

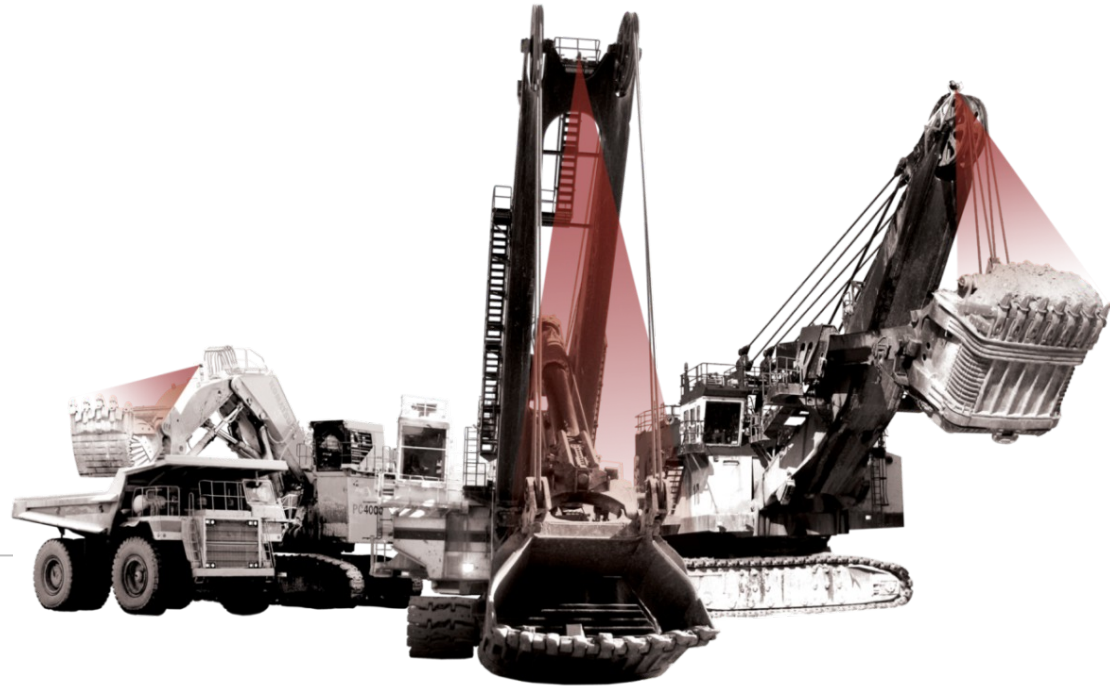
# Real-time Tooth Monitoring System for Wheel Loaders

Dr. Neda Parnian and Dr. Shahram Tafazoli

**MOTION METRICS**



EXTENDED MACHINE SENSES



[www.MotionMetrics.com](http://www.MotionMetrics.com)

# LoaderMetrics

## Missing Tooth Detection for Loaders



The teeth on the loader buckets is breaking off and ending up in the crusher.

- This would jam the crusher for hours or days, costing up to millions of dollars in downtime.
- It is a slow and dangerous procedure to remove a tooth from the crusher.
- The problem is even worse if the tooth passes through the crusher and damages the conveyor belt!



A tooth breaks off the loader.



It is hauled with material to the crusher.



The tooth jams the crusher.

# LoaderMetrics

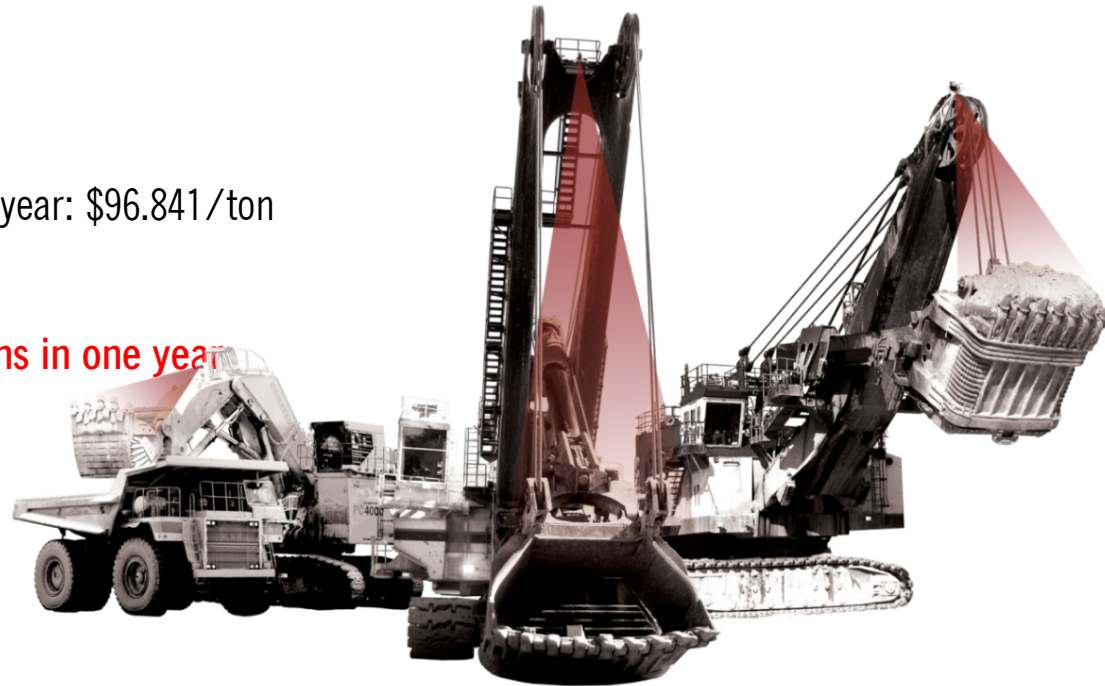
## Missing Tooth Detection for Loaders



### Case Study □ iron mine

- Number of excavators (Shovels+Loaders) = 32
- Number of teeth ended into the crusher in one year: 83
- Downtime: approximately 400 hours
- Loss in production: 2.2 Million tons
- Grade : approximately 62.7%
- Iron average price in that particular year: \$96.841/ton

**Lost: approximately \$133.6 Millions in one year**




Search for Crusher Incident on YouTube:





# LoaderMetrics□

## Traditional Missing Tooth Detection for Loaders

- Operators are responsible for checking Teeth  Issue: Teeth Visibility





# LoaderMetrics<sup>□</sup>

## Missing Tooth Detection for Loaders

- Adapted the missing tooth technology from shovels to wheel loaders.
- Optional surveillance camera views help to prevent the risk of collisions.



# LoaderMetrics<sup>□</sup>

## Camera and Light Location



- Camera and light are mounted between the front wheels to provide a clear view of the bucket teeth as it loads.



# LoaderMetrics

## Challenges



- Dust and mud collection  camera view





# LoaderMetrics<sup>□</sup> Challenges



- Lens Cleaning System



# LoaderMetrics<sup>□</sup>

## Bucket Camera View



- The teeth are visible when the bucket tilts downward, displaying the teeth as silhouettes against the background.
- The bucket will only remain in this state for a short time interval, so the video processing algorithms has to analyze the status of the individual tooth in the short window of opportunity.



# LoaderMetrics

## Challenges



- Short Interval Time Visibility  outside cab view



# LoaderMetrics

## Challenges



- Short Interval Time Visibility  camera view

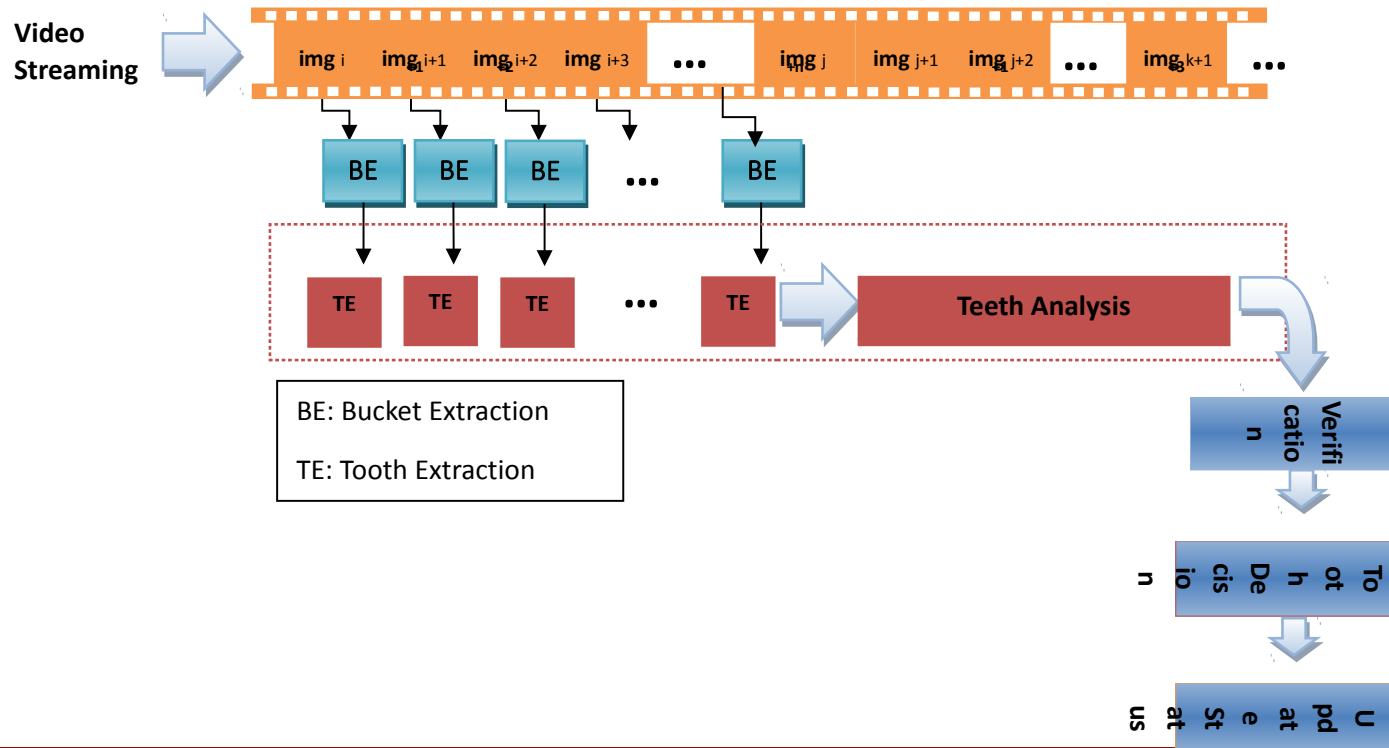




# LoaderMetrics

## Missing Tooth Detection for Loaders

- An embedded computer system will continuously capture images from the video stream from the bucket camera.
- The software will analyze the images by employing sophisticated image processing and artificial intelligence algorithms to determine if the bucket and teeth appear in the image.

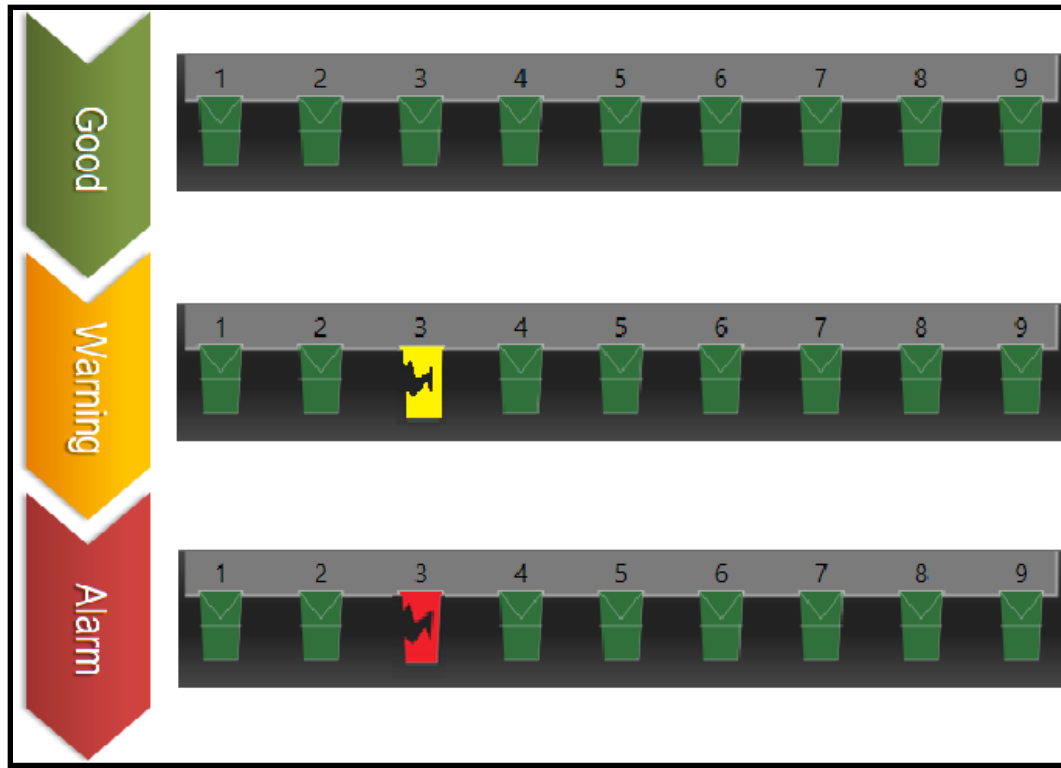


# LoaderMetrics

## Missing Tooth Detection for Loaders



- The software will analyze each individual tooth's appearance and alert the operator if one is missing.

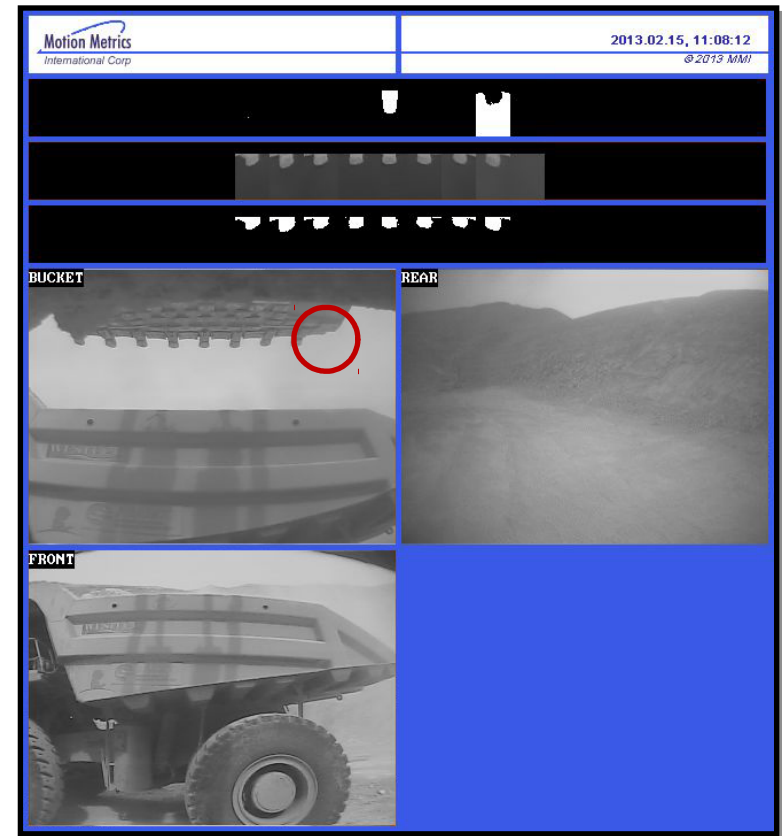
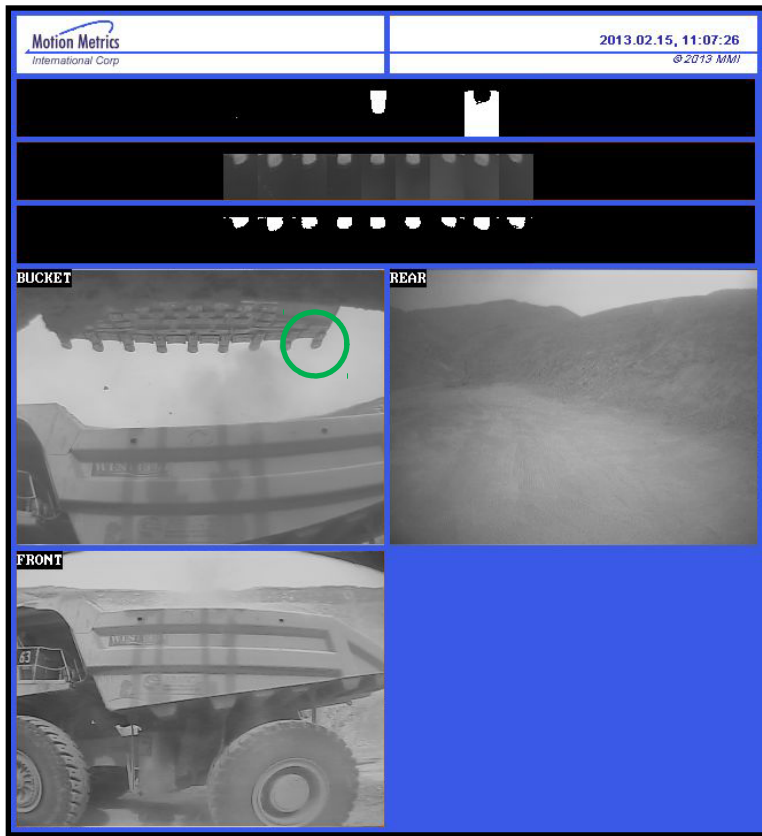


# LoaderMetrics

## Detected Missing Tooth



- When the missing tooth detection system successfully analyzes all teeth, an image file is created and saved on the embedded system.

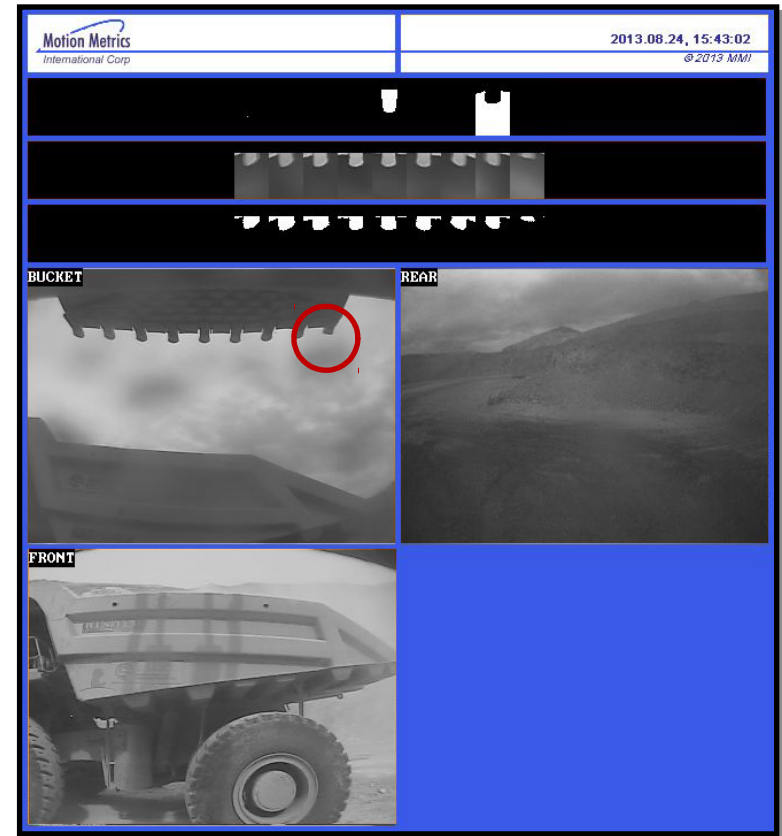
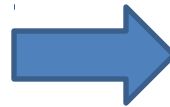
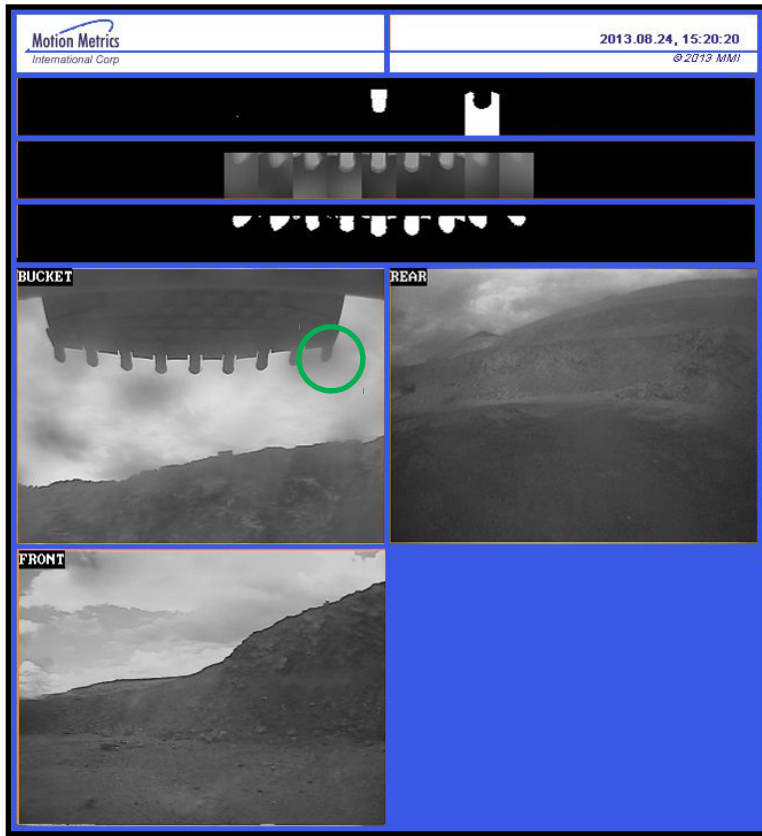


# LoaderMetrics

## Detected Missing Tooth



- Often, a tooth is missing but the adapter is still present. The missing tooth detection system is able to detect this situation as well, but it may take longer.



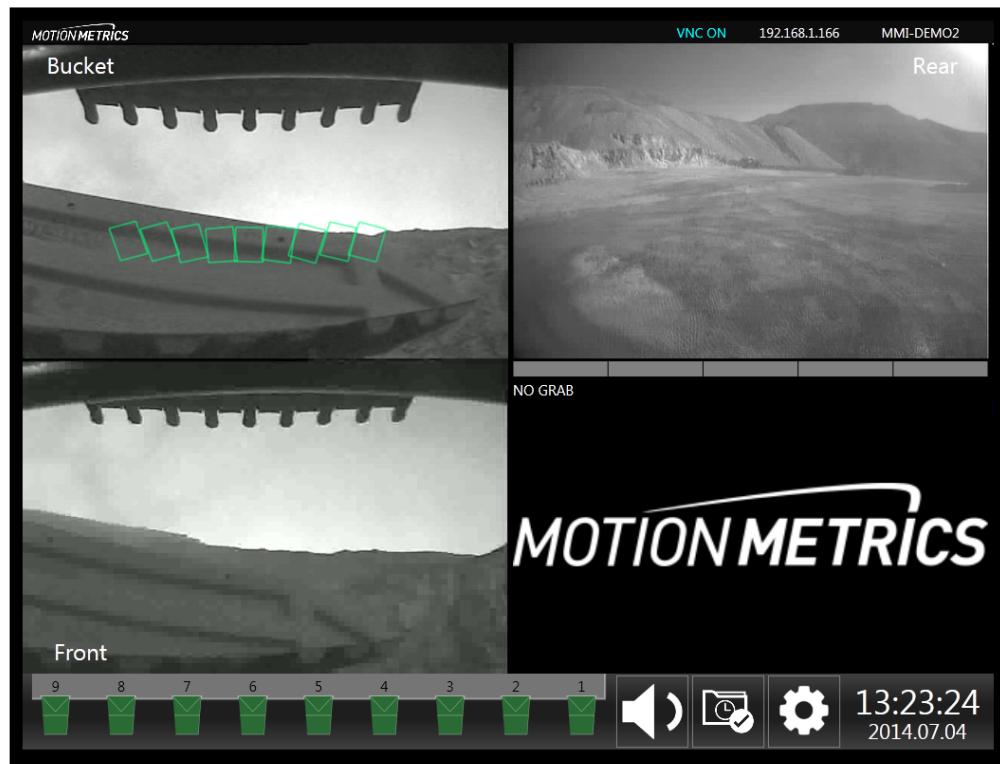


# LoaderMetrics<sup>®</sup>

## Blind Spot Reduction



- The system also includes a front-facing camera and a rear-facing camera.
- All the camera views are displayed to the operator on a 7" touch screen.

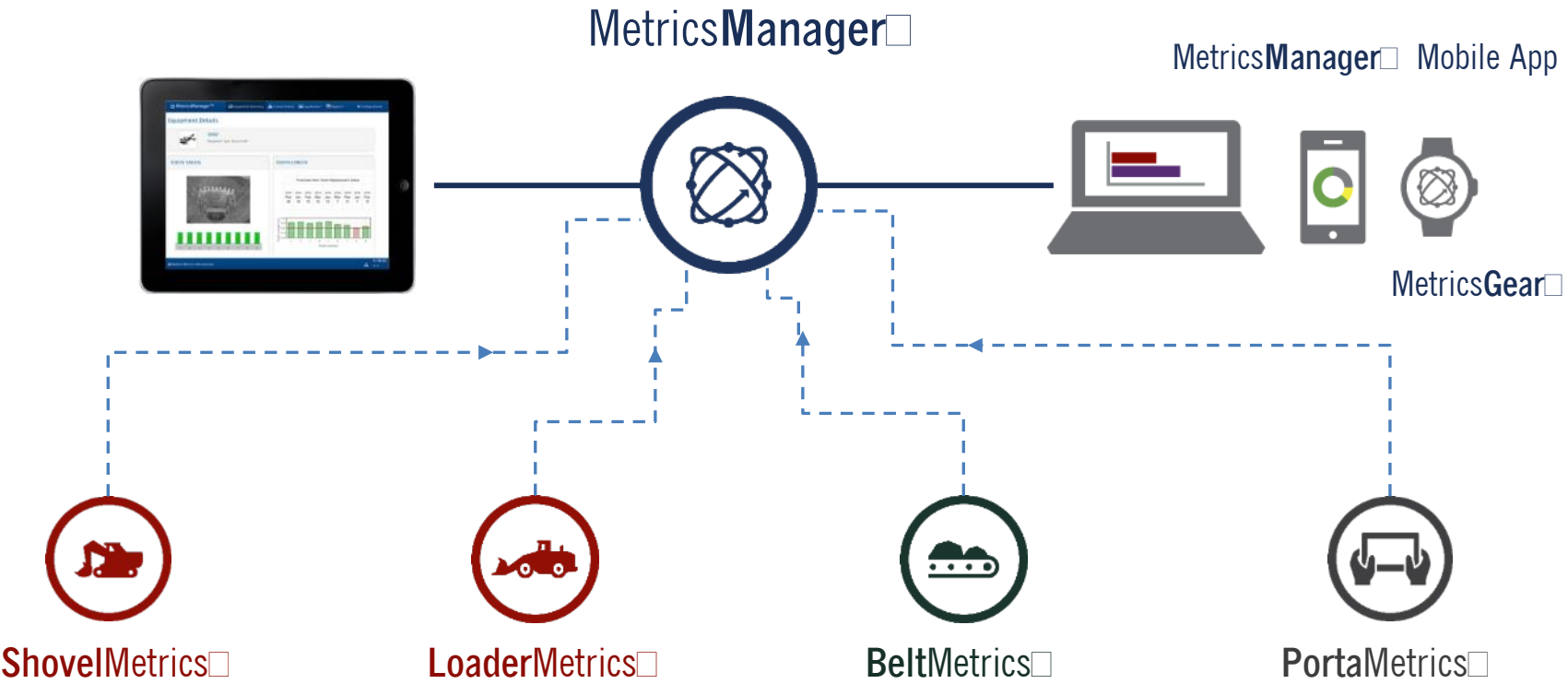




# MetricsManager

Centralized Data Server

- A centralized sever consolidates the information provided by all of our systems.
- The information can be accessed by any device on the network.



# MetricsManager

## Real-time Reporting



- Up-to-the-minute reports on the equipment status.
- Customizable reports can be generated.

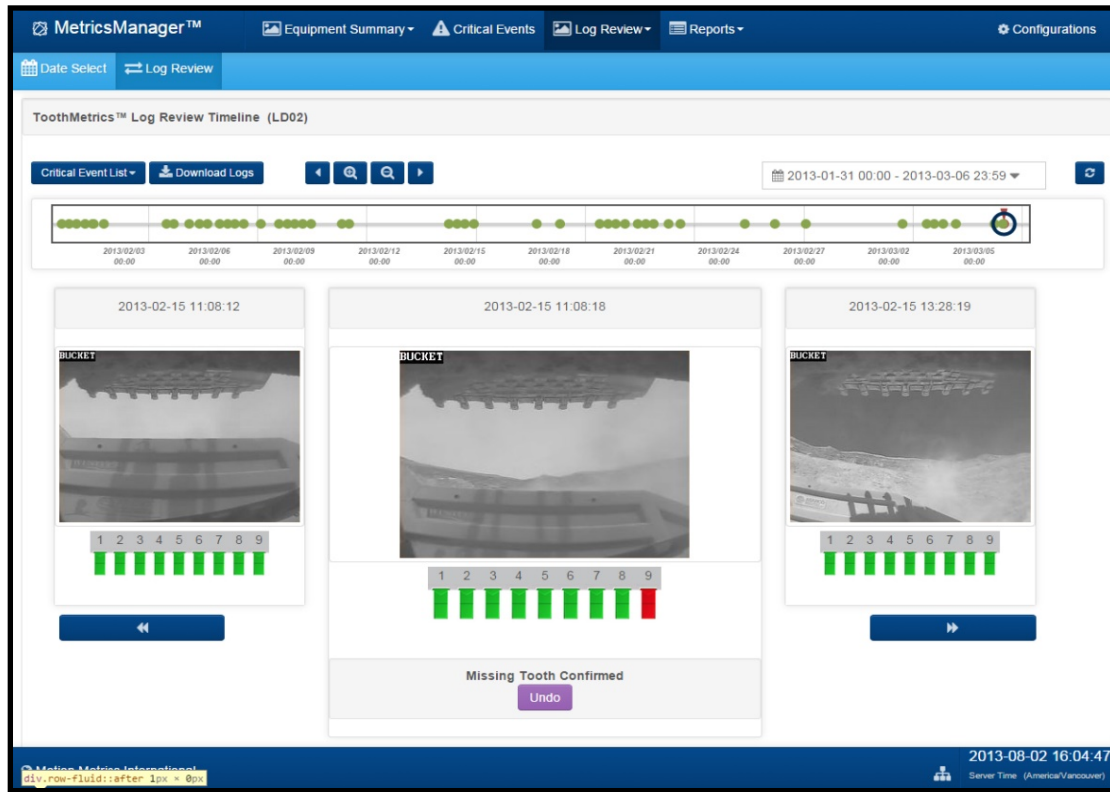
The screenshot displays the MetricsManager™ web interface. The top navigation bar includes 'Equipment Summary', 'Critical Events', 'Log Review', 'Reports', and 'Configurations'. Below this, there are tabs for 'Shovels', 'Loaders', and 'Conveyors'. The main content area is divided into two sections: 'Equipment' and 'Tooth Status'. The 'Equipment' section shows two items: LD02 (CAT 994) and LD03 (LeTourneau 1850). The 'Tooth Status' section shows two status indicators: a red circle with a white 'W' (warning) for LD02, and a green circle with a white 'V' (verified) for LD03. Both status indicators include a 'Last Updated' timestamp: '9 min ago' for LD02 and '11 min ago' for LD03. The bottom of the interface shows the Motion Metrics International logo and the server time: '2013-08-02 22:52:16 Server Time (America/Vancouver)'.



# MetricsManager

## Detailed Data Analysis

- Past events can be reviewed to reconstruct an event.
- Trends can be analyzed to identify inefficiencies.

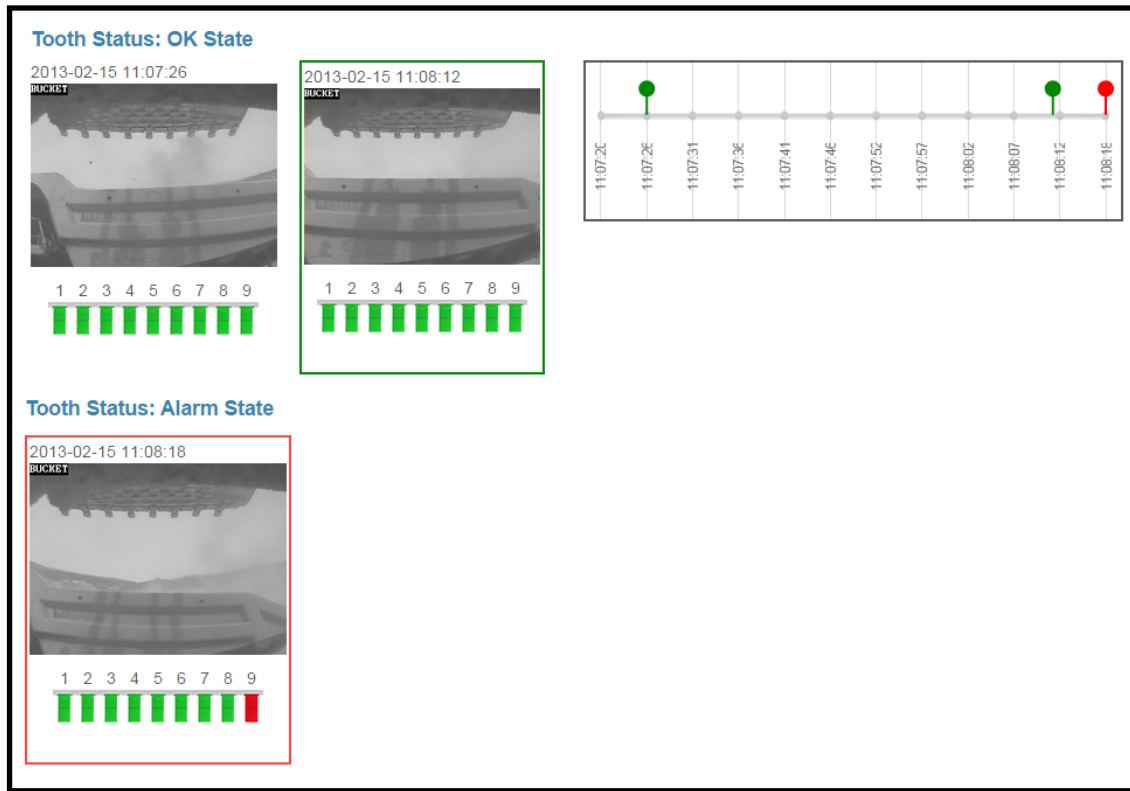


# MetricsManager

## Auto Generated Report



- Generates a report for a defined period of time.
- Shows captured images of alarm and the progression of alarms on timeline.



Thank You!



EXTENDED MACHINE SENSES

Contact Info

Email: [info@motionmetrics.com](mailto:info@motionmetrics.com)

Web: [www.MotionMetrics.com](http://www.MotionMetrics.com)

Tel: +1-604-822-5842