The Memorial Bridge

Design Innovations

&

Fabrication Challenges

by Jerry Zoller, P.E.
NHDOT Bridge Design
for
Mid-Atlantic States QA Workshop
Atlantic City, NJ
February 5, 2014

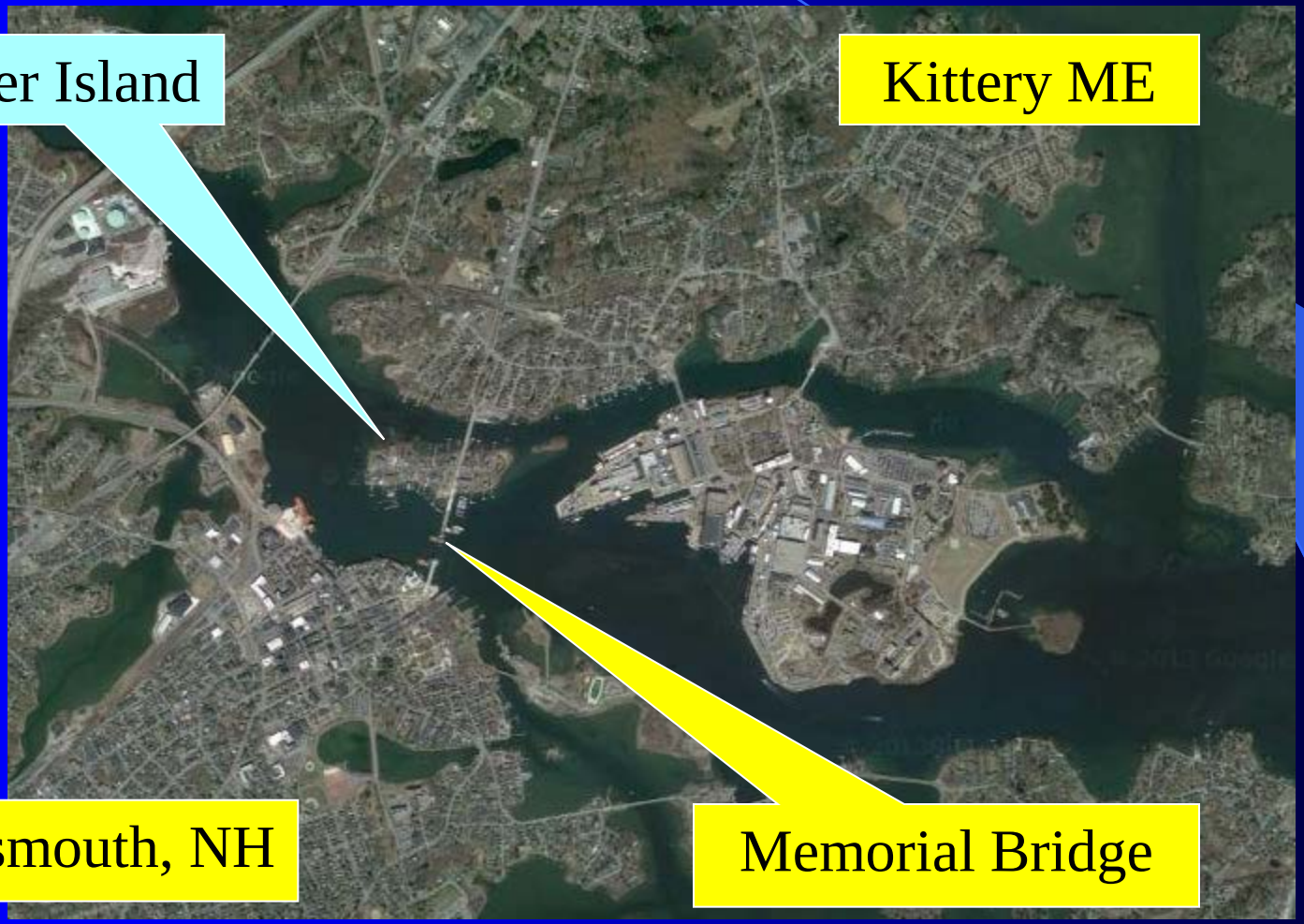
US Route 1 over Piscataqua River – Portsmouth, NH to Kittery, Maine

Honoring sailors & soldiers who fought for liberty

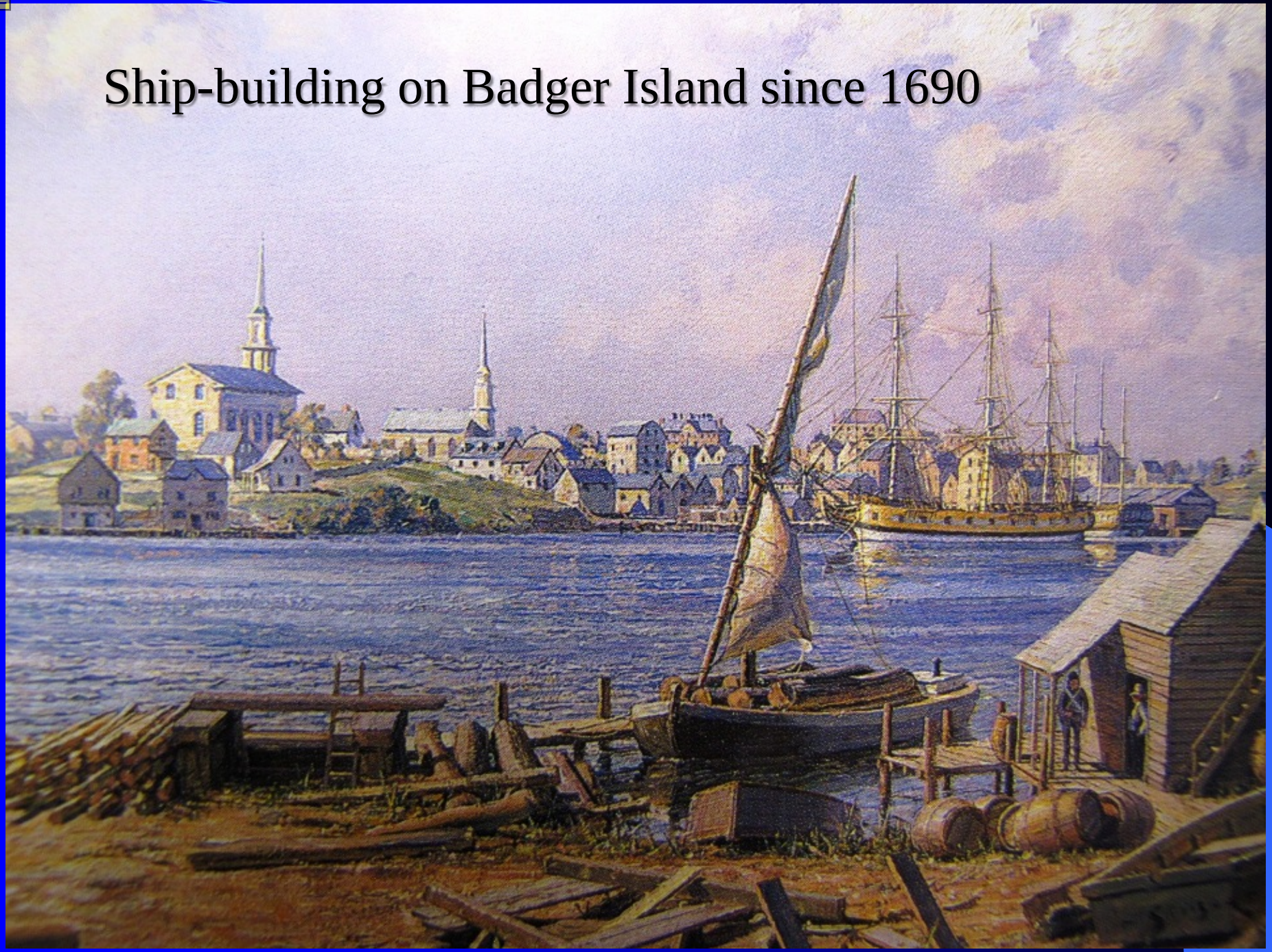
The Memorial Bridge / **QAW** Atlantic City NJ / 2.5.2014 / Jerry Zoller, NHDOT #2

Memorial Bridge - US Route 1 over Piscataqua River

Portsmouth, NH to Kittery, Maine



Ship-building on Badger Island since 1690



Captain John Paul Jones & *Ranger* in 1777

The 1st vertical lift bridge on East coast

Patented 1910 - prototype for many bridges

The iconic 1923 Memorial Bridge

North span float-in July 8, 1922

A celebrated event making world headlines

Designed by J. A. L. Waddell

"Father of vertical lift bridges"

Miller, NHDOT #8

Memorial Bridge is personal to many people

Photo: Jerry Zoller 7/6/07

Inevitable closure - July 27, 2011

Design- Build Team:

HNTB

Archer Western Contractors

Agencies:

New Hampshire DOT Department of Transportation

MAINEDOT Maine Department of Transportation

U.S. Department of Transportation Federal Highway Administration

CITY OF PORTSMOUTH, N.H. SETTLED - 1633 INCORPORATED - 1849

TOWN OF KITTERY, MAINE INCORPORATED 1647

Ted Zoli, HNTB bridge designer

with Waddell spirit of innovation & excellence

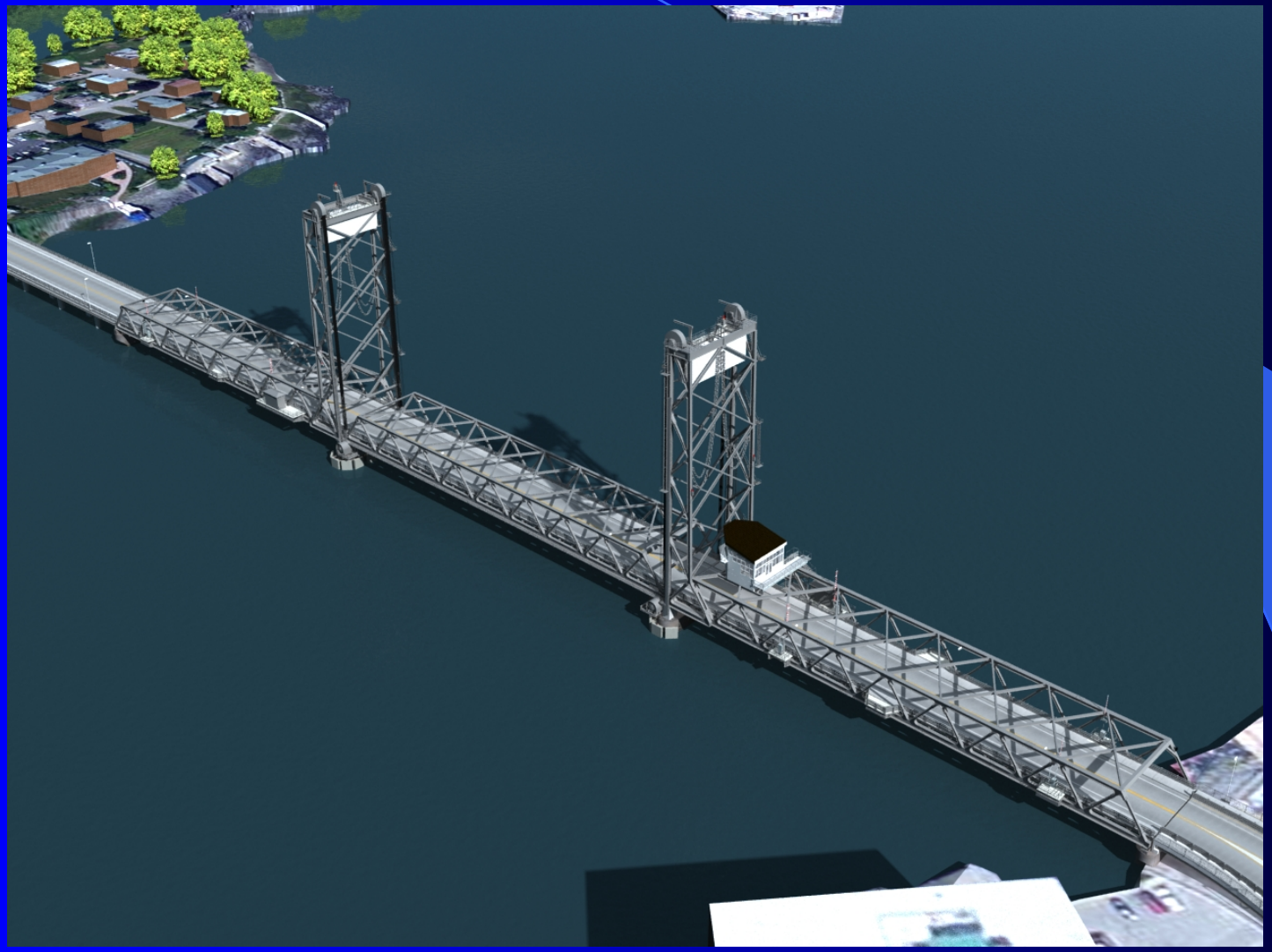
Leonard Zakim Bridge, Boston

Lake Champlain Bridge, NY-VT

The new must have similar silhouette as original

Assembly sequence

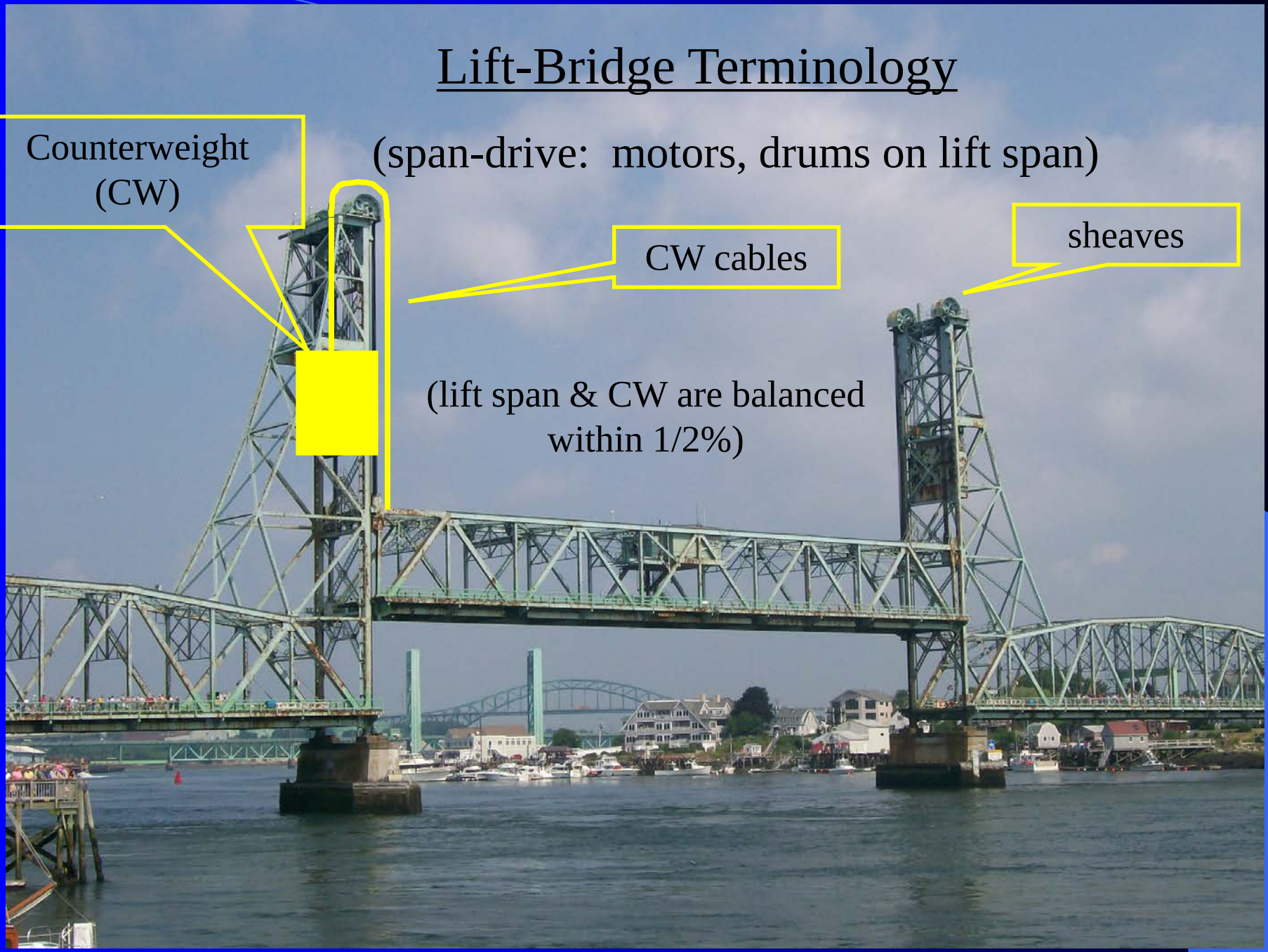
The new look … simpler, uniform, streamlined

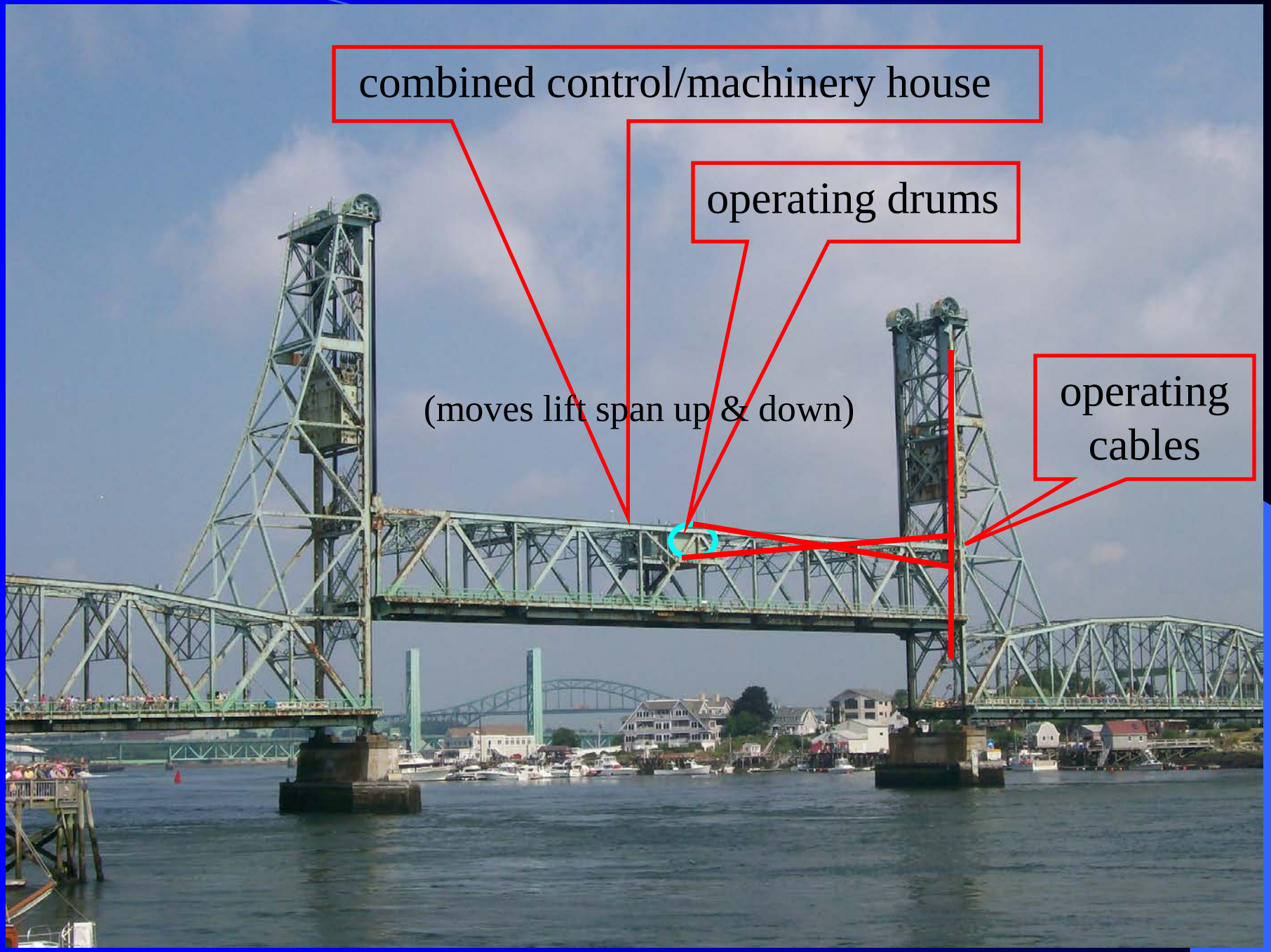


Reuse existing piers

Lift-Bridge Terminology

(span-drive: motors, drums on lift span)



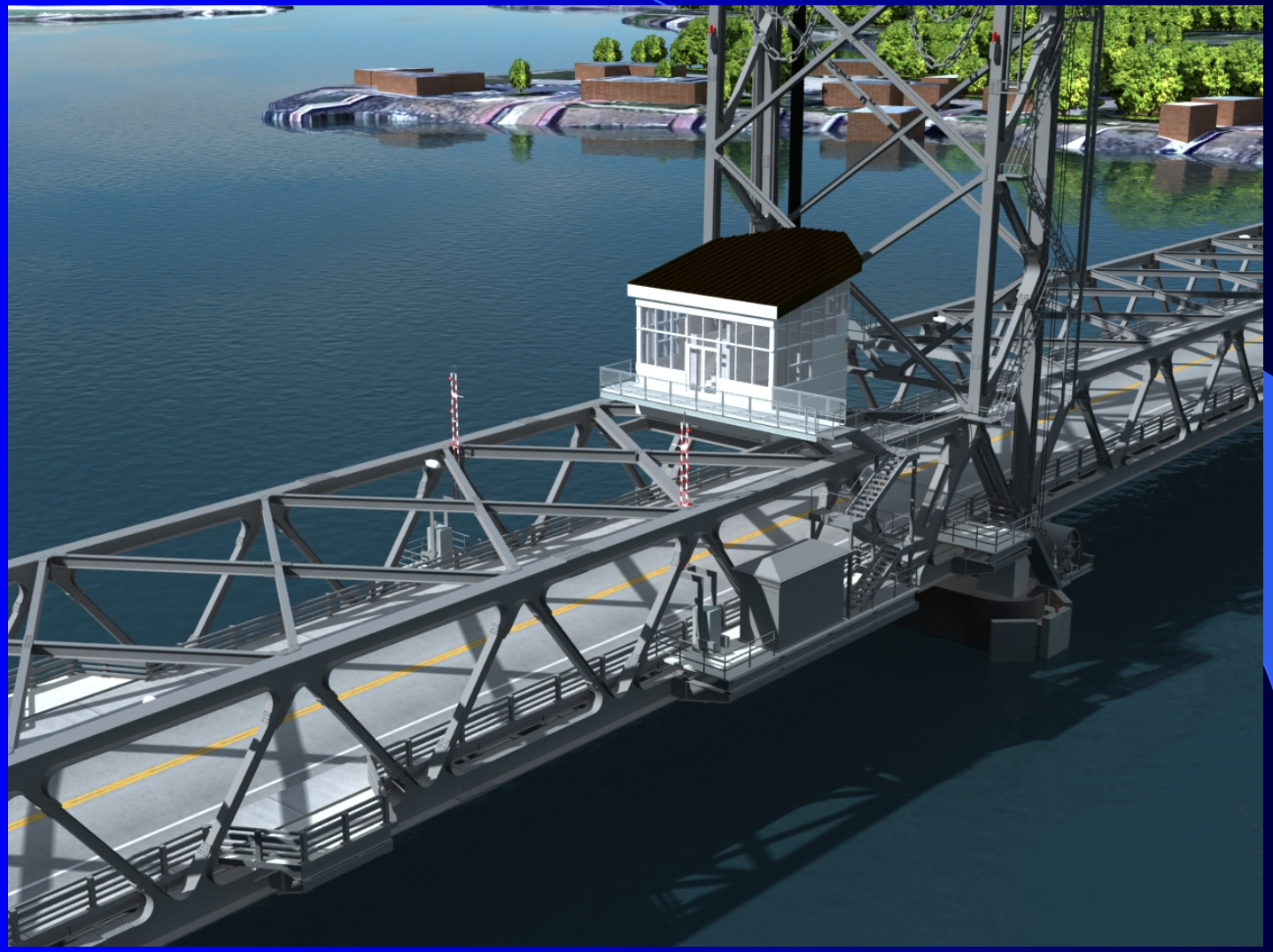

combined control/machinery house
operating drums
(moves lift span up & down)
operating cables

Mechanical Innovations

Mechanical Innovation #1:

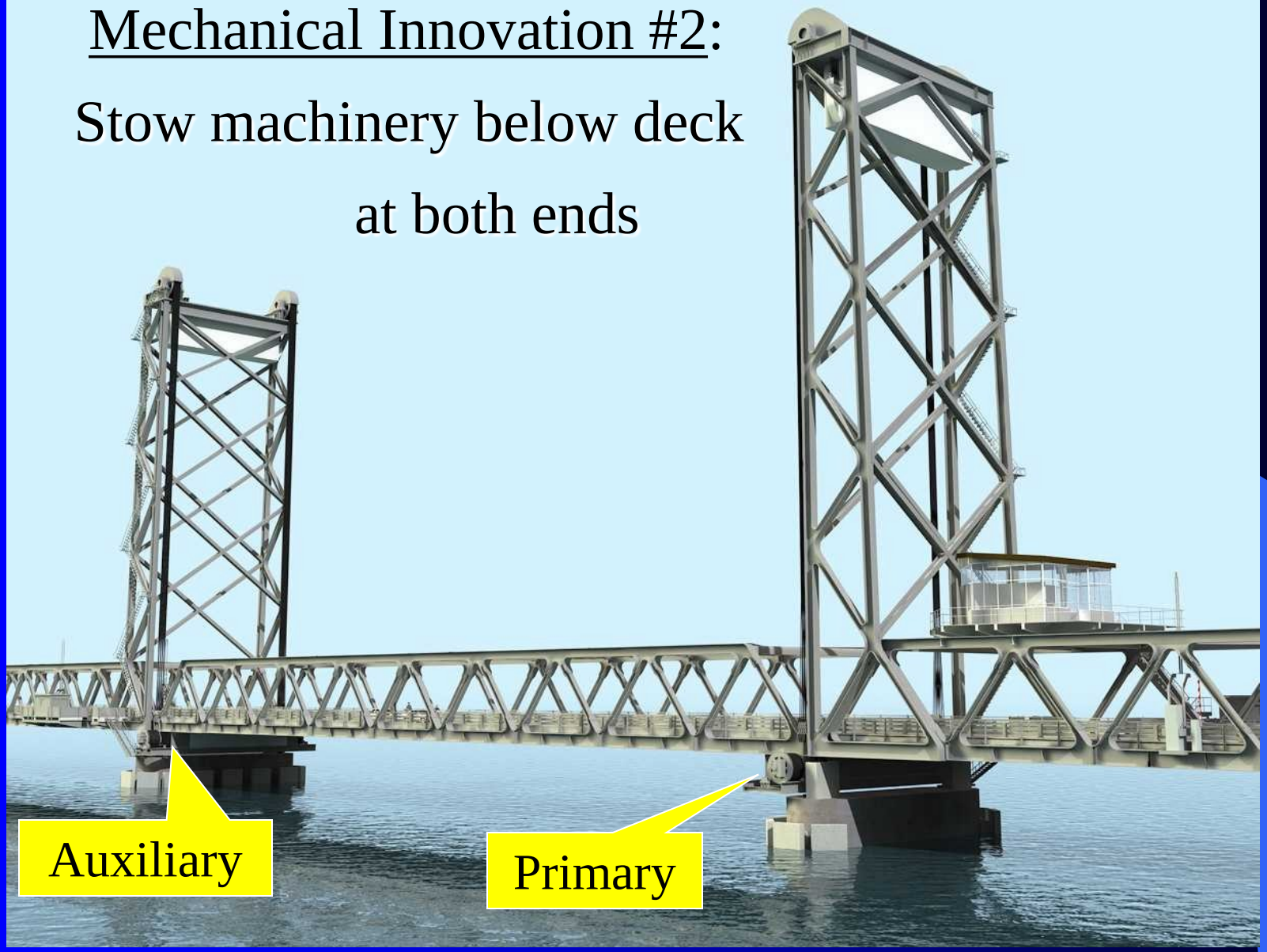
Remove control house & shorten truss height

Move control house to flanking span

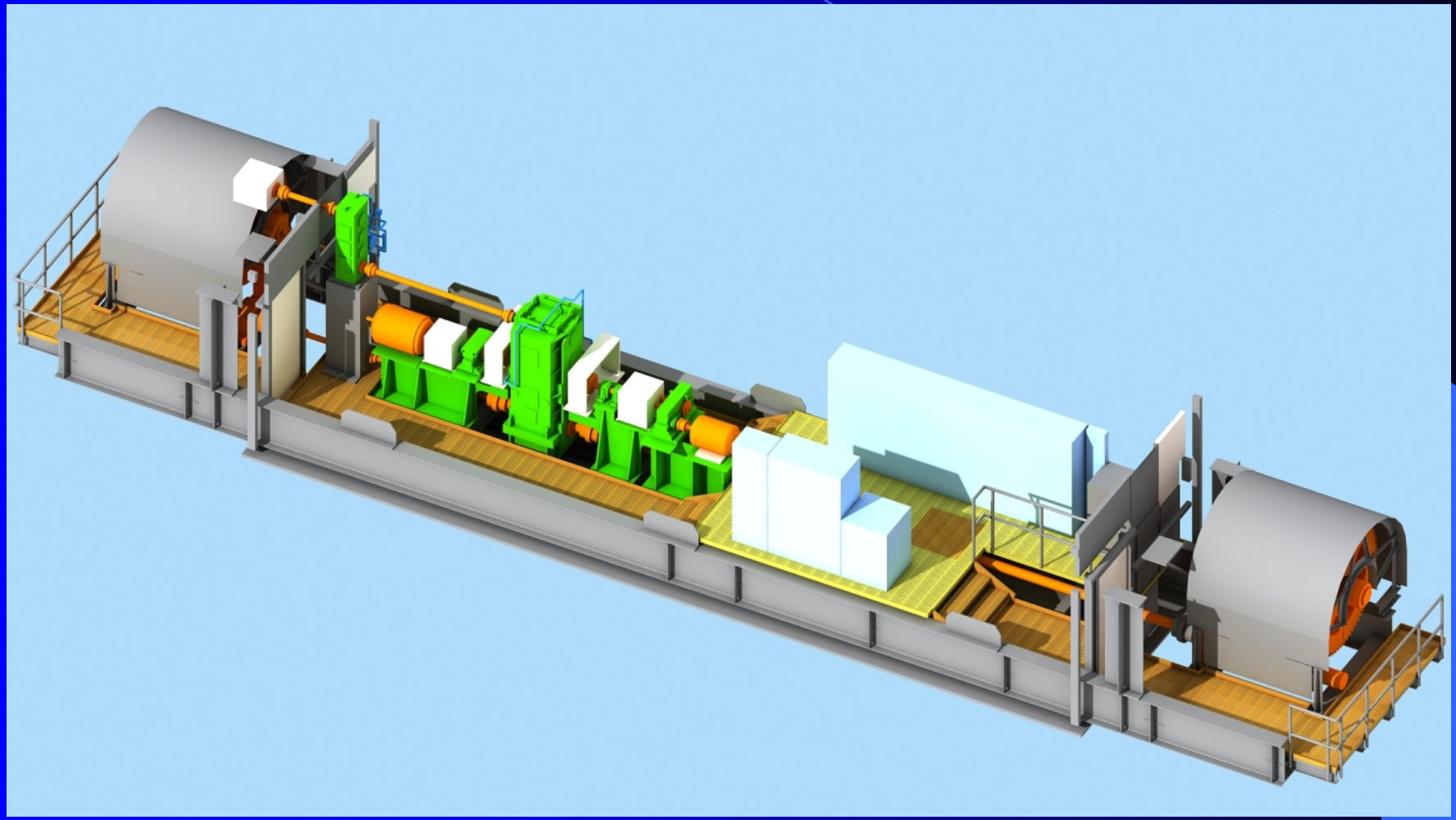


Mechanical Innovation #2:

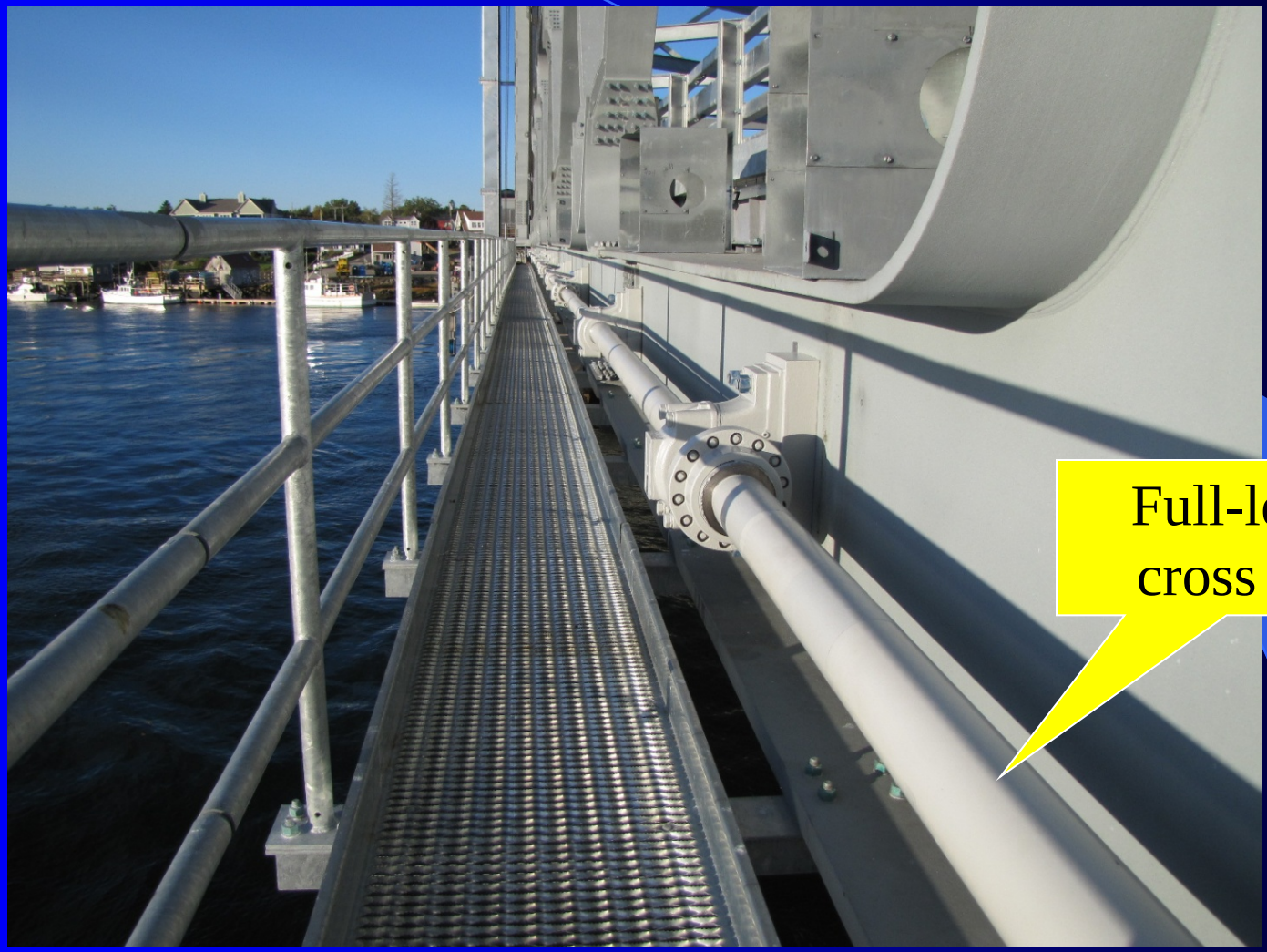
Stow machinery below deck at both ends



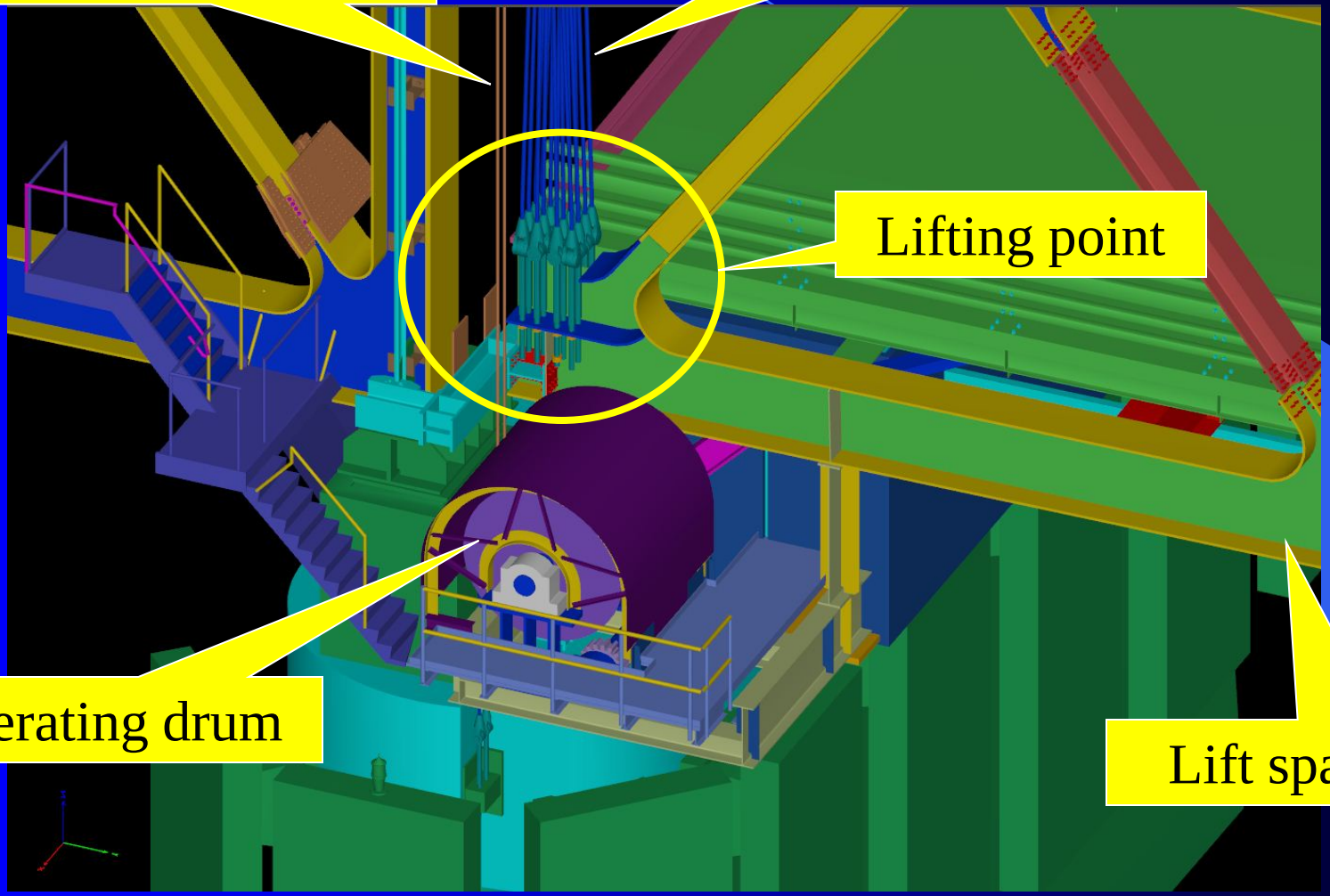
Machinery room contains mechanical & electrical



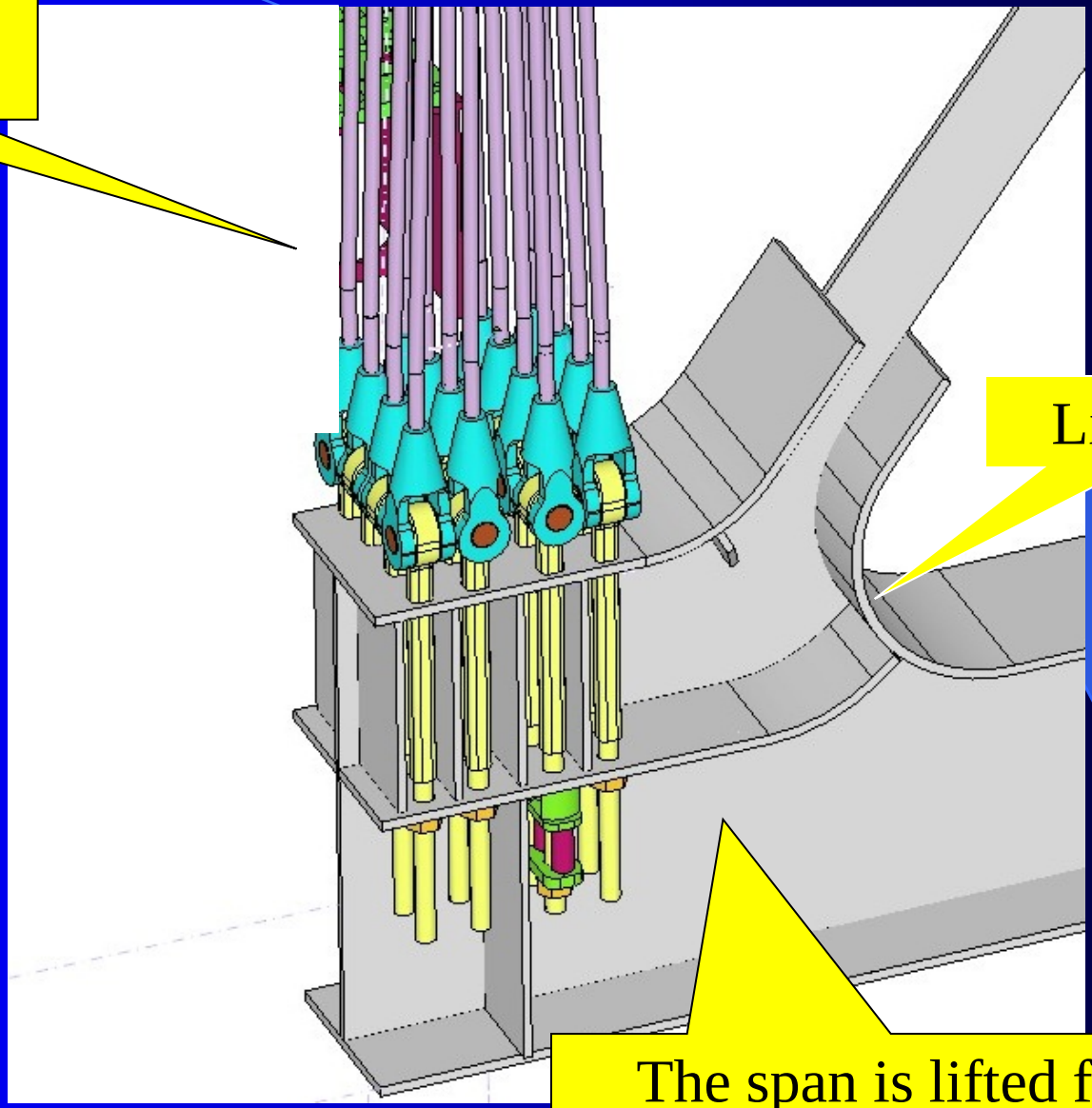
Connect machinery rooms with cross shaft



demonstration


Operating cables- up (2) down (2)
Counterweight cables (16)
Lifting point
Operating drum
Lift span

Counterweight cables (16)

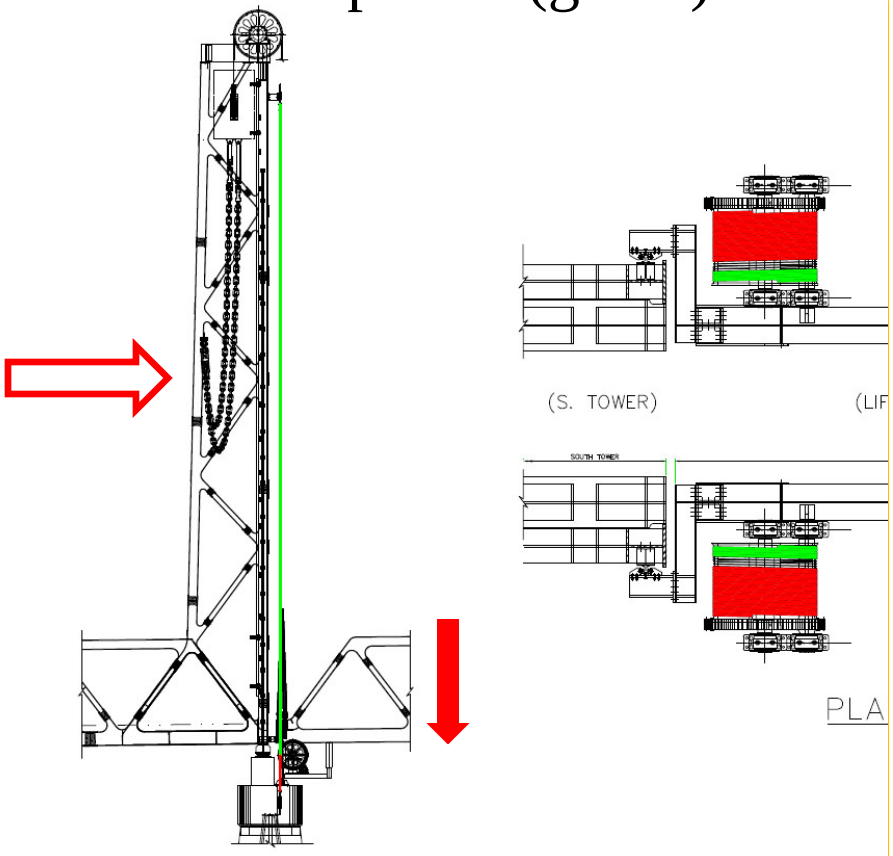


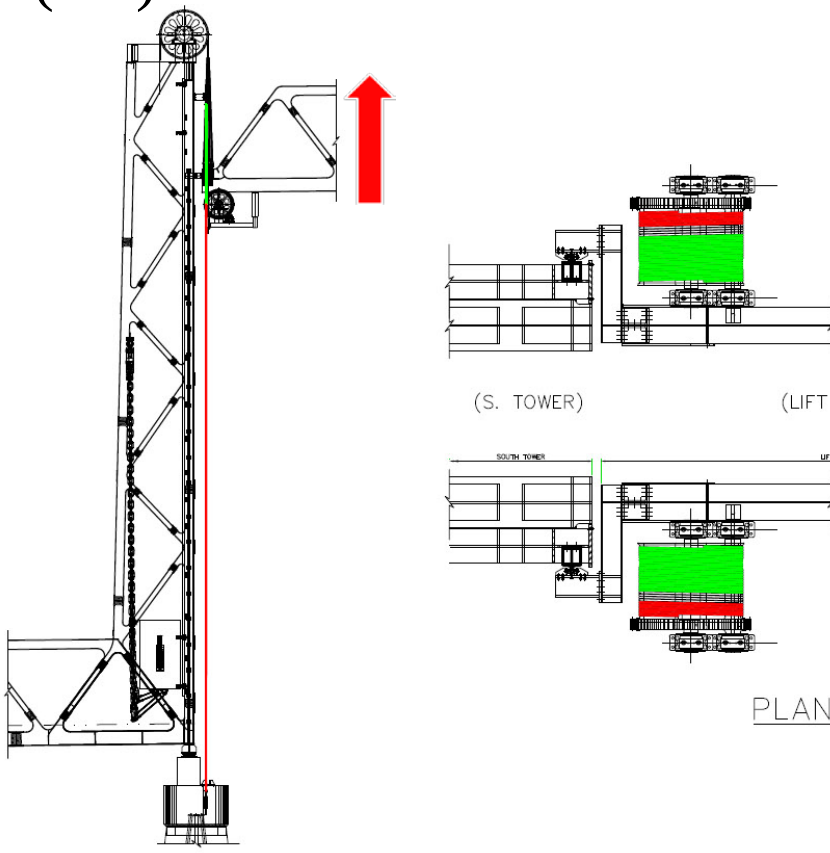
Lift span

The span is lifted from the bottom, shorten towers.

Operating cables play out from the same drum:

up-haul (green) & down-haul (red)





Balance chain is

a ship anchor chain - adds nautical touch

Mechanical Innovation #3

"bicycle wheel" sheave design

more spokes, lighter

better load distribution

original

new

Structural Innovations

Structural Innovation #1 -

Ted Zoli wanted to address

gusset plate connections

The most troublesome truss feature

Gusset plates involved in collapse of Minnesota I-35W bridge August 1, 2007.

On Memorial Bridge deterioration

forced repairs, down-postings, permanent closure

Structural Innovation #1 – No gusset plates

Blend intersecting members into one piece with curved flanges (“knuckles”)

This new strategy
makes this truss
the first of its kind … in the world.

Impact #1 – Cold bending of FCM flanges

Prohibited in AASHTO spec

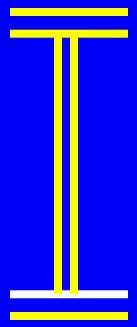
Under review & ballot

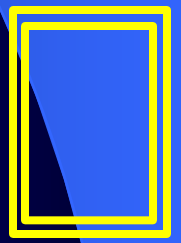
Impact #2 – Move splice higher -
easier to install, maintain, inspect;
use standard bolted splice

Impact #3 – Simplify chord shape

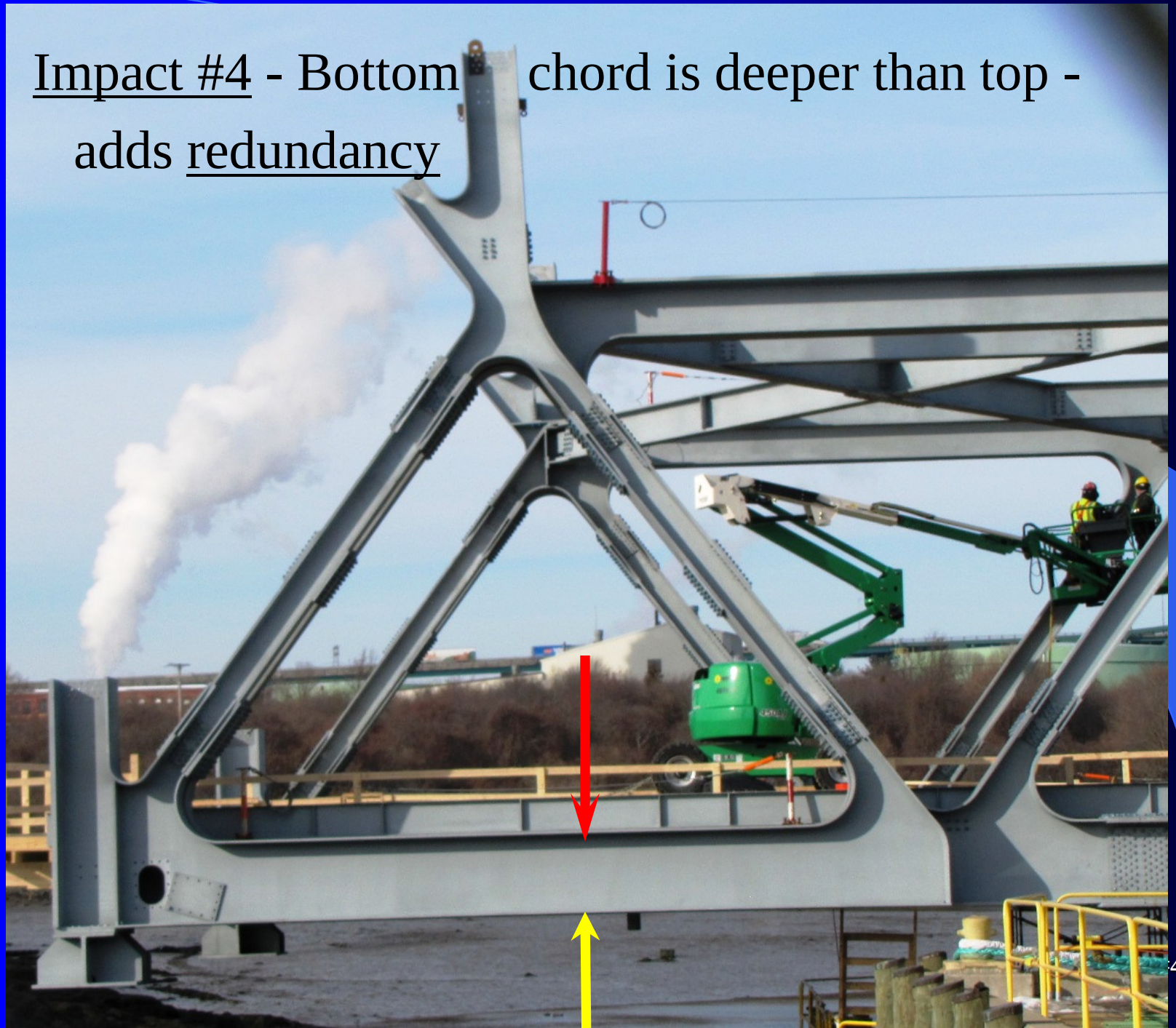
I-shape not box-shape &

use standard girder fabrication





Impact #4 - Bottom chord is deeper than top - adds redundancy



Impact #5 - Outer flanges are larger transfers load away from knuckles

Impact #6 Eliminate stringers – with deeper bottom chord & more floor beams

Impact #7 - Use thicker plates -

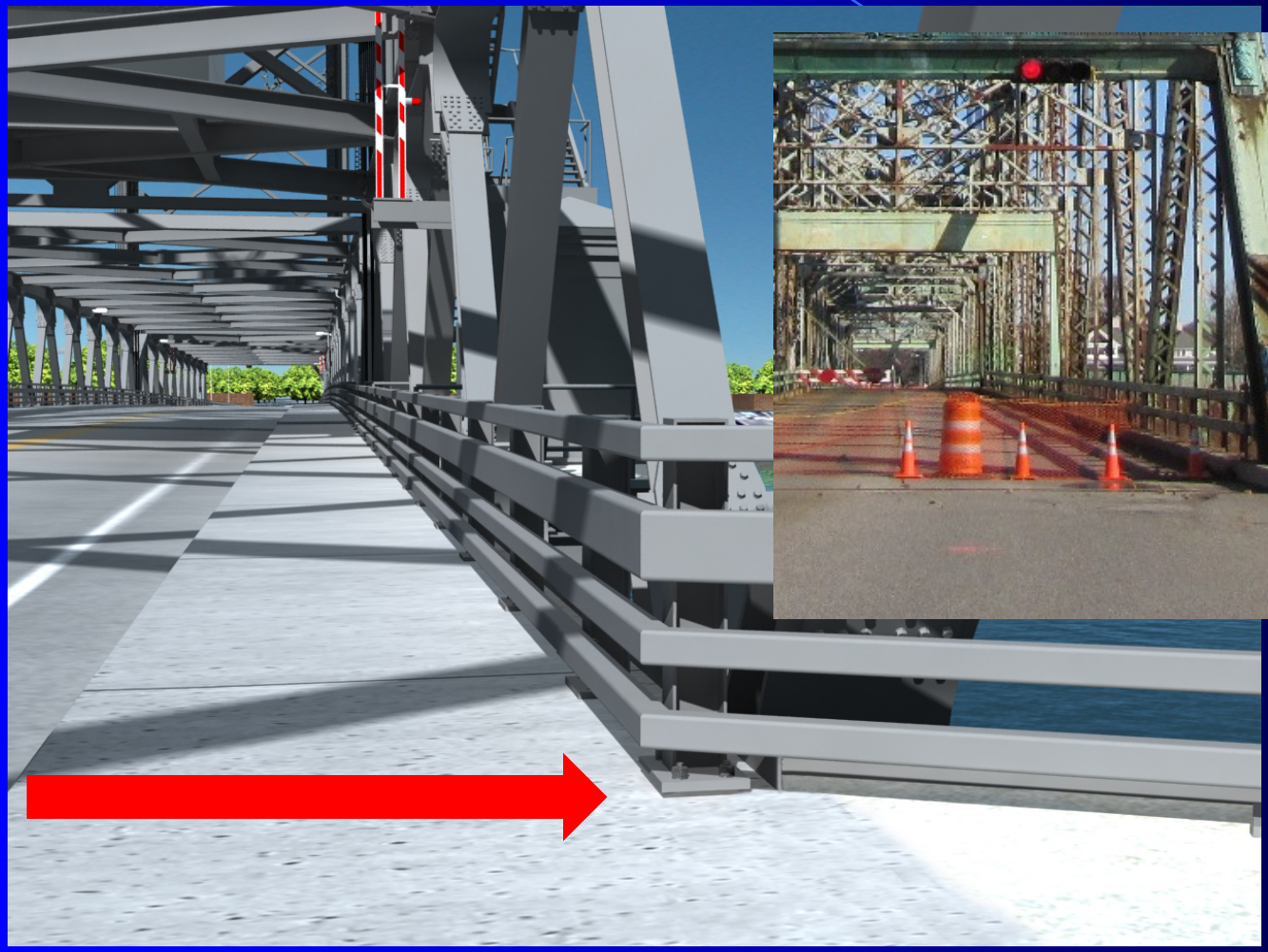
adds robustness -

fewer bolts with standard splice

Impact #8 Use rolled shapes for diagonals

Structural Innovation #2 - Move sidewalks inboard

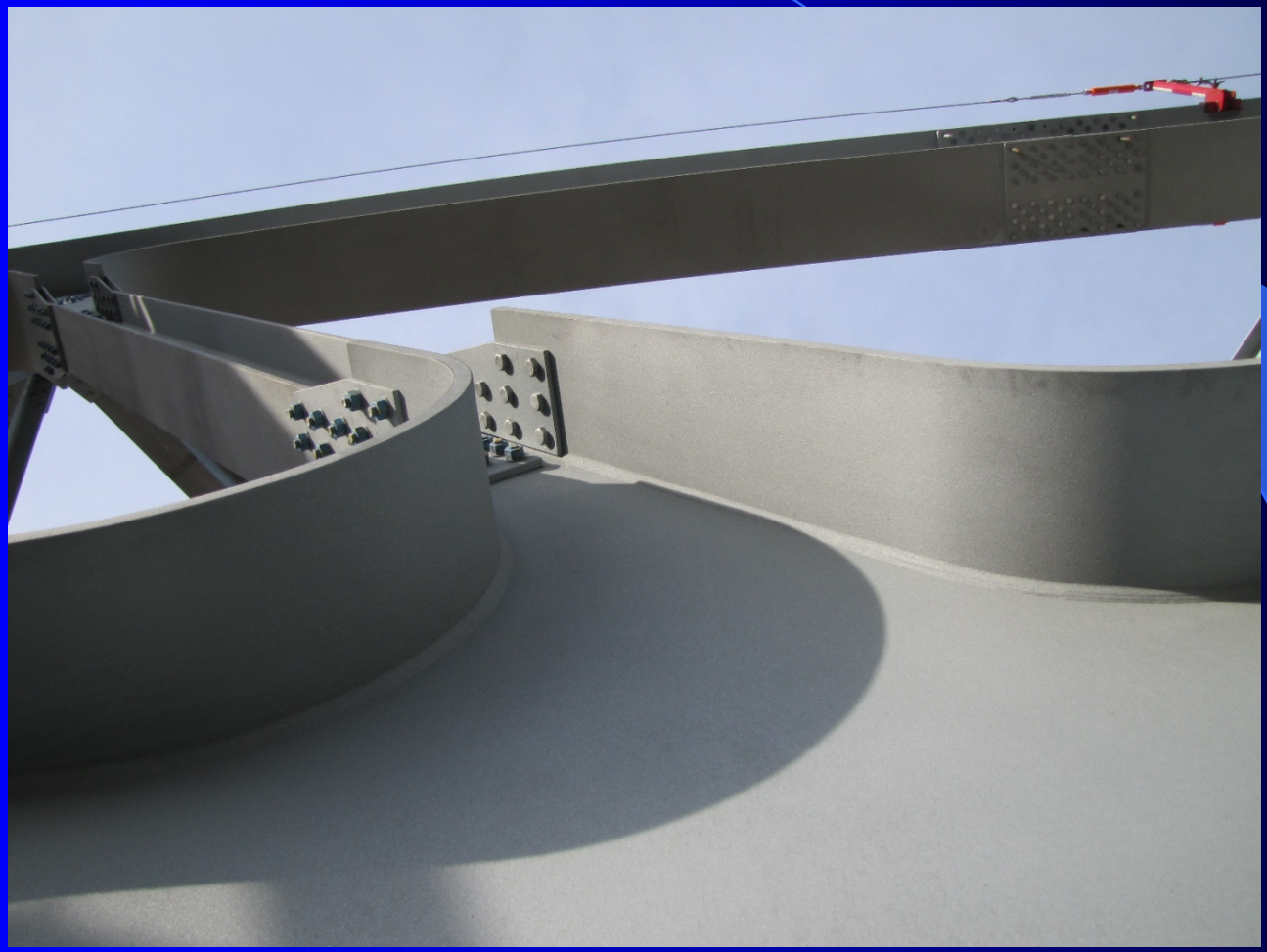
Truss is farther from salty roadway runoff



Structural Innovation #3

Three truss spans have identical geometry

Structural Innovation #4 - Metallize -
most durable industrial coating available



Steel Fabrication Challenges

Fabrication Challenge -

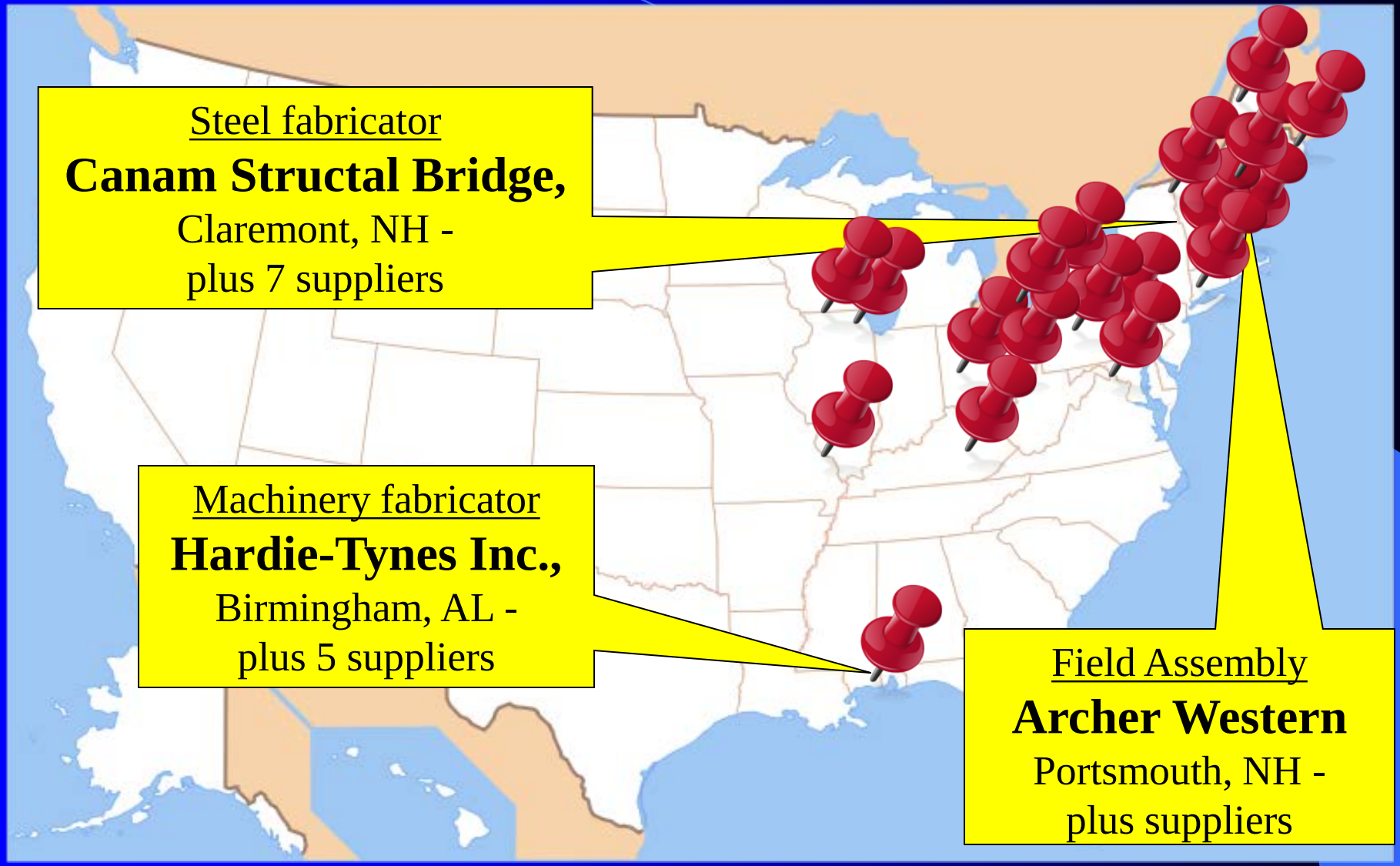
Meet aggressive schedule

January 2012
Contract signing

August 2013
Bridge opening

~~*19*~~ *20 months!*

Fabrication Challenge Coordinating many fabrication sites



Curved Plates

Greiner Industries

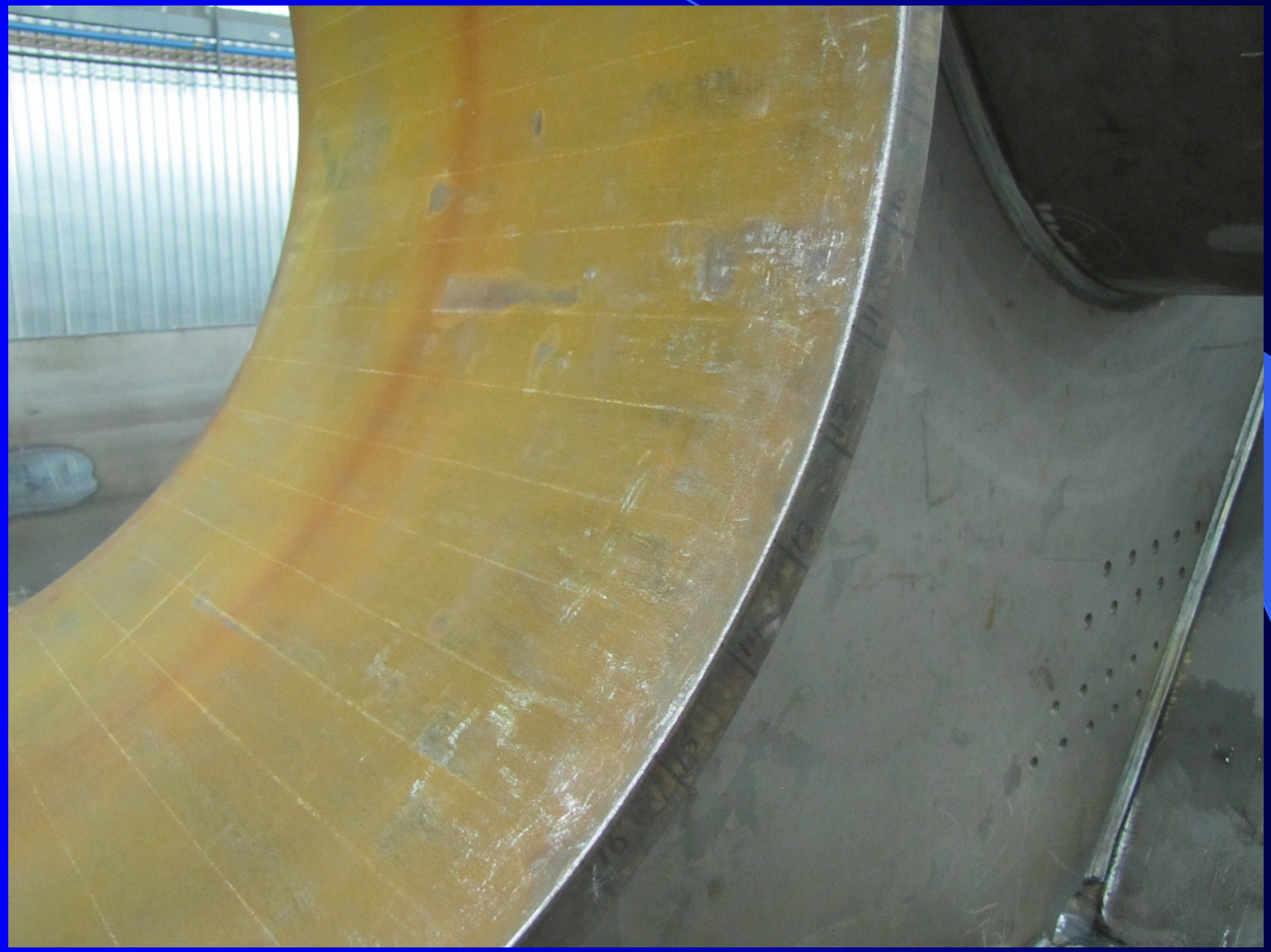
Mt. Joy, PA

Fabrication Challenge #1 – Curved flange plates

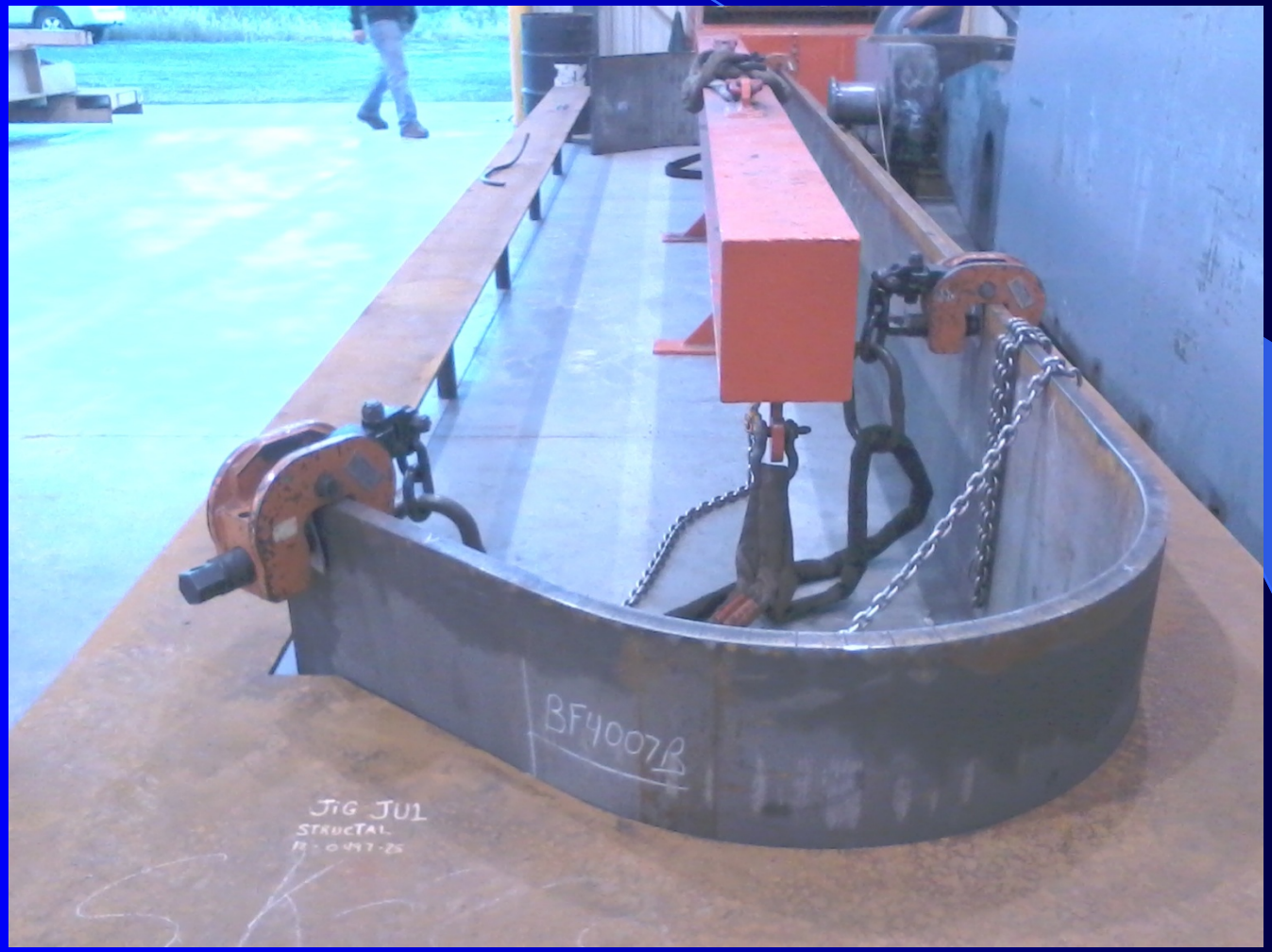
Photo: Greiner Industries

Longer plates required “Bull-Dog” press roll due to overhead clearance

Press roll makes incremental bends



Bent plates must fit template precisely



Inspect bent surfaces for cracks

Check hardness of flame-cut edges

Butt weld longest double-bent plates

Structural Steel Fabricator

Canam Structal Bridge

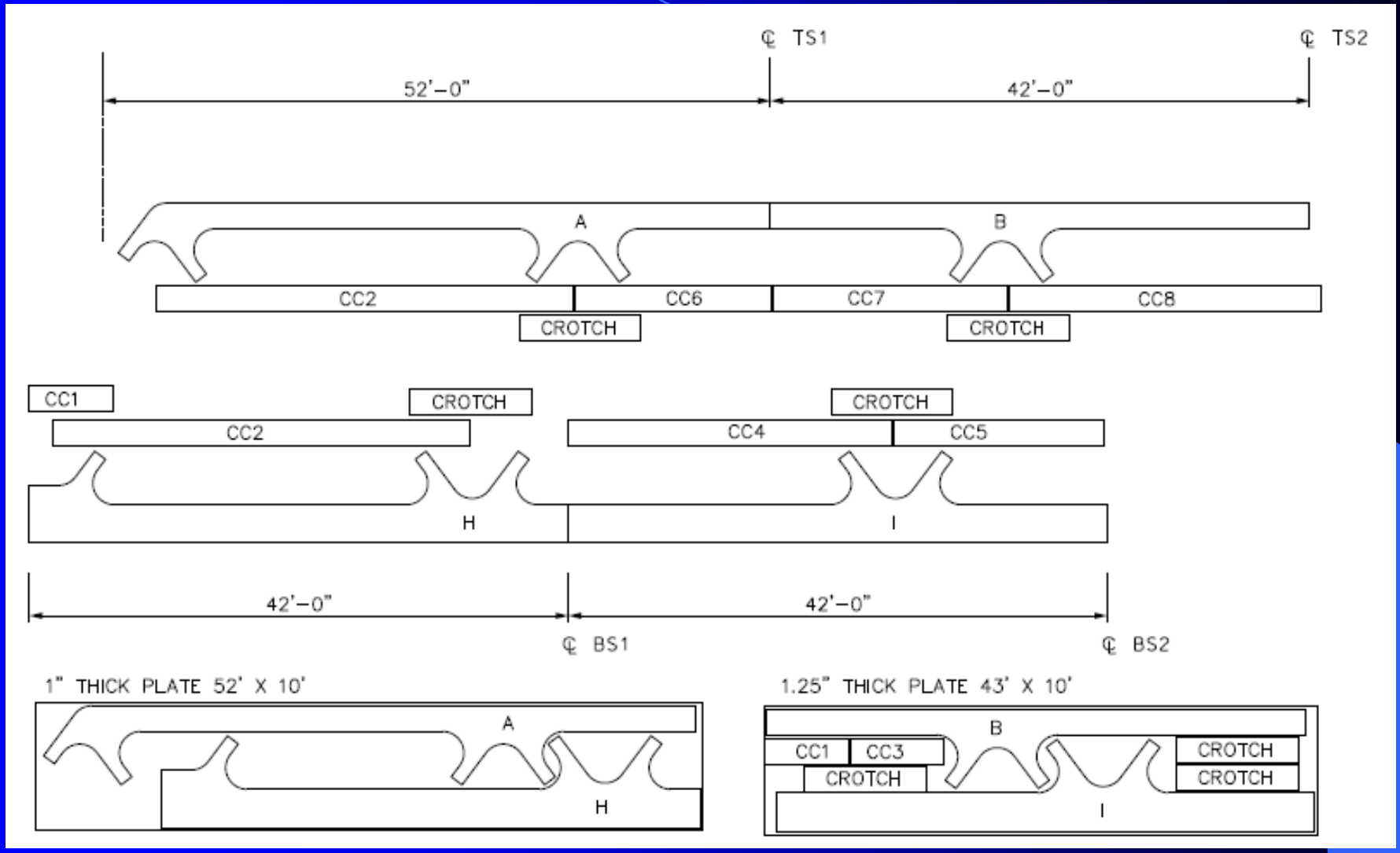
in Claremont, NH

All primary structural steel was fabricated in NH

CNC burning equipment

cuts complex shapes and pre-drill holes

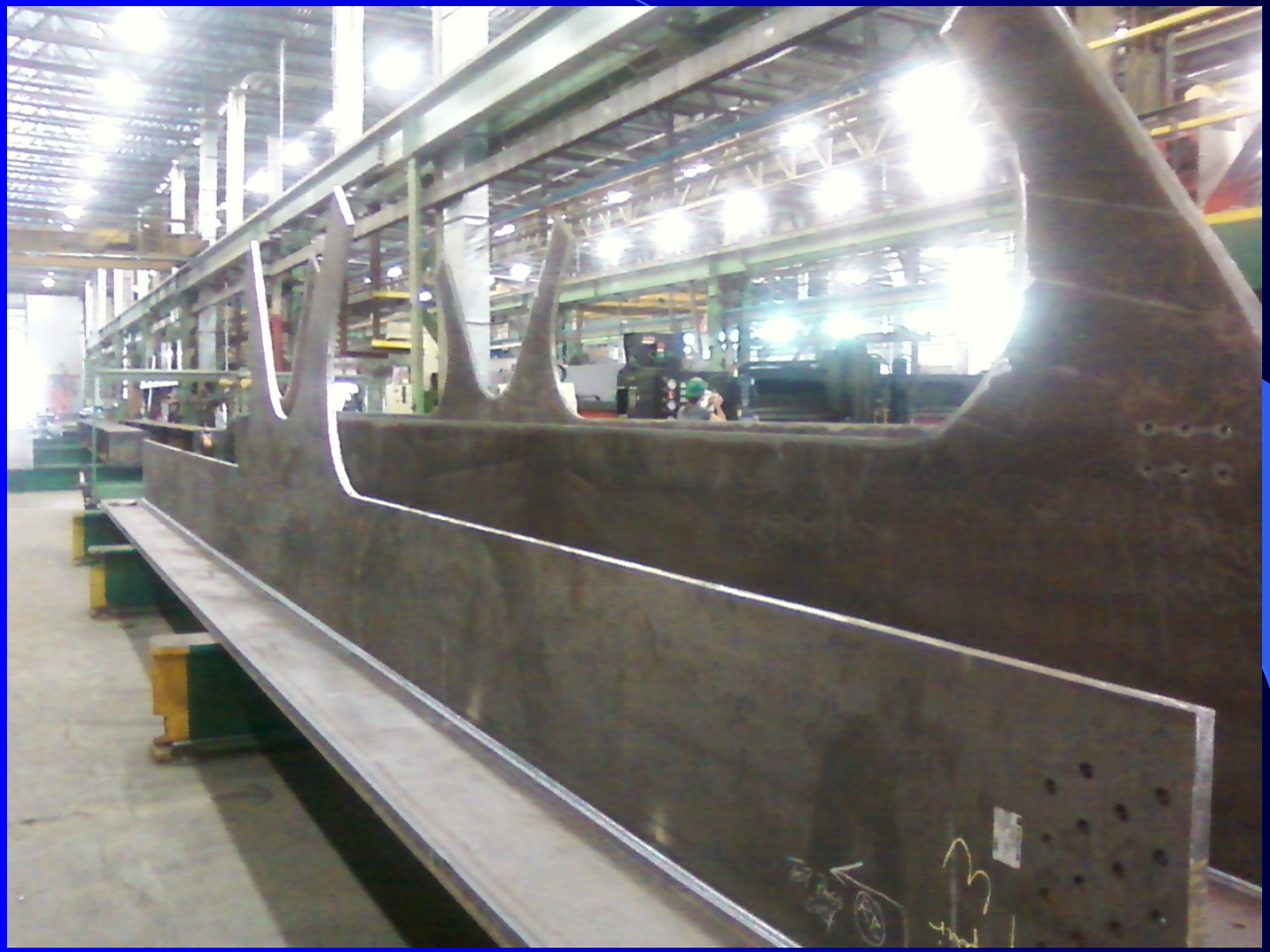
efficient use of plate & minimize waste.



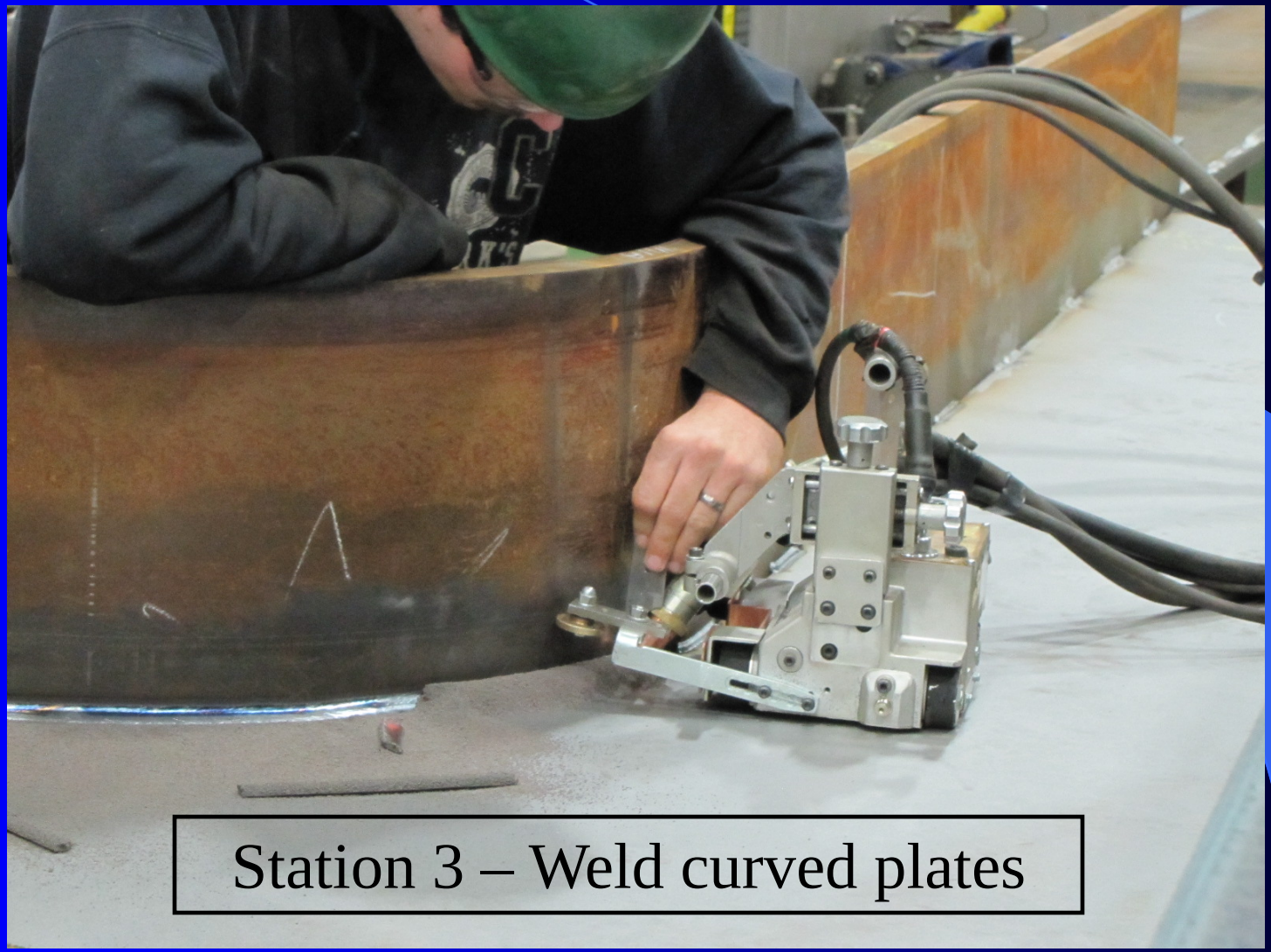
Fabrication challenge - Weld each piece at four stations

Straight runs welded in vertical “girder-maker”.

Ready to fit curved flanges to “knuckles”.

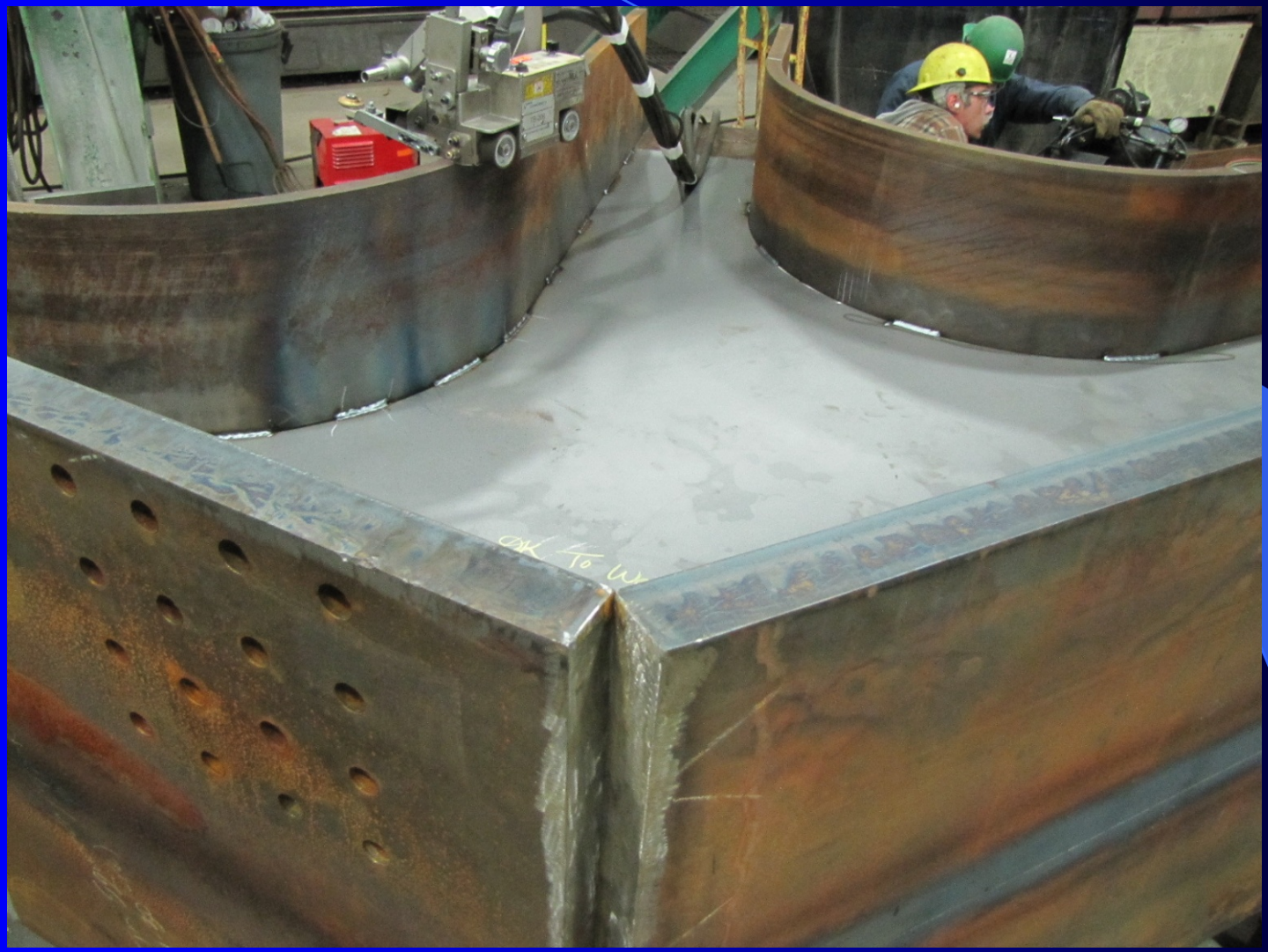


Welding curved plates is new



Demonstration …

Knuckle space is tight for welding equipment



Station 4 - straight weld on curved plates

Large 5/8” welds require three passes vs. one

Fabrication challenge- Requires careful handling

Check for straightness & camber, correct as needed

Fabrication challenge- Full-shop assembly

– little adjustment available

Fabrication challenge – Metallize members ,

i.e. thermal spray coated (TSC)

Qn – How has metallizing performed in testing?

- AWS C2.14 (1953-1974) - 19-year study- TSC is the best
- ASTM Report on TSC Performance (1987) TSC is the best
- LaQue Center for Corrosion Technology (1952-1996)

  44-year study at Kure Beach, NC TSC is the best
- FHWA (1996) RD-96-058 Study TSC is the best
- BSI British Standards Institute BS 5493 TSC is the best
- FHWA (1987-2007) 20-year performance on NJDOT

  Mathis Bridge 20-year study of 47 systems TSC is the best
- KTA Report on Estimated Service Life TSC ranks the best

- Higher cost (1/3 more); Twice expected life vs. paint

Metallized bridges in New England

RI Providence River Br (2005)

Lake Champlain Bridge (2011)

RI Pawtucket River Br (2012)

MA I-95 Whittier Br (2014)

TSC requires cleanest (SP5), angular profile, 100% grit, hand blasting

Twin-wire electric arc (100% zinc)

Demonstration …

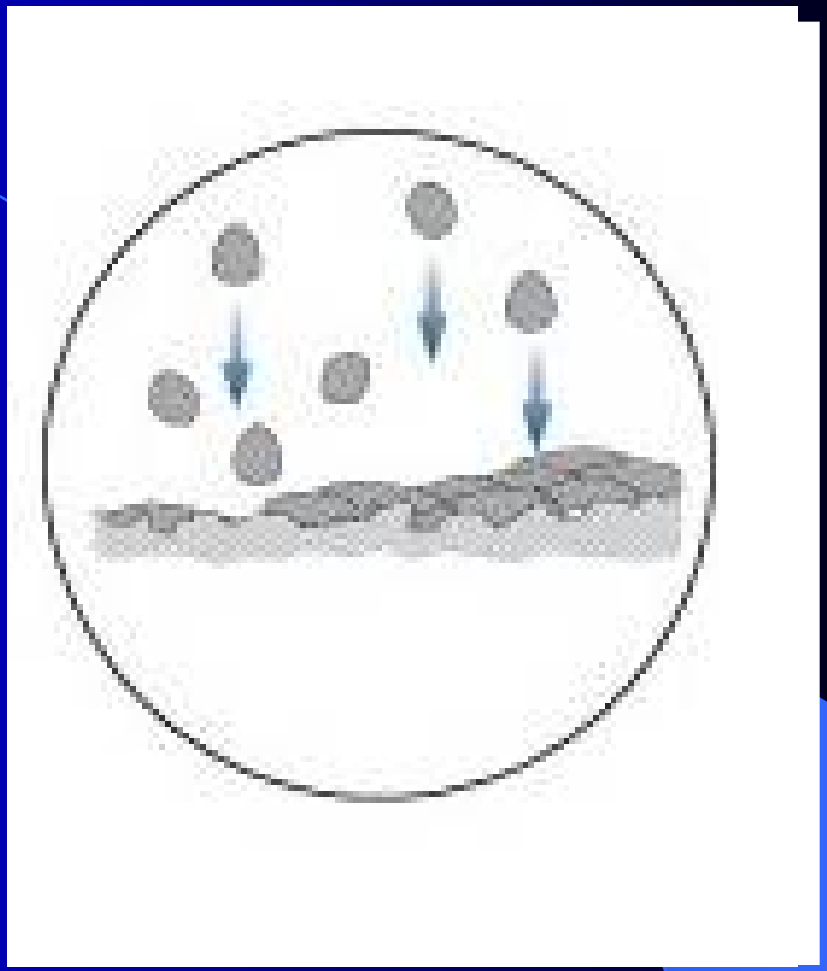
wire melts at arc,

molten particles propelled

by compressed air…

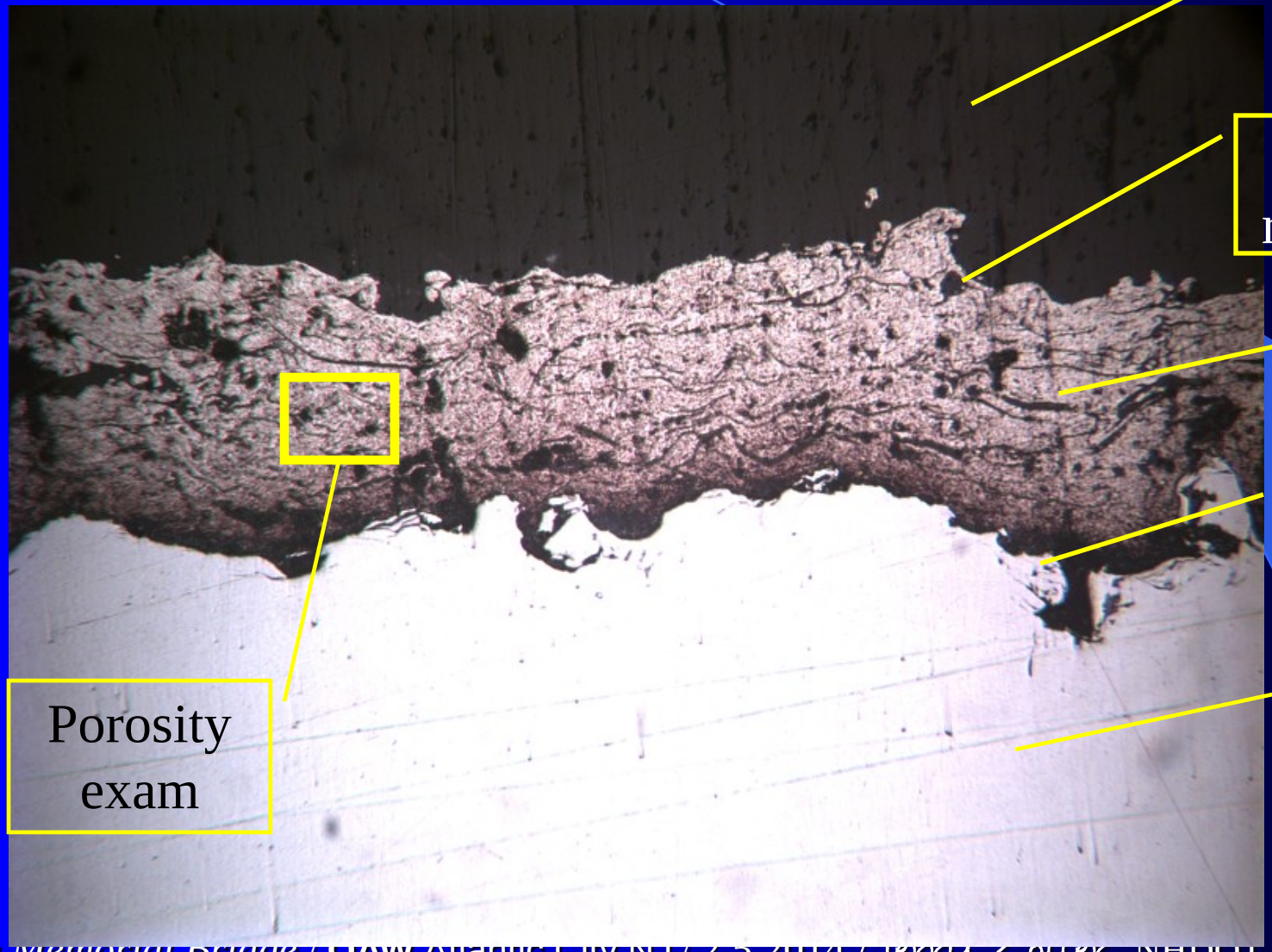
slam onto steel …

solidify

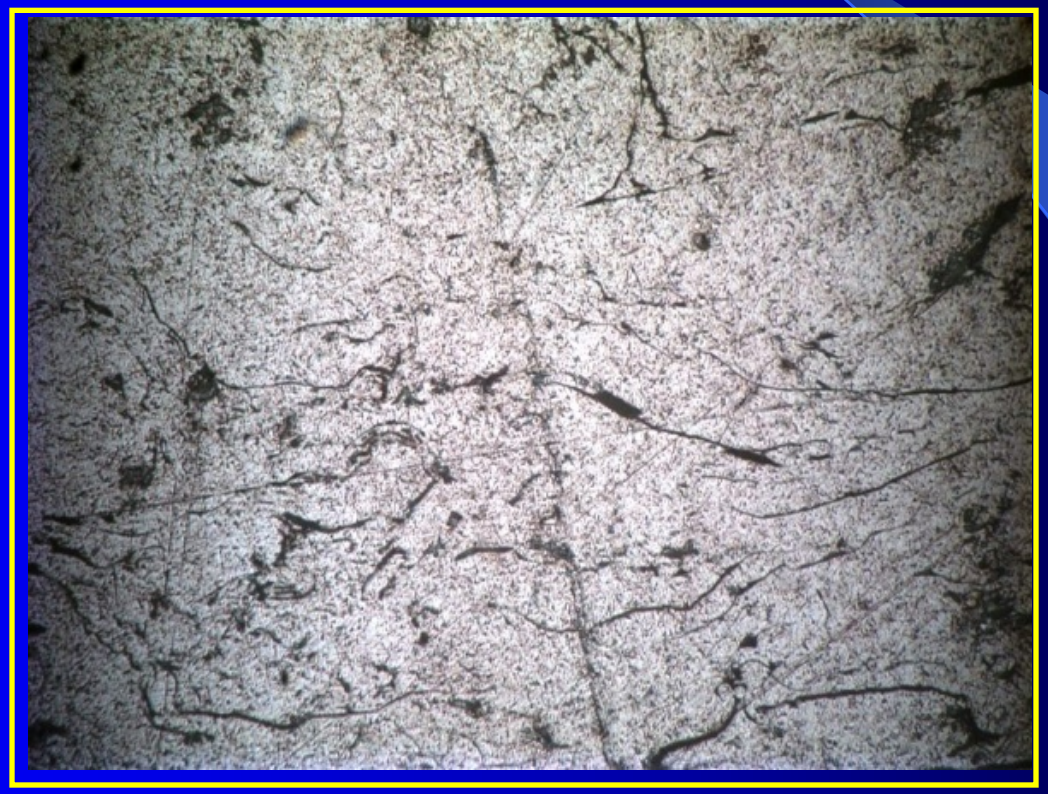


adhesion depends on mechanical bond with profile

- Examine metallizing for porosity (100x)

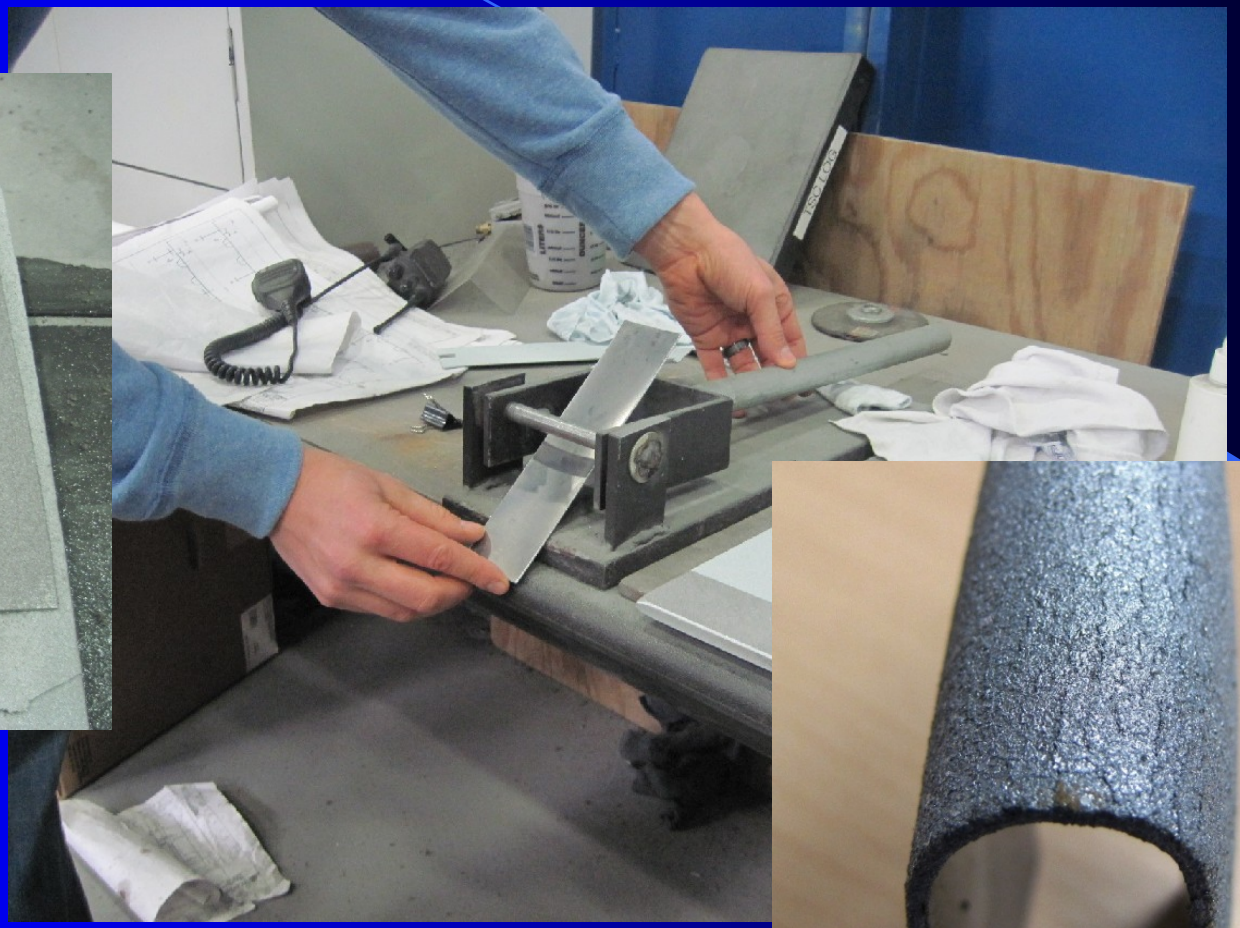


- TSC porosity check (at 630x magnification)
- Require porosity < 10% Achieved 4.6%



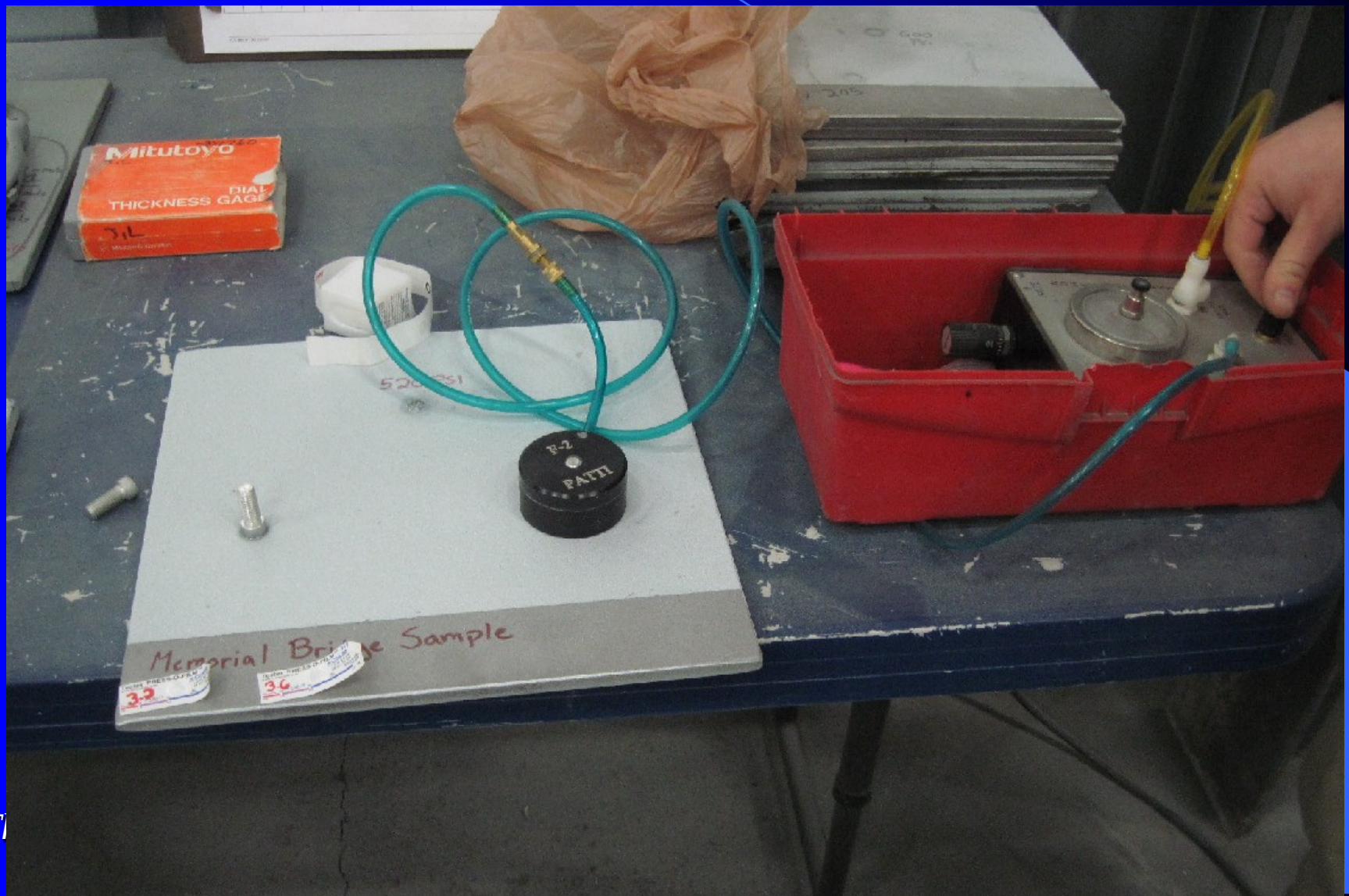
Qn – Testing for quality

Pre-production coupons



Quality Control – adhesion test

require 500 psi min. pulloff



Quality Control – chisel adhesion test

apply clear seal coat

Pleasing “Portsmouth Pewter” finish

Thickness of metallizing

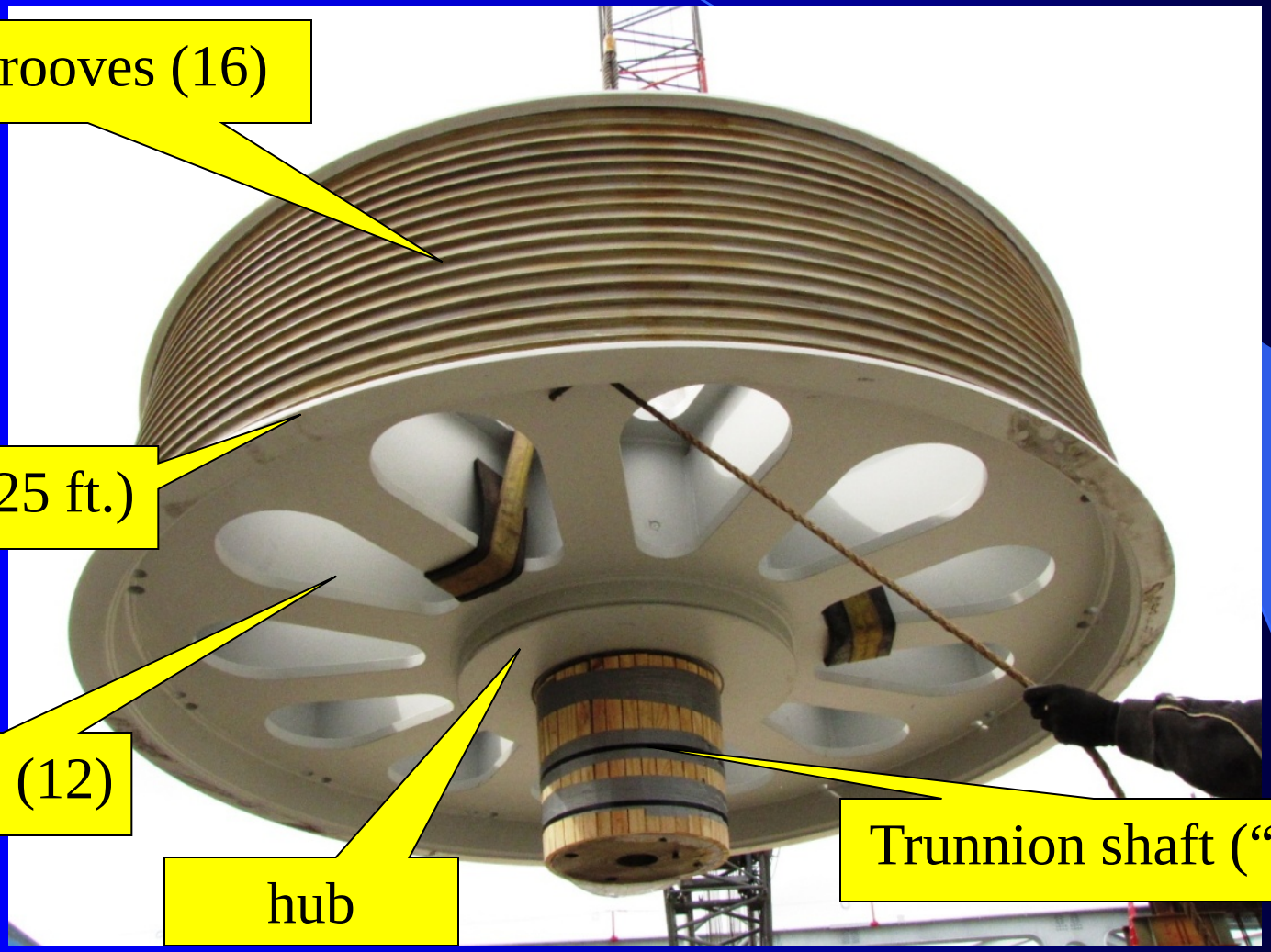
10 mils ± 2

14 mils ± 2

Machinery Fabricator

Hardie-Tynes Company of Birmingham, AL

Terms for Counterweight Sheave



Counterweight Sheave

Machining Trunnion Shaft

The trunnion fit requires shrinking in liquid nitrogen at -325° F.

Lifting jig - lower trunnion into cooling tank

Remove trunnion after 7 hours of cooling

Lower trunnion into hub

Trunnion expands to fit tightly

dowels add safety factor

Machine cable grooves into rim.

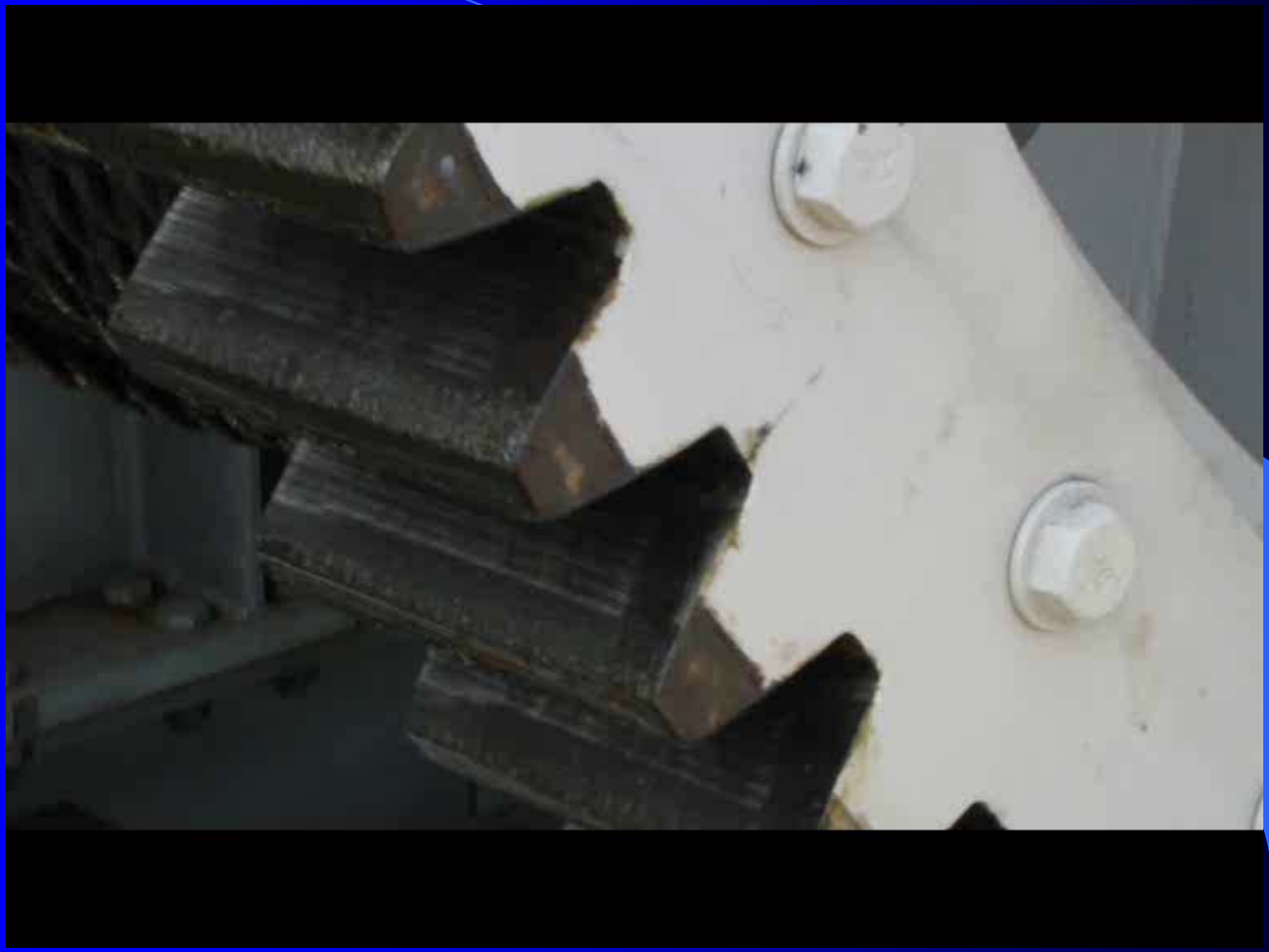
Sheaves are delivered

Finished operating drum

Spiral cable grooves (16)

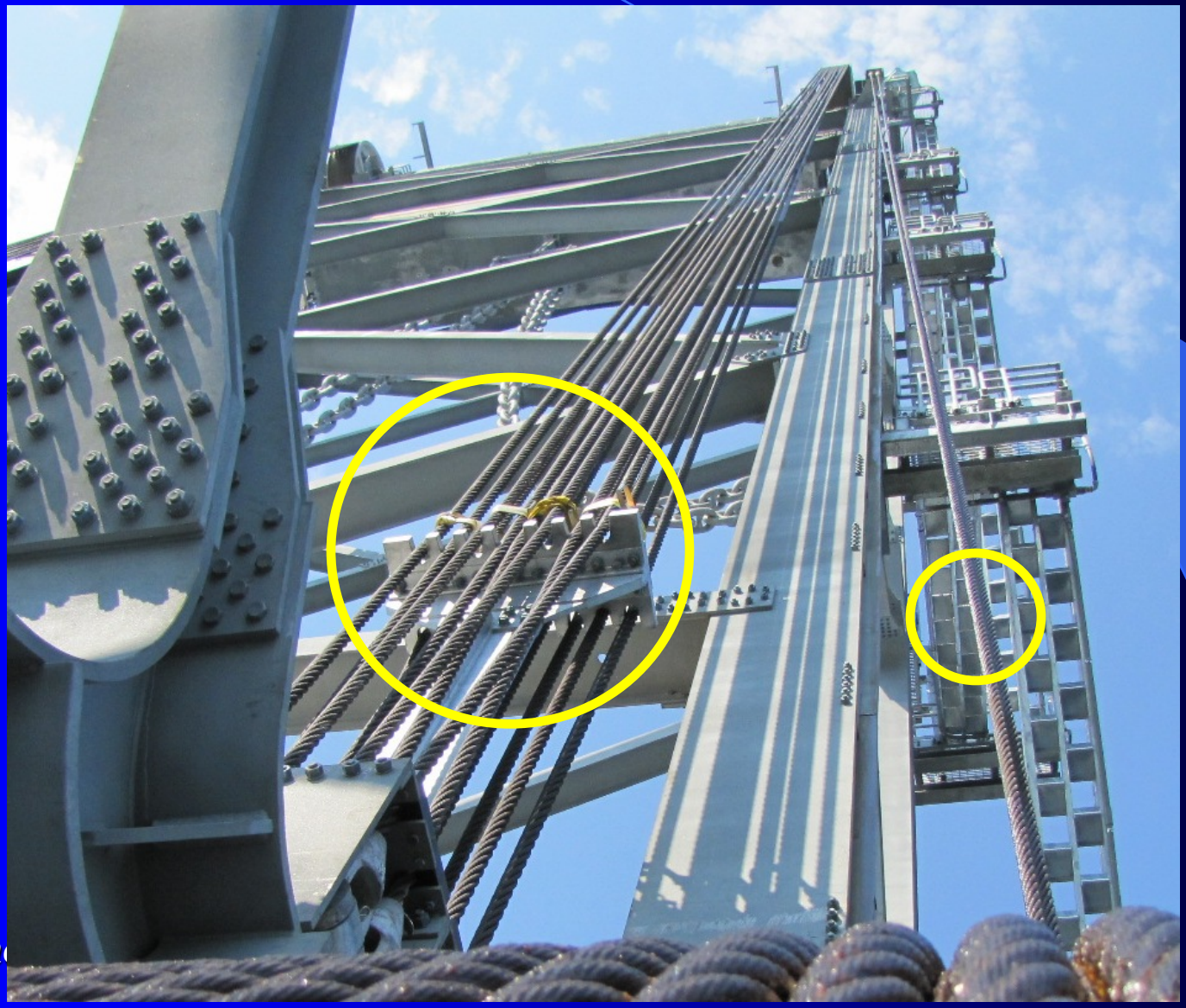
Gear ring

demonstration

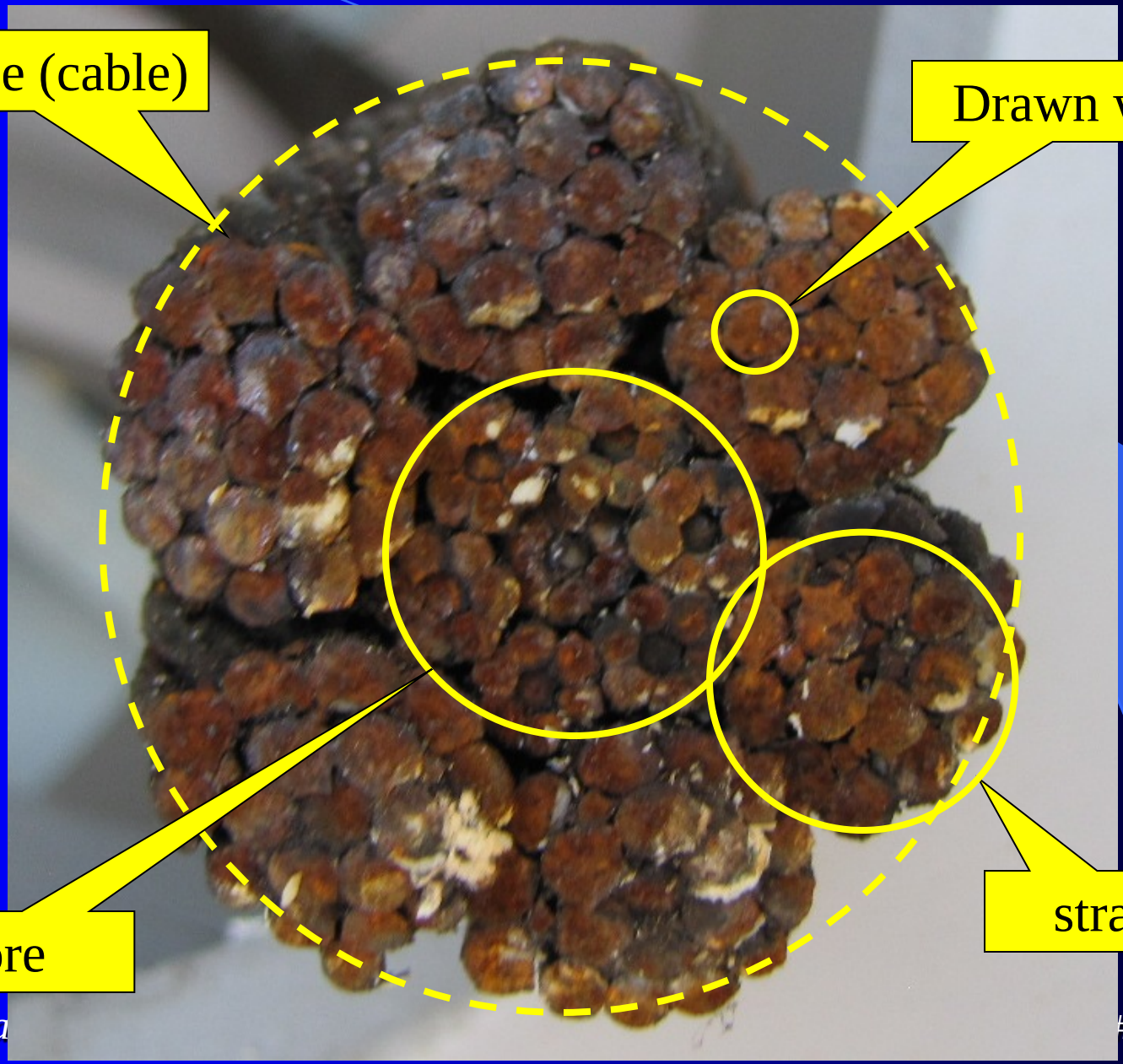


Wire Rope (Cable) Fabricator

Cable supplier – WireCo World Group – St. Louis

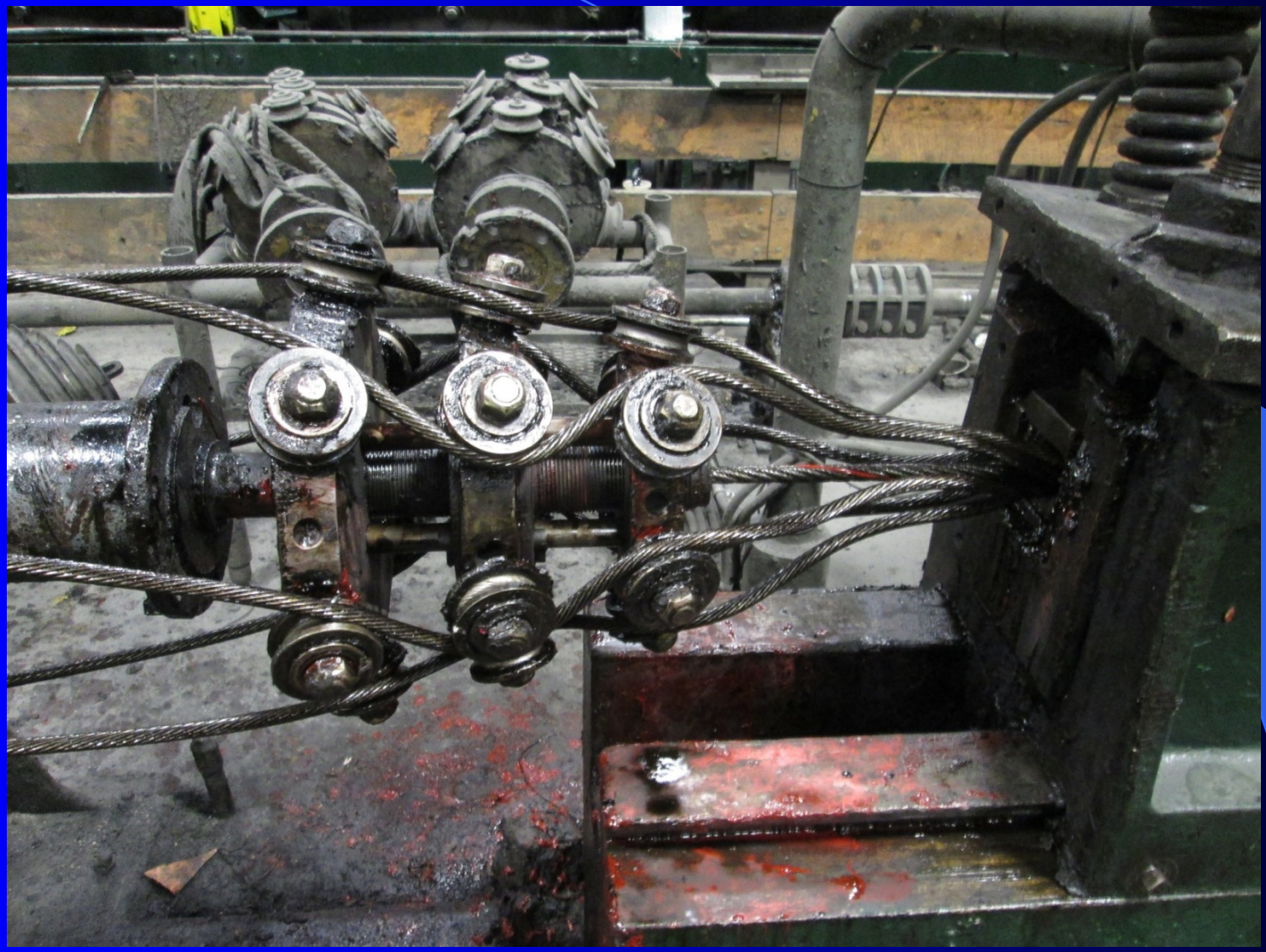


Cable Terminology

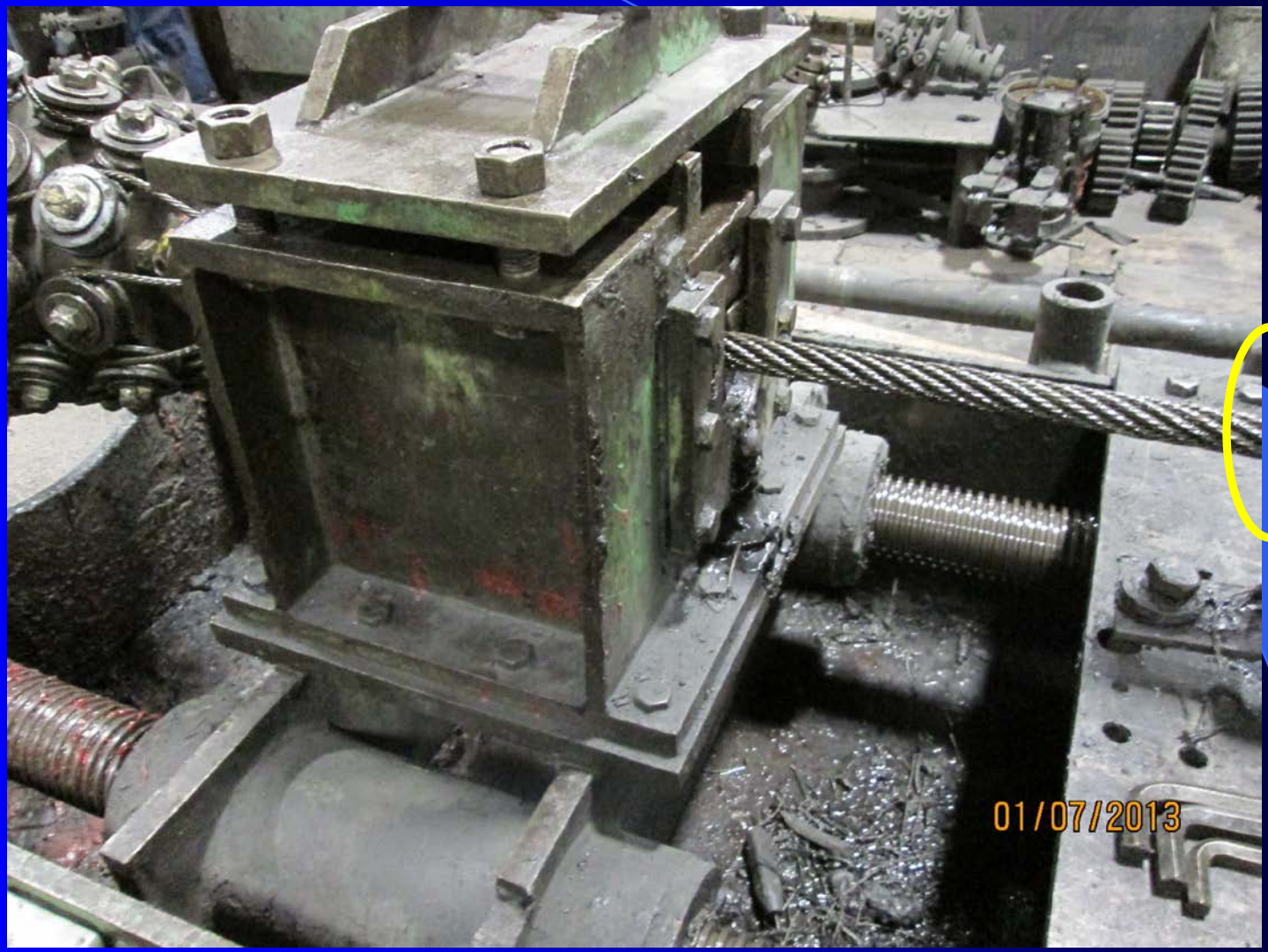


Wires are woven into a strand in the wheel jig…

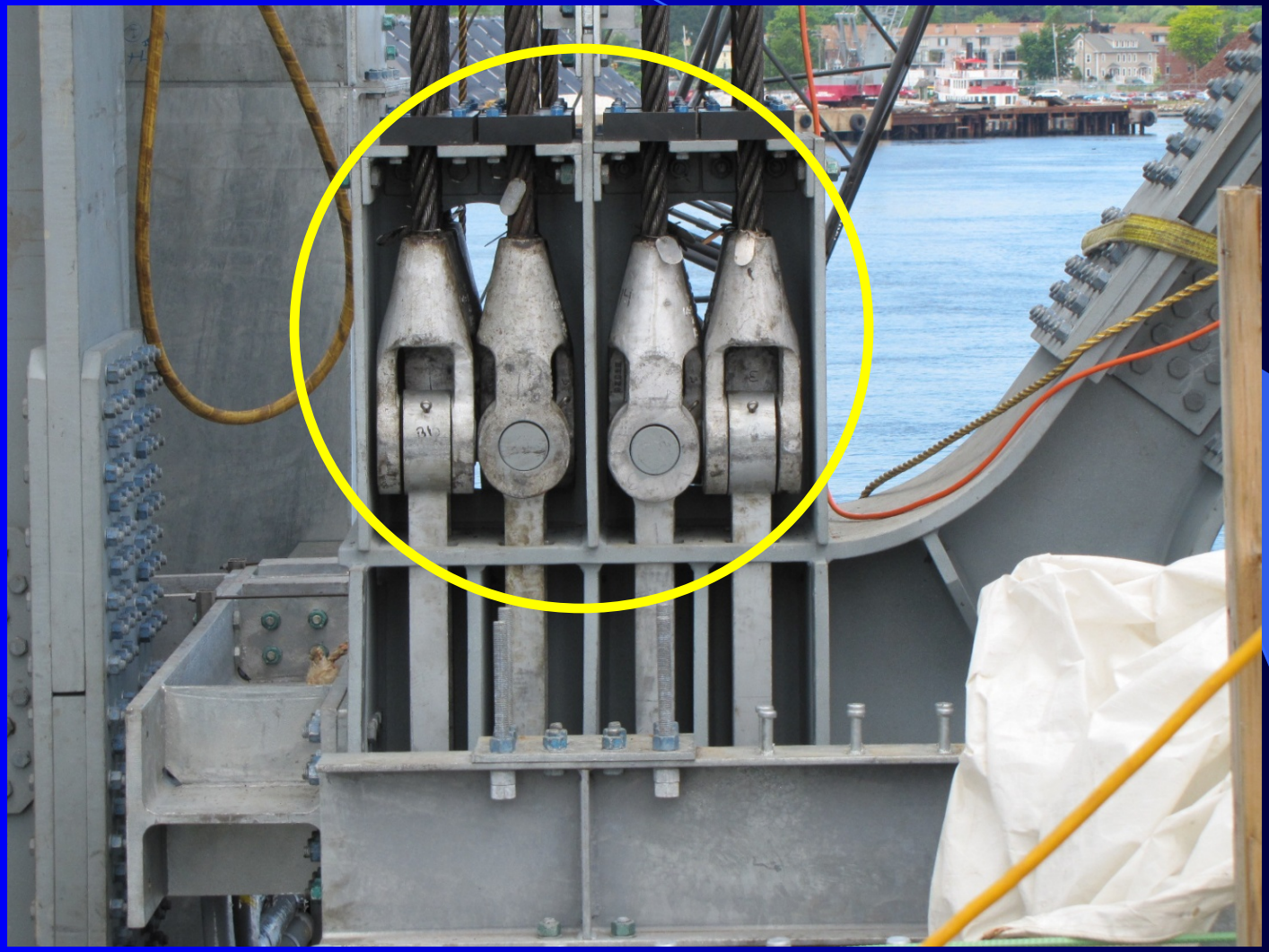
… strands are woven into a cable …



… in the “closing die” box …

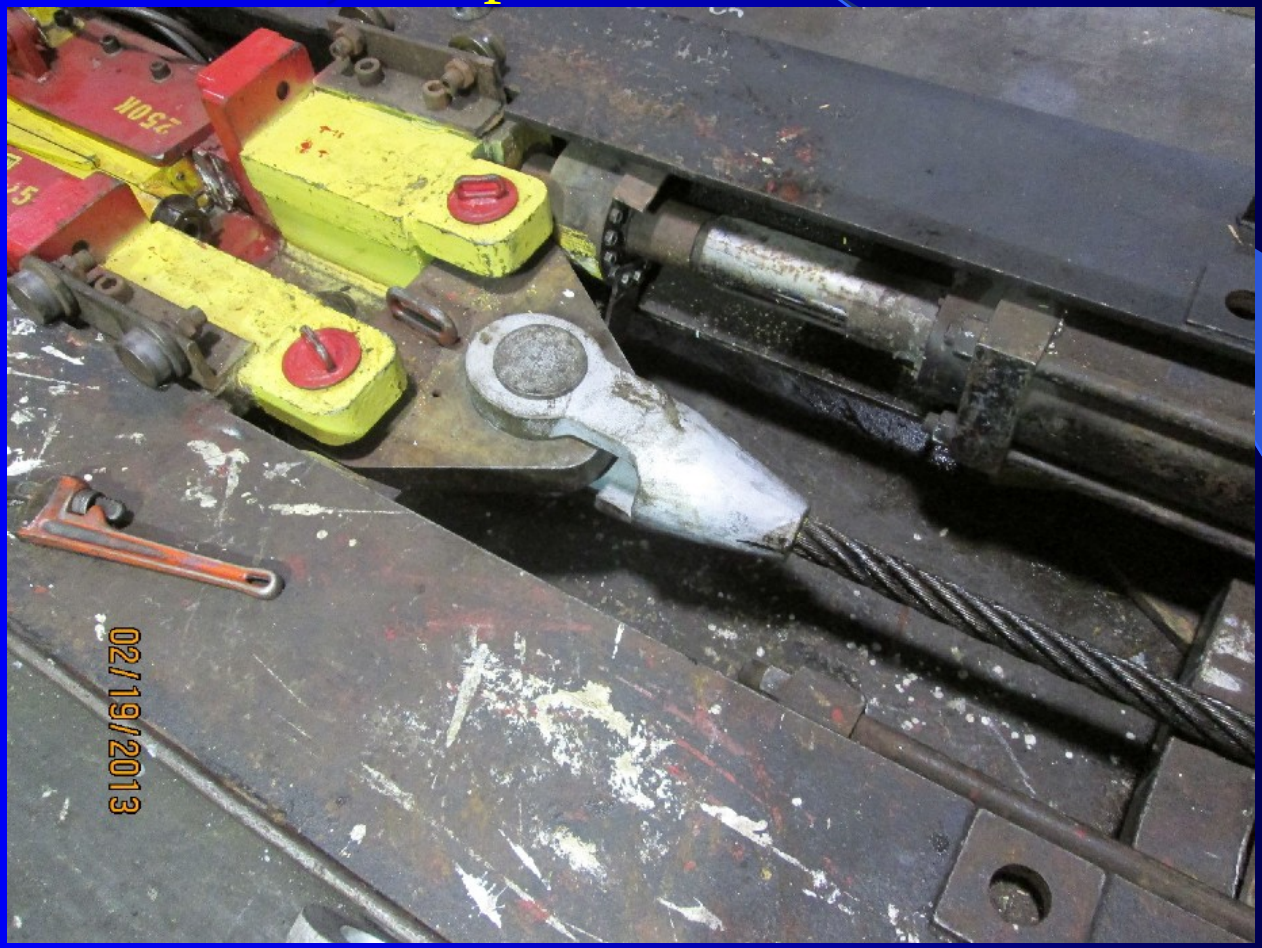


Sockets attach to lift span

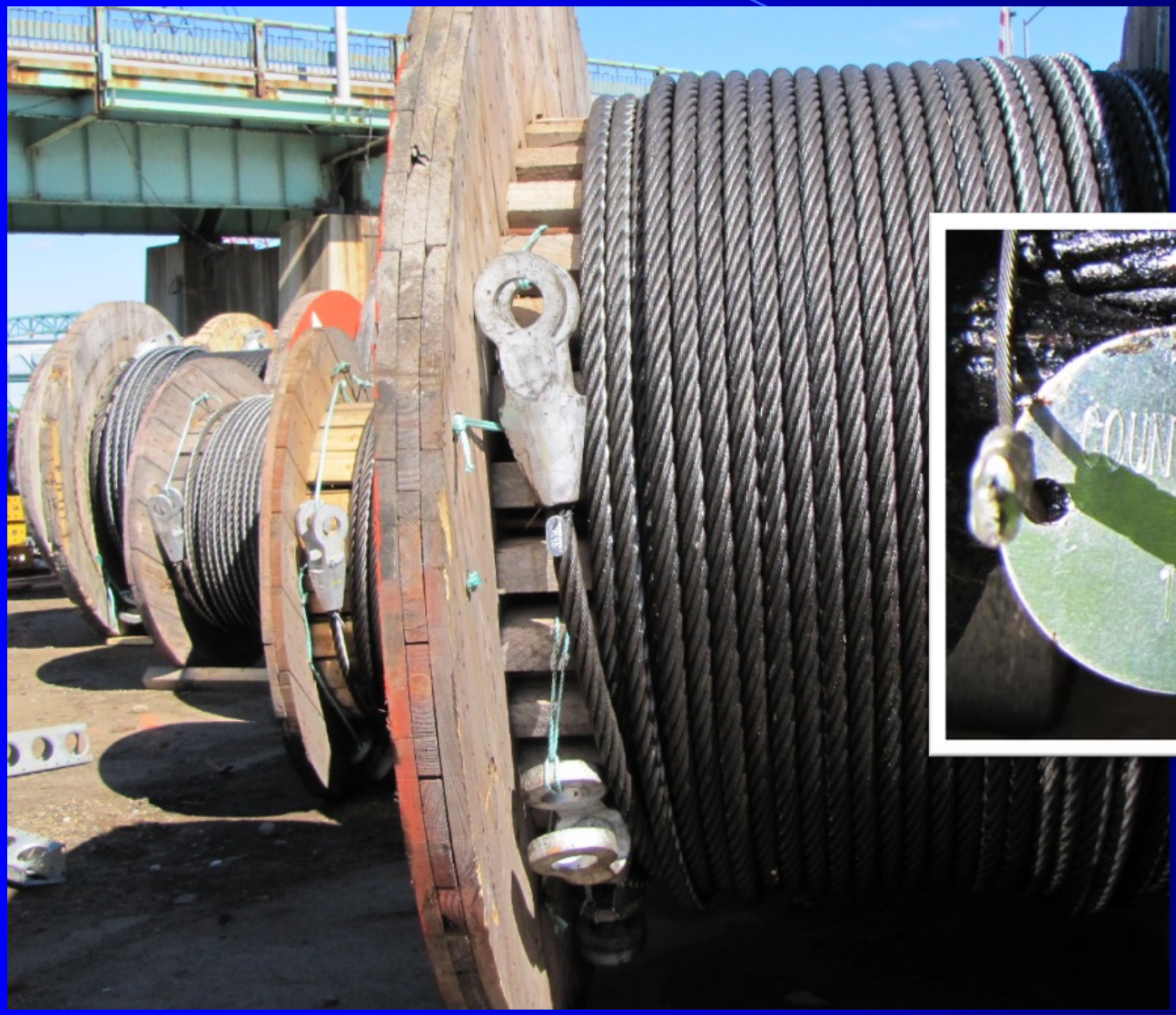


… fit into an (open spelter) socket …

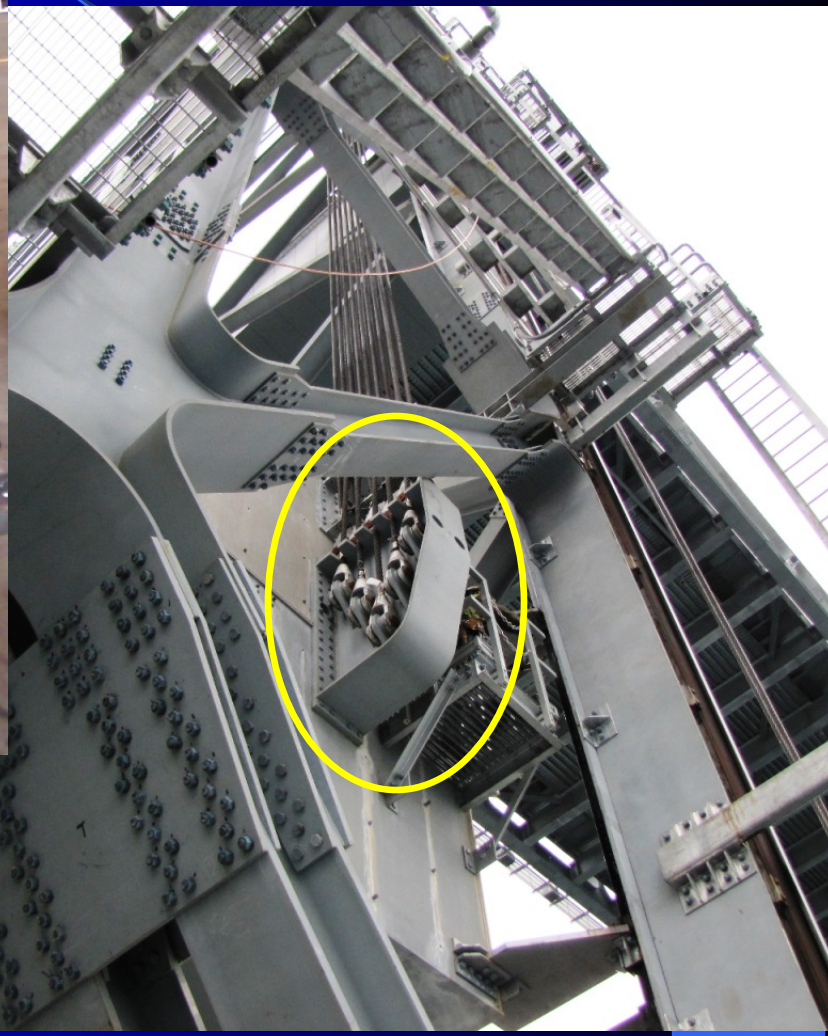
Stretch, length, stripe, cut, socket, and proof test



Tagged … spooled … shipped.



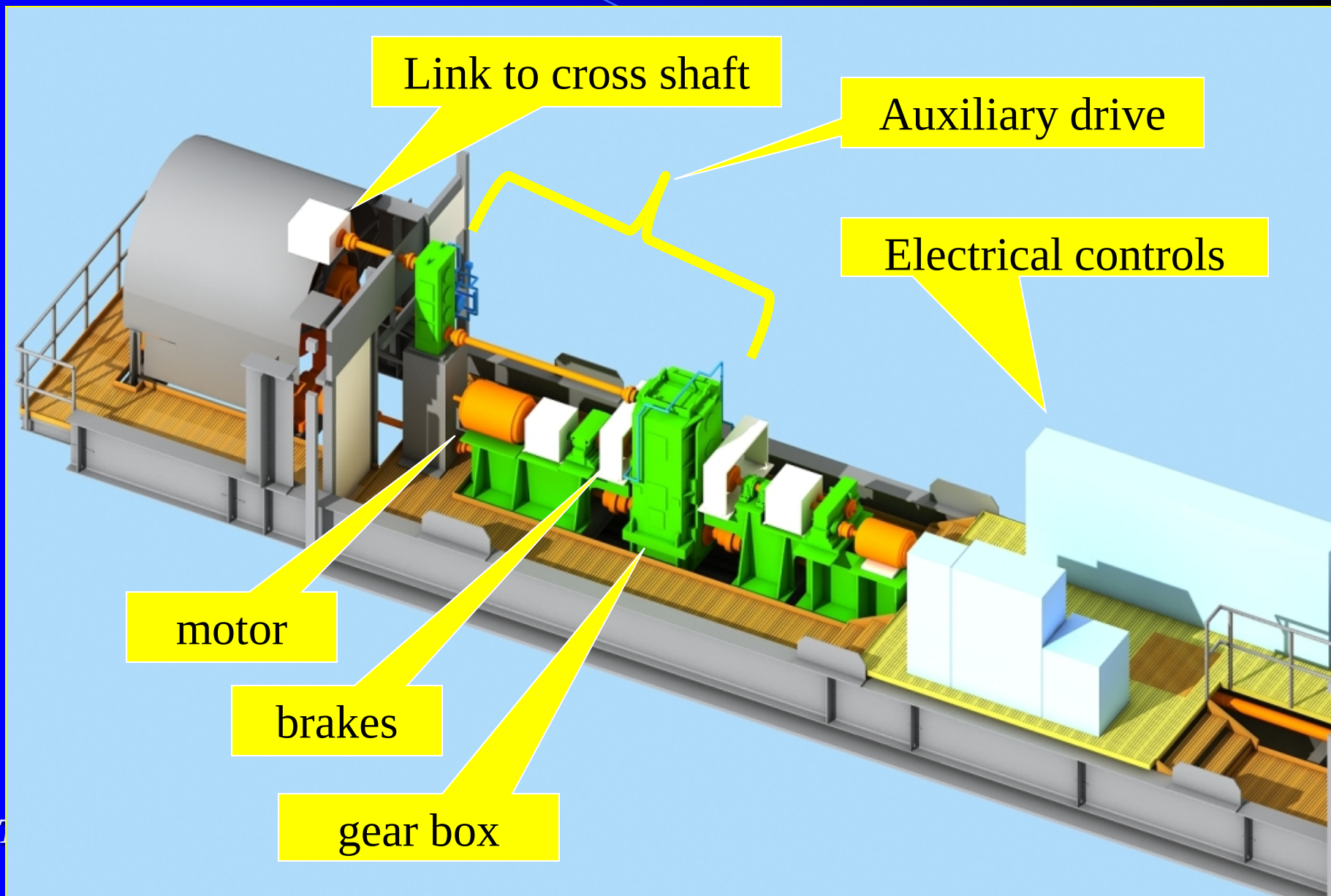
Counterweight cable attachment …
precision machining & complex welding



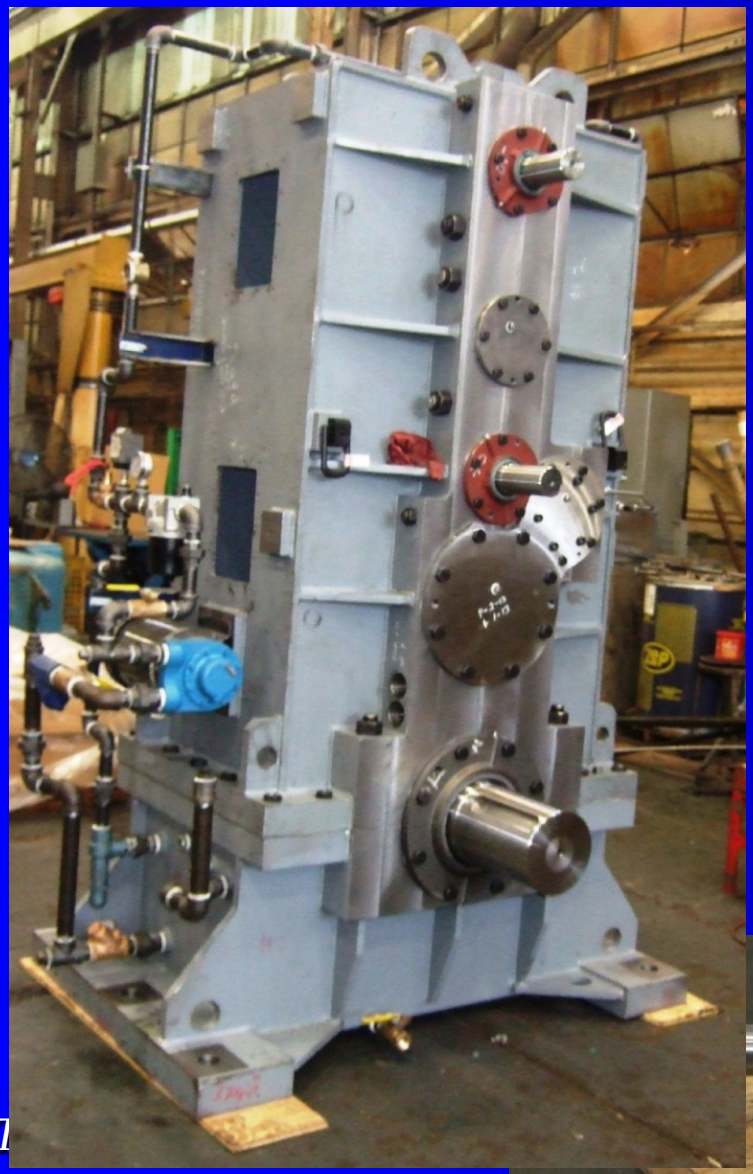
Gear Fabricator

Nuttall Gear of Niagara Falls, NY (since 1887)

Machinery room

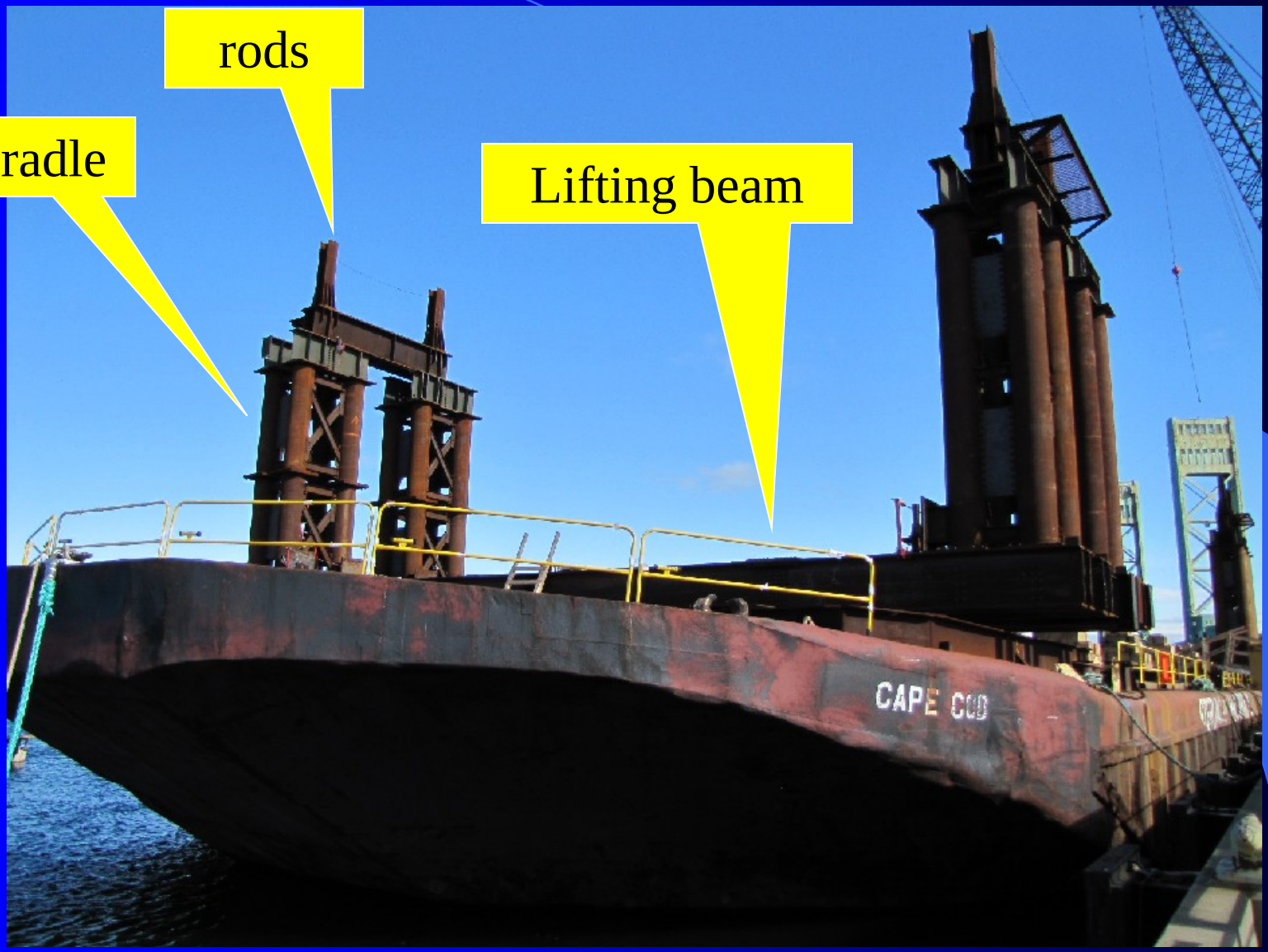


Main gear box …

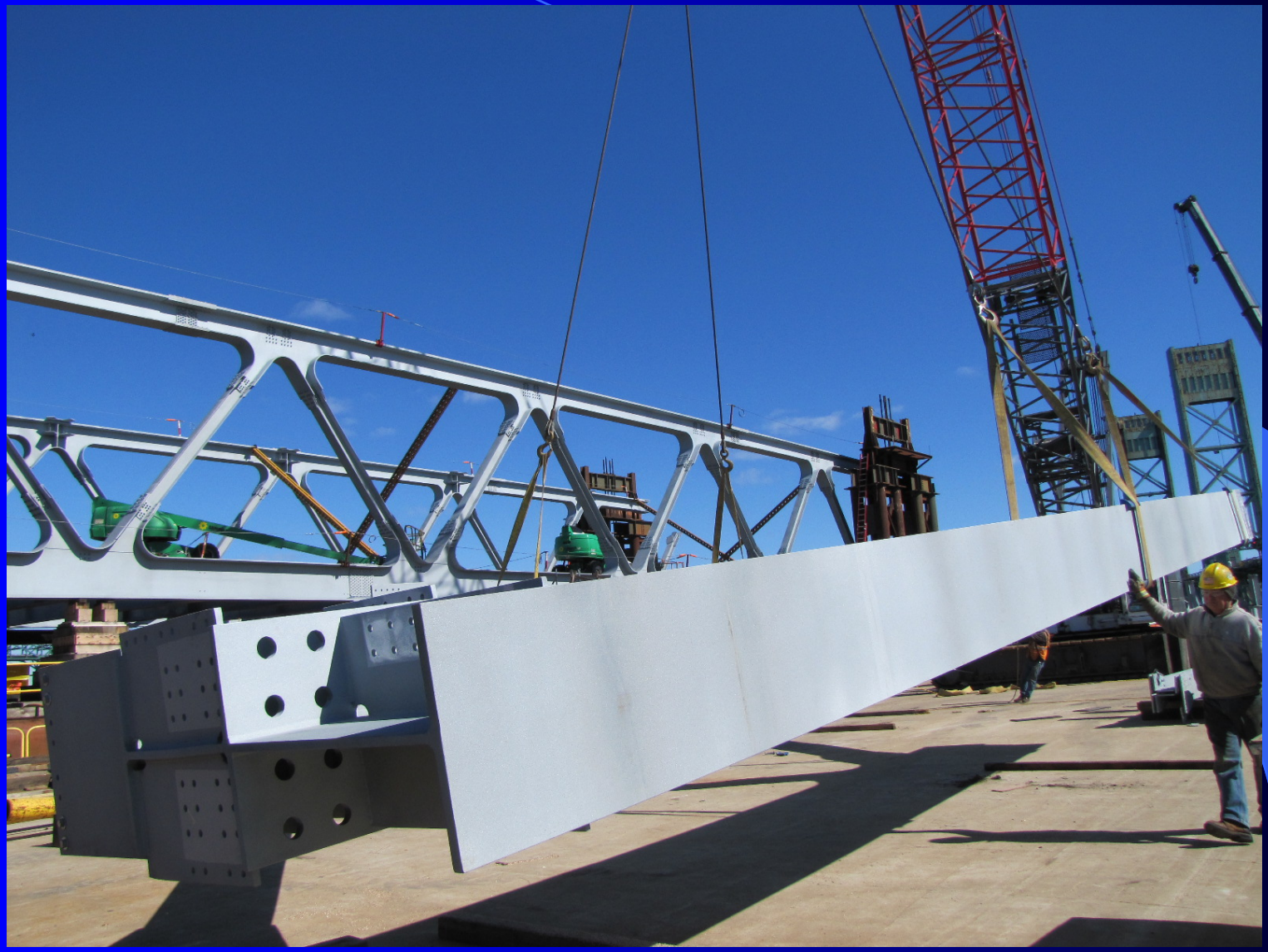


Off-Site
Pre-Assembly

The barge, *Cape Cod*, with cradles



Careful assembly & bracing



The truss takes shape one piece at a time

Install standard A325 galvanized bolts

Raise & lower truss in the cradle assembly.

The assembly area upstream of bridge site

Lift span in Google satellite photo

Bridge Building on Site
January 2013


The site awaits …

First float-in January 2013… the journey is underway …

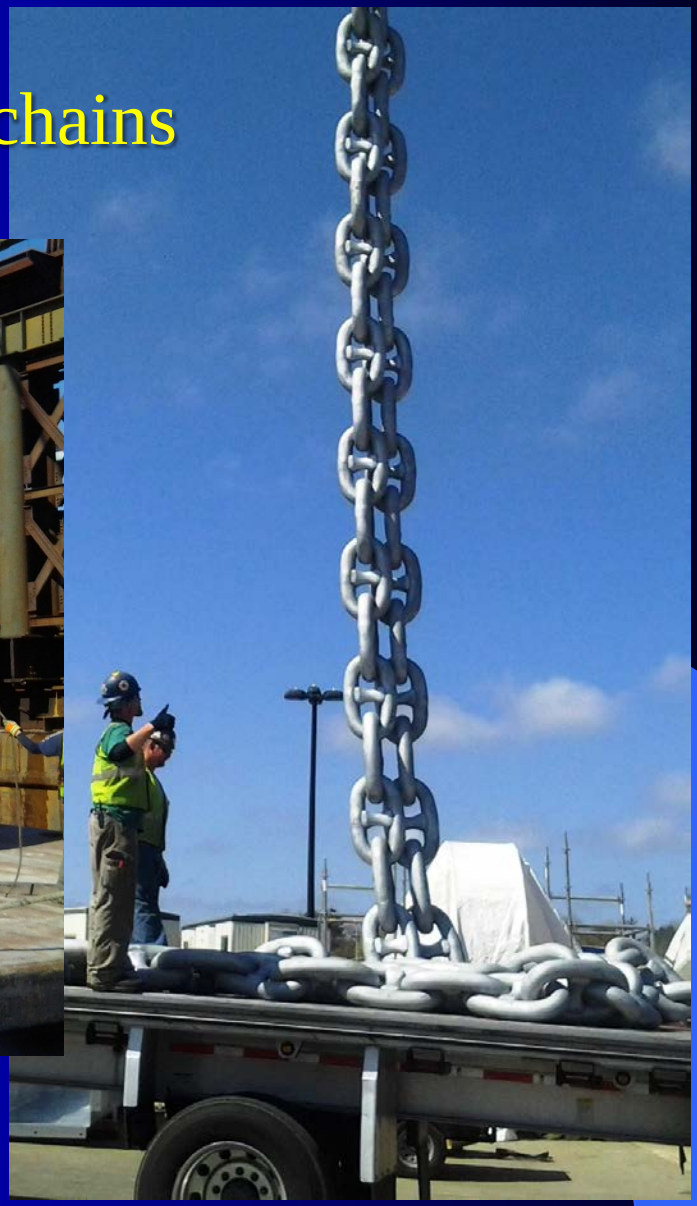
From Engineer's rendering to real in steel

The Memorial Bridge / **QAW** Atlantic City NJ / 2.5.2014 / Jerry Zoller, NHDOT #128

The North fixed-span follows in March


…the towers rise

Add counterweights & balance chains



Pre-assemble machinery rooms

with operating drums, pinions

precision alignment

Machinery rooms assembled

attached to the lift span

Lift span is ready to go


June 15, 2013 ready for 5-day navigation closure


Monday, June 17, 2013 1:00 am
lift-span float-in begins…

… winched into position with incoming tide

Th


The first sun rise on the bridge


Final hours of channel closure
Lift test underway

The grand opening August 8, 2013 at 10:00 am

Open to traffic Aug 8, 2013 at 2:00 pm. (photo 2:04 pm)

Two-time ribbon cutter … Eileen Foley

2013

1923

Bridge designer … Ted Zoli (HNTB)

Iron & construction workers

The Memorial Bridge / **QAW** Atlantic City NJ / 2.5

NHDOT Engineers

Cyclists


A Trail Connecting Cities
East
Coast
Greenway
greenway.org
VOmax
FALL 2004

Artists inspired

The Memorial Bridge / **QAW** Atlantic City

Emergency responders and World War II submarine veteran …

Remembering all armed services …
at the Memorial Park

The Memorial Bridge / **QAW** Atlantic City N

Bronze memorials restored

The Memorial Bridge / **QAW** Atlantic City NJ / 2.5.2014 / Jerry Zoller, NHDOT #154

Aesthetic lighting – to make the bridge
a proud icon – a symbol of the seacoast

The

Connecting the people of Portsmouth and NH

with those of Kittery and Maine

Connecting the past … to the present

We are proud to say,
"we were there" to see it built

The End

of the

Beginning

jzoller@dot.state.nh.us

MaineDOT

In cooperation with the State of New Hampshire

U.S. Department of Transportation Federal Highway Administration

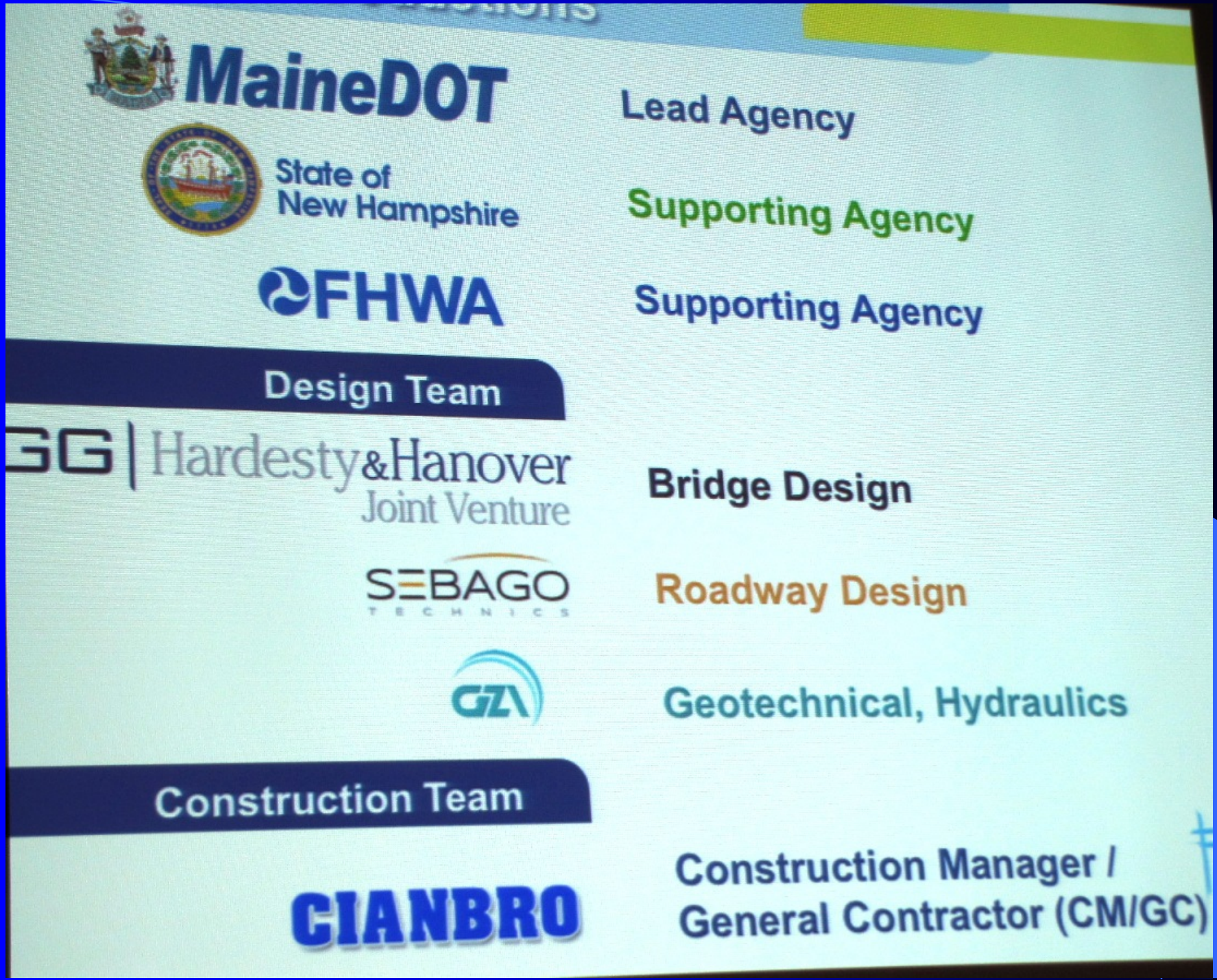
Public Meeting

SARAH MILDRED LONG Bridge Replacement

The Regional River Crossing

Linking Kittery, Maine & Portsmouth, New Hampshire

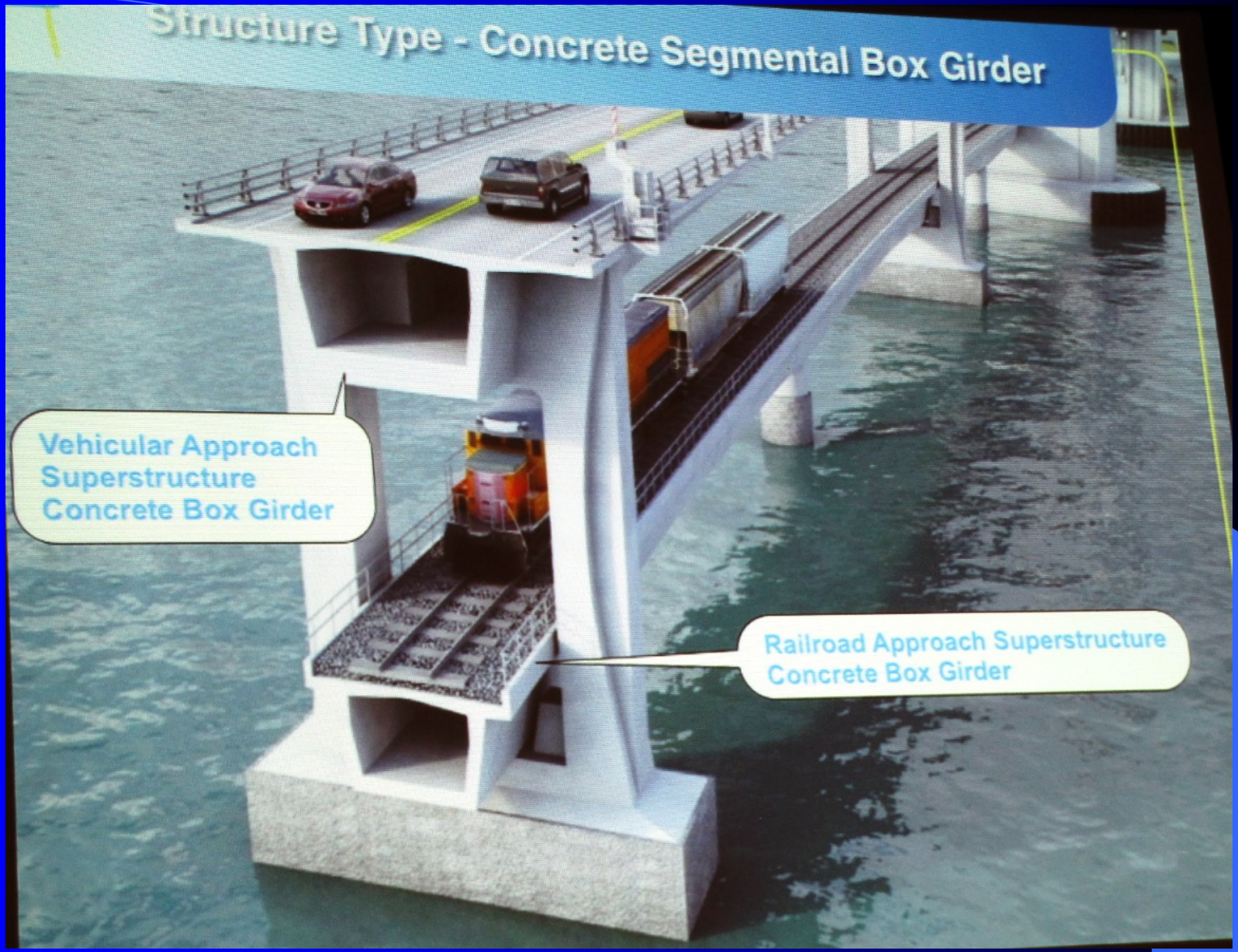
November 20, 2013

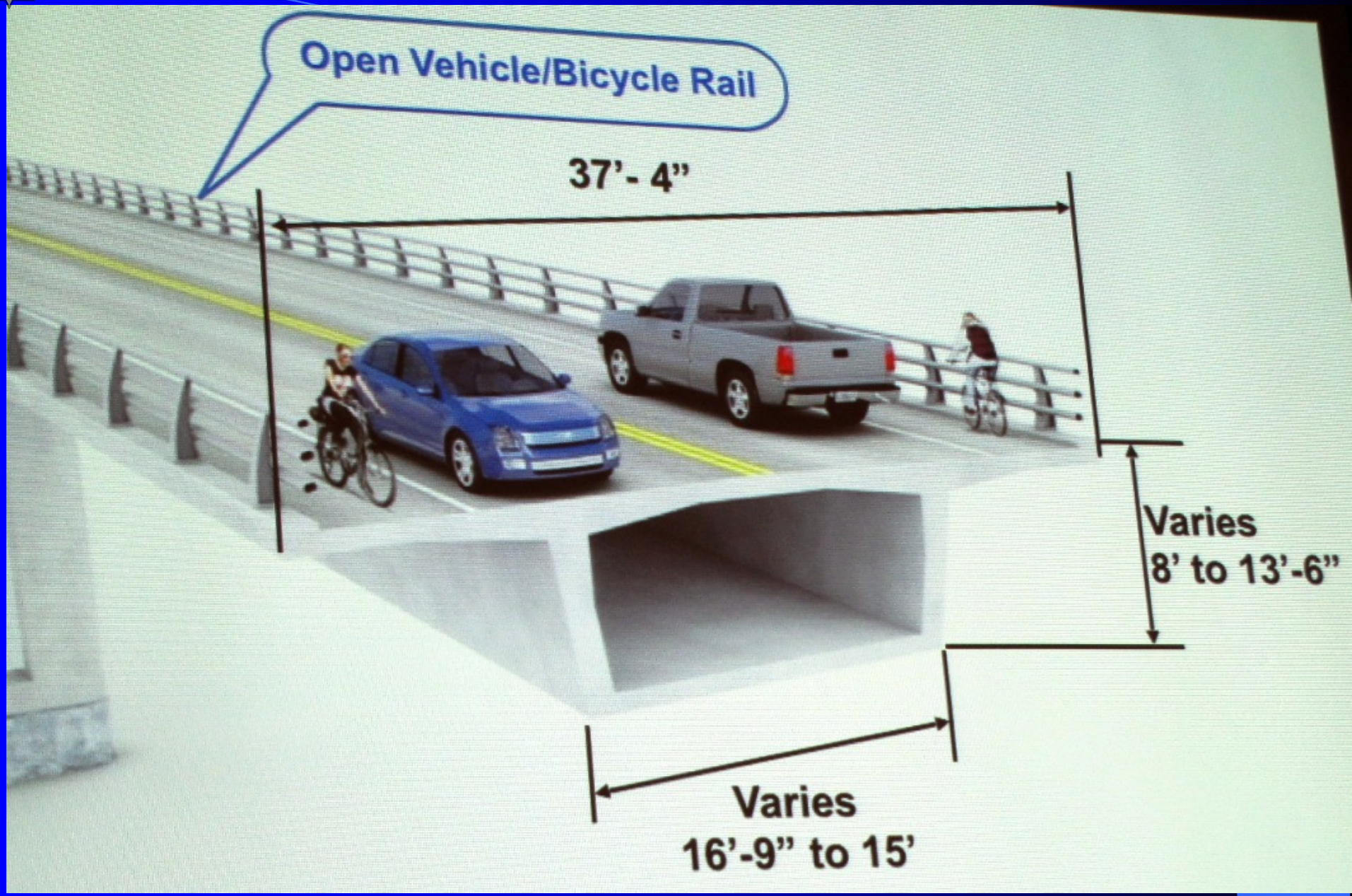

MaineDOT
Lead Agency
State of New Hampshire
Supporting Agency
FHWA
Supporting Agency
Design Team
GG | Hardesty&Hanover Joint Venture
Bridge Design
SEBAGO TECHNICS
Roadway Design
GZA
Geotechnical, Hydraulics
Construction Team
CIANBRO
Construction Manager / General Contractor (CM/GC)

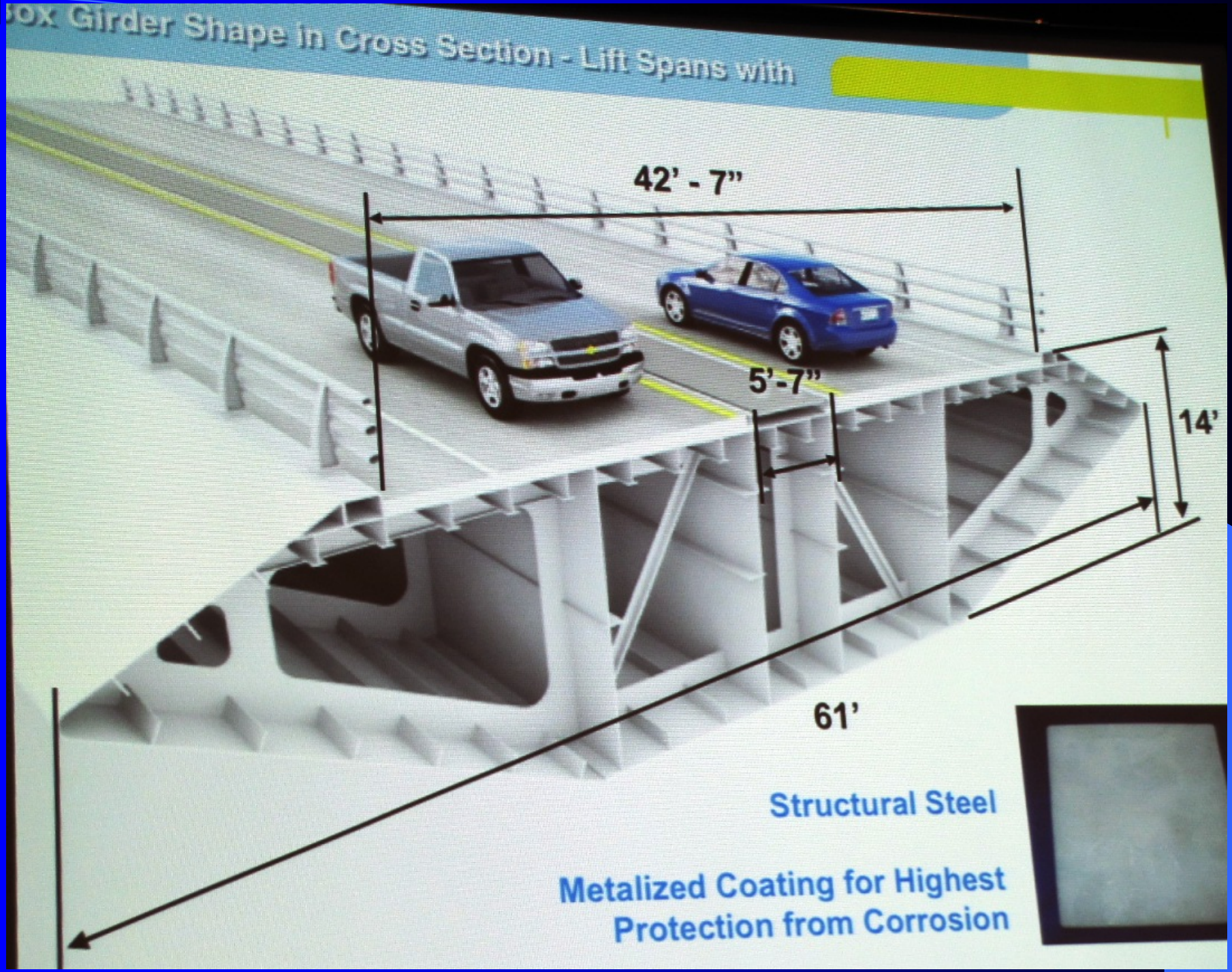
Sarah Mildred Long Bridge Replacement

The Regional River Crossing

View of Proposed Bridge -


Structure Type - Concrete Segmental Box Girder
Vehicular Approach
Superstructure
Concrete Box Girder
Railroad Approach Superstructure
Concrete Box Girder


Open Vehicle/Bicycle Rail
37'- 4"
Varies
8' to 13'-6"
Varies
16'-9" to 15'


ox Girder Shape in Cross Section - Lift Spans with
42' - 7"
5'-7"
14'
61'
Structural Steel
Metalized Coating for Highest
Protection from Corrosion