Under Vehicle Scanners

The need for under-vehicle inspection.

A vehicle can very easily be used as a conduit for transporting contraband and quite often this could happen without the knowledge of the owner / driver of the vehicle. One of the biggest threats around the world is when terrorists use vehicles, especially “trusted vehicles” to smuggle weapons, explosives, contraband, etc. into secure facilities of all kinds. “Trusted vehicles” belong to employees, regular suppliers and frequent guests who are known to the facility and therefore “trusted.” Terrorists know that these trusted vehicles and drivers often do not undergo the same rigorous inspection that all other “unknown” vehicles must go through before entering a secure facility. All that a terrorist needs to do is to know where a trusted employee lives and parks their vehicle. The terrorist can then attach contraband to the undercarriage and later have an accomplice inside the secure area remove the contraband after the vehicle has cleared inspection and entered the secure facility. Over time, the terrorists inside accumulate the weapons and/or aggregate enough small quantities of explosives into much larger devices capable of catastrophic destruction. If a vehicle is stopped because contraband is discovered, there is no one to point to because the trusted employee was not involved. All the terrorist has lost is a small amount of explosives or a weapon. Government offices, hotels, refineries, chemical plants, airports, rail and bus stations could all become victims of such a means of introducing contraband into a “secure area”. Most “secure areas” would have a labour force to assist with general duties such as cleaning, trash removal and receiving of goods, etc. These people have the time and ability to access parking lots to remove and store the contraband. **This highlights the importance of deploying a system that identifies weapons, explosives and contraband planted on the undercarriage of a vehicle.** By identifying the contraband the security forces are alerted about the threat and can deny entry to the secure facility until the threat is removed. Identification from a distance would make it safer for the security personnel.

Manual Inspection.

Most security operations thoroughly inspect the inside of a vehicle (under the seats, in the glove box, the trunk, the hood, etc.) but rarely search under the vehicle, a fact well known to terrorists. In cases where they do search the undercarriage, it is generally done with a stick and mirror, a running video system (little cameras in a row inside a speed bump – impossible to discern anything on screen), or a line scanning system that produce poor quality images of varying dimensions depending on the speed of the vehicle.

Stick & Mirror

These ‘manual systems’ require the human operator to look at pictures or video to try and spot a discrepancy in the undercarriage of the vehicle. Terrorists are unlikely to place contraband, just anywhere under a vehicle. In most cases, terrorists would go to extraordinary lengths to ensure the contraband is not discovered. Often it is wrapped in dirty, greasy cloth pushed in over the top of axles or crossbeams. In many cases, items such as spare tyres are removed and replaced with a metal plate to hide contraband. Manual systems require the security personnel to have the expertise and focus to know what the undercarriage of each vehicle, make and model looks like and be able to concentrate on detecting any discrepancy in the undercarriage. **Security personnel, however well trained they may be, simply cannot know what the underside of every vehicle should look like and whether, for example, a spare tyre should be there and not a plate, or if the vehicle should have two exhaust systems or one. Even well trained, well rested security forces cannot conduct a reliable manual search of the vehicle undercarriage for hidden objects and discrepancies.** With these limitations it is just not realistic to expect security personnel to overcome provide effective surveillance of the under carriage of vehicles.

Besides, manual inspection of the vehicle under carriages takes a significant amount of time to process each vehicle thus causing long lines of disgruntled staff and visitors. This pressurises the security personnel to waive the vehicles through. Dangerous but true! Terrorists are smart and ingenious in their attempts to overcome the security measures used at a "targeted facility". They observe how security forces operate and learn how a security system or procedure works and evolve ways to defeat the same. They look for the weakest points and design their tactics to exploit weak areas and penetrate the facility. **The most common weakest link is the human security force -** often low paid, poorly trained and overworked to the point of being ineffective.
The following factors make manual inspection futile:

- Humans get bored very quickly and lose their attention to detail.
- Humans, most likely, have no idea what a vehicle undercarriage should look like – whether anything has been tampered with.
- Humans most likely have no idea how the terrorist (smuggler) concealed the contraband and therefore have no idea as to what they are looking for.
- Humans can also be paid to look the other way - or they may be threatened with violence to their family if they don't look the other way.

'Manual inspection' is therefore a waste of time, effort and money.

Automatic Inspection is the way forward.

In the industrial world computer powered **machine vision technology** has become the de facto inspection methodology for all types of high speed, rapid inspection of production activities and quality control. Machine vision utilises industrial image processing through the use of cameras mounted over production lines and cells in order to visually inspect products in real time without operator intervention. The machine vision system generally consists of a number of cameras all capturing, interpreting and signalling individually with a control system related to some pre-determined tolerance or requirement. **UVS systems are increasingly using high-speed computer powered machine vision technology to visually inspect undercarriages.**

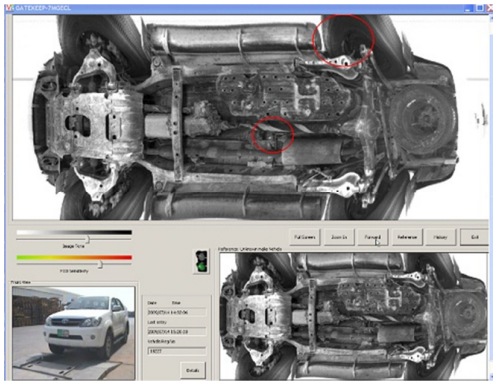
Components of a typical UVSS.

- Platform
- Scanning system
- Automatic change detection software.
- Database (includes Watch List for wanted vehicles, Vehicle Verification vs. License Plate, etc.).
- Embedded networking capability.
- Integrated devices (cameras, traffic light, etc.).
- Touch screen monitor.

A typical Scanning Process.

Vehicles drive over an array of bidirectional scanners as the Software compiles two high-resolution, virtual 3-D digital images of a vehicle's undercarriage to create the vehicle's "fingerprint." Two views make it easier to see any threatening objects that may be hidden on top of an axle or crossbeam. An overview/driver camera captures the normal view of car/driver and displays this on a high-resolution screen.
The **remote scene visualization capability reduces the risk of close-range inspection** for personnel, carrying out the inspection. Most systems deploy a scene verification algorithm for quickly and efficiently finding potential changes to the undercarriage by comparing previously archived scans of the same vehicle. They also

carry out a shape analysis approach that compares available data of various models and makes of vehicles with the scanned real data using a perceptual curvature variation measure (CVM). CVM, that can be understood as the entropy of surface curvature, describes the under vehicle scene as a graph network of smooth surface patches that enables matching with the graph description of the CAD data of a 'safe' undercarriage.
After the vehicle has cleared the scanning device, **it only takes 2-3 seconds for the Software to automatically compare the subject vehicle's undercarriage with that of a safe vehicle (stored in the database)** and display both on the screen. The system then immediately identifies any threatening foreign objects or modifications to the undercarriage by circling them with a red ring (see below) and activating an audio and/or visual alarm.



The operator screen may display the overview / driver image in colour. The undercarriage views are generally displayed in monochrome allowing for more pixel detail and thus better resolution than colour images. As computers analyze the image, monochrome is superior to colour.

Conclusion

Systems Integration is the key. As discussed in earlier articles, a 'secure solution' would require that the UVSS integrates with the access control and the video surveillance systems deployed at the site. The UVSS should therefore have open protocol for integration with other security systems and also networking for any remote monitoring requirements.