Intelligent Railway Systems

Unirail

CAMEA Unirail is a state-of-the-art and field-proven platform for creation of multifunctional and scalable intelligent railway systems dedicated to the railway market sector including traffic safety, operations, maintenance and information. Some of the key technologies used for creating the most innovative products are continuously being developed by CAMEA. While OEM components are available for integration into current systems, fully-featured systems are also being provided. CAMEA closely cooperates with technological and business partners in engineering, installation, maintenance, staff training etc.

- **Wagon number recognition** reads UIC markings and numbers of all railway wagons and helps match the results of other systems with the right wagon.
- **Flat wheel detector** detects inequalities and eccentricities on train wheels. These disturbances lead to increased noise in the neighborhood of the railway.
- **Wheel impact load detector** helps railway preservation and maintenance reduction due to a significant elimination of overloaded vehicles without any traffic flow disturbance.
- **Traffic classification and data** with high accuracy can be obtained by using fusion of data from various sensors and collection applications.
- **Dimension-in-motion** uses a laser scanner to measure vehicle height, width and length as well as to provide a 3D vehicle shape and vehicle classification. It can also be used for over height violation detection.
- **Multifunctional measuring** is a complex of special systems that check and measure the wagon condition.
- **Many other** applications and technologies are available on request (depends on requirements).

Integration

The system is scalable, so new functionality can be added later when required. Isolated systems can be joined in a network which generates a synergistic effect by creating space for novel functionality like overweight wagon detection, tracking of vehicles thrown out of the track etc. The system can also be easily integrated with back offices and systems of other vendors due to standard communication protocols (TCP/IP, SNMP etc.) and interfaces. Heterogeneous intelligent railway applications can be integrated into a single system.

Maintenance

The system offers remote system management with detailed system diagnostics (using standard protocols like SNMP). Extended malfunction codes are also provided for easy system diagnostics and maintenance planning (sensor replacement etc.). The system is designed to require minimum maintenance. Still, basic service operations should be done on a regular basis including cleaning (e.g. cameras when installed) and removing road dirt (mud, slush, snow, sand, etc.) in locations where the sensors are installed.

Security

The system is ready for direct enforcement back office purposes by applying security rules such as prevention of making unauthorized changes to its configuration and measured data by protected access. All user actions are logged and can be read back and analyzed. In direct enforcement system versions the measured data and images of violating vehicles are electronically signed and encrypted. So only competent authorities can access the data and it cannot be undetectably modified.

Installation

The system components allow installation in a wide area, tunnels and train stations using gantries or poles. Standard 110/230V lines can provide power supply to the system. System can use an UPS battery pack as a backup power energy for holding continuity of measuring.

Multi-functionality

There are many applications which can be created using the Unirail platform components. Different functionality can be integrated together to create multifunctional and scalable intelligent railway solutions.

The applications can share components. For example, a wheel sensor placed in a track can be used for triggering the start of hot-box system measuring and the same electrical signal can be routed into the OCR system for train speed calculation and image data processing. This can significantly reduce installation and maintenance costs.

The applications can also be integrated together. For example the flat wheel detector can be joined with wagon number identification and the hot box and hot wheel system, etc. This not only saves money, but significantly improves the system efficiency.

Communication

The system uses both wired and wireless communication interfaces and is also equipped for direct control via configurable galvanically isolated inputs and outputs (e.g. variable message signs etc.). The wired interfaces include metallic/fiber optic Ethernet, RS232, RS485 etc.

Wireless communication interface usage depends on the distance between measuring points. For example Wi-Fi data link can be used for on-line data communication between main measuring point and remote desktop for operator in another place or to send protocol to a patrol location where the sensors are installed.

In case of systems which are separated by larger distances, mobile (cellular) networks (GSM, LTE, CDMA etc.) can be used.

Time Synchronization

Precise and reliable time synchronization is a key feature for creating geographically spread intelligent railways systems. The system is synchronized to GNSS satellite systems (GPS, GLONASS etc.) which ensures accurate data timestamping and time measurement in the entire network of isolated intelligent railway systems.
Components

The system key components are designed from scratch to ensure high reliability, compact and industrial grade design, high degree of environmental protection and wide operating temperature range. For example all measurement circuits for optical character recognition systems are embedded in a single unit including a camera, lighting synchronized with wheel position sensors and temperature sensors.

Intelligent Railway Systems

Cabinet UC-CAB

The Unirail platform 19" rack units can be housed in the UC-CAB cabinet. The cabinet is equipped with accessories including a heating unit, fans, protection circuits etc. The cabinet can be installed on poles, portals or walls using a proper mounting kit or can be set on the ground on metal legs or concrete support. Optionally it can be equipped with a sun shield. All devices comply with the EMC specification and requirements for operation on the railway.

Central Processing Unit UC-CPU

The UC-CPU is a 3U 19" size industrial grade computer (PC) with standard communication interfaces, removable SSD storage, super capacitor backup etc.

Ethernet Switch Unit UC-ESU

The UC-ESU is a 1U/2U rack 19" size industrial grade B/16-port, 1 Gb/s router and switch with Wi-Fi and 3G capability.

Power Supply Unit UC-PSU

The UC-PSU is a 3U rack 19" size power supply unit with embedded power line filters, lightning current arresters and AC/DC circuit breakers. It is remotely manageable with system watchdog capability, controlled voltage outputs, on/off/reset control and auxiliary power source input (e.g. from a diesel generator). Optionally, it can be equipped with a UPS accumulator charger.

Satellite Time Unit UC-STU

The UC-STU is a remotely manageable time unit for precise and reliable time synchronization of the whole system. Accurate time is taken form GNSS satellites (GPS/GLONASS) verified and distributed by an NTP server and hardware signals.

Camera-Illumination Unit UC-CLU

The UC-CLU is a 7U rack 19" size camera and illumination unit with a high speed line camera module and a special linear illumination source. The camera captures a set of images of the train and merges image data with special synchronization inputs from the track (wheel contact) or other systems providing information about the wheel speed and direction. The illumination source is used during low light conditions. The module communicates with the processing unit via Ethernet. The unit requires a special optical window in the cabinet door with an anti-graffiti foil.

Wheel Contact Sensor

The wheel contact sensor is installed into the track on the rail. The signal is transformed by an internal electronic unit and used as a trigger for measuring initialization and information about the axle present for image processing. When combined with a special evaluation board, it generates accurate speed information for a variety of applications. The wheel sensor can be quickly and easily mounted on grooved rails without drilling, a special clamp under the rail is used. In case of a combination of more systems, a signal from one wheel contact can be shared with others while maintaining the system cost. Supported sensors are e.g. by Frauscher - RSR123, RSR180 etc.

Remote Desktop Unit

The Unirail remote desktop shows the measured data. It also helps the operator set the cameras and illumination with live preview. The unit can be connected via Ethernet through a metallic/fibre optic cable or a mobile network. The basic configuration set contains a monitor, a keyboard & a mouse and SW applications.

Hot Box & Hot Wheels Detector

The Unirail HBBHW is a solution for detection of hot wheels and boxes. The main part is a hollow steel sleeper that is installed directly under the tracks. The sleeper serves as a protection housing for sensor modules. Two infrared sensors for inspection of bearing boxes are located at both ends of the sleeper and one sensor for hot wheel and brake detection is between the tracks. Furthermore the sleeper is equipped with an additional heater as a protection against freezing. Supported sensors are e.g., AP HOT BOX by ALTPRO, Pegasus by ITSS or PHOENIX MB by voestalpine SIGNALING etc.

Flat Wheel Detection

The Unirail FLATWHEEL is a stationary system for detection of wheel inequality and eccentricity. The system continuously monitors the entire circumference of the wheel. Precision of the measurement depends on the measurement length, best results are reached with more than eleven elements in one rail. No special sleeper is necessary, no electronic parts are installed into the rail, all electronic components are in an outdoor rack or cabinet (excluding the temperature probe). Measured data is transferred into a central processing unit and onto a remote server. Secondary features of the system are wheel impact load detection and weigh-in-motion for high speed trains. Supported sensors are e.g., Aquila by ITSS, ATLAS FO by voestalpine SIGNALING or by Kyowa etc.

Overview Camera

Third party high-resolution cameras can be used to capture color overview images of vehicles and their surroundings (wide field of view). Supported cameras are e.g. by AXIS - P13 Series etc.

Laser Scanner

3D shape can be obtained and dimension measurement of passing vehicles can be done by third party laser scanners. Supported scanners are e.g. by SICK - LMS51 1 etc.

A variety of third party components can be integrated within the CAMEA platform including high-resolution overview cameras, laser scanners, over height detectors, weighing sensors etc.
Wagon Number Recognition

UnirailOCR

The UnirailOCR is a system for optical recognition of UIC codes and railway vehicle number markings. It uses a high speed line camera with a powerful active linear illumination module. The illumination module is active only in presence of the train and is very helpful in poor lighting conditions. Optical data is merged with synchronization information from the trackside of the wheel detector and used for train speed computation, vehicle classification (personal, cargo, engine...) and image processing for character recognition. All data is transferred via Ethernet to a CPU for processing. The results of UIC code recognition and the train images are saved into a database and transferred into higher level systems.

Additional Features

The system can be used for creating a list of vehicles leaving the classification yards. The operator knows the inventory and condition of a wagon passing through a measuring point without requiring the exact knowledge of the schedule.

The advantage of this system is the possibility of merging the UIC code of the vehicle with measured data from other systems which contain only the sequence number of a wheel and not the wagon number.

In case of faults (hot box, hot wheel, overweight, etc.) the system merges the result with an image of the vehicle and the UIC code, creating a complete report.

It is also possible to create vehicle condition statistics and when combined with weight information, create a list of overweight wagons. It can be e.g. helpful for identification of carriers which systematically violate traffic regulations.

The system creates statistics, provides data collection and vehicle classification.

Basic Specifications

The system has the following technical parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confidence Level</td>
<td>95% (depends on the contrast of markings on the train)</td>
</tr>
<tr>
<td>Speed Range</td>
<td>30 – 160 km/h (300 km/h in the future)</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>230 V (max. 400 W with active heating)</td>
</tr>
<tr>
<td>In-Track Sensor Temperature Range</td>
<td>-40 °C to 80 °C (wheel detector)</td>
</tr>
<tr>
<td>Off-Track Cabinet Temperature Range</td>
<td>-40 °C to 70 °C</td>
</tr>
<tr>
<td>Monitoring Site Height</td>
<td>2.0 m to 4.0 m (can be extended or shortened by the lens)</td>
</tr>
<tr>
<td>Distance From Railway Axle</td>
<td>3.5 m to 5.0 m</td>
</tr>
<tr>
<td>Calibration</td>
<td>auto calibration during the whole day due to changing illumination conditions</td>
</tr>
<tr>
<td>Storage Data Array</td>
<td>1 TB (standard version: 1 year, 80 trains/day; expansion on demand)</td>
</tr>
<tr>
<td>Remote Access, Remote Data Transfer</td>
<td>metallic/fiber optics Ethernet, GSM network, RS232, RS449</td>
</tr>
<tr>
<td>Protection Class</td>
<td>IP 65</td>
</tr>
</tbody>
</table>

Installation

System requires several in-track wheel sensors installed in the railway. Sensors are used for measuring initialization, direction detection and speed measurement. In a bi-directional track two sensors are required. The initialization signal from the wheel contact sensor can be replaced by contactless radar units mounted on a portal or the cabinet.

The cabinet is usually installed near the railway axis out of the clearance profile. The mounting can be done on gantries, portals etc. or at an empty space (a special steel console is installed as a part of the system).

Due to changing illumination condition during the whole day, a special calibrating element is installed into the track.

Output Data

The system provides complete vehicle records including wagon and train images, UIC code read by the OCR with a detail image, vehicle speed/class/length/direction, vehicle/axle count, wheel/axle bases, validity/error status, statistics and study export etc. All data can be stored in a local or a central database on a vehicle-by-vehicle basis. Various traffic data and studies can be exported via the Web interface or through direct database access (SQL, file export - CSV, MS Excel, XML etc.).

Detailed image of a UIC code detected on a vehicle:

OCR result: CZ-CD 73 54 21-91 002-8 Bmz

Real System Images

In case of worsened weather conditions (strong snow, fog, direct sunlight), or unclean vehicles, low contrast marking the system cannot keep its accuracy class.

It is necessary to keep the window in the door clean. This window has a security outer layer with an anti-graffiti foil for easier cleaning. The inner side has an anti-vandalism security foil.

An inner intelligent power source keeps all devices alive and works as a system watchdog. In case of an error, it restarts the failed device and restores its functionality.

The system offers remote system management with detailed system diagnostics and management (using standard protocols like SNMP).

Powerful Linear Illumination

The UnirailOCR system merges the result with an image of the vehicle and the UIC code of the vehicle with measured data from other systems which contain only the sequence number of a wheel and not the wagon number.

In case of faults (hot box, hot wheel, overweight, etc.) the system merges the result with an image of the vehicle and the UIC code, creating a complete report.

It is also possible to create vehicle condition statistics and when combined with weight information, create a list of overweight wagons. It can be e.g. helpful for identification of carriers which systematically violate traffic regulations.

The system creates statistics, provides data collection and vehicle classification.
Hot Box & Hot Wheels
UnirailHBHW

The UnirailHBHW is state-of-the-art solution for detection of hot bearing boxes (HB) and hot wheels (HW). Excess heat radiating from a bearing box indicates a possible problem which can lead to a broken axle. Similarly increased heat of wheels signalizes a locked brake hazard. To prevent these from happening, the system records and analyzes temperatures of bearing boxes, wheels and brakes of every axle of a train going through a measuring point on the railway. This is achieved using a complex set of infrared sensors mounted in the track. If the measured temperature of a given part is higher than the preset limit, the control system automatically notifies the supervising authority. Supported sensors are e.g. AP HOT BOX by ALTPRO, Pegasus by ITSS or PHOENIX MB by voestalpine SIGNALING etc.

Additional Features
Multiple temperature limits can be set based on vehicle classification (locomotive, cargo or passenger) evaluated by the axles' layout analysis, video detection or external source (traffic database etc.).

Modular design of the infrared sensor allows adaptation to a broad range of axle box types and therefore guarantees reliable identification of all possible hazard conditions.

Even higher safety can be achieved by using more sensors in a redundant configuration.

Installation
The measuring system requires a special sleeper placed into the railway and several in-track wheel sensors for measurement initialization and measured data triggering.

Both systems can be combined in a required combination (1 HW+2 HB, 2 HW+2 HB, etc.).

Output Data
The hot box and hot wheels systems provide temperatures of elements passing through the measuring point. All measured data can be shown in a 3D graph. If the limit temperature is set, a warning signal will be activated.

Basic Specifications
The hot box (HB) system has the following technical parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confidence Level</td>
<td>$\pi = 95%$</td>
</tr>
<tr>
<td>Speed Range</td>
<td>30 – 300 km/h</td>
</tr>
<tr>
<td>Temperature Measurement Range</td>
<td>0 °C to 150 °C</td>
</tr>
<tr>
<td>Temperature Resolution</td>
<td>+/- 2 °C</td>
</tr>
<tr>
<td>Temperature Accuracy</td>
<td>+/- 1 °C</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>230 V</td>
</tr>
<tr>
<td>In-Track Sensor Operating Temperature</td>
<td>-40 °C to 70 °C</td>
</tr>
<tr>
<td>Sensor Measurement Width Range</td>
<td>60 - 140 mm 10 beams</td>
</tr>
<tr>
<td></td>
<td>50-120 mm 8 beams</td>
</tr>
<tr>
<td></td>
<td>25-60 mm 4 beams</td>
</tr>
<tr>
<td>Calibration</td>
<td>auto calibration</td>
</tr>
<tr>
<td>Protection Class</td>
<td>IP 65</td>
</tr>
</tbody>
</table>

The hot wheels (HW) system has the following technical parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confidence Level</td>
<td>$\pi = 95%$</td>
</tr>
<tr>
<td>Speed Range</td>
<td>30 – 300 km/h</td>
</tr>
<tr>
<td>Temperature Measurement Range</td>
<td>80 °C to 650 °C</td>
</tr>
<tr>
<td>Temperature Resolution</td>
<td>+/- 5 °C</td>
</tr>
<tr>
<td>Temperature Accuracy</td>
<td>+/- 20 °C</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>230 V</td>
</tr>
<tr>
<td>In-Track Sensor Operating Temperature</td>
<td>-40 °C to 70 °C</td>
</tr>
<tr>
<td>Sensor Measurement Width Range</td>
<td>50 - 140 mm (for brakes and wheel discs)</td>
</tr>
<tr>
<td>Calibration</td>
<td>auto calibration</td>
</tr>
<tr>
<td>Protection Class</td>
<td>IP 65</td>
</tr>
</tbody>
</table>
Flat Wheel Detection
UnirailFLATWHEEL

The flat wheel detection system detects train wheel inequality and eccentricity. Flat spots on the wheel surface produce increasing noise, lower travelling comfort for passengers, increased rail wear due to uneven rail contact, etc. The system uses a precision fiber-optics technology and continuously monitors the entire circumference of the wheel on the rail. It contains special track side elements inserted between the rail and a regular sleeper. The precision of the measurement depends on the monitored site length. No special sleeper is needed. Measured data is transferred to the control room and in case of an error, the system automatically sends an alert/warning signal to other systems. Supported sensors are e.g. Aguila by ITSS, ATLAS FO by voestalpine SIGNALING or by Kyowa etc.

Additional Features
The fiber-optics element is deformed due to the impact load of the wheel on the rail. This principle can be used for wheel impact load detection (WILD) and weigh-in-motion (WIM) of high speed train. The system is designed as a stand-alone system or as a cooperative system to the global measuring point system.

Installation
Special in-track sensors contains loop with fiber-optics. It is installed between rail and regular sleeper in a few hours, and replaced within five minutes. Furthermore, several in-track wheel sensors for starting measure and triggering measured data. Count of sensors depends on monitored length and requirements of precision. For better results is necessary to measure from two to three circumference of the largest wheel. Evalutation electronic boards are placed into rack or cabin.

Output Data
The system detects flat spots and wheel loads in kN. The measured data is transferred into the central processing unit and a remote server. The results are merged with the train axle position. Using a fusion of the UIC number by optical wagon recognition and wagon classification, the whole wagon weight (or overload) can be calculated.

Wheel Impact Load Detector
UnirailWILD

Besides wheel inequality, the flat wheel system detects the impact load of the wheel on the rail and can therefore be used as a wheel impact load detector or for weigh-in motion for high speed trains. It is very useful for detecting overloaded axles or wagons and preventing damage of the track. The results of measurements can be used for enforcement (with approved certificates required).

Basic Specifications
The system has the following technical parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confidence Level</td>
<td>$\pi = 95%$</td>
</tr>
<tr>
<td>Speed Range</td>
<td>30 – 350 km/h</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>230 V (approx. 150 W, 300 W with heating)</td>
</tr>
<tr>
<td>In-Track Sensor Operating Temperature</td>
<td>-40°C to 80°C</td>
</tr>
<tr>
<td>Off-Track Cabinet Operating Temperature</td>
<td>0 °C to 50 °C (standard version, extended with heating)</td>
</tr>
<tr>
<td>Monitored Site Length</td>
<td>4.2 m to 7.8 m (can be extended or shortened on demand)</td>
</tr>
<tr>
<td>Fault Detection</td>
<td>all kinds of faults (flat spots, out-of-roundness...etc)</td>
</tr>
<tr>
<td>Weight Measurement Accuracy</td>
<td>3 %</td>
</tr>
<tr>
<td>Calibration</td>
<td>auto calibration</td>
</tr>
<tr>
<td>Protection Class</td>
<td>IP 67 (in-track sensor)</td>
</tr>
</tbody>
</table>
Traffic Classification and Data Collection

Traffic classification and data collection can be done using wheel sensors including cameras in UC-CLU with video detection and software, weighing, hot-box/hot-wheels sensors etc.

For most applications traffic classifiers can be used. For applications where classification into many classes is required, advanced solutions are also available. Note that no sensor for complete traffic data measurement exists. Available sensors use various measurement principles with different accuracy, data availability and confidence levels. So to improve the quality of traffic data collection, fusion of values from various sensors can be used. As a result highly accurate traffic classification and data collection can be obtained. Systems that are available for such high quality classifications include the advanced traffic counter. Data collection can be used for creating a list of vehicles leaving the classification yards. The operator knows the inventory and condition of a wagon passing through a measuring point without requiring the exact knowledge of the schedule. This list can be automatically compared with a submitted inventory.

Classification Scheme Example

Traffic classification and data collection is done separately using measured values from various sources including axle wheel sensors, speed measurement and video detection. A special database of vehicles consisting of dimensions and other specifications is created for classification. The separate vehicles classes are then fused together to get:

- standard classification schemes of more than 150 pre-set vehicle classes and user defined schemes - cargo, passenger, engine (the set depends on country specifications and mount of vehicle collection).

Dimension-in-Motion

UnirailDIM

Laser scanners (e.g. SICK - LMS511) mounted on gantries can be used for gathering 3D profiles of passing vehicles. Vehicle dimensions are then determined. Detection can be used for recording empty or loaded wagons, for example in the case of arriving local fabric gateway or for cargo weigh estimation.

Real Output Data
CAMEA

The company was founded in 1995 by a group of technical university researchers. With more than 20 years of experience in image processing (algorithms, illumination units, camera design), signal processing (algorithms, sensors, signal conditioning), real-time processing, embedded computing and HW/SW development for various traffic and industry applications, CAMEA is creating state-of-the-art and field-proven platforms for industrial and multifunctional intelligent transportation solutions with hundreds of applications around the world.

All key technologies used for designing the most innovative products are continuously being developed. While OEM components are available for integration into current systems, fully-featured systems are also being provided. CAMEA is a strongly customer-focused company, which creates individual and project oriented customizations of its technology portfolio, performs R&D of unique systems according to the customer’s needs and closely cooperates with technological and business partners in engineering, installation, maintenance, staff training etc.

CAMEA has been certified with a quality management system according to ISO 9001:2001.

Unicam is a commercial trademark for intelligent transportation systems for roads. Unirail is a commercial trademark for intelligent railway systems.

The enforcement Unicam transportation systems have been type approved and hold the appropriate certificates.

Unicam intelligent transportation systems are installed in many countries around the world.

For example in Prague tens of transportation systems are integrated in a complex centrally operated solution.