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DigiBandar

A Digital Twin Blueprint for Indian Ports

October 2025

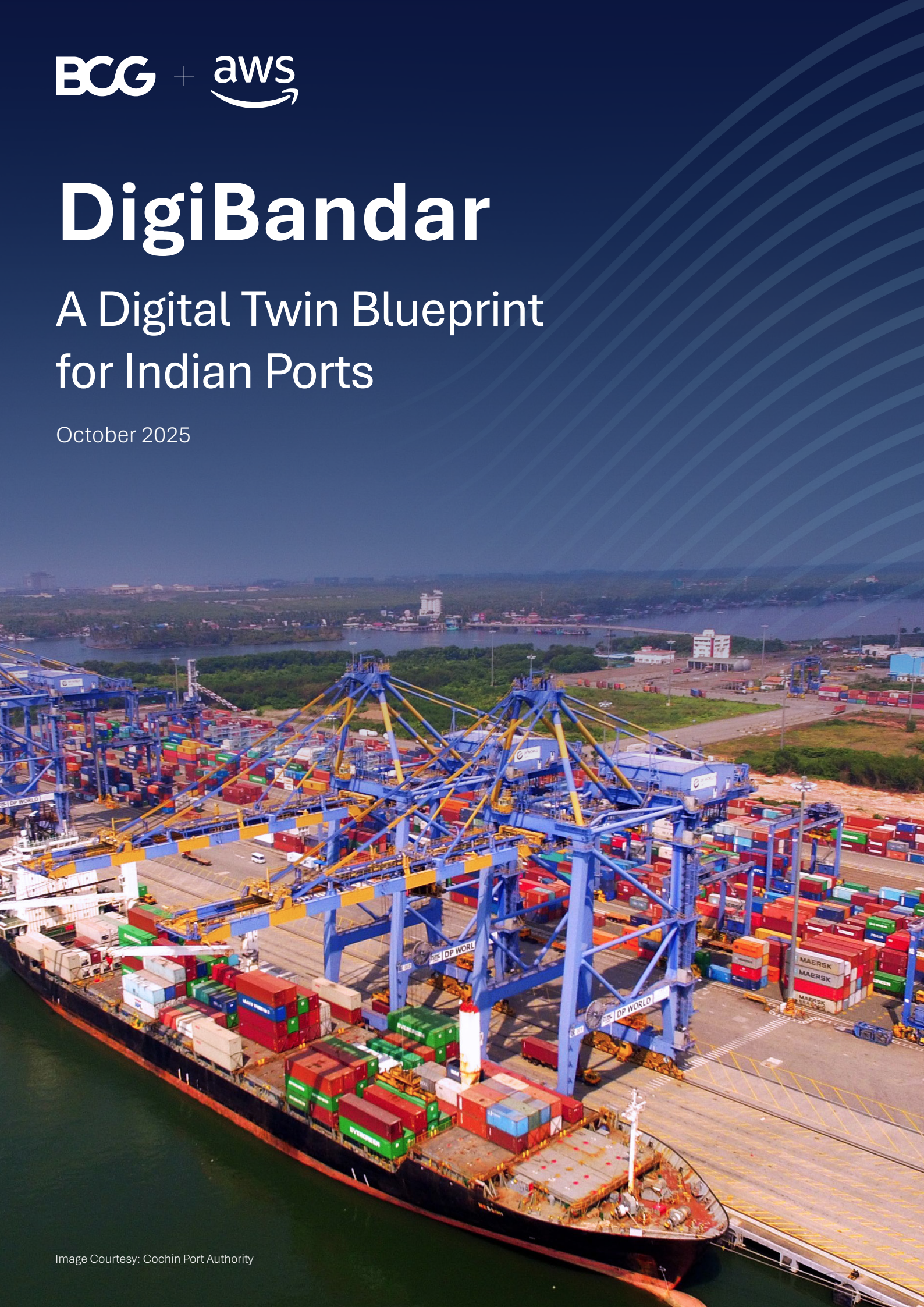

Image Courtesy: Cochin Port Authority

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CHAPTER 1

Digitalization as the New Infrastructure for Global Ports

Digitalization is redefining how infrastructure sectors, from airports and railways to ports and logistics hubs, operate and connect in real time. It is powering a new era of intelligent, data-driven operations that are faster, smarter, and more resilient.

Today, digital infrastructure has become as critical to port competitiveness as berths and cranes, marking a profound shift in how ports enable global trade. Around the world, ports agnostic of size, are investing in scalable platforms, advanced analytics and AI solutions, and automation, to enhance operational efficiency, sustainability, and collaboration across the port ecosystem. While each port's digital journey is unique, most begin by targeting key operational bottlenecks and designing use cases to address them.

Digitalization Elevates Port Performance and Operational Efficiency

Digitalization enhances performance across every link in the maritime value chain:

- **Water-side:** Predictive analytics and real-time vessel tracking improve berth scheduling and reduce vessel turnaround time and idle time at berth through Just-in-Time (JIT) operations.
- **Terminal-side:** Automation and AI can enhance crane productivity, yard and equipment utilization, boosting throughput and optimizing costs.

» **City-side:** Digital gate management, truck-appointment, and integrated scheduling systems coordinate land-side flows, align terminal operations with trucking fleets and rail dispatch, reducing congestion and accelerating cargo clearance.

» **Safety & Sustainability:** Real-time environmental monitoring, vessel-speed optimization, and predictive asset-health analytics help reduce accidents and carbon emissions.

These advances show how data-driven coordination delivers efficiency, resilience, and sustainability simultaneously as demonstrated across global ports:

» **Port of Rotterdam (Netherlands):** Enabled a **20% reduction in vessel anchorage** waiting times by digitizing all port call events and integrating all port stakeholders into a unified platform for port call decision-making.

» **Port of Antwerp-Bruges (Belgium):** Uses the APICA Digital Twin[1] system to manage terminal congestion dynamically, improving truck-appointment reliability and **reducing cargo-clearance time by 15%**[2].

» **Busan New Port (South Korea):** Used a Digital Twin model to **reduce port-related carbon-dioxide emissions by nearly 75%** by optimizing vessel speeds[3], minimizing idling at anchorage, and synchronizing berth allocation.

At the Core: The Digital Twin

At the heart of this evolution is the Digital Twin, a living virtual model that mirrors port operations by integrating data from sensors, systems, and external sources. It provides unified visibility, scenario simulation, and predictive foresight, allowing port operators to plan confidently and coordinate seamlessly.

Global experience highlights not only what is possible but also what is essential for India: using real-time intelligence to strengthen operations, enhance sustainability, and elevate competitiveness. These learnings pave the way for **DigiBandar—India's national blueprint for Digital Twin-enabled smart ports.**

1. Advanced Port Information & Control Assistant; 2. APICA Press Article; 3. Directory of Open Access Journals.

CASE STUDY 1

Port of Rotterdam – Unlocking Operational Excellence through a Digital Twin Ecosystem

The Port of Rotterdam has pioneered Port Digital Twin, integrating data from multiple systems to enable real-time visibility, predictive intelligence, and coordinated, proactive decision-making across port operations. This transformation has been made possible through following key enablers:

1. **360-degree view of port operations by integrating data from multiple sources:** A network of sensors captures over 1.2 million data points daily[1], tracking vessel movements, terminal and city-side operations. This continuous data flow creates a digital replica of the port, enabling 'what-if' scenario planning and predictive forecasting to anticipate disruptions and optimize resources.

2. **Single source of truth for data-enabled decisions:** A unified KPI dashboard and harmonized definition of port call events offers a single, consistent view of operations. This transparency supports timely identification of bottlenecks and informed decision-making.

3. **Real time alerts for proactive response:** The PortAlert mobile app[1] provides immediate notifications on schedule changes, incidents, and disruptions for optimizing city-side movement. This allows transport planners from drivers to terminal operators, to coordinate rapid responses that minimize delays and enhance safety.

4. **Connected ecosystem for collaborative operations:** The PortXChange platform[1] brings together shipping lines, terminal operators, agents, and service providers on one system for coordinated port-call management. By adopting global data standards such as PortCDM[2], IALA[3], and DCSA[4], the port has standardized over 100 event types, ensuring all participants work from the same trusted data and aligned metrics.

1. Port of Rotterdam website; 2. PortCDM: Port Collaborative Decision Making; 3. IALA: International Association of Marine Aids to Navigation and Lighthouse Authorities; 4. DCSA: Digital Container Shipping Association.

Image Courtesy: Jawaharlal Nehru Port Authority, Nhava Sheva

CHAPTER 2

Accelerating India's Port Efficiency through Digital Transformation

Globally, leading ports are redefining operations through Digital Twin use-cases that enhance efficiency, competitiveness, and sustainability. India has embraced this transformation with the **Maritime Amrit Kaal Vision 2047 (MAKV 2047)** setting an ambitious roadmap to leapfrog into next-generation smart ports. The Ministry of Ports, Shipping and Waterways (MoPSW) has identified "Enhancing Efficiency through Technology and Innovation" as a core national priority[4], with clear targets of 100% ports with Just-in-Time vessel arrivals, five world-class smart ports, and complete digital integration across all major ports by 2047.

This marks a paradigm shift in India's approach to port development. For decades, port competitiveness hinged on physical capacity-deeper berths, larger cranes, and expanded yards. Now, efficiency is increasingly determined by a port's ability to sense, predict, and coordinate digitally. Digital transformation has therefore evolved from being a technology initiative to a strategic national capability, enabling India to optimize logistics costs, strengthen trade resilience, and advance toward net-zero commitments.

A Decade of Digital Progress

Over the past decade, India's ports have made significant progress on this journey, marked by a series of national initiatives and pilot programs that together have built a strong foundation for scaling advanced digital and AI-led capabilities.

4. Maritime Amrit Kaal Vision 2047.

India has built a strong digital foundation: Port Community System (PCS 1x) for port workflow digitization[5]; National Logistics Portal (NLP-Marine) as a one-stop platform to integrate all marine stakeholders for logistics coordination[5]. Logistics Data Bank (LDB) for container visibility[5]; Indian Customs Electronic Data Interchange System (ICES) for customs process digitalization[6]; e-Delivery Orders and e-payments for paperless invoicing[5]; RFID/OCR-based gate automation for truck gate processing[7]. Together, these platforms have created the foundation needed to move to performance at scale in line with best-in-class standards.

Ports Taking Initiative Across Multiple Dimensions

Building on these digital foundations, several Indian ports are now piloting advanced, AI-led use cases that demonstrate the power of real-time data and automation. For instance, at Nhava Sheva Port, a Just-in-Time (JIT) vessel arrival system (refer Case study 2) is being developed to accurately predict Estimated Time of Arrival (ETA) and Estimated Time of Departure (ETD), synchronizing vessel arrivals with available berths, integrated through a cloud-based platform connecting multiple stakeholders. This is complemented by truck appointment scheduling and automated gate management systems. Additionally, New Mangalore Port is introducing indigenous Portable Pilot Units (PPUs) (refer Case study 3) to enable pilots with real-time trajectory tracking and safer vessel navigation. These initiatives show how ports are already leveraging technology to plan, predict, and optimize operations.

Translating Digital Adoption into Business Value

The implementation of DigiBandar solution can unlock substantial value for Indian ports across the entire value chain. For instance, **it can drive increased container throughput** through optimized berth planning, Just-in-Time (JIT) operations, and reduced berth idle time. Additionally, Just-in-Time (JIT) planning can enable a **3-4% reduction in fuel consumption**[8] through adjusted vessel speed management and minimized waiting times at anchorage. Together, these outcomes illustrate the transformative potential of data-driven operations under DigiBandar to enhance efficiency, profitability, and sustainability across India's port ecosystem.

From Isolated Impact to an Interoperable Ecosystem

The next step is to connect and scale these digital capabilities through DigiBandar, a unified reference framework that aligns data standards, collaboration platforms, and predictive decision systems across India's ports.

As ports progress along their Digital Twin journey, the focus now shifts from isolated innovation to system-wide transformation. DigiBandar could act as the connective tissue uniting diverse digital initiatives, enabling scale, eliminating duplication, and accelerating value realization.

By establishing clear guiding principles, common data protocols, and harmonized performance metrics, DigiBandar could create an interoperable ecosystem where insights and value can be seamlessly shared across the maritime network. This could allow India to move from digital progress to digital excellence, realizing a network of smart, green, and future-ready ports that exemplify the vision of the Maritime Amrit Kaal 2047.

5. PIB Press Release; 6. National Informatics Center website; 7. Maritime Amrit Kaal Vision 2047;
8. International Maritime Organization report.

CASE STUDY 2

Proof of Concept: Just-In-Time cloud-enabled platform at JNPA

Context: Vessels at ports often experience prolonged anchorage waiting times due to early arrivals or limited berth availability. This highlighted the need for real-time alignment between incoming vessels and berth readiness, while accounting for operational disruptions and delays throughout the day.

Solution: To address this, JNPA has been developing the Just-in-Time (JIT) Platform - a cloud-enabled, indigenous, integrated solution that delivers:

- **Real-time situational awareness** of vessel journey and wait times from anchorage to pilot boarding to berth and back; with insights by shipping line, vessel size, and terminal.
- **Real-time alerts to stakeholders** on vessel delays at anchorage, enabling visibility and timely de-bottlenecking.
- **Predictions of vessel arrivals (ETA) and departures (ETD)**, enabling proactive communication for Just-In-Time operations.
- **Post-ops KPI dashboard** with historical performance enabling root cause identification and a feedback loop for operations improvement.

By enabling proactive communication with shipping lines and agents, the platform enables vessels to adjust sailing speeds, arrive Just-in-Time, and reduce anchorage waiting times – enhancing overall port efficiency and sustainability.

Real-Time Berth Occupancy details and alerts

Integrated view of all incoming vessels to the port for next 7 days

Predicted ETD of vessels at berth

Predicted ETA of incoming vessels

Note: Developed by Vision X.

CASE STUDY 3

Proof of Concept: Smart Vessel Navigation at NMPA

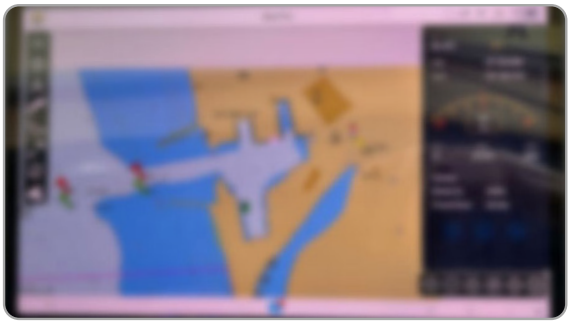
Context: As ports scale to accommodate rising vessel traffic and deep-draft calls, pilotage operations are rapidly evolving toward data-enabled and predictive navigation support, ultimately transitioning towards remote pilotage operations.
The objective is to enhance situational awareness, precision, and safety for vessel navigation- particularly through constrained channels, at night, and under challenging hydro-meteorological conditions.

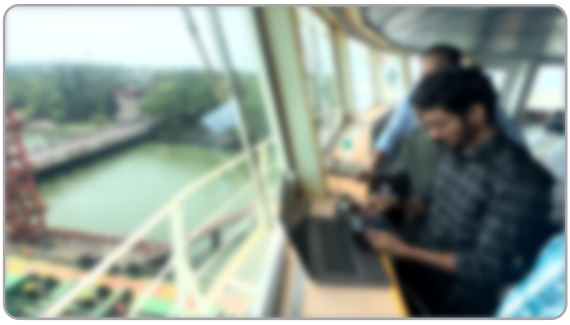
Solution: To enable this, NMPA has deployed Smart Portable Pilot Unit (PPU), an indigenous navigational assistance system comprising:

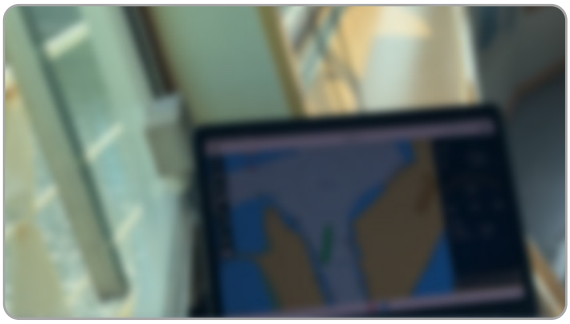
- **Situational awareness:** Live data on vessel traffic, positioning, Speed over ground (SOG), and Course over ground (COG) accessible through portable pilot handsets on-board.
- **Predictive decision support:** Real-time analytics forecasting vessel position and proximity over the next few minutes, enabling proactive maneuvering.
- **Enhanced safety assurance:** Intelligent collision avoidance alerts to support pilots in dynamic and high-traffic conditions.

By bringing live navigational intelligence to pilot's fingertips, the system enhances situational awareness and precision within port limits. It enables safer and efficient pilotage under deep-draft and high-traffic conditions, ensures alignment with IALA/ IMO standards, and supports continuous learning through recorded sessions.

Smart Portable Pilot Unit in action at NMPA







Note: Smart Portable Pilot Units developed by National Technology Centre for Ports Waterways and Coasts (NTCPWC), IIT Madras.

Image Courtesy: Jawaharlal Nehru Port Authority, Nhava Sheva

CHAPTER 3

DigiBandar:

India's National Blueprint for Smart, Data-Driven Ports

India's ports are entering a new phase of digital maturity. DigiBandar could provide the unified blueprint that connects existing initiatives and define how technology, data, and analytics come together to deliver measurable performance.

It sets out the core elements that shape outcomes and set up for success, Digital Twin use cases, harmonized KPI framework, and common data standards that could form the foundation of India's next-generation port ecosystem.

Digital Twin Use Cases within DigiBandar

The first core element focuses on identifying high-impact digital and AI use cases across the port value chain to unlock measurable value. This is critical for three reasons:

» Targets the most pressing operational challenges from the outset, helping build a strong business case by demonstrating tangible gains in capacity

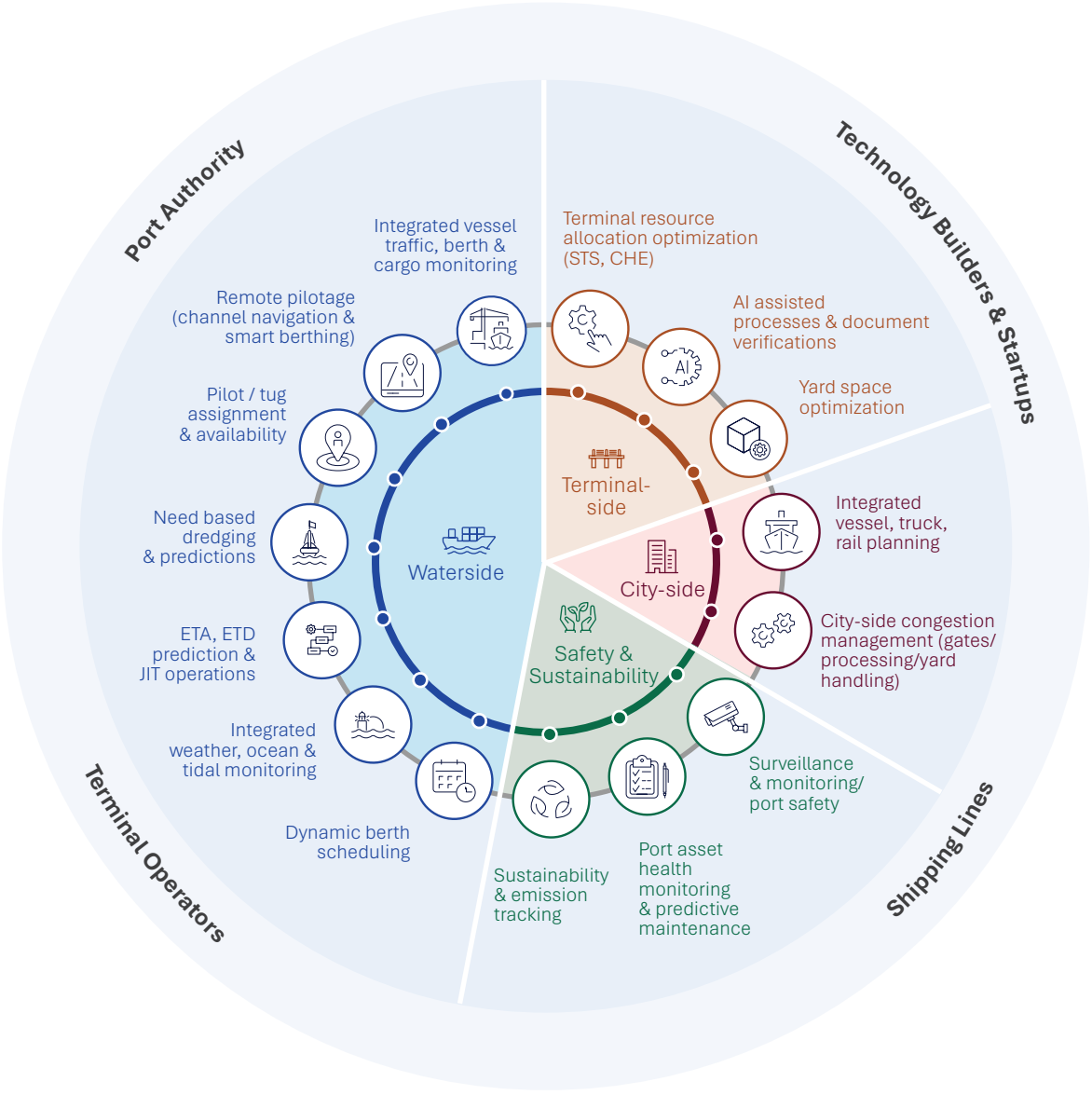
utilization, throughput, cost efficiency, safety, and emissions reduction. This evidence-based approach fosters early stakeholder alignment and accelerates implementation.

» Creates a comprehensive use-case library with a clear roadmap for scale. Once a core set of proven solutions is established, they can be rapidly replicated and adapted across ports nationwide.

» Guides technology architecture design. Use cases define the data sources, analytics models, visualization, and digital infrastructure needed to power them, ensuring the architecture is modular, purpose-built and optimized to deliver tangible outcomes.

Fifteen Digital Twin use cases for India's ports were identified considering learnings from global north star Digital Twin deployments, focus on national priorities, and potential for scalability across the diverse port archetypes. These use cases spanning across waterside, terminal, city-side, and sustainability operations, each contribute to the connected intelligence of DigiBandar.

Exhibit 1: 15 top use cases for value unlock – aligning with global best practices, national vision & priorities, and scalability potential across port archetypes



Real-Time KPI Monitoring for Operational Intelligence

The second core element involves real time monitoring of about 30 critical KPIs, enabled by the following steps:

- **Integrate disparate systems through API gateways to capture data in real-time:** Integrating currently fragmented digital systems, such as IoT sensor networks, Vessel Traffic Systems (VTS), Terminal Operating Systems (TOS), and NLP-Marine can create continuous data streams across the entire port ecosystem. This integration ensures that all defined KPIs are automatically updated in real time, providing real-time situational awareness across port operations.

- **Establish a unified single source-of-truth:** Consolidating integrated data streams into a single visualization pane to create a unified view of port operations. This enables front-line teams to monitor performance in real time, identify bottlenecks quickly, and make proactive, insight-driven decisions.

- **Onboard varied stakeholders onto a unified platform:** Unifying port stakeholders such as terminal operators, shipping lines, customs, marine teams, and logistics providers on a shared digital platform enables synchronized planning and execution. A common interface for data sharing and communication ensures that all parties operate with the same real-time information, improves coordination, and enables timely decisions.

- **Adopt harmonized KPI definitions across ports:** Key operational metrics are defined differently by stakeholders within the port, leading to inconsistent performance tracking and misaligned planning. For instance, in many Indian ports, shipping lines record anchorage, while terminals mark it as the time a vessel is ready to commence cargo operations. These inconsistencies result in resource misallocation, hidden idle times, and unreliable AI-driven forecasts. Standardizing these definitions can eliminate such discrepancies, ensuring right resource allocation at the right time, AI models on coherent data, and like-for-like benchmarking.

The following list of 30 critical KPIs have been identified for real-time monitoring and benchmarking of performance across port operations.

Exhibit 2: 30 KPIs tracked for real time situational awareness and enabling single source of truth

Waterside

Port call planning

- ETA prediction accuracy
- Estimated ETD
- Vessel anchorage wait time
- On-time arrival/ departure (%)

Piloting

- Average pilot idle time
- Average tugboat utilization rate

Berthing

- Pre-berthing delays
- Vessel TAT[13]
- Vessel idle time at berth
- Berth utilization rate

Tidal & Weather management

- Channel depth level
- Average dredging cycle time

Terminal-side

Cargo handling

- Moves/hour (STS[9] cranes)
- Lifts/hour (RTG[10]/RMG[11])
- Daily shift change downtime (minutes)

Yard Management

- Import/Export dwell time
- Custom clearance time
- % yard utilization

Equipment & Maintenance

- Average equipment utilization rate
- Total equipment downtime (hours/month)
- Mean time to equipment repair

City-side

Gate & Landside

- Truck TAT in terminal
- Truck wait time/outside terminal
- Number of trucks (Import/Export)
- Gate processing time

Safety & Sustainability

Safety

- Average incident response time
- Safety incident rate per 1,000 hours worked

Sustainability

- Energy use/TEU[12] handled
- CO_2 emissions/vessel (kg/hour)
- % renewable energy used at port

9. STS: Ship-to-Shore; 10. RTG: Rubber tyred gantry; 11. RMG: Rail mounted gantry; 12. TEU: Twenty-foot equivalent unit; 13. TAT: Turnaround time.

Adoption of common data standards for seamless information exchange

The third core element for establishing a successful Digital Twin is the adoption of common global data standards to ensure interoperability and seamless information exchange across port systems and stakeholders.

Aligning with international data standards such as PortCDM, IALA standards can enable all stakeholders - port authorities, terminals, shipping lines, and customs— to align on same definitions for port events and operate using a common data language. Frameworks such as PortCDM and DCSA offer a structured way to capture and exchange operational data across the port call process, defining standardized timestamps for each stage, from pilot boarding and anchorage to berthing, cargo operations, and departure. For Indian ports with varied digital maturity and processes, adopting these standards can create a common operational language across stakeholders. This not only supports Just-in-Time (JIT) vessel coordination and reduced anchorage time but also strengthens interoperability with global shipping networks. Similarly, aligning with IALA standards on vessel navigation, traffic management, and positioning can enhance safety and predictability in India's congested coastal and channel waters, ensuring that Digital Twin and Vessel Traffic Systems (VTS) systems work seamlessly.

CASE STUDY 4

Global ports are converging on shared digital standards to enable seamless data exchange and synchronized operations

The ports of Rotterdam and Singapore are leading the global shift toward interoperable, data-driven port ecosystems enabling seamless data exchange across ports using common global data standards. These data standards have been defined by global organizations such as DCSA[1], IALA[2] and PortCDM[3] who have established standardized data definition for more than 100 timestamps across Port Call and container journey.

By aligning with this framework, both ports are able to standardize data exchange across 6 operational data elements (shore-to-shore exchange for port planning) for planning purposes, 50 administrative data elements (ship-to-shore exchange for clearances), and 4 nautical data elements (ship-to-shore exchange for berth compatibility).

By adopting these shared standards, ports, terminals, shipping lines, and customs authorities can exchange information seamlessly through their platforms, improving coordination and decision-making across the supply chain. This digital corridor enables ship-to-shore, shore-to-ship, and shore-to-shore data sharing between the two ports, driving synchronization across stakeholders and enhancing efficiency, safety, and sustainability in port operations.

1. DCSA: Digital Container Shipping Association; 2. IALA: International Association of Marine Aids to Navigation and Lighthouse Authorities; 3. PortCDM: Port Collaborative Decision Making.

The Way Forward

Through standardized Digital Twin high-impact use cases, real-time KPI monitoring, harmonized definitions, and global data standards, DigiBandar lays the foundation for a national network of smart, predictive, and sustainable ports.

The next chapter details how this blueprint moves from framework to execution, with lighthouse deployments, strong governance, and a Port Transformation Office (PTO) to scale impact nationwide.

Image Courtesy: Jawaharlal Nehru Port Authority, Nhava Sheva

CHAPTER 4

Pathway to Scale Across Indian Ports

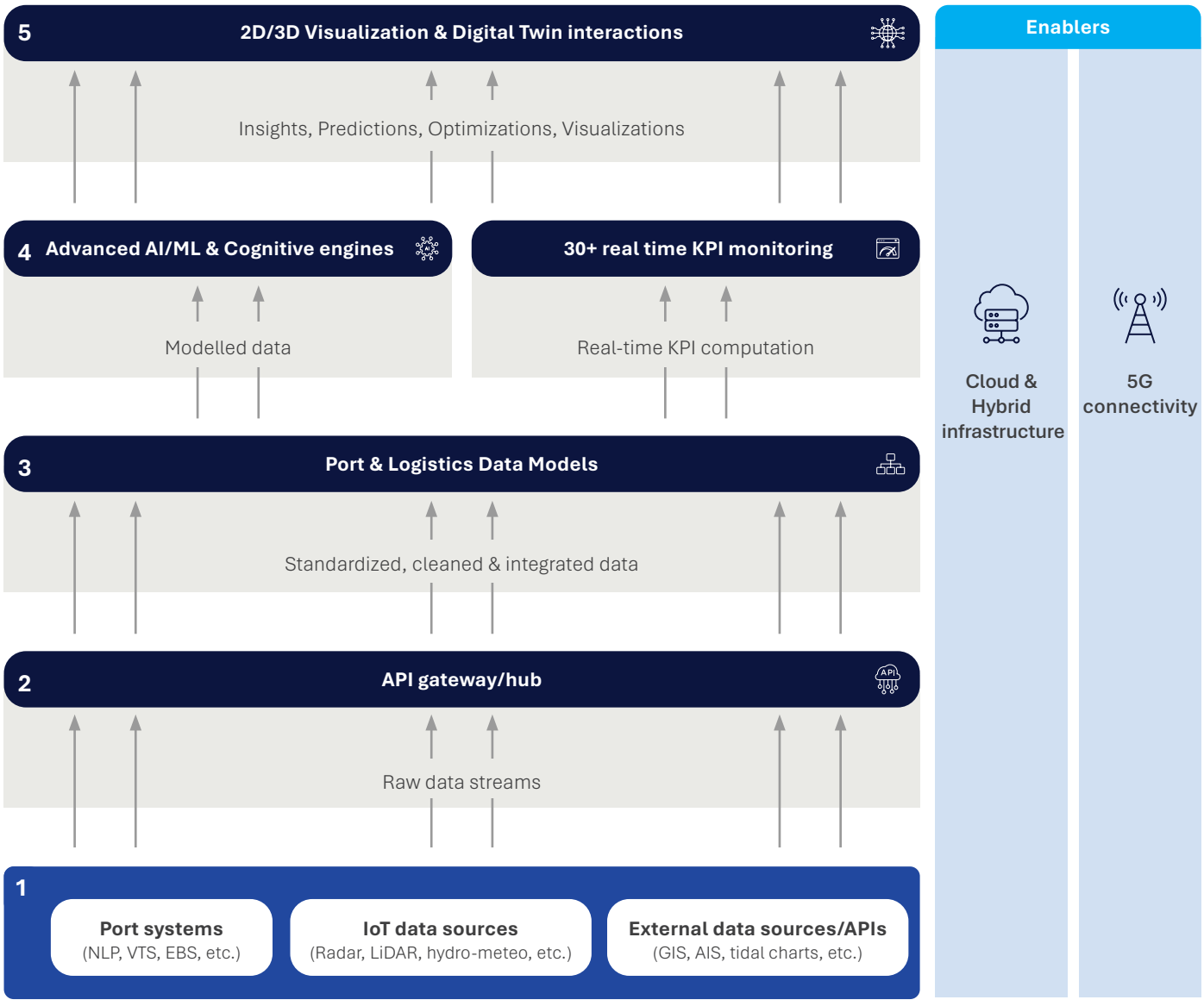
With the DigiBandar blueprint established, the next step is execution, turning vision into value through phased scaling, governance, and capability building. At its core, execution of the DigiBandar blueprint rests equally on three foundational pillars, technology, process, and capability development. First, it focuses on deploying a resilient and scalable technology infrastructure to enable seamless operations. Second, it embeds next-generation ways of working through re-engineered and standardized processes. Third, it emphasizes capability building and orchestration among best-of-breed solution providers to ensure sustained transformation. These efforts are anchored by a dedicated Port Transformation Office (PTO) that drives coordination, execution, and change management across all initiatives.

Building a Scalable and Resilient Technology Backbone

A Digital Twin platform requires secure, scalable, resilient, and modular technology architecture that can keep pace with the complexity of modern port operations. With millions of data points generated every day across vessel movements, cargo flows, and hinterland connectivity, robust infrastructure ensures this information is captured in real time, integrated seamlessly, processed reliably and is safe from cybersecurity concerns. It creates the strong digital foundations needed to support advanced analytics, visualizations and simulation modellings, enabling ports to move decisively towards proactive operational decision making.

While modular architecture forms the technology backbone for digital ports, cloud systems and hybrid infrastructure play a critical role enabling multiple functionalities—it provides the scalability and ability to handle surges during peak seasons ensuring steady performance. Cloud clusters across multiple regions for geo-distributed disaster recovery enable 24x7 operations. Edge infrastructure enables ultra-low latency for time-critical decisions. Elastic compute resources enable the simulation of thousands of "what-if" scenarios in parallel which can be used to optimize berth allocation across multiple variables such as weather, vessel characteristics, cargo types, and equipment availability. Active threat intelligence, AI-based anomaly detection can counter ransomware & targeted maritime cyberattacks, whereas encryption, and fine-grained access enable trusted data sharing among stakeholders. Additionally, Cloud Service Providers also provide direct access to innovation (e.g. cloud-based machine learning services) via ready-to-deploy services and sandboxes to move ideas to pilots quickly.

Exhibit 3: 5-layered architecture for Digital Port Infrastructure



Introducing Next-Generation Ways of Working

Next-generation ways of working move ports from reactive, intuition-led choices to proactive, data-driven operations. The front-line and planning teams can follow re-engineered processes leading to informed planning and next best action. The operating cadence becomes plan–execute–learn through predictive planning, synchronized execution, and post-ops dashboards that drive continuous improvement. These new practices are embedded across the end-to-end port journey, as outlined below:

» **Planning:** Predictive AI-based planning through the Digital Twin can turn visibility into foresight. For example, ETA prediction for incoming ships, coupled with ETD prediction for at-berth vessels can guide automated berth allocation and just-in-time operations. Simulations can enable "what-if" scenario modelling to identify and plan for contingencies.

» **During operations:** A network of IoT sensors across waterside, terminal and city-side operations and integrated systems enables real-time situational awareness and a single operating picture across shipping lines, terminal, customs and city-side stakeholders. Real-time alerts and early-warning triggers enable proactive incident management minimizing delays and wait times. AI-based models and simulations continuously re-optimize berth allocation, yard and marine resources to adapt to evolving conditions and cascading delays during the day.

» **Post operations:** Standardized, time-stamped events across marine, terminal and city-side flows give a clean view of performance (anchorage, TAT, crane/yard productivity, gate dwell, safety) and rapidly trace root causes for bottlenecks. These insights then drive targeted corrective actions and feed the next planning cycle, turning every event into learnings for the next.

The following illustration shows how next-generation ways of working could be introduced upon deployment of a Digital Twin solution:

Exhibit 4: Unlocking value requires transformation in ways of working

Example | Next-gen way of working with JIT vessel arrival and remote pilotage

- When vessel calls port (typically 48 hrs in advance), Digital Twin initiates **ETA prediction**
- ETA gets updated every 3-6 hours for proactive resource planning at Port

- Digital Twin simultaneously **predicts ETD** of vessels at berth basis vessel characteristics & real time operational delays at berth

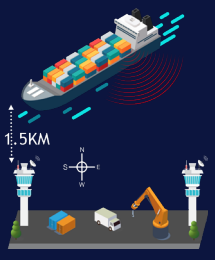
- Digital Twin provides **Requested Time of Arrival (RTA) to ship agent for incoming vessels** basis berth availability, tides & other hydro-meteo factors

- RTA accepted by vessel captain, who then **adjusts vessel speed**
- Once confirmed by agent, Digital Twin **notifies terminal to update berth allocation and plan resources**
- ETA/ETD/RTA **refresh every 6 hours** allowing for advanced planning by stakeholders

- Digital Twin **alerts marine team, customs, & gates** proactively for resource planning, minimizing idle time
- **Rail & truck slots are coordinated** with expected vessel movement

- Port call events are **timestamped**
- **Real time KPI** monitoring & **post operations** dashboards for delay root causes

- **Tug & pilot dispatch alerts** are sent to the marine team as ship nears port limits
- Ship is **remotely guided to berth by on-shore pilot** from remote pilotage center



- Shore-mounted LiDAR **measures ship's speed, angle, and distance to quay wall** for safe berthing

- ETD predicted every 6 hours
- **Marine resources are scheduled ahead of departure** as per predicted ETD, tides & other hydro-meteo factors

A Port Transformation Office (PTO) would need to be set up to serve as the nerve center of the DigiBandar framework, established to drive change management, ensure cross-agency collaboration, data governance, and oversee the rollout of digital initiatives with accountability and speed.

It would monitor performance through live dashboards, coordinate training and innovation programs, and report on value realization to the Port Authorities and Ministry stakeholders.

The PTO could bring together representatives from port authorities, technology partners, logistics agencies, and academia, fostering a balanced blend of operational experience and digital expertise.

Investing in Capability Build and Ecosystem Orchestration

To sustain digital transformation and unlock value at scale, ports would need to invest in capability development and collaboration that aligns people, ecosystem partners, and governance under a unified execution model.

- **Building digital capabilities across stakeholders:** Frontline personnel can be empowered to plan and optimize operations using data, supported by the right tools, clear planning cadences, and structured post-operations reviews. Enabling on-ground teams with mobile and handheld devices for quick data access, with live plan of the day, and resource allocation updates can improve coordination, responsiveness, and decision-making. Establishing Centers of Excellence across major ports could accelerate innovation and value delivery.

- **Orchestrating best-of-breed solution providers:** A complex ecosystem of partners - spanning Maritime SaaS, hardware and IoT, GIS, cloud and cybersecurity platforms, and digital infrastructure (5G, edge) could collaborate to co-develop scalable solutions, ensure continuous innovation and accelerated value delivery.

This people-centric approach creates a digital-first culture of agility, collaboration, and innovation.

The Road Ahead

India stands at a defining moment in its maritime journey. As the nation builds world-class port infrastructure, it could match this with equally world-class digital infrastructure.

To act on this opportunity, India's ports could set off on a phased implementation journey from lighthouse port to national scale illustrated as follows:

1. **Lighthouse Port – Demonstrate Value:** Pilot the complete DigiBandar model at a major port to validate architecture and show measurable improvements.

2. **Refinement and Standardization – Validate and Adapt:** Use insights to refine KPI and architecture and codify best practices into playbooks for replication.

3. **National Rollout – Scale with Consistency:** Scale DigiBandar across major ports with shared cloud infrastructure, standard dashboards, and national KPI scorecards.

This "demonstrate, refine, and replicate" model ensures each success creates momentum for system-wide transformation. The lighthouse port establishes proof of value; the refinement process strengthens the framework; and replication transforms the entire ecosystem at an accelerated pace.

Additionally, regular reviews and global benchmarking ensures that DigiBandar framework continues to evolve in line with emerging best practices. Ongoing refinement of KPIs, advanced use-cases, and process improvements can help the framework remain future-ready, outcome-driven, and impact-oriented.

DigiBandar marks a decisive shift from digital pilots to an integrated, intelligent port ecosystem. Through balanced focus on technology, process, and capability, and under the stewardship of the Port Transformation Office, India could build a network of smart, green, and globally connected ports, anchoring its Maritime Amrit Kaal Vision 2047.

Acknowledgements

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AWS offers the most proven operational expertise of any cloud service provider, including the most functionality, the most flexible and secure cloud computing environment, the fastest pace of innovation, and the largest community of customers and partners, including millions of active customers and more than 100,000 AWS Partners from more than 150 countries.

Image Courtesy: Cochin Port Authority