



RAIN[®]
R F I D

Electronic Vehicle Identification (EVI)

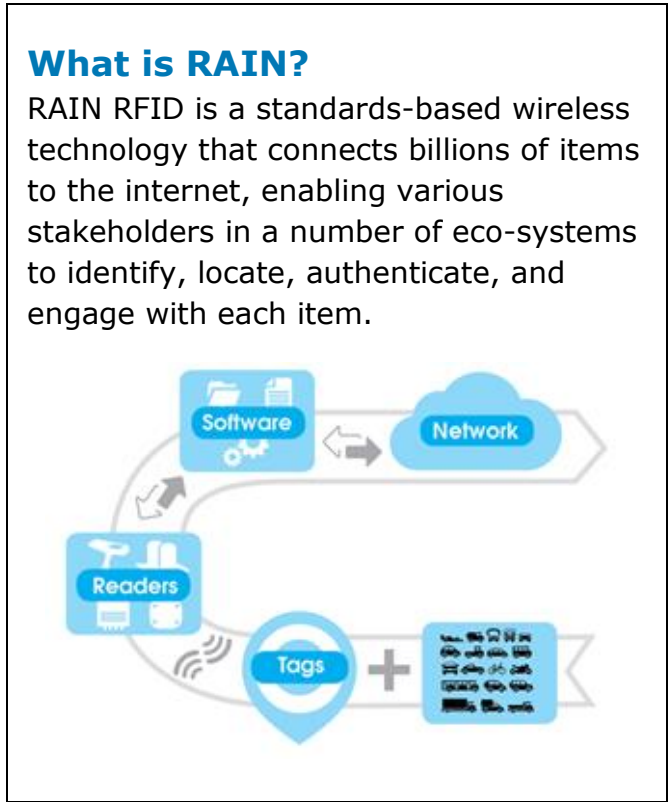
White Paper

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RAIN RFID White Paper

Electronic Vehicle Identification (EVI)

RAIN RFID provides worldwide robust electronic vehicle identification for various applications including vehicle licensing, tolling and congestion management, vehicle access control, parking, fleet management, fuel management and car-wash loyalty programs.



In our consumer-centric society, where convenience and simplicity is demanded by end users in every aspect of their lives, solution providers must deliver smart mobility solutions.

RAIN RFID is making it easier, faster, and more secure to collect toll, pay parking fees, and get an automatic electronic bill at a car wash station.

The long-range high-speed capability of RAIN RFID allows identification of vehicles at speeds exceeding 200 km/h. This enables free-flow identification of vehicles, drastically reducing turnpike and toll plaza costs, and simultaneously reducing congestion at such pay points.

Note that logistics and freight use the same RAIN RFID and therefore reader infrastructures overlap and can be shared, saving infrastructure and maintenance costs.

RAIN RFID has proven to be very effective in the location of vehicles in mass distribution sites. It is reported that the use of RAIN RFID reduced the time to locate a vehicle from days to less than an hour.

Governments are embarking on programs utilising RAIN RFID to enable automated traffic law enforcement and effective vehicle registration operations, thereby

fighting fraud, increasing tax revenue, and ensuring all vehicles on the road are functionally safe and properly insured.

RAIN RFID: the perfect technology for EVI

With ~10 billion tags sold in 2016, RAIN RFID has proven itself in many applications, providing automation, supply chain visibility, stock management, anti-counterfeit, chain of custody and more.



Vehicles form an integral part of human life and industry. The demand for electronic vehicle identification is increasing rapidly as we move towards smart cities.

RAIN RFID is the ideal technology to provide electronic vehicle identification in smart cities, including automated logistics and various localised vehicle-related applications ranging from vehicle access control to loyalty programs.

RAIN RFID is:

Mature: RAIN RFID is specified by international standards and successfully used in many applications. In the modern world non-mature technologies rapidly change. Vehicles are used in a variety of applications and it is generally not feasible to change vehicle tags at short notice; a mature technology, such as RAIN RFID, ensures longer application measured in decades rather than years.

Persistent: Vehicles and roads last for many years; the vehicle identification technology must also last for years. The rapid adoption rate indicates that RAIN RFID will be with us for decades.



Robust: Passive tags, used in RAIN RFID, are particularly suited to long term applications. Tags are easily protected against the harsh environment of long term vehicle identification. They contain no batteries that run flat or get damaged. The tags already work in high temperature paint shops and tough environments like mines, railways, and shipping containers and they require no maintenance.

Affordable: Economies of scale ensures downwards pressure on tag, reader, and deployment costs.

The same RAIN RFID tag can often be used in multiple applications. A parking application can for example use a RAIN RFID licence plate or windscreen label. The cost of issuing a separate tag is therefore removed.

Different applications can share the same reader. For example, an overhead reader that opens the gate for a truck can also identify the freight on the truck.

Acceptable: Tags on vehicles must be aesthetically pleasing, functional, and not hinder the driver or pose a road safety issue. Ease of use, accuracy and reliability are important to drivers and vehicle owners.

AFFORDABLE RAIN TAGS

The same RAIN RFID tag can often be used in multiple applications.

RAIN RFID: enabling capabilities for EVI

Perfect read range: The typical robust read range of approximately one vehicle length (6-8 m), possible with RAIN RFID, ensures that only one vehicle is in the read-zone. It permits cameras to detect tags moved from one vehicle to another by comparing the vehicle in the read-zone with the data provided from the tag.

Shorter read ranges are used in RAIN RFID gating applications where the vehicle speed is controlled, and the vehicle position is managed; i.e. in front of the gate.

Applicable read speed: RAIN RFID identifies vehicles traveling over 200 km/h.

Read multiple tags efficiently: RAIN RFID works in many different applications in one vehicle even if the vehicle has multiple tags. These tags may all be in the read-zone at the same time. RAIN RFID efficiently selects the appropriate tag.

Carries additional data: The tag can carry additional data allowing EVI applications to operate in connectivity-restrained environments.

Secure: RAIN RFID tags are secure and tamper-evident. Tags are placed on vehicles in a publicly accessible space. It is therefore of utmost importance to ensure that the tags are secure and tamper-evident.

RAIN RFID's on-tag cryptography and encrypted data structures facilitate:

- **Authenticity:** Both the tag and reader can validate that the other is genuine.
- **Private:** Data sent over the air appears random when examined by data readers outside the system.
- **Untraceable:** Any data sent over the air cannot be used to track a vehicle by data readers outside the system.

Enabling EVI services with RAIN RFID

Electronic Vehicle Identification use cases are diverse in their desired outcome and operations. The one common aspect in all cases are that the vehicle is used in areas lacking control or detection – whether the tag is fitted to a private vehicle or a managed fleet vehicle. It must be assumed that tags on vehicles are exposed to potential tamper and misuse, be it to disable the tag, spoof another tag, or add additional tags to confuse the system or swamp the reader.



As such, tag and tag data interoperability and authenticity are important in electronic vehicle identification. The following standards are strongly encouraged for EVI and non-EVI applications:

1. **Standard data structures** ensure fast identification of the desired tag and tag data structure to be read. As non-EVI tags will appear in EVI read scenarios all RAIN RFID enabled services/systems should use the ISO

- Application Family Identifier [AFI] or the EPC Tag Data standard [TDS] where applicable.
2. **Cryptography tags** (ISO/IEC 21967) provide tag and reader authenticity, tag data security and tag untraceability that prevent tag spoofing and misuse of tag data. Special care must be taken with key management and revocation.
 3. **Digital Signature data structures** (ISO/IEC 20248) allow for interoperability, the addition of attribute data in the tag, seamless data structure change and roll-out, tag data authentication, key management, and tag revocation for on- and offline read scenarios and use cases.

Electronic vehicle identification is a base line element in overlapping services. Often the same tag will serve one service with more than one outcome (e.g. benefit & access or payment) or more than one service with a combination of outcomes.

Typical EVI outcomes are:

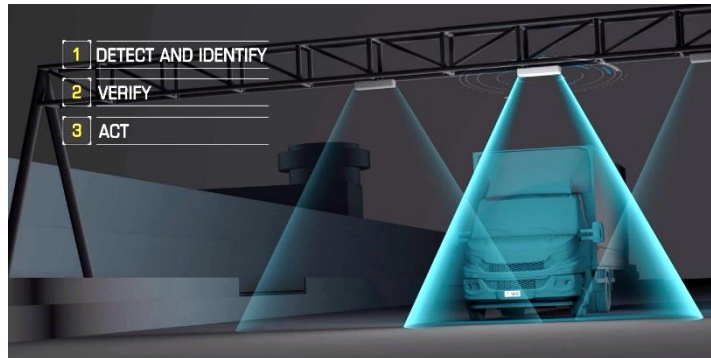
1. **Identification for loyalty programs:** Drive through services like fuel stations, car washes, fast food, and banking may use EVI to provide enhanced services (e.g. fast lanes) within a benefits program. At the same time EVI may also enable security and access service.
2. **Provide access through a gate:** Gated vehicle access automation is a common and effective application of EVI; e.g. compound and site access. Gated exits are commonly used in logistics where the vehicle and cargo are identified using RAIN RFID. The ability of RAIN RFID to read more than one tag at a time assists in improved security, for example where both a driver tag and the vehicle tag is required to enter and exit a secured parking area.
3. **Identification to enact a payment:** eToll (specifically free-flow or open-road tolling) and paid-parking are two of the most well-known EVI applications.
4. **Identification to ensure compliance:** Vehicle licencing and registration falls into this application where the vehicle identity is used in law enforcement and compliance controls which may lead to infringements and legal actions. The ability to identify a vehicle on all roads, in all conditions and by other states and countries is increasingly important in efforts to make roads safer and more efficient.

Typical read operations are:

1. **Stand-alone:** In this application the tag and reader system contain all the information to make a local decision. Compliance and access control

applications where connectivity is difficult (not available, not reliable, to slow, or simply too expensive) falls in this group; e.g. remote mine access (for example, some mines in Brazil), nature reserve access, and police stops in rural areas. In this case, the read event need not be reported or can be downloaded manually at a later stage.

2. **Central-control (closed/proprietary systems):** This read application represents most applications. The reader reads [and authenticates] the tag. The reader reports the event to a central online system which then acts on the read event. Currently most access control and payments services are examples of central-control systems. These tags typically contain a reference to the records in the central system.



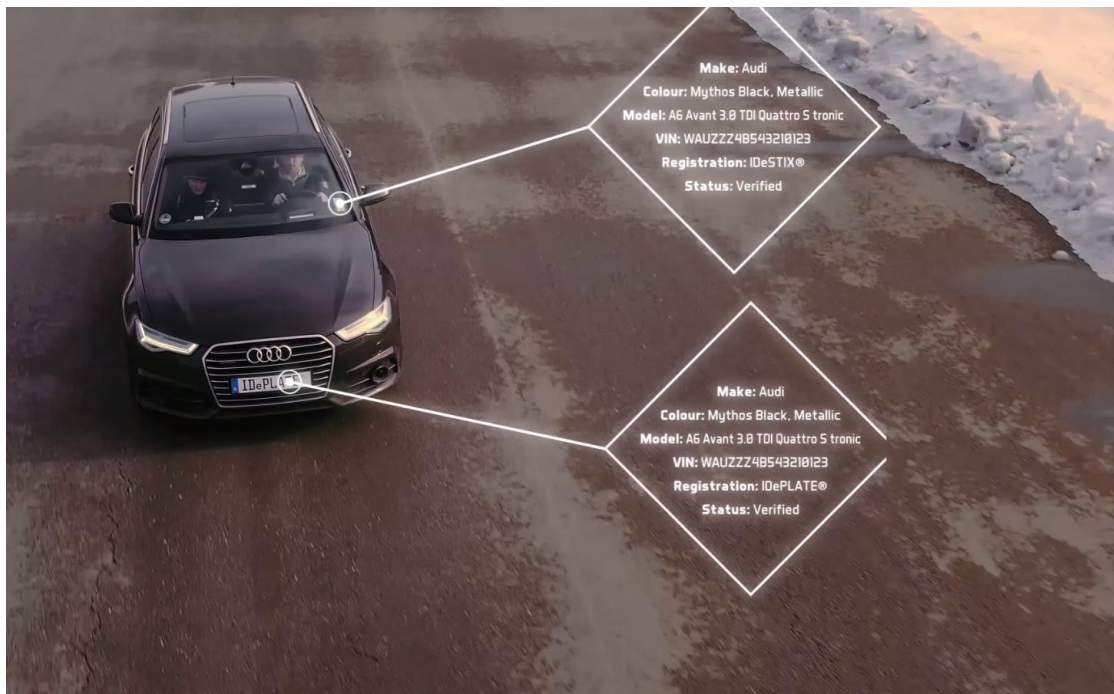
3. **Multi-control (open systems):** In this case more than one independent system uses the tag, often for the same purpose. An example is road tolling where many operators now agree on the same data tag data structure (see the 6C Toll Operators Coalition - <http://6c-toc.com/>) to enable toll interoperability. The nature of these applications requires interoperable and secure tags and tag data. This type of operation (with stand-alone support) is likely to become the predominant EVI method. Different systems will be able to read the tags because the tag data structure is compatible.

Tag placements on vehicles commonly are:

1. **Windscreen** tags can easily be combined with an insurance or registration decal. It is usually placed on the inside of the vehicle and therefore protected from the elements and tamper. However, certain vehicle tints are effective radio shields, and most motorcycles do not have windscreens and a hand on the tag may prevent it temporarily from being read.
2. **Headlamp** tags may overcome the challenges associated with motor cycles, which do not have windscreens.
3. Embedded **licence plate** tags provide good control over the tag lifecycle. It is difficult to disable temporarily but is exposed to physical tamper.

Number plates, which are controlled in all countries by regulation to be visible for human and camera reading, are a long term, constant and interoperable placement for an EVI RAIN RFID tag. A key benefit is that the tag is managed within the plate regulatory life-cycle process. A disadvantage is that plates do not necessarily have space for a retrofit on-metal tag. Supplementing an RAIN RFID enabled licence plate with a windscreen tag provides a direct method to detect plates used on the wrong vehicle.

4. **On-metal** tags fitted on the front, roof, and/or back of a vehicle is an option though tag size, vehicle shape, and private owner perceptions may hamper such placements. It is a possible option for industrial and other controlled applications, i.e. containers, airfields, military and mining vehicles.



Typical read scenarios are:

1. **Manual** reading of the tag and verification of the data. This typically is done on a stationary or slow-moving vehicle through a manned choke point. A handheld or portable side reader is used. The operator will ensure the correct vehicle is read.
2. **Automated gating applications.** The reader configuration must ensure that the tag(s) of only one vehicle are in the reader beam. In this case the driver expecting the gate to open or receiving the service will ensure the correct positioning of the vehicle for an effective tag read. The use of

choke lanes as in toll gates are beneficial in this read scenario. Reader antennas can be placed on the gate, the side, overhead, or in the road, since a single lane needs to be covered. The choice of placement should match the tag placement.

3. **Free-flow applications**, such as open road tolling, are challenging since they need to balance speed against the amount of data to be read. They also need to ensure that a vehicle is always detected even when it drives between the lanes. A requirement to detect the lane a vehicle is traveling in further complicates a free-flow read scenario. Modern RAIN RFID systems have successfully addressed these issues and show reliable operation. Note, free-flow applications are typically used in traffic management, traffic law enforcement, general law enforcement, and road-use charging systems. Detection and punishment avoidance are unfortunately an increasing reality. RAIN RFID enables effective counters to this unwanted behaviour.

Typically, one reader antenna is used per lane. Reader antennas are commonly placed overhead on a gantry or on an existing structure like a bridge. Gantries are however expensive and not allowed in many locations, such as suburban roads. Emerging in-road readers may resolve this issue. Road-side readers are problematic in this application since their use is limited to slow moving single lanes.

RAIN RFID is often used in conjunction with other vehicle identification and traffic sensors; for example, imaging systems (traffic and security cameras and automated number plate recognition systems) where the image linked to the verified data from a RAIN tag may detect licence plate tampering.



As in all RAIN RFID applications careful and skilful consideration of the use case and read scenarios allow for effective and efficient RAIN RFID enabled services and systems. The RAIN RFID community is the first stop for such skills.

ABOUT RAIN RFID ALLIANCE

The RAIN RFID Alliance is an organization supporting the universal adoption of RAIN UHF RFID technology. A wireless technology that connects billions of everyday items to the internet, enabling businesses and consumers to identify, locate, authenticate and engage each item. The technology is based on the EPC Gen2 UHF RFID specification, incorporated into the ISO/IEC 18000-63 standard. For more information, visit www.RAINRFID.org. The RAIN Alliance is part of AIM, Inc. AIM is the trusted worldwide industry association for the automatic identification industry, providing unbiased information, educational resources and standards for nearly half a century.



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Advancing
Identification
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Visit the RAIN RFID website – RAINRFID.org. If you are interested in learning more about the RAIN RFID Alliance, contact us at info@rainrfid.org.