AAPA Crane and Terminal Workshop

November 6, 2001 – Oakland, CA

Mechanical / Electrical

Larry Wright & Bob Slater

Mechanical Engineers

McKay International Engineers

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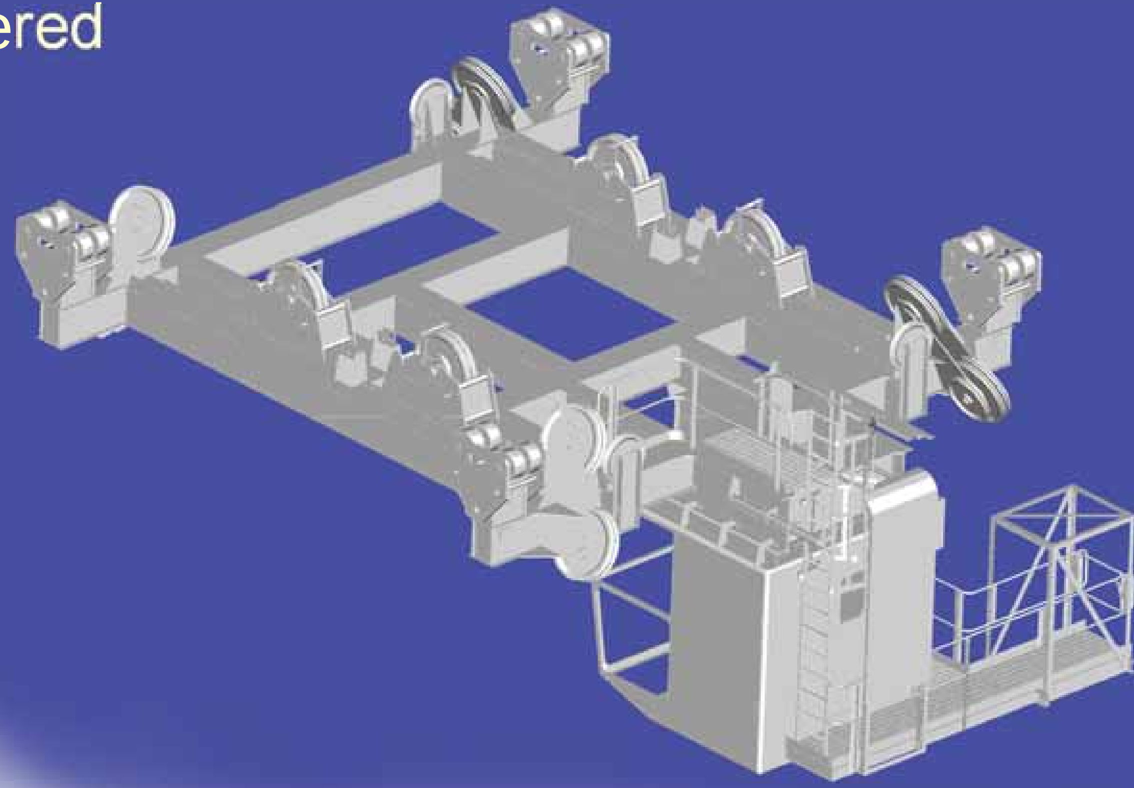
Mechanical / Electrical Topics

- Trolley Types
- Primary Systems
- Drives and Controls
- Power Supply
- Safety Features
- Productivity Enhancements
- Design & Manufacturing
- Component Suppliers

Trolley Types

- Fleet Thru – Rope Towed – Catenary Support Trolleys
- Fleet Thru – Rope Towed – Continuous Catenary Support
- Fleet Thru – Self Powered
- Machinery On Trolley
- Rope Towed
  Machinery On Trolley



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Fleet Thru Rope Towed with Catenary Trolleys

- Catenary trolleys necessary for long spans
- Provides intermediate festoon support
    - Additional sheaves, reeving, tensioners, and trolley machinery

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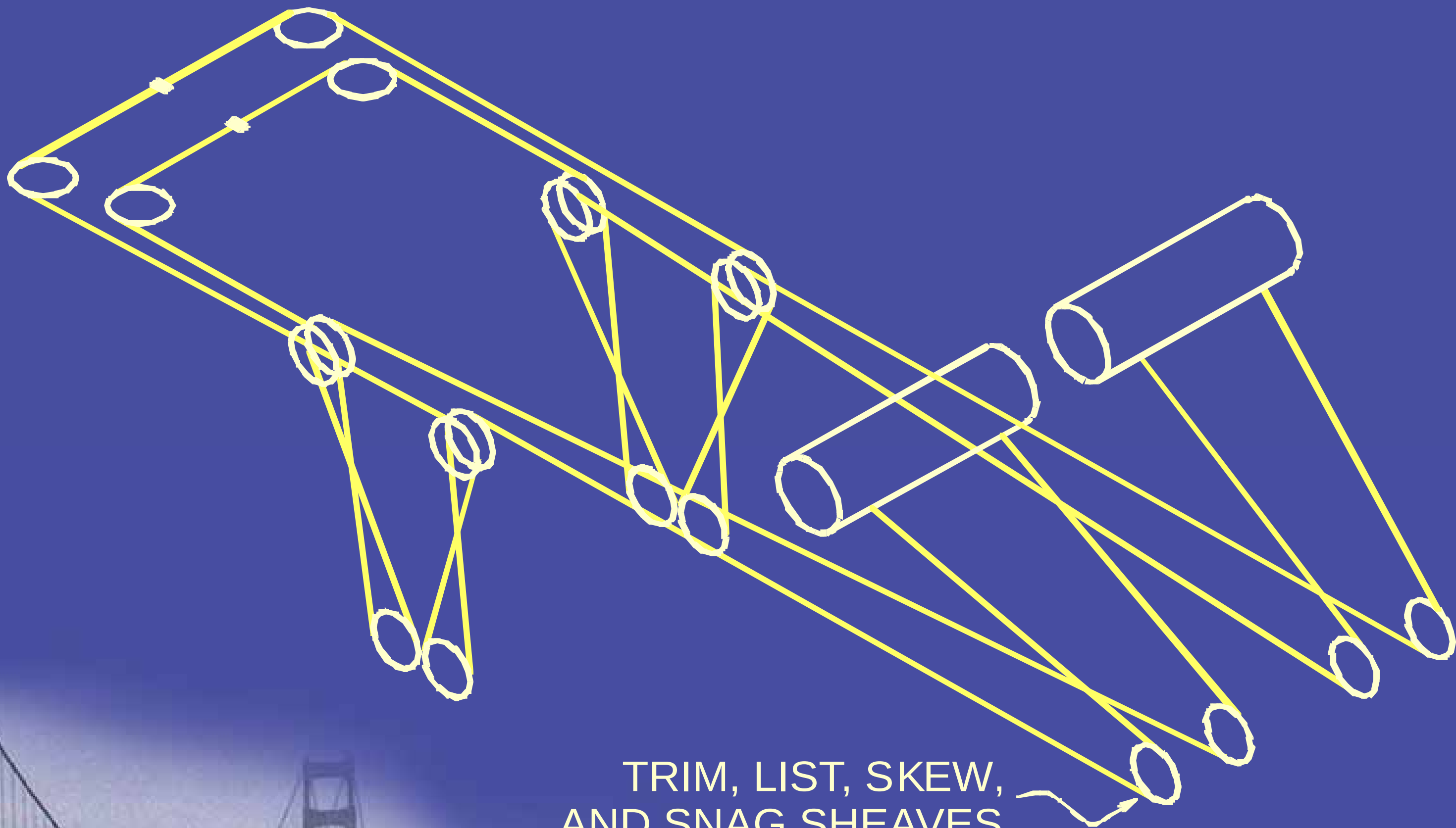
Fleet Thru Rope Towed with Catenary Trolleys

- Main Hoist Reeving



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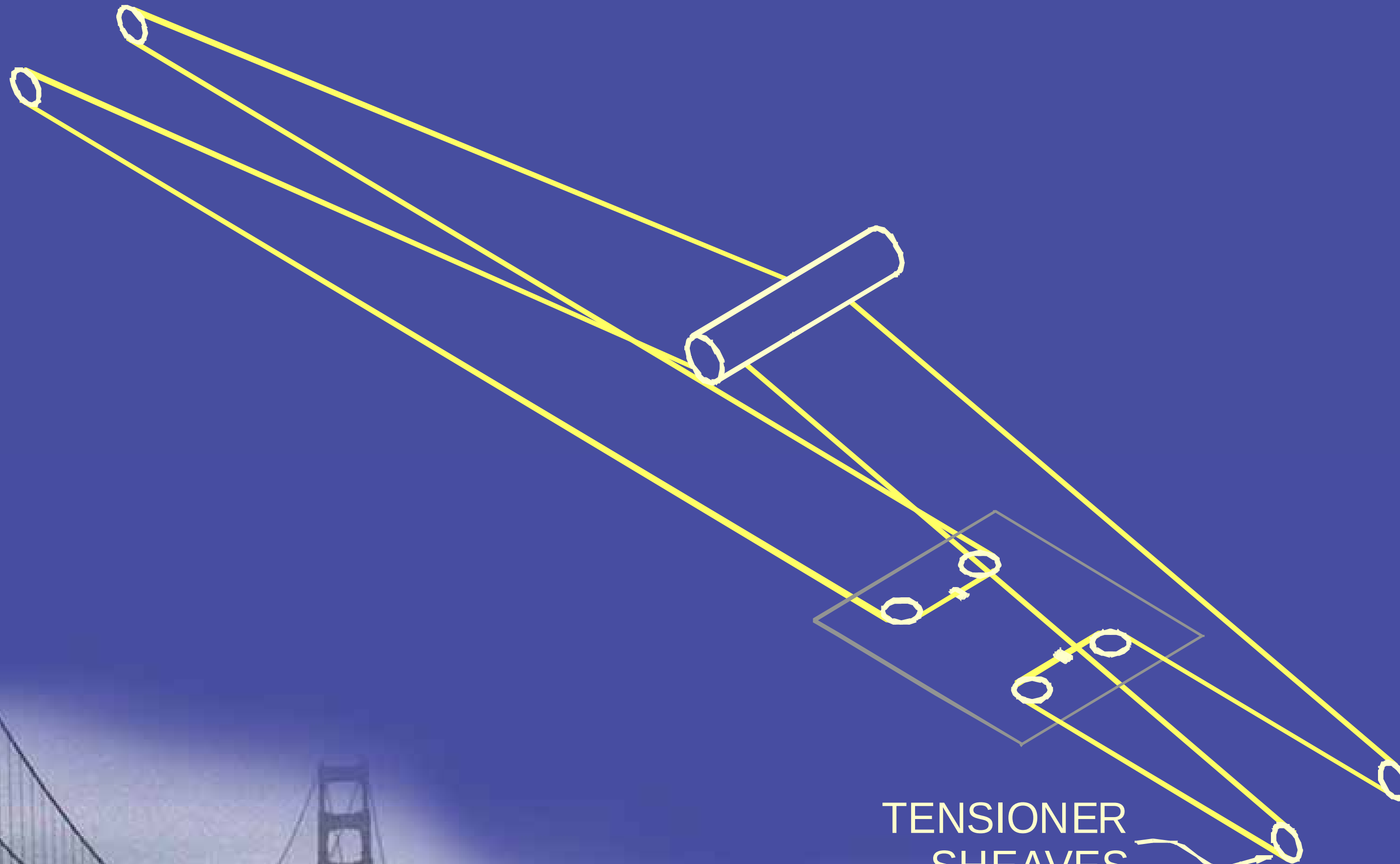
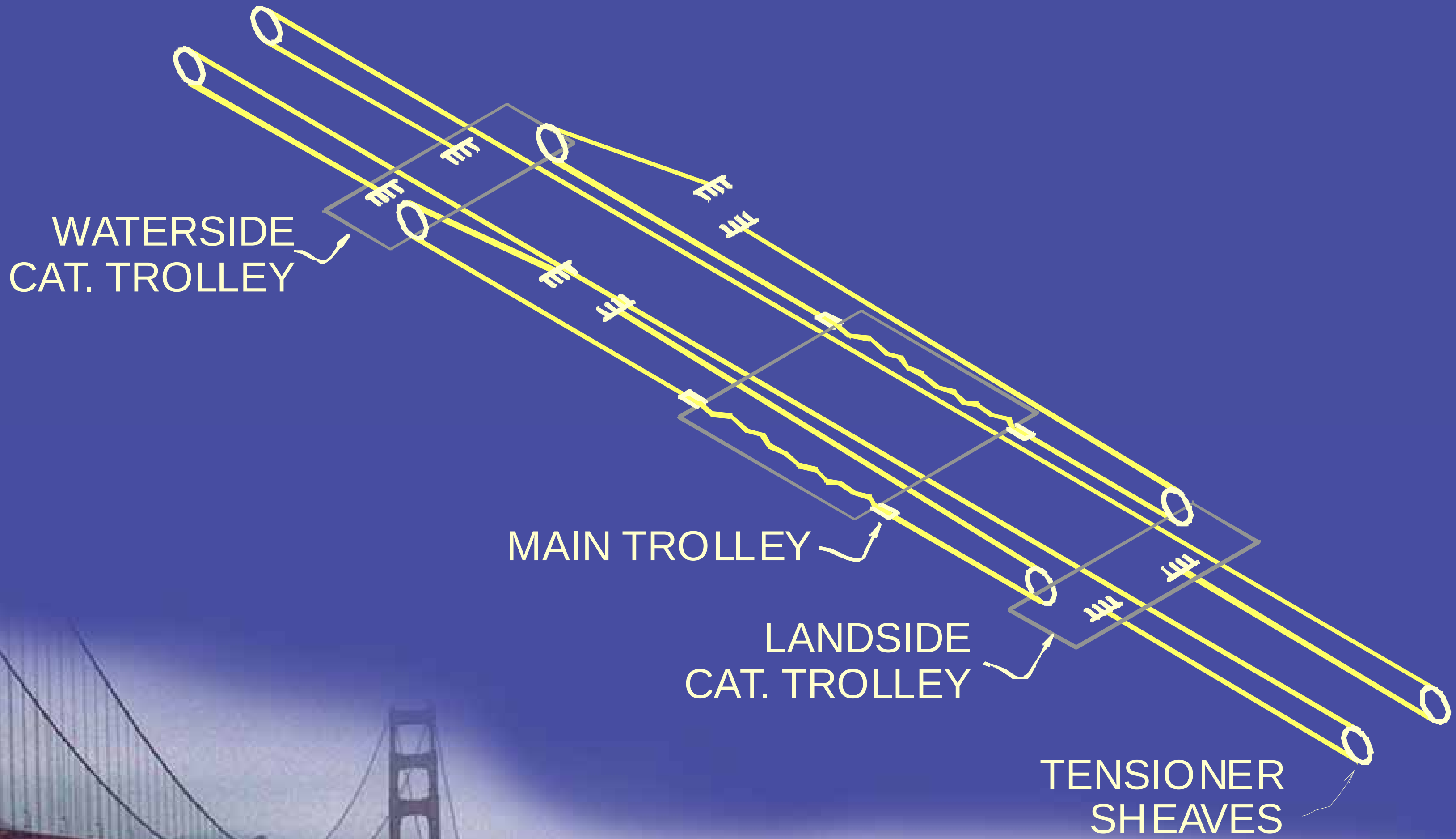
Fleet Thru Rope Towed with Catenary Trolleys

- Trolley Reeving



Fleet Thru Rope Towed with Catenary Trolleys

- Catenary Support Trolley Reeving



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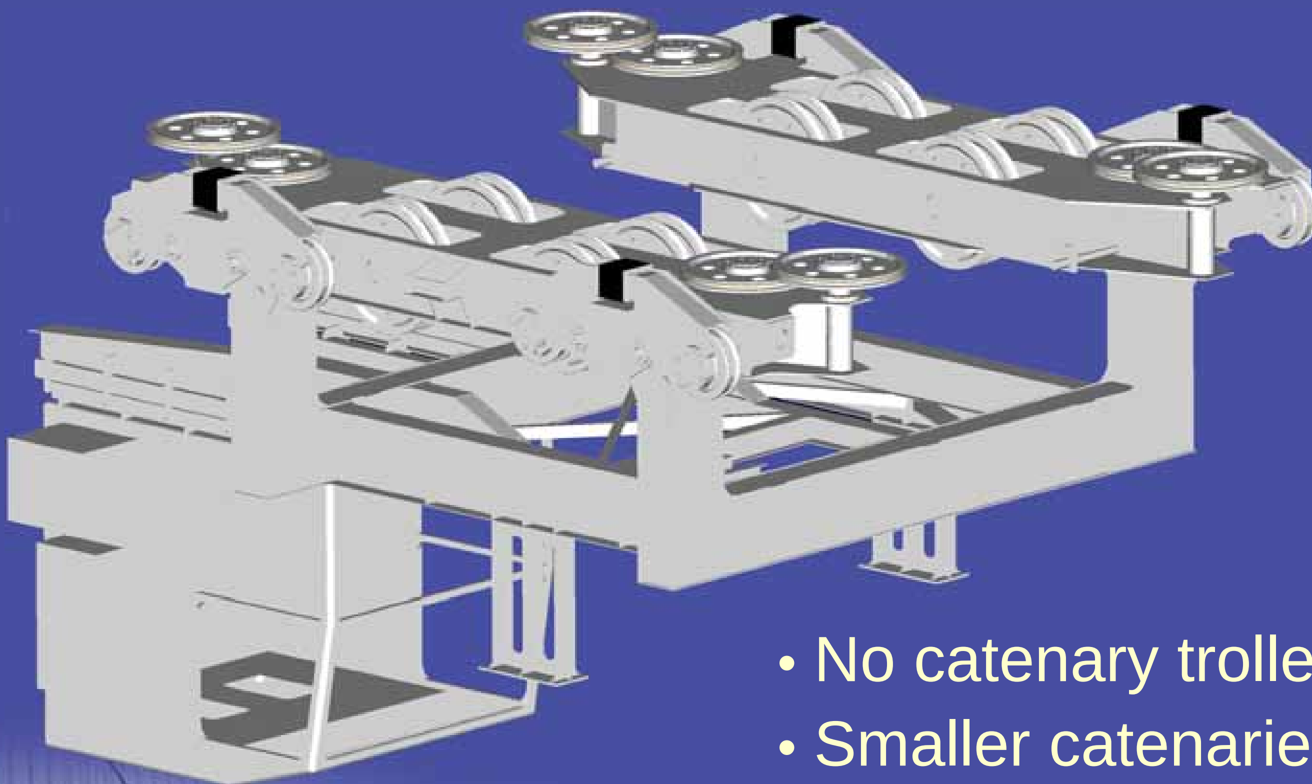
Fleet Thru Rope Towed with Continuous Support



- No catenary trolleys or reeving
- Smaller catenaries = more control
- More sheaves = heavier trolley & larger trolley motor

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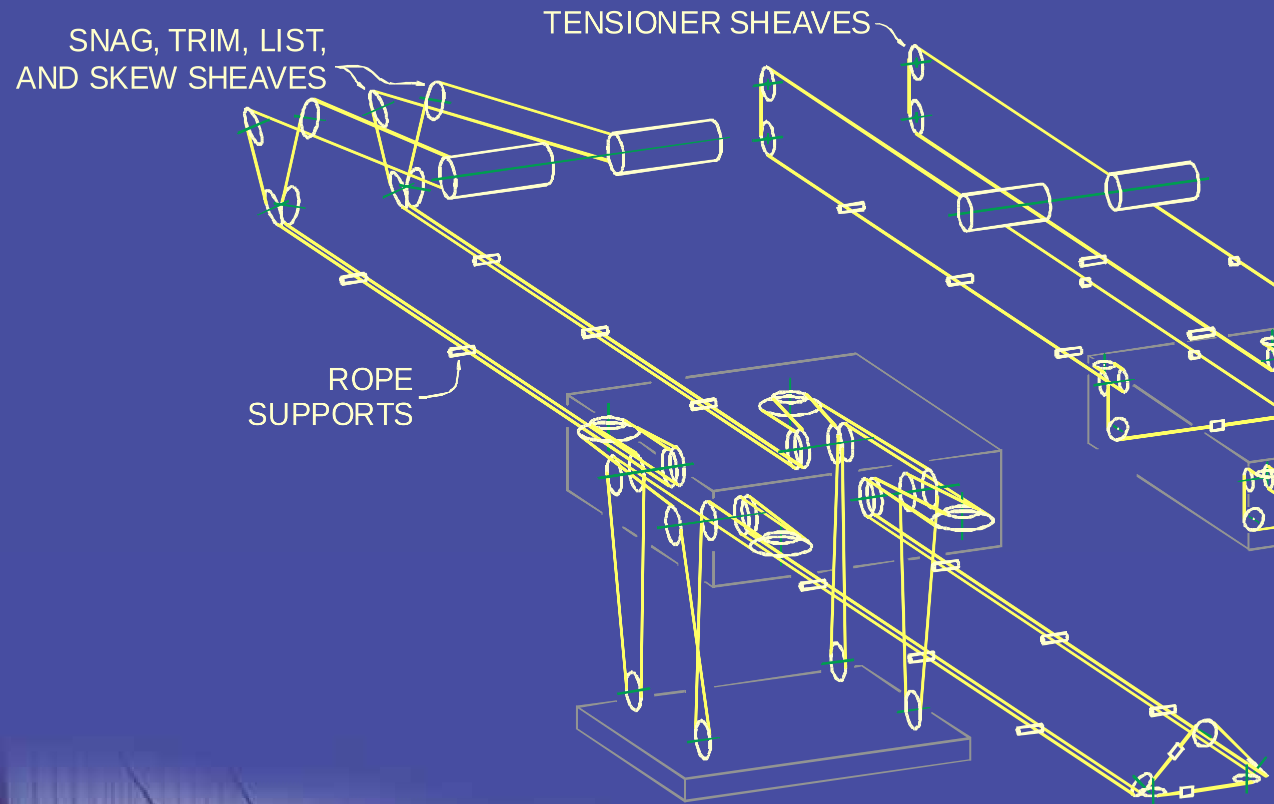
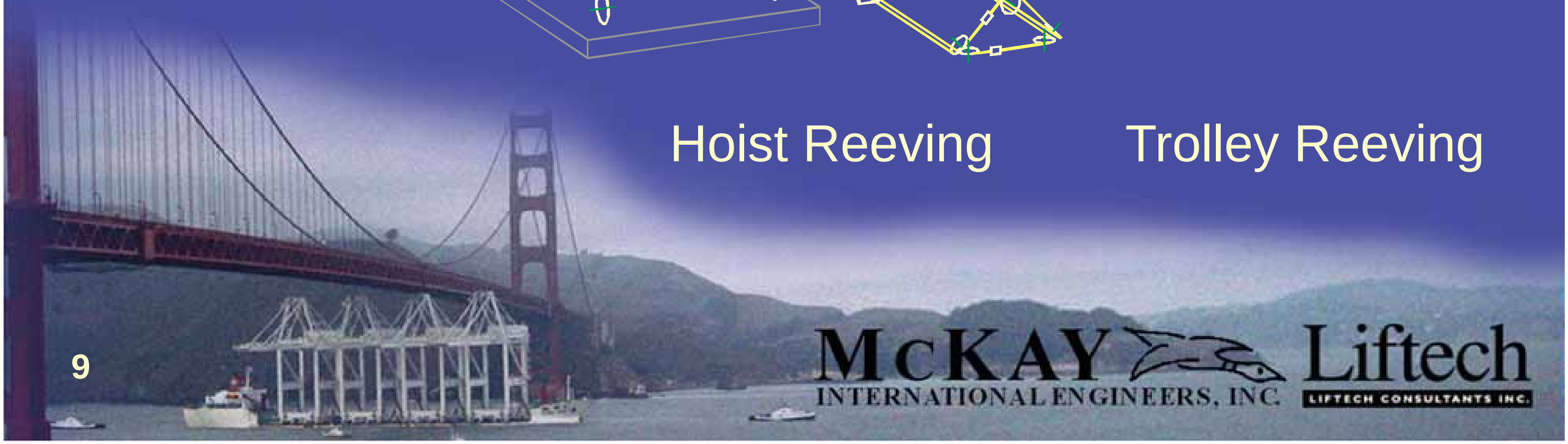
Fleet Thru Rope Towed with Continuous Support



Hoist Reeving

Trolley Reeving



Fleet Thru Rope Towed with Continuous Support

Trolley Types

Fleet Thru Self Powered

- Simple reeving
- No trolley tow ropes or tensioner
- Possibility of wheel slip
- Slower acceleration rates

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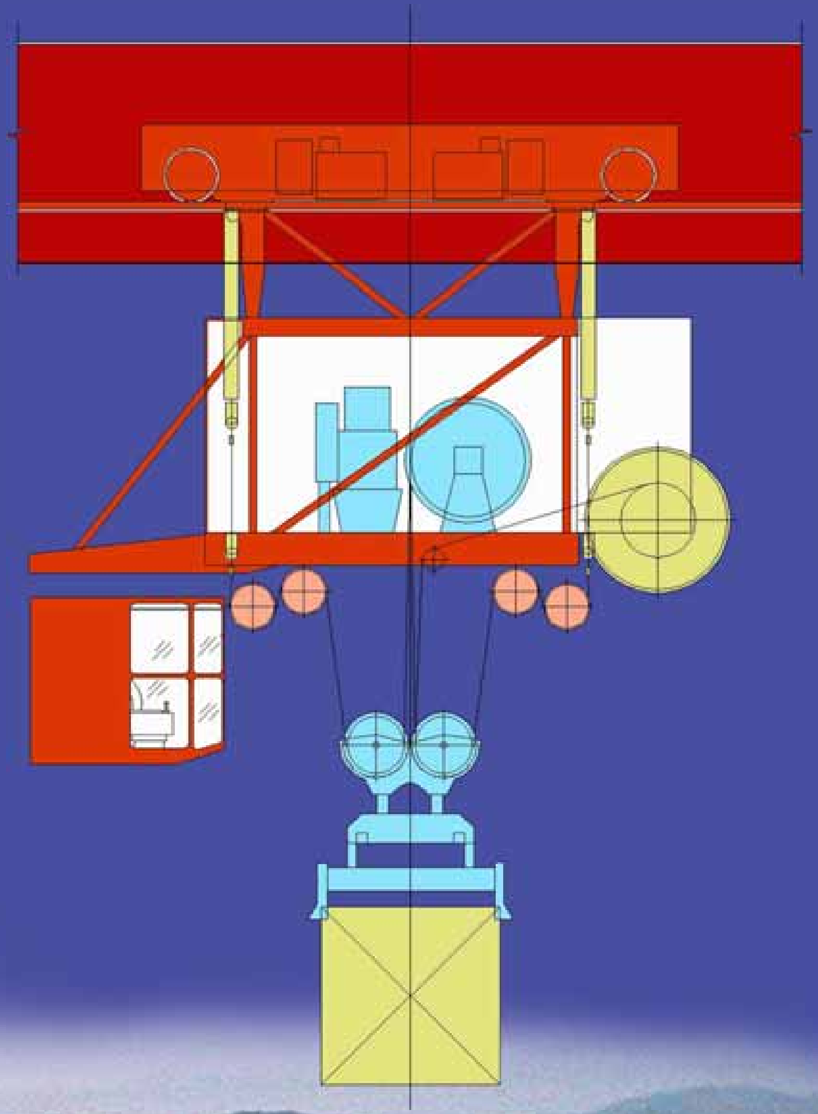
Machinery On Trolley

- Least amount of reeving
- Heaviest trolley
- Possibility of wheel slip
- Slower acceleration rates
- Small machinery room
- Design for maintenance access is important



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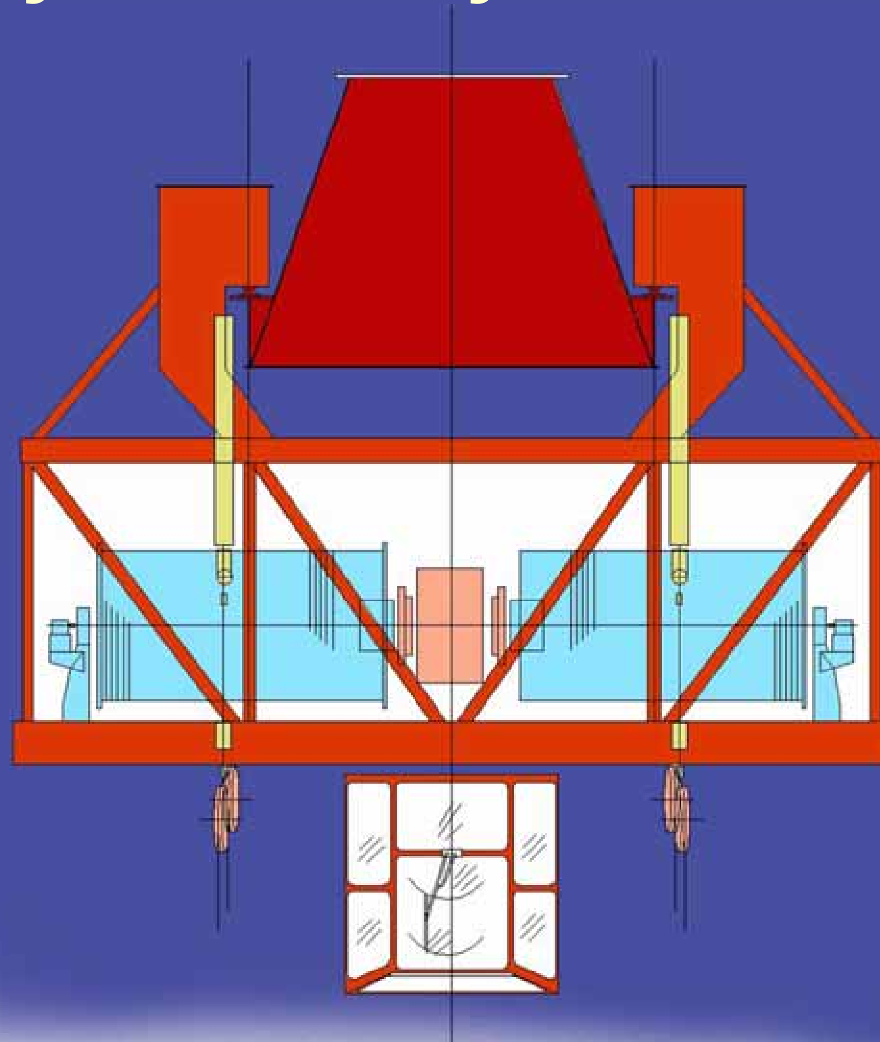
Rope Towed Machinery On Trolley

- Simple reeving
- No concern of wheel slip
- Full acceleration rates
- Requires trolley tow ropes and tensioner
- Design for maintenance access is important



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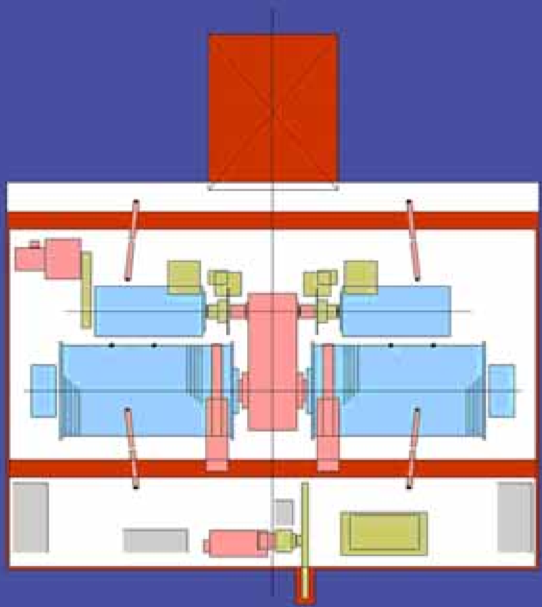
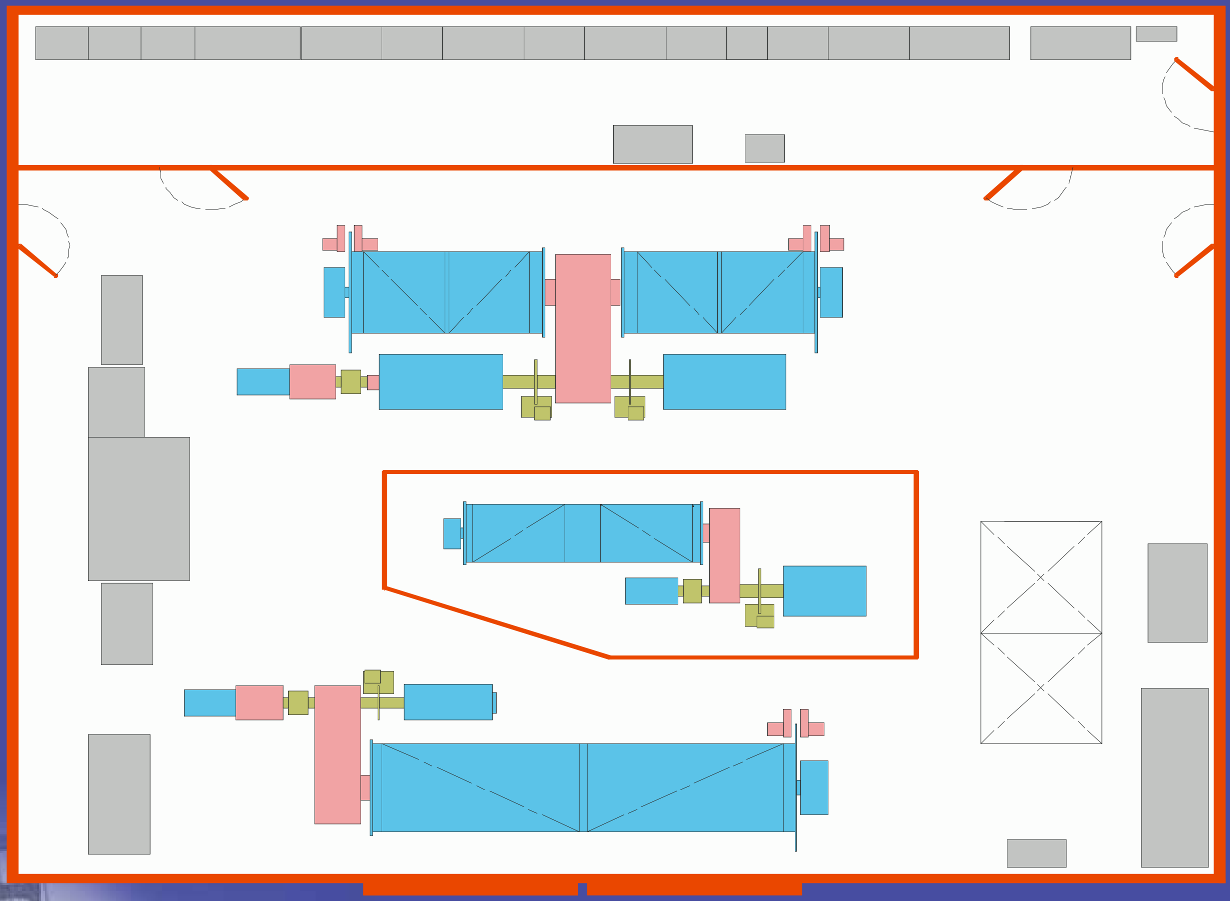
Machinery Area Comparison





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Trolley Type Comparison Matrix

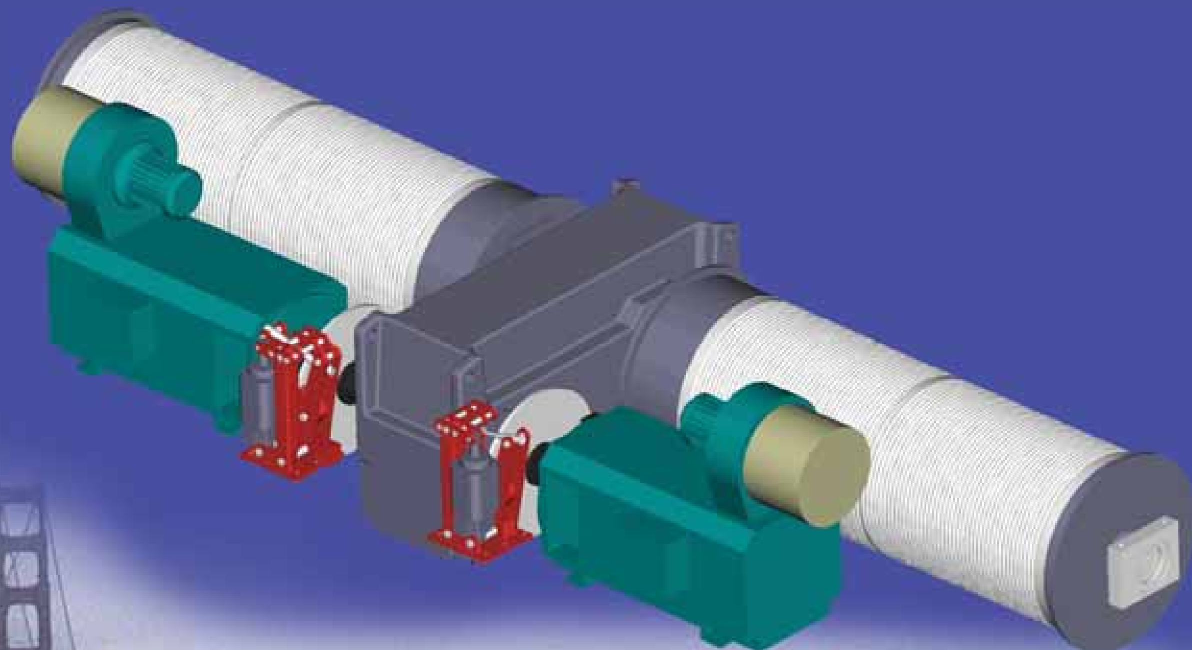
	Fleet Thru Rope Towed Continuous	Fleet Thru Rope Towed Cat. Trolleys	Fleet Thru Self Powered	Machinery On Trolley	Rope Towed Machinery On Trolley
Trolley Weight	Moderate	Lowest	Moderate	Highest	High
Trolley Motors	1	1	2-4	2-4	1
Trolley Motor Power	Moderate	Moderate	Moderate	Highest	High
Trolley Acceleration	High	High	Lowest (Wheel Slip)	Moderate (Wheel Slip)	High
Trolley Tow Ropes, Tensioner, Sheaves	Yes	Yes	No	No	Yes
Catenary Tow Rope, Tensioner, Sheaves	No	Yes	No	No	No
Hoist Rope Length	Long	Long	Long	Short	Short

Trolley Type Comparison Matrix

	Fleet Thru Rope Towed Continuous	Fleet Thru Rope Towed Cat. Trolleys	Fleet Thru Self Powered	Machinery On Trolley	Rope Towed Machinery On Trolley
Approximate Number Of Hoist Sheaves	40	20	20	12	12
Hoist Rope Catenary Support Rollers	Yes	Yes	Yes	No	No
Crane Weight	Moderate	Moderate	Moderate	High	High
Trolley Wheel And Rail Wear	Moderate	Moderate	High	Highest	Above Moderate
Hoist Machinery Access	Good	Good	Good	Limited	Limited
Trolley Drive Machinery Access	Good	Good	Limited	Limited	Good
Trolley Festoon	Light	Light	Moderate	Heaviest	Heavy

Primary Systems

- Reeving
  - Drums
  - Sheaves
  - Ropes
- Machinery
  - Gearing
  - Couplings
  - Brakes
- Hydraulics
  - Snag
  - Trim / List / Skew
  - Tensioner
- Gantry Drives
  - Enclosed Gearing
  - Brakes



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Reeving

- Cost of rope change
- Rope life extension
- Drum & sheave damage
- Groove hardness
- Tensioner

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Machinery

- Simplicity
- Reliability
- Ease of maintenance

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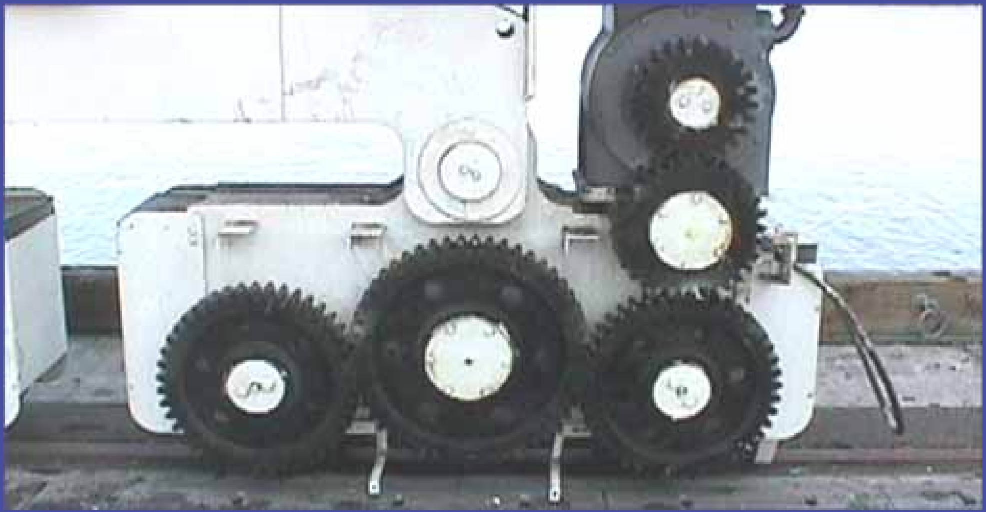
Gantry Drives and Brakes

- Elimination of open gearing
- Shaft mounted reducers
- Piloted motor mounting



Drives and Controls

- AC vs DC comparison
- Distributed I/O
- Spreader communications
- Crane monitoring systems
- Remote troubleshooting

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AC vs DC Comparison

FEATURE	AC SYSTEM	DC SYSTEM
Drive System Physical Size	Requires More Space	• Requires Less Space • Additional Space Needed for Compensation and Filtering
Drive System Weight	Heavier	• Lighter • Additional Weight for Compensation and Filtering
Typical Cost	• Higher than DC without Filtering and Compensation • About Same as DC with Filtering and Compensation	• Lower Than AC if No Filtering And Compensation • About Same as AC if Filtering And Compensation
Cost Distribution	• Motors 1/3 to 1/2 • Inverters 2/3 to 1/2	• Motors 2/3 to 1/2 • Converters 1/3 to 1/2

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AC vs DC Comparison

ABB

FEATURE	AC SYSTEM	DC SYSTEM
Power Factor	• 0.93 to 0.95 Constant • Independent of Motor Speed	• 0.1 to 0.8 Variable • Proportional to Motor Speed
Reactive Power Consumption	• Low • No Compensation Required	• High • Compensation May Be Necessary Depending on Utility Penalty
Short Time Overload Capacity	• 6 to 140 kVA – 160% Average • 215 to 3450 kVA – 135% Avg. • Usually Requires Thermal Oversizing	• Usually 200% • Thermal Sizing Usually Sufficient
Rating Selection	• Selected According to Maximum Torque / Current Requirement • Thermally Oversized	Selected According to Thermal Requirement

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AC vs DC Comparison

FEATURE	AC SYSTEM	DC SYSTEM
Total Power Loss	Similar to DC System	Similar to AC System
Typical Power Loss Distribution	• Motor 1/3 in M-House • Converter 2/3 in E-House • More E-House Cooling Req'd	• Motor 2/3 in M-House • Converter 1/3 in E-House • Less E-House Cooling Req'd
Motor Cabling	• Screened Cables Required • Length Restrictions • Difficulties for Festoon Cabling	Normal Cables Sufficient
Motors General	Motor is "Short and High" (Constant Speed)	Motor is "Long and Low" (Variable Speed)

AC vs DC Comparison

ABB

FEATURE	AC SYSTEM	DC SYSTEM
Hoist Motor Inertia	• Higher than DC • Less Dynamic Performance • Same Performance Needs More Power • Risk of Vicious Cycle	• Lower than AC • More Dynamic Performance
Hoist Motor Nominal Torque	• Base Speed – 100% • Field Weakened Speed – 50%	• Base Speed – 100% • Field Weakened Speed – 50%
Hoist Motor Max. Torque	• Base Speed – 200% • Field Weakened Speed – 50%	• Base Speed – 200% • Field Weakened Speed – 100%

AC Summary

- Lower motor maintenance
- Higher rotational inertia
- Improved inherent power quality
- Larger panels and heat dissipation required

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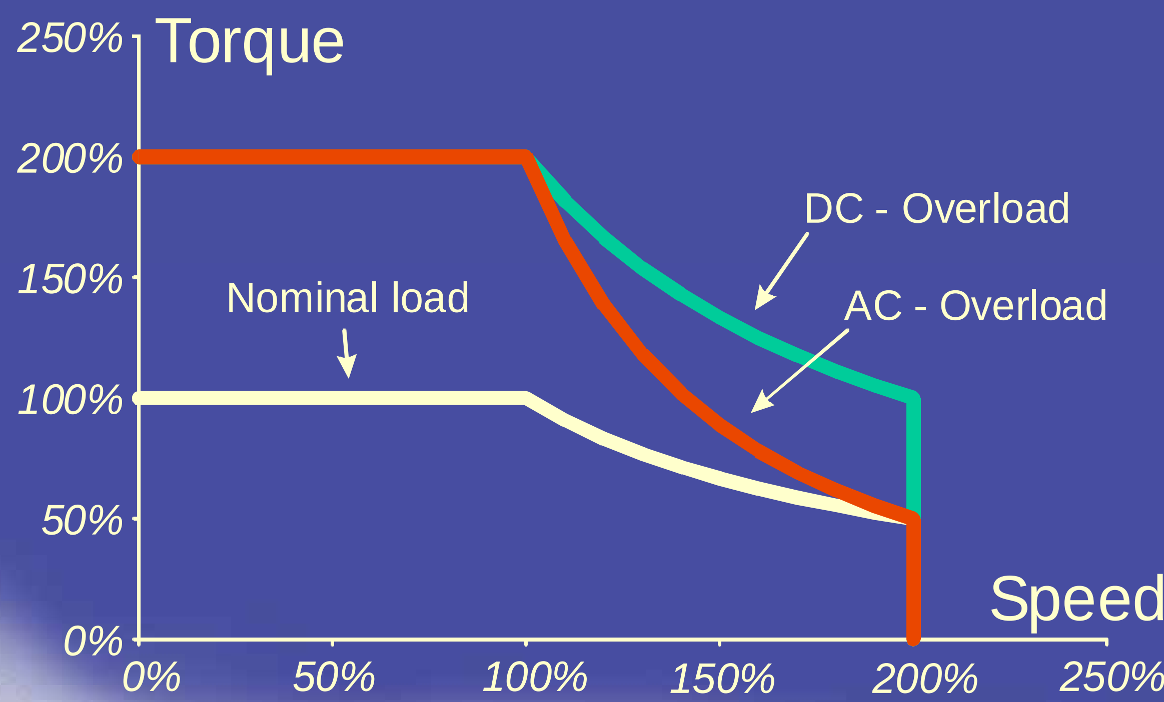
DC Summary

ABB

- Higher motor maintenance
- Requires equipment for power quality and harmonics
- Traditional hoist performance



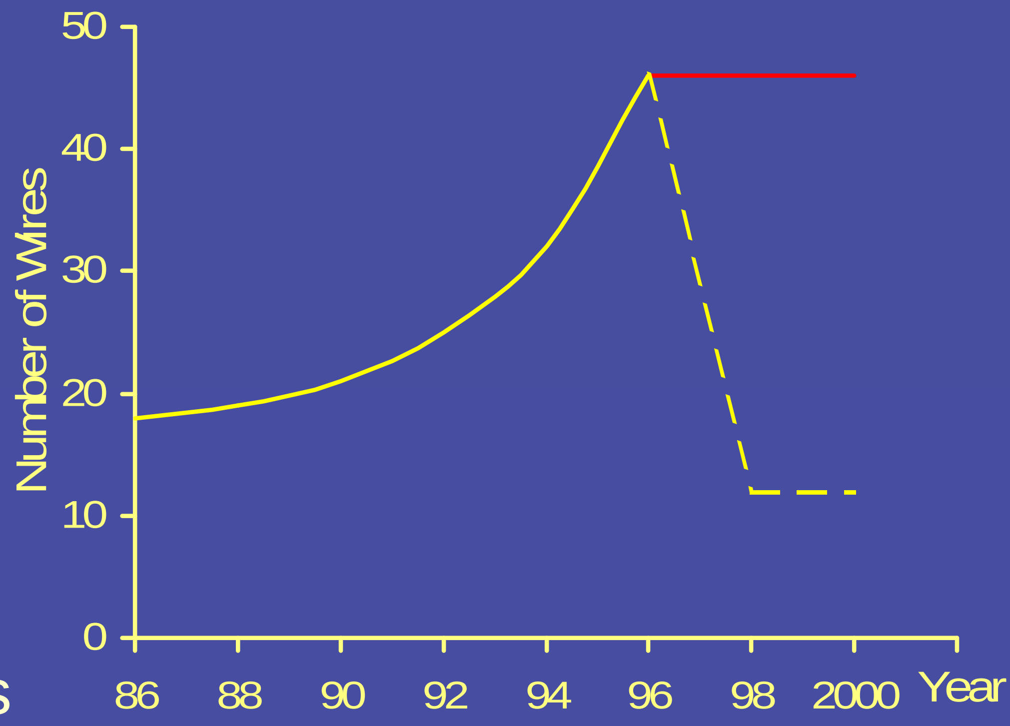
Distributed I/O

- Large amount of information on crane
- Too many signals for discrete wiring
- Distributed I/O nodes networked together
  - Reduces wiring
  - Speeds troubleshooting
- Signals from:
  - Limit switches
  - Push buttons
  - Pressure switches
  - Photocells
  - Etc…
- Signals to:
  - Indicating lights
  - Digital displays
  - Solenoids
  - Relays
  - Etc…
- Industry standard protocols

Spreader Communications

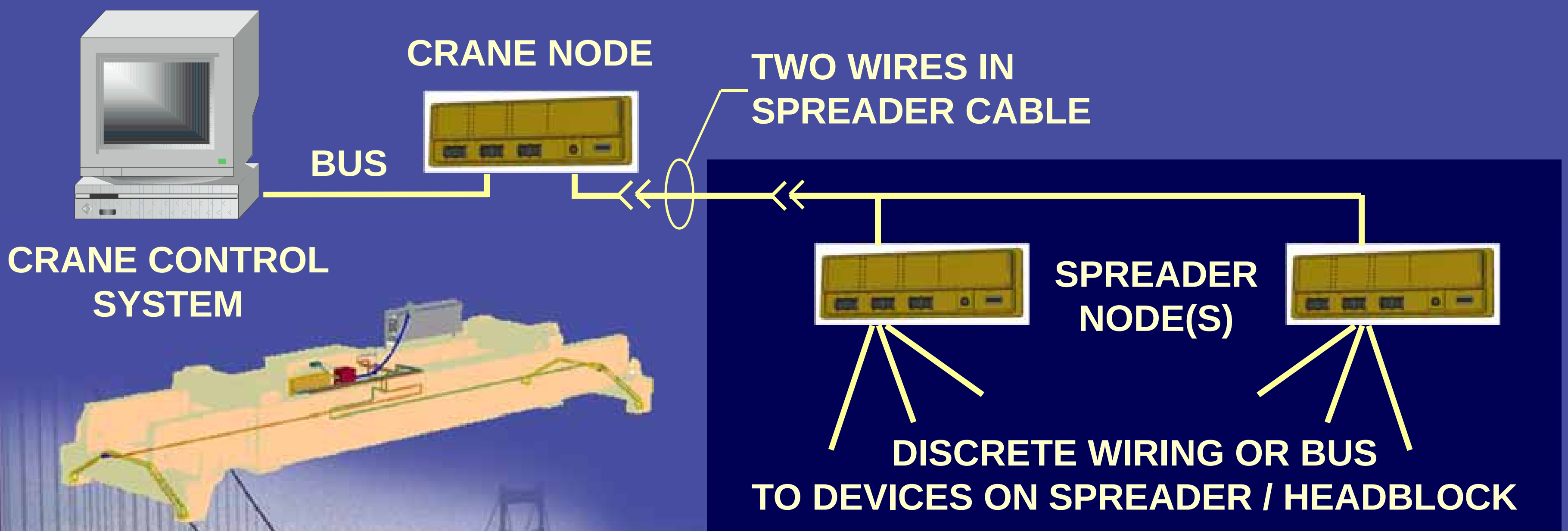
- Increasing amount of I/O necessary for modern spreaders
- Features such as:
  - Twin twenty operation
  - Twin twenty detection
  - Automatic telescoping
  - Separating twins
  - Fall arrest

  All require additional I/O
- Reaching the maximum capacity of existing cables



Spreader Communications

- Two standard copper wires to transmit I/O data
- Smaller cable = smaller cable reel
- Bus topology allows for extensive troubleshooting data



BROMMA

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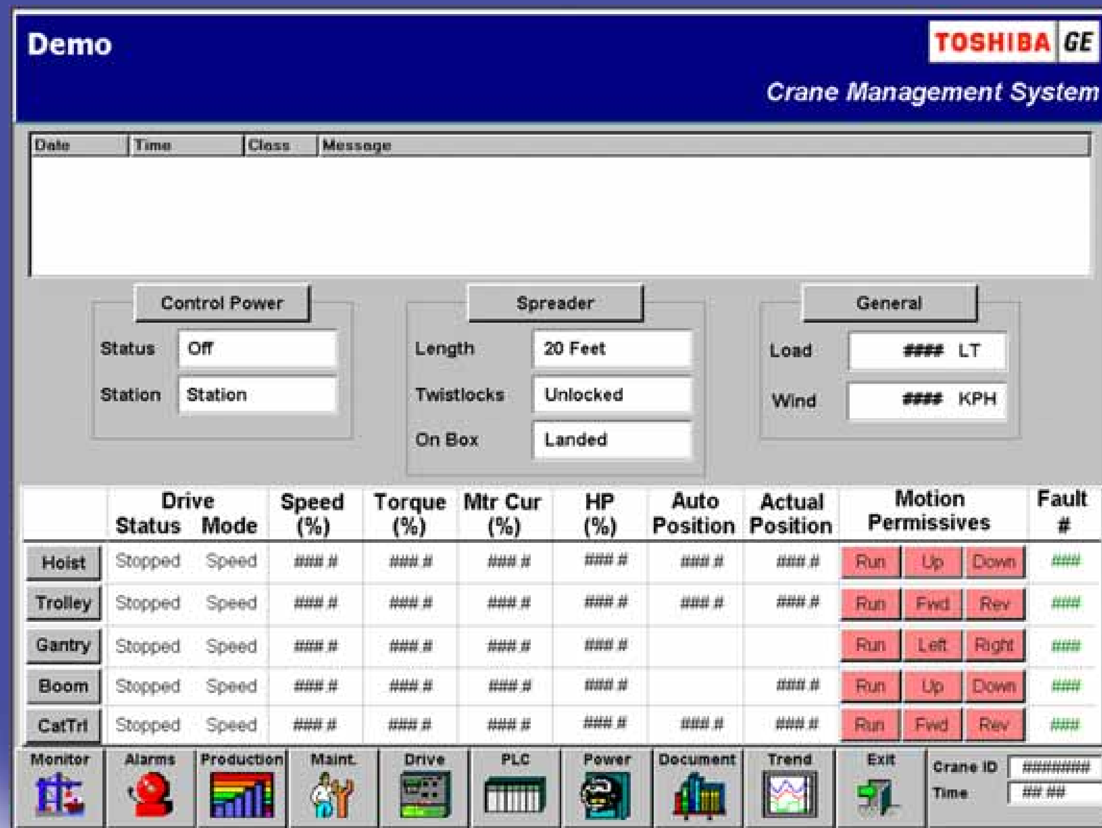
Drives and Controls

- Crane Monitoring Systems
- Remote (Off-Site) Troubleshooting



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Crane Power Supply Options

	Cable Reel	Conductor Bars	Diesel
Power	Cable	Collector	Fuel
Communications With Terminal	Fiber Optics / Radio	Radio / Wave Guide	Radio
Initial Cost of Crane	Moderate	Low	High
Initial Cost of Wharf	Low	Moderate	None
Operating Costs	Low	Low	Very High
Potential Problems	Cable Damage & Replacement Cost	Safety & Conductor Maintenance	Maintenance & Pollution
Supply Voltage	5 to 15 kV	5 to 15 kV	< 600 V

Operating and Safety Features

- Snag device
- Fail safe design philosophy
- Verification of redundant systems
- Operation and maintenance safety
- Additional operating
  and safety features

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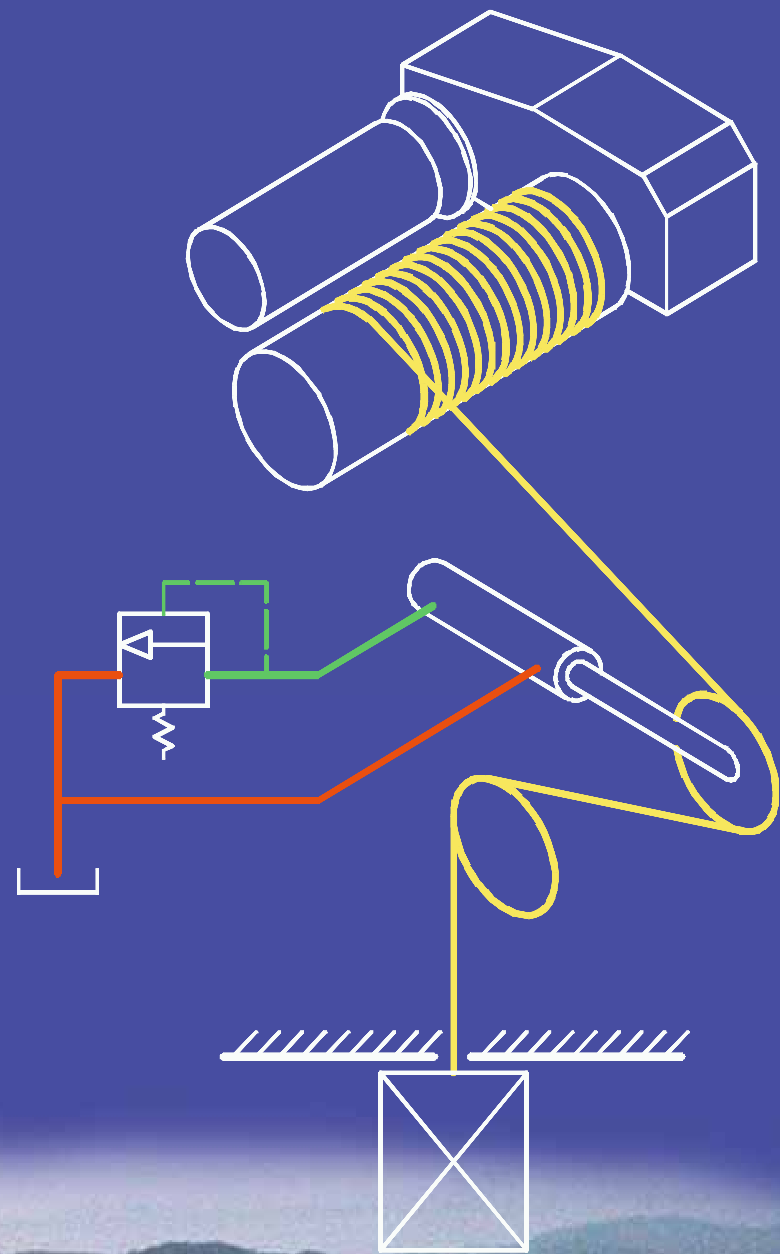
Snag Device

- Hydraulic
- Powered reset
- Flow rate must accommodate main hoist speed
- Cylinder stroke sized to absorb kinetic energy of rotating equipment



Snag Device

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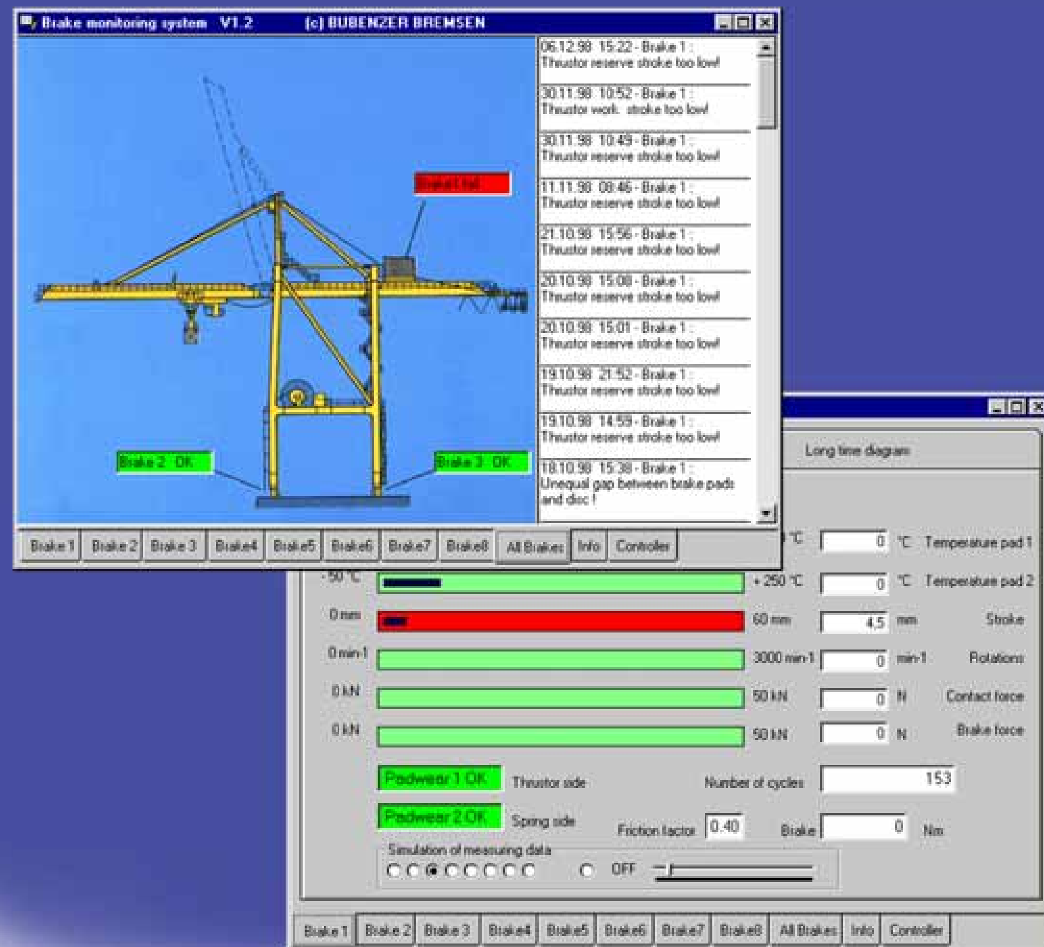
Fail Safe Design Philosophy

- Safety systems and components are single failure proof
  - Components must fail to a safe state
  - Redundant systems used where can not fail to safe state
  - Redundant high speed braking on main hoist motors
  - Redundant braking on main hoist and boom hoist drums
- Systems and devices must not change state during power up

Verification of Redundant Systems

- Brake Torque
- Snag Relief Valves
- Self Diagnostics



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Operation & Maintenance Safety

- Lock-Out / Tag-Out
- Hazard signs
- Means to check redundant systems
- Maintenance mode
- Safe access for maintenance

Additional Operating & Safety Features

- Hoist “two blocking” crumple zone
- Operator seatbelts
- Self rescuing elevator
- Two means of exit from enclosed spaces
- Stairs vs ladders for access
- Boom hoist redundant brake
- Main hoist redundant braking

Productivity Enhancements

Productivity Enhancements

- Crane to Crane Coordination and Collision Avoidance

Productivity Enhancements

- Twin Twenty / Twin Forty Spreaders

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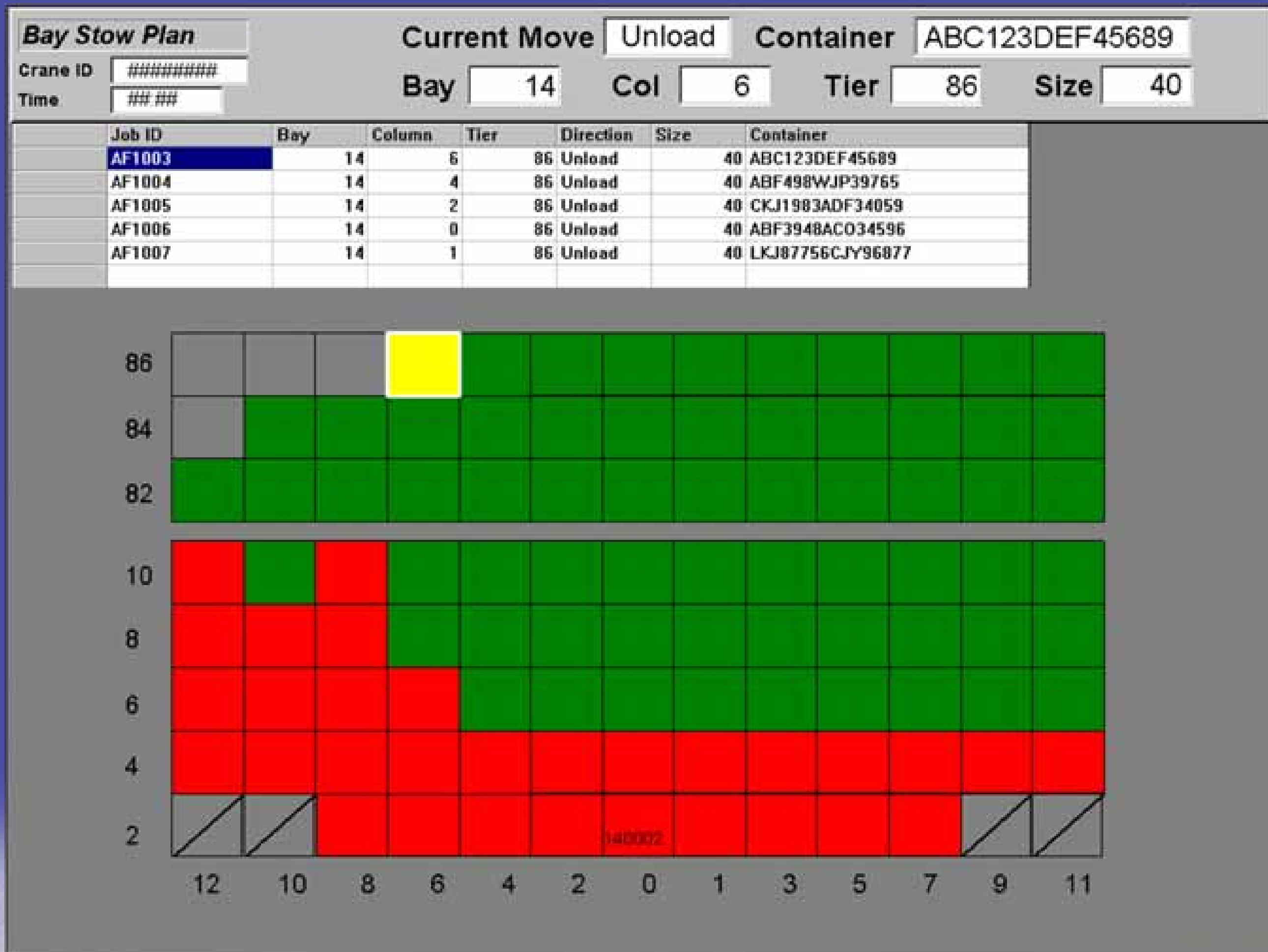
Productivity Enhancements

- CCTV Displays for Operator
- Chassis Positioning Systems

Productivity Enhancements

- Stowage Plan Systems
- Container Recognition Systems



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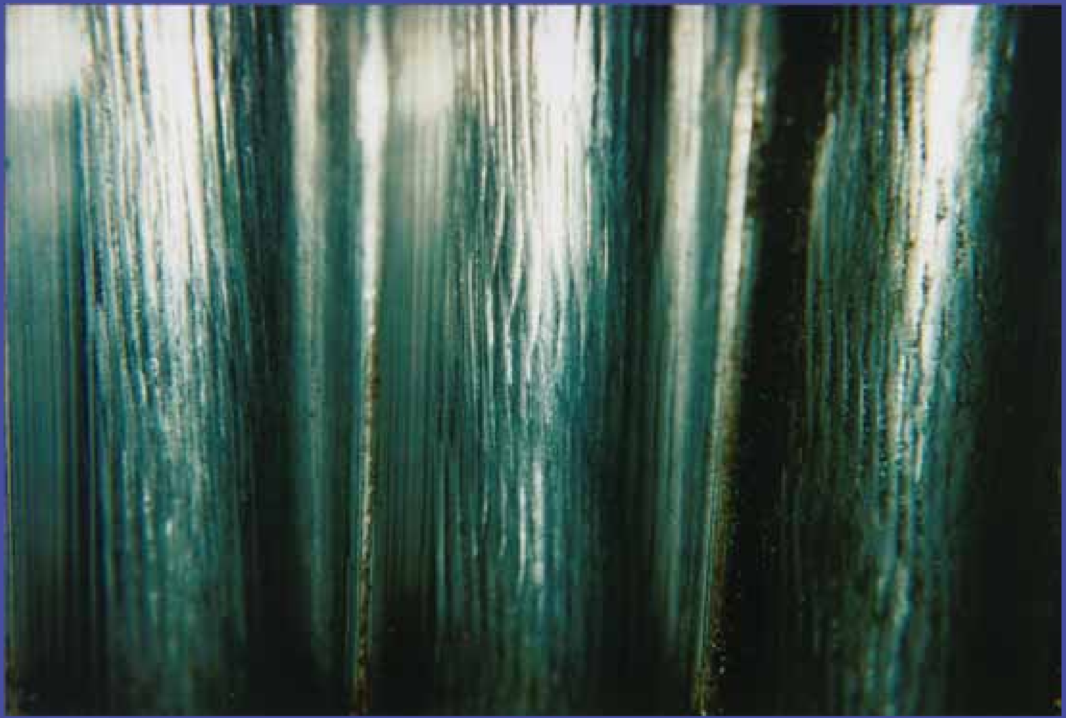
Specifications & Standards

- Standard specifications cover standard cranes, not ***container*** cranes
- Container cranes are unique for many reasons
  - Eccentric loads
  - High speeds
  - Heavy duty cycles
  - Very high reliability requirements
- Standards and specifications must be interpreted by experienced engineers

Specifications & Standards



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Specifications & Standards

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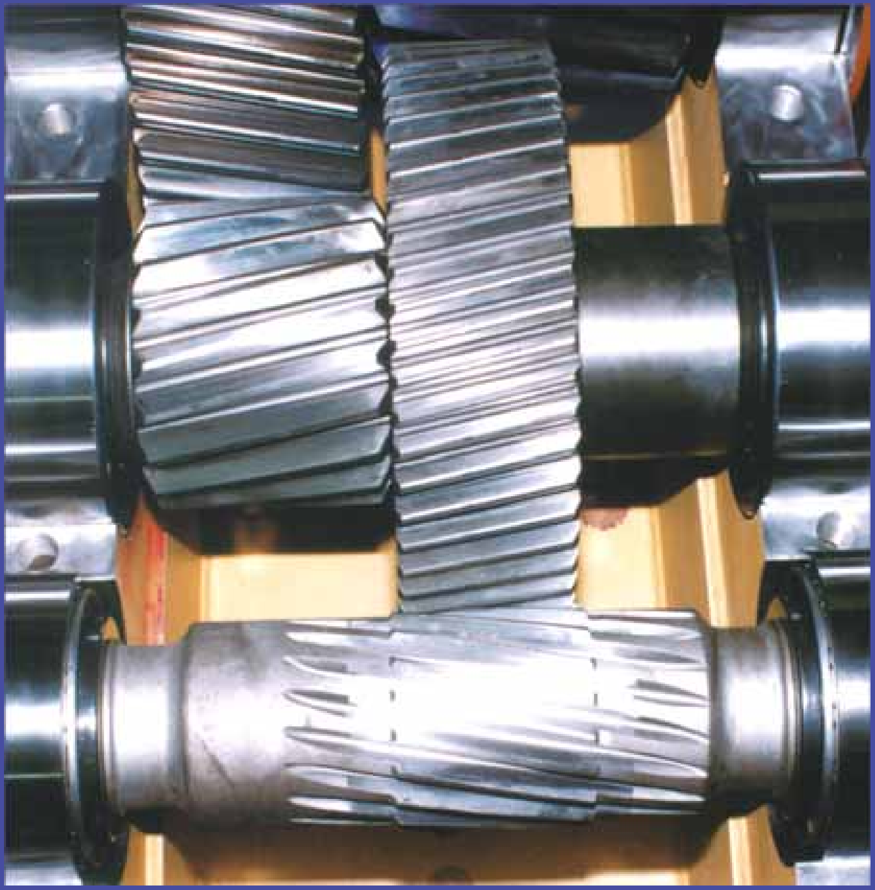
Design & Manufacturing

- Goals:
  - High reliability
  - Low maintenance cost
  - Lowest total acquisition cost
- Total acquisition cost:
  - Purchase price
  - Design and manufacturing review costs to get high reliability and low maintenance

Design & Manufacturing

Good Design:

- Requires design experience
- Meets crane codes worldwide
- Provides crane reliability
- Minimizes maintenance



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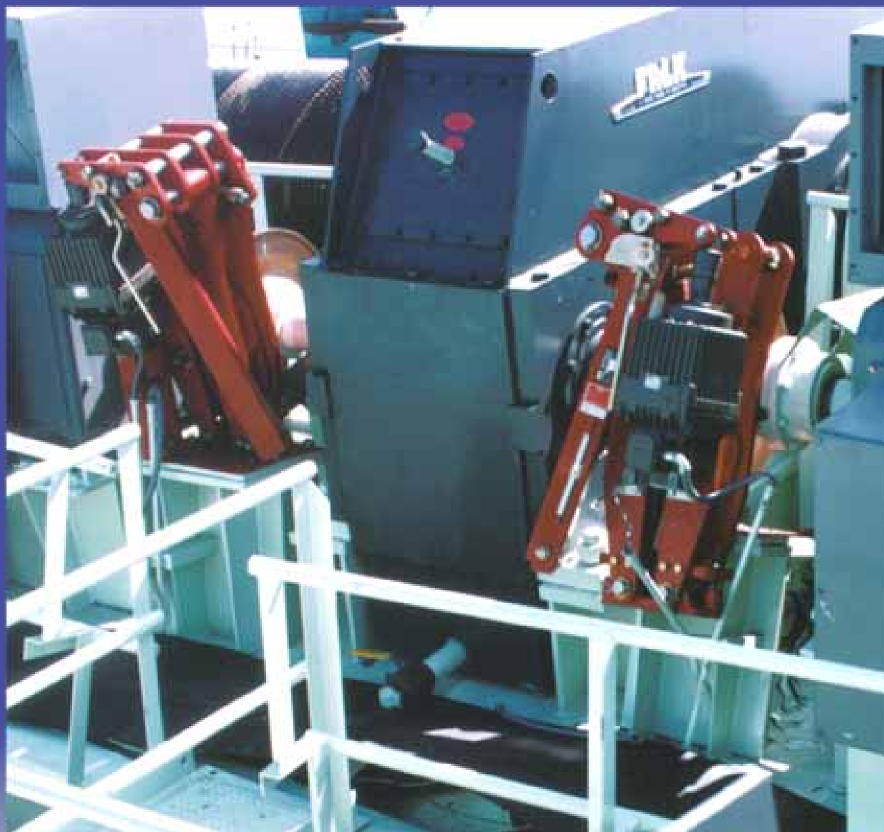
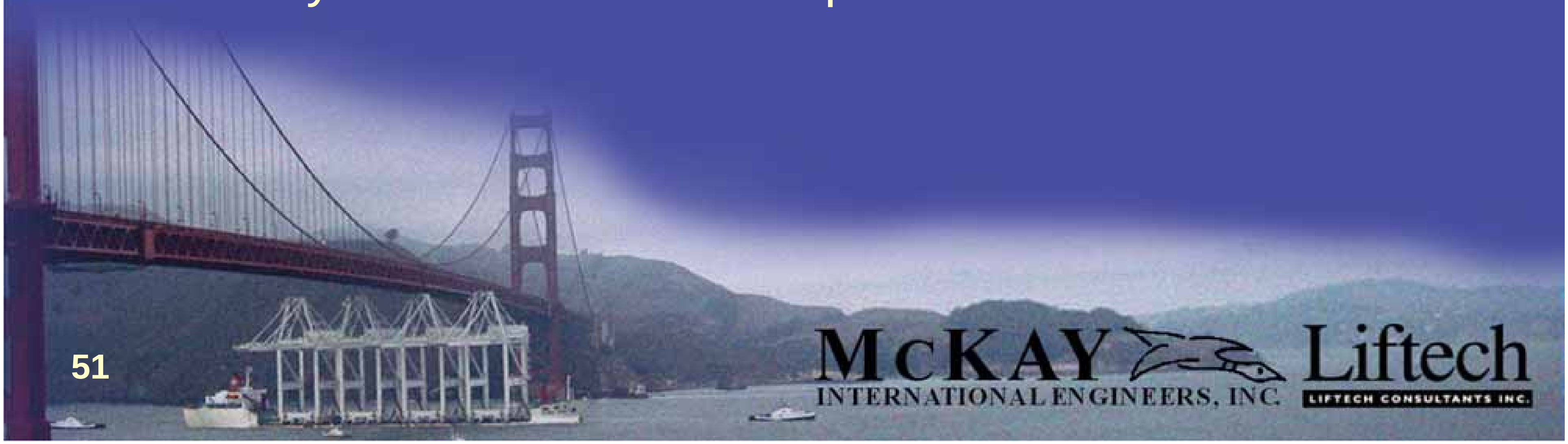
Design & Manufacturing



- Low price is associated with:
  - Poor design
  - Inferior components
  - Low reliability
  - High maintenance
- High price is associated with:
  - Good design
  - Superior components
  - High reliability
  - Low maintenance

Summary

- Crane systems and components are being refined to:
  - Improve performance and productivity
  - Improve reliability
  - Improve maintainability
- Be sure to specify what you want in a crane:
  - Size and speeds
  - Systems and components
  - Safety and maintenance requirements



End of Mechanical / Electrical Presentation

- Comments
- Questions

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