A Project on Intelligent Transportation Systems in UK

A.B HAWKINS – INTERIM REPORT ISSUE No 2

EXECUTIVE SUMMARY:

Today, most if not all transport operators face greater demand from customers to provide a higher quality service (such as JIT etc) at a lower cost. In order to remain competitive and maintain profitability, transport operators are being forced to, look at methods of increasing efficiency and customer service without having to significantly increase resources such as staff and vehicles. The use of modern fleet and vehicle management systems provide operators with interesting options to meet these ever increasing demands.

The role of IT in transport operations is clearly changing from a predominantly administrative role to a more fluid and dynamic one that provides value added information to transport operators. For instance, the introduction of on board computers (OBC) and mobile data communication systems and the electronic transaction possibilities they bring may significantly change the relationship between stakeholders in the supply chain.

However, these new technologies bring managerial issues with them, primarily, the question of what level of technology would be optimal for a particular size of transport operator. In terms of Fleet Management, the systems described here are of a low level. However, the emphasis is placed more upon vehicle and driver management rather than fleet control, and in this respect the systems are very suitable. This second interim report for the ESF funded project aims to outline the current developments and conclusions that can be drawn for the effectiveness of these technologies on an SME transport company.

After a 5 month period of systems monitoring and analysis a point has been reached where the system basics can be described, and the results found thus far discussed.

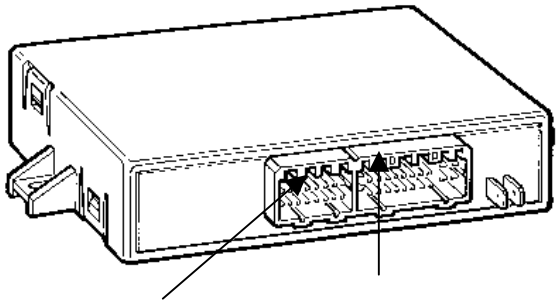
Even in these early stages, the results so far have suggested that there is a definite link between vehicle fuel consumption and individual driving characteristics. Driving errors such as over speeding, over revving and excessive idling periods all appear contribute to a reduction in vehicle fuel efficiency. These conclusions were drawn by analysing data that was recorded for the month of August 2001. To draw these conclusions from the results the average MPG's for each vehicle for the month were analysed. Then, the maximum and minimum values were obtained to get the maximum variance from the average. It was suggested that a larger variance in fuel efficiency suggested irregular or inefficient driving characteristics. The days that yielded the highest and the lowest fuel efficiencies were compared to see if there was a pattern between low fuel efficiency and driving errors. To add credibility to the analysis, the routes taken by the vehicles on these particular days were analysed to see if other variables such as traffic conditions and road types could have affected the results.

A good understanding of the FMS system and its functionality has been acquired. Although it is fair to say that there have been some teething troubles, useful and seemingly reliable data is now being acquired from the system. For the most part, accuracy problems appeared to be caused by mis-calibration of the equipment, such as the tachometer readings.

SYSTEM FUNCTIONAL DESCRIPTION:

The vehicle management systems installed on the vehicles comprise of a VDO-Kienzle FM200 black box.

The VDO Kienzle Fleet Manager 200 is an on-board computer for utilisation in earthbound vehicles, special vehicles and working machines. The system is designed to record vehicle information such as speed, RPM, temperature data and fuel data, parking, stop and driving times as well as other vehicle status information. It is possible to configure the system to record tacho data with a one second interval. This tacho data can include date, time, speed, RPM as well as the current status of the digital/analog inputs. To enforce driver identification, the VDO Kienzle Fleet Manager 200 is equipped with a relay, which can be used to interrupt the vehicle's starter circuit. Driver identification is carried out by means of a driver specific blue plug. A vehicle specific green plug is provided for the data extraction. Trip and status data is analysed and processed using the VDO Kienzle Fleet Manager 2001 application software. The Microsoft SQL Server database provides flexibility and simplifies the processing and exporting of information.



Serial Interface Wiring Harness

Figure 1: VDO-Kienzle FM200 Black Box

Figure 1 shows the black box that records the data from the vehicle senders.

Case	Plastic
Memory	8kb EEPROM Driver ID, Access authorization, Date and Time

Figure 2: Drivers Key (blue)

Case	Plastic
Memory	256kb EEPROM Several memory sectors for trips and tacho data

Figure 3: Vehicle Key (green)

To transmit data to or from the unit, the green vehicle plug is pushed into the vehicle interface. A short beep indicates the start of data transmission. The LED in the vehicle interface will flash quickly during data transmission. A second beep indicates the start of the second phase of data transmission. A third beep indicates that data transmission is complete and the LED will flash at one second intervals. Only data recorded since the last download will be transferred. This is why the time between beeps may be very short.

USING THE FLEET MANAGER 2001 SOFTWARE:

The main area of data output is split into two sections. These areas allow reports to be generated for specified periods following either a vehicle specific or driver specific format. The required format depends whether it is wished to compare vehicle data, or driver data. Many of the reports are very similar in terms of the actual data generated; it is mainly how it is displayed that varies. The following reports are available for the driver:

- Driving Errors Report
- Driver Trip Report
- Driver Event Report
- Driver Fuel Consumption Report
- Driver Performance Summary Report
- Driver Scoring Report

DRIVER SPECIFIC REPORTS

<u>Driving Errors Report</u>
When generated, this report outlines all of the driving errors recorded for each driver for the specified period. Errors recorded are:

- Over Revving
- Over Speeding
- Harsh Braking
- Harsh Acceleration
- Excessive Idling Periods
- Out Of Green Band Driving

The report outlines the number of times the particular errors occurred, the maximum value of the error (except for idling) and the duration that each of the set thresholds were exceeded. If the detailed report is generated, errors for each recorded day within the specified period are given. It is possible to select less detailed reports that list the results, for example, by each month. It is even possible to get a one line report report for each driver giving the totals of driving errors for the specified period. Also provided is a percentage value, relating to how long the vehicle was out of the green band on the tachometer (indicating over revving or labouring of the engine). This report gives a clear indication of drivers individual characteristics. Analysis of this should highlight particular driving error trends that can be tackled on an individual basis.

Driver Trip Report

The driver trip report lists the details for each recorded trip within the specified period for each driver. The detailed report lists for each day include the following:

- Log on time
- Vehicle departure time
- Driving time (actual time driver was moving for)
- Time idling (time the driver was idling for)
- Trip duration (time from log on to log off)
- Halt (time vehicle arrived at destination)
- Standing (time during trip that vehicle wasn't moving)
- End (time driver logged off from vehicle)
- Parking (time vehicle was stationary before current trip commenced)
- Maximum speed reached
- Average speed
- Trip distance

Similarly, if a less comprehensive report is required, daily, weekly or monthly totals can be displayed in a report. This report should help show driving time patterns, and also make sure that drivers are taking sufficient breaks without needing to analyse tachograph readings. Also, accurate driver working times can be taken from these reports to help determine wage payments.

Driver Event Report

The driver event report gives a driver specific list of the recorded events for each day within a specified period. It lists the event, the value recorded and the duration. The typical events are:

- Over Revving
- Over Speeding
- Harsh Braking
- Harsh Acceleration
- Excessive Idling Periods
- Battery Disconnection

This report again can be used to develop driver error profiles for direct comparison and driver training planning.

Driver Fuel Consumption Report

The driver fuel consumption reports are generated from the fuel flow meter connected to the On Board Computer (OBC) on the vehicles. This method provides an alternative to measuring the amount of fuel dispensed in to the tank, and actually accurately measure the amount of fuel that the engine has received. The detailed report is similar to the trip report, but has a focus on the distance covered and fuel measured. The report contains the following data parameters:

- Log On Time
- Driving Time
- Idling Time
- Trip Duration
- Halt (time vehicle stopped)
- Standing (time vehicle was stationary)
- End (time driver logged off)
- Maximum Speed
- Average Speed
- Distance
- Gallons (volume consumed for trip)
- Consumption MPG

Again, less comprehensive reports can be generated listing driving times, distance covered and fuel consumption etc for each month, week or a specified period.

Driver Performance Summary Report

The driver summary report outlines the drivers performance for a specific period in terms of trips made, distance covered, driving time, idling time and standing time. This allows for direct comparisons for drivers within a specific period.

Driver Scoring Report

In order for immediate driver comparisons to be made, the FM2001 software can generate a driver scoring report. Drivers are given a score for the selected period for each of the driving events that are considered to be errors depending on how often they have occurred eg:

- Over Revving
- Over Speeding
- Harsh Braking
- Harsh Acceleration
- Excessive Idling Periods

These scores are then averaged to provide an overall driver error score.

VEHICLE SPECIFIC REPORTS:

The following reports are available in a vehicle specific context:

- Vehicle Driving Errors Report
- Vehicle Trip Report
- Vehicle Event Report
- Vehicle fuel consumption report
- Vehicle Configuration Report
- Vehicle Performance Summary

Note:- many of the reports are identical to the ones previously mentioned in the driver specific section.

Vehicle Driving Errors Report
The vehicle driving errors report is identical to the driver error format report, except that the data is shown for each particular vehicle for each day. Again, parameters displayed are:

- Over Revving
- Over Speeding
- Harsh Braking
- Harsh Acceleration
- Excessive Idling Periods
- Out Of Green Band Driving

Vehicle Trip Report
Similarly the vehicle trip report is identical to the driver trip report except that the data is listed against the vehicles and not the drivers. Also, the odometer reading at the end of the trip is included in the data.

Vehicle Event Report
Again, the vehicle event report mirrors that of the driver event report only in a vehicle specific format.

Vehicle Fuel Consumption
Fuel consumption too is the same except that the odometer reading at the end of the trip is included.

Vehicle Configuration Report
The vehicle configuration report outlines how the black box unit has been configured to the unit. It also provides threshold values for each of the vehicle error events. For example, for the Scania tractor unit (W17 PSH) the event description thresholds are as follows:

Event Description

Battery Disconnection
Battery Disconnect duration > 120 sec

Harsh accelaration
Aceleration > 5 mph/

Harsh braking
Deceleration > 7 mph/s

Idle
Ignition On True AND Road speed < 3 mph AND Engine RPM > 0 RPM AND Engine RPM < 800 RPM

Idle - excessive
Ignition On True AND Road speed < 3 mph AND Engine RPM > 0 RPM AND Engine RPM < 800 RPM

Out of green band driving
(Engine RPM < 1100 RPM OR Engine RPM > 1700 RPM) AND Road speed > 16 mph

Over revving
Engine RPM > 1900 RPM

Other information includes GPS tracking settings such as frequency of position logging, measurement unit settings (i.e Imperial or Metric), and the logging equipment port configuration on the black box unit.

RESULTS OBTAINED:

After 5 months of data collection, a substantial amount of information has been stored relating to driver and vehicle performance. It is fair to say that the equipment installed on the vehicles is designed to target the area of fuel consumption. The fuel flow meter accurately measures the amount of fuel that the engine has received, and the other parameters that are measured are aimed at highlighting driving behaviour that could be considered adverse to fuel consumption. In terms of direct financial benefit, a reduction in total fuel consumption of the vehicles would provide the most obvious and significant. Fuel roughly equated to be 29% of an SME transport companies overheads.

ANALYSIS METHODOLOGY

Initially, the fuel consumption for each vehicle/driver pairing for a selected period will be compared and analysed. The average fuel consumption for the period can subsequently be calculated, then the maximum variance (i.e maximum value above and below the average) can be calculated. Particular instances of very poor or very good fuel consumption can then be investigated to highlight any obvious links between driving behaviour and fuel consumption. These patterns can be derived from matrices for each driver vehicle pairing. Vehicle, driver, and driving errors can be defined as the following:

V_1 = Vehicle 1 (W17 PSH) Scania R124 420 6X2 Tractor Unit 41000 Kg

V_2 = Vehicle 2 (V17 PSH) Scania P114 340 8X4 Tipper 31000 Kg

V_3 = Vehicle 3 (P707 KOV) Volvo FH12 420 6X2 Drawbar

d_1 = Driver 1 (Neil Evans)
d_2 = Driver 2 (Mark Newton)
d_3 = Driver 3 (Simon Mason)

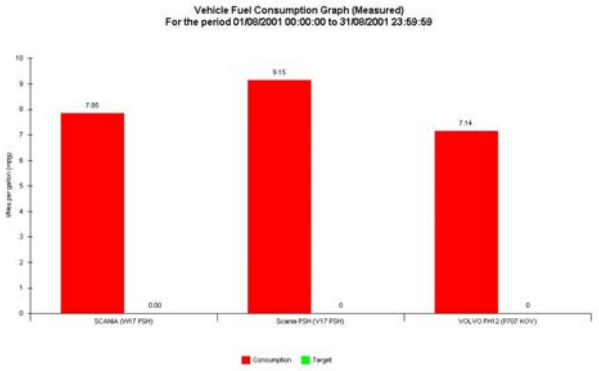
m = Fuel Consumption (MPG)
O_r = Over Revving (number of occurrences)
O_g = Out Of Green Band Driving (as a percentage)
O_s = Over Speeding (number of occurrences)
h_b = Harsh Braking (number of occurrences)
i_e = Excessive Idling (number of occurrences)

Due to the nature of A.E Hawkins operation, under nearly all circumstances, driver/vehicle pairings are the same. This means that for the purposes of data analysis the following matrix can be applied:

	V_1d_1	V_2d_2	V_3d_3
m	V_1d_1m	V_2d_2m	V_3d_3m
O_r	$V_1d_1O_r$	$V_2d_2O_r$	$V_3d_3O_r$
O_g	$V_1d_1O_g$	$V_2d_2O_g$	$V_3d_3O_g$
O_s	$V_1d_1O_s$	$V_2d_2O_s$	$V_3d_3O_s$
h_b	$V_1d_1h_b$	$V_2d_2h_b$	$V_3d_3h_b$
i_e	$V_1d_1i_e$	$V_2d_2i_e$	$V_3d_3i_e$

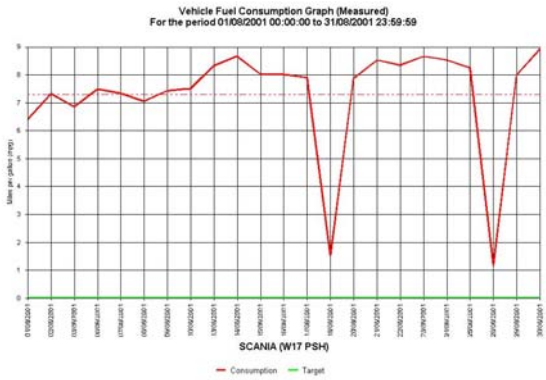
For the period 1/8/2001 to 31/8/2001 the computer recorded results for average fuel consumption are as follows:

V_1d_1m = 7.85 MPG
V_2d_2m = 9.15 MPG
V_3d_3m = 7.14 MPG



The following graphs show the computer generated results for vehicle fuel consumption for the period 1/8/2001 to 31/8/2001 for :

W17 PSH.



The severe troughs in fuel consumption are where the vehicle has been started either in the yard or while parked and the engine as been idling or the vehicle has only been moved for a very short distance and the computer has recorded it as a trip. This results in a low fuel MPG figure, because for example, if the vehicle is stationary and the engine is idling, it is drawing fuel but covering no distance so at that point, the vehicle is doing zero miles per gallon. For the purpose of the analysis we will only consider trips with a distance of more than 5 miles. Therefore the minimum and maximum fuel consumption figures, and the variance for W17 PSH is as follows:

Max MPG	8.92
Av	7.85
Min MPG	6.41
Max Variance	1.44

The driver/pairing of W17 PSH has returned an average fuel consumption of 7.85 MPG. The maximum variance from the average value is 1.44 MPG. It is fair to assume that a large portion of this variance is caused by light loads or running empty, and road type and traffic conditions. However, we can look at the driver error profiles for days with extreme variance from the average value to see if there are any characteristics that are affecting fuel consumption.

01/08/2001
The vehicle averaged 6.41 MPG on this date which was the lowest of the month. The following table shows the driving error counts and duration.

	Count	Max	Duration
Over Speeding	16	63.4	00:04:43
Over Revving	11	2200	00:00:16
Excessive Idling	1	N/A	00:02:34
Out Of Greenband	0.70%	N/A	N/A

30/08/2001
The vehicle averaged 8.92 MPG on this date. The driver error counts are as follows:

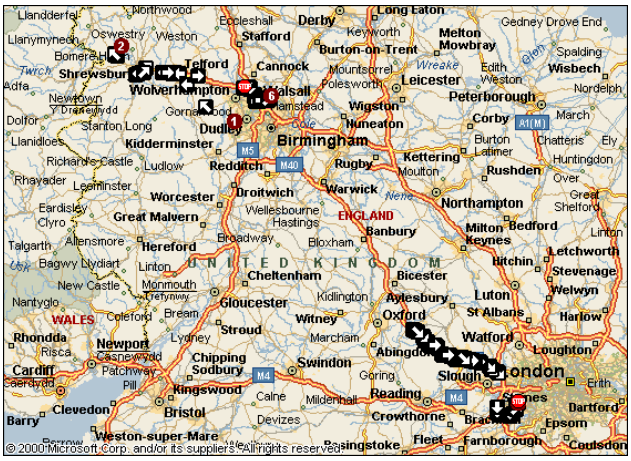
	Count	Max	Duration
Over Speeding	15	69.6	00:07:14
Over Revving	2	2000	00:00:03
Excessive Idling	0	N/A	00:00:00
Out Of Greenband	1.50%	N/A	N/A

On the 1/08/2001 there were 28 recorded driving errors that could be considered to be adverse to fuel efficiency. On the 30th only 17 errors were recorded. This suggests that there is a connection between driving errors and poor fuel consumption. To further analyse these results, we can now look at the GPS logging data and see what kind of roads the vehicle

was operating on, for these 2 dates. The vehicle will evidently use less fuel if it is travelling on flowing A roads or motorways than for busy town driving, where for much of the time, the vehicle is accelerating or idling.

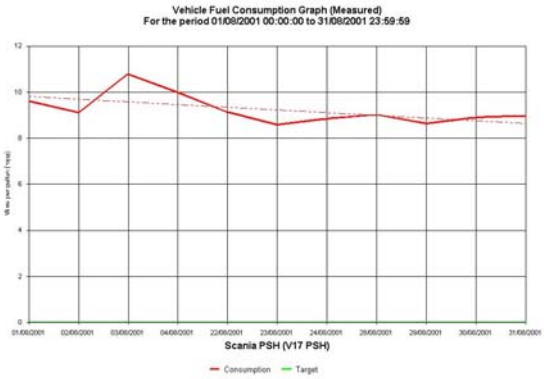
1/08/2001

30/08/2001



The 1st of August was primarily motorway and A-road driving. The GPS points and times don't suggest heavy congestion, so it appears unlikely that traffic conditions were particularly unfavourable for fuel consumption. The 30th of August consisted of a trip from the Hawkins offices to northwest Shrewsbury, then to Walsall and finally down to west London. The first part of this trip consisted of a mixture of A and B road driving with a short motorway stretch. Some busy urban driving then followed and finally a motorway stretch to London. The type of driving on the two days is not significantly different to explain a large variance in fuel consumption. This leads us to conclude that the significant reason for this fuel consumption variance are the recorded driving errors.

V17 PSH



Max MPG	10.78
Av	9.15
Min MPG	8.57
Max Variance	1.63

The lowest MPG that V17 PSH achieved in August was 8.57. This was on the 23rd. The recorded errors are as follows:

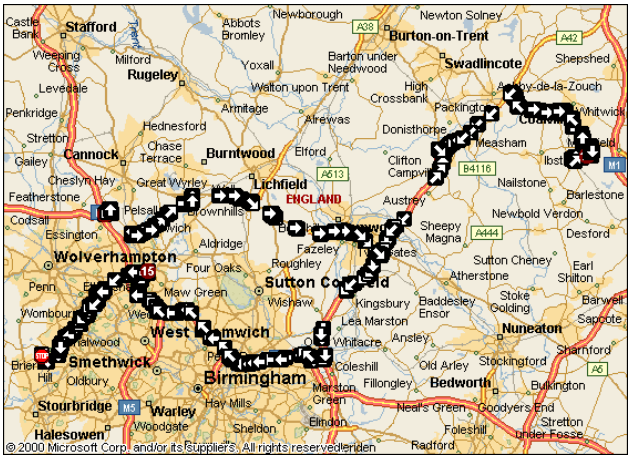
	Count	Max	Duration
Over Speeding	3	59	00:00:41
Over Revving	246	2300	00:12:46
Excessive Idling	0	N/A	00:00:00
Out Of Greenband	9.60%	N/A	N/A

	Count	Max	Duration
Over Speeding	0	57.8	00:00:00
Over Revving	165	2200	00:06:38
Excessive Idling	0	N/A	00:00:00
Out Of Greenband	8.90%	N/A	N/A

V17 PSH achieved its best MPG figures for the month of August on the 3rd. The average MPG for the day was 10.78. The recorded driving errors for this day are as follows:

As the table shows, on the day when the vehicle achieved its best MPG there were no over speeding errors, and fewer over revving errors of shorter duration. The routes taken on these dates are shown below.

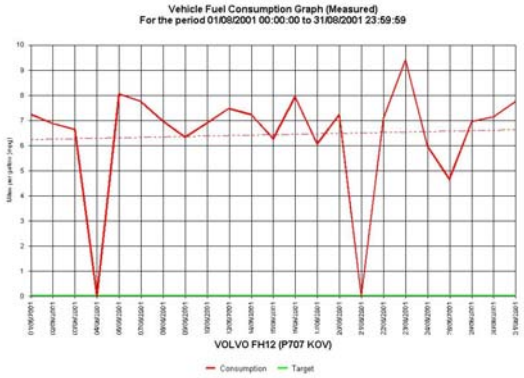
23/08/2001



3/08/2001

Again, the road conditions were very similar for both days with similar work being undertaken. Both days consisted of shuttle runs to a particular location along motorways and A-roads. In fact, much of the route for the 2 days was similar. Again, this suggests that the main cause of the fuel consumption variance were driver errors.

P707 KOV



Max MPG	9.41
Av	7.14
Min MPG	4.66
Max Variance	2.48

The vehicle/driver pairing returned the best and worst values on the 23rd and 28th of August respectively. However, it should be noted that in this case the trips were very different. The trip that returned the worst fuel consumption was only 46 miles long, and the best was 270. It is normal for longer trips to return better average fuel consumption values than shorter ones, especially if motorway journeys are included. However, recorded errors for both days are as follows:

23/08/2001

	Count	Max	Duration
Over Speeding	3	59	00:00:12
Over Revving	6	2000	00:00:09
Excessive Idling	2	N/A	00:24:00
Out Of Greenband	0.00%	N/A	N/A

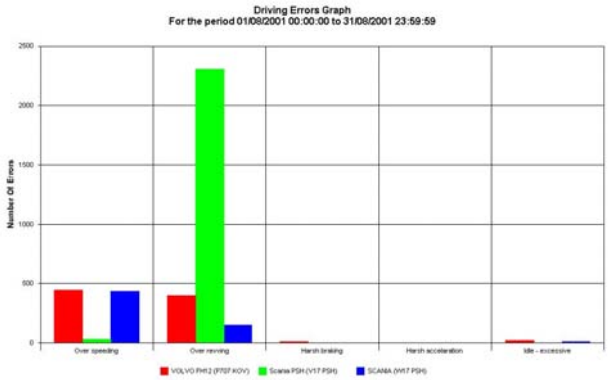
28/08/2001

	Count	Max	Duration
Over Speeding	0	55.9	00:00:00
Over Revving	11	2200	00:00:27
Excessive Idling	2	N/A	00:39:27
Out Of Greenband	0.40%	N/A	N/A

As the tables show, although the trip on the 23rd was a lot longer, there were more driving errors on the shorter trip. There was one idling duration of nearly 40 minutes. The vehicle must obviously have been parked up with the engine running. This is a considerable waste of fuel. There were also 11 counts of over revving compared to 6 and the out of greenband percentage was 0.4 as against 0. No GPS data is available for this vehicle for the month of August so the trips cant be analysed, but the

results obviously suggest that driving errors have an affect on vehicle fuel efficiency.

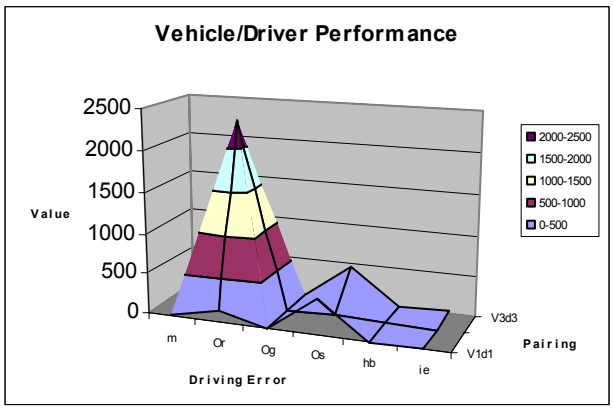
The graph of driving errors for the August period looks as follows:



By creating a driving errors report with FM2001, and using the fuel consumption figures for the month of August, the vehicle/driver matrix can be completed.

	V_1d_1	V_2d_2	V_3d_3
m	7.85	9.15	7.14
O_r	151	2308	398
O_g	0.8	9.3	0.2
O_s	434	32	444
h_b	1	1	10
i_e	10	2	19

The following graph shows the matrix results:



CONCLUSIONS:

It is commonly agreed that a wide range of factors affect vehicle fuel consumption from load weights, right down the scale to tyre pressures. However, the purpose of this report was to determine whether, even in these early stages of data analysis, driving errors could be considered to be a significant cause of reduced fuel consumption. Conversely, can good driving be beneficial to fuel consumption? The results from August seem to suggest that there is a definite correlation between driving errors and poor fuel consumption. Where fuel consumption has been particularly poor, there has generally been an abundance of driving errors. Comparatively, when fuel consumption has been good, there have been fewer recorded driving errors. It is, therefore, a fair assumption that a reduction in driver errors through training and focus groups could increase vehicle fuel efficiency, thereby increasing the efficiency of the company as a whole. Fuel and oil accounts for roughly 29% of the average 38 tonne articulated vehicle total running costs. This translates in to an appreciable amount of money for an SME such as A.E Hawkins. If an improvement of 1 MPG on the average fuel consumption could be achieved for each of the vehicles, the monetary saving for the company would be substantial. The resultant driver training should also reduce brake, clutch and tyre wear. Increasing the efficiency of the individual vehicles will increase the efficiency of the company as a whole.

ENCOUNTERED PROBLEMS:

Most of the problems encountered have been caused by calibration problems. Vehicle V17 PSH developed a tachometer reading fault and the data logging equipment was recording over revving values of 12,000 rpm which is impossible for an engine of this type. In fact more than 2,500 is very unlikely. This problem was easily rectified once identified by re-calibrating the vehicle.

Perhaps more seriously, the Volvo unit (P707 KOV) was not logging any GPS data until September. This problem was identified as being a faulty connection on the GPS receiver unit. All other data is available as normal. This problem had been identified for a substantial period before action was taken by the suppliers to fix the problem. This has been the case for quite a number of problems that have arisen. The general opinion is that the system installation and configuration period has taken far too long. The equipment was initially installed in early February, and still, by august there were still technical problems being ironed out. A period of 4 to 6 weeks would perhaps be more suitable than 5 months for ensuring that the systems are working accurately and providing valid data. Also, the problems should perhaps have been identified by the suppliers rather than have them complete a standard installation and not test the system thoroughly.

Generally the software seems to be robust, however, it was updated with a later version in June 2001 due to some slight glitches with generating some reports. This now seems to have been solved, with all reports being available and accurate.