 250 ha;
- Quay wall: 2 × 2.5 km + 1 km;
- Minimum of 90% for berth on arrival plus 2 hours;
- Environmental impacts.
2. DESCRIPTION OF THE GENERAL TERMINAL LAYOUT

![Fig. 2. Container flow at the terminal](image)

The proposed NGCP terminal layout comprises the following major sections (see Fig. 3):

- the quay walls (ship berths, 2 “long” quay walls with 2,500 m each, 1 “short” quay wall with 1,000 m);
- the apron (for container handling between quay walls and stacking area);
- the seaward stacking area (for storing and sorting the containers);
- the sorting area (for import / export of containers into / out of the stacking area);
- the landward stacking area (for import / export of containers into / out of the NGCP) with the terminal building (for business and recreational purposes);
- the seaward berthing area.

In the following (sub)chapters all relevant information on the sections is given.
2.1. Quay Walls

On both of the area’s long sides (2,500 m), there will be six 400-metres berths for loading and unloading the ships. The remaining 100 metres on each side will remain unused or could be kept as a reserve. The shorter “front” side (1,000 m) will not be used for loading and unloading, but as berthing facility for other purposes.

2.2. Apron

The apron is used for the ship-to-shore handling of containers as well as for the transport from the ship-to-shore cranes (STSC) to the seaward stacking area. Transport is carried out by Automated Straddle Carriers (AStC), which can stack 1 over 1 container.
The layout of the apron is described below and follows state of the art automatic terminals resp. recommendations of equipment manufacturers (e.g. on the basis of Cargotec 2012).

The apron area is operated by Ship-to-Shore Cranes (STSCs) and Automated Straddle Carriers (AStCs).

2.3. Seaward Stacking Area

The seaward stacking area consists of $2 \times 52$ blocks, each one 291 m long and 28 m wide. One block comprises 10 boxes side by side (bay) and 46 TEU ground slots (resp. 23 FEU) in a row.

![Section: Seaward Stacking Area (1 block)](image)

The seaward stacking area is operated by Automated Stacking Cranes (ASC) which are able to stack 1 over 5 containers and have a span of 10 containers per bay. On each block two to three ASCs work on one rail track. The ASCs cannot pass each other, but it is possible for them to cross to the opposite block in case they are needed there.

The seaward stacking area is divided into two sections by the sorting area.

2.4. Sorting Area

The sorting area is used as an “internal” distributor and sorter for transhipment containers and for the transport / distribution of containers between the landward and seaward stacking areas.
The sorting area is located one level below the ground level of the stacking area in a 5.5 m deep and 70 m wide trench construction. Thus a nonintersecting operation of LMTT shuttle cars (at level –1) and ASCs (at level 0) can be guaranteed which enhances the efficiency of container handling considerably.

The sorting area consists of two parts:
- A “longitudinal carriageway” which is located between the northern and southern block of the stacking area;
- A “transverse carriageway” which is located rectangular to the longitudinal section between the seaward and the landward stacking area.

We propose an innovative approach for the logistics in the sorting area: Most suitable for this purpose is the Linear Motor-Driven Transfer Technology (LMTT). The LMTT is an innovative technology for the transport of large volumes of containers with different destinations within a container terminal.

2.4.1. Longitudinal carriageway

On the longitudinal carriageway one LMTT module consists of two through tracks (one into each direction) to provide for a “one-way ring traffic” and one intermediate track which offers enough space in front of each block to load or discharge two shuttle cars. The shuttle cars can transport each kind of container. For the dimensioning of the shuttle cars 45'-containers have been used to guarantee a future-proof layout.

![Fig. 6. Section: Longitudinal Carriageway](image)

The loading and discharging of the shuttle cars in the longitudinal section will be executed by the “inner” ASCs of the stacking area which are equipped with a rotation spreader. In total, four parallel running LMTT modules will be placed in the seaward sorting area (see Fig. 6).

2.4.2. Transverse carriageway

In the transverse carriageway the shuttle cars from the four longitudinal LMTT lines change their moving direction (but not their orientation) from an east-west into a north-south direction. For this purpose the wheels of the shuttle cars rotate by 90 degrees.
Our calculations have shown that two parallel through tracks in the transverse carriageway (in contrast to eight parallel tracks in the longitudinal carriageway) in combination with three intermediate tracks per bay provide enough capacity to handle the required throughput in the landward stacking area even during peak times.

The LMTT modules in the transverse carriageway will provide 4 – 5 parking positions for shuttle cars per container bay.

The containers are loaded and discharged by Overhead Bridge Cranes (OHBCs) for the transport into the landward stacking area or the “Distrizone” in the first floor of the terminal building.

2.5. Landward Stacking Area

On the landward side of the terminal a “landward stacking area” will be provided for the overland import and export of containers (see Fig. 8). The handling of the containers in the landward stacking area is performed by Overhead Bridge Cranes (OHBCs). 3 OHBCs are needed for each block.

The landward stacking area is split into two sections:
In total $2 \times 9 = 18$ blocks for standard containers are allocated here.
In the middle a block for pre-stowed reefer containers is provided.
Furthermore the terminal building and the gates for land-based traffic are located in the landward stacking area. On both sides of the terminal building an area for battery changing / charging of the ASTCs as well as a workshop for maintenance/repair of the terminal equipment is provided.

2.6. Seaward Berthing Area

At the seaward berthing area which is located on the far end of the terminal no ship to shore container operations take place. This area is reserved as a “mixed” berthing space, i.e. for tug boats, service ships, bunkering, etc.

Through lanes for supply and delivery vehicles will be placed here as well. Two through lanes for ASTCs will also be located here in order to have the possibility to interchange the ASTCs between both quay lines. Together with fence and safety distance, a strip of 23 m is provided. The remaining area here is not used for operation resp. may serve as a reserve area for a later usage.

3. ENVIRONMENTAL PROTECTION

Environmental compatibility, sustainability and significant renewable energy supply and production are not contradictory. The energy supply, the security and the ensuring of a probable and lasting functioning of the port operations are guaranteed by redundant energy inputs (renewable energy production and regional power plants). The following supply concept is based on an environmental and resource-saving energy production and energy consumption technology.

- The importance of using solar energy is shown by generating emission-free electricity by a solar field of approx. 330,000 m². Highly efficient photovoltaic panels are installed on the complete roof of the terminal building and landward stacking area. The electricity produced by the photovoltaic system covers approx. 1/5 of the electrical energy demand of the port.
- Additionally the solar radiation/energy which creates naturally heated air below the photovoltaic panels/the roof is used to cover part of the cooling load of the buildings. The thermal heated air-layers are channeled and afterwards compressed by heat pump technology. The compressed hot air is converted by absorption refrigeration with a suitable temperature difference to cooled air masses. This cool air is used to climate the buildings.
- The electricity generation is partly carried out by fuel cell technology. The fuel cells are very sustainable because they are nearly emission-free and highly efficient
• Additionally to the use of solar energy technology geothermal energy is used. For this purpose thermo-active piles with a water pipe system are concreted into the ground. The constant geothermal energy is concerted by heat pump and provided to the absorption refrigeration. The geothermal energy supports the energy supply and represents a sustainable energy potential, which should be used to climate the buildings.

• Concerning water use for energy production rainwater of the roof and the photovoltaic panels are used as grey water for the buildings and for the electrolysis process. For this purpose the rain water is collected, recycled and stored in several tanks, which also allows an independent production of hydrogen at all times. This is an additional contribution to conserve the environmental resources of the supply concept.

Fig. 9. Visualisation of the landscape with rainwater collectors

All the elements mentioned above form a sustainable, economical and technical feasible supply concept. The renewable energy supply and efficient energy use are highly environmental and increase the quality of life in the future. This concept forms the next ecological milestone in port operating technology.

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