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Modern Cars Ensures Safety of Human Life via Implementation of RFID and Sensors

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***Abstract*—**Radio frequency identification is the next wave in the evolution of computing. The RFID (Radio Frequency Identification) market is in a hyper growth phase. After finding its vast application in retail industry, RFID potential is now being explored in automobile industry. RFID in the car-mounted system can be applied to the highway electronic identification charges, car park entrance management system, car plate management and vehicle body (parts) identification and theft. RFID ranks among the key technologies in the automotive industry and performs valuable services in such areas as quality inspections, product tracking and tracing. In this research paper we illustrate many of the challenges being faced by RFID implementations in automobile industry. In the process, we take an in-depth look at cost, technology, standards, privacy and security and business process reengineering related issues surrounding RFID technology in automobile industry.

***Keywords*—**Automotive industry; UHF RFID tags; RFID readers; radio signals; sensors.

I. INTRODUCTION

The term RFID refers to Radio Frequency Identification, a technology which uses radio waves to automatically identify items or people [1, 2]. RFID has extended its applications to identify a wide variety of items, including things like consumer goods or construction machinery. RFID is an automatic identification like bar codes, smart cards, and voice recognition etc., used to help machines identify objects. But unlike bar codes line of sight signals are not required for operation of RFID. This technology makes use of automatic data capture systems to identify objects and capture information and transfer them into computer without data entry.

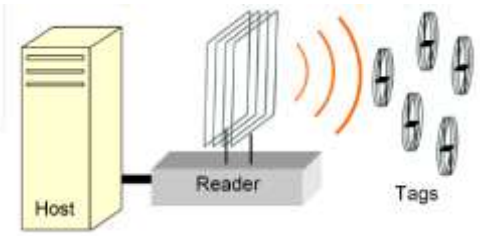

Fig. 1. Working of RFID.

Figure 1 shows a typical system that uses RFID technology. The host machine uses one or more RFID readers to retrieve digital information stored in RFID tags and processes the information according to the needs of one or more applications. In general, a RFID tag contains a globally unique identification (UID) as well as data fields organized in a standard way. A RFID based object locator only needs the UID information; other data fields are not used. No matter whatever is the orientation of the tag, the tag can be read easily. It do not requires line of sight. The RFID technology has now bust the myth that it does not work around water or metal.

Sensors are sophisticated devices that are frequently used to detect and respond to electrical or optical signals. A Sensor converts the physical parameter (for example: temperature, blood pressure, humidity, speed, etc.) into a signal which can be measured electrically. Consider the example of temperature. The mercury in the glass thermometer expands and contracts the liquid to convert the measured temperature, which can be read by a viewer on the calibrated glass tube.

Criteria to Choose a Sensor

There are certain features which have to be considered when we choose a sensor. They are as given below [5]:

- Accuracy
- Environmental condition - usually has limits for temperature/ humidity
- Range - Measurement limit of sensor
- Calibration - Essential for most of the measuring devices as the readings changes with time
- Resolution - Smallest increment detected by the sensor
- Cost
- Repeatability - The reading that varies is repeatedly measured under the same environment

Sensors Based on Power or Energy Supply Requirement

- Active Sensor - Sensors that require power supply are called as Active Sensors. Example: LiDAR (Light detection and ranging), photoconductive cell.
- Passive Sensor - Sensors that do not require power supply are called as Passive Sensors. Example: Radiometers, film photography.

II. RFID IN AUTOMOTIVE INDUSTRY

Over the last 15 to 20 years, an extensive reorganization of the automotive supply chain could be observed. Modern and novel approaches like make-and-deliver-to-order, zero-error-production, lean management, just-in-sequence (JIS) and just-in-time (JIT) production, the constant necessity to reduce costs, reduced cycle time and the need for increasing efficiency had manifold outcomes. On the market side, vehicle manufacturers had to look for both new

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sources of production economies and continuous product development. On the technology side, the fast-growing complexity of the manufacturing processes and products turned the automotive supply chain in one of the world's most information-intensive management processes.

In the dynamic manufacturing environment of an automobile factory, there are thousands of complex processes going simultaneously. There are numerous containers, pallets, boxes, barrels and anything that contain parts large and small that throughout each process eventually make up a functional automobile. As with any complex process, having the right parts on hand at the right moment means the difference between maintaining one's build schedule to missing the schedule entirely and not being able to deliver on time. Automotive manufacturer have highly developed assembly line processes to reduce waste and inefficiencies. However, uneven RFID enables automotive manufacturers to sophisticate their process automation down to the distribution and management of materials. Time, cost, and productivity issues are always at the forefront [1], [2].

Our analysis indicates that the most significant factors of RFID diffusion in the automotive industry are:

- Compatibility (e.g. technological, hardware, software and data standards),
- Costs (e.g. hardware components, system integration and customization),
- Complexity of the technology and its implementation (e.g. because of process change, lack of plug & play components, non-trivial data processing, etc.),
- Performance (e.g. technological capability and environmental influences on systems), and
- Top management support (e.g. perception of RFID as a strategic technology).

Modern cars are loaded with automatic features. Today car has complex computer system along with memory that holds the information related to the car. The information may be comprised of history of the car, its maintenance needs, system failure notifications and reminders. Today the technology has advanced to such a state where one can talk to the car and vice-versa. Wireless cars are connected to databases of information as well as connected to each other. RFID is already present in new cars, usually in the door locks and ignitions to ensure that the proper key is being used to start the car. Another impressive technology is Remote RFID car starters. All it needs is to flash a chip before a reader at a window inside the car opens the doors and starts the car, making keys redundant. Tires are also equipped with RFID sensor tags that measure air compression and alert when a refill is needed. New RFID applications are popping up constantly and enhancing the driving experience. But so far UHF RFID applications are still quite rare besides from a few exceptions.

Fig. 2. UHF RFID Tags.

Fig. 3. UHF RFID Reader.

A smart car is a car that has been equipped with an UHF RFID tag containing an encrypted and secure ID code. UHF RFID is something very different. Using this technology means providing a car with personal ID, something like a registration number which is universally unique and moreover it does not require any visual contact. If UHF RFID tag is placed in the windshield and is not surrounded by any metal, it can be read from longer distances. This opens the door for new world of applications.

Fig. 4. RFID tag can store data such as a vehicle's make, model, color, gas capacity and physical location.

The use of this technology will enhance the comfort and convenience of the car owners to new heights. The processes like parking fees and toll fees can be handled without lifting a finger. The UHF RFID passive tag placed in the windshield is read by RFID readers placed on the way or at the gates of toll plazas and car parking. The payment process is automatic and is withdrawal is made via credit card once a month. This already exists in many parts of the world, but some parking lots are not part of a big car park area with gates. They require the driver to get out of the car, go to a parking meter, estimate how much time the errands will take, pay (usually with coins), get back to the car with the printed parking ticket, place it in the windshield and then, the driver is finally on his way - constantly keeping an eye on the watch to get back before the parking time runs out. By tagging cars and placing sensors under parking lots billing can once again be automated. If the area has a maximum parking time of let's say 2h, the parking lot can send the driver a warning message when the maximum time is about to run out [3], [4].

III. Upcoming Technologies in Near Future

A. RFID Ignition System

In 1997, Ford Motor Co. equipped the Mustang with one of the first RFID ignition immobilizers in the U.S. car industry. Theft levels for the Mustang immediately dropped 70 percent from just two years prior. The results were stunning, and pretty much every other carmaker followed suit. Today, the RFID (radio frequency identification) industry claims a 90 percent reduction in theft rates for car models equipped with RFID starters, immobilizers and entry systems. Both automakers and insurance companies have full faith in the devices, even

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going so far as to label them unbeatable. And certainly, the technology is an impressive display of security innovation.

RFID relies on radio-frequency signals to create a system that, for the first several years it was in use, was indeed impossible to crack. In the 1990s, many a car thief was thwarted by the rather brilliant addition of RFID immobilizers to regular old physical keys. An RFID immobilizer is a chip embedded in the top part of an ignition key. This chip sends out an encrypted string of radio-frequency signals, basically a particular number of impulses broadcast on various radio frequencies to create a specific code, when the driver inserts it into the ignition-key slot. Without this code, the car either won't start or won't activate the fuel pump. So even if someone hotwires the car or copies an ignition key, the ignition isn't going to work because it hasn't received the proper radio-frequency code.

If you have a car that comes with a special valet key, the immobilizer probably shuts down the fuel pump if the car is started without the code. This means the car is going to run only on whatever fuel is left in the fuel line, which will only get it a couple of blocks. Thus the valet key -- valet parkers only have to drive a car very short distances. If they try to drive off with your car, they won't get very far. Neither will any other potential car thief.

Early RFID systems, both keyless entry (the key fob device with the button you press to unlock the car) and vehicle immobilizers, used 32-bit encryption. That means they sent a code of 32 impulses. With 32 bits in the code, there are billions of possible combinations. In newer schemes, including remote starters that let you start a car with the push of a button, the codes have 40 bits, which increases the possibilities. With so many possible codes, the system seems unbeatable.

Keyless entry and immobilizer systems work in pretty much the same way. Keyless-entry fob is a standard radio-transponder setup. Inside is a circuit board, a radio transmitter, a battery and an antenna. When you get near your car, perhaps 5 feet to 10 feet (a few meters) away, you press the button to unlock your doors. The RFID chip in the fob sends out a code of 40 impulses broadcast on different frequencies. The corresponding RFID chip in the car receives this code and accesses the car's software to find out if the code is the right one. If it is, the doors unlock.

This is called an active RFID system, since pushing the button actively sends out the code, instead of receiving it. The immobilizer chips in ignition keys are also active. Keyless ignition, on the other hand, is a passive RFID system. Instead of the ignition chip sending out the code, the car sends out the code and the ignition chip receives it. Ignition systems have no battery (or a different kind), and they have a lower-power antenna, so they won't broadcast as far. It's an additional security measure.

On its face, the system seems impenetrable: There are billions of possible sequences, and brute force will no longer get the car moving. Add in rolling codes, which are becoming more common -- a system in which the expected sequence changes slightly every time you push the button -- and the options get closer to a trillion. But as with any security system, it's only impenetrable until thieves figure out a way around it. Look at safes and burglar alarms; you've got to update those frequently in order to stay ahead of the robbers. Car RFID systems are no different.

RFID hacking is the most high-tech approach to car theft yet. Using hardware that grabs radio frequency signals out of the air, and software that decrypts it, thieves with time on their hands can steal an RFID-equipped car [6].

B. Alcohol Odor Sensors

A hi-sensitivity alcohol sensor [7] is built into the transmission shift knob which is able to detect the presence of alcohol in the perspiration of the driver's palm as he or she attempts to start driving. When the alcohol-level detected is above the pre-determined threshold, the system automatically locks the transmission, immobilizing the car. A "drunk-driving" voice alert is also issued via the car navigation system.

Additional alcohol odor sensors are also incorporated into the driver's and passenger seats to detect the presence of alcohol in the air inside the vehicle cabin. When alcohol is detected, the system issues both a voice alert and a message alert on the navigation system monitor.

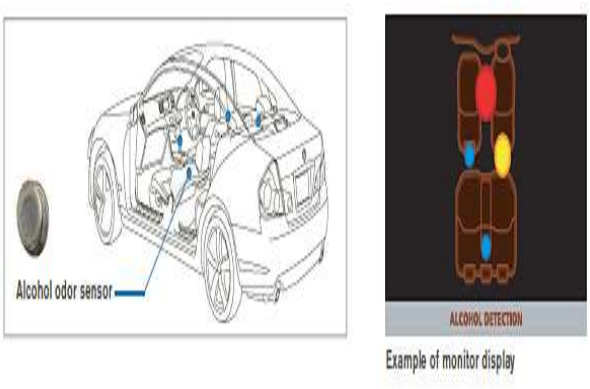

Fig. 5. Location of alcohol detector sensors.

C. Detection Using Facial Monitoring System

A camera is mounted on the instrument cluster facing the driver to monitor the driver's face. The facial monitoring system [7] is calibrated to monitor the driver's state of consciousness through the blinking of the eyes as shown in figure 6. When the system detects signs of drowsiness, a voice and message alert is triggered via the navigation system. Additionally, a seat-belt mechanism is activated which tightens around the driver to gain his or her immediate attention.

Fig. 6. Facial monitoring scheme.

D. Detection of the Driver's State from the Driving Behavior

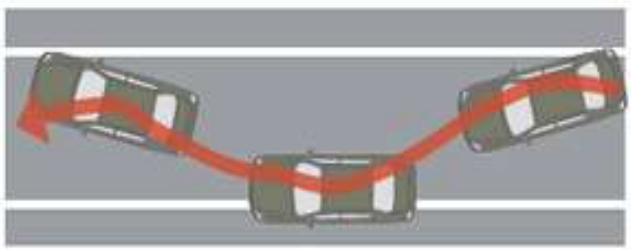

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Fig. 7. Distraction while driving.

By constantly monitoring the operational behavior of the vehicle (e.g. sensing if the vehicle is drifting out of its driving lane), the system can identify signs of inattentiveness or distraction in the driver. When the system detects such behavior, voice and message alerts are issued via the navigation system. The seatbelt alert mechanism is also activated, tightening around the driver to gain immediate attention.

E. Safety Shield

Continuing advances in car safety equipment have helped reach that goal. Most of us know about seat belts and airbags, and advances in other areas, such as crash-absorbing body structures, which further help protect us in the event of an accident. But there are other advances in safety technology that not only help protect us should an accident occur, but actually help prevent an accident from happening in the first place.

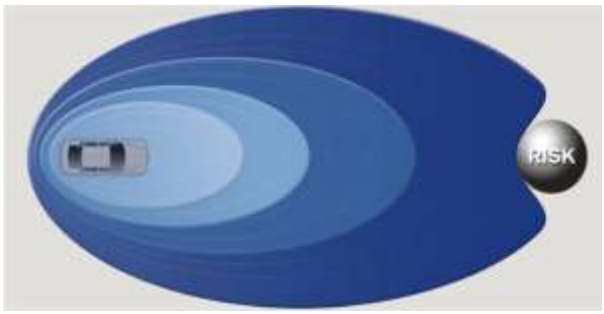

Fig. 8. Safety shield.

Starting in 2005, the concept of "Safety Shield" was introduced in an effort to proactively achieve active safety. The idea behind the Safety Shield Concept is that potential approaching risks are categorized into different phases of driving, and the vehicle activates various "barriers" to help provide multiple layers of protection depending on the type of approaching risk. The car is able to help provide prompts to the driver for safe driving depending on the situation, as well as a succession of other safety features as the risk approaches or if a crash should occur.

F. Distance Control Assist

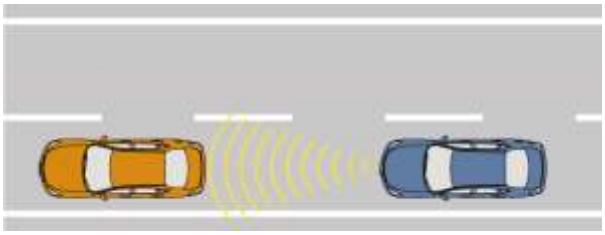

Fig. 9. Distance control assist.

Safety Shield Concept is the "Intelligent Cruise Control" system, a feature that helps facilitate driving in normal "no-threat" conditions. This technology monitors the car's speed and distance from the vehicle directly in front of it and accelerates or brakes the car accordingly, providing automatic cruise control at a speed set by the driver. It automatically maintains space between the car and the other vehicle according to this set speed, making the car cruise at the same pace as the vehicle in front of it. In this manner, this feature helps reduce the driver workload in situations where there is no present danger, helping you to drive with peace of mind.

"Distance Control Assist" [8], like the Intelligent Cruise Control system, is a system located on the very exterior of the Safety Shield Concept. This system helps maintain an appropriate distance to a vehicle directly in front of you by prompting the driver to release the throttle when the driver gets too close to the vehicle ahead.

If the car draws near to a vehicle ahead while the driver is pressing on the accelerator, the system adds resistance to the pedal and the pedal "pushes back. If the driver then takes his or her foot off the gas, the system applies the brakes.

G. Blind Spot Detection Technology

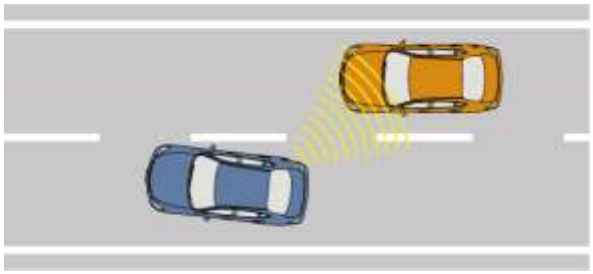

Fig.10. Blind spot detection.

Blind Spot Intervention [9] is a system that helps alert the driver when vehicles are in the vehicle's blind spot areas and issues a warning if the driver attempts to change lanes in such a situation. Two millimeter wave radar units installed on either side of the rear bumper scan for vehicles entering the detection zones on either side of the car, alerting the driver to their presence by illuminating a light on the windshield pillar. If the driver starts to change lanes, the system sounds an alarm. In addition, the brakes are activated to try to help keep the driver from changing lanes, similar to the Lane Departure Prevention system, helping to alert the driver to the threat within the blind spot area.

IV. SAFETY ASPECT IN MODERN AUTOMOBILES

The cars tagged with UHF RFID would definitely make the world a safer place regarding traffic offenders. These tagged cars can be scanned even when they are on the move. Moreover the readers placed along the way could be set to detect car tags or car parts that have been reported stolen. This concept is not just limited to cars; it can be expanded to pets and other valuable possessions. Kidnapped children can be traced as long as they carry something tagged on them. But at the same time it should be taken care of that such application should not impose any kind of threat to person's privacy.

Many countries have adopted RFID tags on driver's license and ID cards. A simple RFID reader installed in the car can detect who is attempting to use it. The car starts normally is driver is an approved user. But if the driver license is not known, then the car will demand a security code before starting. This is surely a obstacle for the thieves. Such system also prevents children from trying their luck at the wheels when their parents are away. Moreover such a technology also reminds people of been responsible and carry their driving license while driving. By tagging everything from house keys to reading glasses this service can be developed to work as no less than a personal assistant. The concept of smart cars requires following ingredients.

- Mandatory UHF RFID tags on the cars.
- Installing RFID readers on roads which carry heavy traffic.
- Police should also possess UHF RFID readers in their hands.
- A secure backend system.

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- Smart driving license

UHF RFID readers have the ability to read tags from a distance of 26 feet. This distance proves enough for medium and small sized roads. For effective reading of tags on bigger roads, there is still room for development.

A smart car can be detected and traced throughout its journey whenever necessary i.e. when there are any valid reasons for tracking a particular vehicle. There is no need by system to keep records of unsuspected cars. Fixed and mobile RFID readers are capable of scanning passing cars. More sensitive information such as owner details, tax/insurance dates, unpaid fines etc. could be requested from a secure cloud-based central system that grants access permission only to authorized police and safety authority personnel. Tags located on inside of car's windshield consist of a waterproof passive sticker tag. These tags last forever and operate well on speeding vehicles and even in poor weather conditions. The idea of e-plates is functional because of use of active or semi-active tags which receives power from cars battery. Active tags are easier to detect by RFID readers. Single reader can read such multiple tags simultaneously at a speed of up to 320km/h from a distance of up to 100 meters.

Accidents on roads are a fateful reality. Time is a very critical factor in case of accidents. Even few seconds delay is too much. The technology should be used in such a manner that rescue team gets as much information as fast as they can. The vehicle information is stored in UHF RFID tags. For instance, some new technology car's are having so complex technical solutions that one slight move in wrong direction, like inflation of air bags, can be fatal for a passenger. In order to avoid this, safety personnel could scan the UHF RFID tag in the windshield/license plate and get thorough instructions on how to remove the roof safely.

Another prospective aspect of UHF RFID tag is in driving license. They do not require any visual contact and therefore could help to recognize the victim within no time without any need to search for driver's license. Crucial health information without a deep glance at a victim can be made. UHF RFID readers also find its applications in catching speeding cars. Currently these systems make use of cameras and not RFID. RFID readers are connected to speedometers which estimate the speed at which vehicle is moving and further RFID reader identifies the vehicle. This information is sent to the backend system from where the fine is imposed on the offender. RFID readers are also placed along the roadsides where they estimate the average speed of the vehicle. If a vehicle passing a road RFID reader reaches the next RFID reader too soon to be driving at a legal speed, the information once again is passed on to the backend system and a fine is automatically sent to the offender.

V. Challenges Faced by The System

There are two types of challenges faced by RFID systems: implementation cost and privacy issue.

When it comes to RFID identification we are always facing two challenges: implementation costs and privacy issues. Both of them can be hard to overcome, but it this particular case it is far from impossible.

The implementation costs of a system like this would fall on the government - meaning, the tax payers. That is never fun, but in this case the system would also save the tax payers money by atomizing the fine writing process. A more efficient identification system means more caught offenders, which means more fine incomes. But most importantly, less traffic hooligans means less traffic accidents and that saves both lives and money. The privacy issue is best tackled by reminding the public that the backend systems would be secure and accessible only to authorized personnel. And the truth is, these people can already access the information if necessary. They already have the permissions and equipment.

As with the internet, GPS navigators and telephones, all innovations can be used for both good and bad. But this fact will not stop us from making innovations. Curiosity is in the human nature. And, a system that saves traffickers lives, creates a safer workplace for police officers and rescue teams as well as ensures that crucial information is accessible in an emergency situation, is definitely worth discussing [9].

VI. Conclusion

RFID is one of the most promising information system technologies for supply chain application in the automotive industry today and in the future. Its potential to increase the transparency in supply chains and thus to advance the control of logistics, manufacturing, distribution, delivery, and reverse-logistics processes is one of the biggest advantages of the technology. However, adoption and deployment of the technology does not come over night – neither in automotive, nor in any other industry.

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