AMERICAN PUBLIC TRANSPORTATION ASSOCIATION

# Wheel Truing Technology Development and Innovations

Simmons Machine Tool Corporation

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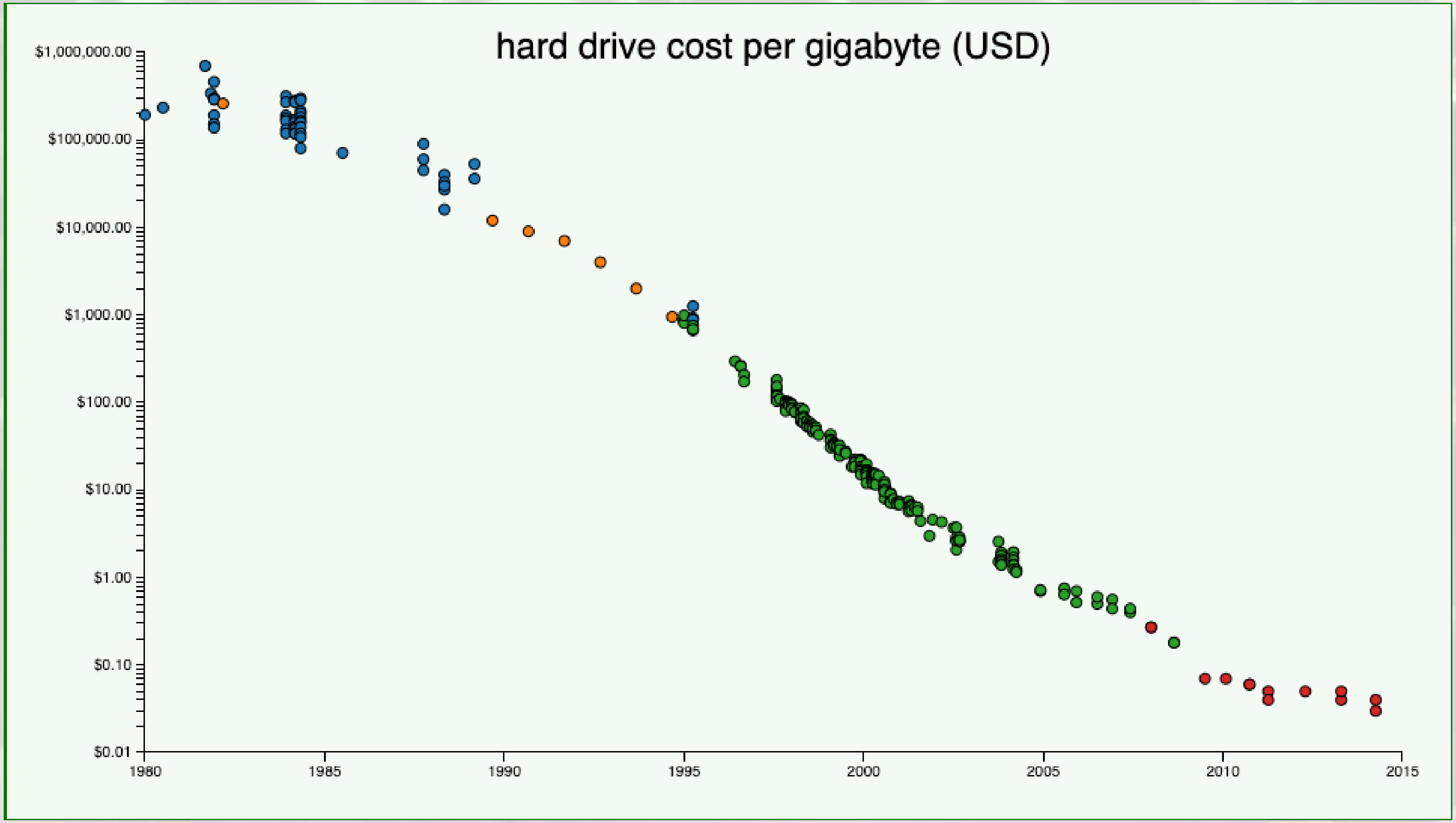
Albany, New York, USA | smtgroup.com

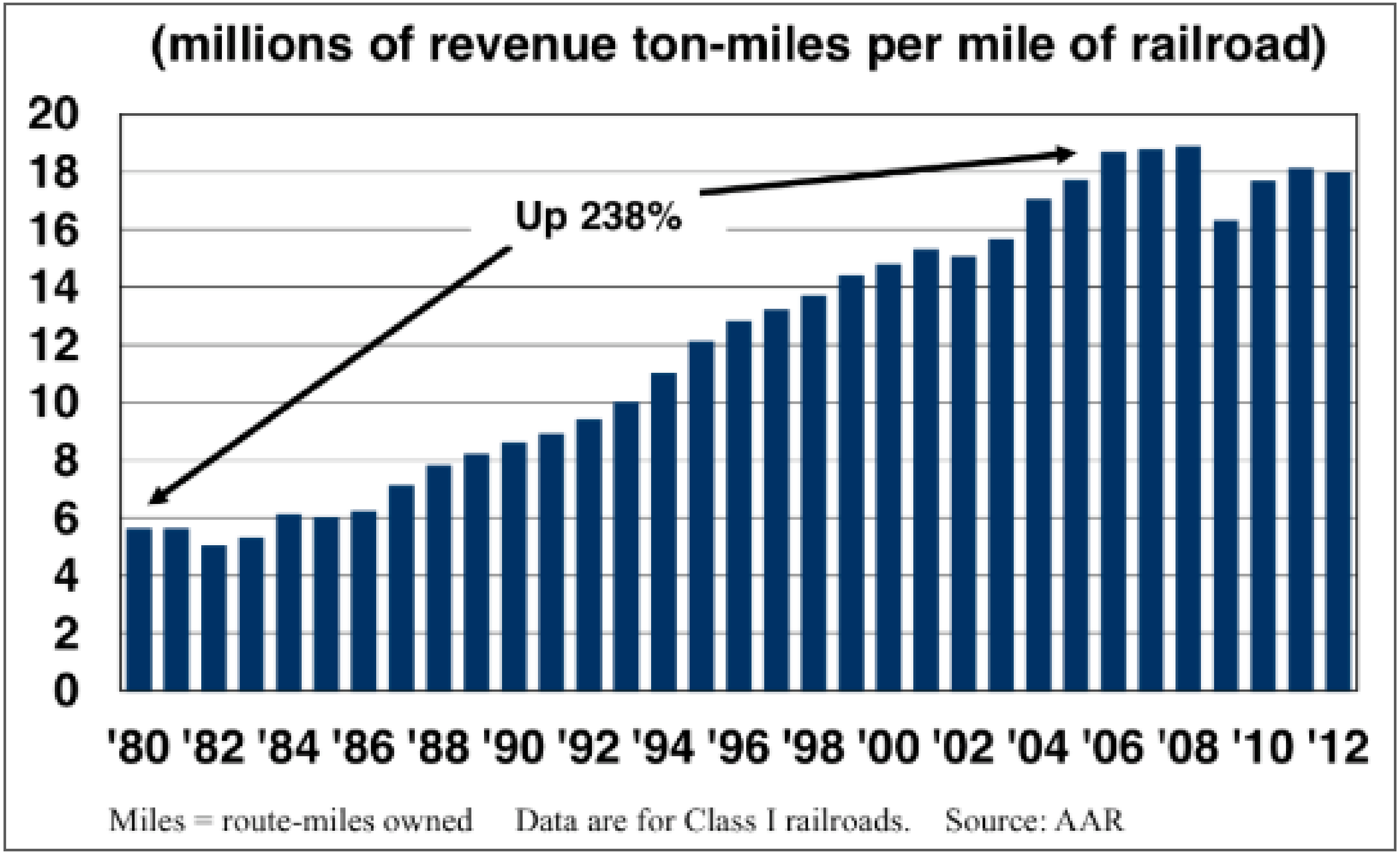
# A Need
# For Innovation




## Computer Hard Drive Cost Per Gigabyte Of Storage (2014)

Source: http://www.mkomo.com/cost-per-gigabyte-update

# A Need For Innovation



# A Need
# For Innovation

- Much of railway industry leveraging new technologies to improve production, efficiency, and safety:
  - Positive train control
  - Autonomous operation
  - Automatic track and rolling stock inspection
  - Digital wheel profile and defect detection

- Wheel reprofiling has largely languished for several decades without significant production increases

**To keep pace with the rest of the industry, innovation is critical.**

# What Is Wheel Reprofiling?

- Machining process to remove defects from a wheel to return the profile to its optimal shape

- Can be one of two machining processes:
  - Milling (wheel truing machine)
  - Turning (lathe)

# Wheel Reprofiling: Milling

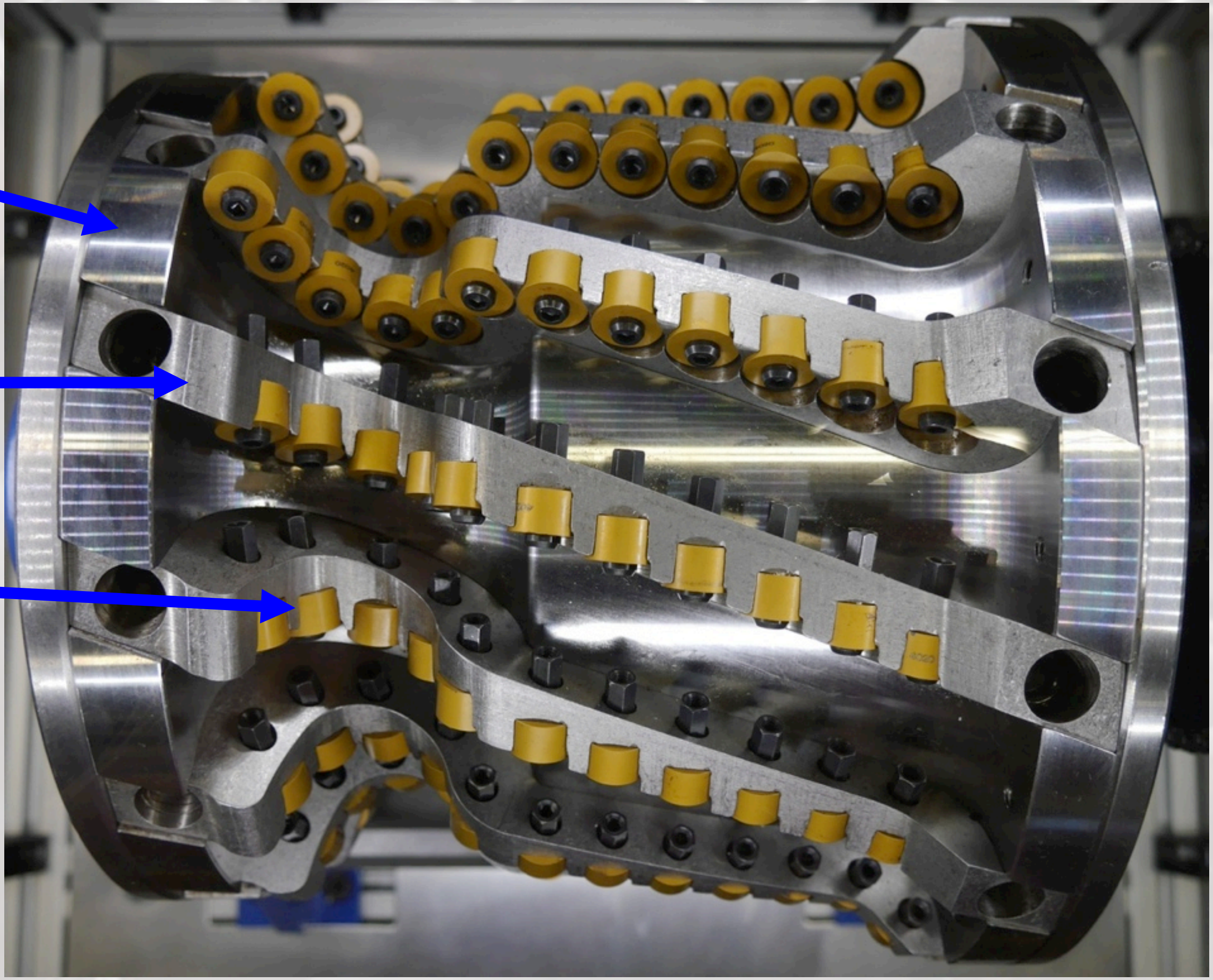
- Cutting tool rotates rapidly
- Workpiece (wheel) rotates slowly
- Multi-point machining

# Wheel Reprofiling: Milling

Cutter Body

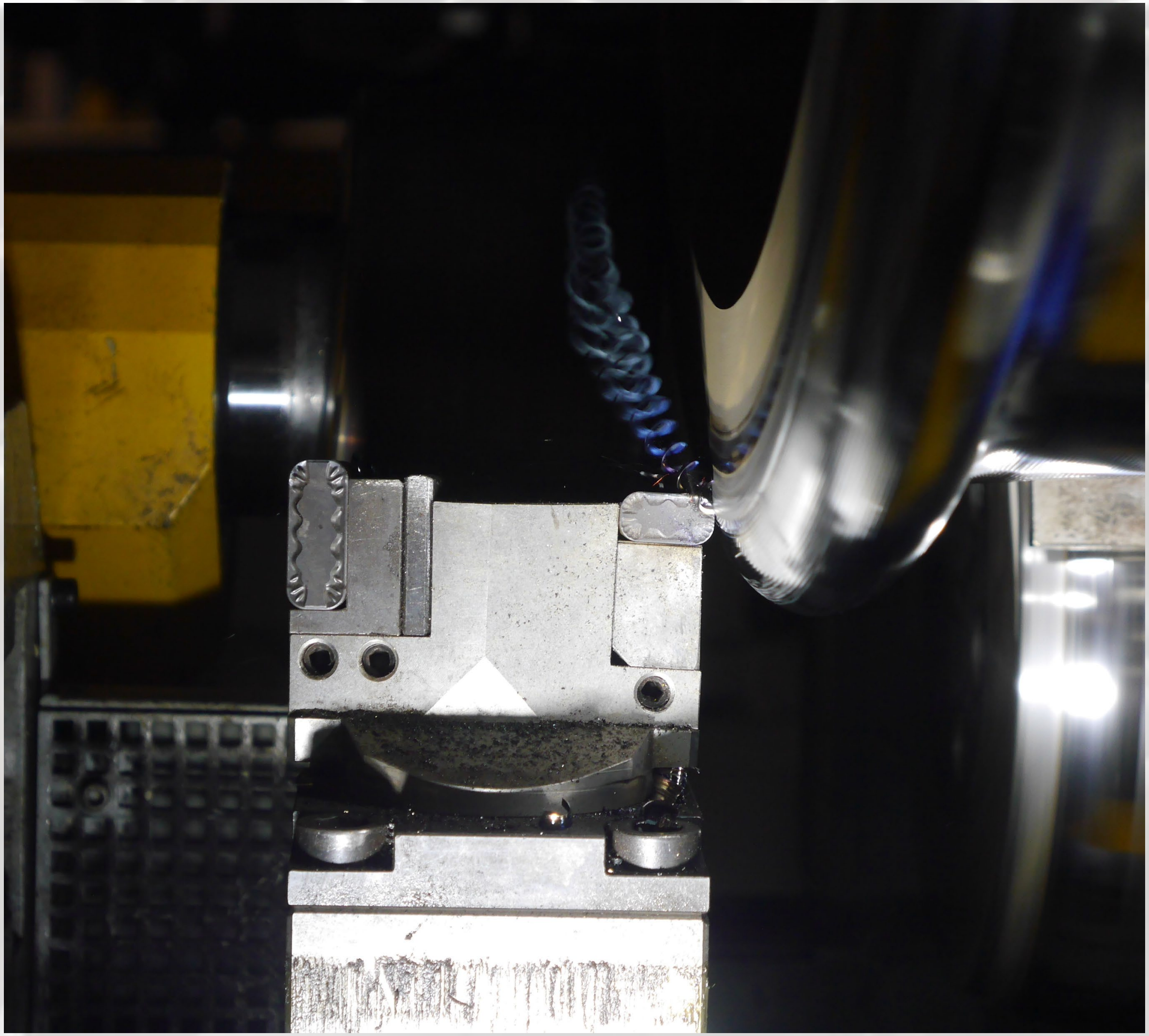
Removeable Blade

Carbide Insert

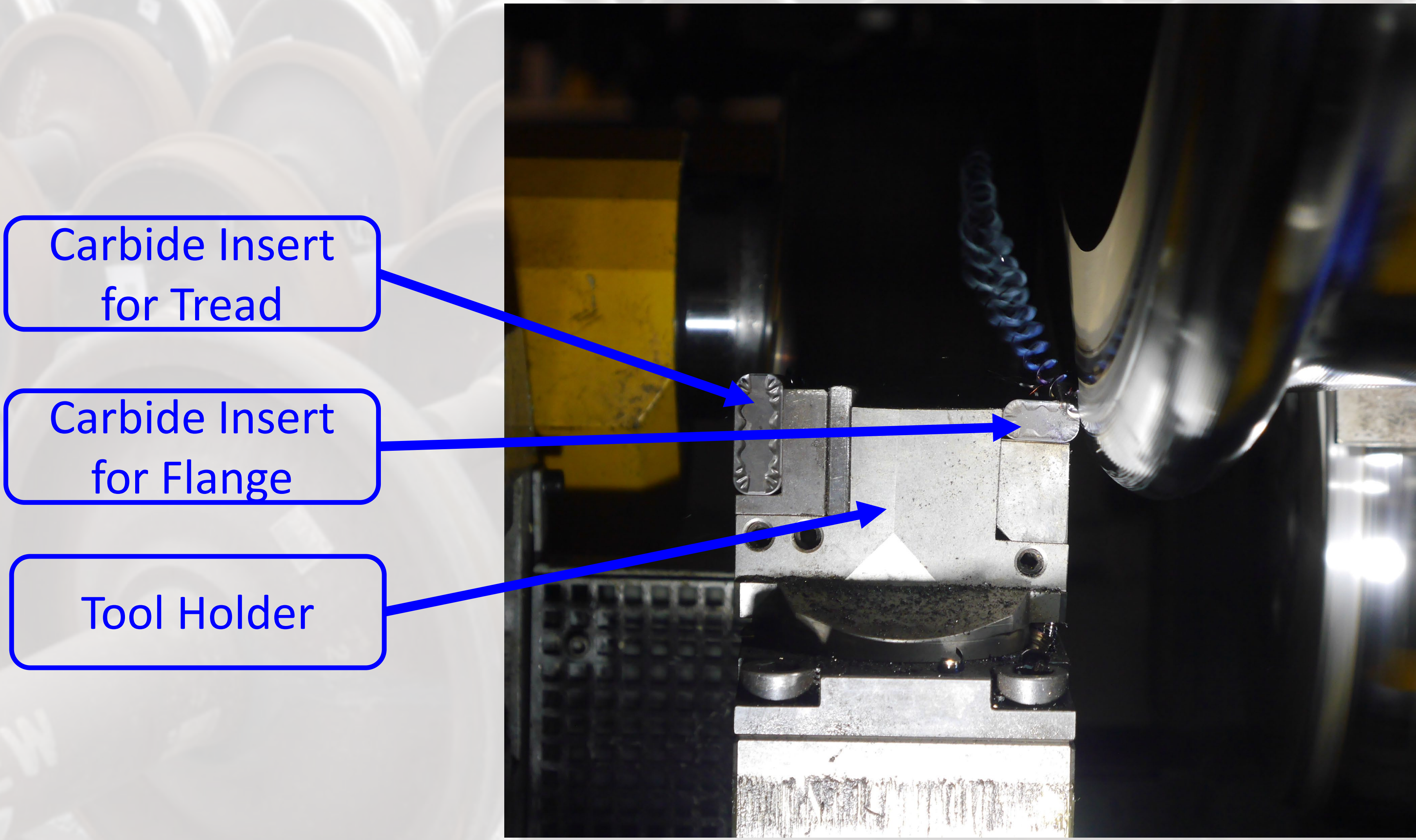


# Wheel Reprofiling: Turning

- Cutting tool is stationary
- Workpiece (wheel) rotates rapidly
- Single point machining

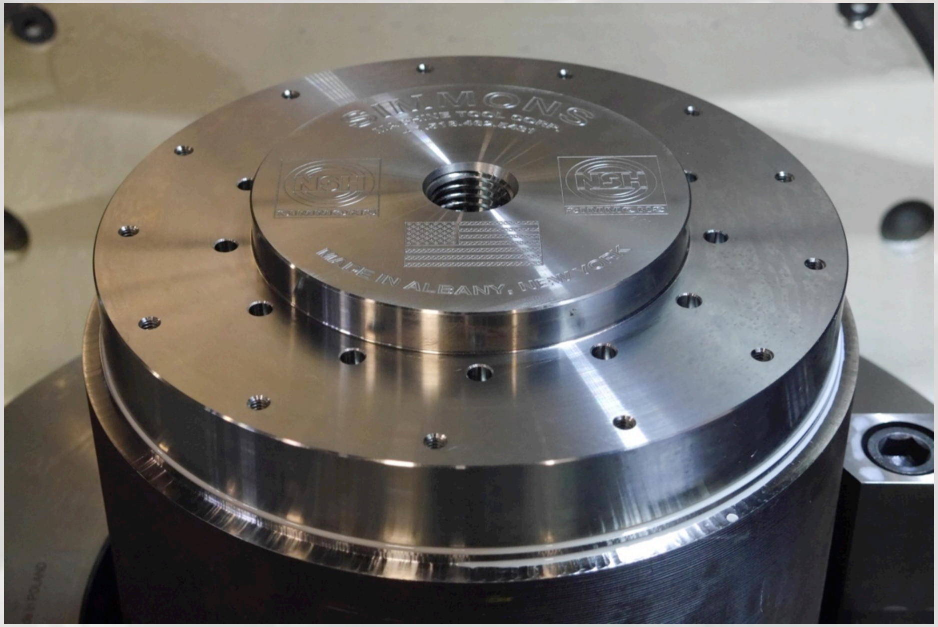


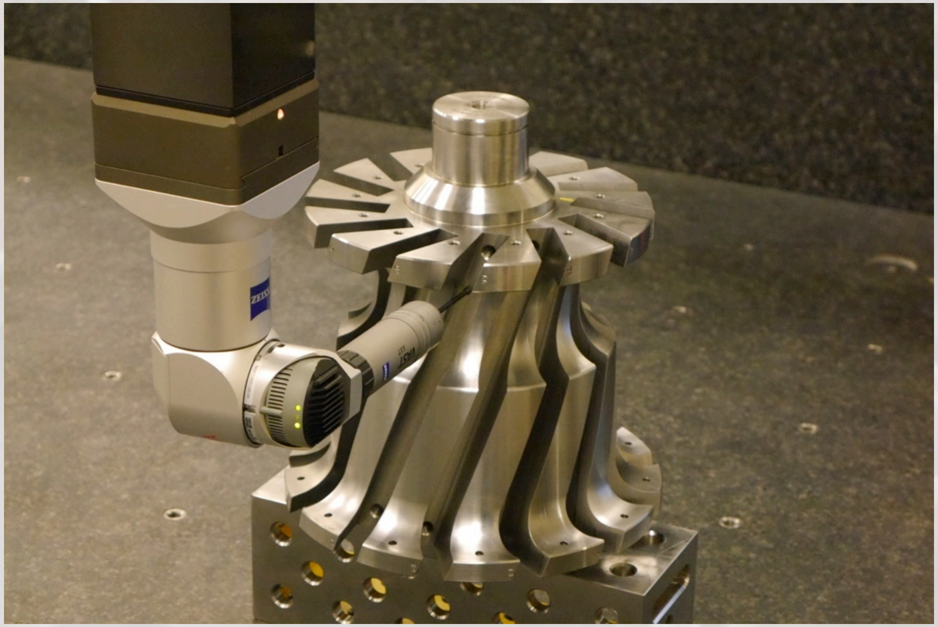
# Wheel Reprofiling: Turning



# Milling and Turning Technologies

- Presentation focuses on innovations to milling process but first lets point out some details about turning

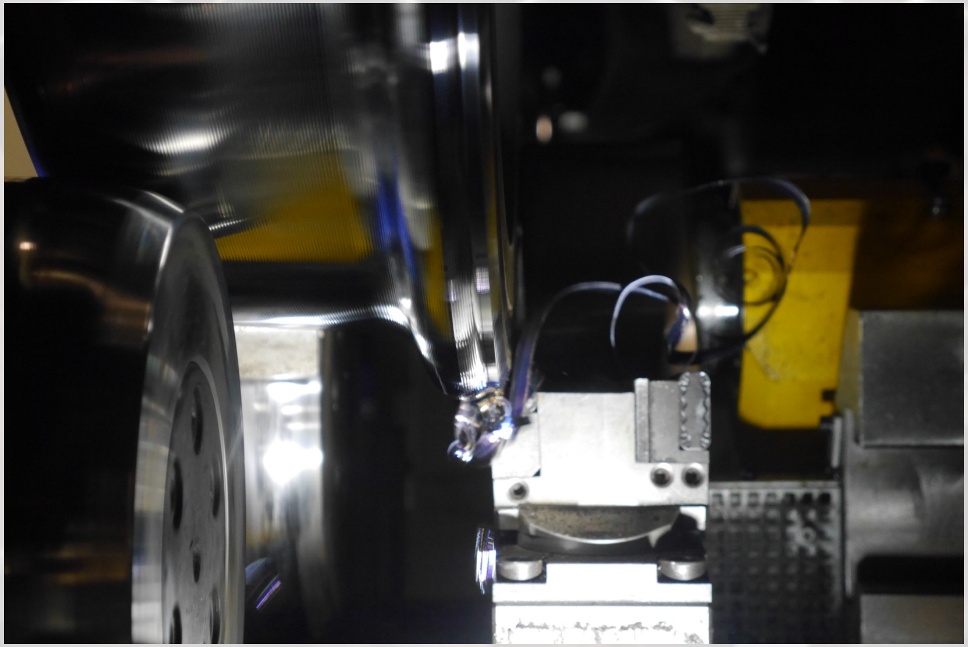


# Milling and Turning Technologies

## Downside of Turning?

- Turning has reached its full potential with the available materials
- Rotating wheel faster decreases maximum depth of cut and creates more risk of damaging tool, particularly with wheel defects
- Decreasing speed allows greater depth of cut, but results in “stringers” and longer cycle times



# Milling and Turning Technologies

## Other turning difficulties?

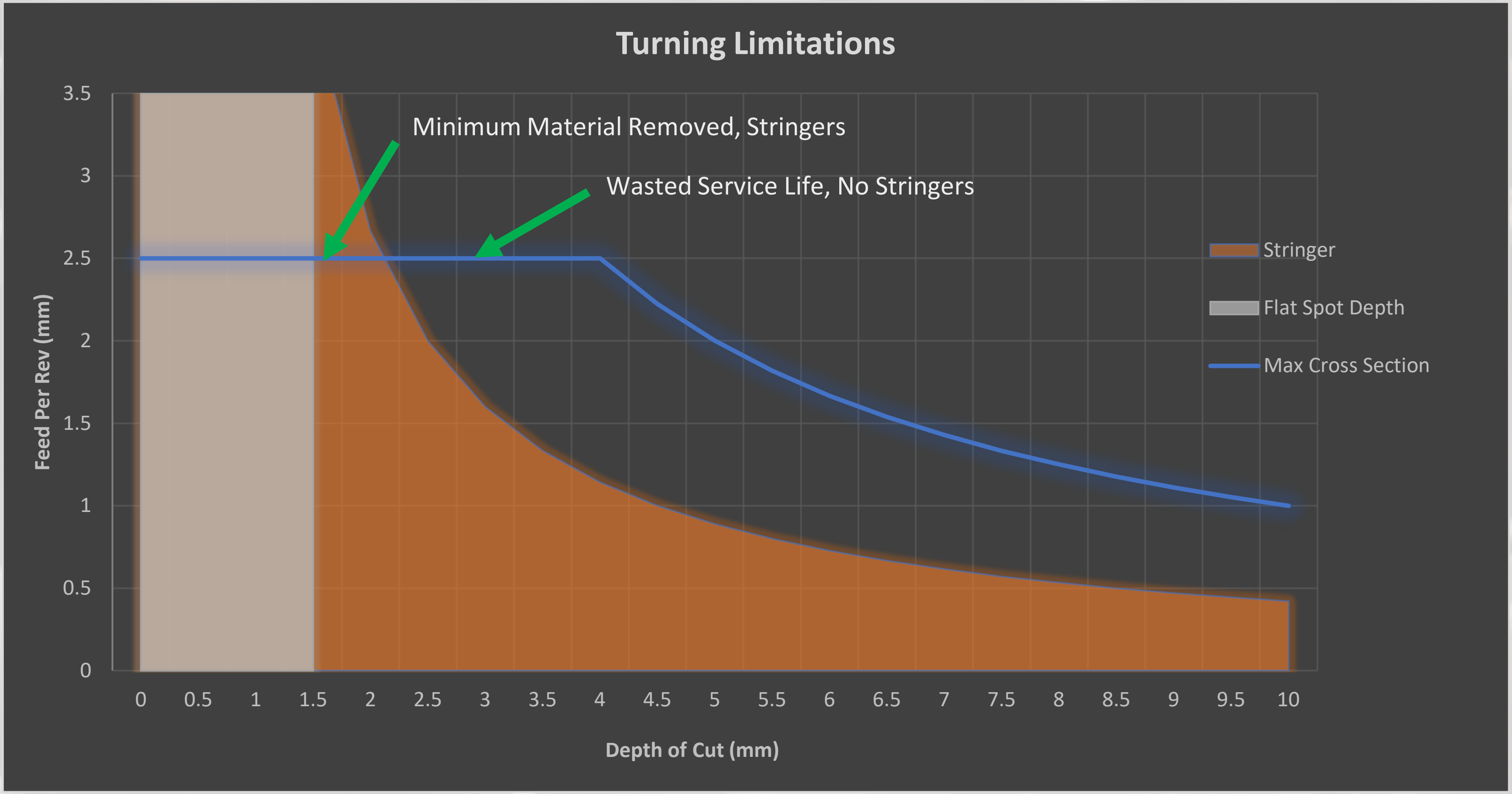
- With turning, the only proven way to increase productivity is by adding machines
- High cost
- Increases required square footage


4 Lathes

# Milling and Turning Technologies

## Why milling?

- With turning, cut depth and feed rate must decrease to prevent tool breakage. With milling, this I not the case.



# Milling and Turning Technologies

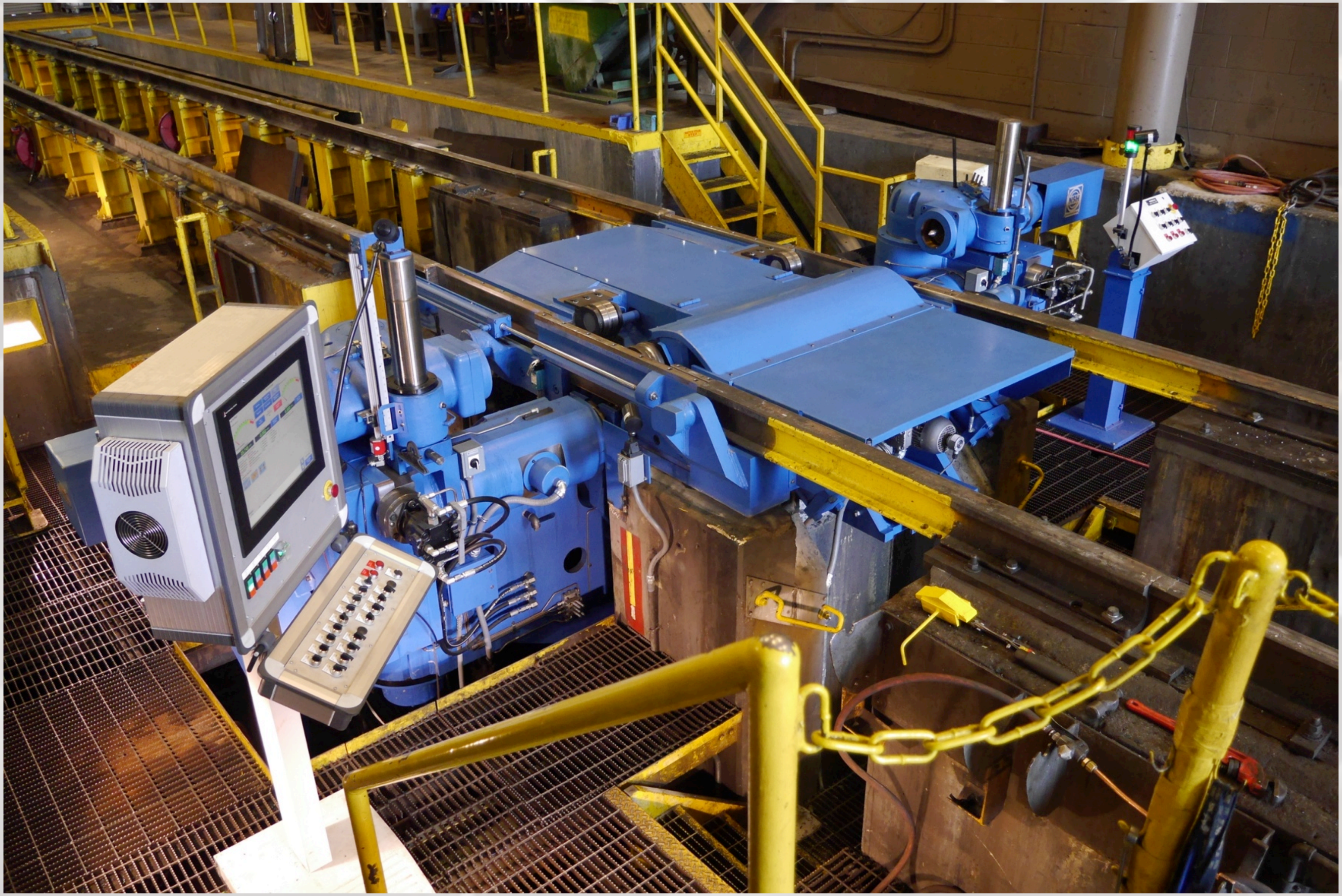
## Why milling?

- Full-profile milling manages wheel wear conditions without operator intervention while cutting
- Cuts through wheel defects (flat spots, shelling) without changing spindle speed or cut depth
- Undercutting of flat spots not necessary
- Slow workpiece rotational speed produces stable machining process
- Easy to set-up, operate and maintain
- Milling process creates small chips – easy to handle and safer to clean up

# Tooling Cost Comparison Minimal Wear ("Good Wheels")

| | Underfloor Wheel Lathe | | Stanray TN-84C Underfloor Wheel Truing Machine |
|---|---|---|---|
| | Tread Insert | Flange Insert | |
| Wheel Sets Per Index | 1 | 6 | 18 |
| Wheel Sets Per Insert | 8 | 48 | 72 |
| Insert Costs (USD) | $150 | $110 | $1500 |
| Insert Cost Per Wheel Set | $18.75 | $2.29 | $20.83 |
| Labor To Index Tooling (minutes) | 3 | 3 | 30 |
| Labor To Index Per Wheel Set (minutes) | 3 | 0.5 | 1.67 |
| Labor Cost Per Wheel Set ($30/hour) | $1.50 | $0.25 | $0.83 |
| Total Cost Per Wheel Set (USD) | $22.79 | | $21.67 |

# Stanray® TN-84C Underfloor Wheel Truing Machine



# Wheel Truing: History and Application

- First underfloor machine installed in 1949
- Installed in freight and commuter maintenance facilities throughout North America
- Underfloor type installation historically the only application of milling technology

- Machine #2 installed in 1951 at Norfolk Southern's Enola shop
- Replaced 55 years later (2016) with remanufactured Stanray TN-84C

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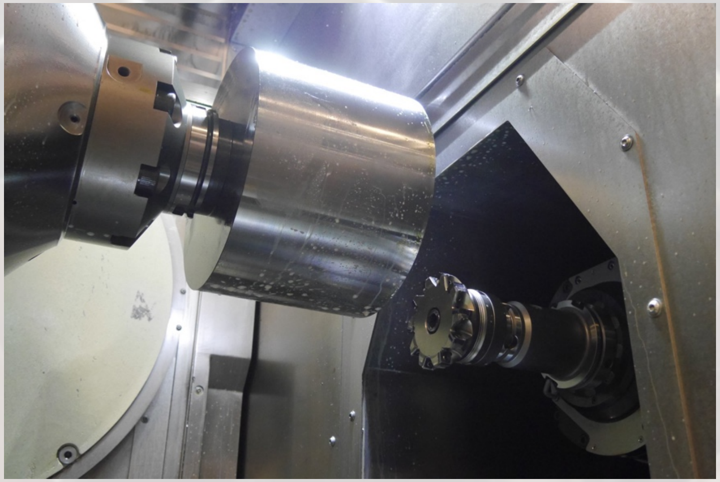
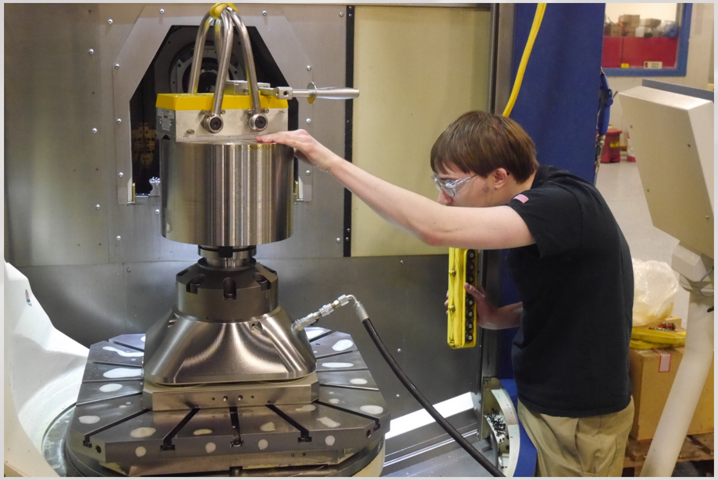
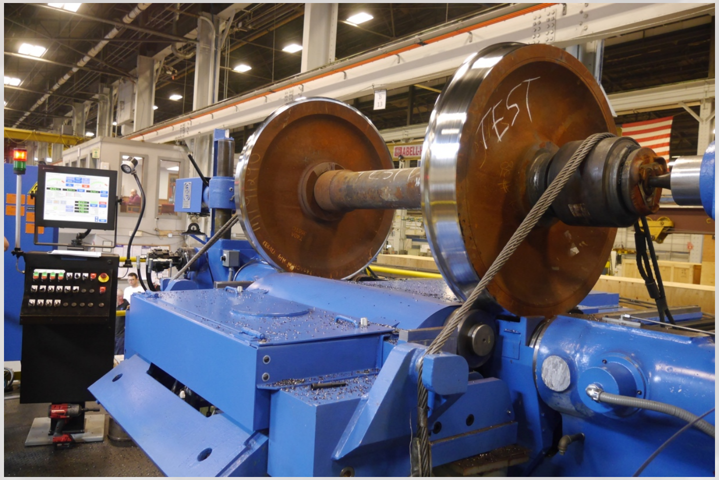
# Stanray® Manufacturing

SIMMONS

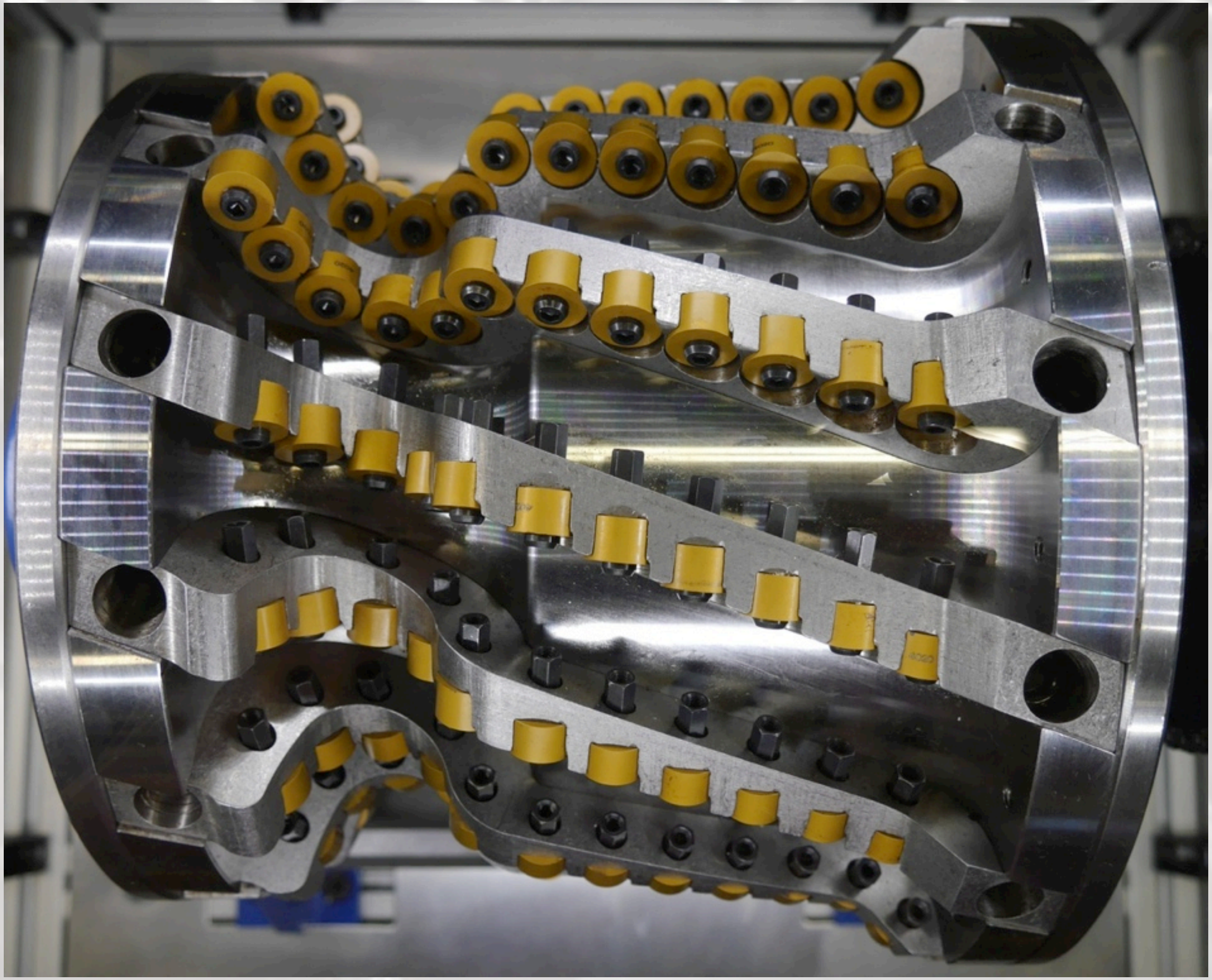







**Designed, manufactured, and assembled in Albany, NY, USA**

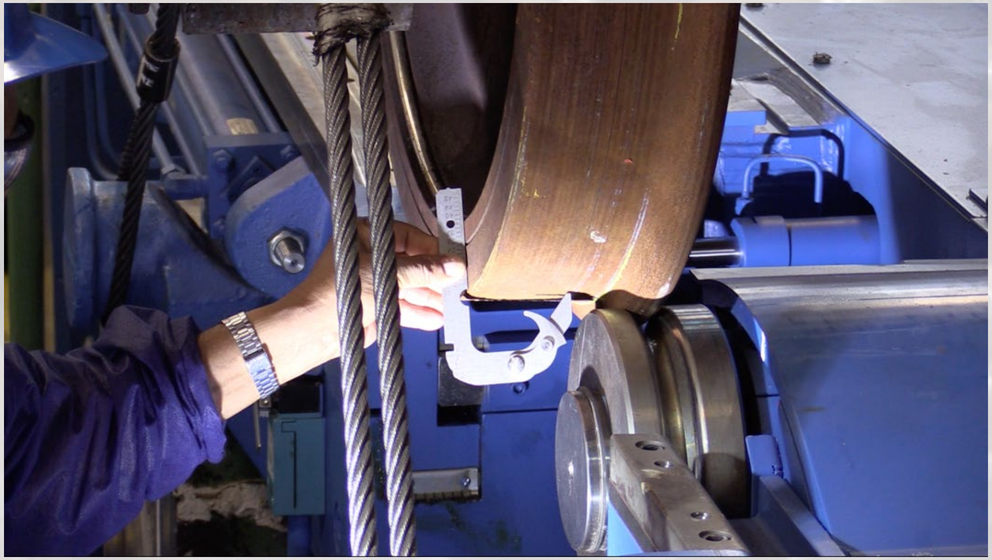
# Wheel Truing Cutter



# Wheel Truing Cutter

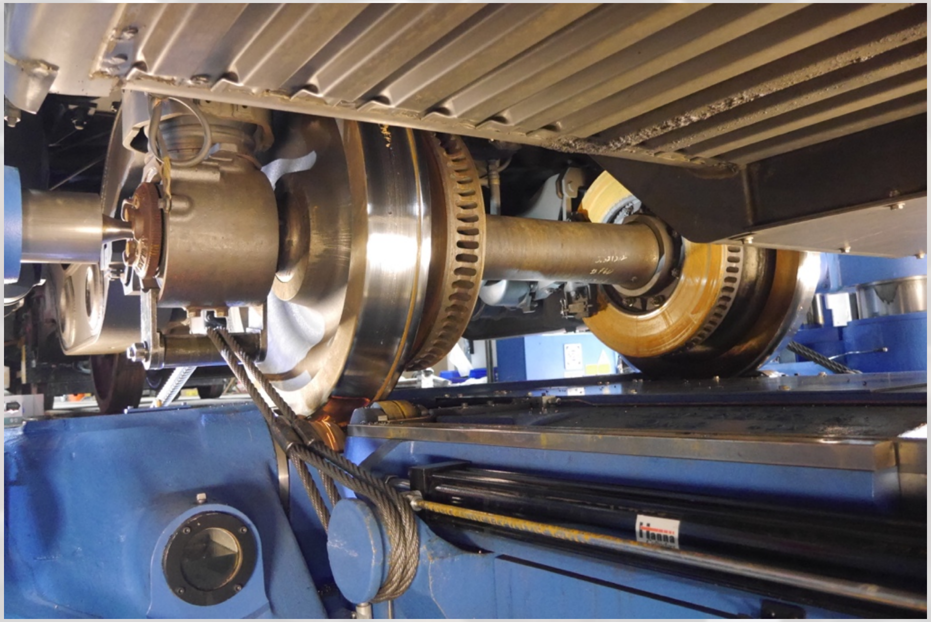
- Original milling cutter design conceived before computer-aided design and modern manufacturing practices possible
- Largely the same since initial design
- Cycle time stagnant despite decades of use: ~40 minutes (normal wheel wear conditions)

# Wheel Truing Measurement



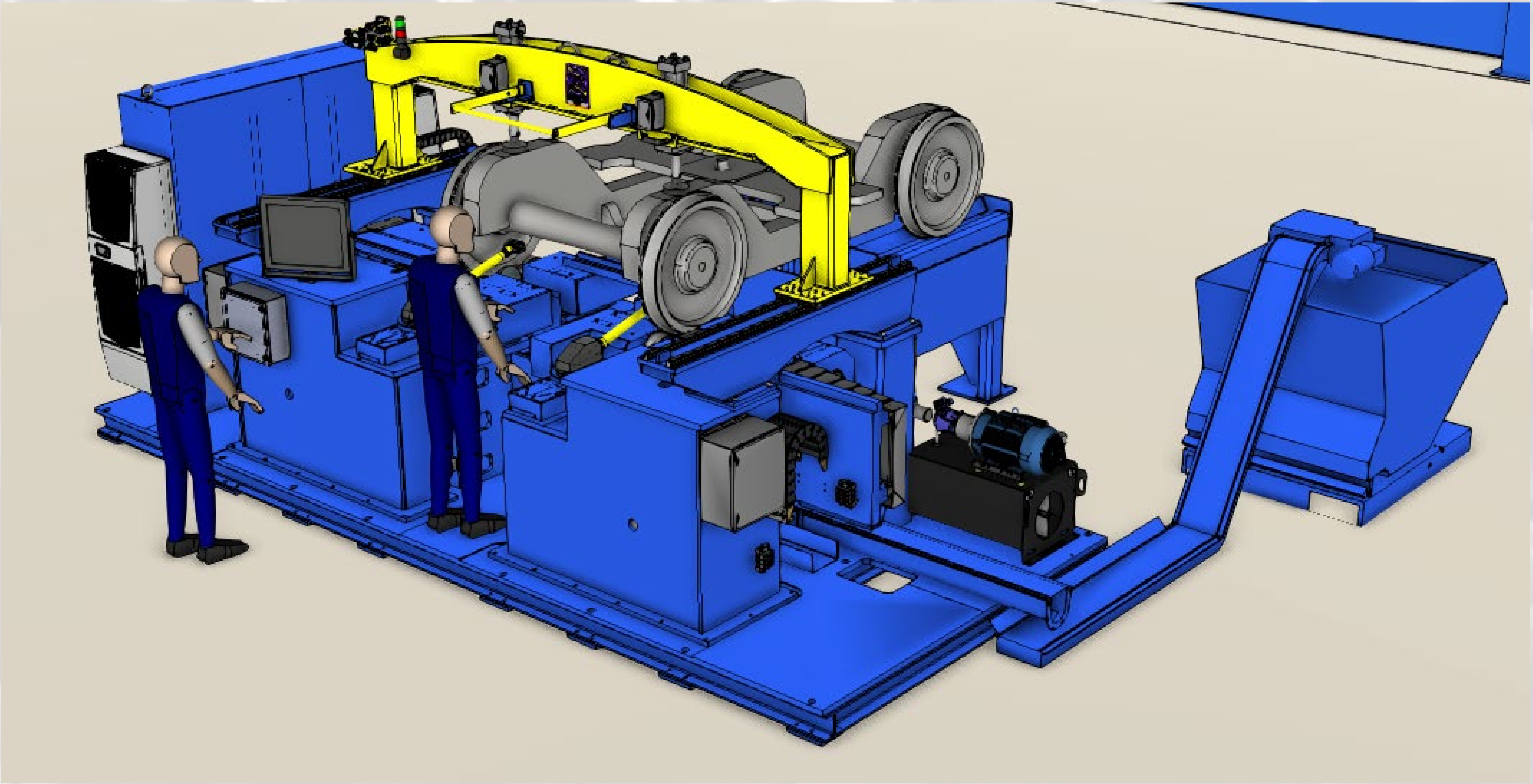
- Using manual tools: AAR finger gage
- Measurement results can vary between operators

# Wheel Truing Clamping

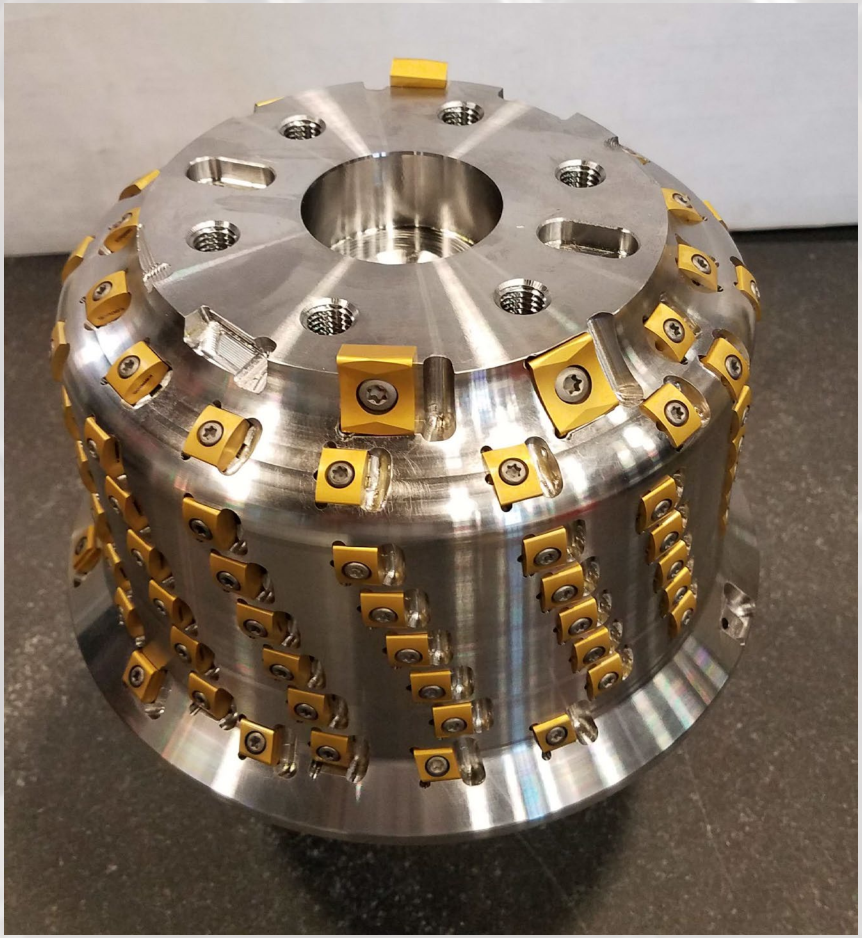



- Wheel set held rigidly on centers
- Requires access to axle center holes
- Increases required machine mass

# Updated Wheel Truing Technology



# Updated Milling Cutter



# Updated Milling Cutter

- **Changes to cutter design**
  - Increased productivity:
    - New design has two effective flutes
    - Twice as much material per revolution removed compared to current single flute design

First Flute

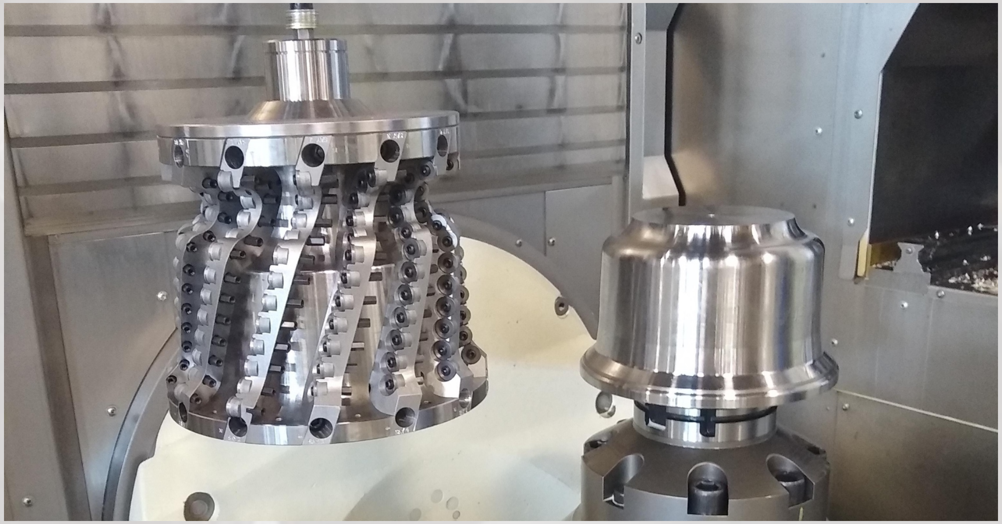
Second Flute

# Updated Milling Cutter

- **Changes to cutter design**
  - Better surface finish:
    - Enhanced insert geometry as well as modern computer solid modeling lay-out tools produce a more optimal wheel surface finish <u>especially in throat of flange</u>

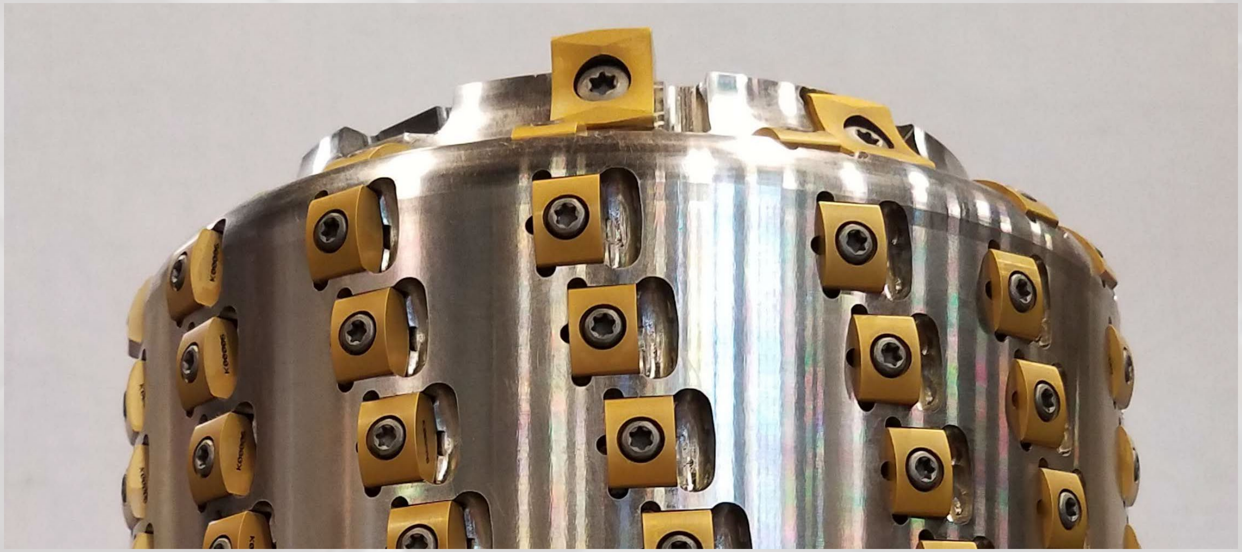
# Updated Milling Cutter

- **Changes to cutter design**
  - Easier wheel profile exchange:
    - Current cutter body assemblies weigh ~300 lbs
    - Can take an hour or more to exchange
    - New cutters are smaller, 60% lighter, and utilize a quick change coupling



# Updated Milling Cutter

- **Changes to cutter design**
  - Increased tool life:
    - New design places indexable carbide inserts directly onto cutter body
    - Creates stiffer, stronger tool holder - extending insert life



# Updated Milling Cutter

| | Current Cutter Design | Smaller Diameter and Two Effective Flute Design |
|---|---|---|
| **Diameter (inches)** | 12 | 8 |
| **Number of Effective Flutes** | 1 | 2 |
| **Cutter RPM** | 239 | 358 |
| **Feed Rate (in/min)** | 4.8 | 14.3 |
| **Machining Cycle Time (min)** | 23.7 | 14.22 |
| **Projected Machining Cycle Time Reduction** | 0% | 40% |

# Updated Milling Cutter

- **Changes to cutter design**
  - Modern computer-aided design and digital manufacturing practices (e.g. 5 Axis CNC machining and automated CMM inspection) enable double effective flute cutter design

  - New design supports improved productivity
  - Less time for vehicle maintenance, more time in revenue service

# Tooling Cost Comparison Minimal Wear ("Good Wheels")

| | Underfloor Wheel Lathe | | Current Underfloor Wheel Truing Machine | Updated Wheel Truing Machine (Projected) |
|---|---|---|---|---|
| | Tread Insert | Flange Insert | Cylindrical Insert | Insert Variety |
| **Wheel Sets Per Index** | 1 | 6 | 18 | |
| **Wheel Sets Per Insert** | 8 | 48 | 72 | |
| **Insert Costs (USD)** | $150 | $110 | $1500 | |
| **Insert Cost Per Wheel Set** | $18.75 | $2.29 | $20.83 | |
| **Labor To Index Tooling (minutes)** | 3 | 3 | 30 | |
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| **Labor Cost Per Wheel Set ($30/hour)** | $1.50 | $0.25 | $0.83 | |
| **Total Cost Per Wheel Set (USD)** | $22.79 | | $21.67 | ≤$21.67 |

# Productivity Updated Cutter Machining Cycle Time (minutes)

| | Underfloor Wheel Turning M/C or Lathe | Smaller Diameter/Two Effective Flute Design |
|---|---|---|
| **Good Wheels (w/o defects, worn profile only)** | 20.27 min | 14.22 min |
| **Bad Wheels (flat spots, shelling, out of round)** | 40-42 min | 14.22 min |

Updated Milling Cutter is 40% more Productive and Reliable

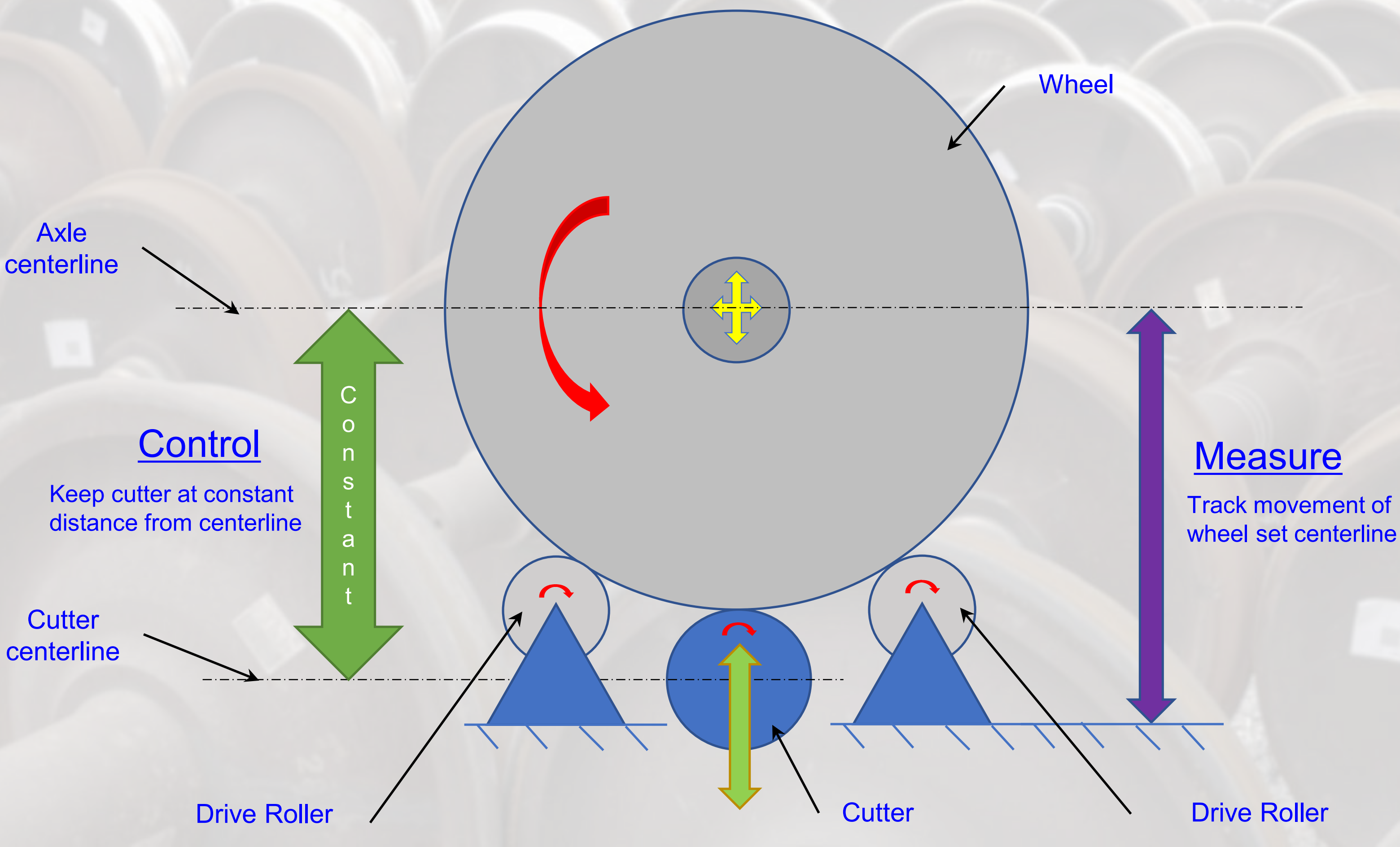
# Fundamental Shift

- Current milling and turning machines force wheel set center line to be held at exactly the same place in space resulting in an <u>expensive and complex operation</u>

# Fundamental Shift

- New wheel truing machine design allows wheel set center line to move
- New following probe monitors wheel set center line and relies on closed loop servo system to keep cutter at correct radius
- New integrated probing system finds initial location of axle center line with respect to cutter position
- If centerline moves, cutter moves with it, maintaining a constant diameter

# Fundamental Shift




## Bringing the cutter to the wheel

# Fundamental Shift

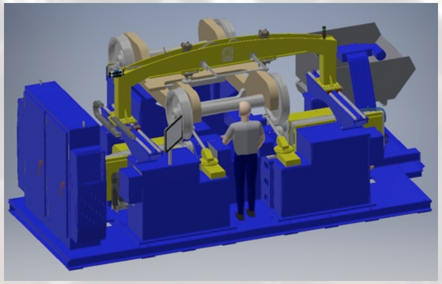
- **Clamping**
  - New design is therefore centerless and completely independent of the condition (roundness) of incoming wheels (*system is patent pending)*

# Fundamental Shift

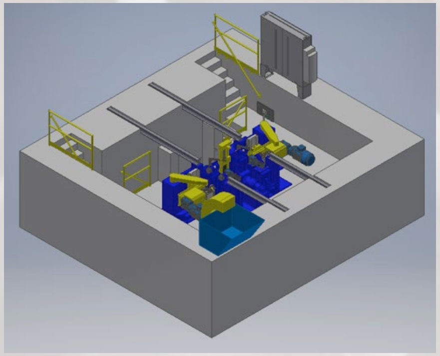
- **Measuring pre and post machining**
  - Wheel location and diameter for cutter alignment
  - Wheel width
  - Profile – worn and reprofiled
  - Back-to-back
  - Radial runout (each wheel)
  - Axial runout (each wheel)

  - Less chance for operator error
  - Better pre-machining measurement data = more precise machining process and less service metal removed
  - Measurement data can be stored and evaluated

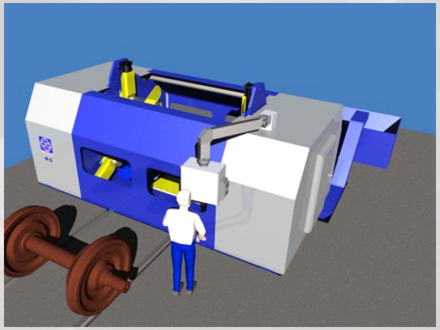
# Applications New Wheel Truing Technology



M1: Above-Floor Machine
For Loose Wheel Sets and Bogies



M2: Underfloor Machine
For Light Rail Vehicles (20 Ton Max Axle Load)



M5: Above-Floor “Portal” Machine
For Wheel Set Production

# Questions?