Variable Crewing Research and Policy

Feasibility Report

Submitted to:

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Project Sponsor – Alan Apps
## Executive Summary

### Introduction

1.1 Executive Summary

2 Test Design

3.1 Previous work

3.2 Test Design

3.3 Limitations

3.4 Authorisation

4 Test Method

4.1 Test Method

4.2 Test Participants

4.3 Test Briefing

4.4 Details of the tests

5 Results

5.1 Test Schedule

5.2 Test Operation

5.3 Incidents

5.4 Physical Demands - Subjective Rating

5.5 Heart Rate

5.6 Mental Demands - Subjective Rating

5.7 Mental Demands - Qualitative Data

5.8 Fatigue - Subjective Rating

5.9 Fatigue - Qualitative Data

5.10 HSE fatigue index

5.11 Mood

5.12 Performance - Subjective Rating

5.13 SME Assessment

5.14 Performance - Qualitative Data

5.15 Data Logger

5.16 Operational Issues - Communications

5.17 Operational Issues - Ergonomics

5.18 Operational Issues - Procedures
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Discussion</td>
<td>43</td>
</tr>
<tr>
<td>6.1 Physical and Mental Demand</td>
<td>43</td>
</tr>
<tr>
<td>6.2 Driving Performance</td>
<td>43</td>
</tr>
<tr>
<td>6.3 Task Performance</td>
<td>44</td>
</tr>
<tr>
<td>6.4 Other Factors</td>
<td>45</td>
</tr>
<tr>
<td>7 Limitations</td>
<td>47</td>
</tr>
<tr>
<td>8 Conclusions</td>
<td>49</td>
</tr>
<tr>
<td>8.1 Conclusions</td>
<td>49</td>
</tr>
<tr>
<td>9 Recommendations</td>
<td>51</td>
</tr>
<tr>
<td>9.1 Recommendations</td>
<td>51</td>
</tr>
</tbody>
</table>

**APPENDICES**

See Appendices Volume.

**CD REFERENCE MATERIAL**

The CD contains historic reports and data that may aid understanding of the subject matter of this report. Specific references are made where appropriate.
GLOSSARY

CCD  CCD Design & Ergonomics Limited  
     A specialist Ergonomics and Human Factors Sub Contractor

DRA  Dynamic Risk Assessment

HA  Highways Agency

HFO  Human Factors Observer
     A Test Participant, refer to report text for further details

IMS  Incident Management Solutions team (HA)

RCC  Regional Control Centre

SME  Subject Matter Expert
     A Test Participant, refer to report text for further details

TO  Traffic Officer

TOS  Traffic Officer Service

VMS  Variable Message Sign

ETM  Emergency Traffic Management

PT1  Pilots and Trials 1
     Highways Agency internal procedure

TLC  Traffic Learning Centre
     Highways Agency training department for Traffic Officers

TOV  Traffic Officer Vehicle

HSE  Health and Safety Executive

RTA  Road Traffic Accident

RTC  Road Traffic Collision

TNA  Training Needs Assessment

RRB  Rolling Road Block

BMIS  Brief Mood Introspection Scale

NWRCC  North West Regional Control Centre
1 EXECUTIVE SUMMARY

1.1 Executive Summary

1.1.1 The Incident Management Solutions (IMS) Team is one of three teams which make up the Network Policy Group within the Highways Agency’s Network Service (NetServ) Directorate. The Group’s mission is “to research, develop and deliver first class policy, advice and techniques to improve the operational performance of the Strategic Road Network”.

1.1.2 The Highways Agency (HA) intends to continue delivering the existing benefits of the Traffic Officer Service (TOS). It is, however, recognised that there is a broader need to deliver greater efficiencies in all areas of Government expenditure. Variable Crewing is one potential means of realising greater efficiency.

1.1.3 The IMS team has been commissioned by the Traffic Management Division to explore the feasibility of variable crewing and its impact within the TOS. This report describes the results of a test of single crewing under “live” network conditions, developed and conducted by CCD and Jacobs, in support of the overall programme. The test was designed to capture data without disrupting normal operations, to be largely non-invasive and to avoid any need to adapt vehicles. The test assessed both dual and single crew operation in order that a direct comparison of performance under either condition was possible.

1.1.4 A total of 14 tests, covering 56 shifts, were completed between December 4th 2010 and March 26th 2011. The Live Network Test involved 14 test subjects from six outstations in the North West (NW) Region.

1.1.5 The test was subject to the following limitations:

- The test excluded some procedures, such as Rolling Road Block (RRB)
- The test participants were willing volunteers, with high levels of enthusiasm
- The test was only undertaken within the North West region
- The test shift duration was limited to 2 days
- The test was suspended over the Christmas period, between 17th December 2010 and 9th January 2011
- The incidents attended could not be planned, as they depend on events on the network. The test may not be representative
- The test did not cover the consequences of personal injury to a Traffic Officer (TO).

1.1.6 The test results show the following:

- There does not appear to be any appreciable difference in physical demand between double and single crewing
- There does not appear to be any appreciable difference in mental demand between double and single crewing
- Single crewing does not appear to result in greater levels of fatigue or frustration than double crewing, nor does single crewing appear to adversely affect the TO’s mood
TO’s overall driving performance is worse when single crewed. This is partially due to the difficulties of operating equipment and using the radio whilst driving. This is likely to be controlled in part by better equipment design and improved training.

1.1.7 Subject to the limitations in paragraph 1.1.5, it can be concluded that from the incidents attended during the test period, single crew operation appears feasible. However, the following points need to be addressed and resolved ahead of any wider deployment of single crewing:

- Communication capabilities relating to Airwave’s capacity and coverage
- Design and layout of the controls / displays to support operation while driving
- Improved design / choice of vehicles to ensure all users are accommodated (especially in terms of access to equipment in the back)
- Amendments to procedures to support single crew operation and dedicated single crew training, particularly relating to the use of equipment while driving
- Mechanisms for the selection of single crewed TO’s
2 INTRODUCTION

2.1 Introduction

2.1.1 The HA’s IMS Team is undertaking a programme aimed at improving incident management and associated policy. As part of this programme the HA appointed Jacobs to develop previous work relating to variable crewing of the TOS.

2.1.2 Jacobs appointed CCD to provide human factors expertise in measuring the performance of the TO’s. CCD have expertise in observing individuals at work and assessing their ability to carry out their work.

2.1.3 The previous work concerning TO variable crewing concluded that:

“A pre-requisite for the feasibility of variable crewing is that it is possible to operate single-crew patrols safely on the network”

2.1.4 It is not possible to directly measure and compare the safety of one operation with another. This is particularly true in an environment such as the HA’s network where there are many variables impacting on each operation.

2.1.5 During a previous phase of the project a test was designed by CCD and Jacobs. As measurement of safety is not possible it was proposed that the test should compare the operational performance of a single crewed TO with that of a double crewed TO in live network conditions. Where there is a change in operational performance the reasons for this change can be examined, the source of additional hazards and changes in risk identified, and potential mitigation measures can be suggested.

2.1.6 This method was approved by the Project Board, and the designed test formed the basis of the current Task Order. The approach was further approved by the signature of Highways Agency form PT1 – Pilot or Trial category selection and approval.

2.1.7 For the purposes of analysis operational performance was divided into driving performance and task performance. Driving performance encompasses work which takes place in the TO vehicle, either when moving or stationary. Task performance encompasses work outside the TO vehicle, such as at the scene of an incident.

2.1.8 The research question was to determine whether a TO’s operational performance deteriorated when they were singly crewed. This includes work to identify possible controls and risk mitigations that might facilitate lone TO activity, whilst maintaining an acceptable safety tolerance. This is understood to mean that risk exposure remains within the HA’s corporate risk tolerance.

2.1.9 Risk tolerance can not be readily measured or quantified. Therefore this report describes areas where there is a change in either the range of hazards faced or the level of risk exposure. It is for the HA to decide whether hazards relating to single crewing, or changes in risk relating to single crewing, are acceptable to them.

2.1.10 Jacobs have not considered the impacts of single crewing in terms of the safety of a lone officer who is involved in a work related accident.

2.1.11 Consideration of the social implications of lone crewing, in terms of loneliness and boredom, did form part of the test, but the environment of the test did not allow them to be fully tested. The reasons for this are described below.
2.2 Test Context

2.2.1 It was envisaged that the Live Network Test would form part of a larger process which might lead to a broader rollout of variable crewing, as outlined below –

- Live Network Test (NW Area)
- Live Network Trial (Potentially national)
- Rollout of Variable Crewing

2.2.2 There were 14 TO test participants involved in the Live Network Test. Each test consisted of:

- Two seven hour days in double crew mode (allowing 1 hour for brief/debrief)
- Two seven hour days in single crew mode (allowing 1 hour for brief/debrief).

Therefore each test subject undertook 1 test, resulting in a total of 14 tests spread over 56 shifts.

2.3 Aims and Objectives

2.3.1 The objective of the task at inception was to investigate ways of improving Incident Management and associated policy. The task was specifically focused on the people involved in Incident Management, the organisational frameworks in which they operate, and the powers they are granted to facilitate their work.

2.3.2 The aim of the task was to design and implement a variable crew test that would consider operational effectiveness (task and driving) of TO’s operating on the network singly crewed. There was also a need to develop an existing Business Case for variable crewing throughout the duration of the task, although this was later removed from Jacobs’ scope.

2.3.3 The purpose of the Live Network Test was to record subjective and objective data against a range of measures which collectively provide a description of the operational performance of TO’s. The test used recognised methods of measuring the performance of TO’s. The data was obtained whilst the TO’s were patrolling the network and managing incidents under normal operational conditions, in so far as was possible. The methods used are described in detail in the Test Methodology report (See CD Reference 5.1).

2.3.4 A key aspect of the test was that it was applied to both double and single crews in order that a direct comparison of performance could be made. Any significant difference in performance between single and double crewing was to be used to make inferential risk and safety analyses. The responsibility to quantify risk and mitigate against it remains the responsibility of the HA. The
output from these analyses, together with potential mitigation measures, forms the basis for an assessment of the feasibility of single crewing.

2.3.5 The Live Network Test was intended to be a pragmatic assessment of the operational feasibility of single crewing. The methodology was specifically developed with this in mind. The use of complex telemetry and detailed batteries of intensive tests (such as computer based psychological testing methods) was avoided on the basis that they would be difficult and highly time-consuming to administer in a dynamic ‘live’ network environment.

2.3.6 Individual tests were non-invasive (i.e. kept modification of the TO’s working environment and procedures to a minimum) and did not require complex technology or in-vehicle equipment.

2.4 Current Working Methods

2.4.1 The TOS currently works to a defined set of processes and procedures, which include risk assessments and methods of working. These are based on typical scenarios the TO might face.

2.4.2 The procedures each describe a specific task. Typically an incident requires the completion of several tasks in order to complete a response. For example, the procedure for attending to a broken down vehicle will be used together with the procedure for stopping in the hard shoulder. Conditions may dictate that Emergency Traffic Management (ETM) is set, which requires a further procedure.

2.4.3 It is recognised that the procedures can not cover all the eventualities that a TO might encounter. TO’s are, therefore, required to undertake Dynamic Risk Assessment (DRA) when they propose to depart from the procedures. Departures from procedures range from minor alterations, such as amending cone spacing in traffic management, to complete departure from process as a result of conditions on the ground.

2.4.4 DRA’s are recorded by the TO, either at the time or shortly afterwards, in an evidential pocket book.

2.4.5 The procedures are included within CD Reference 7.0.
3 TEST DESIGN

3.1 Previous work

3.1.1 Significant previous work has been undertaken looking at the feasibility of variable crewing of the TOS. This work has so far been restricted to desk studies. Reports produced include –

<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
<th>Date Published</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review of Crewing Levels Report</td>
<td>Halcrow</td>
<td>August 2009</td>
</tr>
<tr>
<td>HA Variable Crewing Implementation Study - Business Case</td>
<td>Atkins</td>
<td>December 2009</td>
</tr>
<tr>
<td>Single Crew Test Report</td>
<td>Atkins</td>
<td>December 2009</td>
</tr>
</tbody>
</table>

Table 3.1 – Previous Work

See CD Reference 2.0 for further information.

3.1.2 The previous work discussed the need for a test and recommended various aspects of TO activity and / or performance that might be measured. However, none of the studies reached any conclusions on:

- What data might be collected
- What test methods might be employed to capture that data
- Which data and methods might be practical in a live operational environment
- The relative value of the different types of measures in answering the research question
- The resource and logistical requirements to ensure that the test output has acceptable levels of scientific validity.

3.2 Test Design

3.2.1 The Project Team developed the previous work undertaken by others. We considered a range of methods for gathering data and measuring the performance of TO’s. This included liaison with the HA’s Traffic Learning Centre (TLC). We also used specialist Human Factors Consultant CCD’s experience of similar assessments in other fields, and a literature review. The details of this work are contained in CD Reference 5.0.

3.2.2 The Live Network Test of variable crewing included specific directed assessments of the following aspects of TO operational performance:

- Mood and tiredness
- Workload and Stress
- Fatigue
- Driving Performance
- Task Performance.
The aspects of TO operational performance, as listed above, were assessed using the following questionnaires/assessments –

- Activity and Event Timeline recording
- Pre-test Questionnaire
- Background Information questionnaire
- Brief Mood Introspection Scale (BMIS) questionnaire
- Stanford Sleepiness Scale (SSS) questionnaire
- Workload and Stress measurement
- Fatigue Assessment
- TO Driving Performance Assessment
- TO Task Performance Assessment.

Further details of the specific measures used, and the reasons for their selection, are contained in the Test Design Report (See CD Reference 5.0) and Appendix B.

In addition to the directed assessment methods an event timeline was captured and various post event and post shift debriefing sessions were held to record qualitative data on operations, explanation of decisions, specific issues / problems and to review results.

3.2.3 To provide confidence that the test would be safely achieved, the following activities were carried out:

- Proof of concept session
  A proof of concept session was held at a disused airfield at Samlesbury. The aims of the proof of concept session were –
  - To check that the various data collection techniques were suitable and practical for a Live Network Test by trialling them 'in vehicle'
  - To develop the role of the Subject Matter Expert (SME) and show that they could collect and record useful data. The SME is a highly experienced TO who would participate in the test. Their role includes real-time monitoring of the safety of the test and rating the operational performance of the TO under test
  - To develop and agree testing procedures / protocols and timings with TO's
  - To develop and agree test safety procedures and risk mitigations, especially in relation to observation of incident management outside of the vehicle.

- Check Team Assessment
  This was undertaken by an independent check team. Received comments were incorporated into the final test design (see CD Reference 6.0).

- Procedures Workshop
  A workshop was held to assess the current TO Procedures, to determine whether they could or could not be attempted single crewed
during the Live Network Test. The workshop participants scrutinised the procedures in detail, and amended them where required, to suit single crew operation in the context of the test. This was not an attempt to develop procedures for single crews. (see CD Reference 7.0).

- Risk Assessment
  The test design was risk assessed by the HA Corporate Health and Safety Team, and relevant amendments were made to the final test design, (see CD Reference 8.0).

- Training Needs Assessment (TNA).
  The TNA was undertaken to assess the level of training that would be required to form the pre-test briefing days (See CD Reference 9.0).

3.2.4 For further details of the activities listed above, refer to the Single Crew Test Design Report (See CD Reference 5.0).

3.2.5 Union Consultation was undertaken prior to the commencement of the Live Network Test. Comments received from the unions were considered in the final test design (See CD Reference 10.0).

3.2.6 Following the successful delivery of the proof of concept session and subsequent amendments resulting from discussions with the Project Team, the methodology and test design was finalised (See CD Reference 5.0 for further details).

3.2.7 Specific features of the test design were:
  - The test was a comparative assessment of TO performance under both single and double crewing
  - The test was undertaken in live network conditions
  - The test did not interfere with or compromise normal TO operations
  - The test did not compromise safety of the test participants. The presence of the SME meant that normal double crew operation could recommence at any time (see paragraph 3.2.8)
  - The test did not require material change or adaptation of the TO vehicles
  - The test was relatively easy to administer in a live environment
  - The test did not make unreasonable demands on the TO’s attention or time
  - The test did not materially affect the availability of a patrol vehicle for deployment
  - Individual tests were non-invasive and did not require complex technology or in-vehicle equipment
  - The test did not examine the relative performance of one test subject against another. The results are, therefore, rendered anonymous.

3.2.8 The in vehicle setup for the test is illustrated below –
3.3 Limitations

3.3.1 The Procedures Workshop resulted in some activities which would normally be undertaken by the TOS being removed from the test. These included:

- Work in Tunnels
- Rearward Relief (effectively the turning round of traffic which is trapped in a section of motorway by an incident ahead)
- Various procedures relating to temporary and emergency control of traffic at junctions and roundabouts
- Rolling Road Blocks.

3.3.2 There are no tunnels in the NW region. Rearward Relief and control of traffic are procedures which typically require a multi-agency response and are rare. These are not considered to be significant constraints.

3.3.3 Rolling Road Blocks are a common activity for the TOS. They are typically required for everyday activities such as debris clearance, retrieval of broken down vehicles from live lanes, Road Traffic Accident (RTA) clear-up and the implementation of traffic management systems. This forms a significant limitation on the output of the test.

3.3.4 The TO’s who participated in the test were selected from a pool of volunteers on the basis of their knowledge, training and experience. This process is described in Section 4.2 below. The participants were, therefore, among the most willing and most capable members of the TOS. Findings relating to this group may not be applicable to the remainder of the service.

3.3.5 The HA had, prior to the design of the test, decided that the test would not cover the night shift. The findings therefore relate only to the early and late day shifts.

3.3.6 The test took place in the NW region. We are aware that there are some different interpretations of certain procedures and practices in other areas, and some minor differences were encountered within the NW. This may result
in some discrepancies when applying outputs from this test in other regions. As the procedures are national we would expect such discrepancies to be minor.

3.3.7 The test simulated single crewed conditions as far as possible, but the TO under test was accompanied throughout by the SME, who they could call on for support if required, and the HFO. They were not alone, so the social implications of single crewing, particularly in terms of the potential for boredom and loneliness, were not tested.

3.3.8 The test was designed to look at the operational effectiveness of the TO under test. The test does not measure the change in risk that will be experienced by a lone TO, and does not consider officer safety in the event of an occurrence. It is logical to assume that there are changes to the risk faced by a single TO. This area will require careful consideration before any broader implementation of single crewing.

3.4 Authorisation

3.4.1 The HA form PT1, which authorised a Live Network Test, was signed in May 2010. The form is included within CD Reference 4.1.
4 TEST METHOD

4.1 Test Method

4.1.1 The Live Network Test aimed to record subjective and objective data for a range of measures which collectively provide a reasonable description of the operational performance of TO’s. The test recorded performance data whilst the TO’s were patrolling the network and managing incidents under operational conditions which were as close as possible to those normally encountered.

4.1.2 As many variables as possible were controlled. The same type of vehicle was used throughout, and the same shift patterns were used for both the double and corresponding single crew tests. This added confidence to the reliability of the test data obtained.

4.1.3 It was agreed that video recording of performance or events was not acceptable.

4.1.4 Each TO patrol vehicle in the test contained:

- Traffic Officer (TO) - one or two, dependent on whether single or double crewed
- Subject Matter Expert (SME) – an experienced senior HA TO
- Human Factors Observer (HFO) – a trained and experienced experimental observer.

It should be noted that the SME and HFO were treated as invisible by the TO during operations on the network. There was no engagement or conversation with the HFO and SME, except in relation to possible safety issues.

4.1.5 The role of the SME was two-fold. They were there to manage the activities of the HFO and ensure their safety, particularly when outside the vehicle, and also to provide expert commentary on the driving and operational performance of the TO under test. They were empowered to stop the test if they felt it necessary, on whatever grounds.

4.1.6 The role of the HFO was to collect data relating to the performance of the individual under test. This was achieved by the use of live monitoring and the administration of periodic questionnaires.

4.1.7 For the methodology underpinning the Live Network Test, refer to the Single Crew Test Design Report (See CD Reference 5.0).

4.2 Test Participants

4.2.1 Applicants for the Live Network Test were invited from the NW On-Road TOS.

4.2.2 The aim of the selection process was to obtain a sample of the TOS which was as representative as possible, but was drawn from capable and experienced TO’s. To achieve this the TO’s were required to confirm that they had undertaken specific training and held particular qualifications as follows:

- CTM (Certificate in Traffic Management)
- Coach (Further training to allow to coach/lead new officers).
4.2.3 Following this pre-selection the test participants were chosen using methods which were as random as possible whilst ensuring that the participants were representative of the service as a whole.

4.2.4 For further details of the test selection process, refer to CD Reference 5.2.

4.3 Test Briefing

4.3.1 In response to the HA’s Risk Assessment and subsequent Training Needs Assessment (TNA), the TOS developed a briefing note to support a practical briefing session. This was designed to outline how and when the test would operate. The aim of the briefing sessions was to equip the “On Road” TO’s with the knowledge they needed to ensure safe test operation.

4.3.2 A two day briefing session was held at a hotel in Warrington, and was attended by all the test participants. This was followed by a further track based day to further embed the learning.

4.3.3 For details of the Briefing Sessions, see CD Reference 5.4.

4.4 Details of the tests

4.4.1 A total of 14 tests was planned and completed. This report details the findings of the tests.

4.4.2 The tests were held in the NW, operating from outstations at Milnrow, Rob Lane (NWRCC), Knutsford, Samlesbury and Cumbria (north and south outstations). Testing took place between December 2010 and March 2011, but was suspended over the Christmas period, between 17th December 2010 and 9th January 2011, in order that the prevailing traffic conditions reflect better the normal work of the TOS.

4.4.3 Each test consisted of four shifts, with two shifts completed in a double crew and two in a single crew. Most tests were undertaken on the ‘early’ shifts, which run 0600 to 1400, Tests four and five were undertaken on the late shift which runs from 1400 to 2200. This was not intentional; rather it is a function of fitting the test into the normal shift rosters of the test participants.

4.4.4 In scheduling the test no account was taken of the day of the week, or any events which were planned on or adjacent to the network, such as exhibitions and shows, or any planned maintenance activity. School holidays were not taken into account. There were no Bank Holidays during the testing period.
5 RESULTS

5.1 Test Schedule

5.1.1 A total of 14 tests was completed between December 4th 2010 and March 26th 2011. Each test consisted of four shifts, with two shifts completed in a double crew and two in a single crew. All tests were early shifts, apart from Test 4 and Test 5 which were late shifts.

5.2 Test Operation

5.2.1 Prior to the commencement of the tests, the subjects were told by the HFO that when working as a single crew, they could and should call a halt to the test if they felt that their own safety, or that of the occupants of other vehicles, was at risk or compromised. Equally, the SME was able to intervene if they considered the incident was not suitable for a single crew, or where there were safety implications. There were no instances during the tests where either was necessary. This suggests that the test subjects felt able to complete the tasks required of them at the incidents that they attended and that the SME was satisfied that the subject could cope with the tasks.

5.2.2 There were a small number of instances where the SME intervened to remind the TO of an incomplete element of a task, typically in relation to using the correct type of lights.

5.3 Incidents

5.3.1 During the test period, 227 significant incidents were attended by the TO’s as part of the test schedule. Table 5.1 and Figure 5.1 show the numbers of types of incident that occurred in double and single crews test shifts.

<table>
<thead>
<tr>
<th>Type of Incident</th>
<th>Double Crew</th>
<th>Single Crew</th>
<th>Total for Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine H/S BDV</td>
<td>72</td>
<td>52%</td>
<td>47</td>
</tr>
<tr>
<td>Live Lane Breakdown</td>
<td>14</td>
<td>10%</td>
<td>5</td>
</tr>
<tr>
<td>Hard Shoulder Debris</td>
<td>6</td>
<td>4%</td>
<td>3</td>
</tr>
<tr>
<td>Live Lane Debris</td>
<td>9</td>
<td>7%</td>
<td>15</td>
</tr>
<tr>
<td>Road Traffic Collision (RTC)</td>
<td>4</td>
<td>3%</td>
<td>8</td>
</tr>
<tr>
<td>Rolling Road Block (RRB)</td>
<td>15</td>
<td>11%</td>
<td>N/A</td>
</tr>
<tr>
<td>‘Other’</td>
<td>18</td>
<td>13%</td>
<td>11</td>
</tr>
<tr>
<td>TOTALS</td>
<td>138</td>
<td>60.8%</td>
<td>89</td>
</tr>
</tbody>
</table>

Table 5.1 - Types of incident encountered by double and single crews during the Test

5.3.2 Figure 5.1 illustrates the spread of different incidents encountered during double and single crewing. The most common occurrence under both double and single crewing were routine hard shoulder breakdowns, accounting for over half of the total number of incidents. A greater number of Live Lane

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1 A significant incident refers to those where the SME completed an assessment form and the TO called the RCC to log the occurrence. In some circumstances, the TO completed actions on the hard shoulder, e.g. removal of a small piece of debris from the hard shoulder, and did not alert the RCC nor did the SME did not complete a form. This decision was taken because the length of time outside of the vehicle was minimal (typically less than a minute). This type of scenario only tended to be observed during double crewing.

2 Rolling Road Blocks were not permitted whilst single crewed.
Debris and RTCs occurred on single tests, but these still only accounted for 36 incidents. RTCs tended to involve one or two vehicles, with only one multiple car RTC, attended by a double crew.

5.3.3 RCC operators were asked to record any instances when they did not deploy a single crewed vehicle, preferring a double crew. The data shows that this happened on one occasion, during Test 5 on the 22nd January 2011, when there was a requirement for a RRB and a double crew was deployed.

5.3.4 It may also be possible that an unconscious decision not to deploy a single crew was made by the RCC, and therefore a lower number of non deployments were recorded.

5.3.5 We assume that the lower number of incidents attended by the single crews are a random function of the activity on the network on the days in question.

5.3.6 A Routine H/S BDV refers to a Hard Shoulder Breakdown and RTC refers to Road Traffic Collisions (i.e. involving one or more vehicles and also includes HGV’s that have blown over). The term ‘Other’ refers to incidents such as dealing with vulnerable people, welfare stops, abandoned vehicles, etc.

5.3.7 On Test days a total of 4,108 incidents were attended by 1,059 Highways Agency patrols in the NW region3 (excluding the incidents / patrols involved in the Test), giving an average of 3.8 incidents attended per patrol, per shift over the whole region.

5.3.8 Table 5.2 compares the average numbers of incidents attended by Test subjects with those attended by all the other patrol shifts operating in the region on Test days.

<table>
<thead>
<tr>
<th></th>
<th>Total NW Region (excluding tests)</th>
<th>Average number of incidents per shift</th>
<th>Total for Test Shifts</th>
<th>Average Number of Incidents Per Shift</th>
</tr>
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<tbody>
<tr>
<td>Double Crew Days</td>
<td>2096 Incidents 633 Patrols</td>
<td>3.3</td>
<td>138 Incidents 28 Patrols</td>
<td>4.9</td>
</tr>
<tr>
<td>Single Crew Days</td>
<td>2012 Incidents 426 Patrols</td>
<td>4.7</td>
<td>89 Incidents 28 Patrols</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Table 5.2 – Average number of incidents attended.

The table shows that on average the number of incidents attended by the Test subjects was similar to the numbers attended by the rest of the TOS in NW region on the same days. HA patrols in the NW appear to handle an average of 3 to 5 incidents per shift and this level of activity appears to have been broadly replicated by Test subjects.

---

3 Data supplied by the NW RCC.
5.3.9 There was one occasion when the RCC considered suspending a single crewed test, during a period of exceptionally high winds. They did not consult with the TO, HFO or SME who were undertaking the test, and ultimately decided not to suspend testing. When the HFO and SME were subsequently informed that this course of action had been considered they reported that no problems were encountered or noticed, and that they saw no reason why the test should have been suspended.

5.3.10 There were seven HA near misses recorded during the test. The HA definition of 'near miss' includes the identification of a hazard which might have become a danger were the circumstances different. For example, one near miss was in relation to a driver who was behaving in an erratic manner. It was considered that he might be drunk or under the influence of drugs. He may, therefore, have become abusive or violent. In the event the driver was over-tired, and did not pose a threat.

5.3.11 The near misses have been reviewed, and were all found to be hazard identifications. No link to single crewing was identified. The near misses were not as a result of the test, and therefore have not been considered further within the results.

5.4 Physical Demands - Subjective Rating

5.4.1 During each double and single shift test, subjects were asked on an hourly basis (or after completing an incident) to rate how physically demanding the tasks had been on a seven point scale, ranging from one - not demanding to seven - very demanding.

5.4.2 Figure 5.2 shows the average scores for physical demand in double and single crews for each test subject.
5.4.3 The graph shows that there was no discernable difference in the subjective perception of physical demand between double or single crew modes.

5.4.4 Overall, subjects recorded low levels of physical demand. The vast majority of scores fell between one and three, as illustrated in Figure 5.3.

5.4.5 The physical demand rating scale was asked a total of 367 times during the test schedule and there were only 3 occasions where a test subject recorded a score higher than 4 (moderate demand), as listed in Table 5.3.
<table>
<thead>
<tr>
<th>Test No.</th>
<th>Shift Type</th>
<th>Incident Type</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Single Shift 1</td>
<td>Lane one closure</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>Double Shift 1</td>
<td>Debris removal</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Double Shift 1</td>
<td>Live lane one broken down vehicle</td>
<td>5</td>
</tr>
</tbody>
</table>

*Table 5.3 - Instances of ratings exceeding level 4 for Physical Demand*

5.4.6 There was only one occasion where a score of greater than four was recorded in a single crew test, when a subject recorded a score of seven (very demanding) for a lane one closure. In comparison, a similar lane one closure during another single crew test was rated by the subject as level three.

5.4.7 There were only two other occasions where scores of greater than four were given, both in double crew scenarios (for debris removal and for a broken down vehicle in lane one).

5.4.8 The limited variation in scores that did occur tended to relate to the type of activity performed. Typically, incidents requiring placement of cones, an amount of walking or jogging, vehicle towing or other activities involving physical exertion tended to generate higher scores, but even so the level of effort was in almost all cases perceived as moderate or less. 98% of scores were at or below three.

5.4.9 The ratings of physical demand showed no appreciable variation, over the duration of the test, between subjects or between double and single crews.

5.5 **Heart Rate**

5.5.1 Each subject wore a heart rate monitor throughout the test with the aim of providing an objective measure of physical demand experienced during the test. The heart rate data for all the tests is detailed in Appendix A.

5.5.2 The pattern of each subject's heart rate over each of the four shifts they undertook tends to be relatively stable, largely alternating between resting and mild exercise with some patterns showing occasional peaks of high effort.

5.5.3 It is not possible to draw direct conclusions from the heart rates recorded, as heart rates can vary substantially from person to person. For example, it is common for an athlete to have a low resting heart rate, sometimes less than 50 beats per minute. A resting heart rate of between 60 and 80 beats per minute is normal for a reasonably healthy individual. Mild exercise is likely to cause a peak in heart rate, often rising to over 100 beats per minute. This state is commonly referred to as Tachycardia. A sensible maximum for low intensity activity, such as moving around, is 120 beats per minute.

5.5.4 Figure 5.4 shows two typical example graphs of heart rate over time for the same subject, first on day two of the double crew test and then on day two of the single crew test.
5.5.5 The overall pattern in each case shows higher heart rates at the start, with occasional peaks arising from particular activities, which are not sustained. In neither case did the subject’s heart rate exceed the sensible maximum for low intensity activity of 120 beats per minute. This was generally true for the majority of shifts. This sort of pattern is typical across all subjects.

5.5.6 The heart rate data is summarised in Figure 5.5, which shows average, maximum, minimum and mode heart rates for each subject for each of their four tests, D1 and D2 being double crew mode and S1 and S2 being single crew mode. The cells shaded red highlight the more obvious heart rate peaks of 130 beats per minute or more. There were two instances where the heart rate equipment failed, which are scored as zero in Figure 5.5.

5.5.7 The heart rate peaks can be attributed to specific events or incidents which required a degree of physical exertion from the subject. Overall, there was no appreciable difference in the level or duration of heart rate peaks between double and single crewing modes. A number of peaks in heart rate occurred in both double and single crew modes, with a relatively even split (9 for double and 10 for single). The most pronounced pattern of raised heart rates was recorded for a single crew test as shown in Figure 5.6.
<table>
<thead>
<tr>
<th>Heart Rate Subject</th>
<th>Heart Rate Subject 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>D2</td>
</tr>
<tr>
<td>Average</td>
<td>80</td>
</tr>
<tr>
<td>Maximum</td>
<td>137</td>
</tr>
<tr>
<td>Minimum</td>
<td>60</td>
</tr>
<tr>
<td>Mode</td>
<td>77</td>
</tr>
<tr>
<td>Heart Rate Subject 2</td>
<td>Heart Rate Subject 7</td>
</tr>
<tr>
<td>D1</td>
<td>D2</td>
</tr>
<tr>
<td>Average</td>
<td>94</td>
</tr>
<tr>
<td>Maximum</td>
<td>135</td>
</tr>
<tr>
<td>Minimum</td>
<td>81</td>
</tr>
<tr>
<td>Mode</td>
<td>91</td>
</tr>
<tr>
<td>Heart Rate Subject 3</td>
<td>Heart Rate Subject 8</td>
</tr>
<tr>
<td>D1</td>
<td>D2</td>
</tr>
<tr>
<td>Average</td>
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</tr>
<tr>
<td>Maximum</td>
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</tr>
<tr>
<td>Minimum</td>
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</tr>
<tr>
<td>Mode</td>
<td>65</td>
</tr>
<tr>
<td>Heart Rate Subject 4</td>
<td>Heart Rate Subject 9</td>
</tr>
<tr>
<td>D1</td>
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<tr>
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<td>Maximum</td>
<td>105</td>
</tr>
<tr>
<td>Minimum</td>
<td>57</td>
</tr>
<tr>
<td>Mode</td>
<td>65</td>
</tr>
<tr>
<td>Heart Rate Subject 5</td>
<td>Heart Rate Subject 10</td>
</tr>
<tr>
<td>D1</td>
<td>D2</td>
</tr>
<tr>
<td>Average</td>
<td>84</td>
</tr>
<tr>
<td>Maximum</td>
<td>121</td>
</tr>
<tr>
<td>Minimum</td>
<td>60</td>
</tr>
<tr>
<td>Mode</td>
<td>81</td>
</tr>
<tr>
<td>Heart Rate Subject 11</td>
<td>Heart Rate Subject 12</td>
</tr>
<tr>
<td>D1</td>
<td>D2</td>
</tr>
<tr>
<td>Average</td>
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<td>Maximum</td>
<td>0</td>
</tr>
<tr>
<td>Minimum</td>
<td>0</td>
</tr>
<tr>
<td>Mode</td>
<td>0</td>
</tr>
<tr>
<td>Heart Rate Subject 13</td>
<td>Heart Rate Subject 14</td>
</tr>
<tr>
<td>D1</td>
<td>D2</td>
</tr>
<tr>
<td>Average</td>
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<td>Maximum</td>
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</tr>
<tr>
<td>Minimum</td>
<td>64</td>
</tr>
<tr>
<td>Mode</td>
<td>77</td>
</tr>
</tbody>
</table>

Figure 5.5 - Summary tables showing, mean, maximum, minimum heart rates for each subject over each of their 4 tests (where D1 and D2 are for double crew mode and S1 and S2 are for single crew mode)
5.5.8 This subject's heart rate was raised to over 160 beats per minute over two periods of five minutes in response to a live lane closure. This was one of the very few instances where the TO was observed running while laying out and later retrieving the Emergency Traffic Management (ETM) cones and signs. The subject recorded a subjective physical demand rating of 7 (very demanding) for this activity. The TO chose to run because the circumstances of the live lane incident were judged to require rapid action. The subject stated that he would have taken the same course of action had he been part of either a double or single crew.

5.5.9 It is worth noting that jogging was no more prevalent for, or confined to, single crews; it was rarely observed during the Test and when it occurred it was in response to a sense of urgency dictated by the nature of the incident. Test subjects did not appear to need to run to make up time as a consequence of being single crewed.

5.5.10 By way of comparison, Figure 5.7 illustrates similar heart rate peaks during a double crew shift, in this case relating to two specific events. The first peak is associated with pushing a van onto the hard shoulder, the second with dealing with an RTC in a live lane.
Figure 5.7 - Single crew heart rate showing pronounced peaks

5.5.11 The subject recorded level five ratings for physical demand during both incidents.

5.5.12 All other instances throughout the test, where heart rate exceeded 130 beats per minute (including examples of 160-180 beats per minute), were rated as either two or three in terms of perceived level of physical demand. This indicates that despite the heart rate peak the subject did not find the activity unduly taxing.

5.5.13 The results indicate that generally TO’s heart rate fluctuates between resting heart rate and 110-120 beats per minute in both double and single crew modes. TO’s occasionally experience higher heart rate peaks as a result of more strenuous activity or stressors. These occasions appear to be relatively infrequent, do not appear to be sustained for more than a few minutes and their occurrence does not show any discernable relationship to double or single crewing. Higher heart rates show a clear relationship with physical exertion associated with particular actions and in all but three cases, subjects rated the physical demand involved moderate or less.

5.5.14 There does not appear to be any evidence suggesting physical exertion is any more likely under single crew mode. Subjects typically stated that they would have undertaken activities in the same manner whether double or single crewed.

5.6 Mental Demands - Subjective Rating

5.6.1 Test subjects were asked on an hourly basis to rate how mentally demanding the tasks had been on a scale ranging from one - not demanding to seven - very demanding.

5.6.2 The scores for each test subject were averaged for both double and single crews. Overall test subjects recorded low levels of mental demand with the majority of scores between one and three. Figure 5.8 illustrates the average scores for each subject and shows that there was minimal difference between double and single crew data.
5.6.3 Overall, subjects recorded low levels of mental demand; the vast majority of scores fell between 1 and 4, as illustrated in Figure 5.9. A score of four indicates moderate mental demand. Single crewing received the most ratings of one, which indicates an absence of mental demand.

### Table 5.4: Mental Demand Score Distribution

<table>
<thead>
<tr>
<th>Rating Score</th>
<th>Combined</th>
<th>Single Crew</th>
<th>Double Crew</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>73.9</td>
<td>76.2</td>
<td>71.5</td>
</tr>
<tr>
<td>2</td>
<td>15.4</td>
<td>13.4</td>
<td>17.6</td>
</tr>
<tr>
<td>3</td>
<td>5.1</td>
<td>5.4</td>
<td>4.7</td>
</tr>
<tr>
<td>4</td>
<td>4.6</td>
<td>4.0</td>
<td>5.2</td>
</tr>
<tr>
<td>5</td>
<td>0.5</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>6</td>
<td>0.3</td>
<td>0.5</td>
<td>0.0</td>
</tr>
<tr>
<td>7</td>
<td>0.3</td>
<td>0.5</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Figure 5.9 - % Distribution of rating scores for Mental Demand

5.6.4 The mental demand scale was asked a total of 367 times during the test schedule; there were only 4 occasions where a test subject recorded a score higher than 4 (moderate demand), as shown in Table 5.4. These scores were
all reported by the same test subject. In comparison, other single crews attending similar RTCs recorded scores of 3 and 4.

<table>
<thead>
<tr>
<th>Shift Type</th>
<th>Incident Type</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double Shift 1</td>
<td>Live Lane Broken Down Vehicle</td>
<td>5</td>
</tr>
<tr>
<td>Single Shift 1</td>
<td>Lane one Closure</td>
<td>7</td>
</tr>
<tr>
<td>Single Shift 2</td>
<td>Road Traffic Collision</td>
<td>6</td>
</tr>
<tr>
<td>Double Shift 2</td>
<td>Live Lane Broken Down Vehicle</td>
<td>5</td>
</tr>
</tbody>
</table>

*Table 5.4 - Instances of ratings exceeding level 4 for Mental Demand*

5.6.5 The ratings of mental demand showed no appreciable variation over the duration of the test shift, between subjects or between double and single crews.

5.6.6 The limited variation in scores that did occur tended to relate to the type of activity performed. Typically, incidents requiring decisions or with time pressures tended to generate higher scores, but even so the level of effort was in almost all cases perceived as moderate or less, with 94% of scores being at or below three.

5.7 Mental Demands - Qualitative Data

5.7.1 While the subjective rating scales did not demonstrate any appreciable difference in mental demand between single and double crews, several test subjects stated that the mental processes involved in managing particular incidents were different.

5.7.2 Subjects pointed out that a double crew has the opportunity to discuss their approach to an incident, making a shared DRA, if necessary using the opportunity to share views and advice and come to a mutual agreement over how to deal with a job. A single crew does not have this option and has to decide what tasks need doing and in what priority order without support. Whilst the test subjects did not struggle to do this, they did state that they took more time to think about the actions they needed to complete and how to do them safely and reported that they questioned themselves more frequently about procedures and priorities.

5.7.3 An example of this occurred during a test involving a lane one closure to enable a tyre fitter to access the front offside wheel of an LGV. As per procedure, the subject put out relevant ETM. He was then unsure where he should stand. In a double crew one TO would stand next to the taper to observe the oncoming traffic whilst the other would stand close to tyre fitter to ensure his safety. The subject reported that he felt slightly more anxious than he would have felt as part of a double crew, since he did not have procedural guidance to back him up and therefore had the added mental burden of having to keep reassessing his choices.

5.7.4 A further example related to a first response at a multi-car incident with several members of the public wandering around the hard shoulder. The single crew TO must ensure the safety and control of those people but also try to co-ordinate all other activities that are required, such as ETM and radio communications. The subject reported that deciding on which action should take priority and reassessing that decision as the incident progressed increased the level of mental effort experienced, although this typically remains moderate or less.
5.7.5 Finally, in three different single crew tests the subject either forgot to switch on their lights or omitted to switch off the ‘reds’ when at an incident. During the debrief sessions, these omissions were discussed and the subjects stated that it was probably because they were concentrating on their driving and what actions were required when they arrived at the scene. This may indicate that the TO was briefly being asked to operate beyond their mental capacity.

5.7.6 It is important to note that for most of the test subjects it was the first time that they had had to attend any incident alone and thus it would be expected that some mistakes will be made as they gain familiarity with this method of working. The test subjects who did experience omissions in relation to the lights only did it once, learnt quickly from their errors and did not repeat them at subsequent incidents.

5.7.7 Subjects reported a belief that mental demand in single crew mode will be higher at complex incidents which are encountered for the first time, particularly where there are a number of actions that need to be taken quickly that would normally be shared between two officers. It is interesting to note that the subjects’ subjective ratings of mental demand were marginally lower in single crew mode.

5.7.8 Subjects stated that they felt that these types of issues could be overcome with the review of some procedures, adequate training in single crew operations and with experience.

5.8 Fatigue - Subjective Rating

5.8.1 Test subjects were asked on an hourly basis to rate their level of fatigue using eleven different scales covering a range of fatigue components. For each factor the subjects rated how they felt. The scales are shown in Appendix B. For the purposes of analysis the scales were factored so that 1= I do not feel this to 7= I definitely do feel this.

5.8.2 Figures 5.10 to 5.23 display the average scores for each test subject in a double and single crew. The results show no discernable difference between double or single crewing, the rating for each dimension of the fatigue measures tends to be very similar in both crewing modes. For most dimensions subjects gave low fatigue scores. There is significant variability in the absolute scores for Energy, Activity and Efficiency, but there is little variation when comparing single and double crewing. Subjects generally did not feel fatigued. This holds equally true for both single and double crewing.

5.8.3 Individual test analysis shows subjects in test 6 and 8 attended the most incidents over the four day test period, 17 and 14 incidents respectively. In both cases, more incidents were completed during the single test than the double but the scores that they reported were very similar, indicating that there was no significant change to fatigue levels when single crewed.
Figure 5.10- Test 1 Fatigue scores

Figure 5.11- Test 2 Fatigue scores

Figure 5.12- Test 3 Fatigue scores
Rating Scale
Fatigue Factors

Figure 5.13- Test 4 Fatigue scores

Figure 5.14- Test 5 Fatigue scores

Figure 5.15- Test 6 Fatigue scores
Figure 5.16- Test 7 Fatigue scores

Figure 5.17- Test 8 Fatigue scores

Figure 5.18- Test 9 Fatigue scores
Figure 5.19 - Test 10 Fatigue scores

Figure 5.20 - Test 11 Fatigue scores

Figure 5.21 - Test 12 Fatigue scores
5.8.4 In addition to the fatigue scales, test subjects were asked to rate how sleepy they felt on the Stanford Sleepiness Scale (see Appendix B). Subjects responded at the start, middle and end of each shift.

5.8.5 This scale uses eight points where one is feeling active and wide awake and eight is asleep. Figure 5.24 displays the average scale for each test subject in a double and single crew. Overall, test subjects consistently scored themselves low on the scale, i.e. one, two or three. These are classified as:

One = Feeling active, vital, alert or wide awake
Two = Functioning at high levels, but not at peak
Three = Awake, but relaxed; responsive but not fully alert

5.8.6 There were no discernable differences in feelings of sleepiness scores over the duration of each shift or between double and single crews.
5.9 Fatigue - Qualitative Data

5.9.1 The subjective scales show that the test subjects tended to rate themselves as being alert and awake over the whole test period. Subjects commented that by day three on an early or night shift pattern, they can begin to feel more fatigued. Interestingly, most subjects stated that they feel less fatigued during busy shifts than quieter ones.

5.10 HSE fatigue index

5.10.1 In order to provide a comparative baseline, the typical shift pattern for test subjects was assessed using the HSE’s Fatigue Index Calculator for shift working\(^4\). This is a tool based on observations of all shift working jobs. The index seeks to predict the relative probability of high levels of sleepiness associated with a pattern of shift work. The results showed that the job of the TO’s is not likely to result in high levels of fatigue or sleepiness. The results were significantly below a value of 20.7, which corresponds to an average or general norm. For further details, see Appendix C.

5.11 Mood

5.11.1 The BMIS (Brief Mood Introspection Scale) was used as a comparative tool to understand if a test subject’s mood altered negatively when working as a single crew. The BMIS looks to understand how pleasant, alert, relaxed and positive an individual is feeling. Subjects were required to rate themselves on a scale against 16 descriptive adjectives, e.g. lively, energetic, gloomy, caring. For further details, see Appendix B.

5.11.2 The ratings given for each adjective were then calculated to provide an average score for each test subject on double and single shifts. These averages were compared to the maximum and minimum values on the following spectrums -

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\(^4\) See [http://www.hse.gov.uk/research/rhtm/r446.htm](http://www.hse.gov.uk/research/rhtm/r446.htm)
5.11.3 Table 5.5 shows the average scores relating to all mood scale scores for each test subject in double and single crew tests, illustrated further in Figures 5.26 to 5.29.

![Mood Scale Spectrums for BMIS](image)

**Figure 5.25 – Spectrums for BMIS**

<table>
<thead>
<tr>
<th>Scale</th>
<th>Test Type</th>
<th>Test Number 1</th>
<th>Test Number 2</th>
<th>Test Number 3</th>
<th>Test Number 4</th>
<th>Test Number 5</th>
<th>Test Number 6</th>
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<th>Test Number 10</th>
<th>Test Number 11</th>
<th>Test Number 12</th>
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<th>Total Av.</th>
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<tr>
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<td>57.0</td>
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<td>6.0</td>
<td>7.0</td>
<td>7.13</td>
</tr>
</tbody>
</table>

*Table 5.5 - Average mood scale scores for each test subject in double and single crews*
Figure 5.26 - Averages for Pleasant-Unpleasant scale

Figure 5.27 - Averages for Arousal-Calm scale

Figure 5.28 - Averages for Positive-Tired scale
The data shows that there was minimal difference between double and single crew tests. Test subjects were generally in positive, alert but relaxed moods. It is noticeable that individuals whose mood was less upbeat or more tired reported this consistently between double and single crewing.

**5.12 Performance - Subjective Rating**

Test subjects were asked on an hourly basis to rate the temporal demands of the tasks that they had completed and their levels of frustration and/or feelings of stress, both of which could influence how the subject performed. These were completed on separate scales where one is not demanding and seven is very demanding. Figure 5.30 displays the average temporal demand ratings and Figure 5.31 shows rating scores for frustration.
Figure 5.31 - Frustration rating scores

5.12.2 Overall test subjects recorded low levels of temporal demand and feelings of frustration with scores between 1 and 3; there was no noticeable difference between double and single crew data.

5.12.3 There was only one incident where a subject recorded a score of higher than 4 on the Temporal demand and Frustration scales and this occurred during a live lane 1 closure by a single crew. These scores relate to the same incident noted earlier where the subject gave unusually high scores for physical and mental demand. The scores appear to be a result of the specific circumstances of the incident, rather than as a result of being single crewed. Other similar live lane incidents were rated much lower by other subjects.

5.12.4 Those TO's reporting higher levels of frustration often did so because they were not able to access Airwave to communicate with the RCC, usually as a result of network congestion. On one occasion an RCC operator did not allow the TO to complete their transmission correctly before interrupting.

5.13 SME Assessment

5.13.1 A primary function of the SME was to observe the test subjects during the double and single shifts to determine if there were any observable differences in their performance. The SME was required to complete a series of scales for each incident attended which rated the test subject on the following:

- Incident Driving Performance
- Overall Driving Performance
- Incident Task Performance
- Overall Task Performance.

5.13.2 The scales ranged from -3 (significantly below or very unsafe) to +3 (significantly above or very safe) with a midpoint of 0 indicating the expected level of performance.

5.13.3 A total of 227 SME assessments was completed; 138 in double crew and 89 in single (see Table 5.1). Table 5.6 shows the number of incidents where a score was given either above or below the expected level of performance in double or single tests. It should be noted that some subjects were scored as above, below or expected all within the same incident.
5.13.4 As a double crew, 27 (37%) out of 138 incidents saw the SME scoring the test subject above or below expected levels of performance: 14 incidents were scored above (10.1%) and 13 were below (9.4%).

5.13.5 As a single crew, 38 (43%) out of 89 incidents saw the SME scoring the test subject above or below expected levels of performance: 15 incidents were scored above (17%) and 23 were below (26%).

<table>
<thead>
<tr>
<th>Test</th>
<th>Double Crew</th>
<th>Single Crew</th>
<th>Double Crew</th>
<th>Single Crew</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Test 3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Test 4</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Test 5</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Test 6</td>
<td>5</td>
<td>4</td>
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<td>4</td>
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<tr>
<td>Test 7</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Test 10</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Test 12</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Test 13</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14</strong></td>
<td><strong>13</strong></td>
<td><strong>15</strong></td>
<td><strong>23</strong></td>
</tr>
</tbody>
</table>

*Table 5.6 - Number of incidents where a score was given either above or below the expected level of performance in double or single tests*

5.13.6 These results indicate that during single crew, comparatively, there was a greater number of incidents where the test subject was awarded scores which were below expected levels of performance.

5.13.7 Analysing the data further reveals that most ‘below performance’ scores were related to driving, whilst single crewed. Figure 5.32 shows the cumulative minus scores for all of the tests, for each aspect of the driving performance scale. Steering, acceleration and exiting/entering the hardshoulder show a marked difference between double and single.
5.13.8 Table 5.7 shows examples of SME comments relating to these tasks and what the test subject was doing at the time. Interestingly, it reveals that the test subjects tended to be interacting with the radio or light bar controls or had noticed something too late when their driving performance was compromised.

<table>
<thead>
<tr>
<th>Category</th>
<th>Example of Activity/task being completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enter/exit hard shoulder</td>
<td>“Patrolling in lane 3 and cut across to H/S in approx 300m as failed to notice vehicle in adequate time.”</td>
</tr>
<tr>
<td></td>
<td>“Attempting to activate lights when entering coned hard shoulder area”</td>
</tr>
<tr>
<td>Steering</td>
<td>“During the process of activating the at scene lights steering was compromised.”</td>
</tr>
<tr>
<td></td>
<td>“Slight deviation when answering phone when rejoining from hard shoulder”</td>
</tr>
<tr>
<td>Use of speed</td>
<td>“Asked to assist off network. Drove at 50- 60mph on route”</td>
</tr>
</tbody>
</table>

Table 5.7 Example SME performance commentary

5.13.9 Despite being empowered to do so, there were no instances of the SME stopping the test, asking the TO to reconsider their actions, or situations where the TO asked the SME for support.

5.13.10 In relation to incident task performance, there was very little difference in the scores of the test subject when double and single crewed. But, overall, this is the area where the SME tended to recognise ‘above expected’ levels of performance e.g. customer service, thought process etc.

5.14 Performance - Qualitative Data

5.14.1 Several test subjects stated that one of their main distractions related to the capacity of the communication system, Airwave. They felt that this had an impact on their frustration levels, performance and safety in a single crew.
5.14.2 One test subject was given minus scores by the SME for briskly pulling across onto the hard shoulder to attend to a breakdown. The test subject said that he reacted abruptly because he had not seen the vehicle early enough, due to his position on the carriageway. He was in the middle lane with traffic in lane one obscuring his view of the hard shoulder. Ordinarily the Observer is able to see down the hard shoulder and determine if there is anything which could disrupt the flow of traffic. In a single crew scenario this feedback is lost and it was reported by three test subjects that the driver found it difficult to see the hard shoulder, especially if lane one is congested with lorries or if they are patrolling in lane two.

5.15 Data Logger

5.15.1 A data logger device using GPS tracking was temporarily installed in the TO vehicles to record speed, acceleration and lateral deviation during each Test in the hope of capturing objective measures of driving performance.

5.15.2 The data captured typically shows a number of periods of relatively stable speed (where the TO vehicle is travelling on the motorway) interspersed with a number of stops for incidents or breaks, see Figure 5.33 and 5.34.

5.15.3 The data graphs show very similar speed and acceleration patterns across all the tests with drivers mostly maintaining speeds of between 50 and 70mph. There are occasional speed and lateral acceleration peaks across most of the shifts, with some speeds of greater than 70mph being recorded.

5.15.4 Not surprisingly, speed and lateral acceleration variation increases markedly when the TO vehicle is travelling off motorway, particularly in and around service areas, junctions and on the urban road network.

5.15.5 There was no obvious or consistent difference in the patterns of speed and acceleration between double and single crew tests, for example compare the graphs in Figures 5.33 and 5.34. Single crew tests do not demonstrate any obviously greater frequency or level of variation in speed or acceleration. Generally, single crewed drivers do not appear to perform noticeably differently to double crew drivers in terms of recorded speed / acceleration profiles.

5.15.6 Incidences of poor performance were identified by SME commentary and some of these can be identified (by time) in the data, for example see (A) in Figure 5.35. In this instance the data shows a marked sudden peak in lateral acceleration, which can be matched to an incidence of poor steering noted by an SME when the TO used the radio while driving.
Figure 5.33 - Speed and lateral acceleration graph and route map for a typical double crew test. The graph shows speed (in red) and lateral acceleration (in grey). The route map shows the corresponding circuit travelled over the road network.

Figure 5.34 - Speed and lateral acceleration graph and route map for a typical single crew test. The graph shows speed (in red) and lateral acceleration (in grey). The route map shows the corresponding circuit travelled over the road network.
5.15.7 However, the graph data alone does not exemplify poor performance. For example see the area marked (B) in Figure 5.35, which shows a more extended period of high lateral accelerations but which is actually related to a period of driving off-the motorway on local roads and through an industrial estate. Without the context that would be provided by a contemporary record of each driving activity, such as video images, it has not been possible to determine whether marked peaks indicate unusual or degraded performance.

![Figure 5.35 Speed and acceleration graph showing an incidence of poor steering performance (A) identified by the SME. B marks a more extended period of greater variation whose cause cannot be determined.](image)

5.16 **Operational Issues - Communications**

5.16.1 Subjects reported that there is incomplete radio system (Airwave) coverage within the NW region, and this can result in some "black spots". This was most commonly reported in the Knutsford area. It is understood that the HA are aware of the problem. These black spots can cause ‘drop-outs’ in Airwave communications leaving TO’s unable to communicate with the RCC. In a single crew this is likely to leave the TO in a more vulnerable position with the RCC unaware of where they are or what they are doing and no second crew member to support them.

5.16.2 The extent and location of black spots are not fully known and it is understood that a survey to establish this would be expensive and would have a very short life span. It is understood that mobile phones are used as an alternative. We understand that the Airwave system uses the O2 network and that the TO’s mobile phones use Vodafone, so there is likelihood that mobile phones will have a different level of coverage.

5.16.3 Mobile coverage is relatively good in the Knutsford area. In remote areas such as Cumbria, or where the topography may disrupt the signal this may not be the case.

5.16.4 A further problem is that during busy periods Airwave capacity can be limited with TO’s struggling to access gaps in radio traffic to contact the RCC. In these circumstances they must wait until a channel becomes available. In a double crew, one TO would to wait for a gap and then convey initial information regarding location to the RCC, whilst observing the safety of themselves and their colleague who is likely to have commenced on site operations. As a single crew, this is not an option as the TO will need to leave their vehicle to attend to the incident. There is potential for either a delay in starting incident management while trying to get through on the radio, or commencing on-road activity without informing the RCC where they are or
what they are doing. Either scenario poses a level of risk. The TO vehicles are fitted with trackers which indicate to the RCC where the crew are located but it is understood that these can be unreliable in some instances.

5.16.5 A further problem relates to noise interference from wind and/or traffic when outside the vehicle. In a double crew the TO communicating with the RCC and can readily move to a sheltered spot, perhaps in or by the vehicle, to reduce background noise. A single crew is likely to find it more difficult to move to a sheltered spot, as the incident would typically take priority. This could make accurate communication difficult.

5.16.6 Some test subjects were concerned about Airwave operation in relation to lone working. For example, a single crew lone female, in an area which is prone to black spots or while unable to access a channel, may feel particularly vulnerable and unsupported. CCD had initial discussions with the HA about how this could be addressed if the Airwave issues could not be resolved. It is believed that there are two possible options currently available to the HA:

- RCC monitoring crew at incidents - A ‘fail to update’ for a predetermined interval would prompt a call if necessary
- Lone worker profile – which is used on handheld terminals. At a pre-determined interval the hand held beeps. If this is not acknowledged then an alarm code is issued. A negative of this would be that it might need to be responded to whilst driving and there may also be a possibility that the beep might be missed e.g. on a noisy network. The existing capability of the technology has not been investigated as part of this commission.

5.17 Operational Issues - Ergonomics

5.17.1 There are three types of Traffic Officer Vehicles (TOVs) in current use; the Land Rover Discovery, Mitsubishi Shogun and Toyota Land Cruiser. All TOVs are fitted with the same equipment and tools.

5.17.2 The primary controls in the front of the vehicle include:

- Light bar control pad
- VMS (Variable Messaging Screen)
- Radio controls, speaker and stalk (attached to steering wheel)
- Mobile telephone.

5.17.3 A general ergonomics assessment was completed by CCD in 2010 on all three vehicles and, as a result, the Land Rover Discovery was chosen for the test because the position of the light bar was considered to be more accessible for the test subject when working as a single crew, and it had the best load capacity and physical space to carry the additional people and equipment required for the test.

5.17.4 In a double crew scenario the controls are usually operated by the 2nd officer (acting as observer) and are easily accessible to them from the passenger seat. As a single crew the TO is responsible for the driving task as well as interacting with these controls. An optimum position is crucial to ensure safe operation.

5.17.5 During the single tests, most subjects operated the light bar whilst still driving and had to avert their eyes from the road to locate and activate the ‘At Scene’
button when attending an incident. In some tests, this resulted in minor drifting on the road or the TO attempting to activate the button whilst looking at the road and striking the incorrect function.

5.17.6 It is known that the position of the controls in the Mitsubishi and Toyota vehicles are less suited to single crewing than the Land Rover Discovery. This is especially true in the Toyota, where the light bar control is partially obscured by the gear sticks. Consistent safe operation of these controls in their current location whilst working as a single crew is unlikely.

5.17.7 The test subjects stated a preference for having the light bar controls on the front, central console. Furthermore they stated that the position of the controls should be consistent, relative to the other controls, within all TOVs.

5.17.8 Subjects reported that it is not always feasible to operate the light bar while the vehicle is stationary, which was the agreed operating procedure for the Test (See CD Reference 7.0). Numerous situations occurred where TO’s needed to operate lights while driving. Indeed subjects were commonly of the opinion that the procedures required them to keep lights on whilst they rejoined the carriageway, switching them off once safely in lane one.

5.17.9 Subjects also commonly noted that the light bar has too many buttons, with many functions not being used at all. In order to better support single crew operation the light bar should be designed to be easily operated with the minimum number of required function buttons, ideally organised in frequency or priority order. It should be positioned within easy reach and vision of the driving position. A user trial assessment is likely to be the most appropriate method of understanding the user requirements and ensuring that the controls are positioned optimally to ensure their safe use.

5.17.10 The radio stalk fitted to the steering wheel is for use by the TO when driving and in a double crew this tends to be during a RRB. Commonly, in double crews the Observer TO handles the radio whilst the other TO drives. When working as a single crew, the TO will often need to use the stalk to communicate with the RCC and notify them that they have rejoined the network safely. Some subjects questioned whether the HA perceived it to be safer for the single crew to complete this transmission whilst still on the hard shoulder using the handheld radio, or when they had rejoined the network and needed to use the stalk. This point would need further HA consideration.

5.17.11 Furthermore, when dealing with a more involved incident or a RRB, the RCC will sometimes request that the TO changes radio channels. This will not always be practical as a single crew, as it may not be possible to stop at a place of safety.

5.17.12 The ergonomics assessment completed by CCD also assessed access to the equipment in the back of the vehicle. The Land Rover Discovery has a split tailgate, where part lifts and part drops down. There is a known issue where smaller TO’s find it difficult to access equipment towards the back of the boot storage area. We understand that HA currently manage this issue by using an alternative vehicle with a different tailgate arrangement when smaller TO’s are on shift. Clearly, the choice and design of TO vehicle must support easy operation by all TO’s. The HA should continue to ensure that single crew operation is supported by providing vehicles suited to all the TO’s using them.
5.18 Operational Issues - Procedures

5.18.1 The procedures are currently written based on the assumption that they are to be undertaken as a double crew. Certain tasks cannot be completed as a single crew. Prior to commencing the tests the procedures were reviewed by the HA to understand if any amendments were required ahead of the variable crewing test (See CD Reference 7.0). This review concluded that the only significant change needed was to prohibit a single crew completing a RRB. A number of other less common procedures were also prohibited.

5.18.2 Some test subjects commented that if the procedures did not allow for them to complete RRB’s the benefits of single crewing would be limited as there are concerns about the time lag entailed by waiting for back-up. An example relates to requiring an immediate RRB for a pedestrian in a live lane. If a single patrol comes upon a pedestrian in a live lane then the traffic needs to be stopped immediately. Under current HA procedures, a RRB could not be operated by the single crewed TO and a second patrol may not be close by, especially in more remote areas.

5.18.3 During the tests, incidents requiring a RRB in a single crew were completed by an alternative patrol. This happened once. In test locations where patrol areas are smaller this was not a major issue as an alternative crew was relatively close by. In the more remote areas of the region, such as Cumbria, this is not necessarily the case and thus could have a negative impact on response or incident clear up times. This problem would be exacerbated if there were a minimal number of double crew vehicles on the network following a roll out.

5.18.4 Some test subjects commented that if the procedures did not allow for them to complete RRBs the benefits of single crewing would be limited, as there are concerns about the lag times waiting for back-up. We note that 7% of the incidents attended in double crew mode involved a Rolling Road Block.

5.18.5 Other subjects reported that in a double crew both TO’s sometimes use hand signals to wave traffic through after a block has finished. This would not be possible in a single crew, as it would not be possible to control the vehicles on the nearside of the patrol car.

5.18.6 Some of the incidents attended as a single crew did not necessarily allow for the test subject to follow the existing procedures due to the circumstances. For example, the current procedure for the tyre fitter scenario as described in Section 5.7.3 requires that one TO must stand with the tyre fitter and the other by the taper. In a single crew, the TO needs to understand where the safest place is for them to stand to protect themselves and those working at scene; this needs to be incorporated in the TO procedures and included in TO training.
6 DISCUSSION

6.1 Physical and Mental Demand

6.1.1 The HA wished to determine if TO’s could operate on the network single crewed.

6.1.2 Overall, the Test results demonstrate that there is minimal impact on the TO from a physical perspective when working as a single crew. Some of the tasks that the TO’s have to complete to fulfill their role requires low levels of physical activity, e.g. handling cones, walking down the carriageway to put out or collect ETM etc. The level of activity in a double crew will vary dependent upon which role the TO is undertaking, for example, more walking will be required in the Observer role in comparison to the Driver role. In a single crew, there will be a slightly increased level of physical activity, but this was not perceived to be a problem by test subjects.

6.1.3 In double crew mode incident management tasks and procedures take place in parallel, with one TO undertaking some actions, while the other TO undertakes others. In single crew mode all actions have to take place serially, completed by one TO. In general this does not appear to significantly increase physical effort required or appreciably increase time taken to manage incidents.

6.1.4 The results demonstrate that there is minimal difference in the mental demand placed on a double or single crew. However, the mental processes required to fulfill the role of a TO working alone is reported to be different in some instances. For more involved incidents, test subjects reported higher mental demand scores and stated that this was because they no longer had the support of their colleague when making a DRA and prioritising tasks at scene. Additionally, they are sometimes faced with having to make rapid decisions about what order to do different things, since they have to work serially when alone instead of sharing tasks in parallel with a second TO in double crew mode. Some subjects did forget to turn the light bar on/off or have the ‘reds’ on when at scene. These omissions are likely to be because the test subject is not used to the combined observer and driving task.

6.1.5 Subjects thought that the difference in mental process was largely due to them working in single crew for the first time and having to make decisions alone on complex situations, also for the first time. They thought that this would be more obvious to them with experience and once a planned transition to single crewing had been completed. Such a transition is likely to include elements of training covering how to act as a single crew. There is a risk that officers may come to have an unjustified confidence in their abilities and therefore begin to react inappropriately. The removal of the second officer, who would tend to act as a check on such behaviour, is likely to increase this risk.

6.1.6 The subjective data shows that there was no negative impact on levels of fatigue or on mood during a shift period or when comparing data from double and single crews.

6.2 Driving Performance

6.2.1 The performance data shows that, overall, the test subjects maintained fairly consistent levels of driving and task performance when double and single crewed. However, SMEs made a significant number of negative observations
in relation to driving while single crewed, particularly when entering and exiting the hard shoulder, and in relation to steering and use of speed.

6.2.2 These errors were most often related to interaction with the radio or lights at the same time as driving. Improved position of controls for these pieces of equipment is likely to better support single crew operation. Additionally, it is likely that TO’s will benefit from being trained in how and when to use equipment whilst driving and in how to prioritise activities in order to drive safely, but this test did not assess or measure the change in risk that will be experienced by a single crew as a result of operating in-vehicle equipment while driving. We are therefore unable to comment on whether this changed risk remains within an acceptable tolerance.

6.2.3 We would note the more general guidance provided by HA and the Department for Transport regarding the use of communication devices while driving.

6.2.4 The location of the controls within the Land Rover Discovery is currently not optimal because the TO is likely to divert their eyes from the road and look at the controls to interact with them. Whilst the test was only completed using the Land Rover Discovery, it is known that this layout is better than the Toyota Land Cruiser or Mitsubishi Shogun. It is strongly recommended that user trials are completed to determine where the controls can be positioned to ensure the safest possible use by the TO when driving the vehicle.

6.3 Task Performance

6.3.1 Whilst the subjective and objective data collated indicates that working as a single crew would be possible, operational issues were identified that could have a negative impact on safety and efficiency of the TO when working alone. There are three main areas in relation to task performance that would require attention prior to a roll out of single crewing. These are:

- Robustness of Airwave radio communications
- Layout of the vehicle
- Amended operational procedures.

6.3.2 The HA are aware of the issues with Airwave and are intending to resolve them where possible. If they cannot be resolved it is likely that single crews would be more vulnerable, should the ability to use Airwave be compromised. This increased vulnerability could disproportionately impact on some TO’s, such as lone women.

6.3.3 Issues with the layout of the controls within the vehicle are discussed above. In addition there are problems with smaller TO’s accessing equipment in Land Rover Discovery vehicles, which are currently mitigated by using other models of vehicle. It should be possible for any TO to use any vehicle in the HA’s fleet.

6.3.4 During the test some incidents that were attended by a single crew raised queries about how the current procedure would be applicable when working alone. The example given in the results section relates to the safest place for a TO to stand when ensuring the safety of a tyre fitter who was working on the offside of a vehicle, in lane one. Whilst the test subject was able to easily deal with this incident, they had not been exposed to it as a single crew previously and were initially uncertain how to approach it. The TO was able to cope with the physical and mental demands of the task and to successfully execute it, but they did not have the procedural tools and training to
understand what is required when dealing with the incident as a single crew. The HA need to properly identify the procedural differences between being double and single crew and effectively coach these to the TO’s.

6.3.5 Anecdotal performance information collected makes reference to the concerns that some test subjects and Team Managers have about how single crew TO’s will be selected should variable crewing be rolled out. There seems to be a body of opinion that single crewing would not be suitable for all TO’s, either because of their current performance or due to their general attitude to the job. This could impact on the safety of the TO and others. Subjects suggested that working single crewed should not be mandatory, but instead could be something to work towards. The subjects of this test were selected from the most capable officers currently working in the NW, and were all willing volunteers, so issues of this type were not encountered during the test.

6.3.6 There was isolated evidence of non compliance with HA procedure during the test, although this was not a result of single crewing. Jacobs have not commented or made recommendations in relation to these non compliances, as it is the responsibility of the HA to govern their procedures.

6.4 Other Factors

6.4.1 Following the test serious concerns remain about the safety and vulnerability of a lone officer, particularly if there is a personal injury incident while they are working alone. The issues identified with communications equipment further contribute to these concerns. A safety report for single crewing will be required, which considers these risks in detail. It may be possible to use technology to effectively monitor the movements of a lone TO. For example, it may be possible to automatically detect the TO leaving their vehicle and transmit this information to the RCC.

6.4.2 Many discussions were had with the test subjects about the current procedures, their implementation and training. It is clear that there are regional variations between outstations in how team managers interpret and implement the procedures and how they deal with non compliance. This can cause confusion; some observed examples include patrolling strategies, carrying passengers off the network, requirements for calling in hardshoulder stops to the RCC (e.g. brief stops to clear small amounts of debris) and frequency of welfare checks.

6.4.3 There was a general consensus that TO refresher training and TO operational competence assurance is limited, following foundation training.

6.4.4 Verbal comments were made by several test subjects about the capabilities of some team managers to exercise adequate authority and the perception that many lack network experience and understanding of the job; thus, in some instances, respect is lost among the teams and procedures are sometimes not adhered to or are altered. This tended to be more readily observed in relation to staff welfare such as adhering to correct uniforms and breaks, but can also impact on the overall working environment and team morale.

6.4.5 For single crewing to be implemented, accepted by the TO’s and for the tasks to be carried out safely, the correct training is essential, especially in terms of content, delivery, continuity and assurance. At all stages, there should be heavy involvement with the end users, the TO’s and the Team Managers. Involving test participants, both TO’s and SMEs, in this process is considered to be invaluable as they now have first-hand knowledge and experience of working as a single crew, albeit in a controlled environment.
6.4.6 A recent Audit, Inspection and Consultancy Division report produced for the HA has suggested that a move to single crewing might result in a higher incidence of drug and alcohol abuse among single crewed officers, as a result of reduced incidence of colleagues raising concerns. The Highways Agency will need to consider this possibility and associated hazards.
7 LIMITATIONS

7.1.1 Whilst the testing and analysis methods used are considered to be robust, there are some limitations that need to be taken account of when drawing conclusions.

7.1.2 Firstly, the results and conclusions within this report are based only on the incidents that were attended during the ‘Test shifts’. Test subjects were exposed to very few ‘serious’ incidents that might have put them under greater pressure when working as a single crew. It is not possible to say whether or not a single crew officer would be able to cope with the physical and mental demands of more serious incidents or if there would be any safety implications.

7.1.3 The number of incidents that Test subjects attended appears to be similar to the number attended by the other HA patrols working the NW region. Both Test subjects and the other patrols attended an average of between 3 and 5 incidents per day. It therefore seems reasonable to conclude that the Test results are valid in so far as numbers of incidents attended and typical level of activity / workload is concerned for the NW region. However, it is not known to what extent the NW region is representative of the TO experience in other regions within England. It is possible that single crewing might prove more onerous in other regions if the number or range of incident types were markedly different.

7.1.4 It is worth noting that the number of incidents that were attended during the single crew tests was overall less than in double crew tests. This makes it somewhat more difficult to assess comparative performance between crewing modes since the level of activity under each condition was not quite the same; most notably for live lane events. Some test subjects did not complete any recordable incident actions on their single tests and thus, the results from those tests do not necessarily provide an understanding of how that person would behave or feel working alone. The Test was restricted to two consecutive shift days by various constraints on the Test design, and this had the effect of limiting the level of exposure to the live network and the range of incidents that subjects experienced.

7.1.5 Each test consisted of four shifts, with each TO being tested single crewed and double crewed. Some of the variables that were tested, such as fatigue and mood, are less likely to alter over a two day period than over the normal six day shift cycle. The data collected for fatigue and mood did not show any noticeable difference on the two consecutive shift days, but anecdotal information from some test subjects reveals that their levels of fatigue do change the closer they get towards the end of their six day shift cycle. To understand whether this might be more pronounced under single crewing, future investigation should involve a greater number of consecutive days.

7.1.6 The participants of the test were all willing volunteers with high levels of enthusiasm. The test days were seen as something new, interesting and different to do and this may have impacted upon some of their subjective scales, especially in relation to mood. Furthermore, the scales may also have been affected by the presence of the SME and HFO in the back of the vehicle. Whilst the HFO requested that the subjects be honest when completing their subjective scales, they may have been choosing scores which they thought the HFO would want to see or that would not reflect negatively on them. The implication is that the success of the Test in
demonstrating the feasibility of single crewing is somewhat skewed by the enthusiasm of the test subjects. It is therefore possible that some current TO’s would find single crewing much more challenging than the Test subjects did, and that boredom and loneliness, which were not encountered during the tests, would become serious issues.

7.1.7 Finally, the tests were not designed to provide information on the safety of a lone Traffic Officer, in the assessment of hazards relating to lone working in attending to an incident, or in relation to the consequences of an incident which involves their personal injury. Such considerations are outside the scope of this report.

7.1.8 Lone Traffic Officers will require training so that they are competent to assess any situation before commencing work, and so they can assess where it is necessary to call for back up before responding. Revised contact requirements and emergency response procedures may be necessary to compensate for the absence of a second officer in the event of an incident involving injury to a Traffic Officer.
8 CONCLUSIONS

8.1 Conclusions

8.1.1 From the live network test it can be concluded, subject to the limitations set out in Section 7, that for the sample of TO’s tested:

- There does not appear to be any appreciable difference in physical demand between double and single crewing
- There does not appear to be any appreciable difference in mental demand between double and single crewing
- Single crewing does not appear to result in any greater levels of fatigue or frustration than double crewing, nor does single crewing appear to adversely affect the TO’s mood
- Single crewed TO’s felt that they were capable of undertaking the tasks required of them once on scene, and the SMEs did not note any deterioration in task performance
- TO’s driving performance is slightly worse when single crewed. The difficulty inherent in operating equipment and using communications equipment while driving is a significant contributor to this
- A transition to single crewing will be better supported by improvements to:
  - Communication capabilities, in particular relating to Airwave’s capacity and coverage
  - Design and layout of the controls / displays to support operation while driving
  - Improved design / choice of vehicles to ensure all users are accommodated (especially in terms of access to equipment in the back)
  - Amendments to procedures to support single crew operation and dedicated single crew training
  - Mechanisms for the selection of appropriate TO’s.

8.1.2 In terms of task performance no additional hazards were identified as a result of this test. No substantial changes in risk were observed, and the existing methods of risk mitigation, in particular DRA, did not present the subjects with an undue challenge. Some subjects commented that they found themselves questioning the output of their assessments more, and that they missed the opportunity to discuss their assessment with a partner, particularly when faced with a new or unusual situation. However, the SMEs did not consider that observed performance had deteriorated.

8.1.3 There is an increased risk that the TO will incorrectly assess the particular risks at an incident when single crewed, although we note that this did not happen during the test. This is likely to have an adverse impact on the safety of the officer. This adverse impact has not been quantified.

8.1.4 Driving performance deteriorated while single crewed. It is understood that the factors contributing to this are a set of controls which are difficult to operate whilst driving, a lack of familiarity with the mental and physical processes required, the need to communicate and drive at the same time, and a requirement to concentrate on both driving and scanning the road.
ahead for incidents. Communication and observation tasks are currently undertaken by the second TO.

8.1.5 A move to single crewing is likely to result in periods where the TO is required to concentrate on driving and other tasks simultaneously. This contributes an additional risk to the TO and the travelling public.

8.1.6 Problems with equipment layout can be mitigated by improved interfaces, particularly the light bar controls. Other on board systems would benefit from simplification where possible, and should be standardised between vehicle types so that TO's are not searching for a control. This will require adaptations to vehicles, which is likely to increase their cost.

8.1.7 It would be beneficial to train officers in prioritisation whilst driving, so that the probability of them concentrating on the most safety critical item, and discarding those items which can wait, is increased. Even after mitigation an elevated risk as a result of undertaking a second task while driving remains.

8.1.8 A single crewed TO will be required to take over the role of observer and manage communications.

8.1.9 It may be possible to reduce the risks from these activities by moving to text based communication from the RCC which does not require an immediate response. It may be possible to display messages on a screen which switches off when moving, requiring the TO to stop in a place of safety prior to receiving a communication, although this would reduce the immediacy of messages. Consideration could be given to reducing the amount of patrolling undertaken by TO's, moving to a model where TO's position themselves on or adjacent to the network and respond to issues as they arise. This would make communication safer, as details of an incident could be transmitted while they are stationary, and prior to them commencing driving.

8.1.10 There is an increased risk of the TO making errors whilst driving single crewed, as a result of undertaking additional tasks. This increases the risk of an RTC involving a TO, and therefore also increases injury risks, both to the TO and to the public. This adverse impact has not been quantified.

8.1.11 Single crew operations within the limitations of the test appear to be feasible, but there is an increased risk of officers making flawed DRA's at scene, and there is an increased risk as a result of dividing the attention of the TO while driving. The implications of these reductions in performance, which are likely to impact on safety, need to be understood prior to a wider implementation of single crewing. This test did not address the safety of a lone TO involved in a personal injury accident in the course of their work.

8.1.12 To address these changes in risk we would recommend that the HA review procedures which describe the operation of on board equipment in light of the requirement to do so while driving. Careful consideration must be given to whether such operations remain within the HA's corporate risk tolerance.
9 RECOMMENDATIONS

9.1 Recommendations

9.1.1 It is recommended that the HA consider the following further actions ahead of any wider deployment of variable crewing.

9.1.2 The capacity of the Airwave radio system needs to be addressed. It is understood that the HA are aware of the problems and are looking at methods of improving this. Increased capacity would help to ensure that TO’s are able to quickly contact the RCC, about their whereabouts and incident that is being dealt with. As a single crew this is particularly important. If Airwave cannot be improved then backup technologies could be used to communicate TO locations, for example the use of a form of instant messaging. Furthermore, palm held devices, as used by some Police forces, may be a more efficient way to record information about incidents as opposed to the current method of paper pocket books and incident sheets.

9.1.3 The layout of the controls in the vehicle is not universal within each of the vehicle models and the buttons on the light bar controls do not use consistent terminology. In the long term, working towards an integrated system would allow the light bar, radio and VMS to be controlled through a single interface, such as a touch screen. This would require in-depth research to understand which controls the TO’s use the most frequently, and the design of a system to accommodate their requirements. The objective should be that the functions can be executed easily and safely.

9.1.4 In the short term, user trials could be completed to understand the optimum position for the controls within a vehicle, so that adaptations can be made accordingly, with the objective that they can be all accessed easily from the driving seat, but equally remain accessible for the second TO in a double crew. As far as possible, the positioning should be universal in the vehicles. The layout of the equipment in the back of the Land Rover Discovery vehicles needs to be reconsidered to make the equipment accessible to all TO’s regardless of stature. Again, further work would need to be completed to ascertain what practical changes could be made to meet this requirement. The Land Rover Discovery vehicles are currently a barrier to some TO’s being able to use them to complete a single crew shift.

9.1.5 The issue of RRB’s is perhaps the most important procedure that needs to be resolved in terms of single crewing. This could be progressed initially via a workshop, with selected personnel from the test, to discuss the implications if it were not possible to amend the procedure for single crewing. Further Live Network Testing, specifically looking at this procedure could also be a possibility to explore some of the perceived issues further.

9.1.6 Further live testing of a broader cross section of the TOS would be recommended to ascertain whether single crewing is suitable for all TO’s. The current test can not fully determine the compatibility of all TO’s with single crewing.

9.1.7 Further workshops could be held to discuss other occurrences where the current procedures may not be applicable in a single crew scenario. Again, using personnel that have been involved in the test will be advisable, as they have direct experience. This will also help with the perception, in some outstations, that TO’s are not properly consulted about decisions that directly affect them.
9.1.8 Prior to a wider deployment of variable crewing it is advised that the high-level outputs from the tests are discussed with those in other regions to determine if they are an accurate representation. For example, other regions or specific outstations may have greater exposure to more serious incidents and, as previously explained; subjects in this test did not attend these. Further live testing could be considered, but this would need to concentrate on those areas with high incident rates and/or more serious incidents. If additional testing were to be completed then it is advised that a longer period of time, i.e. a whole shift pattern, is spent with each subject to increase the chances of attending a wider variety of incidents and understanding more accurately the physical and mental demands.