

# DEENDAYAL PORT AUTHORITY

**An ISO 9001 : 2008 & ISO 14001 : 2004 Certified Port**



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File No. - CME/CME/1394/SmartPortDigitalTwin/2024

Date - 07.05.2025

To

Subject: AI-Based Digital Twin for Deendayal Port's Digital Transformation to a Smart Port - reg.

Sir,

Deendayal Port Authority intends to implement AI-Based Digital Twin for Deendayal Port's Digital Transformation to a Smart Port.

Kindly submit your Expression of interest (with acceptance of terms & conditions as sign. and seal on each page) along with Annexure - credentials towards similar works and budgetary offer for referred work & terms.

Last date of submission of your submission for the above work is up to 21.05.2025.

Thanking you,

Yours faithfully,

-sd-

Chief Mechanical Engineer  
Deendayal Port Authority

## **Terms and Conditions**

### **AI-Based Digital Twin for Deendayal Port's Digital Transformation to a Smart Port**

#### **Project Vision:**

This project outlines the creation of a comprehensive Digital Twin for Deendayal Port covering an area of more than 25 sq km. The Digital Twin will provide real-time monitoring, analytics and visualization of port operations, enhancing efficiency, safety, and decision-making processes. By leveraging advanced camera systems, computer vision, and data analytics, the Digital Twin will offer insights into berthing operations, crane usage, vehicle movements and overall port activities.

#### **Key Components:**

- High-Resolution Camera Network
- Edge Computing Nodes
- Central Data Processing Server
- Network Infrastructure
- Data Center & Disaster Recovery (DC-DR)
- Visualization System
- Software Stack
- Weighbridge Camera System
- Infrastructure and Power Supply

#### **Required Components for the execution:**

1. High-Resolution Camera Network:
  - 860 high-resolution IP cameras
  - PTZ (Pan-Tilt-Zoom) capabilities for flexible coverage
  - Weather-resistant enclosures for marine environment
2. Edge Computing Nodes:
  - 46 edge computing units (1 per IO cameras)
  - Processing power: Nvidia Orin
  - 32 GB RAM, 1 TB SSD storage per unit
3. Central Data Processing Server:
  - High-performance server cluster.
  - 4 x Dell PowerEdge R750 or equivalent
  - Each with dual Intel Xeon Gold processors, 384 GB RAM, 10 TB NVMe storage
4. Network Infrastructure:
  - Fiber optic backbone network
  - Cisco Catalyst 9300 Series switches for edge connectivity
  - Cisco Nexus 9000 Series for core switching
5. Data Center & Disaster Recovery (DC-DR):
  - Containerized Data Center & Disaster Recovery (DC-DR) setup
  - Redundant power supply with UPS
  - Precision cooling system
  - Fire suppression system
  - Data storage in DC-DR both location and its GO-location should be different.
6. Visualization System:
  - LED Video Wall: 6m x 3m (e.g., Planar TVE Series)
  - 4 x Operator workstations with dual 4K monitors
7. Software Stack:
  - Custom in-house developed Digital Twin software platform.
  - Computer Vision algorithms
  - 3D modeling software
  - Data analytics and dashboard software

8. Weighbridge Camera System:
  - 4 high-resolution cameras per weighbridge
  - Infrared capabilities for night vision
  - Direct connection to edge computing nodes
9. Infrastructure and Power Supply:
  - Solar-powered poles for camera and sensor mounting.
  - Fiber optic and power cabling network
  - Backup power systems
10. Realtime ticket monitoring tools with advance feature like ticket closing with verification code.
11. The system should be capable to integrate AI-based predictive analytics for equipment failure, integration with ERP/EBS and Port Operating Systems (POS) Augmented Reality (AR) for maintenance and training. Further, Digital Twin should be integrated with Vessel Tracking Systems & Weighbridge systems.

Expected Outcomes:

- Enhanced operational visibility across the entire port,
- Improved berth management and utilization,
- Optimized crane operations and maintenance scheduling,
- Better traffic management and reduced congestion,
- Increased security and safety through comprehensive visual monitoring,
- Data-driven decision making for port management,
- Improved response times to operational issues,
- Potential for future AI-driven predictive analytics,
- Scalable platform for future expansion and integration of additional technologies.

This Digital Twin implementation will transform the Deendayal port into a smart, data-driven operation, significantly enhancing efficiency, safety, and overall management capabilities. The system's reliance on advanced camera technology and computer vision technology providing comprehensive monitoring and analytics capabilities.

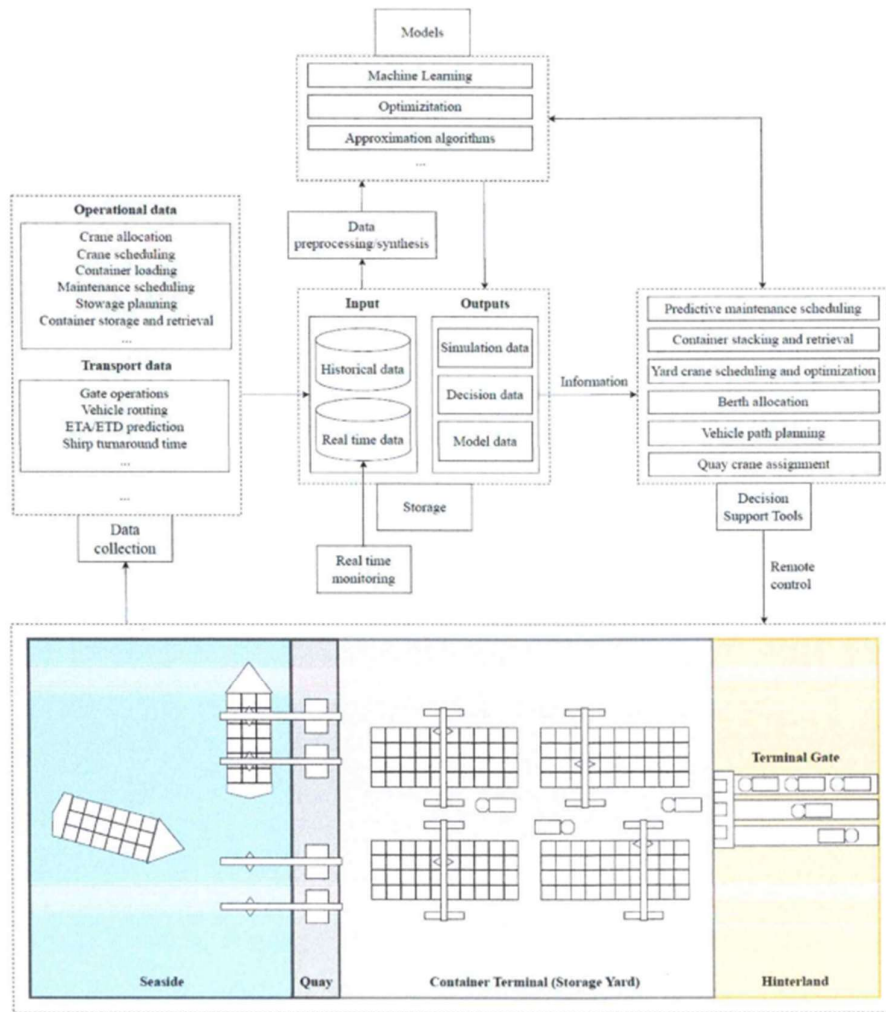
Detailed Proposal & plan for Implementation:

1. 3D Model of the Entire Port
  - LiDAR Scanning:
    - Use airborne LiDAR for large-scale terrain mapping.
    - Deploy terrestrial LiDAR scanners for detailed ground-level scans
    - Utilize mobile LiDAR systems for dynamic area scanning
  - Photogrammetry:
    - Conduct drone surveys using high-resolution cameras
    - Implement multi-angle photography for complex structures
    - Use 360-degree cameras for immersive capture
  - Data Processing using Point Cloud Processing.
  - 3D Reconstruction for photogrammetric reconstruction.
  - CAD Integration:
    - Import existing CAD data of port infrastructure.
    - Use Autodesk Revit or Bentley Open Buildings for BIM (Building Information Modeling) integration
    - Implement IFC (Industry Foundation Classes) standards for interoperability
  - High-fidelity Asset Modeling:
    - Create detailed 3D models of key port assets (cranes, buildings, vessels) using Autodesk 3ds Max or Blender.
    - Implement LOD (Level of Detail) techniques for efficient rendering
    - Use PBR (Physically Based Rendering) materials for realistic appearances
  - Real-time Rendering into the Digital Twin Dashboard.

- Use modular approach for continuous improvement change detection, updating model in real-time, performance optimization.

The 3D Model of the Entire Deendayal Port, when integrated into the Digital Twin Dashboard, becomes a powerful tool for enhancing port operations efficiency:

1. Improved Decision Making: The visual representation allows for intuitive understanding of complex data, leading to faster and more informed decisions.
  2. Enhanced Collaboration: Different departments can easily share and discuss ideas using the common 3D platform.
  3. Optimized Resource Allocation: Visual analytics help in identifying underutilized areas and optimizing resource distribution.
  4. Increased Safety; Virtual safety drills and hazard assessments lead to a safer working environment.
  5. Streamlined Maintenance: Visual cues and AR integration make maintenance tasks more efficient and less error-prone,
  6. Better Long-term Planning; The ability to visualize and simulate future scenarios aids in strategic planning and development.
  7. Improved Customer Experience: Virtual tours and visual project presentations enhance client relations and attract new business.
  8. Environmental Stewardship: The ability to visually assess environmental impacts leads to more sustainable port operations.
2. Live Stream Digital Twin Dashboard
- System Architecture:
    - Front-end with User Interface. Backend for API processing and third-party integration, Data Processing Modules, Database.



- Digital Twin Dashboard Components:
  - 3D POTI Visualization Which is an interactive 3d model Of the entire port.
  - Real-time updates of asset positions (ships. trucks. cranes)
  - Color-coded overlays for various metrics (e.g., congestion, utilization)
  - Grid view of critical area camera feeds
  - AI-enhanced video analytics (e.g., object detection, anomaly detection)
  - PTZ Camera control interface
  - KPI Panels:
    - Real-time display of critical KPIs (e.g., throughput. turnaround times, equipment utilization)
    - Historical trend charts with customizable time ranges
    - Predictive analytics for future performance estimates
  - Alert and Notification Center:
    - A Real-time display of system alerts and notifications.
    - Customizable alert thresholds and notification rules.
    - Integration with external communication systems (e.g., email. SMS or as per port requirements)
  - Weather and Environmental Data from external available APIs.
  - Berth and Yard Management:
    - Interactive berthing schedule,
    - Real-time yard occupancy visualization
  - Traffic Management:

- Real-time traffic now visualization
  - Congestion prediction and alert system
- Integration with Terminal Operating System (TOS):
  - Real-time synchronization of container movements and locations.
  - Integration with berth planning and yard management modules.
  - Bi-directional data flow for work order management
- Integration with Gate Management System:
  - Live updates of gate transactions and queue lengths.
  - Automatic Number Plate Recognition for Vehicle Identification.
  - Live view of customs and security processes.
- Integration with Equipment Management System:
  - Live tracking of equipment location and status.
- Integration with Vessel Traffic Services (VTS):
  - Real-time display of vessel positions and movements,
  - Integration with AIS (Automatic Identification System) data
  - Visualization of planned vessel routes and ETA predictions
- Dedicated widget for weighbridge status monitoring.
- Color-coded status indicators for each weighbridge.
- Digital Twin Dashboard Security & Compliance:
  - Role-Based Access Control (RBAC):
    - Granular permissions based on user roles and responsibilities.
    - Multi-factor authentication for sensitive operations
  - Audit Logging:
    - Comprehensive logging of all user actions and system events.
    - Tamper-proof storage of logs for compliance and forensic purposes
  - Data Encryption:
    - End-to-end encryption for all data transmissions.
    - Encrypted storage for sensitive data at rest
  - Compliance Reporting:
    - Automated generation of compliance reports.
    - Real-time monitoring of regulatory KPIs.

The Live Stream Digital Twin Dashboard serves as the central nervous system of the port, integrating data from all systems and presenting it in an intuitive, actionable format. By providing real-time visibility, predictive insights, and powerful analytical tools, it enables port operators to make faster, more informed decisions, optimize resource allocation and continuously improve overall port efficiency. This comprehensive approach to port management can lead to significant improvements in throughput, cost reduction, customer satisfaction and environmental performance, ultimately enhancing the port's competitiveness in the global maritime industry.

#### Impact on port Efficiency:

1. **Enhanced Situational Awareness:** Real-time visualization of all port activities allows for quick identification of issues and opportunities.
2. **Faster Decision Making:** Comprehensive data integration and AI-assisted analytics enable rapid, informed decision-making.
3. **Optimized Resource Allocation:** Real-time visibility into all resources allows for dynamic reallocation to meet changing demands.
4. **Improved Coordination:** Integrated view of all operations enhances coordination between different departments and stakeholders.
5. **Proactive Problem Solving:** Predictive analytics and early warning systems allow for proactive addressing of potential issues before they escalate.
6. **Increased Throughput:** Optimized operations and reduced bottlenecks lead to increased overall port throughput.
7. **Enhanced Safety and Security:** Real-time monitoring and AI-powered anomaly detection improve overall port safety and security.

8. Environmental Management: Integrated environmental monitoring allows for better management of environmental impacts and compliance with regulations.
  9. Improved Customer Service: Real - time tracking and predictive ETAS enhance communication with customers and improve overall service quality.
  10. Data-Driven Strategic Planning: Comprehensive data analytics and scenario planning tools enable more effective long-term strategic planning.
  11. Operational Flexibility: The ability to model and simulate different scenarios allows greater adaptability to Changing market conditions.
  12. Continuous Improvement: Detailed performance tracking and analytics facilitate ongoing optimization of port processes.
3. Berthing & Occupancy & Shipping Data
    - Deploy 4 high-resolution cameras per berth:
      - 2 x 4K PTZ cameras for wide-area coverage.
      - 2 x 8MP fixed cameras for detailed vessel identification
    - Camera specifications:
      - Frame rate: 30 fps
      - Low-light capability: 0.01 lux
      - IP 68 rated for marine environment
    - Thermal cameras for night operations.
    - Computer Vision Algorithms for vessel detection, vessel identification, berthing status detection.
    - Data Integration:
      - API integrations with the Port Management Information System (PMIS)
      - Real-time data synchronization with shipping schedules
    - Occupancy Analysis:
      - Algorithms to calculate Berth utilization rates, average berthing and unberthing times, and turnaround time for different vessel types.
    - Data Processing Pipeline:
      - Deploy NVIDIA Jetson Xavier NX modules at each berth for initial video processing.
      - Use Apache Kafka for real-time data streaming from edge devices to central servers
    - Visualization and Reporting:
      - Interactive dashboards and automated report generation for real-time berth status visualization.
    - System Integration:
      - Integrate with AIS (Automatic Identification System) data for cross-verification.
      - Develop interfaces with VTS (Vessel Traffic Service) systems
      - Implement data exchange protocols with customs and immigration systems
    - Security Measures:
      - Implement TLS 1.3 for all data transmissions
      - Use role-based access control (RBAC) for data access
      - Implement audit logging for all system interactions
  4. Berth Crane Usage Monitoring:
    - Camera System:
      - 2 x 4K PTZ cameras for wide-area coverage.
      - 2 x 2MP fixed cameras for detailed movement capture.
      - 2 x thermal cameras for night operations and heat detection.
    - Camera Specifications:
      - Frame rate: 60 fps for high-speed motion capture
      - Wide Dynamic Range (WDR) for challenging lighting conditions
      - IP66 / IP67 rated for harsh marine environments
    - Computer Vision Algorithms for Crane Detection & Tracking, Operation Classification, Load Detection.
    - Sensor Fusion to combine thermal and visual data.

- Edge Computing at each crane.
- Data Processing and Analytics for pattern recognition in crane usage.
- Integration with Digital Twin for Real-time Synchronization. 3d Visualization of the cranes and data contextualization to correlate crane usage data with berthing information and shipping schedules.

Specifications of Fixed Camera Vision Sensors:

|                                      |                                                                                                                                                     |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| Angle of View                        | 90°(H)                                                                                                                                              |
| Image Type                           | 1/2.8"SONY STARVIS CMOS Sensor                                                                                                                      |
| Sensor Pixels                        | 2065(H)x1553(V)                                                                                                                                     |
| Min. Illumination                    | Color : 0.2Lux / BW : 0Lux@F2.5, 50IRE                                                                                                              |
| Optical / Digital Zoom               | 20x / 16x respectively                                                                                                                              |
| Scanning Mode                        | Progressive Scan                                                                                                                                    |
| Wide Dynamic Range                   | D-WDR(ATR-EX) ( 120dB)                                                                                                                              |
| Day and Night Mode                   | True D/N(Auto, Day, Night)                                                                                                                          |
| Noise Reduction                      | 3DNR                                                                                                                                                |
| Exposure Control                     | Auto                                                                                                                                                |
| Shutter Speed                        | Auto(1/10,000~1sec), Manual                                                                                                                         |
| Bitrate Control                      | CVBR, VBR                                                                                                                                           |
| Resolution                           | 2048x1536, 1920x1080, 1280x720/1024, 704x480/576                                                                                                    |
| Frame Rate                           | Max. 25/30fps@3MP                                                                                                                                   |
| Streaming                            | 25/30fps(Triple Stream : H.264x2,MJPEGx1)                                                                                                           |
| Audio Compression                    | G.711                                                                                                                                               |
| Audio Streaming                      | 2 Way                                                                                                                                               |
| Video Contents Analysis              | Tampering, Line Detector, Field Detector                                                                                                            |
| Motion Detection Area                | 16 Programmable Area(Include Area 8, Exclude Area 8)                                                                                                |
| Privacy Mask Zone                    | 8 Programmable Zone                                                                                                                                 |
| Event Notification                   | E-mail, FTP, Notification Server, XML Notification, AIHM                                                                                            |
| Login Authority                      | Administrator, Operator, Guest                                                                                                                      |
| Manual Trigger                       | 4 Programmable Trigger                                                                                                                              |
| Security                             | MultiUser Authority, IP Filtering, HTTPS, SSL                                                                                                       |
| Network Time Sync                    | NTP Server, Synchronized Computer, Manual                                                                                                           |
| Remote Upgrade                       | Web Browsing(IE, Chrome, Safari, Firefox), SmartManager                                                                                             |
| Protocol                             | TCP/IP,UDP, IPv4/v6, HTTP, HTTPS, QoS, FTP, UPnP, RTP, RTSP,RTCP, DHCP, ARP, Zeroconf, Bonjour                                                      |
| API Support                          | Open API, Onvif Compliance                                                                                                                          |
| Audio /Alarm                         | 1 Input, 1 Output(Terminal Block)                                                                                                                   |
| Ingress Protection & Corrosion Proof | IP67 / SUS 316 Body Construction.                                                                                                                   |
| Power                                | PoE, 12VDC                                                                                                                                          |
| Key Features                         | 1) Event Boosting, FTP Image Upload, Web Casting, Open VPN, QoS and IP Filtering. Auto Exposure, Auto White Balance and Triple Stream(H.264, MJPEG) |

PTZ Camera Vision Sensors Specifications:

|                    |                                                       |
|--------------------|-------------------------------------------------------|
| Angle of View      | 65.1~2.23°(H)                                         |
| Image Type         | 1/2.8"SONY STARVIS CMOS Sensor                        |
| Sensor Pixels      | 1945(H)x1097(V)                                       |
| Min. Illumination  | Color : 0.35Lux/ BW : 0.013Lux@50IRE, 0Lux(IR LED On) |
| Scanning Mode      | Progressive Scan                                      |
| Wide Dynamic Range | D-WDR(ATR-EX) (120dB)                                 |

|                          |                                                                                                                                |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| Optical / Digital Zoom   | 30x / 16x respectively                                                                                                         |
| Day and Night Mode       | True D/N(Auto, Day, Night)                                                                                                     |
| Noise Reduction          | 3DNR                                                                                                                           |
| Exposure Control         | Auto, Manual, Shutter Priority, Iris Priority                                                                                  |
| Shutter Speed            | 25/30fps : Auto(1/30,000~x8sec), Manual<br>50/60fps : Auto(1/50,000~x8sec), Manual                                             |
| Bitrate Control          | CVBR, VBR                                                                                                                      |
| Resolution               | 1920x1080, 1280x1024, 1280x720/960, 704x480/576,<br>640x360/480, 320x240                                                       |
| Frame Rate               | Max. 50/60fps                                                                                                                  |
| Streaming                | 50/60fps(Dual Stream : H.264x1, MJPEGx1)<br>25/30fps(Triple Stream : H.264x2, MJPEGx1)                                         |
| Audio Compression        | G.711                                                                                                                          |
| Audio Streaming          | 2 Way                                                                                                                          |
| PTZ Functions            | Pan-360° / Min 0.7 ° /sec ~ Max. 50°/sec.<br>Speed & Tilt range - +/-90° / Min 0.6 ° /sec ~ Max. 60° /sec.<br>69 Preset Speeds |
| Motion Detection Area    | 16 Programmable Area(Include Area 8, Exclude Area 8)                                                                           |
| Event Notification       | E-mail, FTP, Notification Server, XML Notification, Audio Alert, AIHM                                                          |
| Privacy Masking          | 16 Programmable Zone                                                                                                           |
| Login Authority          | Administrator, Operator, Guest                                                                                                 |
| Manual Trigger           | 4 Programmable Trigger                                                                                                         |
| Security                 | MultiUser Authority, IP Filtering, HTTPS, SSL                                                                                  |
| Network Time Sync        | NTP Server, Synchronized Computer, Manual                                                                                      |
| Remote Upgrade           | Web Browsing(IE, Chrome, Safari, Firefox),<br>SmartManager, NC-Titanium                                                        |
| Protocol                 | TCP/IP, UDP, IPv4/v6, HTTP, HTTPS, QoS, FTP, UPnP, RTP,<br>RTSP, RTCP, DHCP, ARP, Zeroconf, Bonjour                            |
| Client Software          | Web, SmartManager, NC-Titanium, Tive HD                                                                                        |
| API Support              | Open API, Onvif Compliance                                                                                                     |
| Material of Construction | SUS 316L Electro-polished Stainless Steel for Optimum<br>Corrosion Proof                                                       |
| Camera Cooling           | SUS316L Junction Box with Water tank                                                                                           |

5. Truck Fleet Monitoring:

- Entry / Exit Point Cameras:
  - High-resolution ANPR (Automatic Number Plate Recognition) cameras.
  - 4K overview cameras for vehicle type classification
- In-Port Traffic Cameras:
  - PTZ cameras for dynamic monitoring.
  - Thermal cameras for night operations
- AI-Powered Edge Devices:
  - NVIDIA Jetson AGX Xavier for on-site video processing.
- Supplementary Sensors:
  - LIDAR sensors for precise vehicle dimensioning.
  - Inductive loop detectors for vehicle presence detection
- Computer Vision and AI Algorithms:
  - Vehicle Detection and Classification.
  - License Plate Recognition
  - Truck Tracking using deep learning techniques.

- Traffic Flow Analysis
- Digital Twin Dashboard Integration:
  - Real-time Visualization of truck movements and interactive heatmaps for visualizing traffic density and congestion points,
  - Implementation time-lapse functionality to show patterns over time,
  - Alerting system for a rule based system for generating alerts and implement push notifications for immediate operator awareness.
- Efficiency Impact on Port Operations:
  - Traffic flow optimization for real-time routing recommendations based on current traffic conditions.
  - Dynamic lane allocation for optimizing entry/exit points.
  - Turnaround Time Reduction for Automated gate processes using ANPR for faster check-in/out.
  - Safety Enhancements for Automated speeding detection and alerts
- Advanced Features:
  - Real-time data exchange with Terminal Operating Systems (TOS).

By integrating the Truck Fleet Monitoring system into the Digital Twin Dashboard, port operators gain a powerful tool for optimizing one of the most critical aspects of port operations. The real-time visibility, predictive capabilities, and data-driven insights enable a new level of electricity and responsiveness in managing truck traffic, ultimately leading to improved overall port-performance, reduced costs, and enhanced competitiveness in the global shipping industry.

- Reduced Congestion: Real-time traffic management and predictive routing lead to smoother traffic now and reduced congestion.
- Faster Turnaround Times: Automated gate processes and optimized routing significantly reduce truck turnaround times.
- Improved Resource Utilization: Data-driven decision making allows for optimal allocation of staff, equipment, and space.
- Enhanced Safety: Real—time monitoring and alerts help prevent accidents and improve overall port safety.
- Environmental Benefits: Optimized routing and reduced idling times lead to lower emissions and fuel consumption.
- Better Planning: Historical data and predictive analytics enable more accurate long-term planning and infrastructure development.
- Increased Throughput: Smoother operations and reduced bottlenecks increase the overall cargo handling capacity of the port.
- Improved Customer Satisfaction: Faster turnaround times and more predictable operations improve relationships with trucking companies and cargo owners.
- Data-Driven Decision Making: Comprehensive analytics provide port managers with insights for continuous improvement and strategic planning.
- Adaptability: The system's ability to predict and model different scenarios allows the to quickly adapt to Changing conditions or requirements.

#### 6. Weighbridge Camera System & Monitoring:

- Camera Setup:
  - High-resolution cameras (e.g., 4K or 8K) for clear vehicle and cargo imaging.
  - Multiple camera angles per weighbridge:
    - Overhead view for full truck capture.
    - Side views for container/cargo details
    - Close-up view of the weighbridge display
  - Infrared cameras for night-time operations.
- Additional Sensors (Optional):
  - Load cells integrated with the weighbridge for accurate weight measurement.
  - Laser scanners for vehicle dimensioning

- RFID readers for quick identification
- Local Processing Unit:
  - Edge computing device with AI capabilities for each weighbridge,
  - Local storage for temporary data retention,
  - Real-time video analytics processing.
- Weighbridge Software:
  - Integration with port management systems.
  - Automated weight recording and documentation.
  - Anomaly detection algorithms for weight discrepancies
- Network Connectivity:
  - High-speed, low-latency connection to the central data center.
  - Redundant network paths for reliability
- Integration with Digital Twin Dashboard;
  - Real-time Weighbridge Status:
    - Live feed of each weighbridge integrated into the 3D port model,
    - Color-coded status indicators (e.g., green for operational, red for issues),
    - Real-time display of current weight readings.
  - Vehicle Tracking:
    - Integration of LPR data with the port's vehicle tracking system,
    - Visualization of truck movements to and from weighbridges.
  - Reporting and Documentation:
    - Automated generation of weighbridge reports.
    - Integration with customs and regulatory compliance systems

#### Impact on Port Operations Efficiency:

- Streamlined Weighing Process:
  - Reduction in manual data entry and human errors.
  - Faster processing times through automation.
  - Improved accuracy of weight measurements.
- Enhanced Traffic Flow:
  - Real-time visibility of weighbridge status allows for better traffic routing,
  - Reduction in congestion around weighbridge areas,
  - Ability to balance load across multiple weighbridges.
- Improved Resource Allocation:
  - Data-driven decisions on staffing and operating hours for weighbridges
  - Ability to predict and prepare for peak usage times
- Increased Security and Compliance:
  - Automated cross-checking of weights against declared values
  - Visual evidence for dispute resolution
  - Easier compliance with regulatory requirements
- Better Integration with Customs Processes:
  - Seamless data flow between weighbridge and customs systems
  - Faster clearance times for cargo
- Real-time Decision Making:
  - Immediate access to weighbridge data for operational decisions
  - Ability to quickly respond to anomalies or issues
- Performance Optimization:
  - Continuous monitoring and analysis of weighbridge performance
  - Identification of bottlenecks and inefficiencies
- Fraud Prevention;
  - Cross-verification of weights at different points
  - Anomaly detection to identify potential weight manipulation

By integrating the Weighbridge Camera System & Monitoring into the Digital Twin Dashboard, the port will gain a powerful tool for optimizing a critical aspect of its operations. This integration will

provide real-time visibility, enhances decision-making capabilities and contributes to overall operational efficiency. The result will be more streamlined weighing process, improved traffic flow, enhanced security, and better resource utilization. These improvements collectively contribute to increased throughput, reduced costs and improved customer satisfaction; ultimately enhancing the port's competitiveness in the global shipping industry.

7. Data Center & Data Recovery (DC-DR) with LED Wall Display:

- Data Center & Data Recovery (DC-DR) Components:
  - High-performance servers (e.g., blade servers) data processing and storage,
  - GPU clusters for AI and video analytics processing,
  - Network-attached storage (NAS) systems for data archiving,
  - High-speed network switches and routers,
  - Uninterruptible Power Supply (UPS) and backup generators,
  - Advanced cooling systems (e.g., precision air conditioning, liquid cooling for high-density racks),
  - Fire suppression systems.
- LED Wall Display Specifications:
  - Size: Large-scale display (e.g., 10m x 4m)
  - Resolution: Ultra-high resolution (e.g., 8K - 7680 x 4320 pixels)
  - Type: Direct View LED with small pixel pitch (e.g., 1.2 mm) for close viewing
  - Brightness: High brightness (e.g., 800 nits) with automatic adjustment
  - Color Depth: 10-bit color processing for accurate color representation
  - Refresh Rate: High refresh rate (e.g. 120 Hz) for smooth motion
  - Viewing Angle: Wide viewing angle (e.g., 160° horizontal and vertical)
  - Control System: Advanced display controller for multi-source input
- Integration with Digital Twin Dashboard:
  - Real-time Data Visualization:
    - The LED wall displays the 3D digital twin model of the entire port.
    - Real-time updates reflect current port status based on camera and sensor data,
    - Color-coded overlays indicate various operational statuses (e.g., berth occupancy, crane activity)
  - Multi-layered Information Display;
    - Split-screen capability to show multiple data streams simultaneously.
    - Ability to overlay different data layers (e.g., traffic flow, Equipment status) on the 3D model.
    - Dynamic KPI dashboards displayed alongside the 3D model
  - Interactive Interface:
    - Touch-enabled sections for operator interaction.
    - Ability to drill into specific areas or assets for detailed information.
  - Alert System:
    - Prominent display of critical alerts and notifications.
    - Visual and auditory cues for different alert levels.
    - Ability to highlight affected areas on the 3D model.

By integrating this advanced DC-DR with LED Wall Display into the Digital Twin Dashboard, DPA can transform raw data into actionable, visual in-sights. This setup creates a powerful command and control center that enhances decision-making, improves resource utilization, and ultimately increases the overall efficiency and competitiveness of the port operations.

8. Infrastructure Setup:

- Comprehensive Camera Network:
  - High-resolution IP cameras (4K or higher) with wide dynamic range.
  - PTZ (Pan-Tilt-Zoom) cameras for flexible monitoring
  - Cameras night vision and heat detection

- Specialized cameras for license plate recognition at gates
- Deployment:
  - Coverage of all critical areas: berths, cranes, gates, roadways, storage areas, weighbridges.
  - Minimum of 860 cameras for a 25 sq km port,
  - Weatherproof, marine-grade housings for all outdoor Cameras,
- Edge Computing Devices:
  - Rugged, industrial-grade edge computers with GPU acceleration.
  - Deployed near camera clusters for initial data processing.
  - Capabilities:
    - Real-time video analytics.
    - Data compression and filtering
    - Local storage for temporary data caching
- Network Infrastructure:
  - Fiber Optic Backbone:
    - Single-mode fiber for long distances (>500m).
    - Multi-mode fiber for shorter runs,
    - Redundant paths for critical areas.
  - Wireless Mesh Network:
    - High-bandwidth, low-latency wireless links.
    - Coverage for areas where fiber is impractical.
  - Network Switches and Routers:
    - Enterprise-grade, managed switches with POE+ capability.
    - Layer 3 switches for inter-VLAN routing
    - Core routers with high throughput capacity.
- Cybersecurity Infrastructure:
  - Next-generation firewalls,
  - Intrusion Detection and Prevention Systems (IDPS)
  - Security Information and Event Management (SIEM) system
  - Encrypted communication channels
  - Regular vulnerability scanning and penetration testing tools

By implementing this comprehensive infrastructure setup, the port can create a powerful and flexible Digital Twin Dashboard. This system will provide unprecedented visibility into port operations, enabling data-driven decision making, optimized resource allocation and continuous improvement. The result is a significant increase in overall port efficiency, competitiveness, and sustainability.

#### 9. General Setup for Vision System:

- Pole System:
  - Deploy 300 poles throughout the port area.
  - Specifications per pole:
    - Height: 6-8 meters (adjustable based on location requirements)
    - Solar Panel: 300W monocrystalline panel
    - Battery: 200Ah deep cycle batteries for 24-hour operation
    - Mounting: Reinforced base with anti-corrosion treatment
  - Features:
    - Integrated camera and sensor mounting brackets
    - Weather-resistant equipment enclosures
    - Lightning protection systems
- Cabling Infrastructure:
  - Fiber Optic Network:
    - Deploy 75 km of single-mode fiber optic cabling
    - Implement a ring topology for redundancy
    - Use armored, water-resistant cable suitable for marine environments

- Power Cabling:
  - Install 40 km of underground power cabling
  - Use marine-grade, waterproof cabling
  - Implement separate circuits for critical and non-critical systems
- Cable Management:
  - Underground cable conduits for main routes
  - Overhead cable trays in restricted areas
  - Regular inspection points for maintenance access
- Network Nodes:
  - Install 20 weather-resistant network cabinets throughout the port
  - Each cabinet equipped with:
    - Fiber optic patch panels
    - Power distribution units
    - Edge switches
    - Climate control systems
- Backup Power Systems:
  - Deploy 1 diesel generators (50 kVA) at strategic locations
  - Implement automatic transfer switches for seamless power transition
  - Install uninterruptible power supplies (UPS) for critical systems
- Installation Process:
  - Conduct a detailed site survey for optimal pole and cable routing
  - Obtain necessary permits and approvals for installation
  - Use minimally invasive installation techniques to reduce disruption
  - Implement a phased installation approach to maintain port operations
  - Conduct thorough testing of each installed component before integration
- Maintenance and Monitoring:
  - Develop a regular maintenance schedule for all infrastructure Components
  - Implement remote monitoring systems for solar power efficiency
  - Create a digital map of all installed infrastructure for easy maintenance reference.

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Annexure  
Submission to be made with Expression of Interest

Credentials of Firm

| Sr. | Description                                                                                                                                                                                      | Inputs from Firm |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| 1.  | Name of Firm                                                                                                                                                                                     |                  |
| 2.  | GST No.                                                                                                                                                                                          |                  |
| 3.  | Whether Similar Work of Digital Twin system has been executed?<br>If Yes, please provide the details of<br>(a) Detailed specifications,<br>(b) location and<br>(c) employer of referred project. |                  |
| 4.  | Please share the copy of Work Order / Completion Certificate of referred project.                                                                                                                |                  |

Budgetary Offer

| Sr. | Description                                                                                                                                                                              | Qty.                                                                                                                                                                                                                                                                                                        | Unit | Rate | Amount for the |          |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|----------------|----------|
|     |                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                             |      |      | Qty.           |          |
|     |                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                             |      |      | in figures     | in words |
| 1   | Costs for Software Development, Infrastructure Development, Including AI and Machine Learning Models, Implementation, Testing, Integration, Training and Documents such as User Manuals. | 1                                                                                                                                                                                                                                                                                                           | Lot  |      |                |          |
|     | <u>Hardware &amp; Equipments</u>                                                                                                                                                         | <u>Minimum Specifications</u>                                                                                                                                                                                                                                                                               |      |      |                |          |
|     |                                                                                                                                                                                          | -                                                                                                                                                                                                                                                                                                           |      |      |                |          |
| 1   | High Resolution RGB Cameras                                                                                                                                                              | 2M Corrosion Proof HD IP Fixed Camera NCX-2203F                                                                                                                                                                                                                                                             | 600  | Nos. |                |          |
| 2   | PTZ Cameras                                                                                                                                                                              | -                                                                                                                                                                                                                                                                                                           | 60   | Nos. |                |          |
| 3   | Thermal Cameras                                                                                                                                                                          | -                                                                                                                                                                                                                                                                                                           | 40   | Nos. |                |          |
| 4   | ANPR Camera at Entry & Exit Gate                                                                                                                                                         | -                                                                                                                                                                                                                                                                                                           | 15   | Nos. |                |          |
| 5   | Weighbridge Cameras                                                                                                                                                                      | 2M Corrosion Proof HD IP Fixed Camera NCX-2203F                                                                                                                                                                                                                                                             | 100  | Nos. |                |          |
| 6   | 5G Private Infrastructure                                                                                                                                                                | 5 GHz routers capable of Wi-Fi speeds up to 867 Mbps on 5 GHz band and 400 Mbps on 2.4 GHz band, Each router must have 5 Gigabit ports, at least 4 external antennas, MU - MIMO technology, dual-band support, and must be suitable for coverage across the port area with Access Point Mode Functionality. | 100  | Nos. |                |          |
| 7   | GPU Farm + Containerized Data Center &                                                                                                                                                   | GPU farm equipped with NVIDIA A100 GPUs, each with 320 GB GPU memory. The                                                                                                                                                                                                                                   | 1    | Nos. |                |          |

|    |                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                 |     |      |  |  |  |
|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------|--|--|--|
|    | Data Recovery (DC-DR)                                                                                                                                                                                            | associated CPU must be AMD with 128 cores and 3.4 GHz speed, complemented by ITB RAM and 30 TB internal storage for high-performance computing tasks + Containerized Data Center & Data Recovery (DC-DR) which includes communication facilities, data wall/LED monitors, alarms, system status indicators, workstations, office furniture, etc.                                                                |     |      |  |  |  |
| 8  | Cabling Cost including Fibre Optic, networking & power cable                                                                                                                                                     | Networking and Power Cable Installation with Connectors, Patch Panels and related Hardware along with Testing and Commissioning                                                                                                                                                                                                                                                                                 | 75  | KM   |  |  |  |
| 9  | Pole Fabrication Cost & Installation with Civil work                                                                                                                                                             | Galvanized steel poles typically in height, designed to withstand coastal weather conditions. Costs associated with labor, cranes, and other necessary equipment for erecting the poles along with Concrete foundations to ensure the stability of the poles.                                                                                                                                                   | 300 | Nos. |  |  |  |
| 10 | Edge Computing Rugged HW: Implement rugged edge computing hardware for feature extraction at poles throughout Deendayal Port, enabling real-time data processing and analysis in harsh environmental conditions. | Rugged Edge Computing Hardware Equivalent to specs: Model: Premio Inc. RCO-6000-CML Series Processor: Intel® Core™ i7/i5/i3 processors. Memory: Up to 64GB DDR4 Storage: Multiple SATA SSDs with options for hot-swappable drives Operating Temperature: -40° C to 70° C Enclosure: Fanless, IP65-rated for dust and water resistance Connectivity: Multiple I/O ports including USB, Ethernet and serial port. | 100 | Nos. |  |  |  |
| 11 | UPS 20 KVA - 40 AH battery bank                                                                                                                                                                                  | UPS system 20 KVA with batteries for redundant power backup for electronic systems during interruptions.                                                                                                                                                                                                                                                                                                        | 1   | Nos. |  |  |  |
| 12 | Power Back up: DG Gen-set 50 KVA.                                                                                                                                                                                | 50 KVA MIL Grade Genset with automatic switching system                                                                                                                                                                                                                                                                                                                                                         | 1   | Nos. |  |  |  |
| 13 | Multi-layer 3D Scan GPS                                                                                                                                                                                          | Implementing a multi-layer 3D scan GPS-GIS system at DPA is                                                                                                                                                                                                                                                                                                                                                     | 1   | Nos. |  |  |  |

|       |                                           |                                                                                                                                                                                                                                                                                                                |  |  |  |  |  |
|-------|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|
|       | – GIS Cost of the complete Deendayal Port | feasible and beneficial for enhancing port management and operational efficiency, By integrating advanced LiDAR technology, drone-based surveying and robust GIS software. DPA can achieve accurate, real-time mapping and data analysis, significantly improving decision making and infrastructure planning. |  |  |  |  |  |
| Total |                                           |                                                                                                                                                                                                                                                                                                                |  |  |  |  |  |

(Total Rupees \_\_\_\_\_ Only)

GST Charges shall be extra.

*Signature of Bidder with seal*

*Place:*

*Date:*

-sd-

*Chief Mechanical Engineer  
Deendayal Port Authority*