Case Study

Stopped Vehicle Detection (SVD) M4 Motorway (England)

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This case study describes the first long-term trial of the Ogier Electronics SVR-500 radar, which was undertaken on the M4 motorway in England during 2020-2021. The objective was to demonstrate the SVR-500 radar was able to reliably detect stopped vehicles on a live motorway within 20 seconds with low false alarm rate.

Background

A large number of vehicles break down or run out of fuel on motorways every day. In cases where radar is not used to detect stopped vehicles, the response time can be extremely slow, leading to increased risk of collisions with other vehicles. In 2016 a Highways England report showed breakdowns on all-lane-running sections of the M25 took an average of 17 minutes to be detected.

We decided we could dramatically improve this situation by using our radar expertise to develop a Stopped Vehicle Detection (SVD) radar product that would dramatically reduce response time from minutes to seconds. Rapid detection is important in most situations, but especially on Smart Motorways where there may not be a hard shoulder. Thus the SVR-500 product was created.

Summary of Previous Trial on M6 using Scan-360 Hardware

The initial trials ran from April 2018 to January 2020 on the M6 motorway close to the Coleshill interchange. The hardware was based on our standard Scan-360 security radar with software modified to detect stopped vehicles. Although Scan-360 was not optimised for roadside operation, the results were judged sufficiently encouraging to proceed with planned hardware developments prior to a new trial on the M4.

Hardware Improvements: Scan-360 to SVR-500

The radar antenna was upgraded to a new design with improved angular resolution to better discern vehicles from one another. To take further advantage of the narrower antenna beam, the processing speed was increased to give a higher measurement rate. A further increase in resolution was achieved by adjusting the frequency synthesiser configuration. These changes improved range and angular resolution, as well as extended the total operating range from 400m to 500m.

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Location of SVR-500 Trial Site

The trial site was located on the M4 motorway east of Bristol as indicated below:

The M4 is a major transport link that runs east/west across England and Wales.
Due to a lack of similar east/west routes, the M4 has high traffic levels so is ideal for testing the SVR-500 in realistic high density, high speed traffic. It is generally accepted that detection systems have to "work harder" during heavy traffic.

Site Details

A 500m stretch of roadway was used for the trials as shown below.
Three traffic lanes operate in both directions with a speed limit of 70 mph (113 km/h). Like many motorways in the UK there are no streetlights.

The image below shows the layout of the road and defined detection areas.
SVR-500 radar (circled in white) was positioned on a lay-by with coverage of six lanes (shown in green), two hard shoulders (shown in red) and two short lay-bys on both sides of the road (shown in orange). The central reservation in the middle of the road separates the two sets of carriageways with a low concrete wall.

By mounting the radar on top of a mobile trailer, line-of-sight was maintained over the top of tall vehicles and fixed obstructions. A PTZ camera was co-located with the radar to record footage for later analysis to determine false alarm rate.
As shown below, SVR-500 is the black object on the very top left of the pole; the camera is the white dome slightly lower and to the right. Simple network and power requirements permit roadside usage where there is limited infrastructure.

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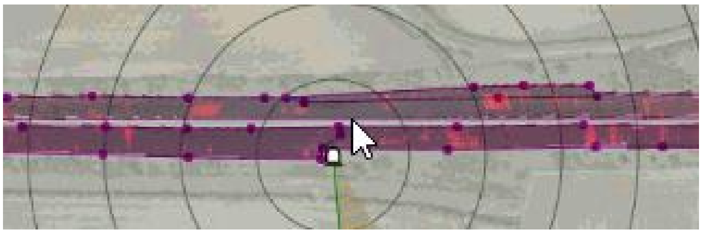
SVR-500: Operating Principles and Site Configuration

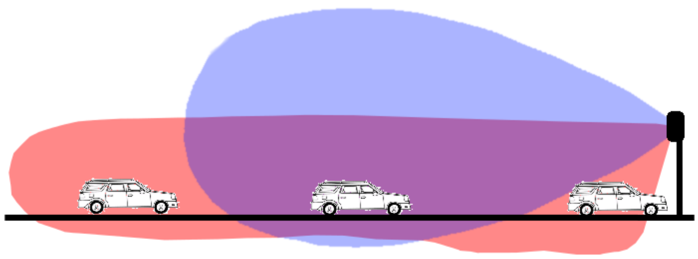
SVR-500 is a scanning radar which measures a full 360 degrees every second. Each radar measures 250m in all directions, giving total road coverage over 500m. Therefore the radar was situated in the middle of the coverage area. The measurement range is designed to match the typical length of road that can be observed from one position before obscuration or bends start to affect performance.

Since the radar covers 360 degrees it can be installed facing in any direction. Precise alignment and detection zone coverage is set up remotely using the web interface. A satellite map with overlaid “live” data for the radar is used to confirm the detection areas correspond to the layout of the road.



The radar sensor emits safe, invisible high-frequency radio waves (microwaves) that bounce off all solid objects. The location and speed of the object is determined based on the characteristics of the reflected signals. Since microwaves do not bend, line-of-sight between radar and object is required, so SVR-500 was mounted on top of a pole.

The vertical “fan beam” provides wide elevation coverage that enables the detection of near and far targets even when installed on tall columns thereby minimising obscuration from other vehicles and avoiding the need to infer the presence of stopped vehicles in blind sectors. During installation precise tilt adjustments are infrequently needed because the fan beam is optimised to accommodate most road gradients.



Self-contained multi-stage signal processing continually measures the speed of objects within the field of view. The instantaneous determination of target speed allows stopped vehicles to be detected without the need to correlate data from scan to scan, which can lead to errors creating false alarms and reductions in detection probability. The system was configured to take no more than 20 seconds to classify a stopped vehicle then to automatically point the PTZ camera toward the vehicle.

SVR-500 operates within the license-exempt 24GHz ISM frequency band so avoids mutual interference with 77GHz automotive radars that are fitted to modern cars for adaptive cruise control. No special arrangements were required to prevent unwanted interference, although there are hardware filters that may be optionally fitted to mitigate out-of-band interference should it present an issue, if for example installed very close to very large radio transmitter masts or high power airport radar systems.

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Method of Determining Radar Performance

Since SVR-500 automatically slewed a PTZ camera to point toward all stopped vehicle detections, the false alarm rate was determined by observing the recorded video footage and noting if the radar detected a valid stopped vehicle or otherwise.

Further footage was carefully checked for vehicles that may have stopped but were not recorded in the system logs. The detection probability was calculated using the number of valid detections against the number of missed detections or detections that exceeded the allowed reporting time (20 seconds).

Road activity was as realistic as possible because the presence of the radar and nature of the trials was not published beforehand. SVR-500 is small and discrete so even if observed by members of the public it would not have be obvious that it was radar equipment and even less obvious that is was in continuous operation.

Installed Performance

The results showed detection probability of >85% and false alarm rate of <15%.

A statistically significant sample size was available due to the relatively high number of stopped vehicles that were observed throughout the trial, often with multiple vehicles in a single day.

Based on anticipated customer requirements the SVR-500 was configured to detect stopped vehicles within 20 seconds. Extending this time will improve both detection and false alarm rates.

A more detailed report with commercially sensitive performance data is available upon request (subject to non-disclosure agreement).

Footage from the trial is freely available on our website: www.ogierelectronics.com

Further Enhancements

Although the trial site was primarily for proving the performance of the SVR-500 hardware and algorithms, the raw radar data was also stored and analysed off-line to feed in to our continuous improvement programme.

We have developed a variety of computer models and simulations that are continually refined by real world data. These simulations are used to identify where new or revised algorithms may be used to further reduce false alarms. SVR-500 firmware can be updated remotely to take advantage of future refinements to the detection algorithms.

Conclusion

SVR-500 has demonstrated a high level of detection performance in a live motorway environment, demonstrating its suitability for SVD applications.

Radar is the key technology to improve road safety and SVR-500 with its all-weather operation and low false-alarm rate makes it ideal for Smart Motorways.

Our long-term M4 trial showed excellent performance in a real operating environment with genuine stopped vehicle events generated by members of the public.
SVR-500 is largely based on our Scan-360 hardware, which is field proven with an enviable reliability record. Despite the straightforward configuration, and low power consumption, SVR-500 offers an effective long-range solution for rapid detection of stopped vehicles in all weather conditions.

On the M4 test site the absence of streetlights may cause difficulties with optical sensors such as video analytics. Since SVR-500 uses microwave radar technology it is not affected by light levels so will work in total darkness as well as bright sunlight.

The radar itself is similar in size to a typical PTZ CCTV camera, uses the same mounting arrangement and is easy to install and configure.

Please visit our website to discover more about our radar solutions and to discover why roadside SVD radar is superior to other technologies, including radars fitted to vehicles and video analytics.

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