American Association of Port Authorities

Alliance of the Ports of Canada, the Caribbean, Latin America and the United States

PLANNING, DESIGN, and REALIZATION OF AUTOMATED TERMINALS

Ashebir Jacob P.E.

Senior Port Engineer / Vice President

moffatt & nichol

Creative People, Practical Solutions.®

Moffatt & Nichol

- Founded in 1945 in Southern California to serve the U.S. Navy & the evolving port & maritime industries
- 600+ employees w/29 offices (North America, Europe, Latin America, Middle East, Pacific Rim)
- A recognized leader in marine terminal planning, analysis, design & goods movement economics

Services for Development of Automated Terminal Matrix

Services	Moffatt & Nichol	Typical Simulation Consultant	Typical Infrastructure Consultant	Typical Equipment Vendor
Master Planning	✓	✓	✓	
Investment Advisory	✓			
Basis of Design	✓		✓	
Simulation	✓	✓		✓
Interface Plan	✓			
Equipment Specifications	✓			✓
IT, Application Specifications	✓			
Design (infrastructure)	✓		✓	
Procurement Process:				
Equipment	✓			✓
IT, Application	✓			
Program Management (infrastructure)	✓		✓	
Contract Management (equipment)	✓			
Emulation	✓	✓		
Training	✓			
Go-Live Support	✓			
Optimization	✓			

The Business Case

E^3

Economical

(meeting the business case)

Efficient

(delivering capacity, speed and reliability at lowest cost)

Environmentally sustainable

(lowest energy consumption)

Planning and Layout – Tailoring to Fit the BC

- So, the planner is like a tailor
- He must try to fashion the terminal to fit the business case perfectly

CAPACITY
- Annual throughput

PRODUCTIVITY
- Vessel
- Gate
- Rail

COST
- Facilities
- Equipment
- Labor
- Energy

- **One size does not fit all!**

Conventional "Bottom-Up" Planning

Operations

Logistics

Equipment

Infrastructure

Traditional

New "Top-Down" Planning

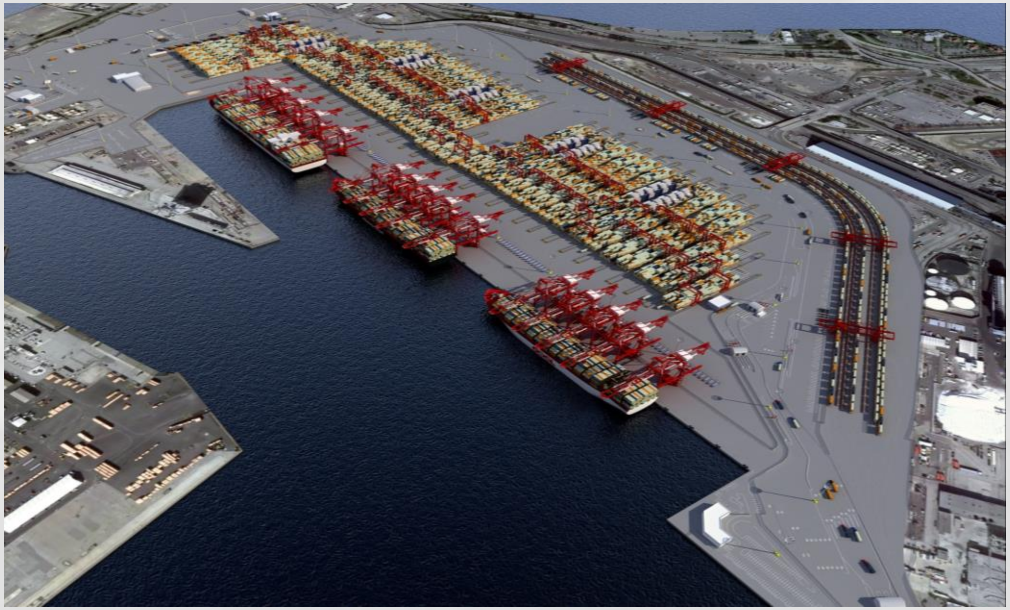
New

Operations

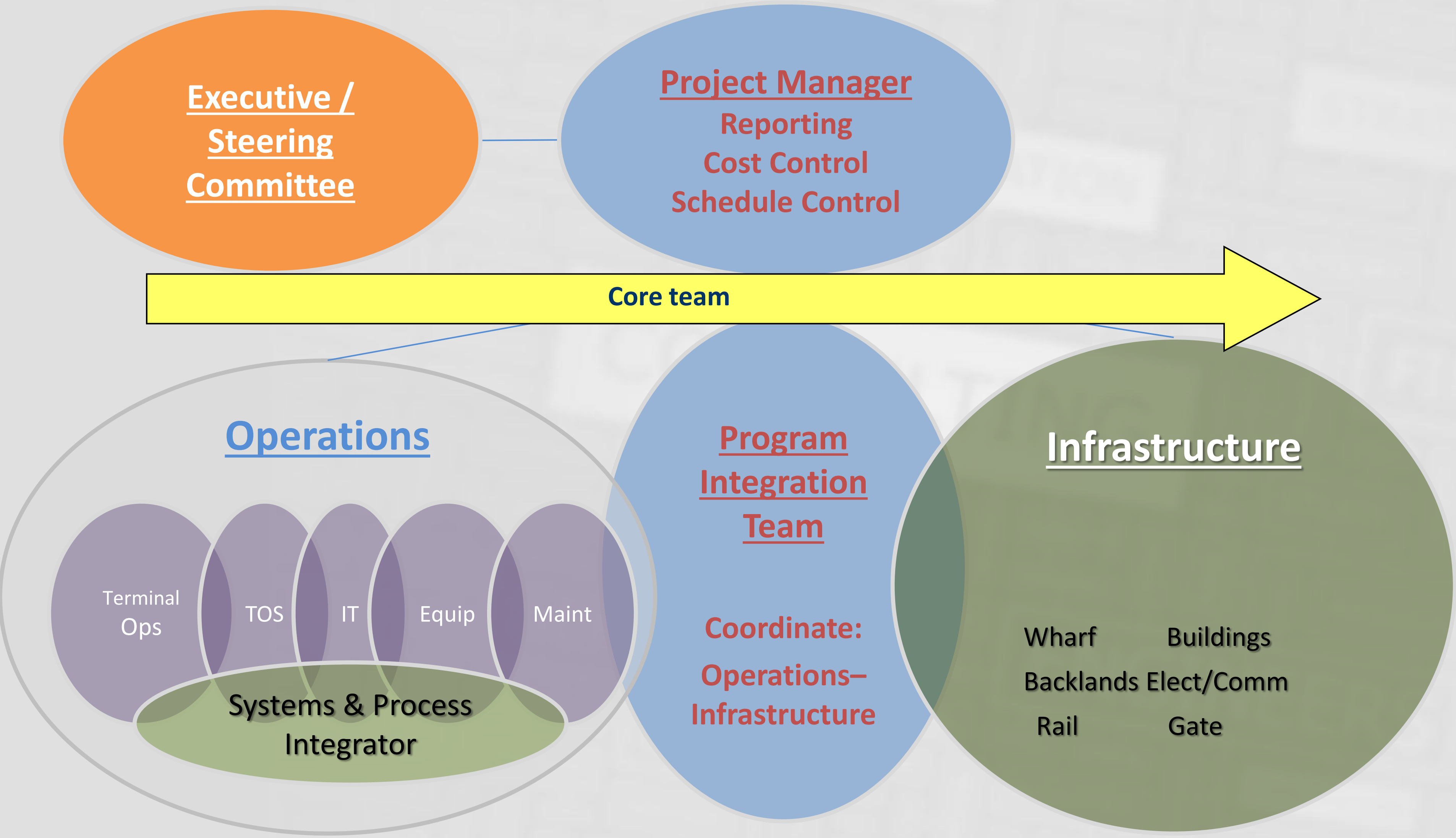
Logistics

Equipment

Infrastructure



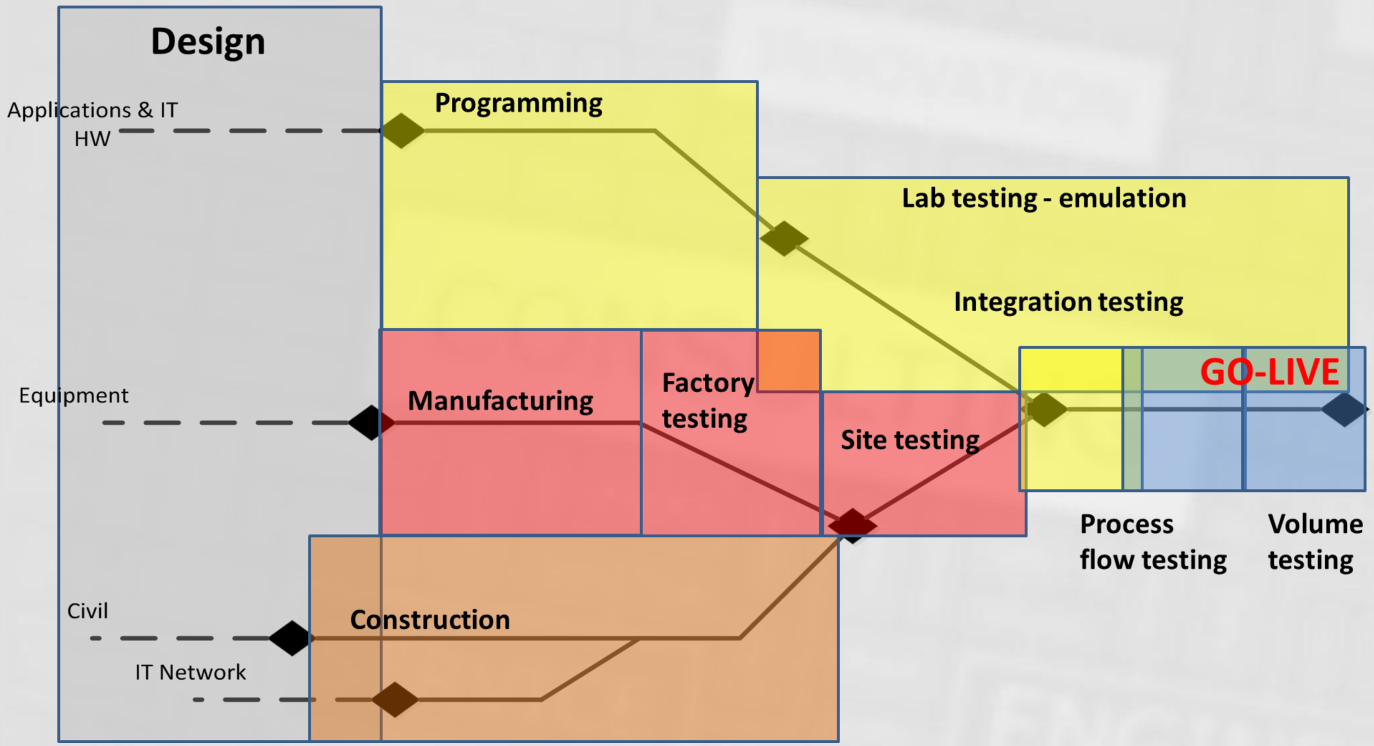
Project Organization?



Development Philosophy

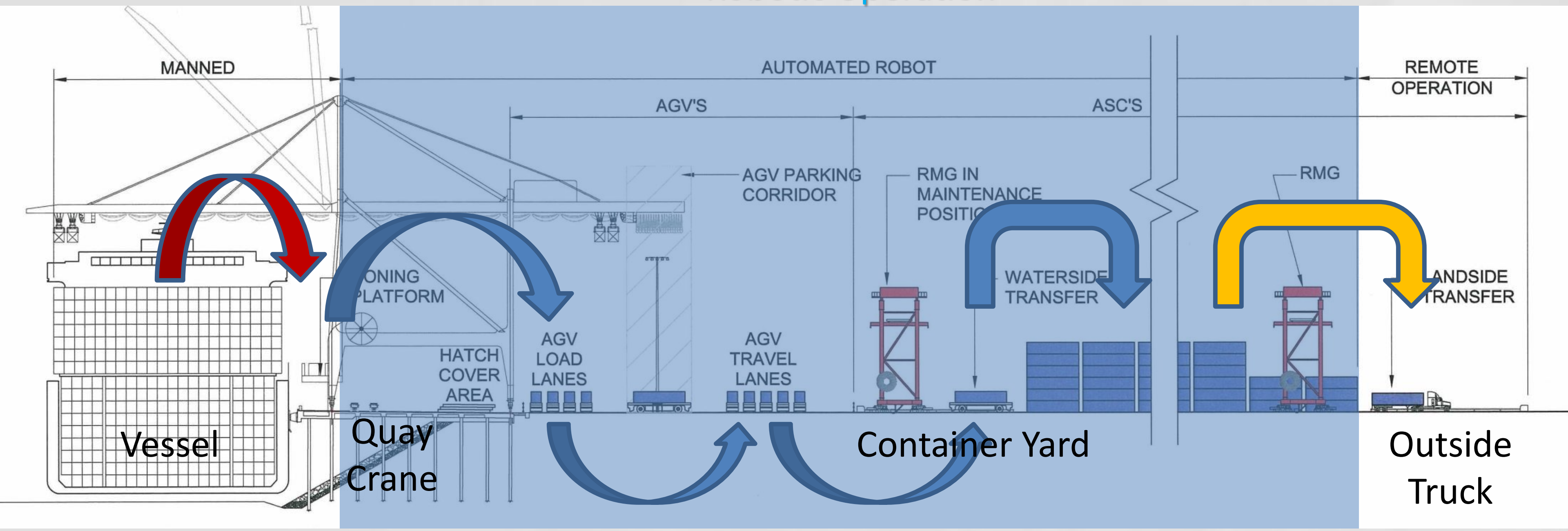
- The infrastructure for an automated terminal is fixed for its economic life
- An automated container terminal will be designed to perform under high utilization
- It is critical to predict performance and operating cost for the life of the infrastructure
- An early preparation of well-integrated, long-term masterplan and development plan is required

Path to Completion is Complex



Wharf

Robotic Operation



Manned Main Trolley

Automated Secondary Trolley

Automated Horizontal Transport AGV's

Automated Container Stacking, Retrieval, Shuffling ASC's

Semi-Automated Delivery to Outside Truck

Wharf Design Issues

Wharf Design Issue

- Quay design load will depend on crane:
  - Gage
  - Back reach
  - Out reach
  - Setback from face of the quay
  - Type of operation (tandem, single, double trolley etc.)
  - Wind and seismic load
  - Crane wharf interaction

Seismic Design Approach

- Performance-based design approach:
  - Operating Level Earthquake (OLE)
  - Contingency Level Earthquake (CLE)
  - Code-Level Design Earthquake (DE)

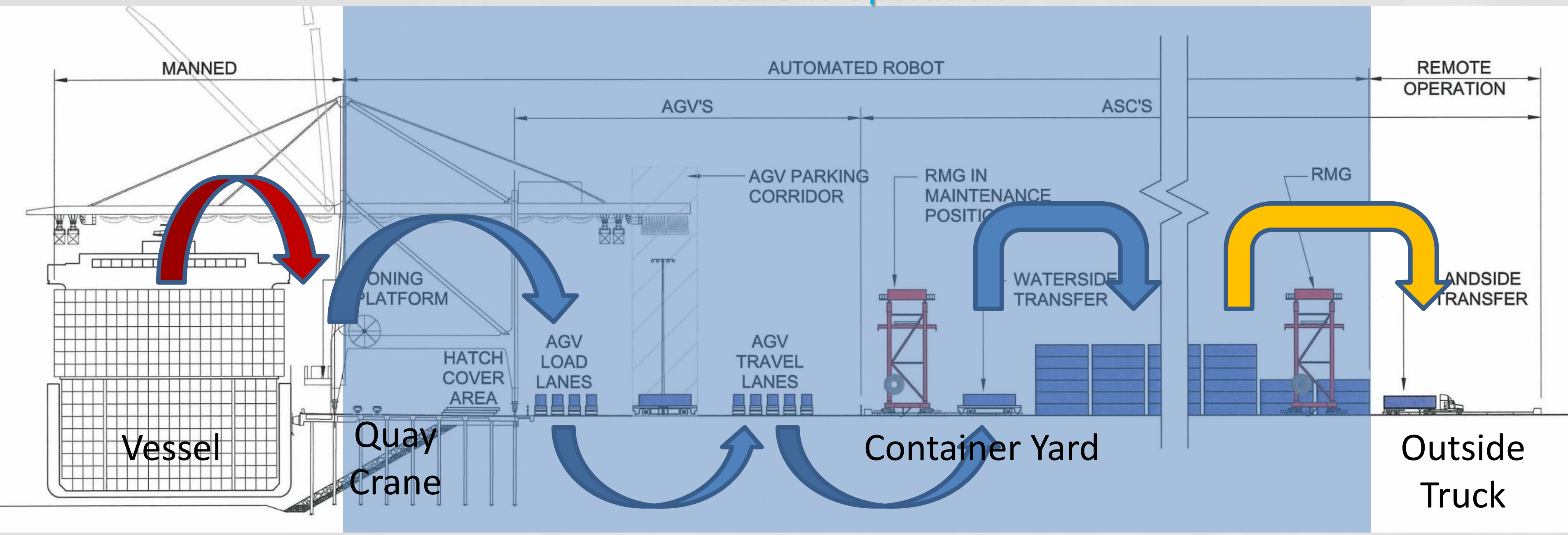
- Performance goals:
  - OLE performance = No damage
  - CLE performance = Repairable damage
  - DE performance = No collapse

Berthing and Mooring Loads

- Berthing Load
  - Design Vessel — 20,000 TEU +
  - Ship Approach Velocity and Angle — 0.26 ft/s , 5^{o}
  - Length Overall (LOA) — 1,300 feet +
  - Maximum Displacement — 254,000 metric tons +
  - Beam — 194 feet
  - Maximum Draft — 50.8 feet
  - Allowable Hull Pressure — 4.13 ksf
- Mooring Load
  - 200 metric ton bollards

Horizontal Transport Area

Robotic Operation



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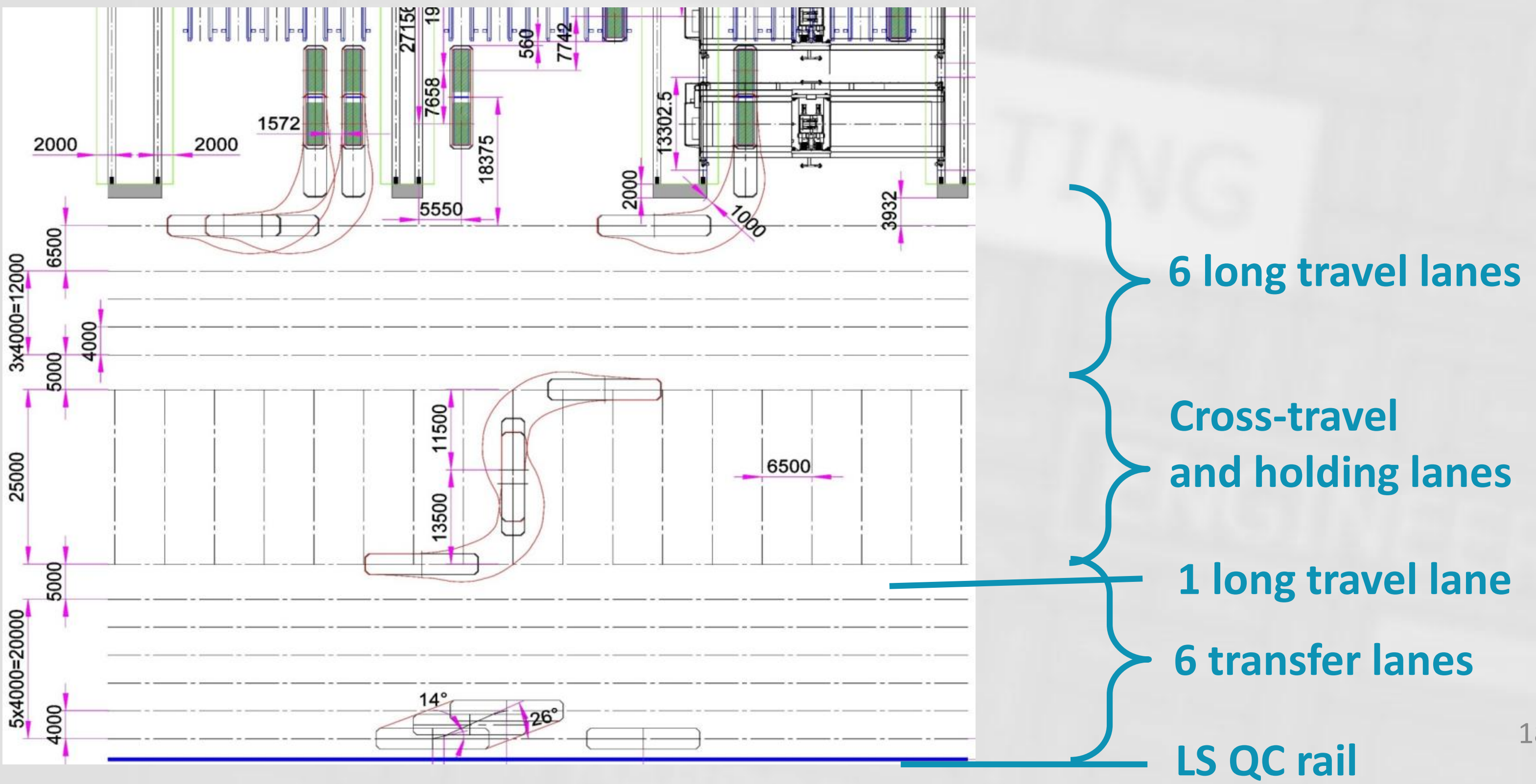
Horizontal Transport

- Gathering and distributing tasks to/from storage
  - Move any box, from any location to any location at any time
- Must be rubber-tired
  - AGV/L-AGV (diesel/ battery operated)
  - AShC/AStraddle (hybrid diesel)

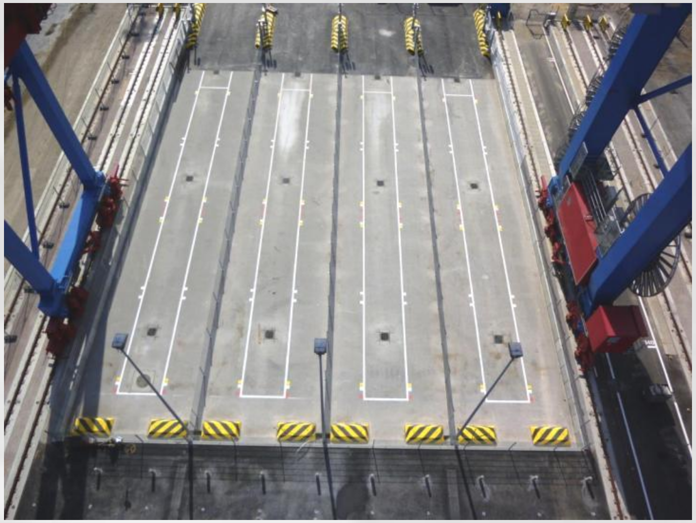
Typical AGV Traffic Layout

- It is important to understand the traffic pattern
- Operationally acceptable grades
- Requirements for systems such as transponders and magnets
- Appropriate position for all above ground structures



WS Transfer Area

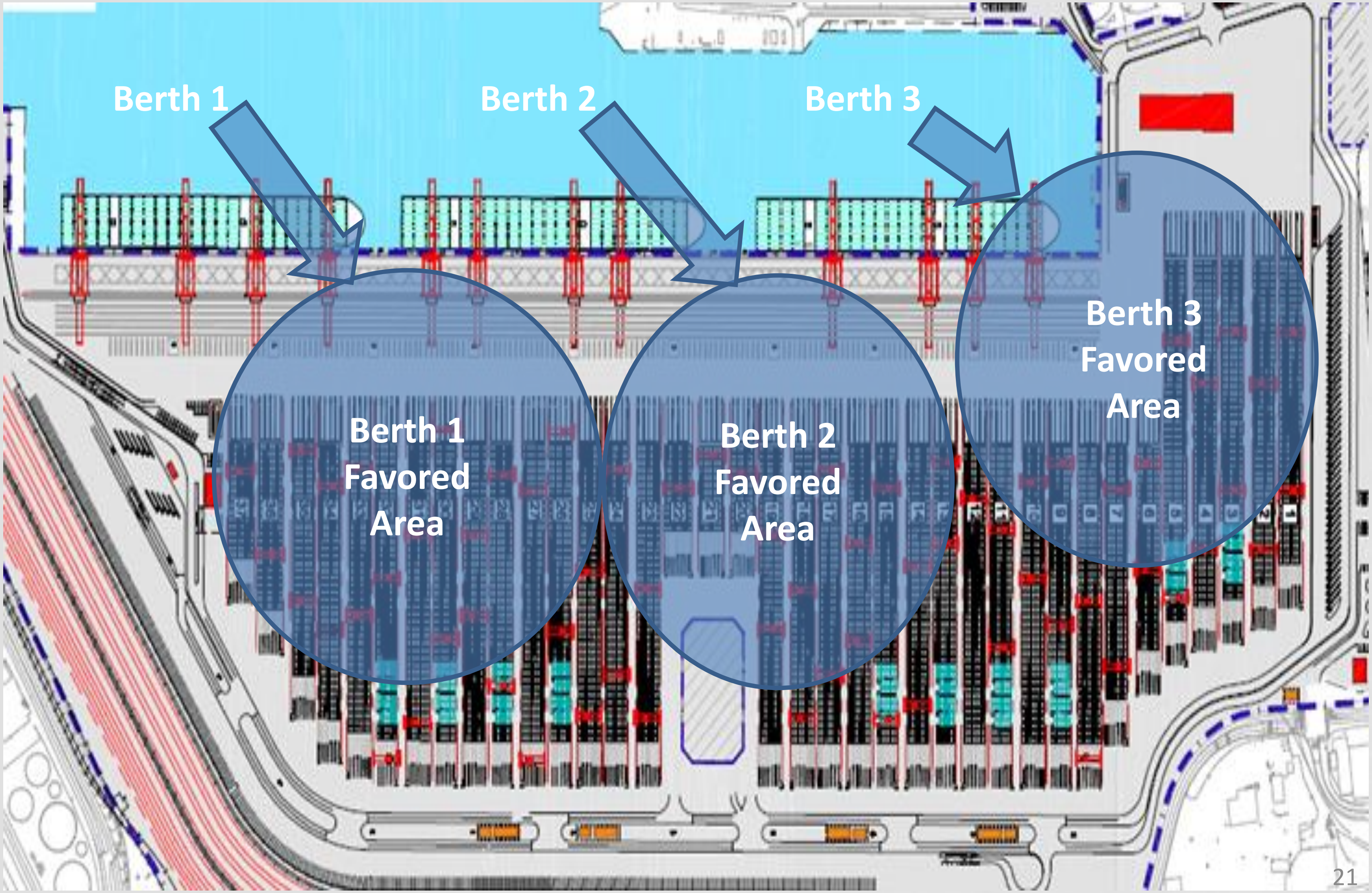
- Understand the operational requirements
- Interface with AGV system
- Interface with ASC control/ safety systems
- Load repetition
- Durability of pavement
- Different solutions for different modes of operation



Pavement Areas

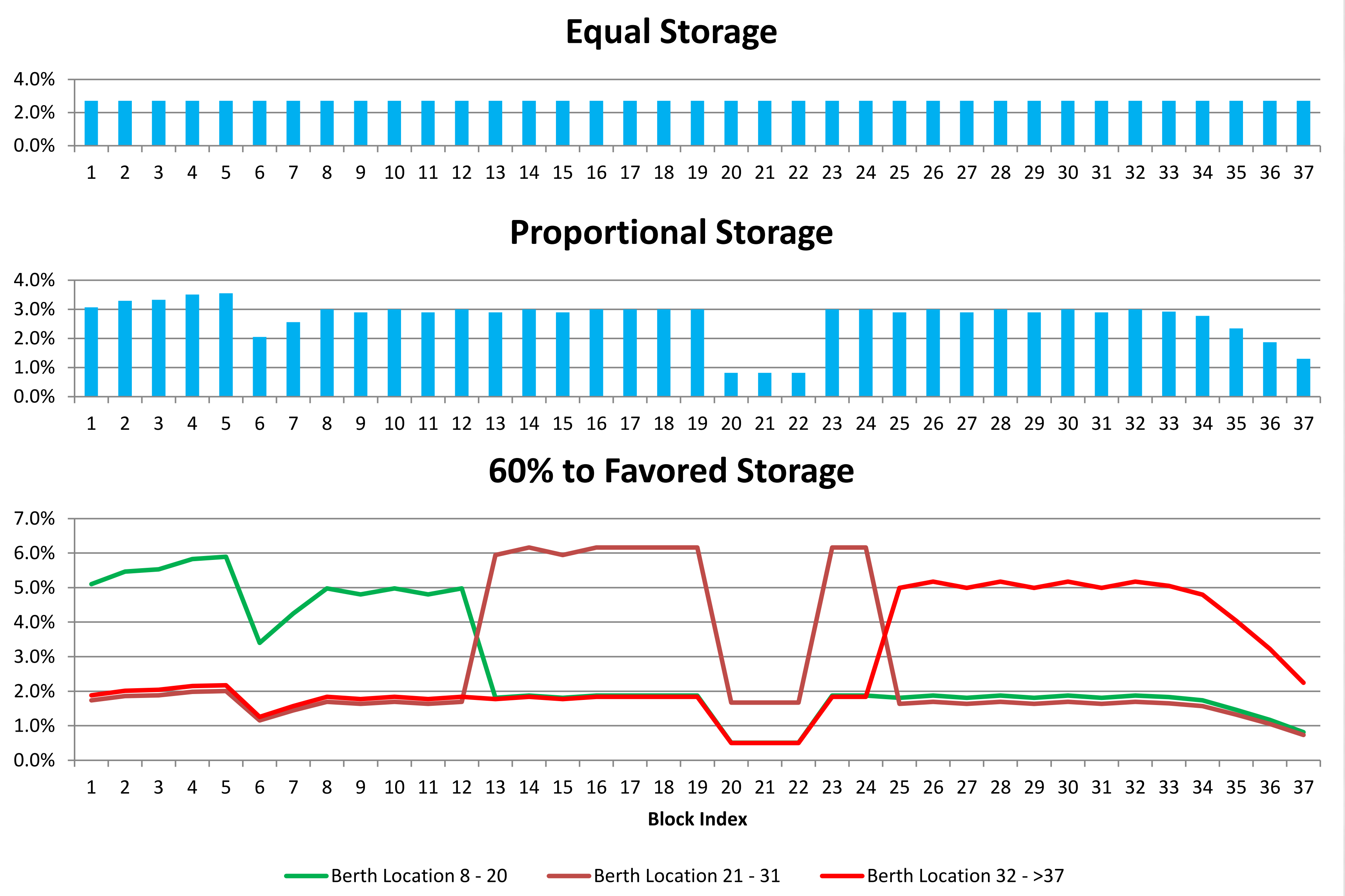
Vehicle / Wheel Load Repetition

Favored Storage Location



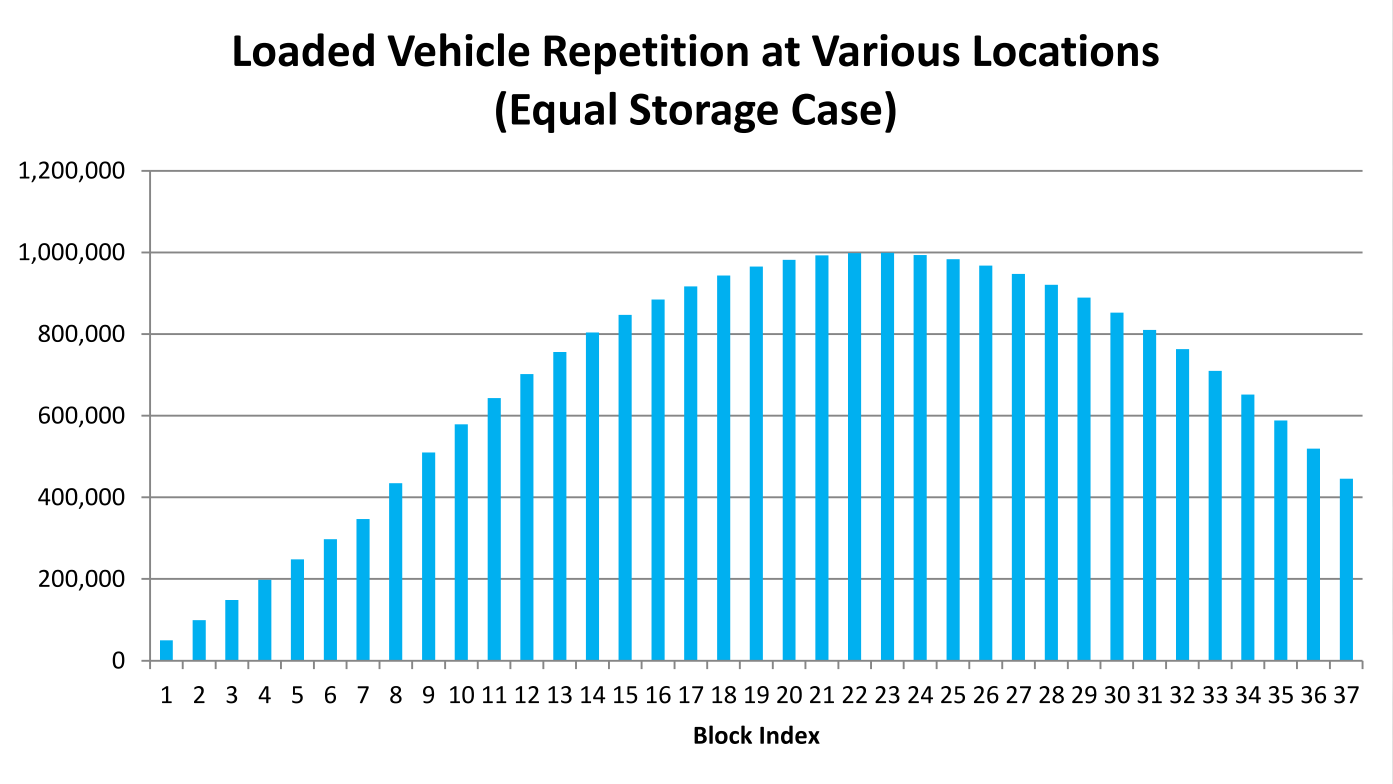
Vehicle / Wheel Load Repetition

Container Location Distribution



Vehicle / Wheel Repetition
Results – Equal Storage Case

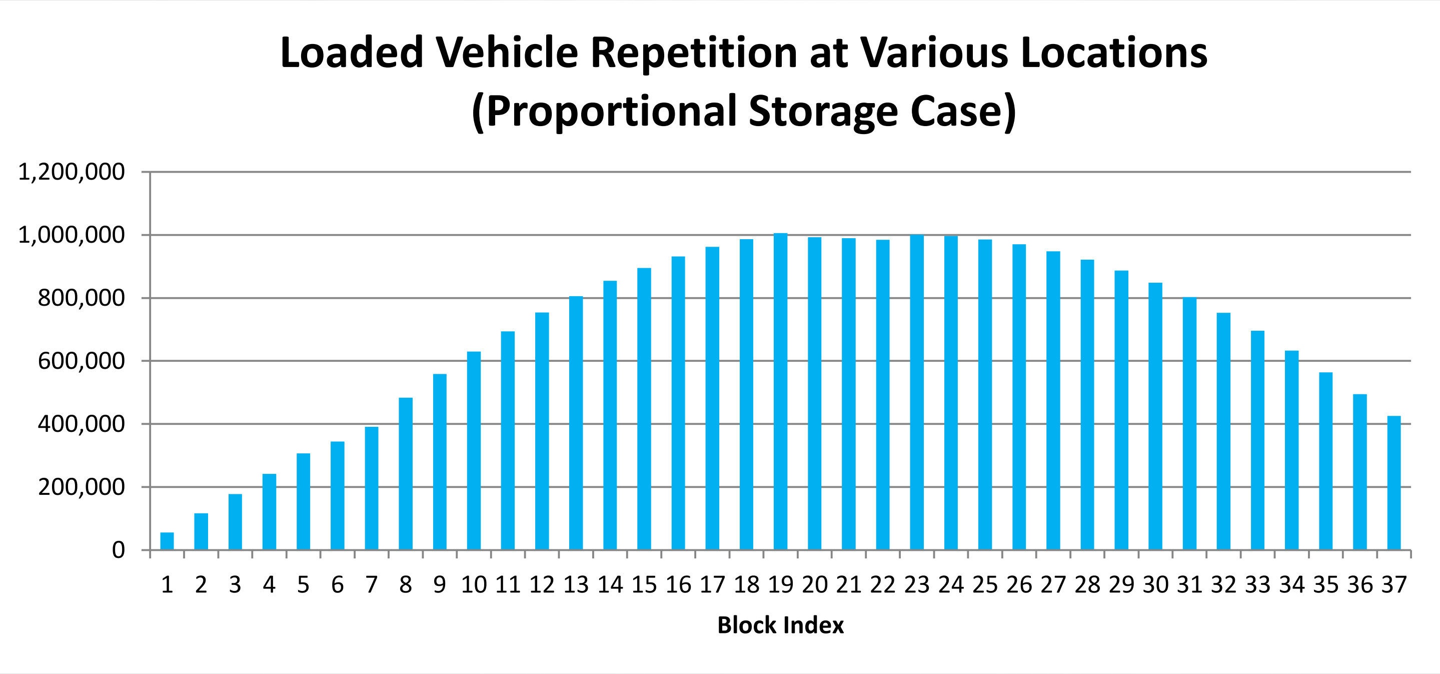
- Max Reps at middle of blocks
- 1M reps ~ 55% of terminal throughput



Vehicle / Wheel Repetition

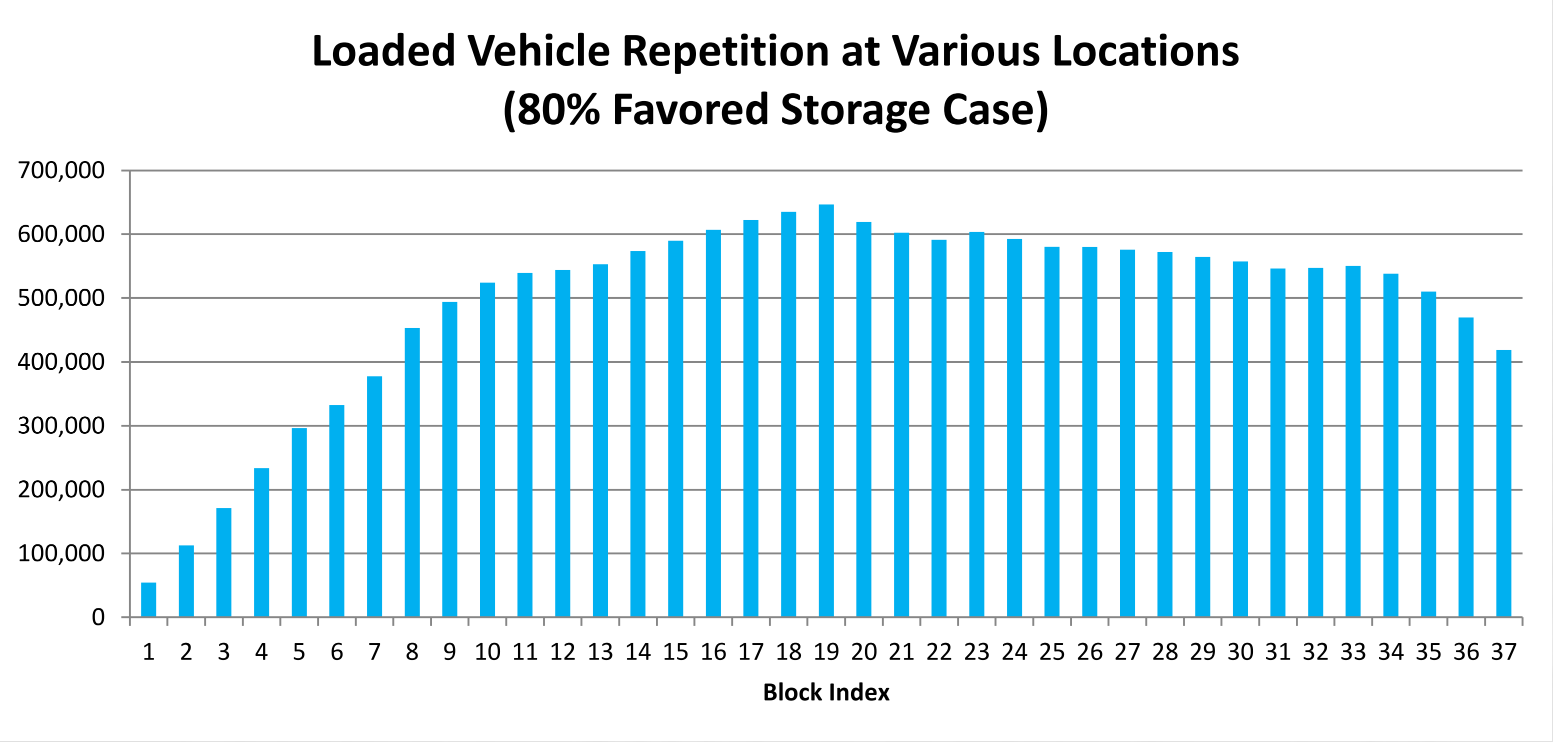
Proportional Storage Case

- Max Reps at middle of blocks
- 1M reps ~ 55% of terminal throughput



Vehicle / Wheel Repetition
Favored Storage Case

- Max Reps flattened and reduced
- 0.65M reps ~ 35% of terminal throughput



Vehicle / Wheel Repetition

Summary of Result

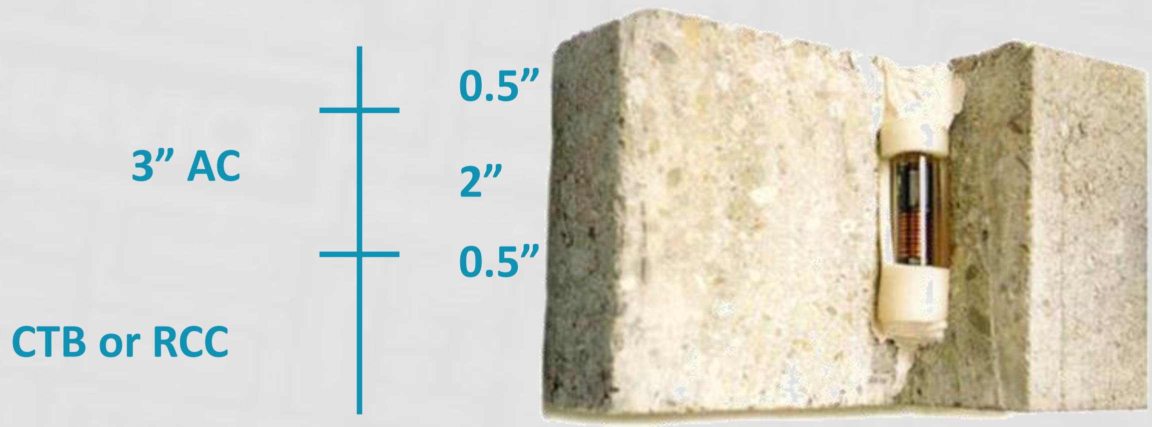
Allocation Assumptions	Equal Storage	Proportional Storage	Favored Storage					**Worst Case**
			40%	50%	60%	70%	80%	
Max Vehicle Repetition (Loaded)	998,746	1,005,520	973,410	891,698	809,986	728,275	646,563	**1,005,520**
Block Location When Max Repetition Takes Place	23	19	19	19	19	19	19	**19**
Percentage of Throughput	54%	55%	53%	49%	44%	40%	35%	55%

Other Pavement Performance Factors

- Performance after Earthquake
  - PCC
    - Significant damage expected during DE
    - Catastrophic failure
    - Will take months to repair
    - Significant impact to operation to replace pavement
  - AC or Paver Block on CTB
    - Some damage during OLE
    - Can be repaired rapidly
      - Overlay AC on top
      - Adjust paver blocks

Other Pavement Performance Factors

- Transponder Installation for AGV
  - App. 20 mm in diameter, 50 mm long (2 inches) glass body sealed with foam cushioning
  - Insert in holes 25 mm in diameter, 80 mm (3 inches) deep, sealed with glue
  - Leaving 0.5 inch gap between transponder and RCC pave for 3-inch AC
- 3-inch AC if rutted, damage on Transponder?

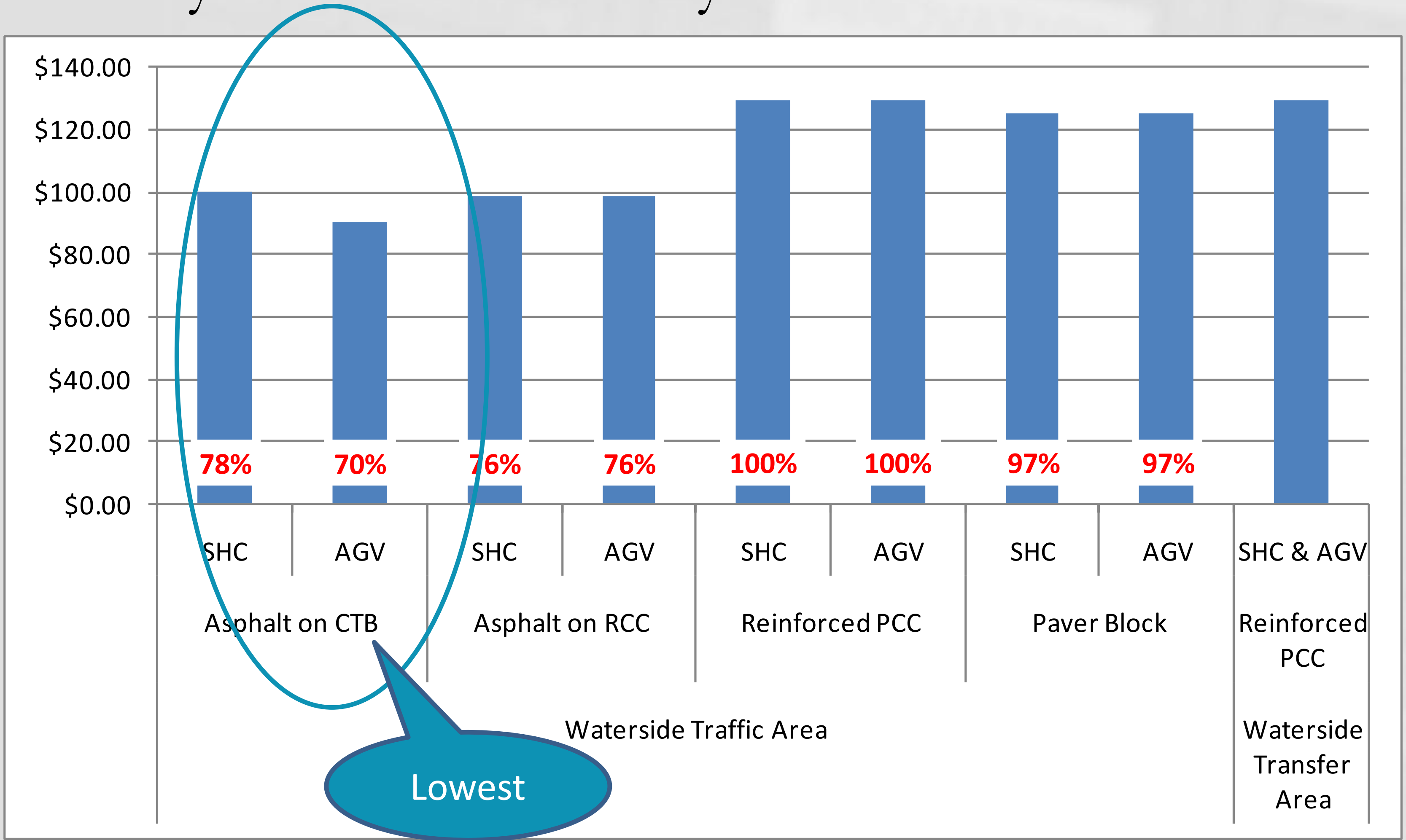


Other Pavement Performance Factors

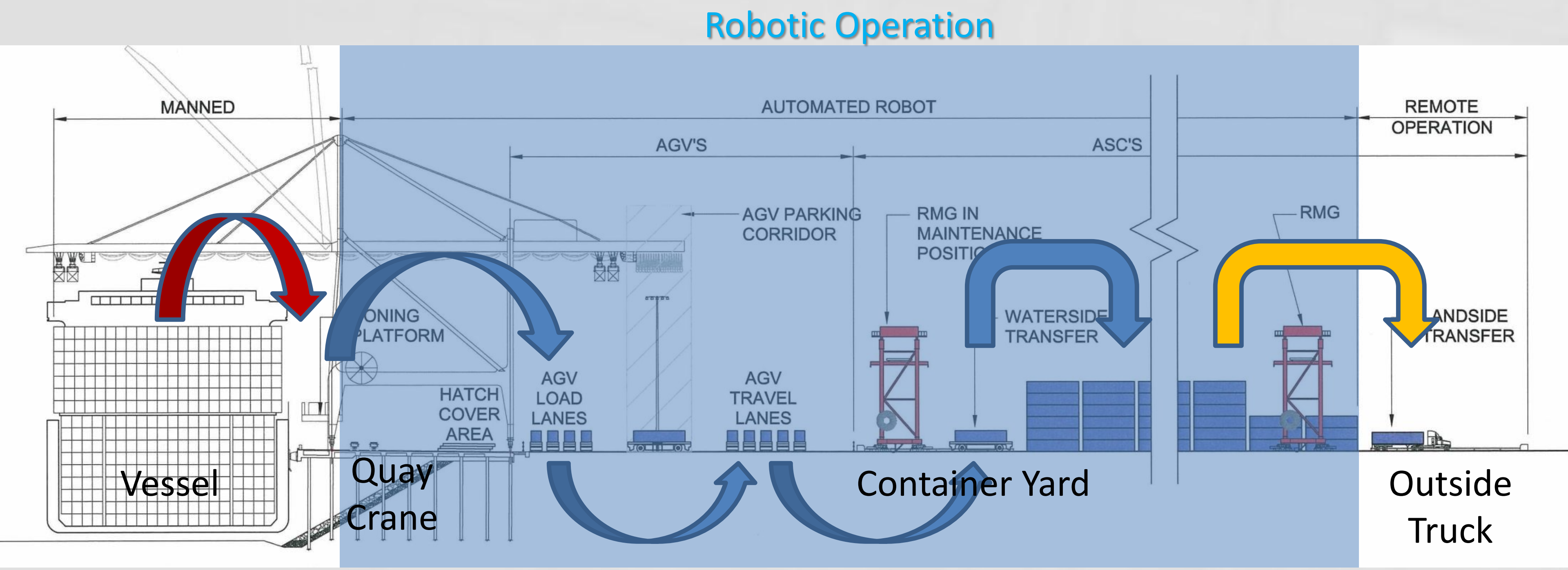
- Rescue of Automated Equipment
  - Typical rescue method for AGV
    - Reach stackers
    - Permanent damage to pavement
  - Alternative rescue method
    - By terminal trucks with "gooseneck"
    - Lighter wheel load

Comparative Cost

- Life Cycle Cost Summary



Automated Stacking Area



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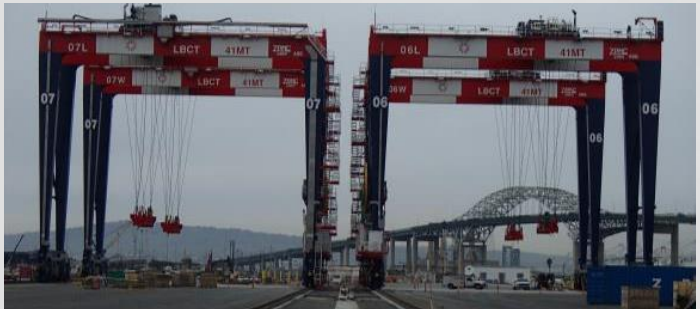
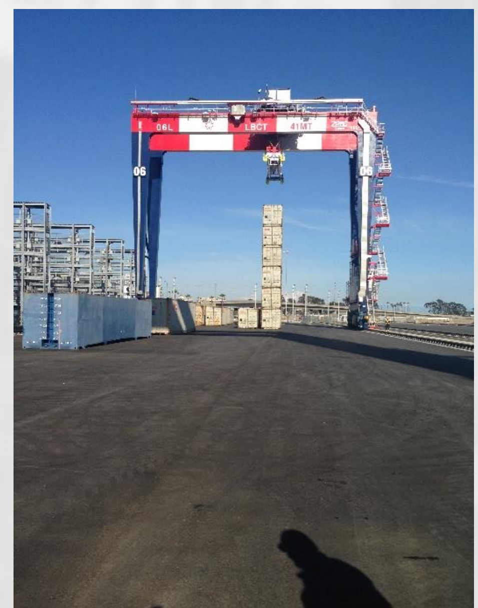
Container yard



- End-loaded stacking/retrieval cranes
- Side-loaded stacking/retrieval with landside transfer cranes



Why Low Tolerance?

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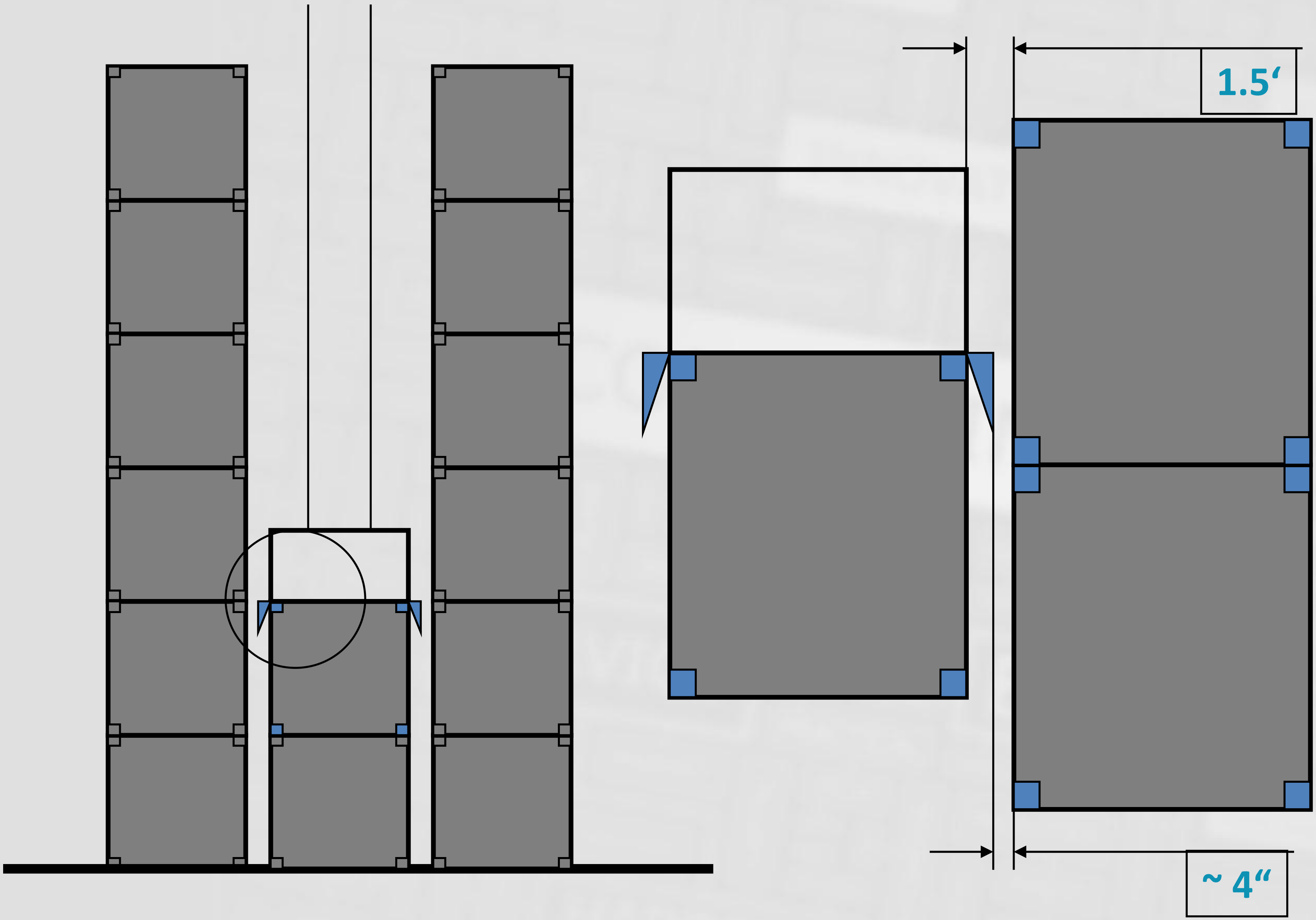


Well Consolidated Landfill

- Critical to minimize total and differential settlements due to:
  - Dynamic loads created by crane operation
  - Stacked container storage
  - Impact loads from container stacks

Drainage

- Stacking area flat and drainable
- Drainage and storm water treatment
  - Design slope that meets operational requirements
  - Comply with local regulation in treating storm water

Other Utilities

- Fresh water supply
- Sanitary sewer
- Light poles (do we need any?)
- Antenna poles
- Camera poles
- Fencing
- X-ray inspection (VACIS)
- Fire protection
- Security systems

Power System

- Redundancy
- 100% fault tolerance
- Reliable
- Location and size of substations, transformer
- Each crane in same stack energized from two independent sources

Design Issues ASC Blocks

- RMG rails and beams
- Reefers
- Hazardous
- Grading and drainage

Reefer Racks

- Clear understanding of operational requirements
- Consider all safety requirements
- Understand the access control and interfaces with crane system
- Comply with building requirements

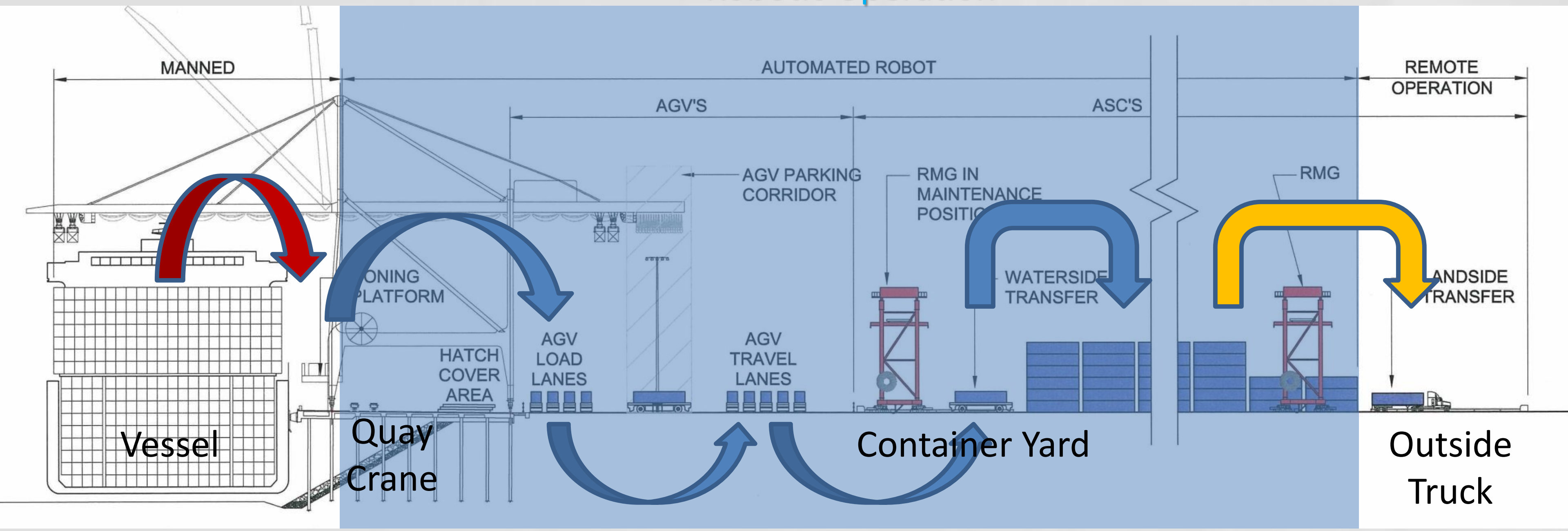

ASC Runway
EVERGREEN


Pre-fabricated Runway Beams

ASC Runway

Land Side Transfer Area

Robotic Operation



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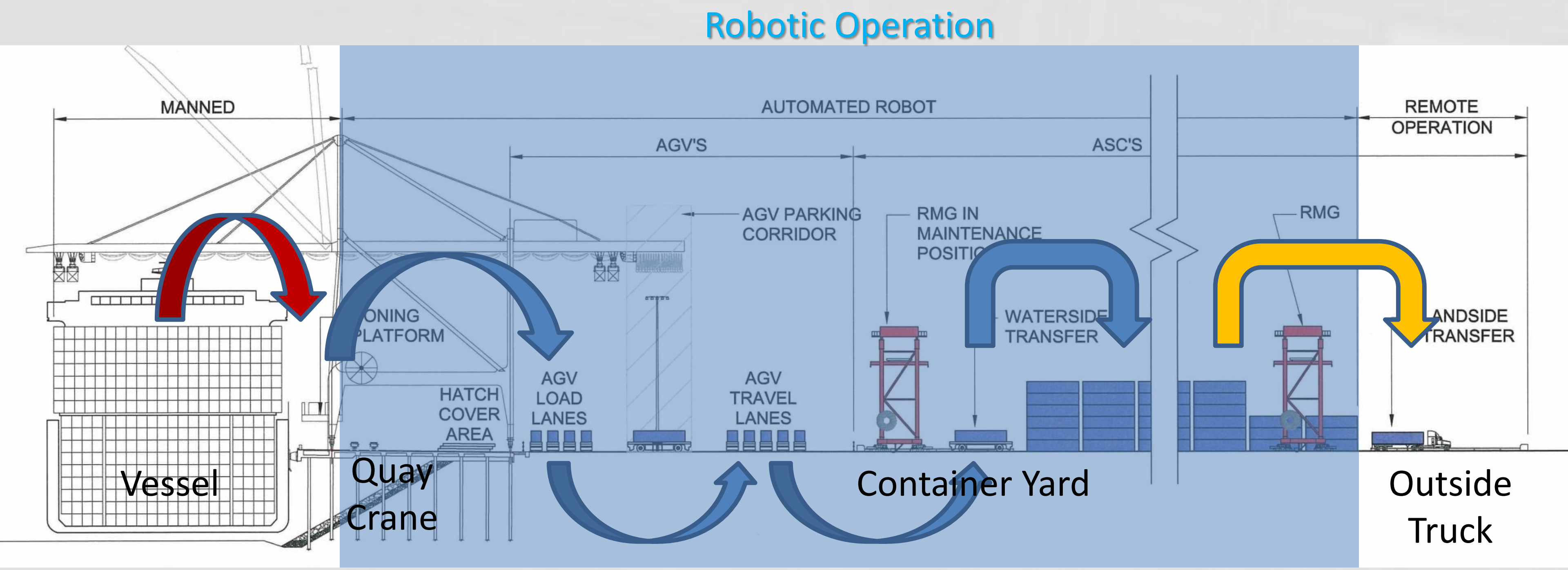
Landside Transfer Area

- Understand the operational requirements
- Interface with gate systems
- Interface with ASC control/ safety systems
- Load repetition
- Durability of pavement

Landside Transfer Area

- Truck maneuvering to the transfer area
- Use island to locate electrical substations and communication hub building

Intermodal Rail Area



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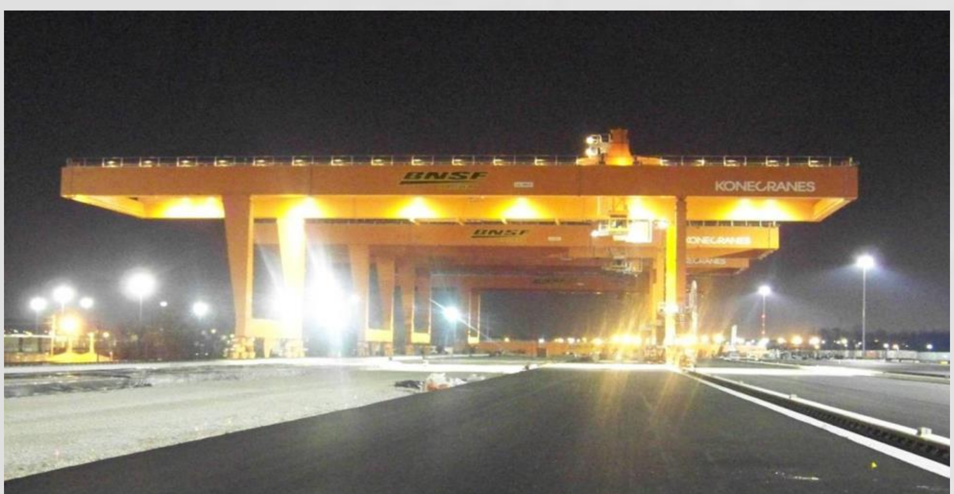
IY Area

- On dock rail
- Designed for efficient rail loading operations
  - Semi-automated remotely operated rail loading cranes
  - Safety fence and gate locations and access control
  - The right crane rail

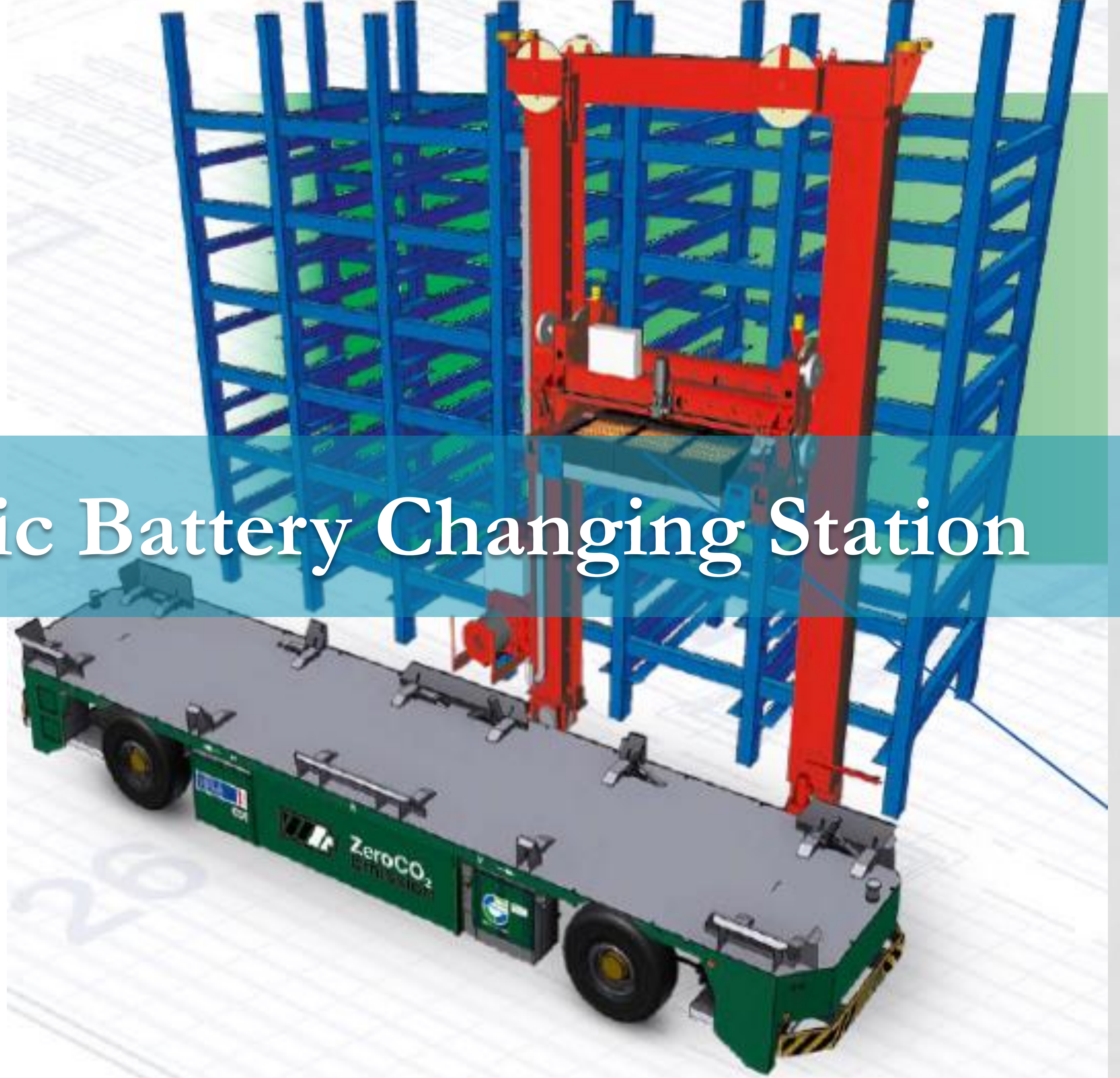


Rail Operation

Buildings

- Gates
  - Highly automated
  - RFID for truck identification
  - OCR
  - TWIC reader for security
  - Truck holding areas
- Administration/Operation/IT
  - House IT systems
  - Remote operator’s room(s)
  - Other operation
- Maintenance
  - Provide sufficient storage for spare parts
  - Almost all electrical equipment
  - Almost all maintenance is performed at the equipment site, not in the workshop
  - Connected to IT systems
  - Location depends on
    - Mode of waterside transport
    - Mode of fueling (battery/diesel)
- Battery Exchange Building

Robotic Battery Changing Station



Example of Operations Control Room

- Orientation
- Windows
- Light
- Noise
- Table space

Integration Management

- An automated terminal is a highly integrated system of components that must fit together perfectly
- The only standard is the container

THIS IS WHERE PROJECTS TYPICALLY SUCCEED OR FAIL

Thank You