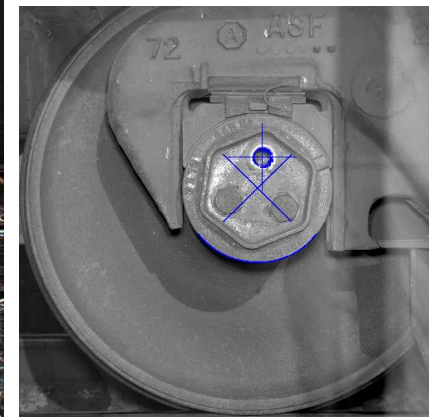
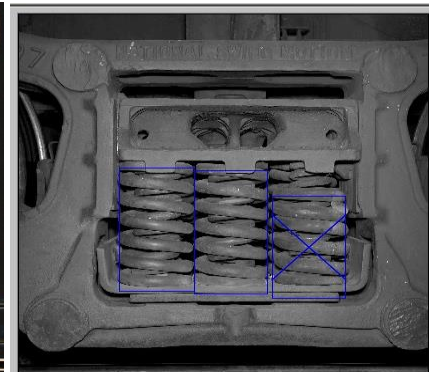


Fundamentals of Machine Vision for Railway Applications



Machine Vision - What is it?

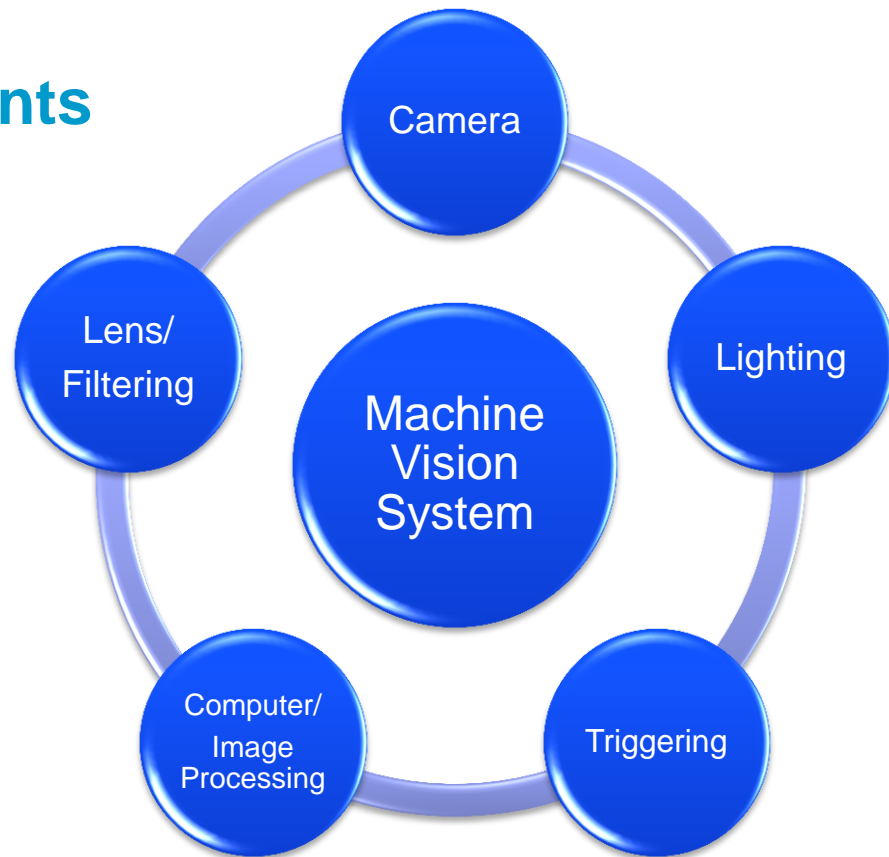
Machine vision is the technology and method used to provide imaging-based automatic inspection and analysis.



And many others....



Machine Vision Key Components



At the Center of a Machine Vision System are Cameras



Area Cameras



Line Scan Cameras



Infra-Red Cameras

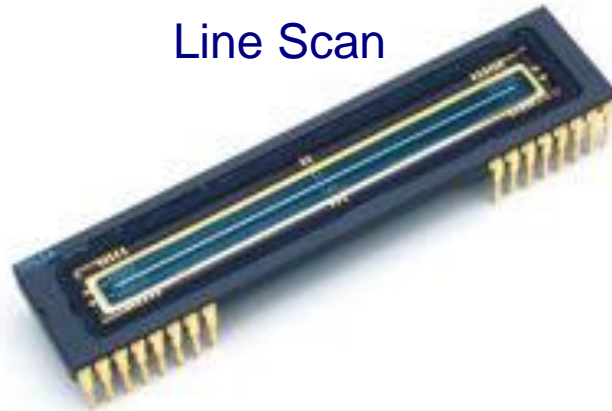


At the Center of a Machine Vision System are Cameras



Area Scan

Line Scan

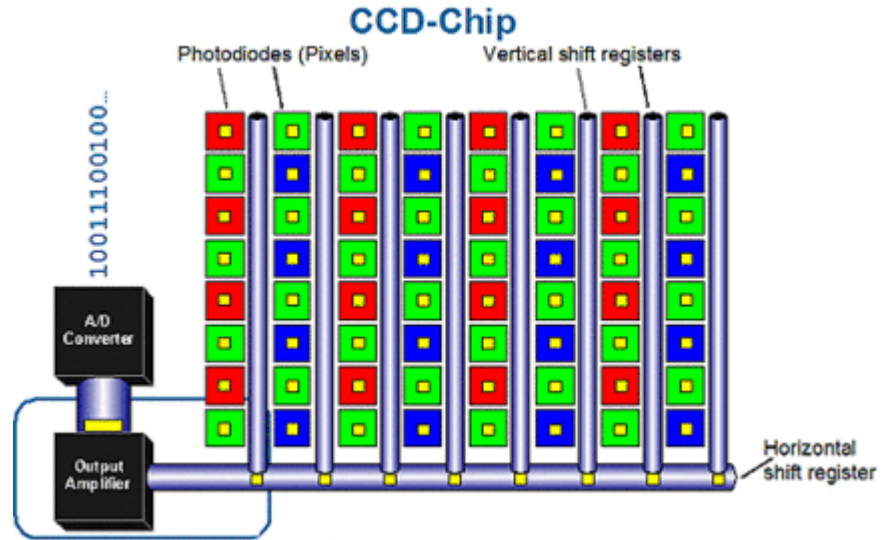


CCD
Charged Coupled Device

CMOS
Complementary Metal-
Oxide Semiconductor

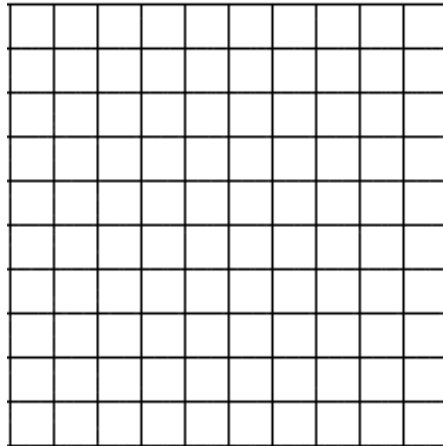


At the Center of a Machine Vision System are Cameras

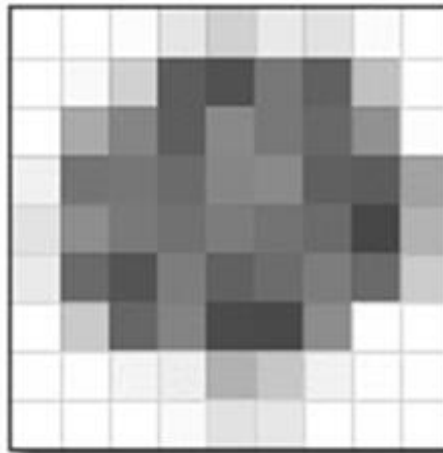


At the Center of a Machine Vision System are Camera(s)

Area Sensor



Digital Sampling



Pixel Quantization

249	244	240	230	209	233	227	251	255
248	245	210	93	81	120	97	193	254
250	170	133	94	137	120	104	145	253
241	116	118	107	134	138	96	92	163
247	142	121	113	124	115	107	71	179
234	106	84	125	97	108	125	106	204
241	202	102	132	75	73	141	246	252
253	252	244	239	178	199	242	250	245
255	249	244	250	226	231	240	251	253



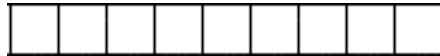
Typically 8-bits for greyscale

**Bonus Question: If black is represented by 0
What value is represented by pure white?**



At the Center of a Machine Vision System are Camera(s)

Line Scan Sensor



Digital Sampling



Pixel Quantization



Image Data Generated:

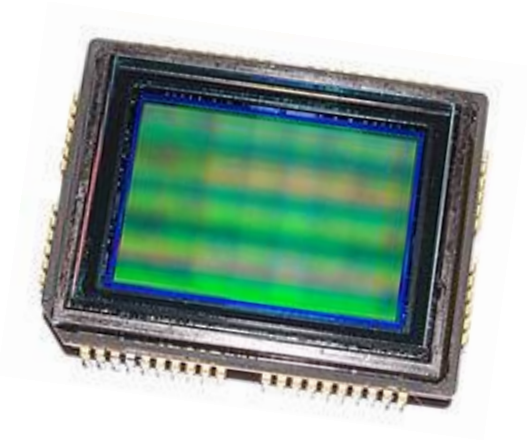
Area Scan Camera – Function of Number of Pixels (1MP, 2MP, 5MP. etc)

5 MegaPixel (B/W) = 5MBytes/Image.

Four spring packs/rail car= 20MB.

100 rail cars/train = 2 GB for one train.

25 trains/day = 50 GB even if we apply compression 5GB



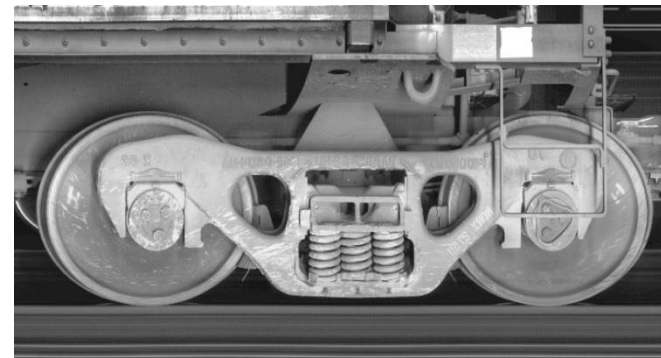
Data Generated:

Line scan camera – Function of the number Pixels as well (2K, 5K. Etc.)

If we have 1 mm per line scan

Rail car will require ~ = 30MB/Camera/Rail Car

100 cars x 14 cameras x 30 Mbytes per camera per car = 42 Gbytes



Lens and Filters for Machine Vision Systems



- Ensures high quality input to the sensors and not all lenses the same
- Filters enable blocking certain wavelengths
- Filters can also reduce glare



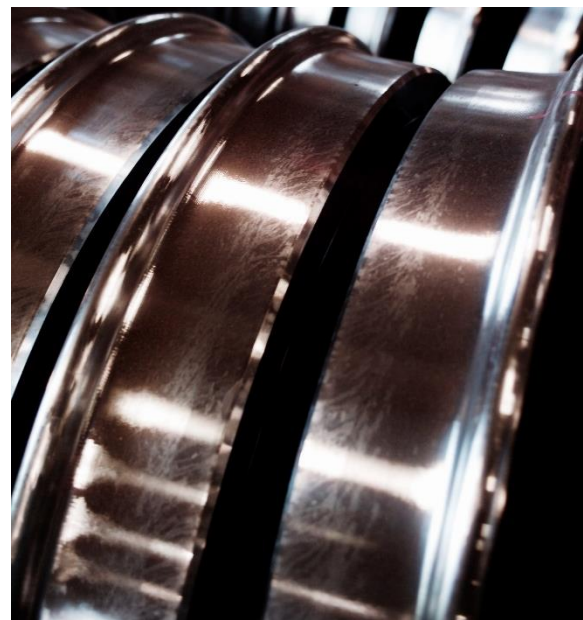
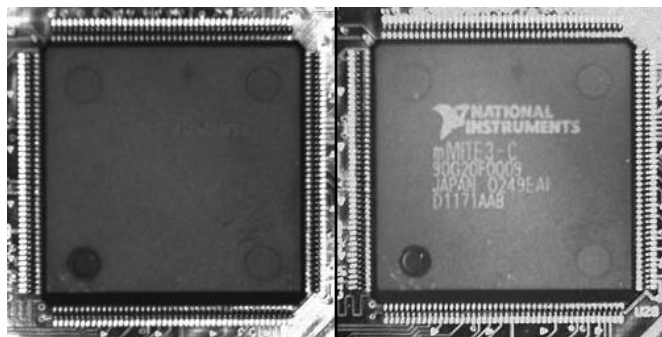
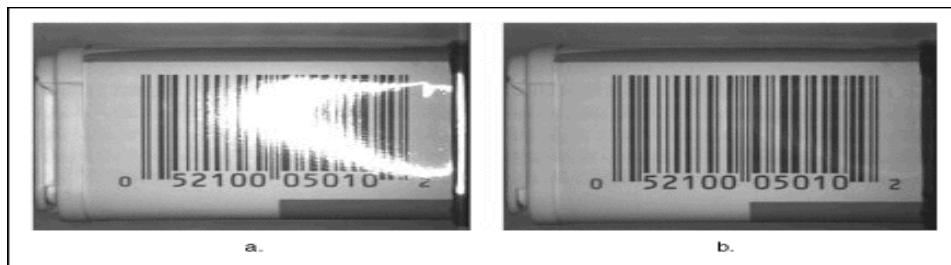
The art of illumination is critical to the MVS



Strobed, Continuous, Broad Spectrum or Narrow Band Light Sources



The art of illumination is critical to MVS



Diffused, Area, Line, Off Angle. Head on, Back Lighting



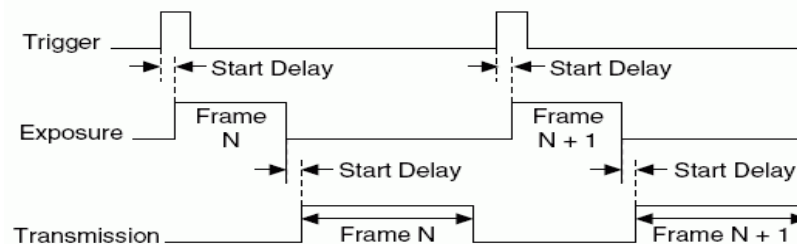
Computer and Control Electronics:

- Climate Controlled Bungalow
- Electronics Rack
- Industrial Computer
- Control Electronics
- Environmental Control
- Data Communications
- RFID System

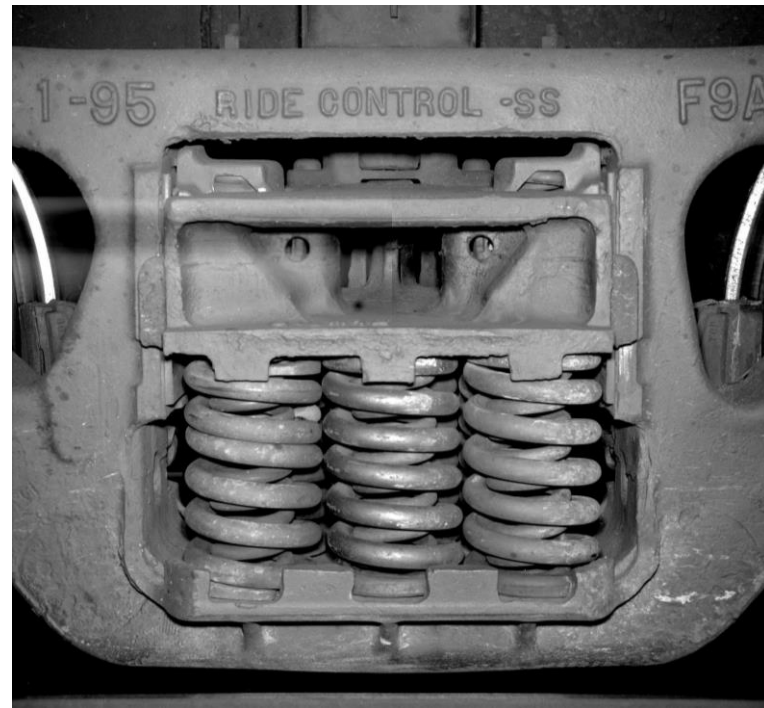


Triggering Considerations:

- Speed
- Change in speed considerations
- Stopping? Reverse?
- What component are we imaging?
- Directionality (Uni/Bi)
- Single or multiple image/camera sampling?



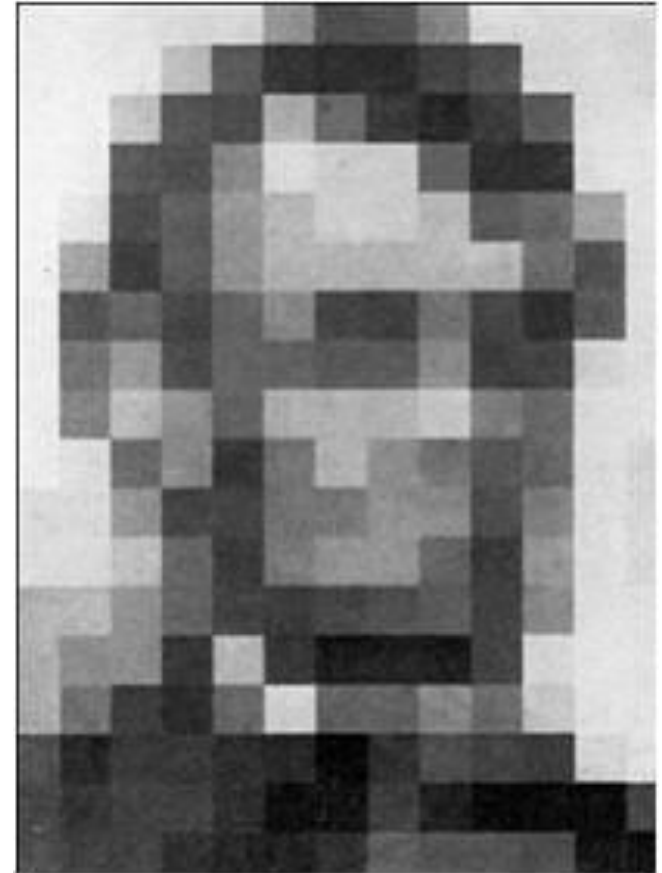
Triggering the System



Software Imaging Consideration:

- Manual Image Review
- Automated Processing
- Blend (Manual/Automated)
- Types of Defects

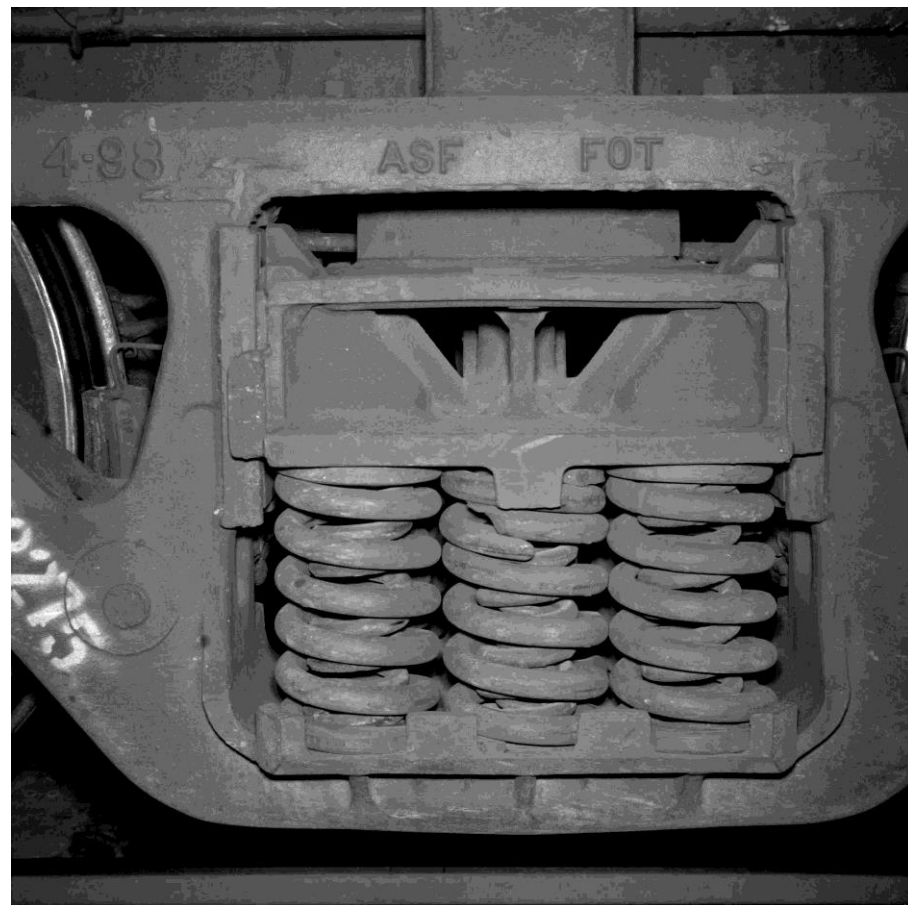
Bonus Question:
If you know who this is a picture of
raise your hand.



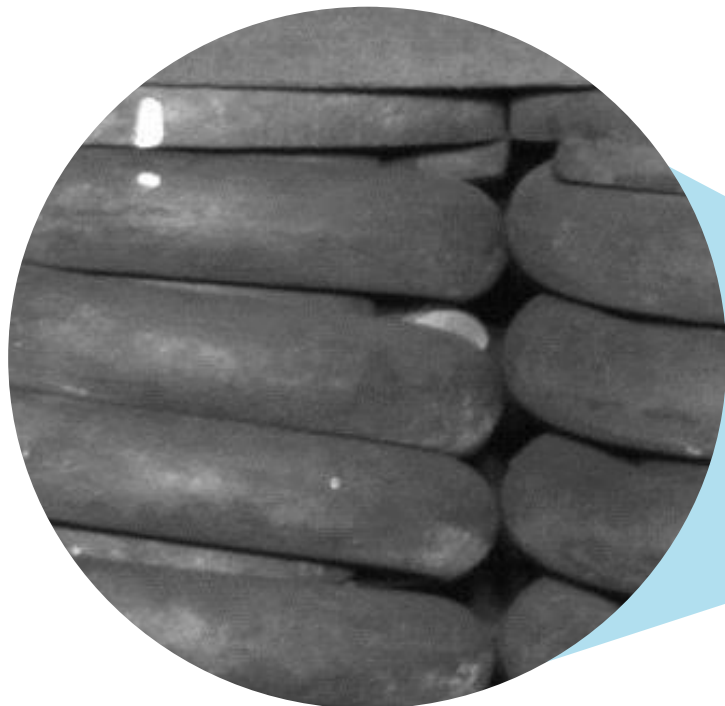
Software and Image Processing:

Bonus Question:

If you know what is wrong with this truck raise your hand?



Software and Image Processing:



Environmental & Site Considerations

- Installation location
- Sunlight
- Reflectivity
- Weather
- Diversity of fleet
- Infrastructure Access



Growing Number of Machine Vision Systems for Railway Applications:



Infrastructure Components



Rolling Stock Components



The Need for Machine Vision – North America RR

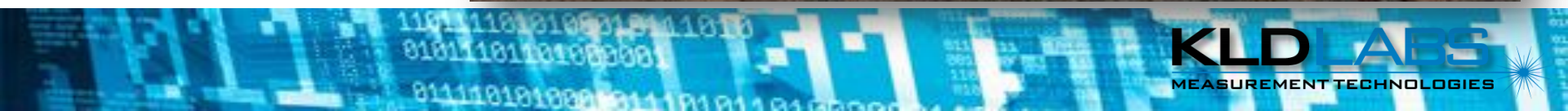
- ~200,000 Miles of Track
(Wrap the Earth 8 times)
- Wide Variety of Rail
Section Sizes



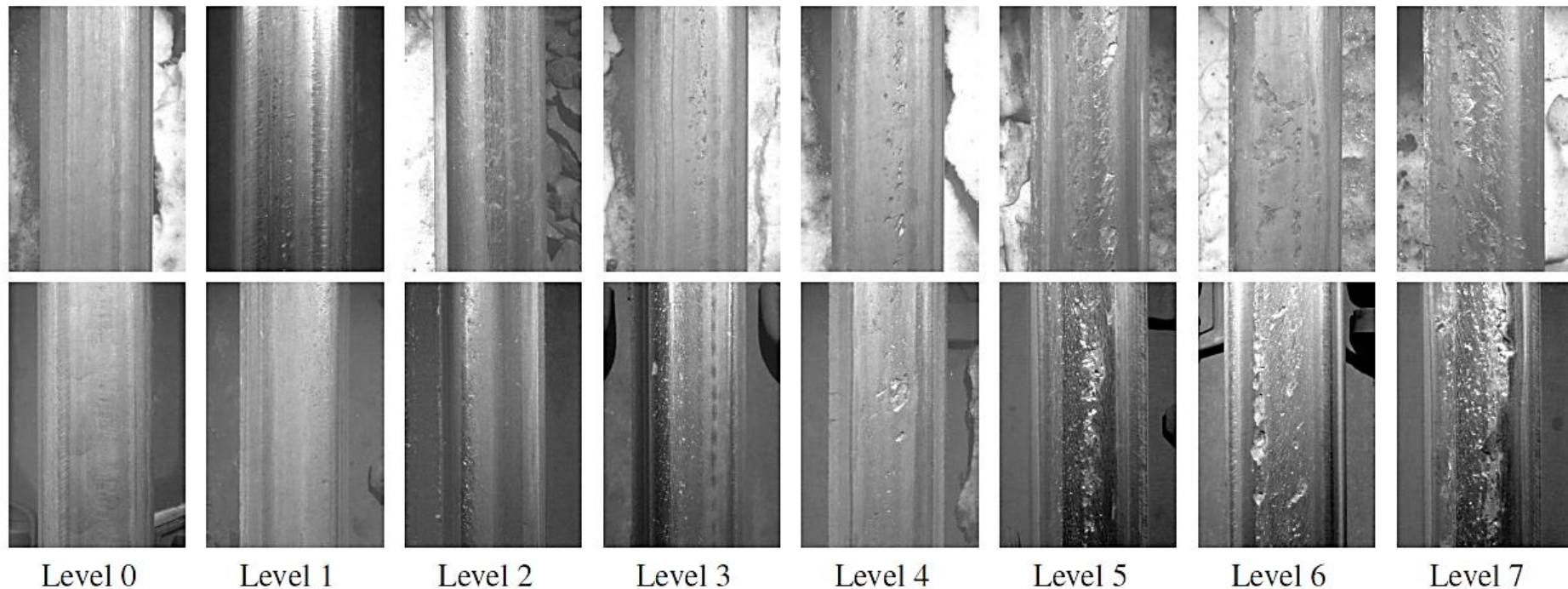
Machine Vision for Rail Wear Assessment



Machine Vision for Rail Surface Evaluation



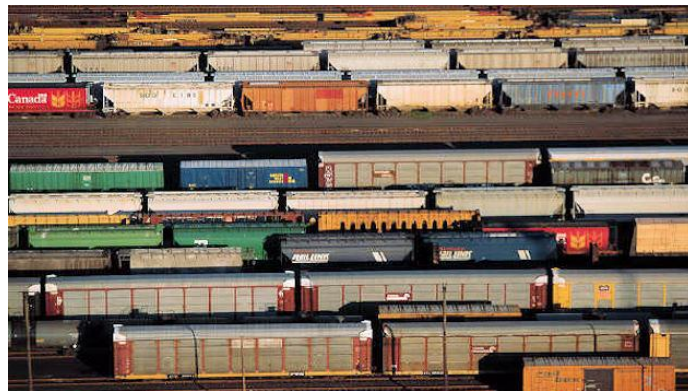
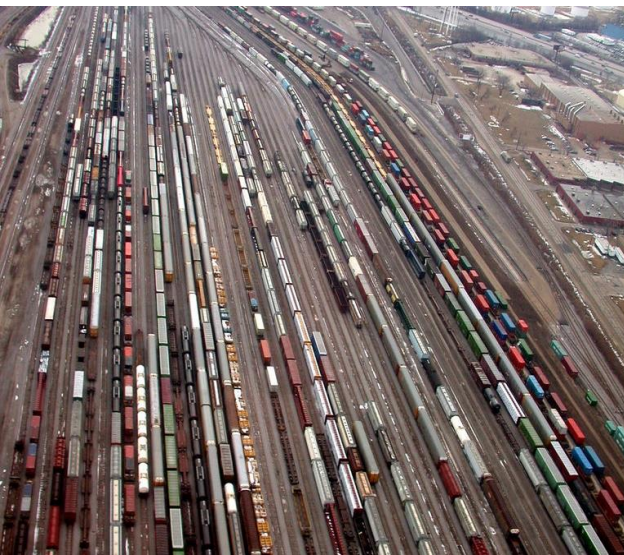
Machine Vision for Rail Surface Evaluation



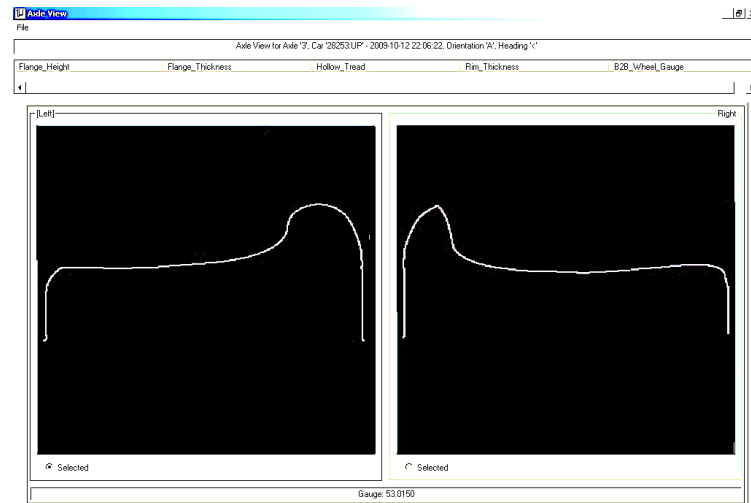
The Need for Machine Vision North American Railroad

(Rough Numbers)

- 1.5 Million Cars/~12M Wheels
- 26,000 Locomotives/~300k Wheels
- Diverse Fleet



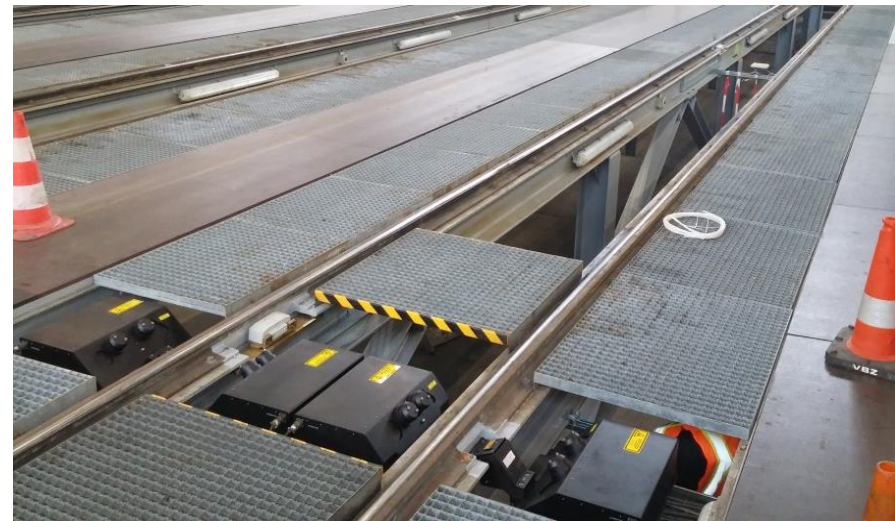
Machine Vision for Wheel Wear



Machine Vision for Wheel Wear



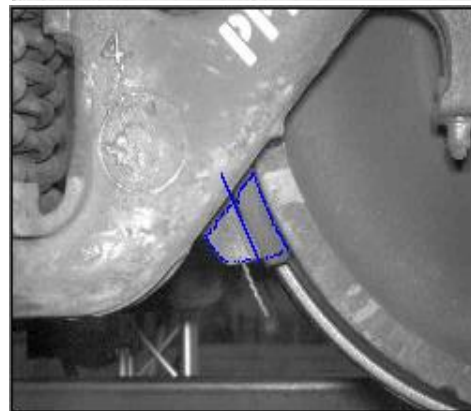
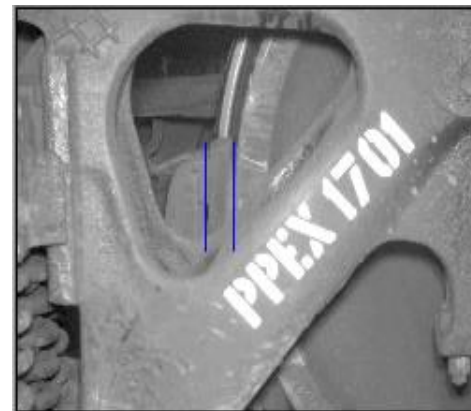
Outdoor Installation



Indoor Installation



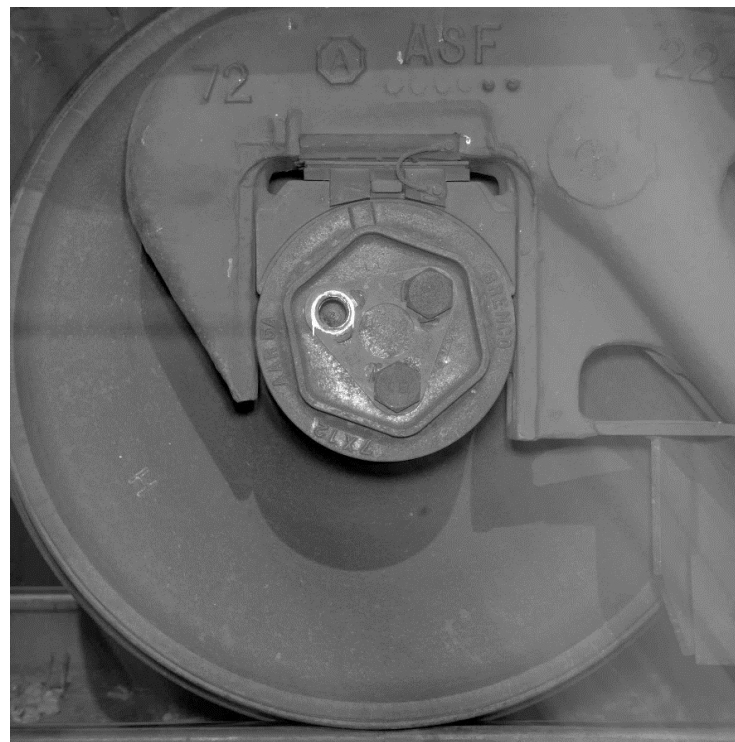
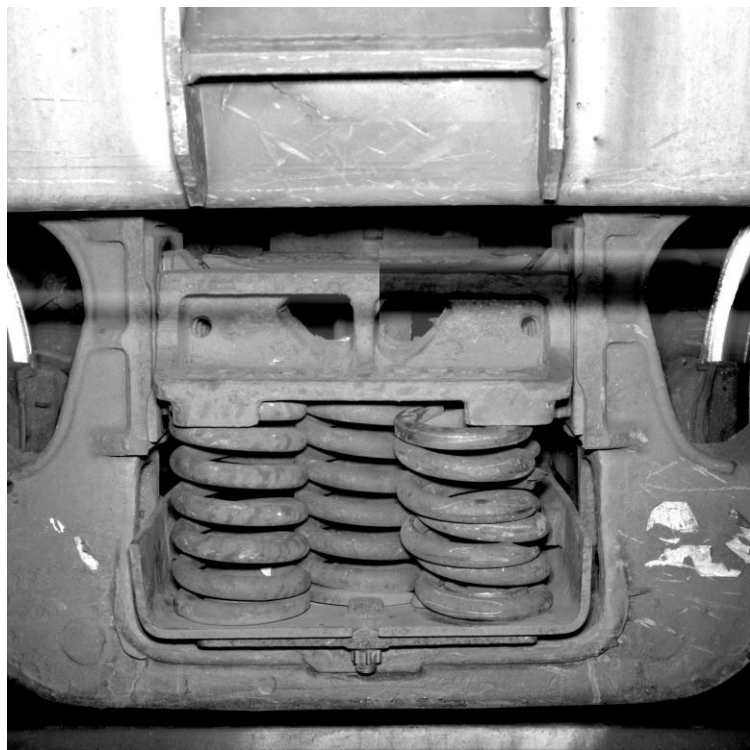
Machine Vision for Brake Shoe Evaluation



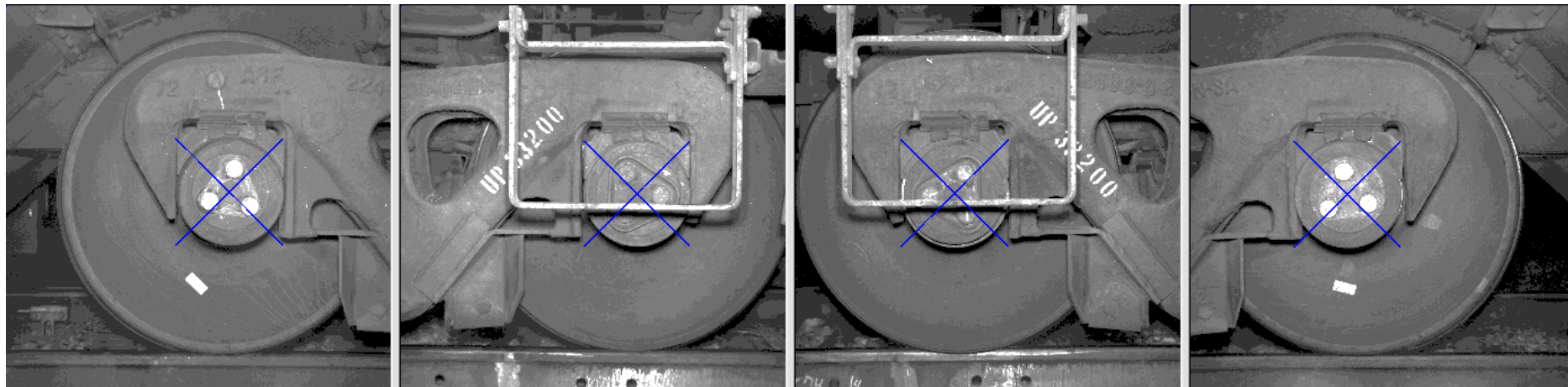
Machine Vision for Truck Evaluation



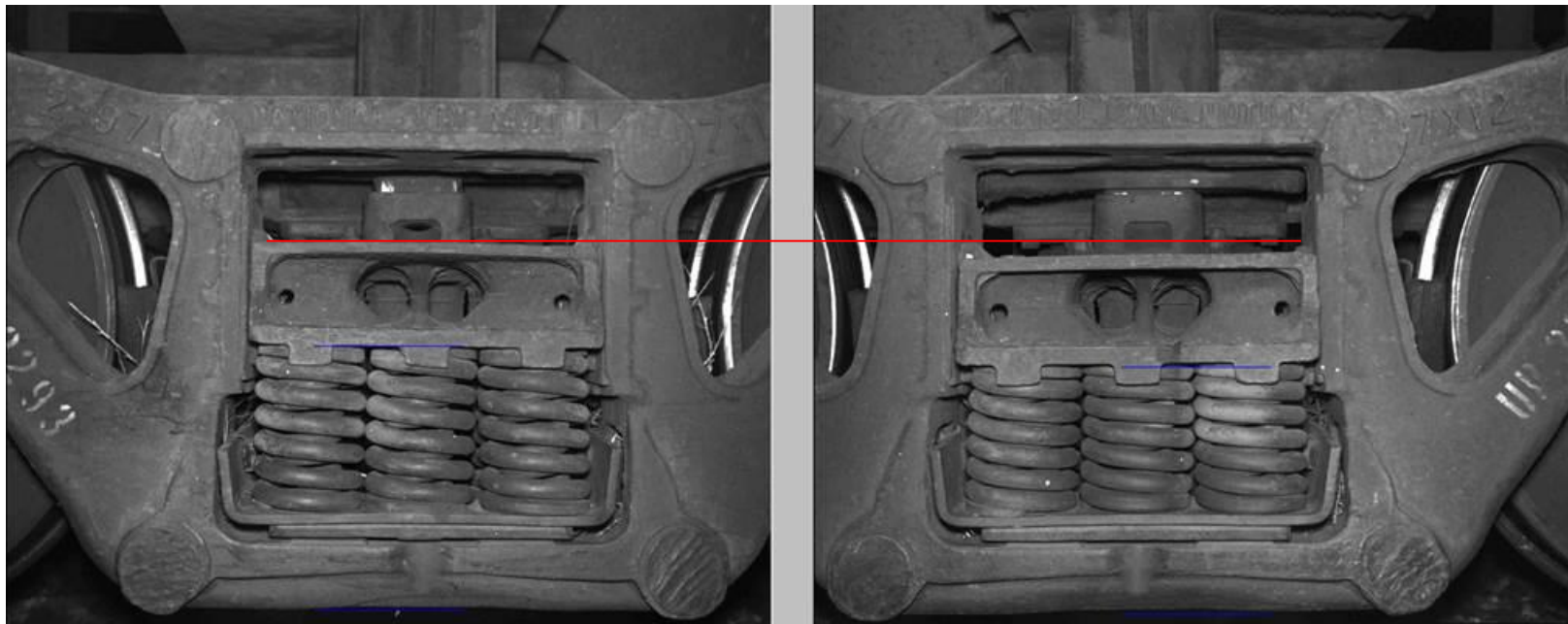
Machine Vision for Truck Evaluation



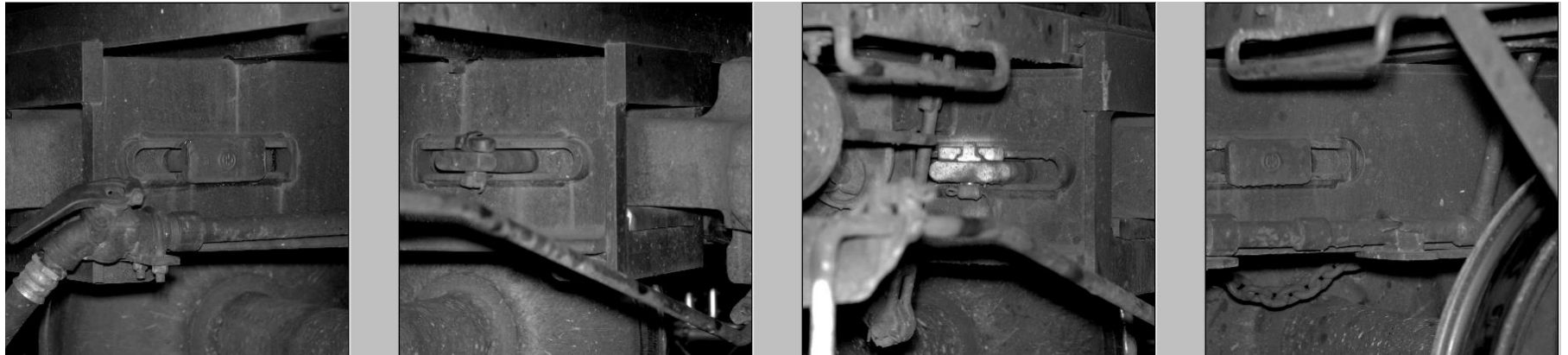
Machine Vision for Truck Evaluation



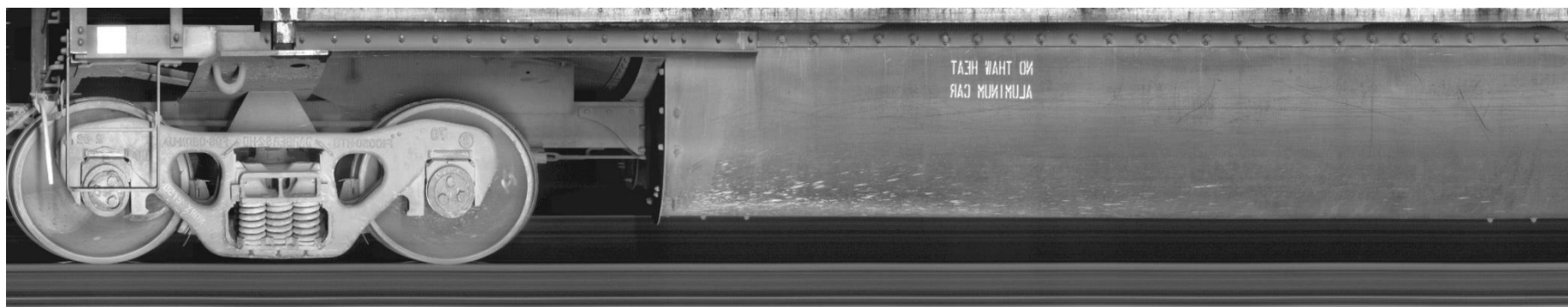
Machine Vision for Truck Evaluation



Machine Vision for Coupler Evaluation



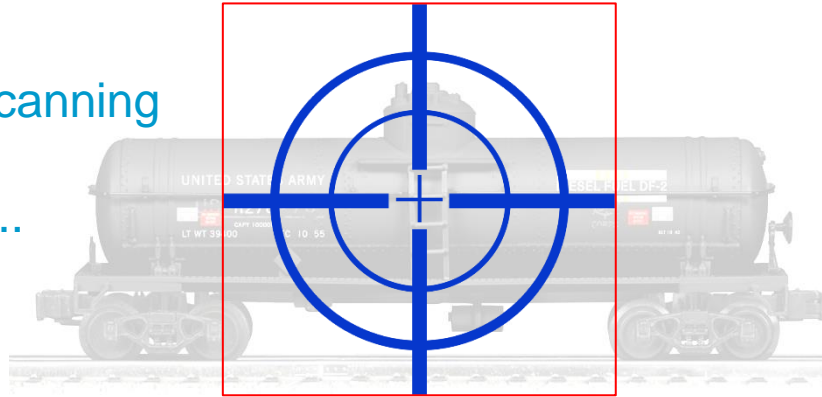
Machine Vision for Train Scanning



Growing Number of Machine Vision Railway Applications:

Rolling Stock

- 1) Wheel Measurements
- 2) Brake Measurement
- 3) Truck Component Evaluation
- 4) Coupler Evaluation
- 5) Undercar
- 6) Tread Surface
- 7) Complete Train Scanning
- 8) Tank Cars Doors
- 9) And more coming..



Infrastructure

- 1) Rail Measurements
- 2) Track Assessment
- 3) Fasteners
- 4) Tie Assessment
- 5) Joint Bars
- 6) Rail Surface
- 7) Right of Way
- 8) Vegetation
- 9) And more coming..



Summary:

- 1) MVS have many design considerations
(cameras, lighting, resolution, triggering, etc.)
- 2) If integrated correctly can yield high resolution imagery for both manual and automated analysis
- 3) MVS generate Big Data quickly
- 4) MVS have many environmental and site installation considerations
- 5) Currently a wide variety of machine vision applications already deployed and more coming..





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