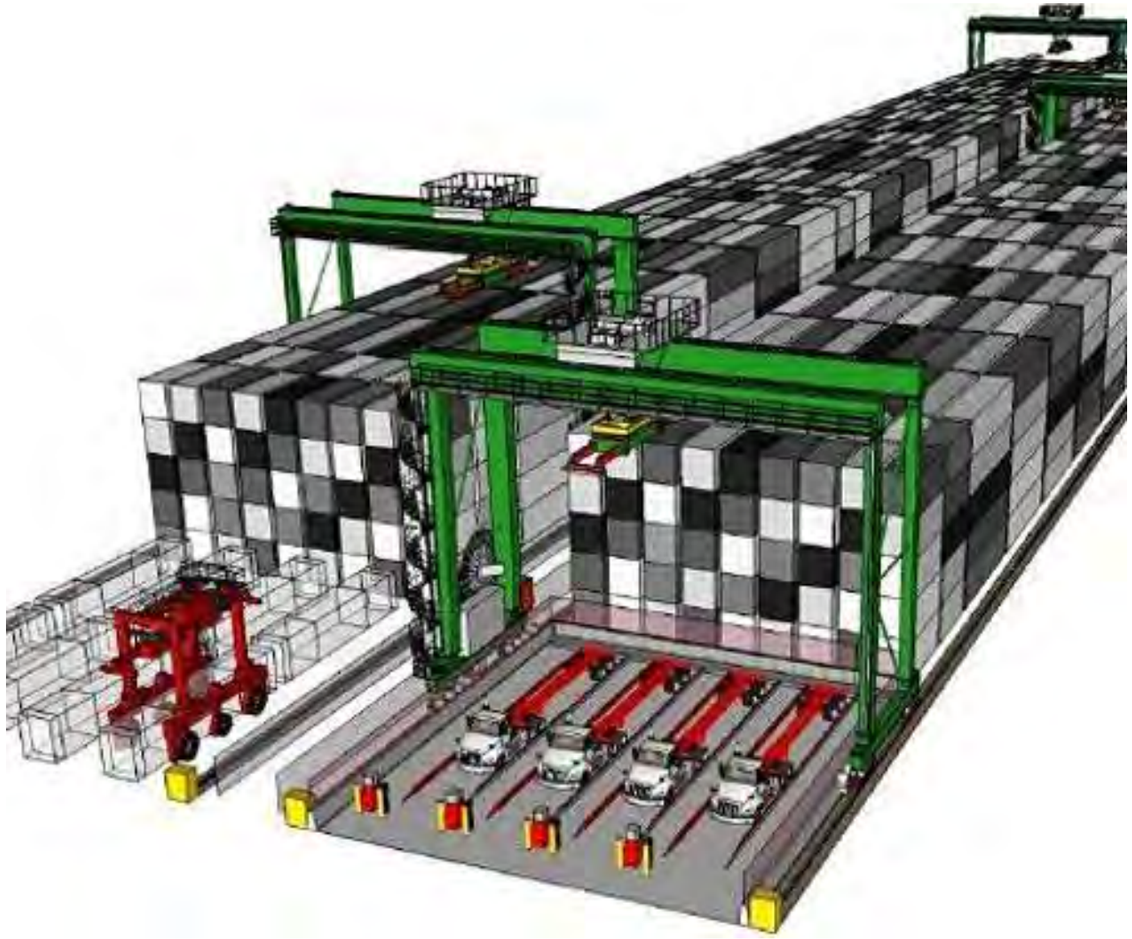
PIANC ANZ Northern Chapter

PLANNING FOR AUTOMATION OF CONTAINER TERMINALS

Part Two of Presentations 28 July 2021



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Carsten Varming – NSW Ports
Michael Houen – Hatch

4 - PLANNING

4.1 THE TERMINAL PLANNING PROCESS

Primary Planning Principles

- **Capacity**
  - Maximum annual container throughput transferred between vessel and land while maintaining acceptable performance
- **Productivity**
  - Flow rate of containers per hour through the terminal components
  - Production rate of equipment
- **Balance**
  - All the areas of the terminal have similar capacity and productivity
- **Flexibility**
  - Terminal's operation can adapt to changes in operational demand, business model, technology, or regulatory framework
- **Phasing**
  - Terminal capacity can be expanded over time to meet demand

4.1 THE TERMINAL PLANNING PROCESS

The Core Team

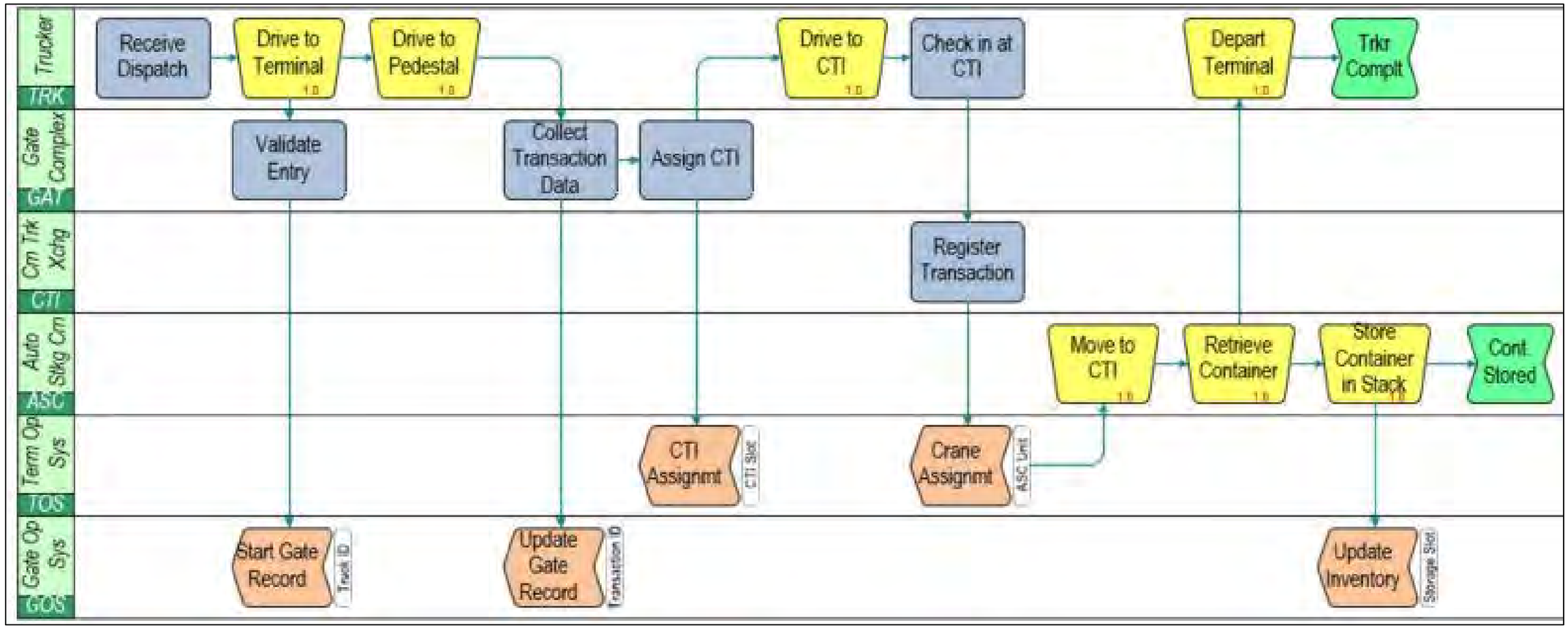
- Management
- Operations
- Equipment
- Infrastructure engineering
- Finance
- TOS,IT systems, cyber security
- Labour relationships
- Local regulation, standards and requirements

Planning Process

- Business Case
- Opportunities and Constraints
- Business Process Modelling
- Potential Operating Modes
- Primary Sizing
- Major Buildout Elements
- Static and Dynamic Models
- Select Finalist(s)
- Phased Development
- Final Plan Testing
- Prepare for Engineering

4.2 OPPORTUNITIES AND CONSTRAINTS

4.3 BUSINESS PROCESS MODELLING



- **Level 1: Enterprise Level**
- **Level 2: Operational Process Level**
- **Level 3: Operational Task Level**

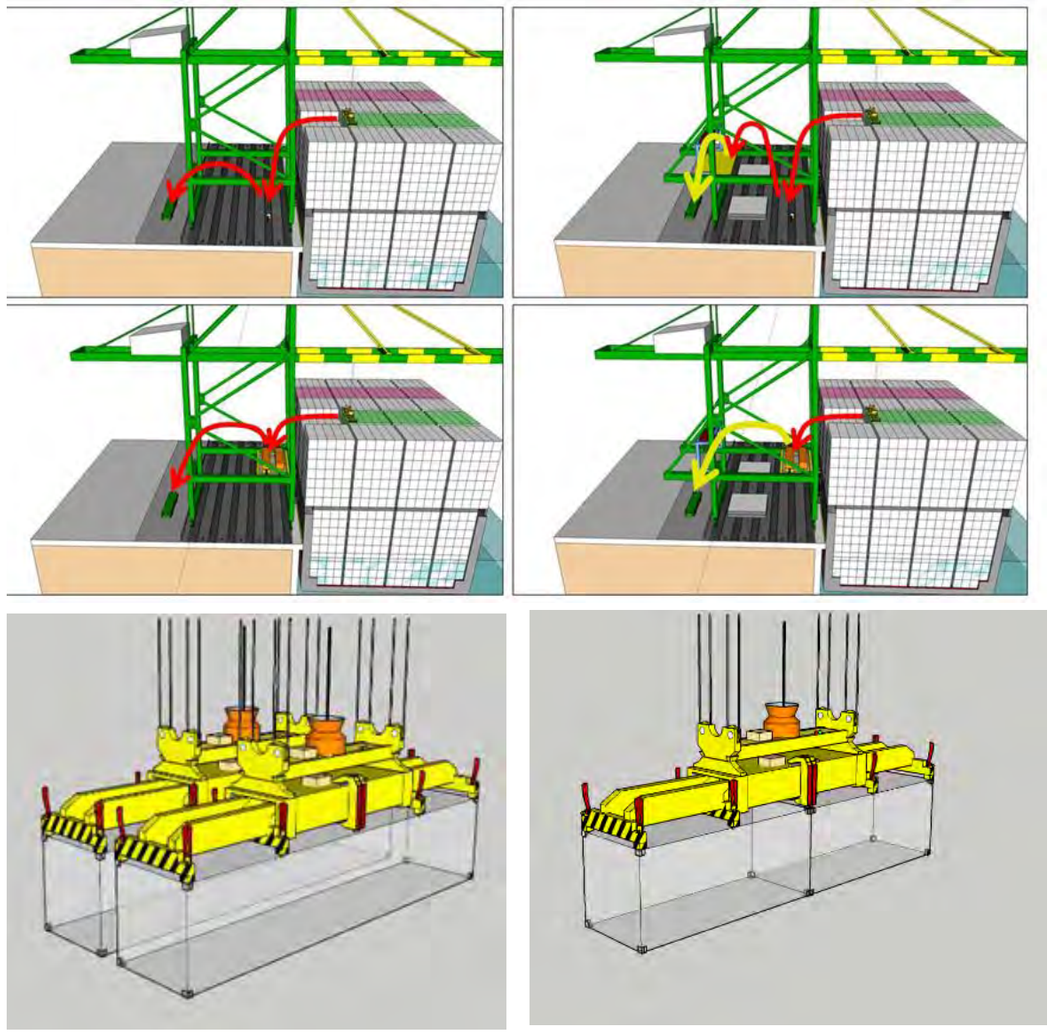
4.4 POTENTIAL OPERATING MODES

- **Degree of Automation**
  - STS Cranes
  - Yard cranes
  - Horizontal transport
  - Rail yard
  - Street truck interface
- **Converting from manual**
  - Remote controlled
  - Supervised
  - Semi-automated
  - Automated

Levels	Sea-side Transport	Stacking Cranes			Land-side Transport
		Sea Side CTI	Machine Motions	Landside CTI	
Level1	Manual Strad/Shuttle, Tractor Trailers	Remote Controlled	Automated	Remote Controlled	Manual Street Truck
Level 2	AGV, ALV, Shuttle Carriers				
Level 3					
Level 4					Automated Truck, AGV, ASTR

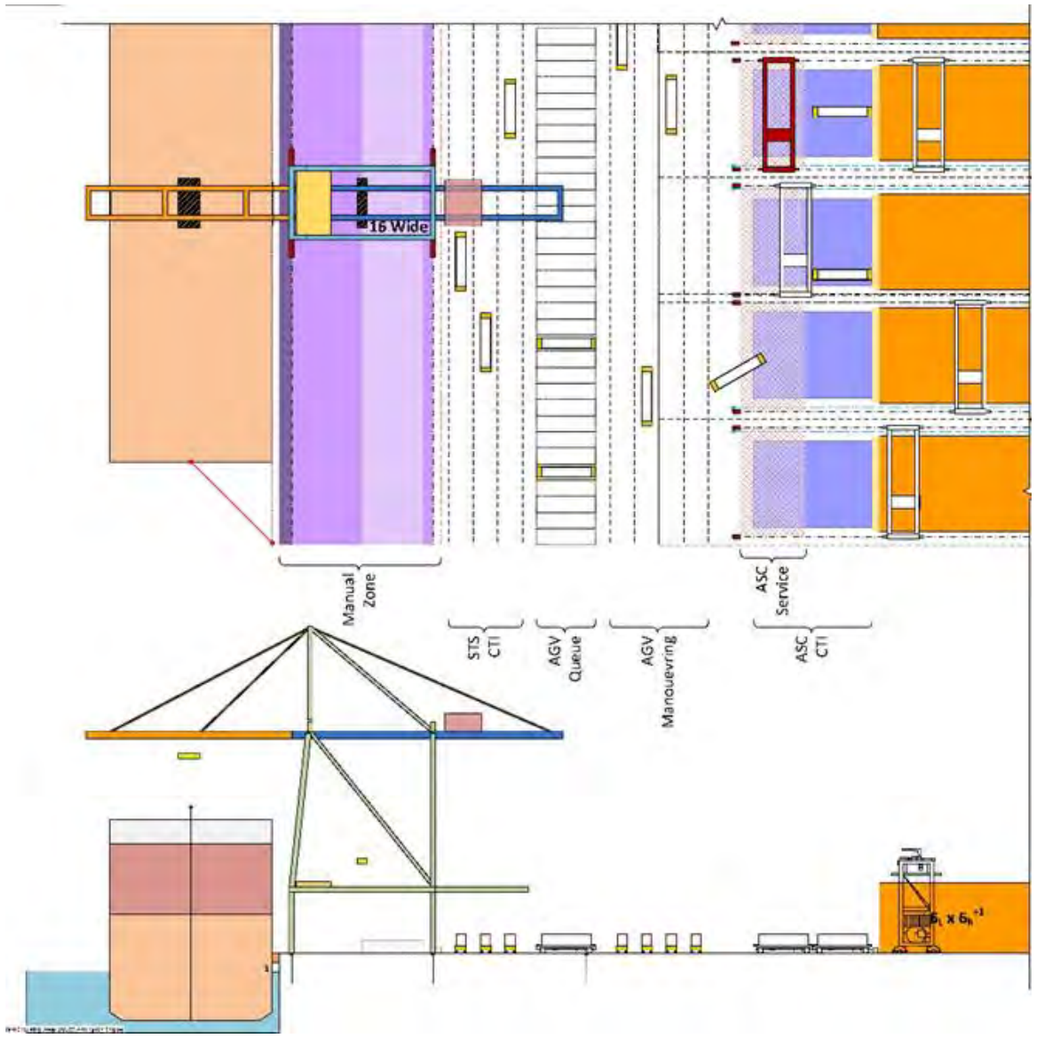
EQUIPMENT CONSIDERATIONS

- **STS crane selection**
  - Dimensions/gauge
  - Performance
  - Twin lift/tandem/quad lift
  - Coning platform
  - Remote operations
- **Yard cranes**
  - Available machine technologies
  - Performance
  - Range of historic site deployments
  - Orientation (parallel/perpendicular, end/side accessed)
- **Transporters**
  - STS crane configuration
  - Available machine technologies
  - Performance
  - Power source
  - Transfer zone – dimensions, buffering ability
  - Manoeuvring space
  - Level of labour deployment
- **Manufacturers and procurement**
- **TOS and other operating systems**



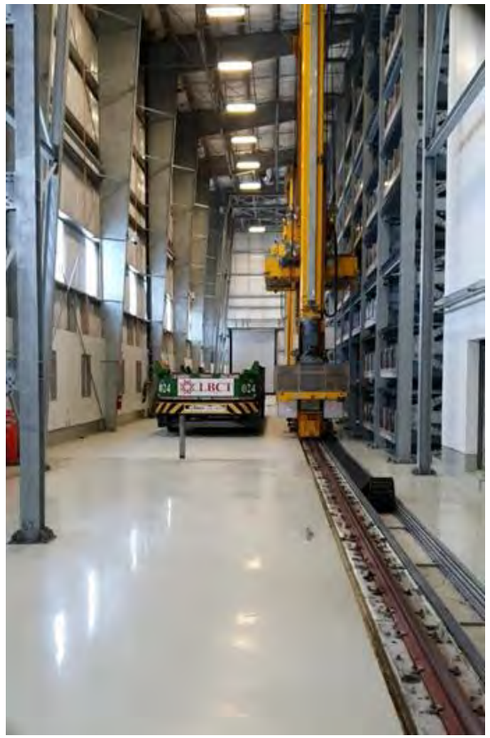
4.5 PRIMARY SIZING / 4.6 CONFIGURATION

- **Berth capacity**
  - Throughput volume projection
  - Vessels – sizes, schedule, frequency, lifts per call, target call duration
  - Crane productivity and deployment
  - No. berths and utilization
  - Operational lost time
  - Seasonal peaking
- **Yard capacity**
  - Logistics split (import/export/transshipment, gate/rail
  - Cargo mix (e.g. dry, reefer, empties, 20’/40’)
  - Storage dwell times, stack heights and utilisation
  - Seasonal and tactical peaking
- **Initial plans**
  - Wharf, stack, circulation configurations
  - ASCs, CRMGs, automated RTGs
  - Reefer racks and empty containers
  - Static analysis



OTHER ELEMENTS

- **Buildings and Auxiliary Support**
  - Administration & Operations
  - Maintenance
  - Battery operations
  - Container scanning
  - Fueling
- **Exception Handling**
  - Out-of-Gauge
  - Hazardous
  - Leaking
  - Damaged
- **Interfaces with landside transport**
  - Gates
  - Intermodal rail yard
  - Exchange between container yard and rail



4.7 EQUIPMENT SIZING

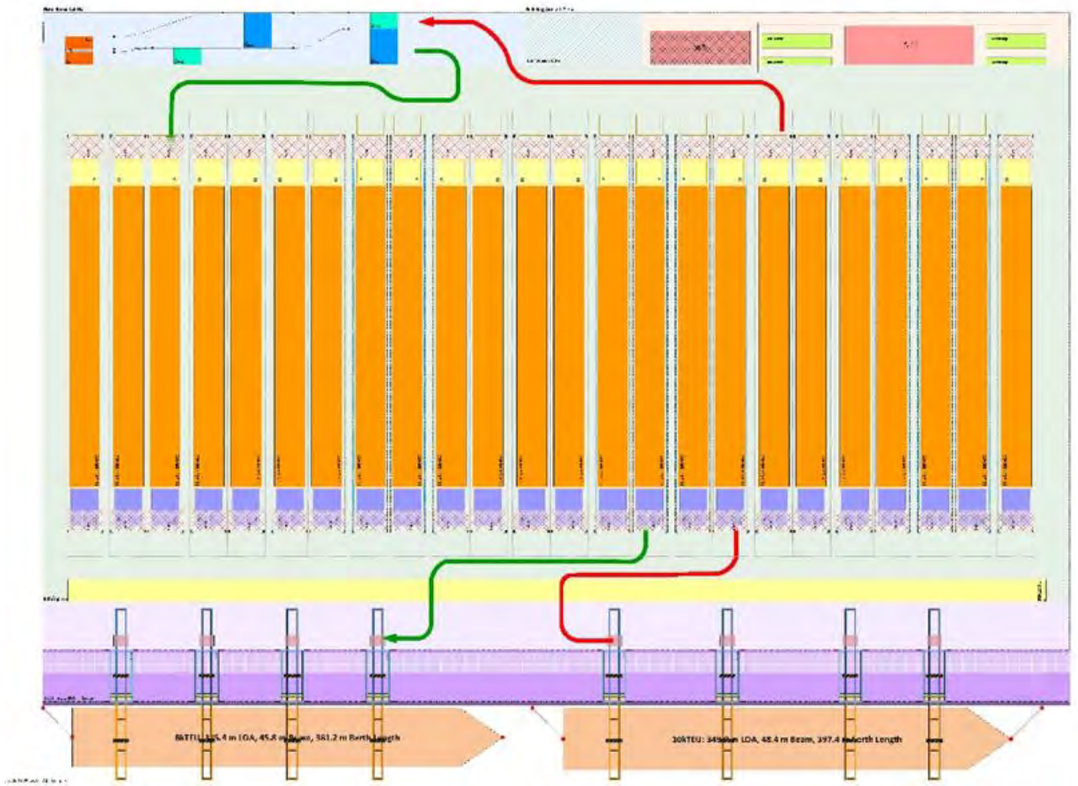
- **4 main transaction interfaces**
  - Vessel/quay
  - Quay/container yard
  - Container yard/gate
  - Container yard/rail
- **Interface productivity goals = adequate equipment fleets**

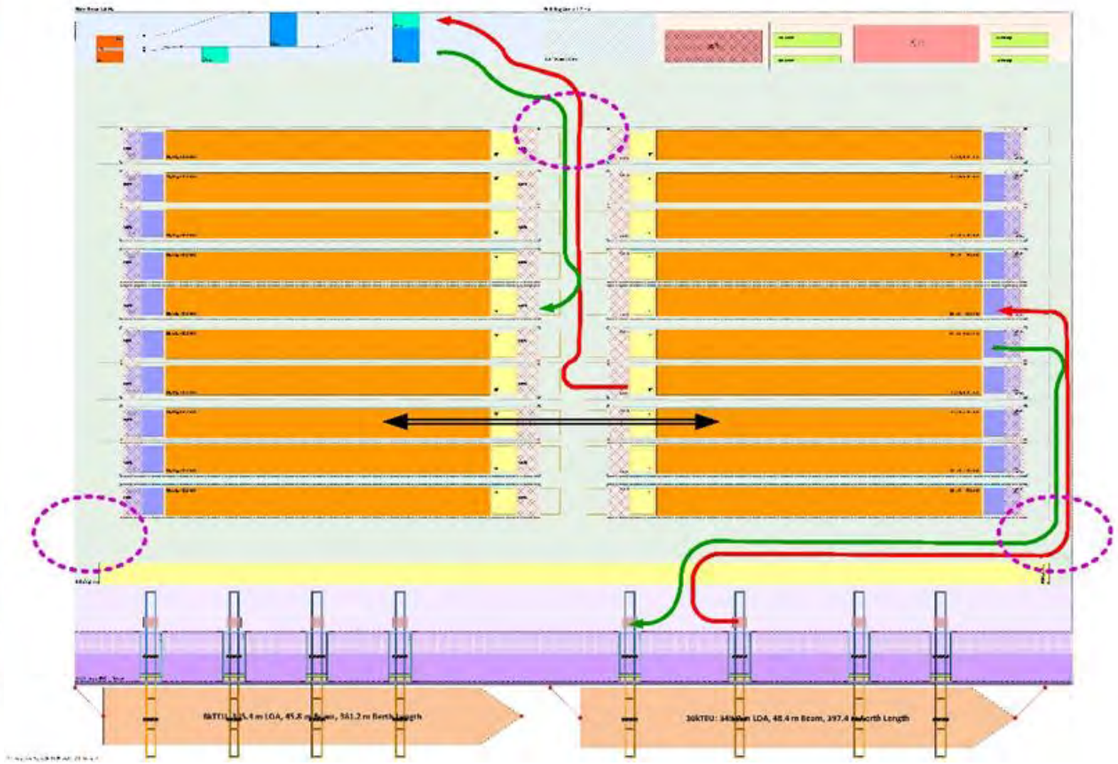
- **Manual**
  - ✓ Dealing with complex/exceptional situations and conflicts
  - X Attention span, stamina, variable skill levels, deployment constaints
- **Automated**
  - ✓ Overcome human limitations
  - X Less flexible, exceptions/conflicts, ‘intelligent’ information processing

4.8 STATIC AND DYNAMIC FLEET ANALYSIS

- **Initially static analysis and empirical comparisons**
- **1 – 2 preferred configurations → dynamic analysis/simulation**
  - Test performance for complex variability of terminal operating environment
- **Appendix D – detailed additional information**

4.9 TERMINAL LAYOUT STRATEGY





- **Perpendicular**
  - Transport moves between waterside block ends and apron only
  - OTR trucks between landside block ends and gate
  - Cranes dedicated to one block

- **Parallel**
  - Transports serve either end of each block
  - OTR may be mixed with transports or in separate aisles
  - Yard cranes can shift between blocks

4.10 PLANNING ISSUES

- **Automated Stacking Cranes**
  - Crane block orientation
  - CTI safety for OTR trucks
  - Door orientation
  - CTI flexibility for yard transport
  - Maintenance locations
- **Automated Strads**
  - Navigation and sensors
  - OTR truck interface
  - STS crane interface
- **Automated Cantilever RMGs**
  - End zones
  - CTI's along the side
  - Landside / waterside segregation
- **Manual Transport**
  - Transaction coordination
  - Transport presence in CTI
  - Driver safety at CTI
  - Anti-jostle systems

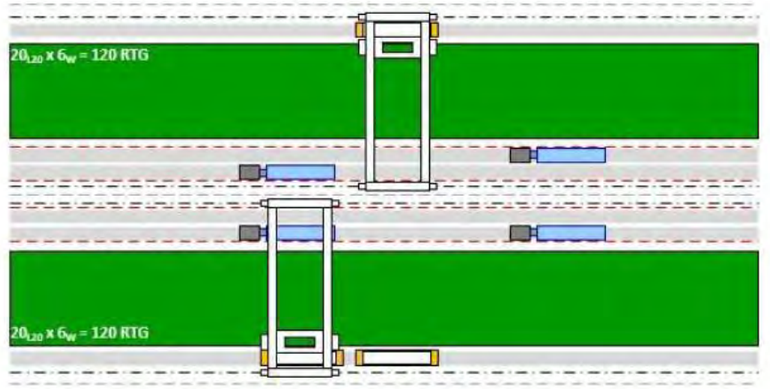


Figure 4-29: Side-Loaded RTG with Separate OTR and AGV Interchanges

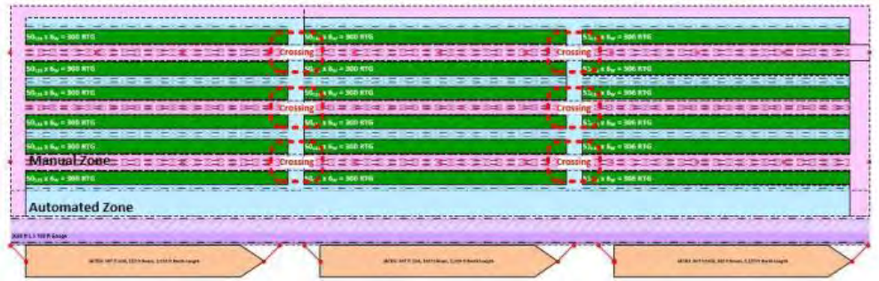


Figure 4-30: Side-Loaded RTG with Separate OTR and AGV Circulation

- **Automated Transport**
  - Separation from manual transport
  - CTI buffer spaces
- **Automated RTGs**
  - End-loaded vs. side-loaded
  - CTI safety for OTR trucks
  - Separation of manual and automated transport

4.11 SELECTION FINAL PLANS

- **Business case goals**
  - Technology and Performance: capacity, productivity, balance, flexibility, and efficiency
  - Capital Costs: infrastructure, equipment, systems, lost revenue
  - Operating Costs: labor, management, energy, parts, supplies, overhead
  - Finance: escalation, cost of capital, development timing, phasing
  - Safety: loss time incidents, catastrophic incidents
  - Environmental Impact: emissions, noise, light, resource disturbance
  - Social Impact: employment, training, displacement
  - Risk: missed milestones, missed performance, missed capacity
- **Consensus on importance of goals important**
  - Core team
  - Mix of quantitative and qualitative assessments

4.12 FINISHING THE PLAN

- **Detailed analysis & refinement**
  - Simulation and emulation
- **Phasing plan**
  - Initial conditions
  - Construction phases
  - Operation phases
  - Capacity and performance
  - Conformity to goals
- **Financial plan**
  - Capital costs
  - Revenue impacts
  - Go-Live transition
  - Operating cost vs. volume
  - Life cycle cost
  - Financial metrics
- **Basis of Design**
  - Infrastructure
  - Equipment performance
  - Operation plan
  - Information and integration
    See Chapter 5
- **Monitoring During Engineering**
  - Ongoing planning team engagement critical

5 - INTEGRATION

5.1 Introduction

5.2 Integration Requirements

5.3 Ship-to-shore Cranes

5.4 Horizontal Transport

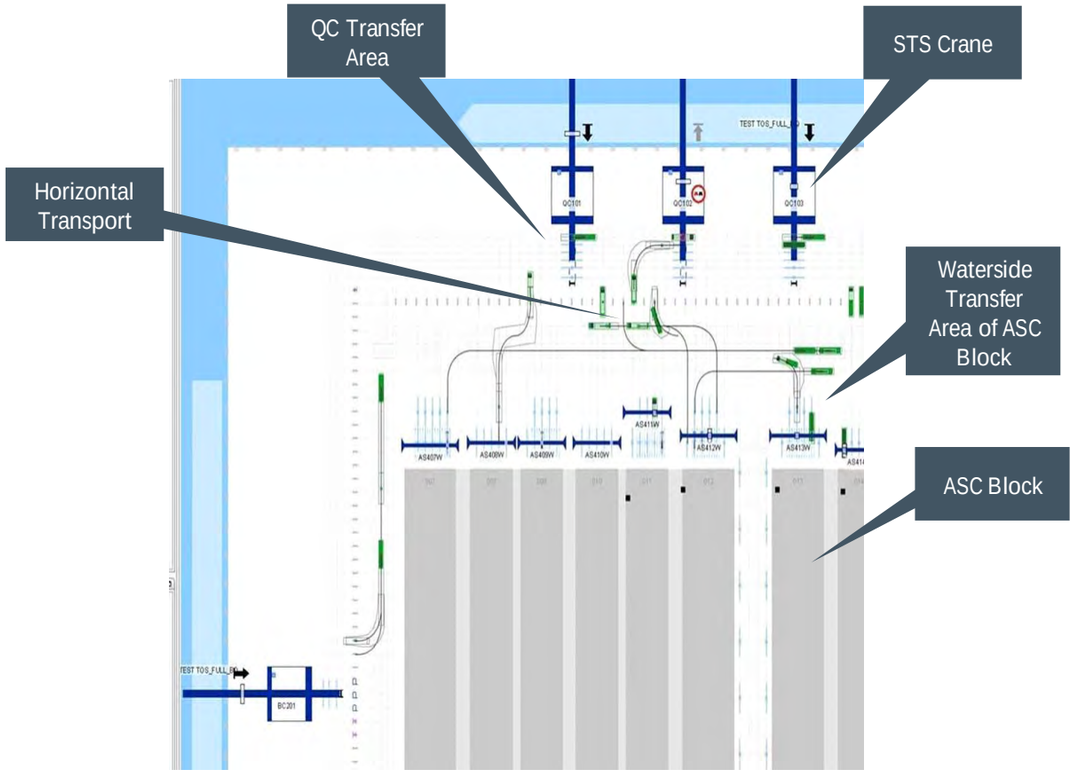
5.5 Storage and Retrieval Cranes

5.6 On-dock Rail Cranes

5.7 Management and Control Systems

5.8 Integration Management

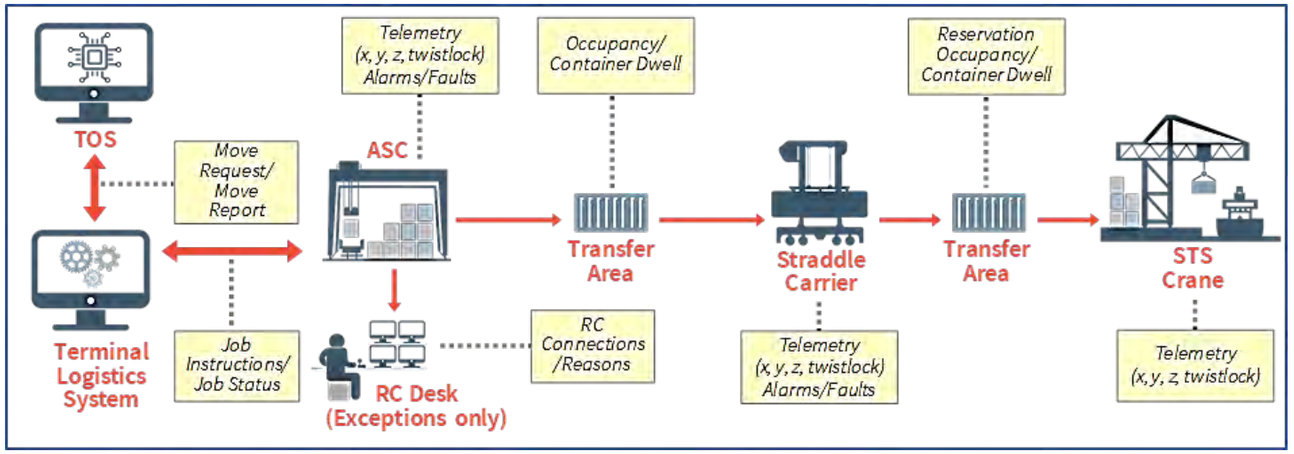
5.1 INTRODUCTION



- **The three most important steps in automation planning are:**
  1. Integration
  2. Integration
  3. Integration
- **It is not enough to buy and install components – they must interact properly**
- **Integration begins at the earliest stage in planning**
- **Integration never really ends**
  - Operations may change
  - Components may change
  - Changes to one part of the system can impact the entire system
- **Specialist expertise**
  - Continuity of roles

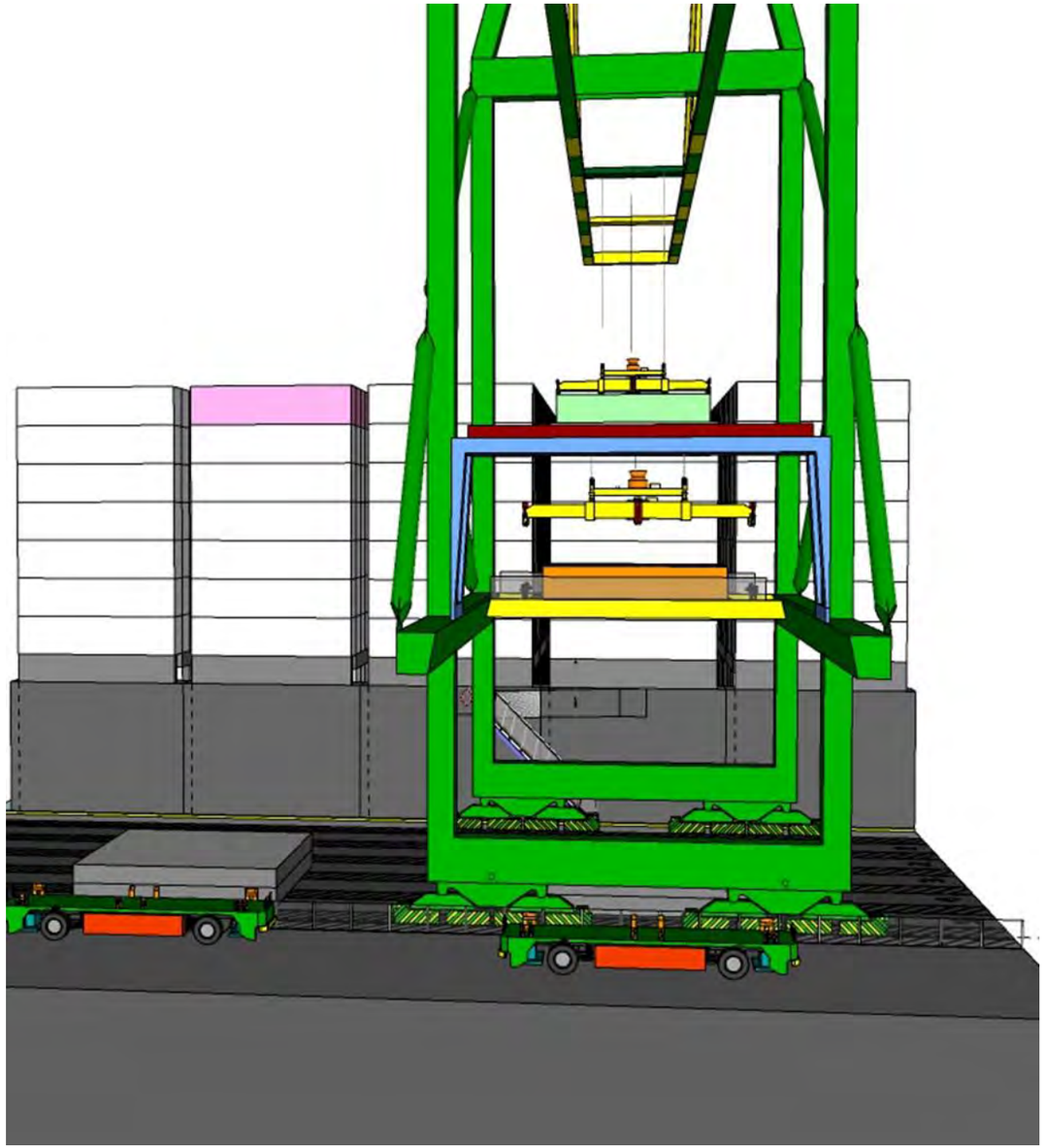
5.2 INTEGRATION REQUIREMENTS

- **Equipment**
  - STS Cranes
  - Horizontal Transports
  - Storage and Retrieval Cranes
  - On-Dock Rail Cranes
- **Civil Infrastructure**
  - Site Instruments
  - Power Supply and Distribution
  - Pavement and Drainage
  - Equipment Foundations
- **Systems**
  - IT Infrastructure
  - Sensors and positioning systems
  - Control & execution management Systems
  - Access Control and Gate Systems
- **Operational processes**
  - Coordinating Terminal Operations
  - Coordinating manual and automated
  - Protecting workers
  - Security and safety systems



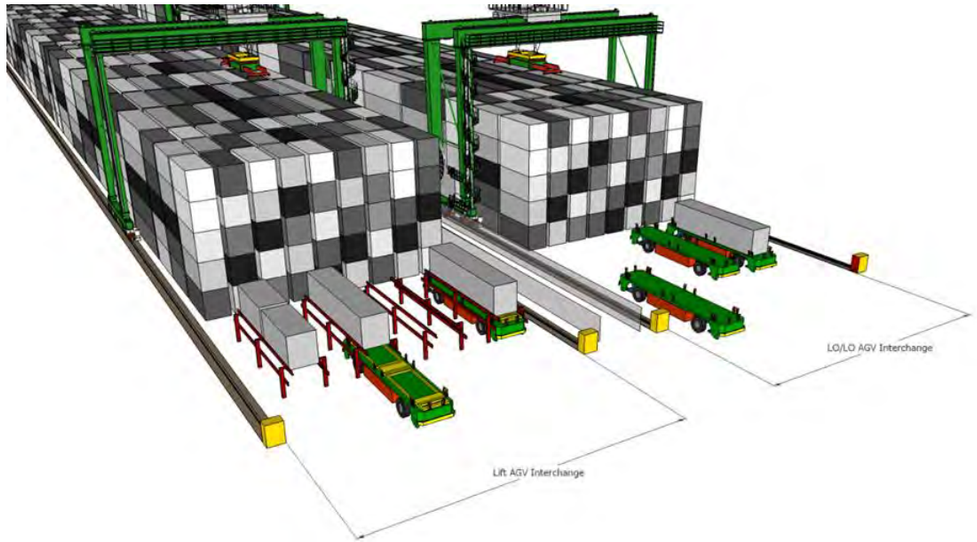
5.3 SHIP-TO-SHORE CRANE

- **Manual operations**
  - Interbox connectors, Out-of-Gauge, hatch lids, gantry movements etc.-
- **Integration:**
  - Crane instruments & Human Machine Interface (HMI)
    - Spreader position, cameras, equipment positions and status, container weights, workers etc.
  - Maintenance control system (MCS)
  - Fiber optic cable
  - TOS, ECS
  - Terminal maintenance
  - Worker protection
- **Operations**
  - Container identification, ISO code, door orientation, transfer area access, transfer lane availability, worker and operator access etc.



5.4 HORIZONTAL TRANSPORT

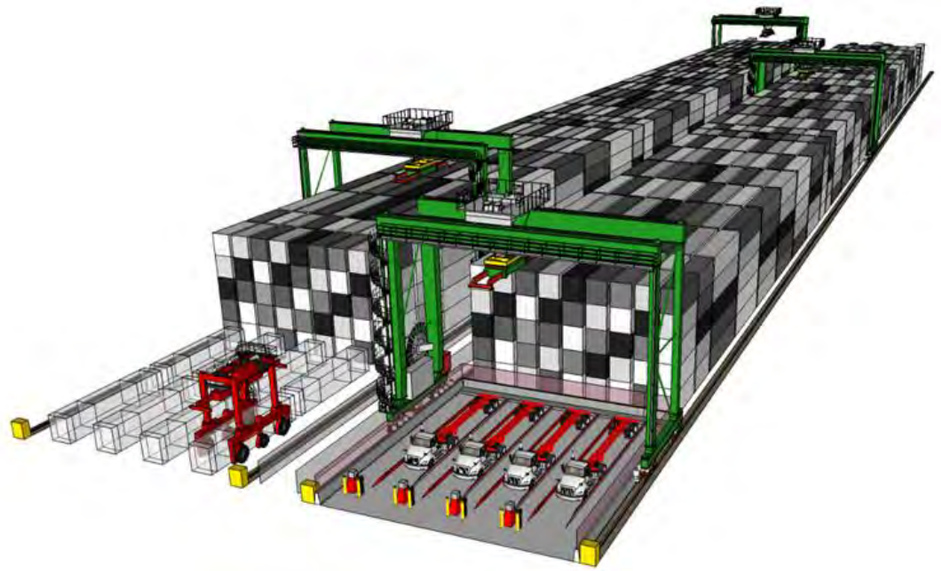
- **Automated Guided Vehicles**
- **Automated Shuttle Transports**
- **Civil infrastructure**
  - Navigation markers,
  - Refueling and/or battery recharge / replacement
  - Travel path concentration on pavement
  - Maintenance shop access
  - Truck exchange with auto shuttles
    - Sensors, RFID, Pedestals, Safety Instruments
- **Transporter instruments**
  - Transponder reading / recognition, obstacle detection, container size/weight
  - GPS / DGPS / Radar
  - Equipment condition
  - Communication – WiFi, 5G? LTE?
- **Equipment Maintenance**
- **Transporter Operations**
  - Container yard map, airlocked areas, reefer storage areas, etc.
- **Equipment Interactions**
  - Destination/transfer lane assignment, geo-zone mapping, routing/location control
- **Worker Protection**
  - Access to manned areas
  - Detection and response to obstacles



5.5 STORAGE AND RETRIEVAL CRANES

- **End-loaded ASCs**
- **Side-loaded CRMGs**
- **RTGs**
- **Civil Infrastructure**
  - Stable runways and stack foundations
  - DGPS
  - Position transponders
  - Interface zone
    - Ground loops, cameras, lasers, RFID, Pedestals, safety instruments
  - Safety fencing
  - Power and fiber optic cable
  - Remote control center
- **Terminal Operations**
  - Inventory updates, storage map, container storage instructions,
  - Housekeeping moves
  - Scheduling and dispatch
  - Equipment maintenance
  - Worker protection
  - Fail-safe exception handling

- **Yard crane instruments**
  - Spreader position, container position
  - Container stack profile
  - Horizontal transporter presence/position
  - Gantry travel position and obstacles
  - Gantry travel obstacles
  - Onboard cameras
  - Twistlock action
  - Container weight
  - Inter-crane detection



5.6 ON-DOCK RAIL CRANES

Automation potential

- Horizontal to/from the rail buffer
- Discharging from/loading to rail cars
- Inventory identification via OCR
- Profiling and rail car positions
- Scanning of import containers

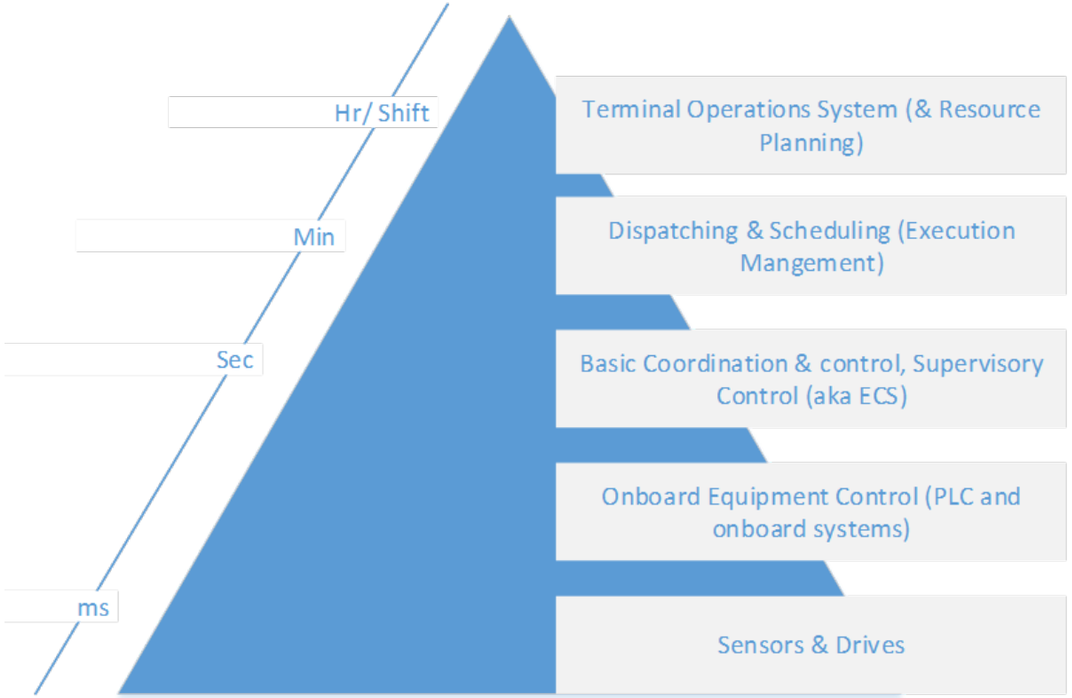
Manual activities

- Hoisting from safe height onto/off of rail car via remote control desk
- Inter-box connectors on double-stack
- Car inspections/switching
- Removal of gensets on reefer containers

Integration elements

- Electronic data interchange (EDI) data
- Car/well identification OCR/RFID
- Car/well positioning sensors
- Car/well configuration data
- TOS
- Rail planning system
- Vessel booking system
- Equipment dispatch system
- Onboard crane control system
- Crane OCR
- Horizontal transport control system
- People tracking system
- Customs system
- Video and RC Desk systems
- Buffer area management system

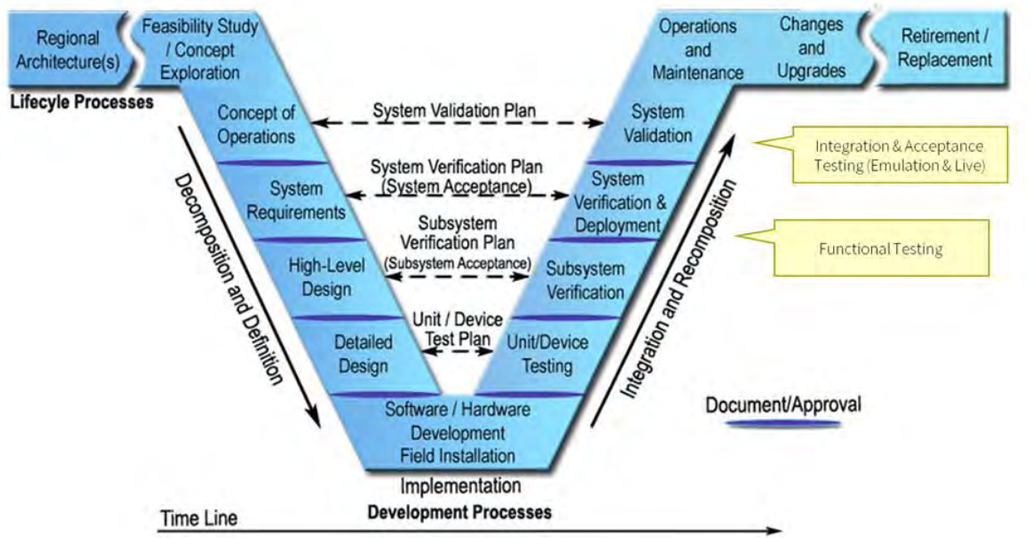
5.7 MANAGEMENT AND CONTROL SYSTEMS



- **Administration and planning**
  - Booking
  - Yard planning
  - Terminal Operating System
  - Gate Operating System
- **Optimization and scheduling**
- **Equipment Control System**
- **Onboard controls – PLCs, PCs**
- **Human machine interfaces**
- **Maintenance systems**
- **External systems?**

5.8 INTEGRATION MANAGEMENT

- Vision, Strategy, Roadmap
- Program Management and Contracting
- Requirements Definition
- Interface Management
- Machine Manufacturing
- System / Software Development
- Equipment Delivery / Installation
- Commissioning
- Integration Testing
- Acceptance Testing
- Training, Go-Live, Handover
- Ramp-up and Evolution



6 - ENGINEERING, IMPLEMENTATION, & OPERATION

6.1 INFRASTRUCTURE AND UTILITY REQUIREMENTS

6.2 TERMINAL CONSTRUCTION

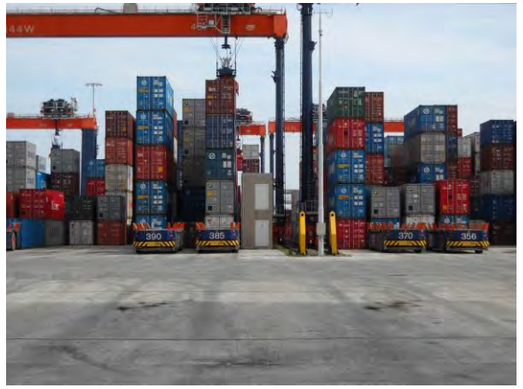
6.3 PROCUREMENT AND DELIVERY STRATEGIES

6.4 OPERATION, MAINTENANCE AND ASSET MANAGEMENT

6.5 SAFETY, SECURITY AND CYBER SECURITY

6.1 INFRASTRUCTURE AND UTILITY REQUIREMENTS

- Principally the same requirements as a manual terminal, “with a twist”
- Pavements need careful consideration due to increased channelization and higher dynamic forces
- The time between maintenance is increased significantly due to high level of interruption
- Limitations on location of in ground services
- Data network requirements much higher in automated terminals both wired and wireless



- Positioning system for mobile equipment
- Electrification of most handling operations putting pressure on power availability and distribution
- Protection of humans from interfacing with automated equipment
- Segregation of yard into smaller segments in case of emergency repairs

6.2 TERMINAL CONSTRUCTION

Be mindful of the potential impact of global pandemics on your ability to carry out equipment testing and commissioning and have a plan in place to deal with this.

Brownfield

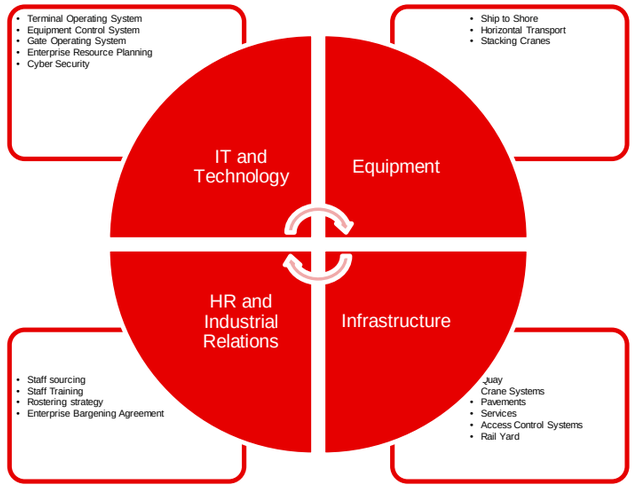
- Interruption to exist operations
- Change of TOS and introduction of ECS
- Land required for construction and laydown
- Reconfiguration of services
- Reconfiguration of equipment maintenance facilities
- Reconfiguration of road and rail interchanges
- Testing and commissioning of equipment
- Training and development of operators and maintenance personnel

Greenfield

- Sequencing of work for optimal outcome
- Laydown areas for equipment delivery, preparation and testing
- Pressure for early handover of completed works to operation
- Source and stability of site wide power supply
- Sourcing suitably skilled and trained operators and maintenance personnel

6.3 PROCUREMENT AND DELIVERY STRATEGIES

- **Procurement is very complex due to wide scope, careful consideration of in-house capability and availability required**
- **Risk profile of various delivery strategies is very different, pick one that suits your organization**
- **Very different skillset to procurement for an operating terminal**
- **Three typical procurement models:**
  - Turnkey
  - Base Civil and Operator Civil & Equipment
  - Multiple Contract



Multi Contract Procurement	• Large owners/developers/operators team required, must be agile • High Risk delivery due to interface issues between various contracts • High level of control over each contract and its deliverables • Extensive interface resolution required by owners/developers/operators team
Turnkey Procurement	• Relatively small owners/developers/operators team • Low risk delivery • Minimum control over each contract and its deliverables

6.4 OPERATION, MAINTENANCE AND ASSET MANAGEMENT

Operational Planning

- Detailed planning of operational & maintenance processes to inform design – terminal and organization

Staffing & Training

- Workforce profile
- Shift from manual to digital mindset
- Identifying new skills and deliver training
- Preparing customers and external parties

Go-Live and Ramp Up

- Plan for the transition
- Risk Management
- Commercial and customer strategy

Maintenance

- New technologies require a specialized skill set
- New processes – layout, access, etc
- Equipment operates within defined parameters
  - Less risk of damage vs. less tolerance for error
  - More pre-emptive vs reactive
  - Equipment is monitored through digital rather than by operator

Asset Management

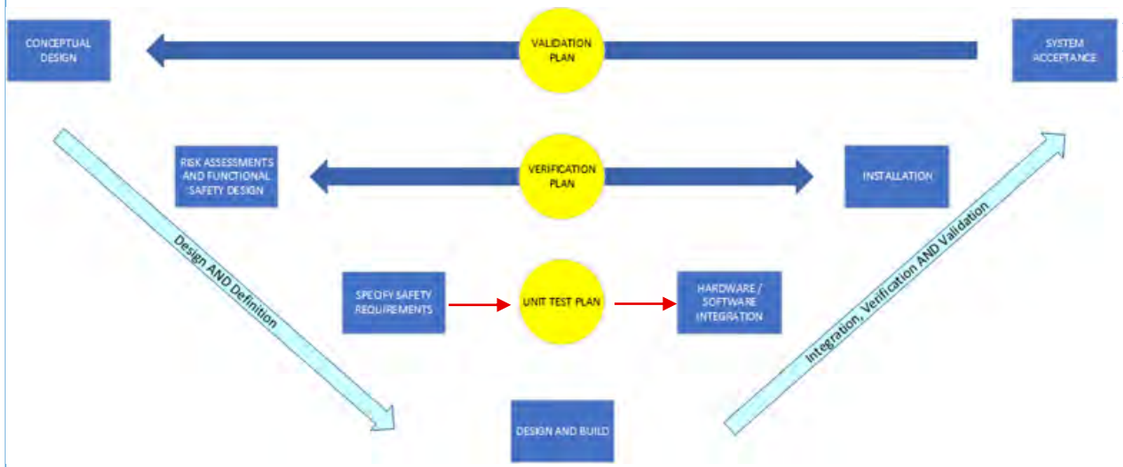
- New possibilities using Integrated Data and Analytics
- Digital Toolkit and skills needed to utilise
- Empower the shift from reactive/planned to predictive

6.5 SAFETY, SECURITY AND CYBER SECURITY

Safety

Automated environments offer significant opportunity to improve safety outcomes by removing people from the hazardous environment.

- New challenges to integrate **functional safety** as part of the overall safety solution.
- Functional safety depends on a system or equipment responding correctly in response to its inputs - shift from training and process to embedded system behaviours
- Design standards – example ISO 13849
- Safety lifecycle activities should be part of design, development, testing and operation



Security

Automated facilities can support security through tighter process control

- SOLAS obligations still apply
- Plan for security provisions during design process

Cyber Security

Defence, against negligent and wilful actions, to protect devices and facilities

- The scale, variety and frequency of cyber attacks is growing rapidly – worldwide and across all industries
- Automated equipment adds another area of vulnerability
- Connectivity and integration of the supply chain must be supported by robust protections

CONCLUSION

- **The port industry is no exception to the global wave of technological innovation - Industry 4.0. brings change**
- **Supply chains are transforming, through digitization and equipment / process automation, to become more capable, connected, efficient and insight-driven.**
  - Significant opportunity in automation – Safety, Productivity, Consistency, Efficiency, Competitive Advantage
  - The decision to automate should be based on a robust business case – the risks are real, costs are high, effort is significant
  - Numerous forms of automated container handling equipment, and the model adopted should be based on delivering clear functional goals and fit-for-purpose
  - Holistic planning is vital, and expertise is important. Multiple aspects of terminal design to consider in addition to the container handling equipment
  - Plan and test (a lot!) – successful integration is a critical factor. Automation requires precision
  - Organizations must be readied to operate automated facilities – not as simple as “plug an play”. Significant impacts to process, personnel, customers and other stakeholders – change management is important