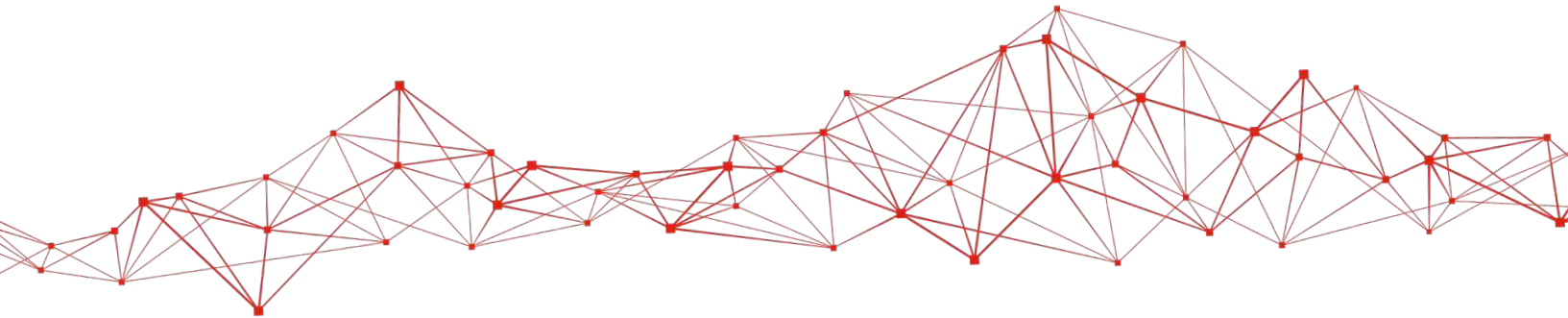


BROCHURE

Intelligent Transportation Systems

Multi-Lane Free Flow – Single-Lane Free Flow – Plaza – Parking



KATHREIN
Solutions GmbH

Enabling technologies for digital transformation

From proof of concept (PoC) to go-live implementation, Kathrein Solutions supports its partners to implement turnkey projects in the areas of intelligent transportation systems. By seamlessly integrating any identification technology such as RFID and ANPR solutions, we combine the most suitable features and generate interfaces to all types of backend systems and

management solutions. Together with our partners we provide RF simulation, application support, software integration and implementation as well as operation and maintenance. First-class service and customer-oriented support complete our portfolio.

> **Hardware**

The Kathrein Solutions RFID readers and antennas are the leading IoT devices for all professional AutoID solutions. They are the first choice for vehicle identification in ruggedized environments. Kathrein's Portfolio provides modularity for high speed identification and end-to-end security at the same time.

> **Transponder**

RFID license plates, windshield labels and headlamp tags serve for the automatic, contactless identification of vehicles (Automatic Vehicle Identification, AVI). One tag fits for various applications such as Electronic Vehicle Identification (EVI), Electronic Toll Collection (ETC), parking, smart fueling, smart city, etc. The state of the art ICs for such applications are RFID crypto chips with an AES co-processor and a 128-bit AES group key.

> **Software**

Using Kathrein API is the most powerful way to embed Kathrein devices into a partner software ecosystem, enabling maximum detection speed and read rate, keeping 100% control of the software layer. CrossTalk is a modular IoT suite for different identification applications. RFID, ANPR cameras, peripheral sensors and various other technologies can be handled with CrossTalk. We provide centrally controlled integration – from device management to back ends.



ITS & AVI scenarios

Each country, government, community and city has its domestic and urban requirements with regards to intelligent transportation on the roads. Based on the customer needs, Kathrein offers a broad portfolio of ITS scenarios:

- ETC: Electronic Toll Collection
- EVR: Electronic Vehicle Registration
- EVI: Electronic Vehicle Identification
- IPI: Intelligent Parking Interface
- SCA: Smart City Applications
- PTS: Public Transportation Systems

> Multi-Lane Free Flow (MLFF)

Multi-Lane Free-Flow tolling systems (MLFF) can be integrated into any existing infrastructure and use the most advanced technologies to perfectly fit into the given requirements. MLFF systems automatically determine read events and enable automatic toll charging without disturbing the free flow of traveling vehicles on the toll road.



> Single-Lane Free Flow (SLFF)

Single-Lane Free-Flow tolling systems (SLFF) can be integrated into any existing infrastructure as they perfectly fit into the given requirements. In addition, SLFF systems are a great option if an agency or an operator is experiencing difficulties in transforming an existing system from manual to all electronic.



> Plaza / Stop & Go

This solution allows drivers to pass through toll stations hands-free with lane-based identification. The toll charge for each vehicle is collected automatically by identifying the RFID transponder. There is no need to use cash (coins or notes), bank cards, vouchers, etc.



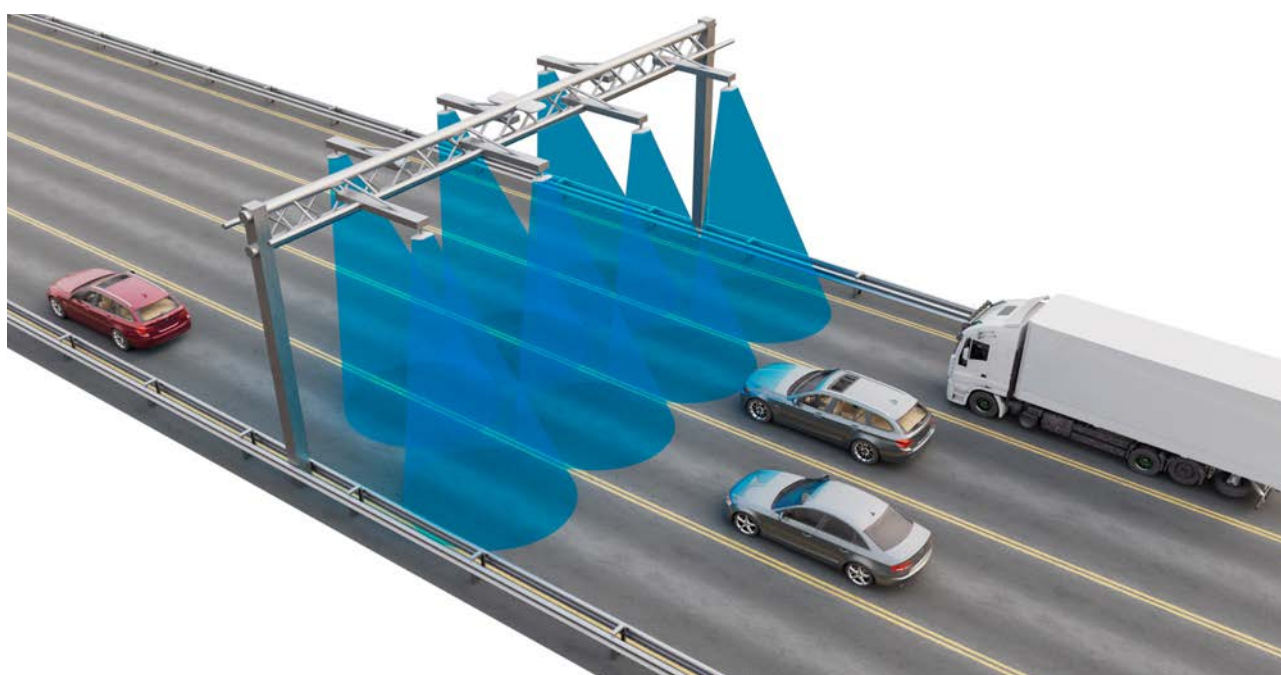
> Parking

Parking solutions enable the quick and easy entry and exit for authorised vehicles to parking lots and garages. Lane based identification is based on a modular portfolio to be perfectly integratable into an existing infrastructure. It allows handsfree and seamless identification.



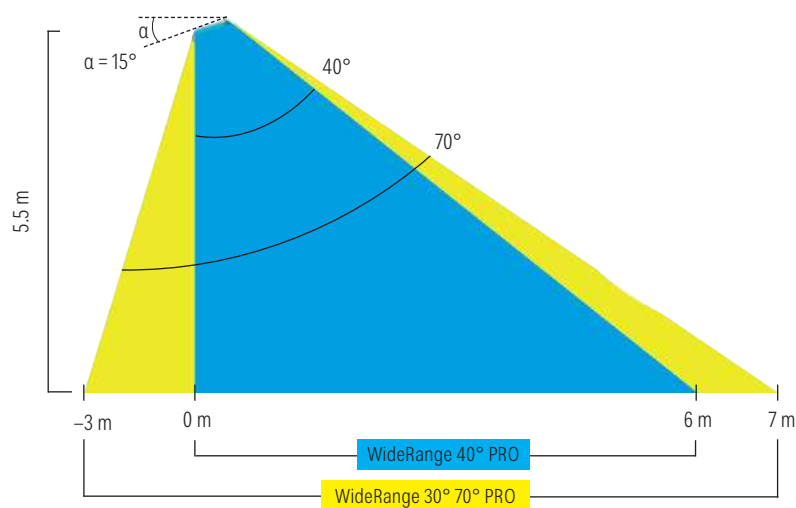
Free Flow solutions

> Multi-Lane Free Flow solution

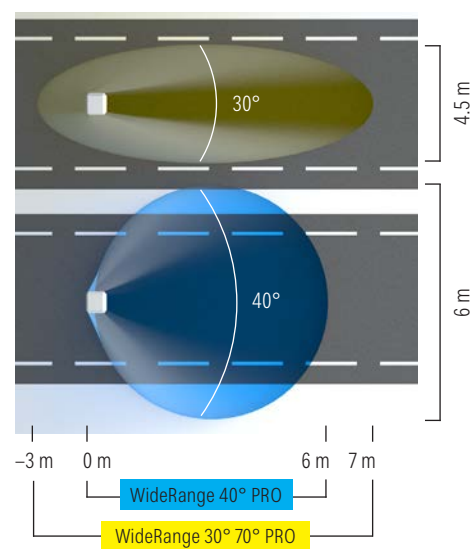


> Antenna pattern and parameters for Multi-Lane Free Flow installation

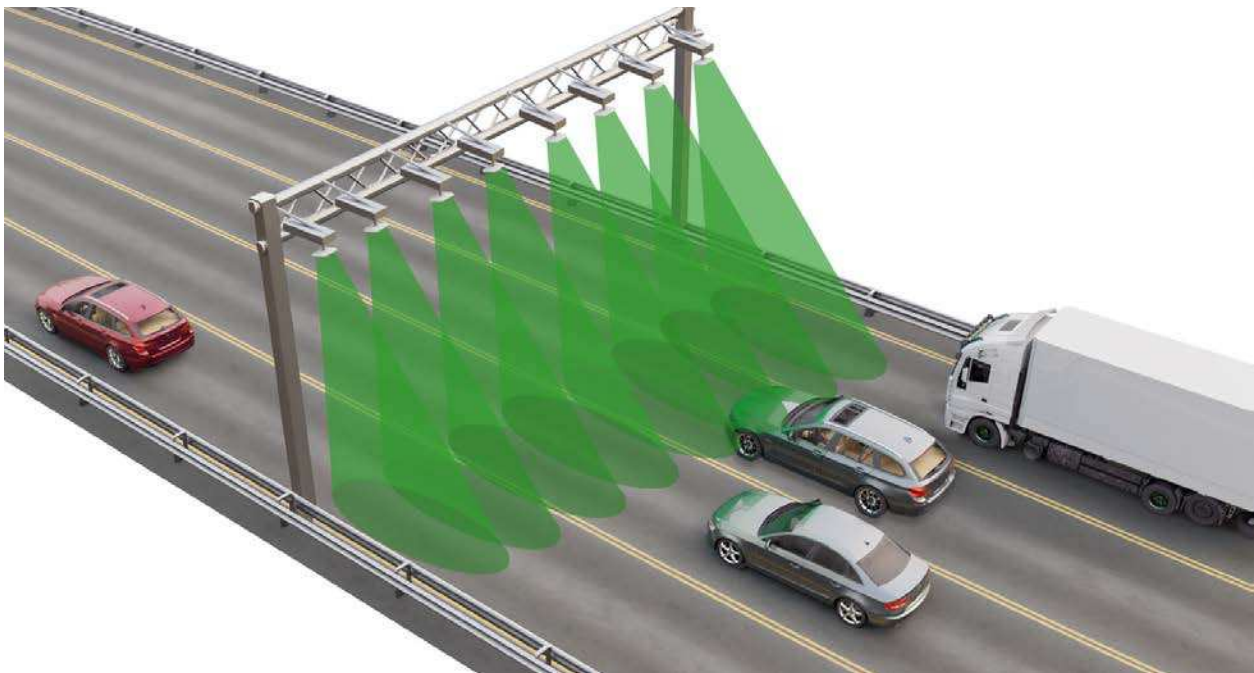
Side view



Top view

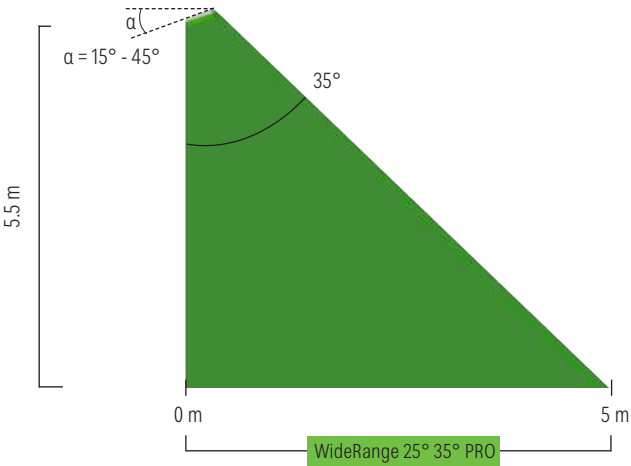


> Multi-Lane Free Flow solution with narrow lanes

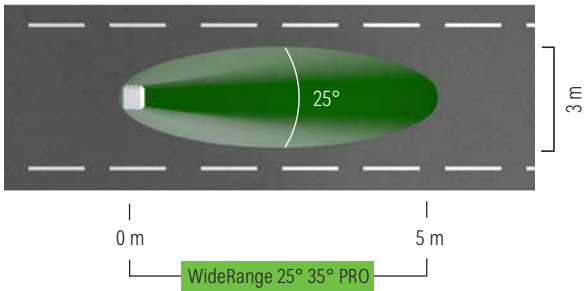


> Antenna pattern and parameters for MLFF installation with WiRa 25° 35° PRO antenna

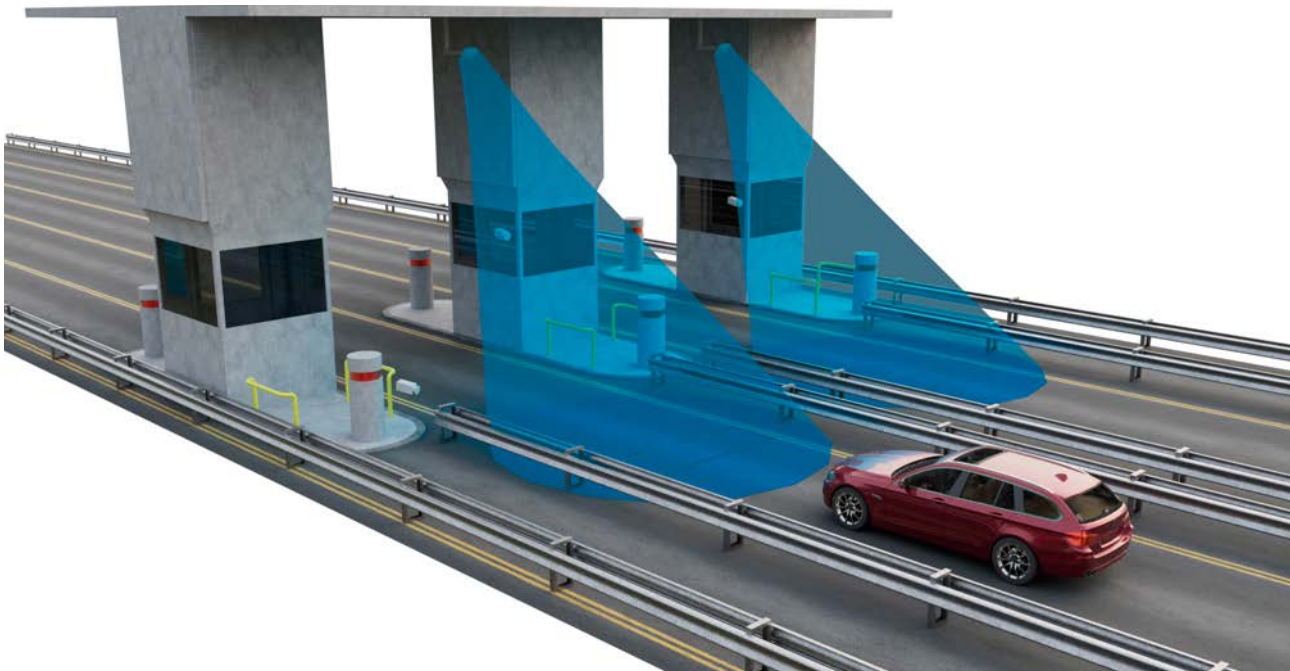
Side view



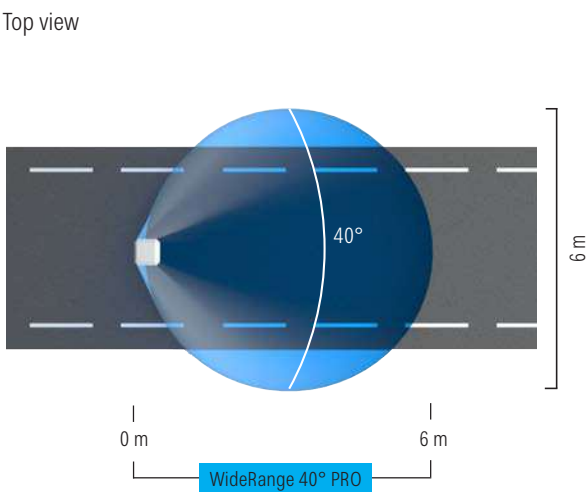
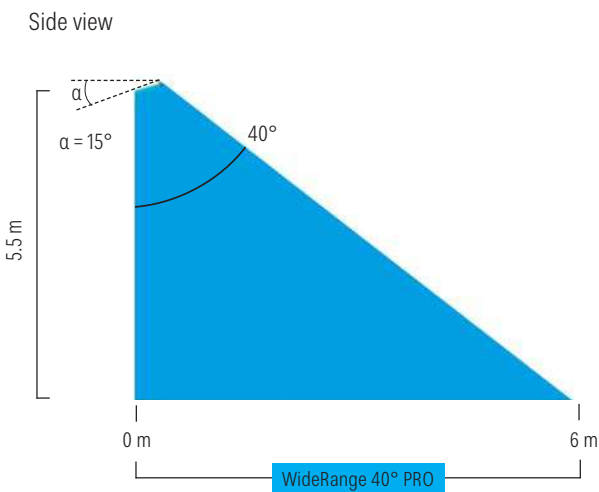
Top view



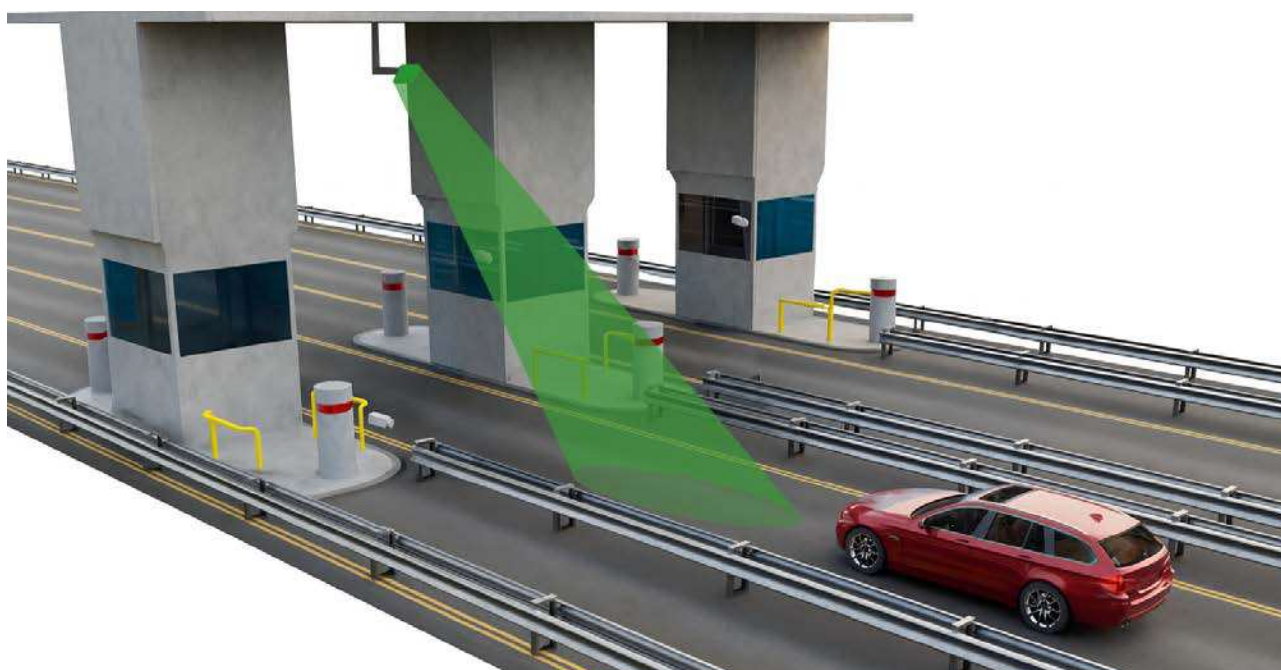
> Single-Lane Free Flow solution with WiRa 40° PRO antenna



> Antenna pattern and parameters for SLFF installation with WiRa 40° PRO antenna

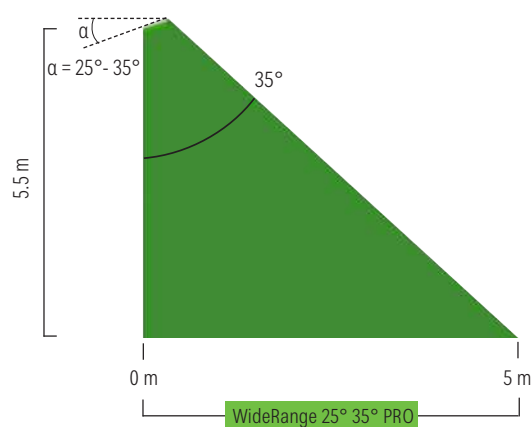


> Single-Lane Free Flow solution with WiRa 25° 35° PRO antenna

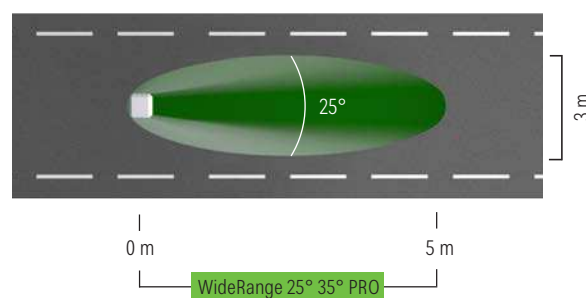


> Antenna pattern and parameters for SLFF installation with WiRa 25° 35° PRO antenna

Side view



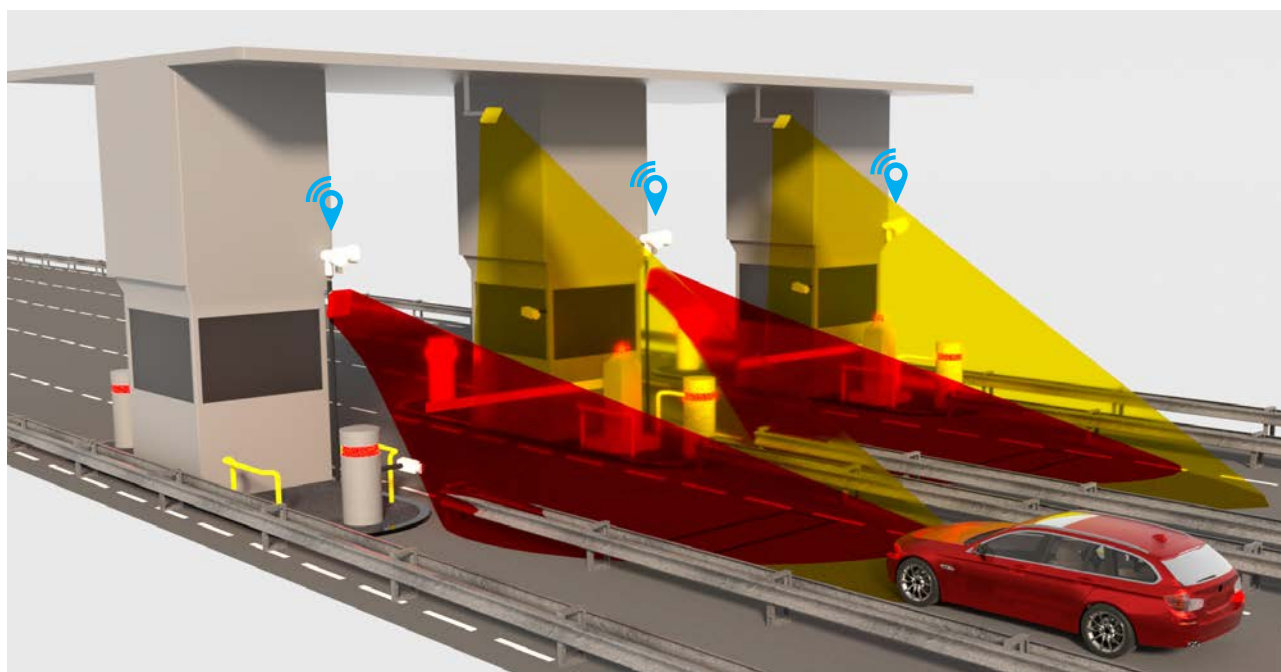
Top view



Plaza / Stop & Go

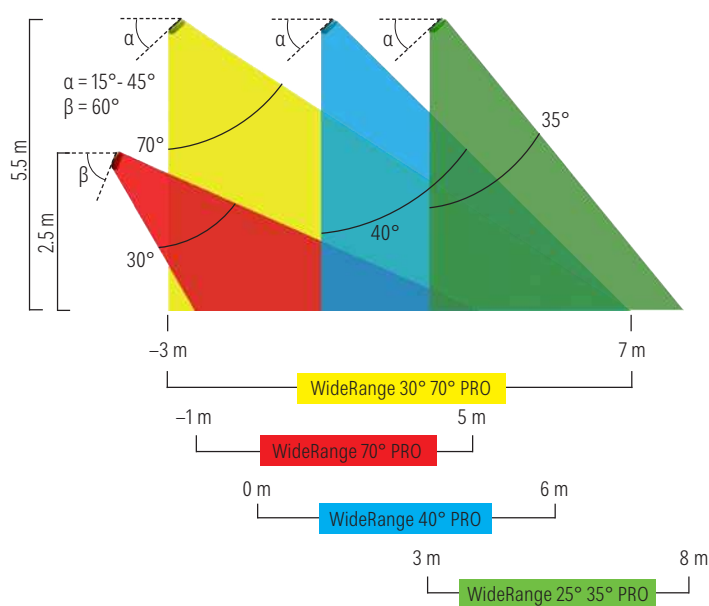


> Barrier / gate solution

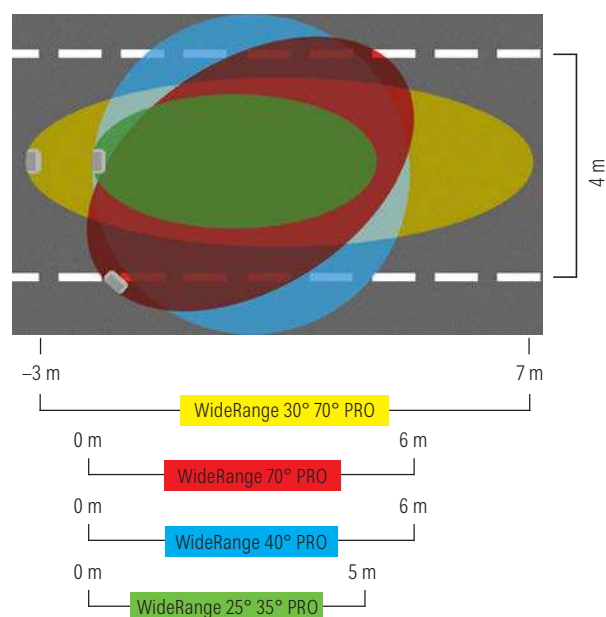


> Antenna pattern and parameters for plaza installation

Side view



Top view



Parking

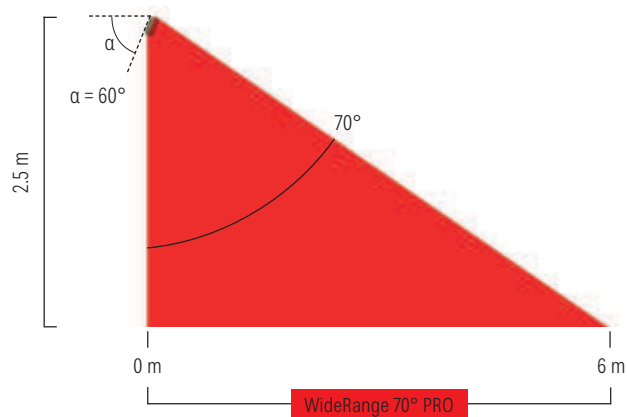


> Parking solution

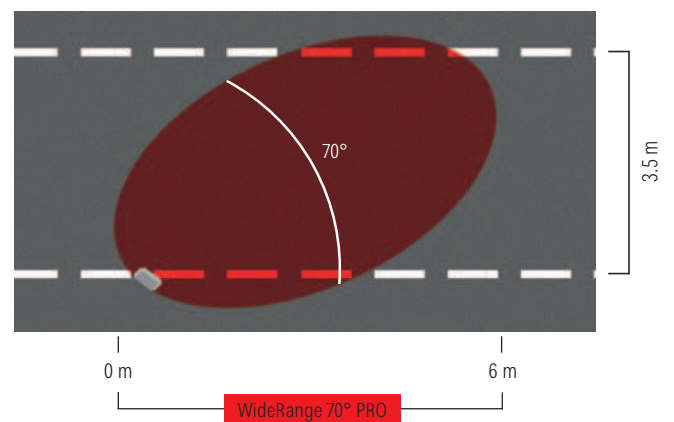


> Antenna pattern and parameters for parking installation

Side view



Top view



RFID hardware overview

Kathrein Solutions is one of the leading providers of auto-ID solutions and offers scalable RFID solutions for a wide range of requirements. The devices feature a compact design for ruggedized environmental applications and the highest IP rate degree of protection, perfectly suitable for outdoor use.

> RFID reader series – key features



ARU 3500



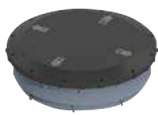
RRU 4500



ARU 7700



RRU 7700



InLane Reader

	ARU 3500	RRU 4500	ARU 7700	RRU 7700	RRU 7800	InLane Reader
Integrated antenna	1 65° antenna	–	1 65° antenna	–	–	1 steerable beam in 4 directions
Ports for external antennas	3	4	3	4	4	–
Radiated power	up to 36 dBm ERP/4 W ERP					
Processor speed	ARMv7-A based processor, 2 cores @ 800 MHz					
Air interface protocol	EPCglobal UHF Gen2v2 / Gen2v3 / ISO 18000-63 RFID				ARTEFATO SJ-5511	EPCglobal UHF Gen2v2 / Gen2v3 / ISO 18000-63 RFID
Crypto engine based on ISO EN 29167-10	✓	✓	✓	✓	✓	✓
Key handling on edge	HSM I	HSM I	HSM II	HSM II	HSM II	HSM II
Key diversification	–	–	✓	✓	–	–
Remote power supply	PoE+					
Wireless options		RRU 4560 WiFi RRU 4570 4G				

> RFID reader series – mounting options

	ARU 3500	RRU 4500	ARU 7700	RRU 7700	RRU 7800	Inlane Reader
Mounting option	M6; 100 x 100 mm					Manhole
Wall mount	with MK-WPM3-OSS 52010351					–
Pole mount	with MK-WPM3-OSS + MK-PMA-OGV 52010351 + 52010368					–

> RFID antenna series – key features



WideRange 70° PRO Antenna



WideRange 30° 70° PRO Antenna



WideRange 40° PRO Antenna



WideRange 25° 35° PRO Antenna

	WideRange 70° PRO Antenna	WideRange 30° 70° PRO Antenna	WideRange 40° PRO Antenna	WideRange 25° 35° PRO Antenna
Read range	12 m	20 m	20 m	20 m
Polarisation	Right hand circular polarization	Right hand circular polarization	Linear polarization for optimum reception of weak transponders	Linear polarization for optimum reception of weak transponders
Protection class	IP67			

> RFID antenna series – mounting options

	WideRange 70° PRO Antenna	WideRange 30° 70° PRO Antenna	WideRange 40° PRO Antenna	WideRange 25° 35° PRO Antenna
Mounting option	M6; 100 x 100 mm		100 x 100 mm	M6x8;
Wall mount	with MK-WPM3-OSS 52010351		with MK-WPGM-100-100- Outdoor; 52010262	with MK-WiRa Gantry Mount 52010751
Pole mount	with MK-WPM3-OSS + MK-PMA-OGV 52010351 + 52010368			

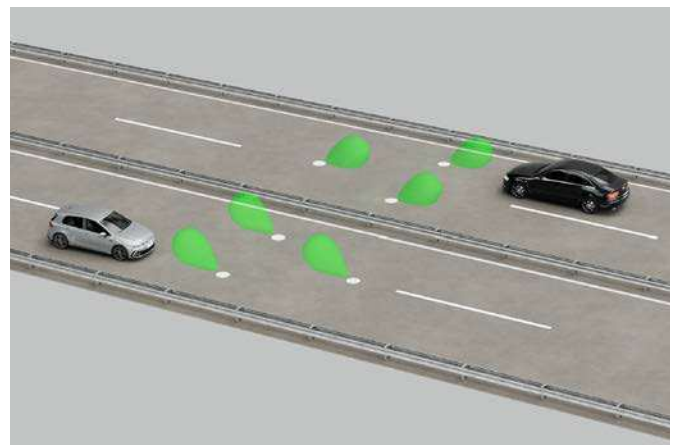
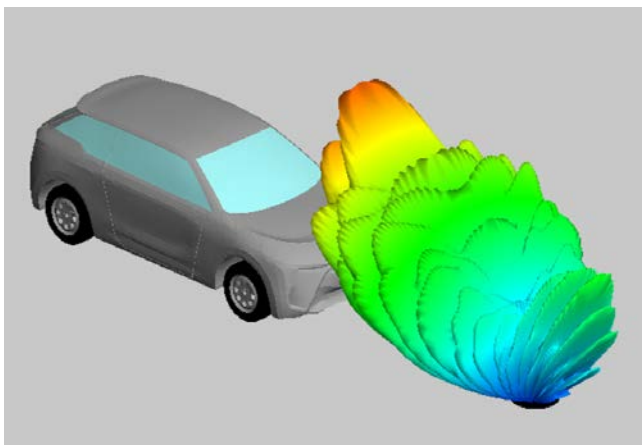
> InLane reader

- Ruggedized high-end RFID reader
- Built-in steerable RFID antenna beams
- 4 orthogonal selectable beams
- Embedded dual-core 800 MHz PC
- Open source Linux OS
- Basic computing module
- Enhanced RF design
- IP67 outdoor use
- Powerful IoT gateway for security applications
- PoE+ supply

The RFID InLane reader from Kathrein Solutions is a special RFID reading solution and the perfect answer to the ever-increasing requirements for vehicle detection – e.g., at access points, in toll systems, parking garages, or control stations. The reader is embedded directly into the road and is optimized for capturing vehicles with compatible license plate tags. High installation costs for a previously required gantry are eliminated.

As the device has an integrated antenna with the option to selectively switch the orthogonal beams in four directions, it is also suitable for direction detection. In addition, the beams can be combined to enable a front/back separation. For precise alignment, the InLane reader can be aligned in 15° increments. Whether for tolling on expressways or for granting access, with the InLane reader you always have the perfect solution for identifying vehicles.

The complete InLane reader unit consists of the actual reader unit, an insert for vibration damping and the manhole cover.





RFID transponder overview

The RFID UHF windshield labels and headlamp tags serve for the automatic, contactless identification of vehicles (Automatic Vehicle Identification, AVI). The UCODE DNA authentication uses an AES co-processor and a 128-bit AES group crypto key. The privacy protection is realised via an untraceable command and a 128-bit AES group crypto key.

> Windshield labels



The windshield label is adhered to the inside of the windshield. The development of the RAIN RFID windshield label has been focused on a very high read range due to the special antenna behind the glass and a passive function without a battery. There are two types of windshield labels, monolabel and Z-folded, the latter consisting of two layers for onsite personalisation. Special cuts and other features can improve security against removal and re-use. The protection class of the windshield label is IP65.

> Headlamp tags



The RFID headlamp tag is used for the automatic, contactless identification of motorcycles (AVI) and is attached to the outside of the motorbike's headlamp. The headlamp tag was designed to achieve a particularly high reading range, enabled by a specialized antenna mounted on the headlamp and a fully passive, battery-free design. To enhance security against tampering and unauthorized re-use, the tag incorporates special cut patterns and additional protective features. It meets protection class IP65, ensuring reliable performance in challenging environments.

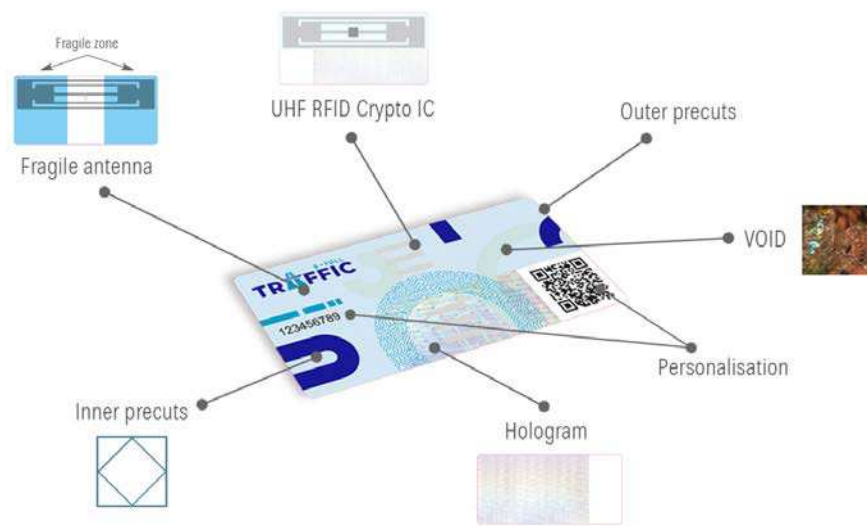
> RFID license plate



The IDePLATE® imprinted aluminum RFID label is equipped with a forgery-proof, theft-proof data chip, making it an outstanding solution for the future. The IDePLATE® guarantees reliable and secure identification of vehicles in stationary and moving traffic, irrespective of traffic volume, weather conditions, vehicle model and speed.



> Modular security features



Performance features

- Patented tag antenna design
- Read range up to 20 m *
- Maximum speed up to 200 km/h **

* MLFF gantry with high gain antennas

** depends on crypto application

Mechanical security features

- Detachment of chip from aluminum antenna
- Destructible aluminum antenna
- Reinforcement of fragile antenna
- Customizable VOID scripture
- Parts of the layer remain on wind-screen / headlamp
- Protection of re-use
- Invisible on undamaged tag

Crypto security features

- Privacy protection based on cryptographic security
- Tag authentication based on cryptographic security
- Based on ISO EN 29167-10 or ISO/IEC 29167-13
- AES-128 or Grain-128AcCrypto suites
- Authentication on edge

Optical security features

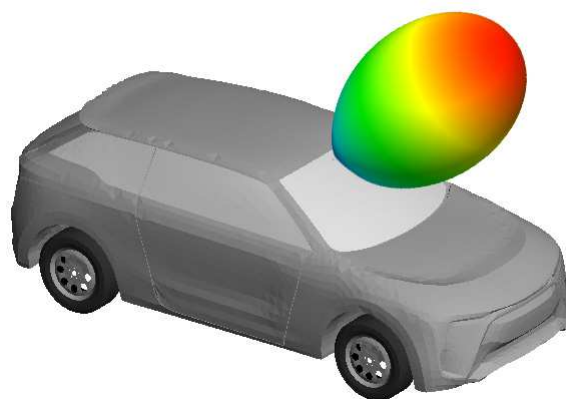
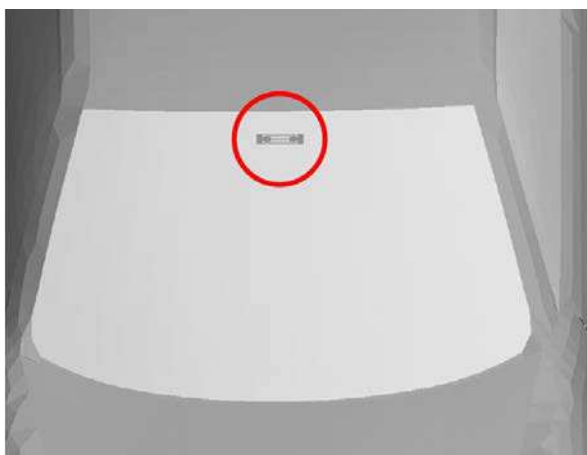
- Customizable hologram
- Partial-released
- Validation feature
- Protection of duplication



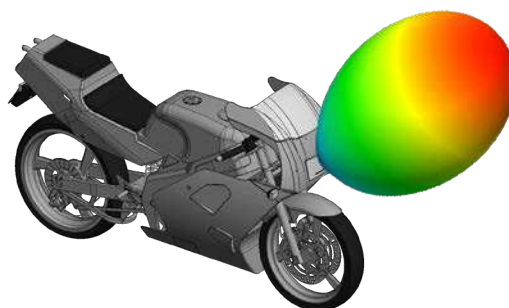
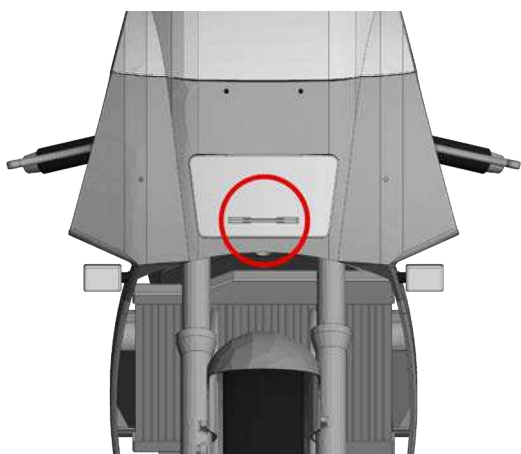
RFID transponder attachment

The position of the tags on the windscreen has an influence on where the antennas should best be placed in order to achieve optimum reading results. The best tag positions on a windscreen / motorbike headlamp and its behaviour during the reading process are shown in the example simulations below.

> Optimum tag position of windshield label



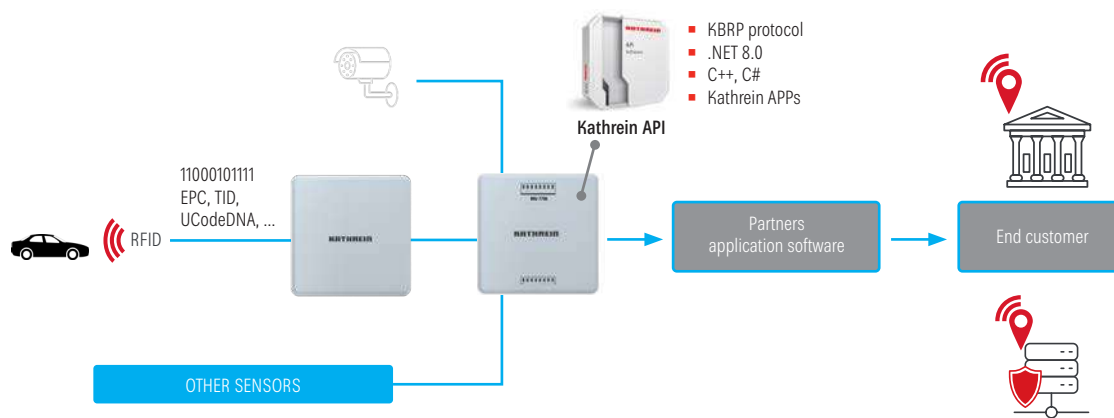
> Optimum tag position of headlamp tag



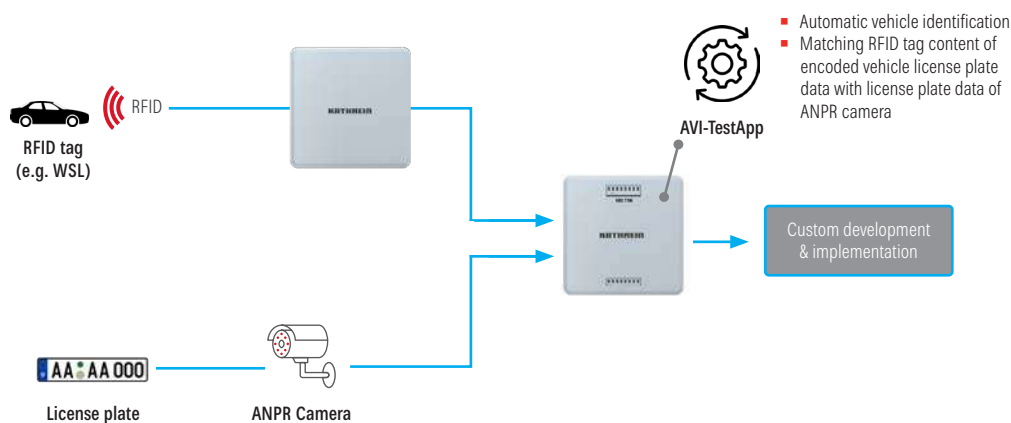
Software integration options

Supporting our partners has the highest priority at Kathrein. That is why we offer our integration partners on site various options for integrating our devices into their overall systems and solutions. Kathrein acts as the technical backbone and supports the partners in all matters.

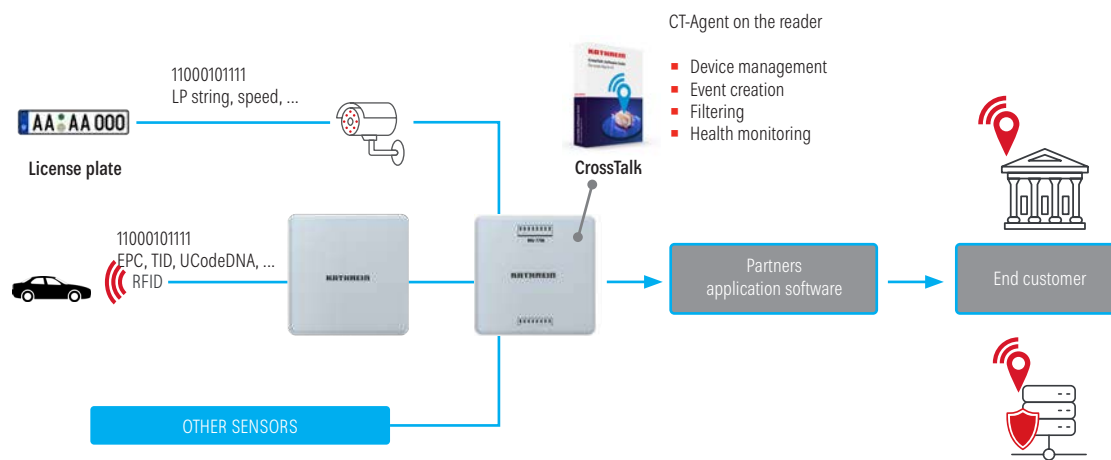
> Integration with Kathrein API for high speed scenario



> Integration with AVI-TestApp



> Integration with CrossTalk for basic scenario



Integration with Kathrein API

For a matter of security, flexibility and performances, especially in MLFF scenarios, the complete control of the software layer is a must in the ITS business.

Using the Kathrein API to embed our devices into partner software ecosystems is the more safe and efficient way to deploy the system integration. This allows our partners to have 100% control on the software to be more flexible and reactive based on the request of the project and being independent from third party software suppliers.

> Key features



Customer App

- C++
- C#
- API related to hardware



.NET

- Platform independent API
- Easy to use for
 - Windows
 - Linux
 - Android
 - macOS

> Added value

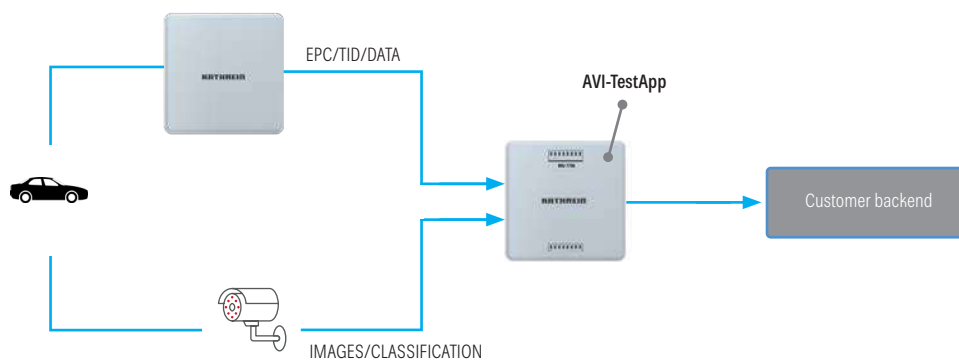
- Highest speed detection rate
- Low level powerful control of the devices
- More flexibility
- Third party independent
- App can run inside the Linux module embedded in the reader
- Most efficient key management

Integration with AVI-TestApp

The AVI-TestApp is designed to handle the “Intelligent Transportation Systems” (ITS) use case to match RFID tag content which contain the encoded vehicle license plate data with the license plate data provided from an “Automatic Number Plate Recognition” (ANPR) camera.

The app is designed to run directly on any Kathrein Solutions ARU/RRU x5xx RFID Reader device (Gen3) on its embedded pc.

> Key features



> Added value

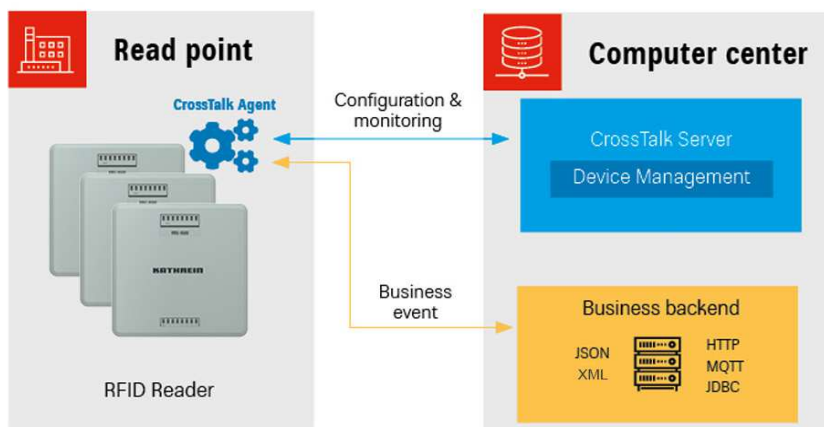
- Match RFID data with camera
- Send data via HTTP
- Run on linux module
- Open source software, can be easily updated to fulfill needs of the projects

Integration with AutoID software CrossTalk

As with all complex systems, the perfect interaction of hardware and software is of the utmost importance. CrossTalk fulfills this requirement to the highest degree and simplifies the implementation of a wide range of RFID customer requirements and solution requests without additional development effort.

CrossTalk's agent-based architecture supports the operation of several thousand devices of different technologies in a distributed network environment. The plug-and-play connection of a large number of devices from common AutoID manufacturers in various model versions is already integrated.

> Key features



> Added value

- Technology independent
- AutoID device management
- Template designer
- Smart filtering and event creation
- Backend integration

ITS performance test

As part of a comprehensive ITS certification test at the airport Eberswalde-Finow near Berlin, Kathrein readers and antennas, as well as newly developed high-security transponder systems, were thoroughly tested for their performance and subsequently certified by an external testing institute.

The following scenarios were tested:

- Multi-Lane Free Flow (MLFF) with RFID gantry
- Single-Lane Free Flow (SLFF) with RFID gantry
- Multi-Lane Free Flow with RFID InLane reader

These devices were used:

- RRU 7700 RFID reader unit / ARU 7700 RFID antenna reader unit
- InLane reader unit
- WideRange 40° PRO antenna
- WideRange 30° 70° PRO antenna
- Newly developed high-security transponders

> Testing Multi-Lane Free Flow (MLFF) applications

For the test, proven ITS readers such as the RRU 7700 and ARU 7700 were used. The focus, however, was on new, optimized antenna configurations based on the WiRa 40° PRO and WiRa 25° 35° PRO antennas and their enhanced functionality in modern ITS scenarios. These include vehicle detection and identification in Multi-Lane Free Flow (MLFF) and Single-Lane Free Flow (SLFF) toll systems.

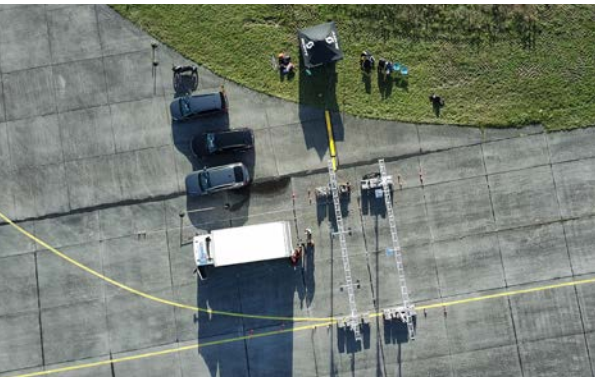
A new generation of security transponders, capable of reliable detection at speeds of up to 200 km/h, was also part of the verification process.

The aim of the performance test was to identify the optimal antenna position and ensure that the transponders could be read reliably even under these demanding conditions.

> Testing the InLane reader at different speeds and traffic scenarios

The InLane reader can be fully installed below the street surface and is optimized for reading number shields with integrated transponders, such as IDePlates®.

During ITS testing in Eberswalde-Finow near Berlin, the InLane reader's performance was evaluated under various speeds and traffic scenarios. Equipped with an integrated antenna capable of selectively switching orthogonal beams in four directions, the device was proven not only effective in detecting passing vehicles, but also in determining their direction.





Use cases

We offer comprehensive end-to-end solutions – including RFID hardware, CrossTalk IoT software suite and services – for identification, real-time localisation, tracking and management processes. Find out how our customers are already successfully using our IoT technology.

> **Tolling system at India's longest sea bridge in Mumbai**



The Mumbai Trans Harbour Link, also called Atal Setu, is a 21.8 km long, six-lane sea bridge that connects the Sewri district in southern Mumbai with the suburb of Navi Mumbai and one of India's largest ports. The state-of-the-art toll management system was developed by Efkon Strabag. The hybrid gantry tolling system is based on Kathrein RFID technology and has three operating modes: stop & go, open barrier and open road tolling. This solution reduces waiting time at the toll booth and ensures smooth traffic, resulting in a massive reduction in carbon dioxide emissions by an estimated 47,421* tons per year.



> **Nationwide vehicle identification at the foot of the pyramids**



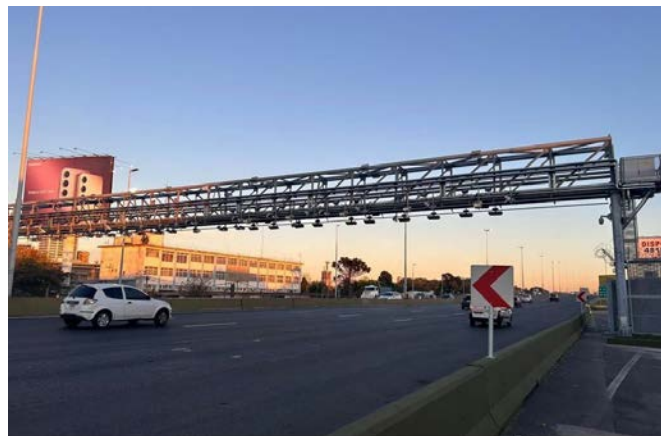
The contactless GS1 RAIN RFID Gen2V2 technology offers end-to-end identification including 128-bit AES encryption for tag authentication, which provides best performance even at high speed. Egypt is setting a big exclamation mark with this project, as it is globally unique in this composition.



> Argentina highway runs with Multi-Lane Free Flow



In Argentina, a free-flow solution was installed on a highway using the Kathrein RRU 4500 RFID reader and the WideRange 30° 70° antenna. The main objectives of the implemented technology were to improve the flow of traffic on the 10.5 km section of the highway and to improve the travel experience for the 93,000 drivers who use it every day. The system also allows a reduction in polluting emissions of 1,154 tons of CO₂ per year thanks to the elimination of queues, a fundamental result in terms of sustainability.



> Toll collection system in Girona, Spain



More than 11,000 vehicles a day are detected using our RRU 4500 reader series and WideRange 40° PRO antenna in the Girona area on the AP7 Highway.

This adoption helps to reduce the waiting time and eliminates all the paper/tickets in use in the previous version of the system.

This is one of the first and most successful adoptions of RFID based tolling systems in Europe.



> **Fleet management at insurance company**



Kathrein Solutions was able to implement an innovative cloud-based solution for the automated entry and exit of employees as well as fleet vehicles at the headquarter of a leading European Insurance company. RAIN RFID and CrossTalk device management enable a precise cost distribution in fleet management.



> **Scheidt & Bachmann parking provider rollout**



The Scheidt & Bachmann group is one of the leading providers of innovative system solutions for mobile living. With their unique portfolio, they support a wide range of transport systems, thus keeping millions of people and goods on the move worldwide. Their smart solutions can be used for various applications: parking, refuelling or charging, public transport or in the railway sector.

In the parking industry, Scheidt & Bachmann Parking Solutions GmbH is a leading provider of integrated, modular system solutions for parking management of any size.

With its solutions – supplemented by Kathrein hardware – the digital transformation in the parking industry is actively shaped and supported in various forms. Together with partners, parking is seen as an essential part of the mobility chain and cross-sector, urban mobility concepts are linked.



> Can you see us? RFID can, @200 km/h with full 128 bit AES encryption



The world is getting smarter and IoT is on the advance. The automatic detection of vehicles with RFID is no exception. Contactless GS1 RFID Gen2v2.0 provides long range identification and cutting-edge cryptographic security implementation for tag authentication, which also works at highest speed of more than 200 km/h. This allows our customers and partners all over the world to use an established, smart, secure and efficient solution.



> Colombian tolling plaza



Colombia is one of the countries in South America with the largest RFID adoption for tolling systems. Kathrein hardware like the RRU 4500 readers and the WideRange 30°70° PRO antennas are installed in several tolling plaza.

Interoperability brings a series of incredible benefits: less time at toll booths, less wear and tear on the vehicle, better mobility by reducing congestion, more agile and safer operations, less cash in circulation, and less paper waste. Another big advantage is the more efficient administration for companies with frequent transfers, as you can manage all your tolling and also a huge network of parking with one label.



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