Multipurpose Sea Port
DIGITAL TWIN

NEXIS.SPACE

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DIGITAL TWIN

Services for

Smart Port World

NEXTGEN PORT

INTRODUCTION

BACKGROUND

Multipurpose Seaport as Greenfield Transshipment Port development with container and passenger cruise, coast guard, cargo container and navy terminals are a common trend in India. The projects are developed in phases on dryland or reclaimed land by the seaside.

The container terminal will be utilized for transshipment and gateway. The breakwater in the sea-front will have a long sleeves with seaward extension, making the overall length up to 5000 m in the rough Indian ocean fonts. The breakwater in the Bay of Bengal can be developed with shorter breakwater structures due to calmer water.

SMART PORT INFRASTRUCTURE

With a proposed capacity of several 1000s million TEU/annum, the chain of Sagarmaala Ports are expected to be the port of choice for at least 50% of the nearly 20,000 ships that pass through the Suez Canal every year between east and western sources & consumer markets.

The ports are designed to accommodate vessels with a total of five, 400m each container berths and draught of 18m. The shape/ layout of the northern breakwater has been designed in such a way that bunkering vessels can also be berthed in future.

The port designs being made futuristic by considering 18,000 TEU vessels as the design vessel in with a turning circle of 700m diameter, to cater to tug assisted rotation of even futuristic vessels of 400+ m length. Considering that about 18m draft is naturally available at mother Port, currently the biggest 18,000 TEU vessels (like MAERSK EEE class) shall also be able to berth.

PLANNING, DEVELOPMENT, OPERATIONS MANAGEMENT

The current approach and proposal outlines the potential trajectories for the Ports and its catchment areas. The higher purpose of the current proposal involves the following visionary approaches, solutions and systems for the Port and its catchment areas.

- Digital Twin Models (DTM) Solutions for efficient, Sustainable and Resilient facility on the Port and catchment area Operations Management
- Asset & Facility Management Systems (A&FMS) for effective and efficient Quality Transhipment Mobility & Logistics Operations and Management.
- Professional Services for continuous Sustainable Port & Catchment with Planned Sustainable Resilient development and growth management.

AUTONOMOUS PORT

DIGITAL TWIN (DTM)

- Efficient & Sustainable outcomes

- Resilient Facilities

- Visualize development digitally.

ASSET & FACILITY MANAGEMENT

- Migrate and integrate Asset Management Workflows

- Solve facility issues with Sensor analytics.

SHIPPING & LOGISTICS NETWORK

- Connected Logistics network.

- Detect Asset and Manage Security remotely.

- Secure vessels, assets and routes with integrated controls

The strategic Port Development Model and Vision above utilize a three-prong approach to steer a comprehensive growth journey in and around the port site and the supportive catchment region. The Ports technologies are pointing towards inclusion of more Autonomous Port Logistics and robotics to improve operational efficiencies. The key areas listed above are discussed in detail below.

Digital Twin Model for Port Catchment Region

Digital Twin model forms a software to represent assets and processes for understanding, predicting, and optimizing performance. 'Twin model' is because it is an expanded use of the BIM (Building Information Model) and GIS (Geographic Information System), Augmented Reality (AR) and Virtual Reality (VR) tools with data and methods for information management.

There are three parts in the twin model namely, a data model, real-time data integration, analytics or algorithms, and knowledge or information. In other words, it is the digital mirror image of both physical entities, functions, and processes. The integration of artificial intelligence, machine learning and sensor data results in creating digital twin model. The data connection should ensure the same rate of convergence between the physical state and the virtual state so as to view the entire life cycle of the physical entity as well as processes, which help to optimize and sustain the performance of the port operations.

Digital Twin Process

Digital twins integrate physical models, sensor updates, and operating history to simulate operational processes. The mapping of physical entities in virtual space allows to reflect the whole life cycle process of a physical entity. This simulation model in the digital world is completely consistent with the operating performance of the real-world system and can realize real-time simulation. The sensor data installed on the real system use the boundary conditions of the simulation model to realize the synchronous operation of the real-world system and the digital world system. The dynamic and stationary assets with unique tag database and works integrated with Digital Twin for Visualization and operations management. Potential high-risk and profile crew and mobile carts monitor with sensors and tag IDs on Digital Twin visualization platform.

1. Create clear **PURPOSE for Digital Twin Model** that create value for its stakeholders.
2. Define **STAGES and SPATIAL BOUNDARIES** for progressive evolution of the Digital Twin models.
3. Generate **Data Inventory for all dimensions** of information integration to integrate on the Digital Twin environment.
4. **Design, Develop Digital Twin platform and integrate** functional and operational sensors and data dimensions.
5. Create Operational and stakeholder interfaces to deploy the Customer centric features of Digital Twin.

Port Facility and Catchment Region Growth Model & Vision

Life Cycle of Digital Twin Model

The life cycle of virtual entities in digital twin includes initiation, design and development, verification and validation, deployment, operation and monitoring, re-evaluation and decommissioning, corresponding to the full life cycle of physical entities, applying the capabilities of big data analytics, cloud computing, AI and ML.

The model of the Port facility and its catchment allows to plan, develop and regulate Green Port and NBS for Climate Risks as active-planning tools, instead of passive plans and data. The platform supports future phases of planned development and reEconomic strategies of existing historic and traditional settlements and industries as feeder ancillary growth centers. The Digital Twin platform allows for advanced Metaverse applications by the participating agencies, business and other stakeholders.

Sample: Digital Twin Model with real-time IoT integration

DIGITAL TWIN TECHNOLOGY

These operational and warehousing data will flow into a digital twin of the container on the network, which uses machine learning to ensure that containers are deployed as efficiently as possible. Digital twins can be applied not only to a single asset, but also to the entire logistics network, making it easy to make predictions and autonomous decisions on inventory or distribution. Therefore, digital twin technology is very suitable for the design and deployment of logistics hubs and logistics networks for VIDMS.

A digital twin model of Port related supply chain operations (Source: DHL)

Pre-construction investment potential scenarios and evaluations is supported with the Digital Twin platform which can be repeated for several iterations for successful project implementations and outcomes. The Digital Twin platform supports detailed scenario planning, design, multi-modal mobility planning, green technology component selection, and sustainable material selection. The integrated and connected Digital Twin platform allows for creating values.

DIGITAL TWIN BENEFITS

Regulatory, policy and operational **Compliances** for the authorities. The Digital Twin supports compliance audits on assets, physical built environments and its operations on a continuous basis.

A platform to **Reduce Cost** using economic and market dynamic data integration. Digital Twin provides real-time cost reduction tools for projects in the port, warehouse area and industrial estates.

Increase ROI, TCO and **Cost Savings** on projects based alternative scenario analysis on design and materials for construction and asset operations.

Enhance Security control, operations, crew deployments, monitoring and manage valuable assets as all-weather tool.

Customer Experience Hubs and portals for diverse cultural, age and skills to participate and contribute to the success of the project.

Real-Time Sensor Network integration with Digital Twin

DIGITAL TWIN PROCESS

The application focusses on port digitization and integrated management needs, such as spatio-temporal correlation of anchorage, quay crane, port machinery, and gate infrastructure. Specific applications include the following:

1. **Infrastructure**: *Websites, Monitoring centres, Cloud computing resources, Computer rooms, Computer and Network equipment to strengthen monitoring, storage, computing, and transmission capabilities.*

2. **Data integration:** *Traditional surveying and mapping data, three-dimensional model data such as 3D GIS, BIM, oblique photography, laser point cloud, geographic location data based on the Internet, real-time perception data based on the Internet of Things, port operation production data, industry data, and unstructured videos, pictures, documents, etc.*

3. **Information model construction:** *By using BIM plus GIS technology, image matching technology, more oblique photography, texture mapping technology, and three-dimensional model storage optimization, the information model can be set up. The wharf apron loading and unloading zone, yard, buildings, car parks, green space shall be processed into the model as monomers, providing digital twin port from inner to outer in a structured manner. IoT perception data should be quickly loaded, fused, and presented in real time on the model platform to realize real-time operation of video images, air pollution index, traffic flow, pedestrian trajectory, and berth operation volume.*

4. **Application service platform construction:** *Before implementing the digital twin model, the effect and perception after its implementation should be tested in advance. Through the port model of virtual and real, every time the planning adjustments and program changes can predict the impact on the overall development pattern of the port in advance. The port status can be fully displayed during port operation, the bottleneck of port operation can be analysed, and the efficiency and capacity can be improved through successful implementation.*

   Artificial Intelligence (AI), intelligence demonstrated by machines, converts data with powerful algorithms to replicate the thought process of humans to assist in Smart Port and Terminal Operations. Machine learning, a subset of AI when machines are programmed to replicate and imitate human decision-making processes together assists in this process. As port operations are redundant, there is a lot of past and real-time data produced that can be plugged into these AI algorithms and technologies to aid in automated vessels and trucks movement.

   Digital AI technology shall be used for system automation, safety and security improvements, vessel route, vessel turnaround time, container dwell time optimization, accurate estimated time of arrival forecasts, real-time performance forecasts, and to create a Digital Twin of the Port (a real-time digital representation of the port operations).

FACILITY &ASSET MANAGEMENT

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DIGITAL TWIN: ASSET & FACILITY MANAGEMENT SOLUTIONS

The effective and efficient port functions highly depend on more real-time data collection, analytics, coordination and response processes, procedures, and supportive systems. The current and future trends of integrated Port Operations are based on the competitive edge on the readiness of the Port and related Facilities, in relation to the wider regional capabilities.

The Facility Management is more about facilitating all operational functions including logistics, transportation, power, water, waste management, Public Transport, Pedestrian, 2Way Signal Controls, dedicated mobility corridors etc. The integrated Facility, Logistics and Mobility control systems are required for an efficient Transshipment operation at the Port.

Real-Time Sensor Network Integration with Digital Twin

Sample: Asset and Facility Models along roads

The Digital Twin platform for Port follows a comprehensive cycle of Analytics, Planning and Delivery using digital and physical process workflows. The process starts from Design to Close outs of all Assets and Facility related life cycles during the Infrastructure Assets and Facilities Planning and Delivery Phases.

FACILITY MANAGEMENT

The Facility Management of The Port follows a comprehensive cycle of Analytics, Planning and Delivery using digital and physical process workflows. The process starts from Design to Close outs of all Assets and Facility related life cycles during the Infrastructure Assets and Facilities Planning and Delivery Phases. The Analysis phase of the Digital Twin is about identifying the functional and operational features and enterprise system integrations needed. The Facility and Asset Management using the Digital Twin need careful planning and design of the 3d and 2d data and information base as required for Asset Management or Facility management scope for a given project.

The Facility Management support systems would evolve into a hybrid format of physical (including robotics) and digital systems. The planning, development, delivery, analytics, operations, and performance management life cycle needs the hybrid approach too. The NEXIS proposal is to adopt a long-term vision and actionable Systems Framework to lead Asset & Facility Management as a Sustainable Port Region.

Model

Asset and Facility Management includes the life cycle of assets and related facilities associated to the assets. The physical world of the Port and Catchment Region has diverse economic, business, functional and social growth trajectories. As Port Operator and Manager an objective and constructive involvement in the planning, development, operation and management of the Port and Catchment Region is required. The wholistic approach to maintain effective operational readiness, continuous improvement, and lean operations.
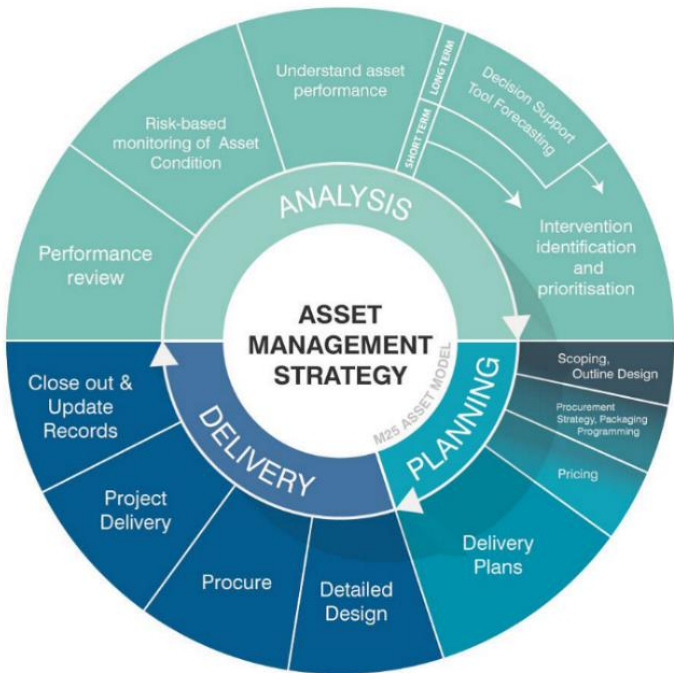
Asset & Facility Management Framework

The shipping and logistics workflow and enterprise system integration along with Digital Twin for the maximum advantage for a modern Autonomous Port operation future. The Digital 3D Models attempts to transpose the real-world physical environment become useful to all stakeholders when the model is connected to physical operations and functions by integrating real-time sensors, data and systems. The model building takes the journey of building the base data in stages and maintain a steady path of covering more area, data and systems as it evolves and create values for stakeholders. The Model integration stages are more critical to produce the information and functional features.

The real-time data integration from the Port region on Key Indicators and Operations data is envisaged to make the Asset and Facility Management platform the most relevant and ubiquitous platform.

Technology

The technology spectrum is evolving and influences mobility, asset and facility management systems. The combination of prudent solutions and technology stack is proposed here to coordinate the Asset and Facility Management for the Port. The Intelligent Buildings and Facilities requires integration of site or regional data integration into geospatial and BIM platforms with IoT data-streams. A quality & risk-based analytics by sectors for collection, mobility, containers, quality controls for export and import regulations.
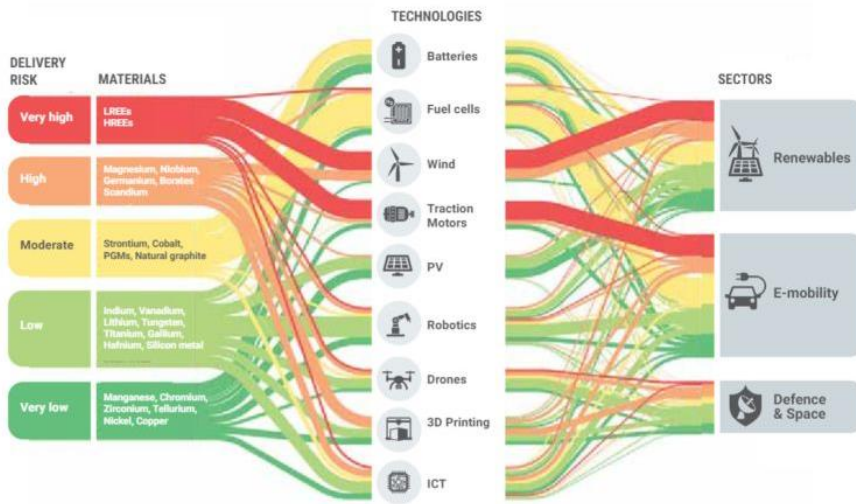
Figure 7 ► Overview of the different critical metals needed for the various technologies, based on the expected development of these technologies within the EU (source: European Commission).[23]

Technology: Relationships with Predictive Lineage Model & Analytics

1. **Infrastructure:** *The infrastructure includes Cloud and On-premises systems and network architecture to strengthen data collection (hybrid process + real-time), monitoring, storage, computing, and transmission capabilities.*

2. **System integration:** *Traditional surveying and mapping data, three-dimensional model data such as 3D GIS, BIM, oblique photography, laser point cloud, geographic location data based on the Internet, real-time perception data based on the Internet of Things, port operation production data, industry data, and unstructured videos, pictures, documents, etc.*

3. **System Development:** *By using Data Science options with Data Governance, Lineage, AI, ML DL, BIM, GIS, Video/Picture Image Analytics, AR & VR and three-dimensional the information model can be set up. The IoT data stream integration for real-time data for Asset and Facility related operations and conditions.*

4. **Risk Management:** *The Asset and Facility platform for Risk Management with automated data gathering, analytics and mitigation for*
   - *Natural Risks: Sinking, Collision, Fire/Explosion,*
   - *Climate risks: Flood, Cyclone, Typhoon, Tornado, Hurricane, Tsunami*
   - *Security Risks: Sea – Robbery, Riots/Strike,*
   - *Facility MEP/Mechanical Electric & Plumbing OMR risks: Engine Boiler, M/C Mechanical Failure, Shaft, Propeller Brakeage /*
   - *Navigation risks: Navigation Problems, Lost Routes, Damages, Port Congestion, Stranding of a Vessel*

SUSTAINABLE DEVELOPMENT & GROWTH

The NEXIS Professional Service component includes a comprehensive set of Services to anchor, steer and align various projects and programs for the Port Region. The Solutions delivery, Business Management and Professional Design & Planning Service helps to steer and align the current and future programs and operations within the overall sustainable development master plans. The potential gap in the individual business verticals as each segment grows wider from the projected 52% of the World trade is a Silverline for the growth of Port operations.

The potential growth in the volume of traffic origin from India and the Asian region through the VIDMS port facilities need an all-round growth plans, operations and management systems. The NEXIS professional services include planned and ad hoc Professional Services for the same sites or region.

Services and Implementation

The Phasing of Solutions and Professional Services Digital Twin Model installation for The Port Seaport.

1. Infrastructure Capacity and Utilization Management *with Digital Twin at Port Site and Catchment Region. The Professional Services would utilize the data, servers and network infrastructure created for the rest of the proposal scope and any facilities available.*

2. Intelligent Mobility Corridors
The two-way road ipCAM/Sensor data and Signal controls based Intelligent Mobility Corridors for fright containers and logistics support for VIDMS. Time-definite Delivery, Quality-Assured Product lines and support services for Warehouses in the Port and Catchment region provides a World-Class Quality Management Framework.

3. Environment Planning Services i*ncludes environmental planning services and related water, air and soil pollutant data collection analytics & integration for Environmental Quality compliance. The environmentally sensitive conditions data collection and analytics for routine quality.*

4. Environmental Information Governance: *The services include data and analytics services for Bathymetry, Current, Salinity, Biomass, Water Quality, Air Quality, MARPOL security management.*

5. Site & Catchment Region Planning and Design Services *The professional services includes the integrated Sustainable Development planning services. We propose use cloud-based design creation and collaborative BIM based design outputs.*

6. Nature Based Solutions Design *The professional services for sustainable materials, design options and development using locally available materials and integrations. The narrow port site based environmental design with NBS would result mis alignment with the environmental quality of the region.*

7. Quality Management *used for the proposal are based on applicable industry standards (like ISO 9000, 14000, 37000 Series, TQM and CMM models) and other best practices by verticals, products and services. The partner ecosystem includes AI/ML based EXIM focused product quality management systems.*

8. Port Catchment Planning *The Port Catchment demarcation requires detailed analysis of key parameters for the Port Catchment. Preparation of business scenario plans, short to long term physical and logistics proposals, policies, management structures and regulatory frameworks, business promotion plans (by market vertical) for coordination among all stakeholders etc would form the tasks in this module.)*
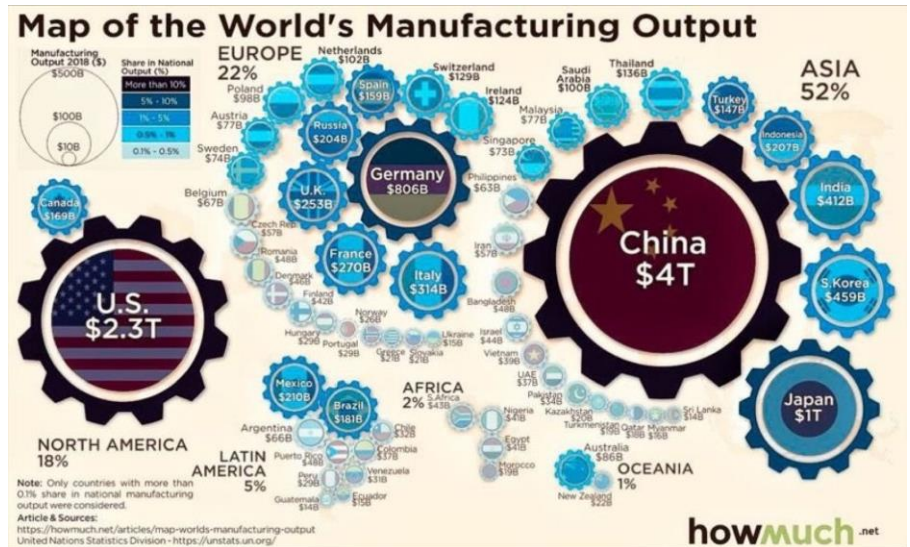
Implementation

The project implementation plans include the following processes. These steps are outline for the Digital Twin implementation. Additional functions and features for enterprise integration requires separate requirement and support.

1. The three segments of the proposal require progressive agile format of project design, development, scheduling.
2. Create Digital Twin Master Plan for detailed real-time, high-quality data is the basis for any digital twin solution.
3. Digital Twins based investment planning for port site and the catchment region.
4. With direct connection to physical objects, digital twins should maintain high cyber security solutions and access limit to different levels of staff to avoid possible trials to disrupt the operations.

Key Advantages of the approach and proposal

The key advantage of the prosed solution is outlined here are pointers for clients to review and define their priorities and outcomes from the Digital Twin implementation.

1. **The Digital Twin Solutions**
   a. Digital inventory true to scale and option for quick sharing of dynamic information and aids in automatic updating of facilities using sensors.
   b. Assistance in effective decision making for routine operations and during emergency situations.
   c. The ETA forecasting will change all aspects of port operations. An accurate and reliable vessel arrival prediction creates a domino effect of benefits for the planning and allocating of resources. These benefits will affect administrative tasks and paperwork, berth allocation, human workers (like dockers), materials (like cranes), port infrastructure and maintenance, and resource planning.
2. **Asset & Facility Management Systems (A&FMS)**
   a. The A&FMS is an integrated approach to collect, analyse, integrate, for regular operational workflows.
   b. The integrated systems help to build KPI based facility data collection, analytics for operations, management.
   c. The Quality Management framework of export and import materials with Digital Scan with AI/ML based enterprise systems for the catchment region.
   d. The shipping and logistics workflow and enterprise system integration along with Digital Twin for the maximum advantage for a modern Autonomous Port operation future.
3. **Professional Services**
   a. The professional Services focus on align and integrate various projects and initiatives in the port site and regions.
   b. Sustainable Port & Catchment with Planned Sustainable development and growth management.

The Digital Twin solutions for Ports are meant to create an ecosystem for all stakeholders to use and innovate on the platforms to create new values and integration potentials. The increased efforts by all business verticals to embrace Digital Transformations with Enterprise Resource Planning (ERP), Supply-Chain Management or Customer Relationship Management (CRM) integrations are pointing towards effective and efficient Port Operations and Management.

The potential of Digital Twin to provide universally familiar environment to envisage the real-world conditions with real-time data integration is the most ideal practical solution for Next Generation Ports.

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