Traffic Officer Service – Specialist Human Behaviour Evaluation of Single Crewing Deployment

Feasibility Report

Submitted to:

HIGHWAYS AGENCY

Date – 22/12/11 / Ref No – OD/005
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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

610	A directional sign used in Traffic Management
AFR	Accident Frequency Rate
BDV	Broken Down Vehicle
CCD	CCD Design & Ergonomics Limited - A specialist Ergonomics and Human Factors Sub Contractor
CCTV	Closed Circuit Television
CTM	Certificate in Traffic Management
DRA	Dynamic Risk Assessment
GRRB	Ghost Rolling Road Block
HA	Highways Agency
HF	Human Factors
HFO	Human Factors Observer - A Test Participant, refer to report text for further details
HS	Hard Shoulder
IMS	Incident Management Solutions team (HA)
LL	Live Lane
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
VMP	Variable Message Panel
ETM	Emergency Traffic Management
PT1	Pilots and Trials 1 – A 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 (HA) 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 As part of this programme, the HA sought assistance to make an assessment of variable crewing of the Traffic Officer Service (TOS) which was duly reported as Test A (live network testing), implemented and completed between December 2010 and January 2011. Test B was subsequently developed to validate the findings of Test A and to widen the scope of the test to include previously excluded procedures, such as Rolling Road Blocks (RRB).

1.1.3 Test A concluded that variable crewing is feasible within certain constraints and subject to a number of caveats. In order to be assured that variable crewing might be implemented successfully, the HA decided to complete further testing, with fewer constraints. The Test Design used for Test A was revised and further testing was undertaken between October and November 2011, referred to in this report as Test B.

1.1.4 A total of 16 tests, covering 144 shifts, were completed between October 2nd 2011 and November 27th 2011. The Live Network Test involved 16 test subjects from five outstations in the North West (NW) Region.

1.1.5 Over the test period a total of 349 significant incidents were attended to by test participants. The results show that for the test participants:

- There does not appear to be any appreciable differences in physical demand between double and single crewing.
- There does not appear to be any appreciable differences in mental demand between double and single crewing.
- Subjects do not suffer from high levels of fatigue routinely in either crewing mode; however, a minority of subjects found that they were marginally more fatigued in single crew towards the end of a 6 day shift block.
- Single crew mode does not appear to cause greater levels of frustration or adversely affect mood.
- Driving performance overall was found to be somewhat worse when single crewed, specifically for elements of judgement, planning/awareness and compliance to operational guidelines.
- The task performance, overall, was found to be better when single crewed. Elements of poor task performance are related to use of the VMP and light bar controls, via the rocker switch. This is likely to be improved by better design of equipment and positioning within the vehicle. It is unlikely that this improvement will be sustained and there is a risk that this occurred as a result of the test itself.
- The RRB procedure appears to be feasible in single crew mode; however the design of the current VMP and limitations of the rocker

switch have the potential to make the procedure difficult to execute safely.

1.1.6 Subject to the limitations within Section 7, it can be concluded that from the incidents attended during the test period, single crew operation appears feasible from an operational perspective. However, further consideration of the health and safety aspects of single crewing is required, particularly taking into account the relatively high AFR for Traffic Officers. We recommend that 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 TOs
- Adequate training provision for TOs and support staff should be implemented
- A procedure for risk assessing the suitability to deploy single crewing in a particular area, and training to support this should also be considered
- Adequate and reliable procedures should be in place for emergency situations when single crewed.

1.1.7 It should be noted that the test subjects were not alone during the single crewed tests, and so the tests were not able to identify any psychological impacts of working alone such as increased levels of boredom or inattention. This aspect would need careful monitoring in any live deployment of single crewing. In addition, single crewed operation should be considered as 'lone working' under the definition used by the HSE. The additional measures recommended by HSE to be taken by employees of lone workers need to be followed. In particular, special attention should be given to contingency plans in the event of the single officer being injured or placed in a dangerous situation; and to enhanced communication protocols to minimise any additional risk arising from the absence of a companion to summon emergency assistance.

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 have appointed Jacobs to develop previous work relating to variable crewing of the Traffic Officer Service (TOS). Currently Traffic Officers (TOs) always work in pairs.

2.1.2 The research question was to determine whether a TO's operational performance deteriorates when they work alone. 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.

2.1.3 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.

2.1.4 The previous work comprises a series of research reports by others, a research report by Jacobs, and the results of a programme of on road testing undertaken in late 2010 and early 2011, also by Jacobs. This testing is referred to as Test A.

2.1.5 This report describes the output of a second test, Test B, which builds on the work undertaken in Test A.

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

2.2 Test A Outputs

2.2.1 A summary of Test A conclusions are as follows:

- There did not appear to be any appreciable differences in physical demand between double and single crewing
- There did not appear to be any appreciable differences in mental demand between double and single crewing
- Single crewing did not appear to result in any greater levels of fatigue or frustration than double crewing, nor did single crewing appear to adversely affect the TO's mood
- TO's driving performance, overall, was worse when single crewed. This was thought to be almost entirely due to the difficulties of operating equipment while driving, e.g. light control pad, or using the radio
- From the incidents attended during the trial period, single crew operation appears likely to be feasible, but will be better supported by improvements to:
    - 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
- Amendments to procedures to support single crew operation and dedicated single crew training
- Appropriate mechanisms for the selection of appropriate TO's.

2.2.2 For further information relating to Test A and the background information, refer to the Test A Feasibility Report (See CD Reference 3.1 and 3.2).

2.3 Test B

2.3.1 Test B is a development of Test A. During Test A there were certain constraints placed on the testing which potentially affect the robustness of the conclusions that were drawn. In summary, the following major restrictions applied:

- Only early and late shifts were tested (no night shifts)
- Each test subject was only tested for a total of four shifts (two double, two single) limiting the ability to assess fatigue over realistic working shift patterns
- Rolling Road Block (RRB) procedure was not allowed to be carried out by single crews
- No changes were made to the position and location of the VMP, light bar and radio controls
- No CCTV cameras were allowed to be used within the vehicle
- Only Traffic Officers holding Certificate of Traffic Management (CTM) could volunteer to take part
- Only the Land Rover Discovery vehicles were used.

2.3.2 The aim of Test B was to obtain further data to validate, or disprove, the outputs of Test A and further to establish the feasibility of single crewing of the Traffic Officer Service in relation to the previously excluded activities.

2.3.3 The design and methodology of Test A was otherwise broadly applicable to Test B, although there were some modifications as a result of the changed scope. The differences between Test B and the original Test A are summarised in Table 2.0 below –

	Test A	**Test B**
Dates	2010	2011
Region	North West	North West
Prequalification Criteria	Participants have Certificate in Traffic Management (an advanced qualification) and were selected to be in a pool of candidates	Candidates volunteered to take part
Selection from prequalified candidates	Random selection by Jacobs and HA	Selection by HA
Shift Pattern	2 days double crew, no rest days, 2 days single crew	6 days double crew, 3 rest days, 6 days single crew

	Test A	Test B
Aims	Overall feasibility of single crewing for majority of procedures	Overall feasibility of single crewing across all procedures.
Mock-up elements	None	Potential to mock up RRB on demand
Vehicles	Landrover Discovery only. No modifications.	Landrover Discovery and Mitsubishi Shogun with some modification of controls
Number of test subjects	14	16
Man Days' of Test Data obtained	28 Double: 28 Single	96 Double: 96 Single
CCTV	None used	In vehicle CCTV used to gain useful context and commentary

Table 2.0 – Differences between Test A and Test B

2.3.4 However, Test B still had some constraints. These were:

- Procedures relating to tunnels could not be tested as there are no tunnels in the North West HA network
- The test was undertaken within the North West region
- The test did not cover emergency response to the personal injury to the Traffic Officer
- The procedure for Rearward Relief was excluded (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 were excluded.

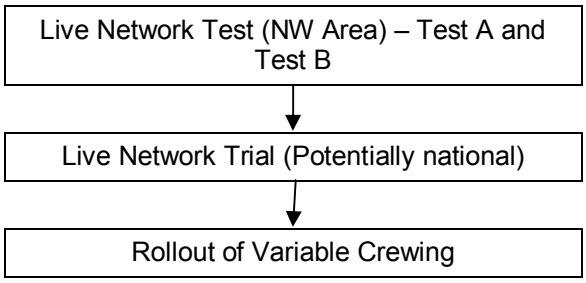
2.3.5 For the purposes of analysis operational performance was divided into driving performance and task performance. Driving performance encompasses work which takes place in the TO vehicle, either when moving or stationary. Task performance encompasses work outside the TO vehicle, such as at the scene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

2.3.6 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. However, Jacobs have analysed Accident Frequency Rate (AFR) data from TMD, to better understand the safety performance within the TOS (See Discussion).

2.3.7 Consideration of the social implications of lone crewing, particularly in terms of loneliness and boredom, did form part of the test, and the test was modified for Test B in order to better understand the effects. This is further detailed in the results section of the report, but the results carry a significant caveat, as the tested officers were never entirely alone.

2.4 Test Context

2.4.1 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 –



2.4.2 The breakdown of participants and the nature of the test durations for both Test A and Test B are summarised in Table 2.1below –

	Test B	Test A
Number of Test Participants (TO's)	14	16
Each Test Consists 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).	Six seven hour days in double crew mode (allowing 1 hour for brief/debrief) Six seven hour days in single crew mode (allowing 1 hour for brief/debrief
Number of Shifts	56	144

Table 2.1 – Test A and Test B breakdown

2.5 Aims and Objectives

2.5.1 The objectives of Test A and Test B are summarised in Table 2.2 below:

Test A Objectives	Test B Objectives
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 To record subjective and objective data against a range of measures which collectively provide a description of the operational performance of TO's. Obtain data whilst the TO's were patrolling the network and managing incidents under normal operational conditions, in so far as was possible	To repeat Test A over a full six day working shift pattern, including nights, RRB operations, with adapted in car controls and with a broader range of subjects (i.e. not carefully selected based on level of training) To record the same subjective and objective data measured in Test A, which would collectively provide a description of the operational performance of Traffic Officers To record performance data with the TO's patrolling the network and managing incidents under normal operational conditions, in so far as possible

Table 2.2 – Test A and Test B Objectives

2.6 Data Analysis

2.6.1 The data collected was then used to determine if there were any measurable differences between double and single crews with respect to workload, fatigue, mood and operational performance. As per Test A, a key aspect of the test was that it was applied to both double and single crews in order that a direct comparison could be made. The output from these analyses, together with potential mitigation measures, formed the basis for the assessment of the feasibility of single crewing.

2.6.2 Both Test A and Test B were 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.

2.6.3 For Test B, video footage was taken during the test in order to gain commentary and context which could be used to support any data obtained with regards to driving performance. The video recording equipment was able to take footage behind the vehicle (particularly relevant to RRB) and in front of the vehicle. See Paragraph 3.3.10 for further details.

2.6.4 The methods used for Test A and Test B are described in detail in the Test Methodology Report (See CD Reference 5.1 and 5.5).

2.7 Current Working Methods

2.7.1 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.

2.7.2 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 is commonly 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.

2.7.3 It is recognised that the procedures can not cover all the situations 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 a complete departure from process as a result of conditions on the ground.

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

2.7.5 A procedures review was undertaken for both Test A and Test B, with the aim of identifying those procedures that could not be undertaken single crewed or required prior modification before commencement of the tests.

2.7.6 The procedures used and modified for Test A and Test B are included within CD Reference 7.1 and 7.2.

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. The majority of the work has been restricted to desk studies, these are detailed below -

Title	Author	Date Published
Review of Crewing Levels Report	Halcrow	August 2009
HA Variable Crewing Implementation Study - Business Case	Atkins	December 2009
Single Crew Test Report	Atkins	December 2009

Table 3.1 – Previous Work

See CD Reference 2.0 for further information.

3.1.2 The Test Design for Test B was based upon that used for Test A, however there were some differences as detailed in Table 2.0. These modifications are detailed further within this section.

3.2 Test Design

3.2.1 The Project Team developed the previous work undertaken by others when producing the Test B design. 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 5.1 and 5.2.

3.2.2 The Live Network Test for both Test A and Test B included specific directed assessments of the following aspects of TO operational performance:

- Mood and tiredness
- Workload and Stress
- Fatigue
- Driving Performance
- Task Performance.

3.2.3 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 5.2, 5.5 and Appendix A).

3.2.4 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.

3.2.5 A RRB checklist (See Appendix A) for use by the SME was introduced during Test B in order to ensure that the procedure was applied consistently whilst also recording any differences that may be present when undertaking the procedure singly crewed.

3.2.6 To provide confidence that both tests would be safely achieved, the following activities were carried out in preparation for Test A and Test B:

Test A	Test B
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.	A further exercise was undertaken at Samlesbury Airfield in order to undertake several common procedures within a controlled environment, with particular reference to RRBs. The concept session was also an opportunity for the Test Participants to become familiar with the `rocker switch', introduced for Test B.
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).	

Test A	Test B
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 9.1 and 9.2).	

Table 3.2 – Test Preparation

3.2.7 The activities outlined above were reviewed and amended as appropriate for Test B. For further details see the Test A and Test B Design and Methodology Reports (CD Reference 5.1, 5.2 and 5.5).

3.2.8 Union Consultation was undertaken prior to the commencement of Test A and Test B. Comments received from the unions were considered in the final test design (See CD Reference 10).

3.2.9 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).

3.2.10 Specific objectives addressed by the test design included:

- The test was a comparative assessment of TO performance under both single and double crewing
- The test was deployed 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
- Whilst Test A did not require material change or adaptation of the TO vehicles, Test B drew on the findings from Test A and key vehicle amendments were made with the aim of ensuring driver attention to the primary driving task whilst singly crewed
- 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.

3.2.11 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 TO or Team Manager
- Human Factors Observer (HFO) – A trained and experienced experimental observer.

3.2.12 The SME and Observer were treated as `invisible’ by the TO when under test. When the TO was single crewed there was strictly limited interaction (or conversation) between the TO and the SME/Observer, except in relation to possible safety issues.

3.2.13 The individual characteristics and roles of each person in the test are described in detail in the Test A and Test B Design and Methodology Reports (See CD Reference 5.0).

3.3 Test Design Differences between Test A and Test B

3.3.1 Test B had some specific design inclusions that were not part of Test A. The following section details each of these test elements –

Fatigue

3.3.2 Participants in Test A were observed over a two shift cycle (two for double crew and two for single crew). This was not representative of a regular working shift cycle of a Traffic Officer and therefore the effects of fatigue associated with single crewing could not be fully understood. Therefore Test B participants were tested over six shifts (six for double crew and six for single crew) in order to better understand any difference in fatigue levels when comparing double and single crews.

Rolling Road Blocks

3.3.3 Test A did not consider Rolling Road Block (RRB) as it was deemed to be a procedure that was not suitable until a greater appreciation of the safety aspects of single crewing could be made. Test A was successful in providing this confidence and the HA now consider that RRB is within risk tolerance and was included within Test B.

3.3.4 There was no requirement for a specific test method for RRB; data capture methods previously employed were suitable. A specific protocol for the implementation of a Rolling Road Block to examine potential operational improvements was produced (See Appendix A5 of the Test B Methodology Report).

3.3.5 The Live Network Test for Test B included RRB. However, several of these were in the form of “mock ups” in addition to any actual incident responses.

Night Testing

3.3.6 The Test A design did not cater for night shift tests, at the request of the HA. It is noted that testing in the hours of darkness did happen within the first Live Network Test.

3.3.7 In order to assess variable crewing under all aspects of a Traffic Officers shift pattern, night testing was included in Test B. It was not anticipated that any additional measures were required to be implemented into the design to accommodate night shift tests.

New Procedures

3.3.8 Since the first phase of testing, a new procedure has been incorporated into the Traffic Officer Service. The Safety Intervention procedure allows the Traffic Officer to attempt to stop a vehicle where there is imminent danger to themselves or to other road users (e.g., lorry about to shed its load, running on a flat tyre).

3.3.9 This procedure was incorporated into Test B. The HA were responsible for developing any required protocol needed for its use when singly crewed.

CCTV

3.3.10 The HA decided that it was not suitable to undertake video footage of the test during Test A. However, it was deemed appropriate to include it for Test B, in

particular due to the inclusion of the RRB procedure, in order to support data obtained with regard to driving performance.

3.3.11 The data loggers used during the previous test have video capture technology and were used to capture video footage behind the vehicle (particularly relevant to RRB) and of the carriageway in front of the vehicle.

3.3.12 The video equipment was temporarily fixed to the vehicle (e.g. using cable ties, tape) and did not require any formal modification of HA vehicles.

3.3.13 The video data was used only for test data analysis and was destroyed after use.

Test Arrangement and Volunteers

3.3.14 In a double crew scenario both Traffic Officers would be tested simultaneously and they would swap roles (Driver or Observer) during each shift.

3.3.15 Any Traffic Officer could volunteer to take part in the test (i.e. no selection process based on training/assessment would limit participation).

Vehicle Modification and Vehicle Type

3.3.16 The vehicles were modified with a 'rocker switch', placed in a location more accessible from the driver's seat. This would allow for immediate control of the lightbar (See section 4.6.5).

3.3.17 The Landrover Discovery and Mitsibushi Shogun vehicles were used for Test B.

3.4 Limitations

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

- 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 which require multiple TOs to control traffic – often these procedures could not be carried out by a double crew patrol alone.

3.4.2 There are no tunnels in the NW region.

3.4.3 Rearward Relief and control of traffic are procedures which typically require a multi-agency response and are rare. These were not considered to be significant constraints.

3.4.4 The TO's who participated in Test A were selected from a pool of enthusiastic volunteers who had specific relevant experience and training. In order to test a broader representation of the TOS, Test B invited TO's without any pre requisite for training or experience. This process is further described in Section 4.2 below. There remains a risk that findings relating to this group may not be applicable to the remainder of the service, as the group who volunteered may not be representative of the broad service.

3.4.5 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 further discrepancies or anomalies when applying outputs from this test in

other regions. As the procedures are national we would expect such discrepancies to be minor.

3.4.6 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.

3.4.7 The test was designed to look at the operational effectiveness of the TO under test. The test did 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 unplanned 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.

3.4.8 Shift patterns are not consistent across the different HA regions and there are variations within the NW region. Rob Lane outstation works a different shift pattern to other outstations, and was therefore excluded from this test. There remains a risk that the results of this test may not be applicable to those regions operating under a different roster regime.

3.5 Authorisation

3.5.1 The HA form PT1, which authorised a Live Network Test in the form of Test A, was signed in May 2010. The same form for Test B was signed in September 2011. Both forms are included within CD Reference 4.1 and 4.2.

4 TEST METHOD

4.1 Background

4.1.1 Test A and Test B 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 The methodology used for Test A can be found in CD Reference 5.1.

4.1.3 A control fleet of vehicles was used for Test B (Landrover Discovery with modifications and Mitsibushi Shogun), but this was not always the same type of vehicle.

4.1.4 The following section highlights key elements of the Test B design. For further details refer to the Test B Design Report (CD Reference 5.5).

4.2 Test Schedule

4.2.1 As far as possible, Traffic Officers would undertake the tests whilst working within their usual shift roster. There were however some instances where their shift roster had to be modified in order to accommodate them.

4.2.2 An appropriate rostering schedule was arranged by the HA, with each Test Participant being observed over 12 shifts, comprising six shifts of eight hour durations in double crew mode followed by three 'rest days' and then six shifts of eight hour durations in single crew mode.

4.2.3 It was important that the roster included, as far as possible, an even spread of early, late and night shifts and that some of the subjects were tested in a double and single crew following the same pattern, e.g. three early shifts followed by three late shifts (EEELLL) on double and EEELLL on single – this proved possible for 10 subjects, with the others having to follow a different pattern in a single crew. This type of shift pattern was the same as would normally be followed if the subjects were not being tested. A subject was always tested in a double crew scenario before being tested in a single crew.

4.2.4 The original schedule accounted for a total of eight tests (each with two test participants). This schedule included 144 shifts, 48 in double crew and 96 in single crew. The test shifts were all a standard eight hours long and followed regular shift patterns distributed across week days and weekends. Table 4.0 below shows an overview of the test schedule.

Subject No.	Test No.	Location	Shift Pattern	Number of Shifts				Vehicle Model
				Total	Early	Late	Night	
1	1	Knutsford	EEELLL/EEELLL	12	6	6	0	Mitsibushi Shogun
2	1	Knutsford	EEELLL/NNNNNN	12	3	3	0	
3	2	Milnrow	EEELLL/EEENNN	12	6	3	3	Landrover Discovery
4	2	Milnrow	EEELLL/EEELLL	12	6	6	3	
5	3	Cumbria	EEELLL/EEELLL	12	6	6	0	Landrover Discovery
6	3	Cumbria	EEELLL/EEELLL	12	6	6	0	
7	4	Samlesbury	EEELLL/EEELLL	12	6	3	0	Landrover Discovery
8	4	Samlesbury	EEELLL/NNNNNN	12	3	3	6	
9	5	Knutsford	EEELLL/EEELLL	12	3	6	0	Mitsibushi Shogun
10	5	Knutsford	EEELLL/NNNNNN	12	3	3	6	
11	6	Milnrow	EEENNN/EEENNN	12	6	0	6	Landrover Discovery
12	6	Milnrow	EEENNN/EEENNN	12	6	0	6	
13	7	Samlesbury	EEELLL/EEELLL	12	6	6	0	Landrover Discovery
14	7	Samlesbury	EEELLL/NNNNNN	12	3	3	6	
15	8	Samlesbury	EEELLL/EEELLL	12	6	6	0	Mitsibushi Shogun
16	8	Samlesbury	EEELLL/NNNNNN	12	3	0	6	
Totals				**192**	**78**	**64**	**36**	

Table 4.0 – Overview of Test Schedule

4.3 Test Participants and Selection Process

4.3.1 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.

4.3.2 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.

4.3.3 The individual characteristics and roles of each person in the test are described in detail in the following sections.

Subject Matter Expert

4.3.4 There was one SME per test vehicle. The primary role of the SME was to ensure the safety of the HFO during the test. The SME accompanied the HFO at all times, managing how and when they left the TO patrol vehicle, and what they did and where they were positioned when observing any incidents.

4.3.5 The secondary role of the SME was to provide expert assessment of TO performance (especially driving, call handling and incident management), with

an emphasis on appraising the TO's adherence to procedures, safe working and task quality via checklists and debriefing notes. The SME thus provided both expert assessment and interpretation or explanation of TO behaviour / decisions for the benefit of the HFO's recording.

4.3.6 Thirdly, under single crewing, the SME provided mitigation for any situation that a single TO could not manage or cope with alone; i.e. the SME was available to provide operational back-up / support to the TO in an "emergency" situation, or one requiring the timely conduct of one or more TO procedures that currently preclude single person operation. The operational protocol for such an event was as follows:

- The TO would make the normal suitable and sufficient DRA of a situation / event / incident
- Should the DRA indicate that the TO cannot safely manage / cope alone, they could ask the SME to act as a second supporting TO
- In this event, the SME's first concern would be to get the HFO to a place of safety (e.g. beyond the hard-shoulder barrier), before undertaking any other activity
- Once the safety of the HFO was assured, the SME could act as a TO until the situation was suitably dealt with (i.e. DRA indicates safe reversion to single crew mode / or the incident has been cleared)
- This option would be considered a "last resort" where circumstances were determined to require instant / rapid response; the "normal" preference for events / activities that a single TO cannot manage, for whatever reason, would be to call for back-up
- The SME was not expected to make the assessment of whether or not an incident could be handled by a TO, nor to suggest or recommend that the test should be stopped and returned to normal operation, except in the most exceptional circumstances – the TO's DRA should be the key driver and under all circumstances the SME's primary responsibility was to ensure the safety of the HFO.

4.3.7 The SME needed to be:

- A highly experienced TO or Traffic Officer Manager
- Ideally be currently (or until recently) operational as a TO
- Preferably have been involved in Test A either as a test subject or SME
- Be trained to undertake the test methods
- Be reasonably open minded about the feasibility of single crewing.

4.3.8 The SMEs had to have an extensive and up to date knowledge of the working procedures and the operations of a TO. They had to have had a wealth of on-road experience and have attended a range of situations/incidents. They also needed to have a positive attitude and good communications skills coupled with a willingness to share information.

Human Factors Observer (HFO)

4.3.9 There was one HFO per test vehicle. The primary role of the observer is to brief participants, manage and deliver tests, record the event timeline and record / capture test data.

4.3.10 The HFO needed to be:

- Suitably experienced in administering subjective questionnaires and in data collection and social survey observation methods
- Experienced and capable of facilitating and managing post test debriefing sessions
- Personable and good at teamwork
- Capable of taking and strictly adhering to direction from the SME.

4.3.11 The HFO needed to be experienced in social survey methodology and recording practices. In addition they had to have an in depth knowledge of the testing methodology and aims. A total of five HFO's were used; four of these were CCD employees with the fifth being recruited internally from the HA and placed on secondment to the variable crewing project.

TO Test Participants

4.3.12 In each vehicle for each test, there was either one TO (for a single crew test) or two TOs (for a dual crew test).

4.3.13 A total of 16 test subjects were recruited, which exceeded the minimum number of TO test subjects required for statistical validity established as 14[1]. The demographic of the test subjects were as follows:

- Number of male subjects = 15
- Number of female subjects = 1
- Average age of subjects = 43 years
- Average years of experience = 5 years.

4.3.14 The TO test subjects regular role on the network did not change. They performed any and all of the normal duties of a TO.

4.3.15 TO subjects were unable to take part in the test if any of the following were relevant to them:

- Pregnant
- Have a pacemaker
- Have a heart condition
- Be a newly qualified / inexperienced TO
- Taking any fatigue accentuating medicines.

4.3.16 The subject had to be knowledgeable and have enough experience to be able to make a detailed assessment of the way in which they work on the network and will feel comfortable working as a single crew. It was also necessary for

[1] This is based on a statistical power calculation, combining the level of error detection required. This is currently set at the absolute minimum for scientific validity. D.C.Howell, 1992. Statistical Methods for Psychology, 3rd Ed. *PWS*, Kent.

them to have a positive attitude and good communications skills with a willingness to share information.

4.3.17 The TOs currently work in a double crew with two distinct roles:

- Driver
- Observer.

4.3.18 The main role of the driver is to control the vehicle on the network and attend incidents. Additionally, the driver will attend to radio communications with the RCC when initially on scene at an incident, e.g. marker post and vehicle registration and will also act as a 'look-out' for the Observer.

4.3.19 The primary role of the Observer in the vehicle is to attend to the radio communications whilst in motion and interact with the light bar and VMP as necessary. On scene they will communicate and co-ordinate with those involved in the incident, e.g. drivers, police, fire and ambulance, recovery services and Incident Support Units.

4.3.20 In single crew mode, the TO acts as both Driver and Observer, undertaking all tasks for both roles.

Test Participants' Selection Process

4.3.21 The HA were keen for TOs of all experiences and backgrounds to have the opportunity to be involved in Test B either as a TO or SME. Officers from five outstations (Milness, Lowhurst, Samlesbury, Milnrow, Knutsford[2]) in the North West region were asked to volunteer to take part in Test B: those that did were then randomly selected or, in some instances, chosen based on the rostering schedule and availability. In total, 16 test subjects were chosen.

4.3.22 The demographic of the test subjects was predominantly male, with an average age of 43 years, in good health and relatively fit.

4.3.23 A total of seven SME's was required to take part in the Test B schedule. Volunteers were selected based on their skills, experience and previous involvement in Test A, but did not have to possess coaching qualifications.

4.4 Test Methods

4.4.1 Test B included specific directed assessments of the following aspects of TO operational performance:

- Mood and tiredness
- Workload and Stress
- Fatigue
- Driving Performance
- Task Performance
- RRB Procedure Checklist.

4.4.2 The various methods for measuring each of these aspects of performance are detailed in the following sections.

4.4.3 In addition to the directed assessment methods an event timeline was completed by the HFO during the shift to capture key events and points in

[2] Volunteers from Rob Lane outstation had to be discounted due to them operating to a different rostering system to the rest of the outstations in the North West.

time when the vehicle was stationary, e.g. service stations, strategic positioning, etc. This information was then used, if necessary, during the debriefing sessions to clarify any points and understand decisions made by the TO. The timeline was also used as a reference point against the subjective scales, data logger (where applicable) and heart rate monitor output.

Activity and Event Timeline Recording

4.4.4 The HFO recorded occurrences and environmental considerations for correlation with the recorded data. In addition they only consulted the SME for resolution of confusion on those occasions where they were unsure of the process being conducted.

Questionnaires

4.4.5 The following sections detail the various questionnaires that were administered; the questionnaires themselves are illustrated in Appendix A.

Background Information Questionaire

4.4.6 This was administered to all TO test subjects and SMEs at the start of their test period.

Brief Mood Introspection Scale (BMIS) questionnaire

4.4.7 A BMIS questionnaire was administered by the HFO at the beginning of each daily shift, at a convenient time during the shift (approximately the middle) and again at the end of the shift.

Stanford Sleepiness Scale (SSS) questionnaire

4.4.8 An SSS questionnaire was administered at the beginning of each daily shift, at a convenient time during the shift (approximately mid-way through) and again at the end of the shift. The SSS can be found in Appendix A.

Workload and Stress Measurement

4.4.9 A key element of the assessment was to determine the physical and mental demands on the TO in single and dual crew scenarios. The methods used for the live network test included heart rate monitoring and subjective rating scales:

- A heart rate monitor was used to record the subjects' heart rate throughout the daily shift. The heart rate monitor used was a non invasive unit consisting of a remote data recording device on a wrist strap and a lightweight heart rate monitor attached to a strap placed around the chest of the subject. The wrist strap was worn by the TO. The heart rate results were used in conjunction with the subjective rating scales against the activity timeline to determine if there were any correlations between heart rate and physical / mental demands, particularly in comparing dual and single crewing. It should be noted that the resting heart rates of the subjects was not taken before commencement of the test
- There were four subjective assessment scales that subjects completed during the test:
    - Mental – determine how mentally demanding a task/period of time was

- Physical - determine how physically demanding a task/period of time was
- Temporal – determine how hurried or rushed the task/period of time was
- Frustration – determine how frustrated, discouraged, irritated, stressed the subject was during the task/period of time.

4.4.10 All four of the Workload scales were administered to each subject by the HFO at the start and finish of each daily shift and at regular hourly intervals throughout the shift, as well as immediately after any event that required the TO's to undertake task's outside of the vehicle.

4.4.11 The subjective assessment scales are shown in Appendix A.

Fatigue Assessment

4.4.12 Fatigue levels were assessed using an adapted Visual Analogue Scale, which included a series of different questions assessing various aspects of fatigue related symptoms specifically related to the task/s being undertaken.

4.4.13 All of the scales were administered to each subject by the HFO at the start and finish of each daily shift and at regular hourly intervals throughout the shift, as well as immediately after any event that required the TO/s to undertake task/s outside of the vehicle.

4.4.14 The subjective assessment scales are shown in Appendix A.

TO Driving Performance Assessment

4.4.15 An assessment of TO driving performance was conducted by the SME on an incident attendance basis. The incident period includes the driving period preceding the incident and up to the point where the TO vehicle has rejoined the carriageway. On those shifts where there were no incidents then the prolonged period of driving counted as an incident and a form was completed. The network and environmental conditions were noted during the trip (by the HFO and SME) as part of the timeline information capture.

4.4.16 A data recording box was temporarily installed into test vehicles used at Knutsford for the duration of Test 1 (Subjects 1 & 3) and Test 5 (Subjects 9 & 10) and Milnrow for Test 2 (Subjects 3 & 4) and 5 and Milnrow for Test 2(Subjects 3 & 4). The data logger uses GPS technology and feedback from two small cameras to provide speed distance time and acceleration data. This was planned to be used as a supportive tool to provide objective data on driving performance. The CCTV images were used to provide context to incidents and occurrences which were considered important during the analysis phase such as RRBs in single crews, complex incidents or occasions where the SME may have given the test subject a minus driving performance score.

4.4.17 Note: The camera positions were determined and fitted by HA with one mounted facing out of the rear window and the other located centrally on the dashboard directed out of the windscreen. There were no cameras directly facing the subject or any other occupants of the vehicle.

4.4.18 The SME completed a driving form whilst the vehicle was in motion. This information was then used at debrief by the SME to clarify any decisions made by the TO.

4.4.19 The form requires an “overall” assessment of driving performance, a log of any key events and an assessment of various detailed aspects of driving related activities.

4.4.20 The HFO facilitated a debrief session following each shift which included both the SME and TOs. These sessions provided the opportunity for the team to discuss any incidents that had occurred during the shift and to add useful qualitative information, including observations, explanations and or qualifications that may better illuminate the results. Members of the HA delivery team were present at the first and last brief / de brief in order to gather useful information and to use lessons learnt to inform the future tests.

4.4.21 The assessment forms are shown in Appendix A.

TO Task Performance Assessment

4.4.22 An assessment of the TO task performance was conducted by the SME who observed TO activity in company with the HFO from a safe position on the network.

4.4.23 The assessment was conducted on an incident attendance basis. The incident period commenced from the moment the TO emerged from the vehicle (the driving elements will be assessed in the driving assessment) and ended when the TO had re-entered the vehicle at the end of the incident. The network and environmental conditions were noted during the trip (by the observer) as part of the timeline information capture.

4.4.24 The SME completed a task performance for each event / incident scene attended. Additionally, the SME provided an explanatory commentary, where required, that enabled the HFO to capture any specific detail of interest.

4.4.25 The TO Task Performance recording form is shown in Appendix A.

TO Rolling Road Block Procedure Checklist

4.4.26 An assessment of the TO performance during RRB’s and Ghost Rolling Road Block (GRRBs) was conducted by the SME. This consisted of a checklist taken from the HA procedures. The purpose of the checklist was to identify any task elements which were omitted or not possible during single crew RRBs.

4.4.27 The SME completed a RRB checklist after every RRB or GRRB.

4.4.28 The RRB checklist can be found in Appendix A.

Test Delivery

Test Timing and Daily Schedule

4.4.29 The hourly administering of questionnaires (workload / stress and fatigue) was conducted with the vehicle stationary and ‘off network’.

4.4.30 The HFO was responsible for managing timing, warning the TO of an impending data recording session and asking them to find an appropriate exit / location to stop the vehicle off the network.

4.4.31 The TO was responsible for determining when and how to proceed to a location where they felt it was safe to stop the vehicle and complete a questionnaire.

4.4.32 A pragmatic and realistic approach was taken to the timing of questionnaire sessions, such that the hourly timings were treated as approximate, allowing the TOs to find the most convenient time and location to stop.

4.4.33 Post event / incident questionnaires were administered only in so far as it was convenient for the TOs to stop off-network.

4.4.34 The duration of each stop for completion of all hourly questionnaires was approximately 5 minutes.

Operational Philosophy

4.4.35 The TO was to act in a fully operational capacity at all times and all were briefed to understand that operational necessities / requirements should take precedence over the Test at all times. This meant that the TO could decide to abandon the Test at any time and for any reason, they could also call on the SME to help, if circumstances required, thereby ceasing operation in single crew mode. There were instances during Test B where the test was halted at the request of the test participants.

4.4.36 For the live network Test to provide realistic and useful data it was intended to be conducted under ”normal” operating conditions, i.e. the crews would undertake normal patrol shifts and be dispatched by the RCC to incidents or events, regardless of whether the vehicle was single or double crewed.

In Vehicle Arrangements

4.4.37 The in-vehicle arrangements are shown in Figure 4.0 and the same as in Test A apart from two subjects were being tested simultaneously in the double crew phase.

4.4.38 The test vehicles for the single and double crew conditions were kept the same.

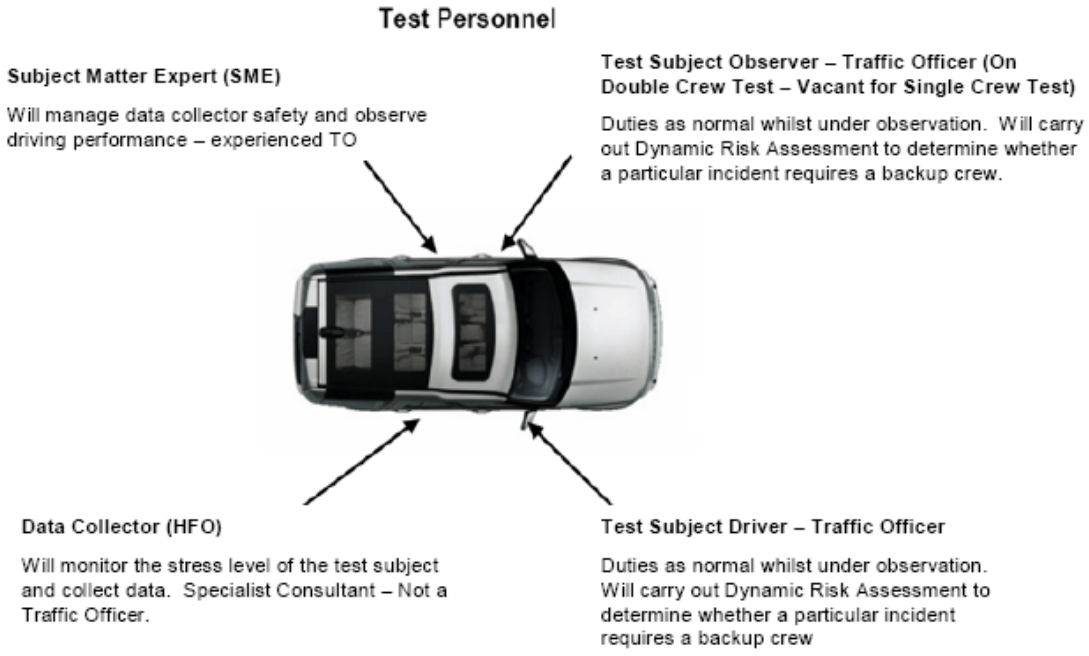


Figure 4.0 – In Vehicle Arrangements

Test Operation and Safety Protocols

4.4.39 The following operational and safety protocols were implemented within the test:

- The SME had primary responsibility for the safety of the HFO and this responsibility took precedence over all others
- The HFO were not actively identifiable by the public as they were not intended to have any direct contact with them. The HFO wore appropriate Hi Vis clothing (similar to that of the Traffic Officers but without the official markings)
- On arrival at an incident the SME made a DRA and decided on the safest way to proceed. The SME and Observer always exited the vehicle when stationary on the network. However, if the SME's DRA dictated a deviation from this, the SME explained the decision and relayed action to the HFO who would act as requested
- At incidents, the following protocol was applicable, where possible:
    - Vehicle stops in lane 1 or on the hard shoulder: the HFO and SME should exit via the nearside and proceed immediately with the SME and under his / her guidance to the place of safety the SME chooses. The SME (sitting always on the near-side rear seat) will exit the vehicle first and the HFO will slide across to follow
    - When the vehicle stops in lane 2 or 3, the HFO and SME should exit via the offside and proceed immediately with the SME and under his / her guidance to the place of safety the SME chooses. This may entail the HFO leaving the vehicle first, which will only be done if the SME determines that this is the safest option, rather than waiting for the SME to leave by the nearside door and come around the vehicle first
    - When the TO vehicle stops in a carriageway of greater than 3 lanes the SME will decide and explain the safety procedure for exiting the vehicle. The default will always be to exit the vehicle on the opposite side to the 'live' traffic
- The normal "place of safety" on the nearside (hard shoulder) will be beyond the crash barrier. Whether this is in front of or beyond the incident will be determined and decided by the SME
- The normal "place of safety" on the far-side (3rd lane) will also be beyond the crash barrier, where the carriageway includes a suitably sized central reservation with a gap between barriers for either carriageway, or wherever the SME otherwise deems most safe. Whether the location is in front of or beyond the incident will be determined and decided by the SME
- The SME will keep the HFO with them at all times when attending an incident. The exception will be if reversion from single to double crewing has been decided upon, in which case the SME will ensure that the HFO is placed in a position of safety before undertaking any other tasks or leaving the HFO alone.

Equipment Adaptations for the Test

4.4.40 The standard primary controls in the front of the patrol vehicle include:

- Light bar control pad
- VMP

- Radio controls, speaker and stalk (attached to steering wheel)
- Mobile telephone.

4.4.41 In a double crew the controls within the vehicle are usually operated by the Observer and are accessible from the passenger seat. An issue was raised in Test A relating to the position of the light control pad when in a single crew; the TO has to be in control of driving as well as interacting with the pad, which is located in the central console on the passenger side. In Test A the subjects had to avert their eyes from the road for a short time whilst driving to activate the 'At Scene' button on the pad. There were a few occurrences where this caused minor drifting on the road or the TO striking the 'Reset' function in error. To counteract this, the HA proposed that a 'rocker switch' be installed in Test B. The rocker switch was designed to allow the TO to be able to activate the primary functions of the light bar whilst driving without having to interact with the standard light control pad. The switch is shown in Figure 4.1 and has the following functions:

- Red – equivalent of selecting 'Arr' on the control pad. This activates the rear ambers and reds. This option should be used in live lane. The red section of the switch is illuminated when pressed
- Amber – equivalent of selecting 'Emer' on the control pad. This activates the front and rear ambers. This should be used when on the hard shoulder or in slow moving traffic. The amber section of the switch is illuminated when pressed.

Figure 4.1 Rocker switch used to activate light bar

4.4.42 It is not possible to operate the main light control pad if the rocker switch is in use. Use of the control pad is only possible if the rocker switch is in neutral.

4.4.43 The HA decided on a suitable location for the rocker switch and designed and implemented the type shown in Figure 4.2.

4.4.44 Figure 4.2 shows the rocker switch installed in the Landrover and Mitsibushi vehicles used for Test B.

Figure 4.2: Location of rocker switch in Land Rover Discovery

Location of rocker switch in Mitsubishi Shogun

4.5 Test Briefing

4.5.1 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" TOs with the knowledge they needed to ensure safe test operation.

4.5.2 A two day briefing session was held at the Warrington Wolves Rugby League Stadium on the 12th and 13th of September 2011, and was attended by all the test participants. This was followed by a further track based day at Samlesbury Airfield to further embed the learning.

4.5.3 For details of the Briefing Sessions, see CD Reference 5.4 and 5.7.

5 RESULTS

5.1 Overview

5.1.1 This section details the results of Test B only. For Test A results refer to the Test A Feasibility Report (CD Reference 3.1 and 3.2)

5.2 Test Implementation

5.2.1 A total of 8 tests was completed between October 2nd 2011 and November 28th 2011. Each test was scheduled to consist of two TO test participants completing a double crew test and a single crew test, totalling 144 shifts (48 double crewed and 96 single crewed). During Test B a total of six shifts were cancelled so a total of 138 shifts were completed over the test period.

5.3 Cancellation of tests

5.3.1 Prior to commencing the tests, the subjects were told by the HA that when working as a single crew, they could call a halt to the test at any time if they felt that their own or the other vehicles occupants safety was at risk or compromised. Equally, the SME was able to intervene if they considered the incident was not suitable for a single crew to deal with and there could be safety implications. A total of six shifts was cancelled for these reasons.

5.3.2 During Test 1 single testing, a test subject and the SME terminated the test half way through a block of six shifts as they were concerned about their safety. This occurred during a late shift when the test subject came across a traffic cone in live lane and swerved to avoid it. This was unexpected and the test subject reached to use the rocker switch but had difficulty locating it in the dark, as it is not backlit. The test subject then took his eyes off of the road to try and locate the light control pad causing a minor vehicle swerve. The incident caused the SME and test subject to feel unsafe; that is they did not consider the rocker switch to be a safe item of equipment to use. For this reason they suspended the remainder of the shift and did not feel able to complete the rest of the test. No other test subjects or SME's on other tests reported feeling unsafe because of the rocker switch.

5.3.3 Following on from this incident, as a quick short term solution to ensure that remainder of the tests went ahead, the HA made a decision to modify all rocker switches within the vehicles taking part in Test B. The modification involved sticking white tape around the surround of the switch with the aspiration that the location would be more obvious in the dark, see Figure 5.0. However, the same SME was due to take part on another batch of tests and declined to continue in the role as SME without further switch adaptations. For Test 5 vehicle only, the HA authorised that the rocker switch be removed and the light control panel to be relocated close to the VMP (See Figure 5.0). This modification was acceptable to the SME and Test 5 went ahead as scheduled.

Figure 5.0: Rocker switch highlighted by white tape.

Re-located light control panel in Mitsubishi Shogun.

5.3.4 During the test period a further 2 shifts had to be cancelled because of test subjects needing to take unforeseen leave (Subject 3, Test 2 double and Subject 9, Test 5 double) and 1 shift cancelled because the SME was unable to get to the outstation due to a motorway incident (Subject 15, Test 8 single). In addition, the SME on Test 8 terminated the second double shift, as he was called to assist with an urgent technical issue elsewhere, independent of the Test, relating to light bars.

5.4 Reverting to Double Crew

5.4.1 The presence of the SME (who is also an experienced TO) in the vehicle meant that reversion to double crew mode was possible, should the TO or SME feel that the incident could not be completed safely in a single crew or the incident required extra resource e.g. a serious, multiple RTC.

5.4.2 During the test period there were 3 incidents where the SME had to assist the single crew TO, as shown in Table 5.0.

Test No.	Date / Time	Incident Details	Reason for reversion to double crew
5	25th Nov / 00.45	Abandoned vehicle. Driver returned to the vehicle. Vehicle was not insured.	Customer appeared agitated and SME was concerned for the safety of the TO. In the debrief the SME stated that he had been hasty and the TO could have handled it alone.
8	7th Nov / 17.00	Sheep in carriageway	Extra resource required to help capture sheep.
8	6th Nov/ 01.45	Major RTC	Extra resource required to assist with the RTC. SME also had to complete Silver Command duties.

Table 5.0 - Reversion to double crew

5.5 Near Misses

5.5.1 The HA consider a 'Near Miss' to *"be an event which could have injured you or could have damaged property and equipment, e.g. when unloading cones from the vehicle the bottom cone in the stack drops out just missing your foot. It could also be unsafe conditions or circumstances, e.g. first aid kit missing from a vehicle."*

5.5.2 Reporting of a near miss is actively encouraged as they may indicate that risk assessments, procedures or equipment need to be reviewed.

5.5.3 During the test schedule there were a total of 14 near misses was reported. A 'Near Miss Wash-up' meeting was held by the HA on November 28th 2011 at NW RCC. A total of nine test participants (TOs and SMEs) attended the meeting along with union representation, health and safety and management. The purpose of the meeting was to discuss each of the near miss reports and determine if it was safety critical and whether or not it needed to be resolved before any possible roll out of single crewing.

5.5.4 Table 5.1 provides a summary of the near miss reports. Some of the near misses are applicable to single crewing and are discussed in this report. A formal document is to be prepared by the HA that will report on all of the near misses.

Near Miss	Total for test
Unable to see buttons on VMP	2
VMP display too bright/could not be seen clearly	2
Unable to find rocker switch	1
Rocker switch does not allow for front lights to be used	1
Collapsed 610	1
Airwave failure during RRB	1
Single crew put on stand-by and could not radio in location	1
Unable to read airwave screen whilst driving due to reflection	1

Near Miss	Total for test
Signals set on the wrong motorway for simulated RRB	1
Gantry VMS not visible to LGV	1
Patrol back VMS not visible in the sun	1
Lane 3 target vehicle overshot due to distraction from another vehicle	1

Table 5.1: Near Misses reported during the test

5.6 Incidents

5.6.1 During Test B, 349 significant incidents[3] were attended to by the TOs as part of the test schedule. This is in comparison to 227 incidents attended in Test A. Table 5.2 and Figure 5.0 shows the numbers of types of incident that occurred in double and single crew test shifts.

5.6.2 Overall, test subjects attended a greater number of incidents in single crew (213 incidents) than in double (136 incidents). The most common type of incident under both double and single tests was routine hard shoulder breakdowns (29% and 31%). A greater number of RRBs were completed in single where as the number of GRRBs was similar in double and single crew.

Type of Incident	Double Crew		Single Crew		Total for Tests	
Routine H/S BDV	39	29%	67	31%	106	30%
Live lane debris	16	11%	30	14%	46	13%
Minor RTC (non injury)	11	8%	11	5%	22	6%
Major RTC (multiple/fatality)	5	4%	1	1%	6	2%
Rolling Road Block	11	8%	28	13%	39	11%
Ghost Rolling Road Block	26	19%	30	14%	56	16%
Live lane breakdown	9	7%	16	8%	25	7%
Pedestrians	3	2%	5	2%	8	2%
Abandoned vehicle	3	2%	5	2%	8	2%
Lane Closure	2	1%	6	3%	8	2%
'Other'	12	9%	14	7%	26	7%
TOTALS	**136**		**213**		**349**	
Note: Routine H/S BDV refers to a hard shoulder breakdown. The term 'Other' refers to incidents such as dealing with welfare stops, vehicles stopped on the hard shoulder, etc.						

Table 5.2: Numbers of incident types encountered by double and single crews during the Tests

[3] A "significant incident" refers to one 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 (i.e. usually less than a minute). Incidents where TOs were 'stood down' before completing any tasks have not been included but may have been scored by the SME on elements such as driving aspects.

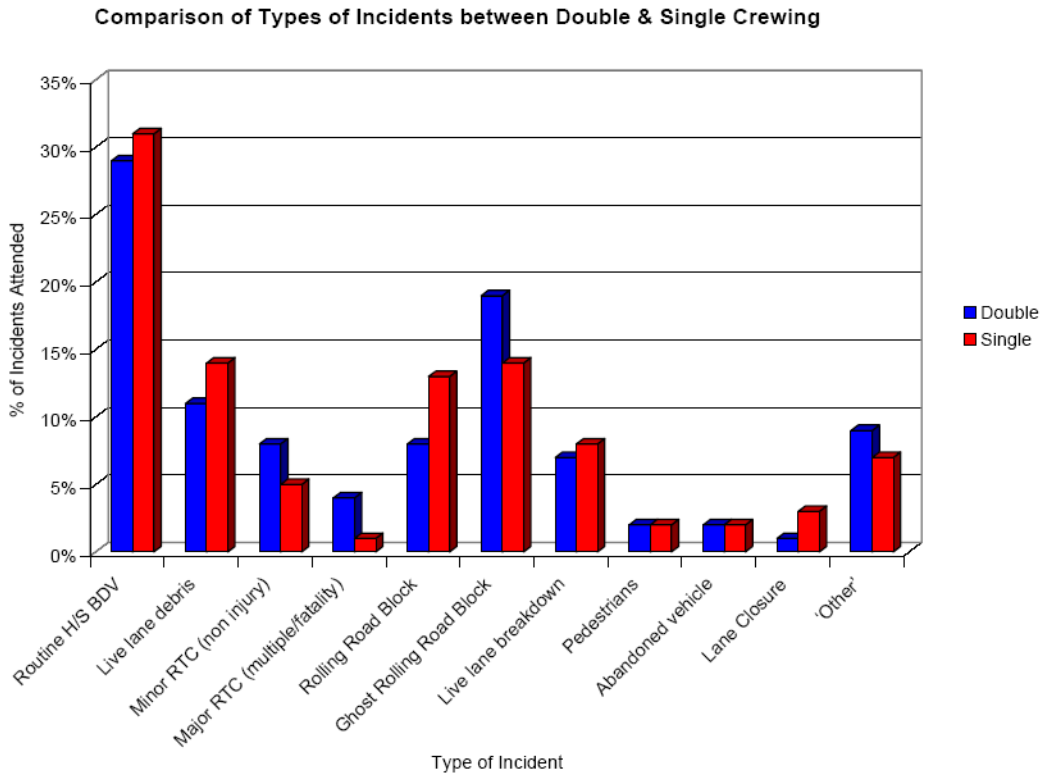


Figure 5.0: Comparison of incident types attended by double and single crews

5.6.3 For comparison, Table 5.3 shows the incident data recorded by the HA[4] for the North West region during Test B, A total of 9,054 incidents were attended by 2,313 Highways Agency patrols: 5011 incidents during the double testing phase and 4043 in the single phase, excluding the incidents / patrols involved in the test. During the double phase of testing, on average patrols attended 6 incidents per shift and 2.7 incidents in single. In comparison, on average, those patrols actually involved in the test attended 3 incidents per shift in double and 2.5 incidents in single. It should be noted, that in reality more incidents were attended overall in single testing than double.

5.6.4 The table below breaks down the number of incidents attended by the North West region during the test period and compares this with those incidents attended during the test.

	Total Number	Double Crew	Single Crew
Total Number of Incidents Attended in NW Region	9054	5011 (55.4%)	4043 (44.6%)
Factored Numbers (See Note 1 below)	349 349	193 (55.4%) 139 (40%)	156 (44.6%) 210 (60%)
Total Number of incidents attended during Test B	349	136 (39%)	213 (61%)
Variance		-3	+3

Table 5.3 – Comparison of number of incidents attended during Test B

[4] Data supplied by the NW RCC

Note 1 – The incidents attended in the NW Region have been factored down to compare against the number of incidents undertaken during Test B. The second set of factored numbers reflect the fact that for every double crew test there are two single crew tests (A 1/3 – 2/3 split).

5.6.5 Table 5.3 shows that the number of incidents attended during Test B are representative of the number of incidents attended by the North West region as a whole over the same period. There are more incidents attended whilst single crewed, however this is not surprising, considering that for every double crew test there were two single crew tests (excluding cancelled or halted tests).

5.7 Physical Demands

5.7.1 Subjective Rating

5.7.2 During each double and single test, subjects were asked on an hourly basis (or after completing an incident) to rate how physically demanding the tasks had been on a 7 point scale, ranging from 1=Not demanding to 7=Very demanding. The physical demand rating scale was asked a total of 1385 times during the test schedule.

5.7.3 Figure 5.1 shows, on average, the differences in physical demand between double and single for each test subject.

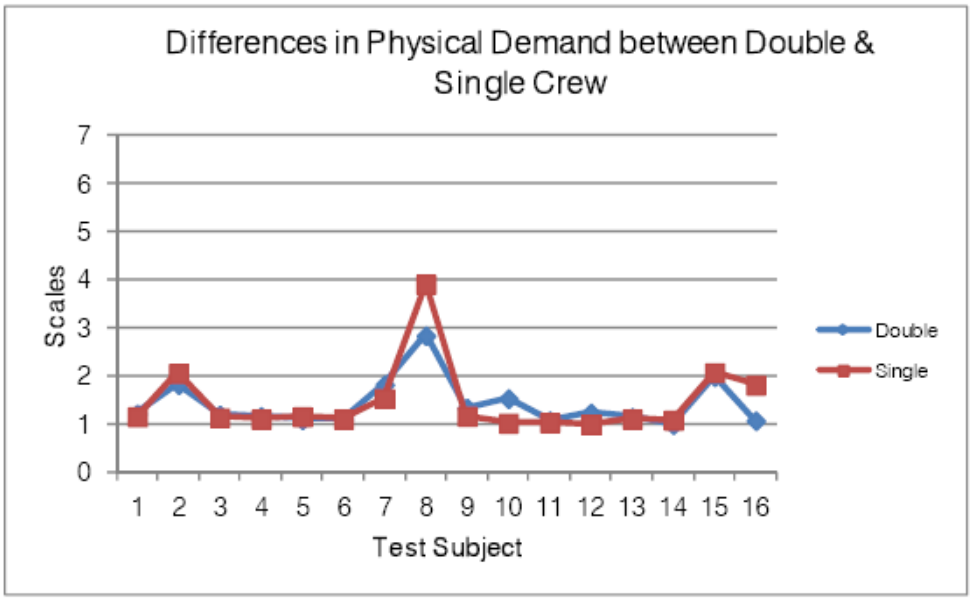


Figure 5.1: Averages differences for physical demand

5.7.4 The graph shows that there was no discernable difference in the averages of the subjective perception of physical demand between double or single crew modes.

5.7.5 Analysing the results in further detail, Figure 5.2 displays the cumulative physical scores where 4 (moderate demand) and >4 (with 7 being very demanding) were chosen in double and single crew.

5.7.6 A score of 4 was recorded 23 times in double and 53 times in single. However, it should be noted that 43 (81%) of these scores in the single category are attributable to Subject 8, Test 4. Furthermore, in double crew, the same test subject consistently recorded scores of 4 equating to 52% of the overall total.

5.7.7 A score of greater than four, i.e. 5, 6 or 7, was recorded 13 times in double crew and on 5 occasions in single crew. Subject 8 was accountable for 30% of the >4 scores in double crew.

5.7.8 The high scores recorded by the test subject are surprising given that the other subject on Test 4 reported comparatively much lower scores during their double shifts. Furthermore, it is interesting to note that the test subject completed their single shifts on nights and contextual information indicates that they attended, on average, less than one incident per shift and that these were minor, e.g. simulated RRB, H/S BDV etc, and on two of the shifts the vehicle did not leave the outstation.

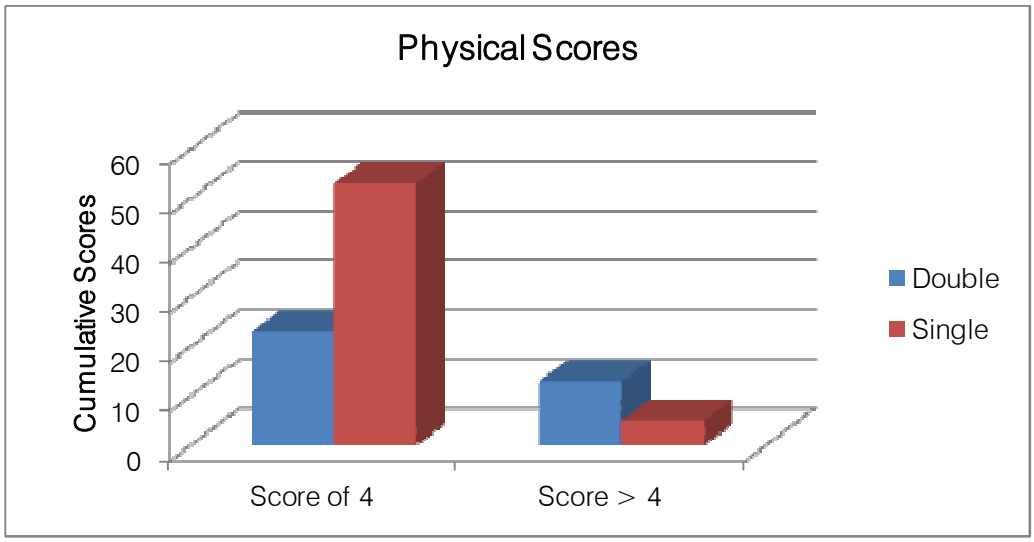


Figure 5.2: Comparison of cumulative scores of 4 and >4

5.7.9 This information suggests that, overall, this test subject either perceives the job as more physically demanding than the rest of the subject group or perhaps misinterpreted the scales.

5.7.10 Figure 5.3 shows the cumulative physical scores again, but with the relevant Test 8 subject scores removed in both double and single crewing. It clearly shows that the cumulative scores are dramatically reduced in both modes and are now lower in single crew mode, indicating that most test subjects did not find being single crewed anymore physically demanding.

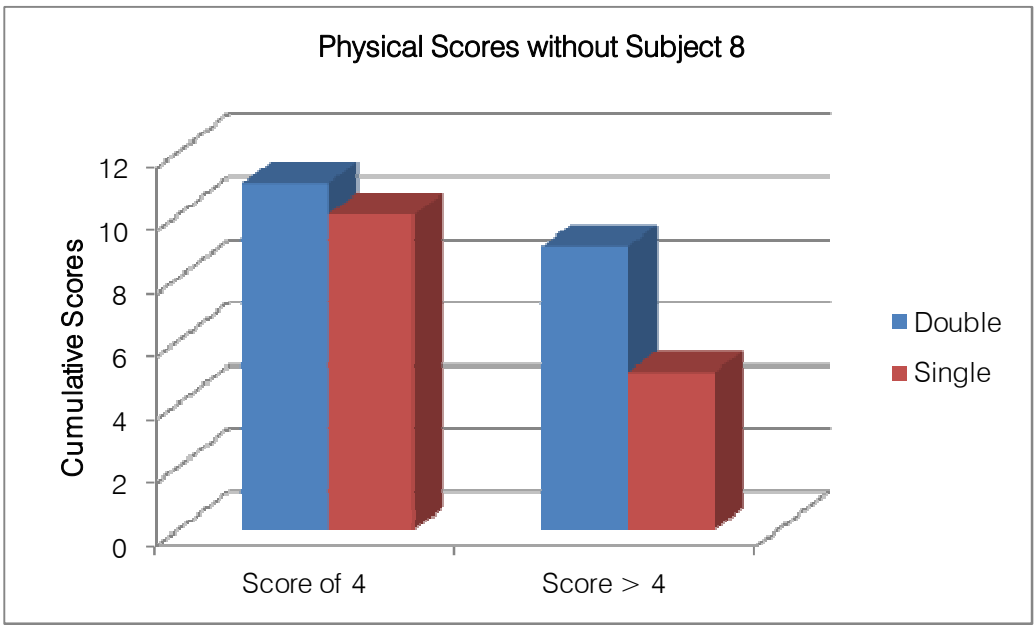


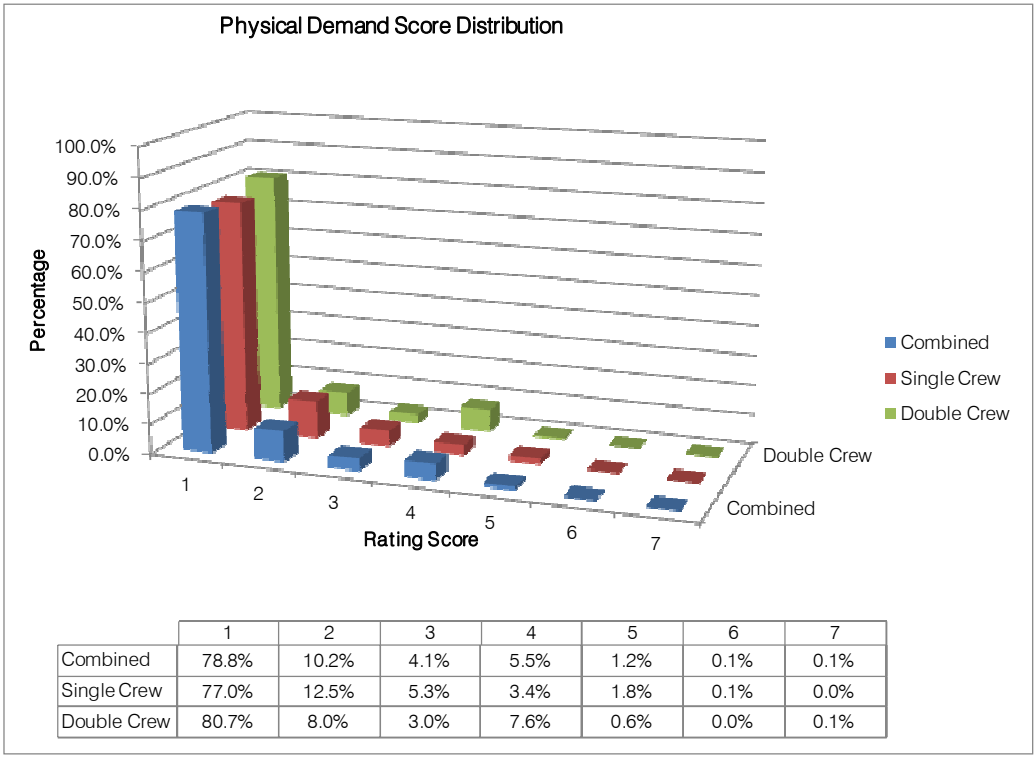
Figure 5.3: Comparison of cumulative scores of 4 and >4 without Subject 8

5.7.11 Table 5.4 gives further details regarding the incidents that were dealt with by test subjects when scores of >4 were chosen. Given the type of incident that the subjects were dealing with these, scores are not unexpected.

Test No.	Shift Type	Incident Type	Score
1	Nights	Placing ETM for a lane 1 closure	5
8	Lates	Placing ETM in lane 3	5
8	Lates	Sheep in carriageway	7
8	Nights	Attendance at multiple RTC	5, 5 (over 2 hours)

Table 5.4: Instances of ratings greater than level 4 for Physical Demand in single crew

5.7.12 Overall, subjects recorded low levels of physical demand; the vast majority of scores are 1; 93.1% in 1-3 (combined), 94.8% single and 91.7% double,as illustrated in Figure 5.4.



	1	2	3	4	5	6	7
Combined	78.8%	10.2%	4.1%	5.5%	1.2%	0.1%	0.1%
Single Crew	77.0%	12.5%	5.3%	3.4%	1.8%	0.1%	0.0%
Double Crew	80.7%	8.0%	3.0%	7.6%	0.6%	0.0%	0.1%

Figure 5.4: Distribution of scores for Physical Demand

5.7.13 The ratings of physical demand were overall perceived to be moderate or less, with 93.1% of scores being at or below 3. This result indicates that there is no appreciable variation, over the duration of the test, between subjects or between double and single crews.

5.8 Heart Rate

5.8.1 Each subject wore a heart rate monitor throughout the duration of the test shifts with the aim of providing an objective measure of physical demands experienced during the test.

5.8.2 On some occasions the monitor malfunctioned and did not record data, this occurred on seven shifts. The reason for the malfunction is not clear, but it is often due to a loss of connectivity between the skin and electrode strap. Heart rate data was also lost when shifts were cancelled, as discussed in Section 5.3.

5.8.3 Analysis of the data shows that, overall, the pattern of each subject's heart rate over of the six shifts in double and single crews is relatively stable and alternates between resting and mild exercise. There are some instances where subjects' heart rates spike indicating peaks of higher effort, but this would be expected during challenging incidents requiring increased physical activity, e.g. putting ETM out for a lane closure, and the effort was not sustained over long periods of time.

5.8.4 The heart rate data is summarised in Figure 5.5, which shows average, maximum, minimum and mode heart rates for each subject. The cells highlighted in yellow indicate a heart rate of over 140bpm. The highest average heart rate recorded was for Subject 1 on the fourth double shift. A rate of 193 bpm was recorded, but for less than one second. Contextual information can provide no reasonable explanation for this as at the time the subject was completing routine patrolling. Considering the short duration of the elevated heart rate it is not particularly perturbing and may have been an

artefact (i.e. minor device malfunction). For other subjects there were also other occurrences of increased rates but these too were for a short duration and occurred in both double and single crewing.

Heart Rate Subject 1

	D1	D2	D3	D4	D5	D6
Average	67	76	61	71	77	72
Maximum	119	132	86	193	156	144
Minimum	52	58	48	56	57	57
Mode	62	69	60	67	67	65

Heart Rate Subject 1

	S1	S2	S3	S4	S5	S6
Average	70	67	78	68	75	67
Maximum	137	129	181	99	138	119
Minimum	55	51	49	55	51	52
Mode	63	61	58	65	76	62

Heart Rate Subject 2

	D1	D2	D3	D4	D5	D6
Average	90	91	75	85	90	82
Maximum	129	137	118	140	165	162
Minimum	72	72	60	69	68	62
Mode	85	81	70	77	82	71

Heart Rate Subject 2

	S1	S2	S3	S4	S5	S6
Average	84	88	79	No test	No test	No test
Maximum	163	152	121	No test	No test	No test
Minimum	59	60	60	No test	No test	No test
Mode	74	82	74	No test	No test	No test

Heart Rate Subject 3

	D1	D2	D3	D4	D5	D6
Average	68	62	65	70	64	No test
Maximum	119	102	102	101	97	No test
Minimum	55	50	53	60	55	No test
Mode	63	60	63	64	60	No test

Heart Rate Subject 3

	S1	S2	S3	S4	S5	S6
Average	65	65	64	58	54	58
Maximum	108	122	100	105	80	141
Minimum	51	53	52	42	44	47
Mode	63	60	60	56	53	55

Heart Rate Subject 4

	D1	D2	D3	D4	D5	D6
Average	74	74	78	78	73	77
Maximum	119	112	127	107	108	110
Minimum	51	57	60	62	49	58
Mode	78	70	78	79	72	76

Heart Rate Subject 4

	S1	S2	S3	S4	S5	S6
Average	82	No data	No data	79	83	76
Maximum	124	No data	No data	121	132	110
Minimum	62	No data	No data	57	43	56
Mode	70	No data	No data	73	80	70

Heart Rate Subject 5

	D1	D2	D3	D4	D5	D6
Average	61	49	112	64	67	62
Maximum	114	101	109	112	129	110
Minimum	46	44	43	49	50	48
Mode	53	52	56	58	60	55

Heart Rate Subject 5

	S1	S2	S3	S4	S5	S6
Average	61	62	65	71	62	60
Maximum	121	103	151	169	137	116
Minimum	46	44	46	47	45	44
Mode	53	57	61	62	54	53

Heart Rate Subject 6

	D1	D2	D3	D4	D5	D6
Average	85	79	81	88	79	84
Maximum	149	115	121	128	115	122
Minimum	48	49	61	70	62	67
Mode	83	73	74	80	75	79

Heart Rate Subject 6

	S1	S2	S3	S4	S5	S6
Average	91	95	91	94	85	91
Maximum	151	127	139	129	123	136
Minimum	67	72	69	71	66	61
Mode	97	90	90	86	82	96

Heart Rate Subject 7

	D1	D2	D3	D4	D5	D6
Average	86	76	88	80	80	87
Maximum	146	119	170	118	118	169
Minimum	64	54	57	61	61	56
Mode	81	76	74	75	75	77

Heart Rate Subject 7

	S1	S2	S3	S4	S5	S6
Average	80	81	72	72	71	77
Maximum	141	125	106	107	114	121
Minimum	59	54	55	54	53	59
Mode	71	77	72	74	67	73

Heart Rate Subject 8

	D1	D2	D3	D4	D5	D6
Average	77	77	92	81	77	No data
Maximum	124	123	170	131	107	No data
Minimum	60	54	22	66	61	No data
Mode	65	72	72	80	72	No data

Heart Rate Subject 8

	S1	S2	S3	S4	S5	S6
Average	63	No data	79	78	81	82
Maximum	125	No data	112	116	114	126
Minimum	33	No data	64	51	43	66
Mode	77	No data	77	74	78	82

Heart Rate Subject 9						
	D1	D2	D3	D4	D5	D6
Average	79	79	No Test	104	87	No data
Maximum	112	120	No Test	171	148	No data
Minimum	62	64	No Test	74	70	No data
Mode	77	79	No Test	90	80	No data

Heart Rate Subject 9						
	S1	S2	S3	S4	S5	S6
Average	83	79	81	87	89	90
Maximum	151	114	130	118	129	146
Minimum	58	62	64	69	69	71
Mode	75	77	77	86	83	88

Heart Rate Subject 10						
	D1	D2	D3	D4	D5	D6
Average	75	75	74	89	81	81
Maximum	108	102	129	125	135	141
Minimum	59	59	58	70	61	63
Mode	69	70	73	86	77	77

Heart Rate Subject 10						
	S1	S2	S3	S4	S5	S6
Average	71	68	73	75	83	73
Maximum	105	99	98	120	117	114
Minimum	54	56	57	62	68	61
Mode	70	65	73	70	78	67

Heart Rate Subject 11						
	D1	D2	D3	D4	D5	D6
Average	69	73	70	62	64	67
Maximum	144	106	108	102	99	103
Minimum	49	57	53	49	49	50
Mode	61	70	60	60	66	63

Heart Rate Subject 11						
	S1	S2	S3	S4	S5	S6
Average	69	74	77	74	69	69
Maximum	109	114	141	111	105	144
Minimum	52	57	62	59	56	49
Mode	69	70	73	72	66	61

Heart Rate Subject 12						
	D1	D2	D3	D4	D5	D6
Average	77	69	84	57	54	59
Maximum	114	111	179	113	110	90
Minimum	57	49	58	41	41	42
Mode	70	57	77	52	48	53

Heart Rate Subject 12						
	S1	S2	S3	S4	S5	S6
Average	69	74	74	No data	62	54
Maximum	102	120	115	No data	103	93
Minimum	52	53	53	No data	46	38
Mode	69	72	68	No data	58	49

Heart Rate Subject 13						
	D1	D2	D3	D4	D5	D6
Average	82	79	85	87	89	82
Maximum	128	126	131	126	140	136
Minimum	68	67	67	70	67	59
Mode	76	75	77	82	85	79

Heart Rate Subject 13						
	S1	S2	S3	S4	S5	S6
Average	81	86	82	84	87	83
Maximum	117	130	137	116	156	114
Minimum	63	64	54	65	65	69
Mode	79	86	73	81	81	80

Heart Rate Subject 14						
	D1	D2	D3	D4	D5	D6
Average	76	78	77	83	79	No data
Maximum	104	137	112	122	116	No data
Minimum	66	65	63	72	67	No data
Mode	70	74	77	79	77	No data

Heart Rate Subject 14						
	S1	S2	S3	S4	S5	S6
Average	71	95	69	75	77	75
Maximum	105	156	103	89	103	85
Minimum	18	56	55	53	29	69
Mode	70	99	61	85	72	76

Heart Rate Subject 15						
	D1	D2	D3	D4	D5	D6
Average	54	51	57	61	58	59
Maximum	131	85	106	126	97	94
Minimum	43	42	45	49	49	47
Mode	51	49	52	56	57	56

Heart Rate Subject 15						
	S1	S2	S3	S4	S5	S6
Average	55	53	55	63	55	No data
Maximum	101	79	102	150	81	No data
Minimum	44	43	42	46	46	No data
Mode	52	50	54	56	54	No data

Heart Rate Subject 16						
	D1	D2	D3	D4	D5	D6
Average	78	67	85	76	72	82
Maximum	140	109	170	157	133	157
Minimum	57	53	56	46	56	56
Mode	78	61	75	75	67	82

Heart Rate Subject 16						
	S1	S2	S3	S4	S5	S6
Average	67	72	No data	No data	No data	No data
Maximum	127	156	No data	No data	No data	No data
Minimum	51	45	No data	No data	No data	No data
Mode	60	64	No data	No data	No data	No data

Figure 5.5: Summary tables showing: average, mode, maximum, minimum heart rates for each subject (>140bpm highlighted)

5.8.5 The heart rate data for Subject 6 shows that there was a consistent (although relatively small) difference between their heart rate in double crew and in single crew with the rate remaining elevated (by around 10 bpm) for the entire single shift testing period. Review of contextual information from the shifts shows that the workload was not particularly intense or challenging with incidents including routine H/S breakdowns and LL debris. Analysis of the physical demand scales completed by the same test subject show that they consistently chose scores of 1 (not demanding). This information indicates

that elevated heart rate was not related to physical exertion and therefore is assumed to have resulted from their mental state; the subject may have been more apprehensive during the single shifts because of having to complete all tasks alone. The subject did not appear to perceive a higher level of anxiety / mental effort, since they only recorded one or two higher scores for mental effort or frustration in either mode over the entire test, which further indicates the difference in heart rates between crewing modes is relatively marginal.

5.8.6 There does not appear to be any evidence to suggest that single crewing is likely to place consistently higher physical demands on TOs. However, some individuals may initially experience anxiety at being singly crewed, which may in turn increase their heart rates.

5.9 Mental Demands

5.9.1 Subjective Rating

5.9.2 During each double and single test, subjects were asked on an hourly basis (or after completing an incident) to rate how mentally demanding the tasks had been on a 7 point scale, ranging from 1=Not demanding to 7=Very demanding. The mental demand rating scale was asked a total of 1385 times during the test schedule.

5.9.3 Figure 5.6 illustrates the average scores for each subject and shows that there was minimal difference between double and single crew data and on average, test subjects, recorded low levels of mental demand with the majority of scores between 1 and 3.

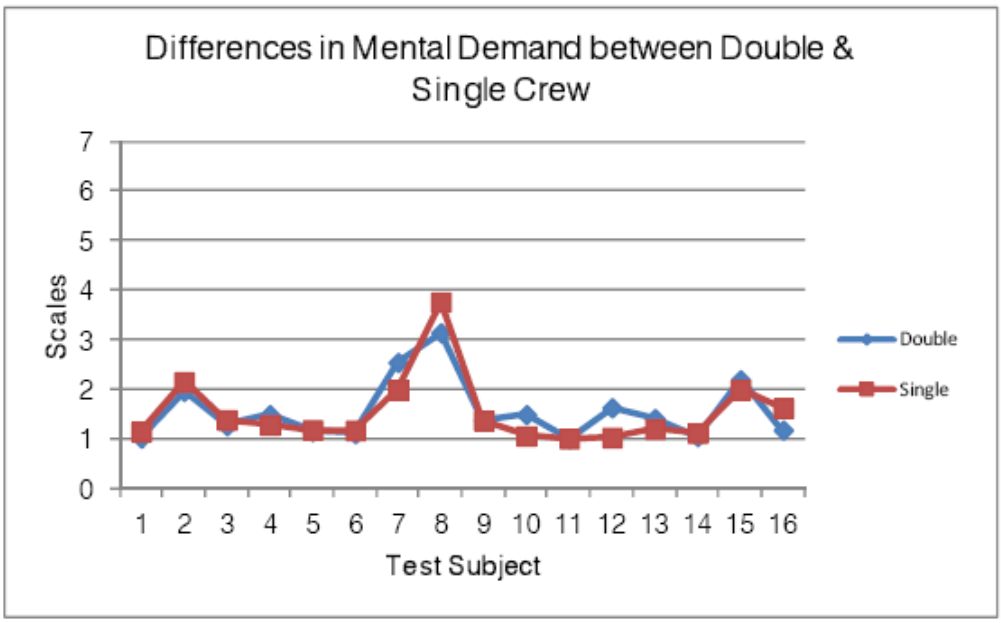


Figure 5.6: Average scores for mental demand

5.9.4 Analysing the results in further detail, Figure 5.7 displays the cumulative mental demand scores where 4 (moderate demand) and >4 (with 7 being very demanding) were chosen in double and single crew.

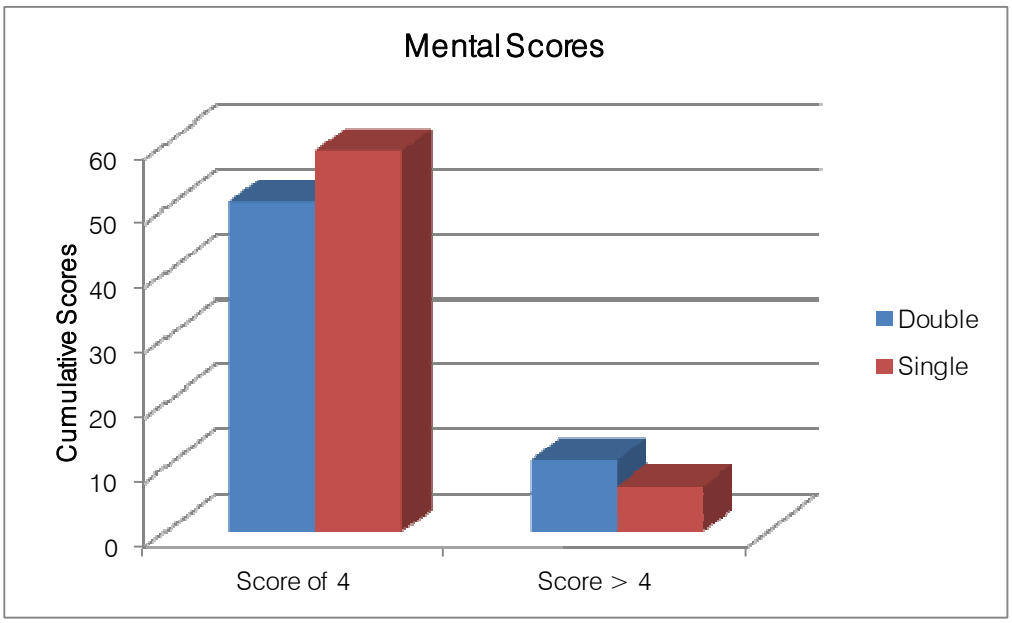


Figure 5.7: Cumulative mental demand scores of 4 and >4

5.9.5 A score of 4 was recorded 51 times in double and 59 times in single. However, it should be noted that 19 (30%) of the double scores, and 40 (68%) single scores are attributable to the same Test 8 subject, as discussed in Section 5.7 Physical Demands.

5.9.6 A score of greater than four i.e. 5, 6 or 7, was recorded 11 times in double crew and on 7 occasions in single crew. Subject 8, Test 4, was accountable for 30% of the >4 scores in double crew.

5.9.7 Figure 5.8 shows the cumulative demand scores again, but with the relevant test subject scores removed in both double and single crewing. It clearly shows that the cumulative scores are reduced in both crewing modes and is actually less in single crew indicating that test subjects did not find being single crewed more mentally demanding.

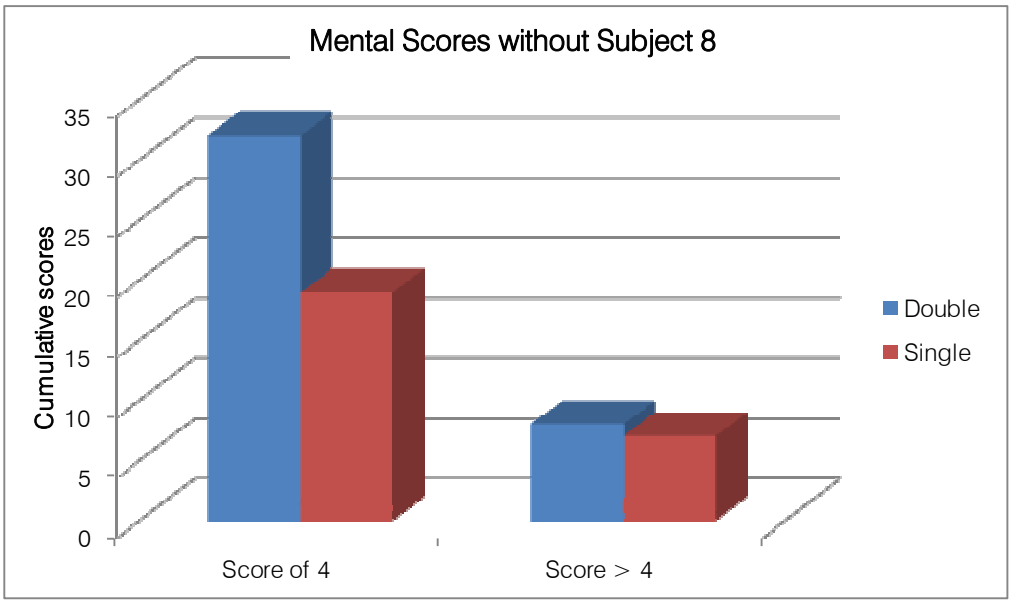


Figure 5.8 - Cumulative mental demand scores of 4 and >4 without Subject 8

5.9.8 As previously discussed, the high scores recorded by Subject 8, Test 4, subject are unexpected given the level and types of incidents and completion of night shifts during single testing.

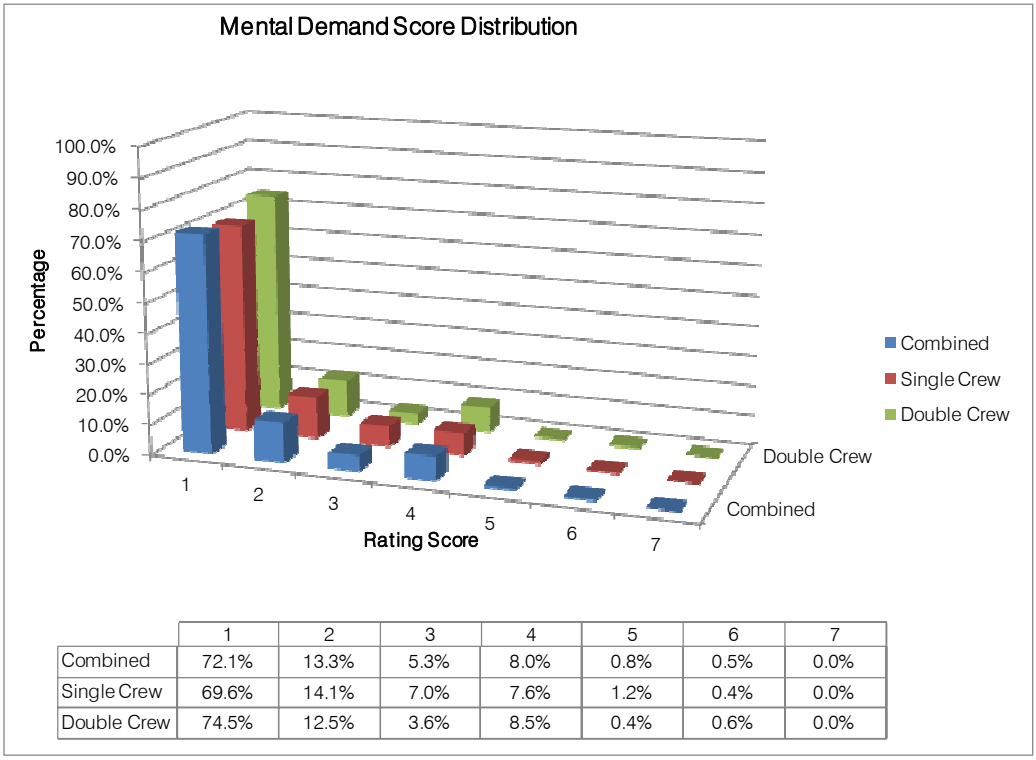
5.9.9 The information indicates that, overall, Subject 8 either perceives the job to be more mentally demanding than the rest of the subject group or misinterpreted the scales.

5.9.10 Table 5.5 gives further details regarding the incidents that were dealt with by test subjects when scores of >4 were chosen. Given the type of incident that the subjects were dealing with these scores are not unexpected. It is difficult to determine if the same subjects would have reported similar scores had they been in a double crew as equivalent incidents did not occur during these particular subjects' double testing phase.

Test No.	Shift Type	Incident Type	Score
1	Night	Putting out ETM for a lane 1 closure	5
1	Night	Attending to H/S BDV needing statutory removal	6
3	Late	Minor RTC – multiple vehicles on H/S	5
8	Late	Attending to car in central reservation	6
8	Late	Sheep in carriageway	6, 5 (over 2 hours)
8	Night	Attendance at multiple RTC	6, 5 (over 2 hours)

Table 5.5 Instances of scores > 4 for Mental Demand

5.9.11 Overall, subjects recorded low levels of mental demand; the vast majority of scores fell between 1 and 3, as illustrated in Figure 5.9.



	1	2	3	4	5	6	7
Combined	72.1%	13.3%	5.3%	8.0%	0.8%	0.5%	0.0%
Single Crew	69.6%	14.1%	7.0%	7.6%	1.2%	0.4%	0.0%
Double Crew	74.5%	12.5%	3.6%	8.5%	0.4%	0.6%	0.0%

Figure 5.9: Distribution of rating scores for Mental Demand

5.9.12 The ratings of mental demand shown in Figure 5.9, showed no appreciable variation over the duration of the test shift, between subjects or between double and single crews.

5.9.13 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 90.7% of scores being at or below 3.

5.10 Qualitative Data

5.10.1 On a few occasions, single crew subjects missed radio transmissions from the RCC when at scene and dealing with an incident. This resulted in repeat transmissions being made until the subject responded; this was usually on the second attempt. During double crewing one TO tends to handle radio communications whilst the other is conversing with others at scene, so the likelihood of this happening in double crew is less and this particular problem was not observed or reported during any of the double tests.

5.10.2 On a small number of occasions some subjects failed to turn off the red lights when on the hard shoulder at an incident. It is usual for the Observer in a double crew to be responsible for this; in a single crew the TO must complete this task as well as attending to the requirements of the incident. Again, this omission was not observed during double crew. During the debrief sessions, these omissions were discussed and the subjects stated that it was probably because when they normally complete the driving role they are not normally responsible for operating the lights.

5.10.3 For those subjects dealing with incidents where they were first on scene and there were multiple vehicles, some reported that it was more challenging to attend to the tasks that needed doing, e.g. speaking with the RCC, dealing

with ETM, whilst keeping an eye on customers on the hard shoulder, for example.

5.10.4 For most of the test subjects it was the first time that they had had to attend any incident alone. Thus it would be expected that some mistakes will be made and mental load would be higher as they are not familiar with this method of working and their training beforehand was limited to 3 day group sessions.

5.11 Fatigue

5.11.1 Subjective Rating

5.11.2 Test subjects were asked on an hourly basis to rate components of fatigue over eleven different factors (the factor rating scales are provided in Appendix A).

5.11.3 To provide an overall comparison of fatigue ratings between double and single crewing modes, the scores for each factor were averaged across all shifts and days for each subject. The results are illustrated in Figure 5.10 to Figure 5.25. For the purpose of analysis all scales were arranged so that 1= “I do not feel this”, to 7= “I definitely do feel this”. The higher the score, the less fatigued a subject was feeling.

5.11.4 The first factor (column) on each of the graphs shows the subject’s overall rating of fatigue. The remaining factors on the graph relate to various physical and mental elements that contribute to feelings of fatigue, e.g. feeling active, need to close eyes, able to concentrate, etc. It is important to note that whilst the absolute fatigue scores do offer value, it is the difference between double and single crewing that is the key aspect of the data.

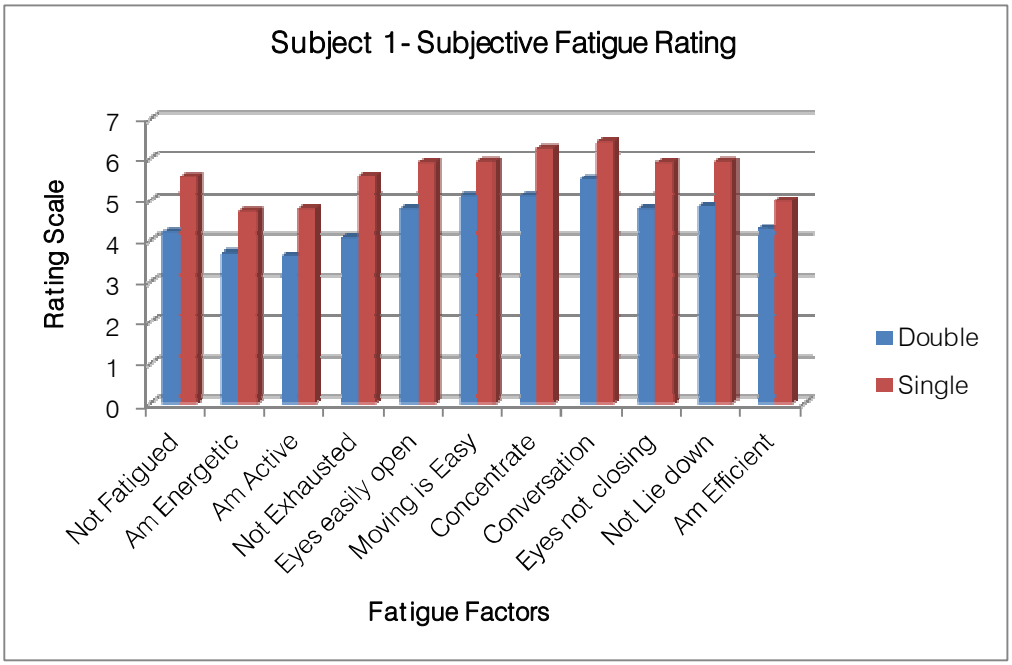


Figure 5.10: Subject 1 fatigue scores

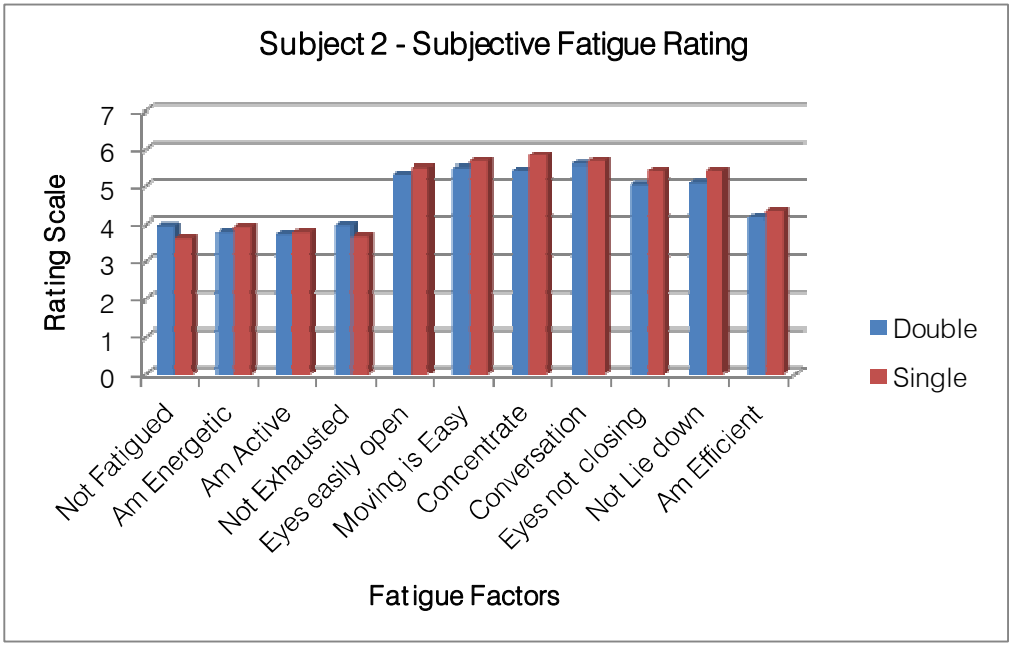


Figure 5.11: Subject 2 fatigue scores

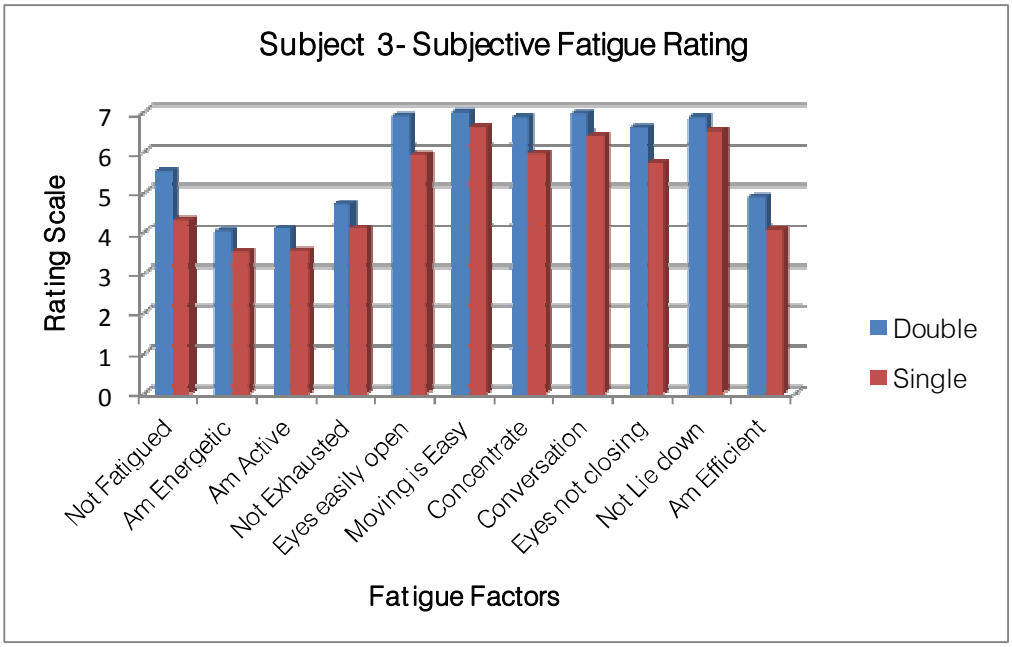


Figure 5.12: Subject 3 fatigue scores

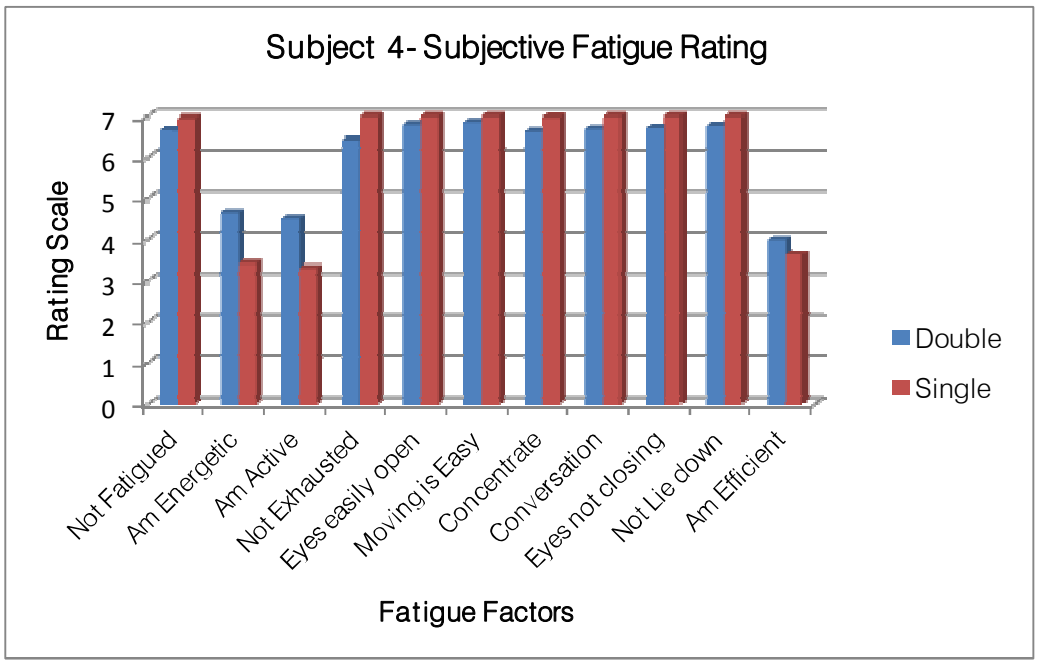


Figure 5.13: Subject 4 fatigue scores

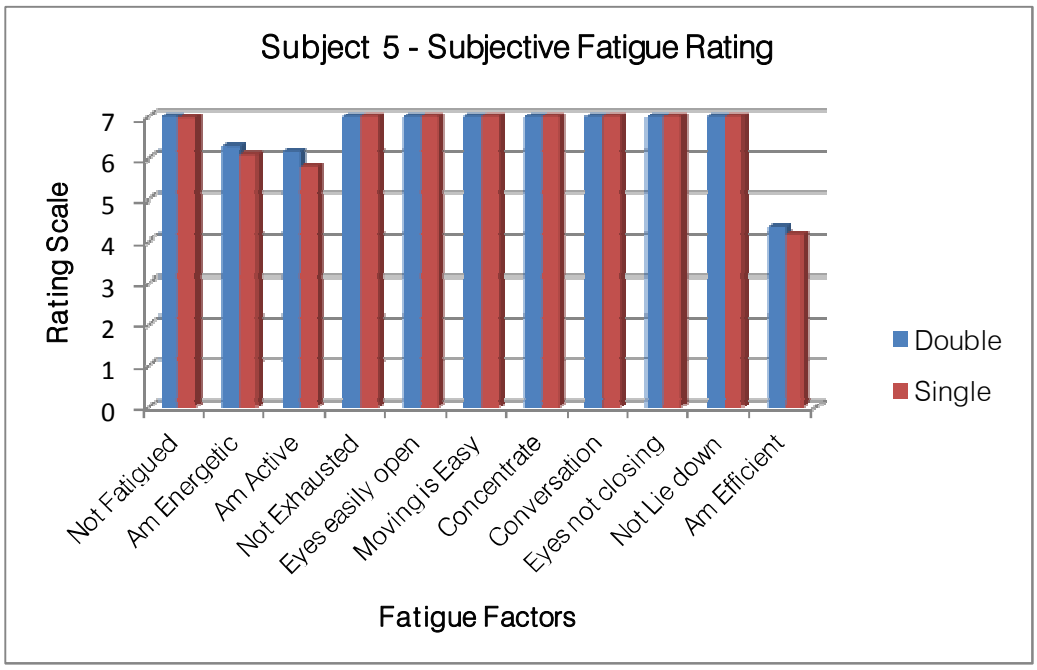


Figure 5.14: Subject 5 fatigue scores

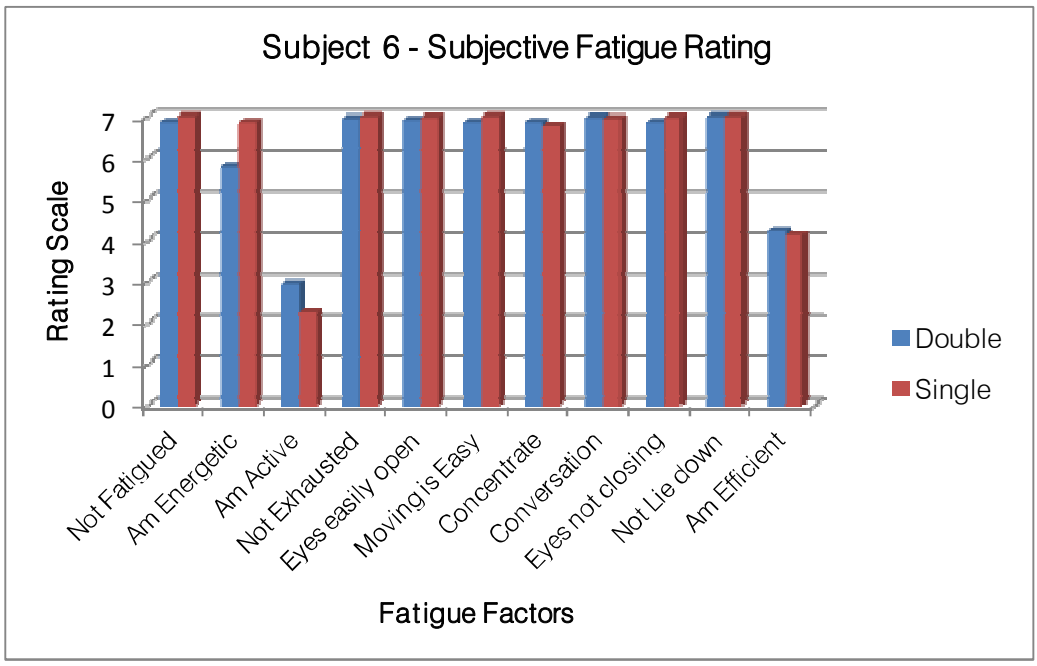


Figure 5.15: Subject 6 fatigue scores

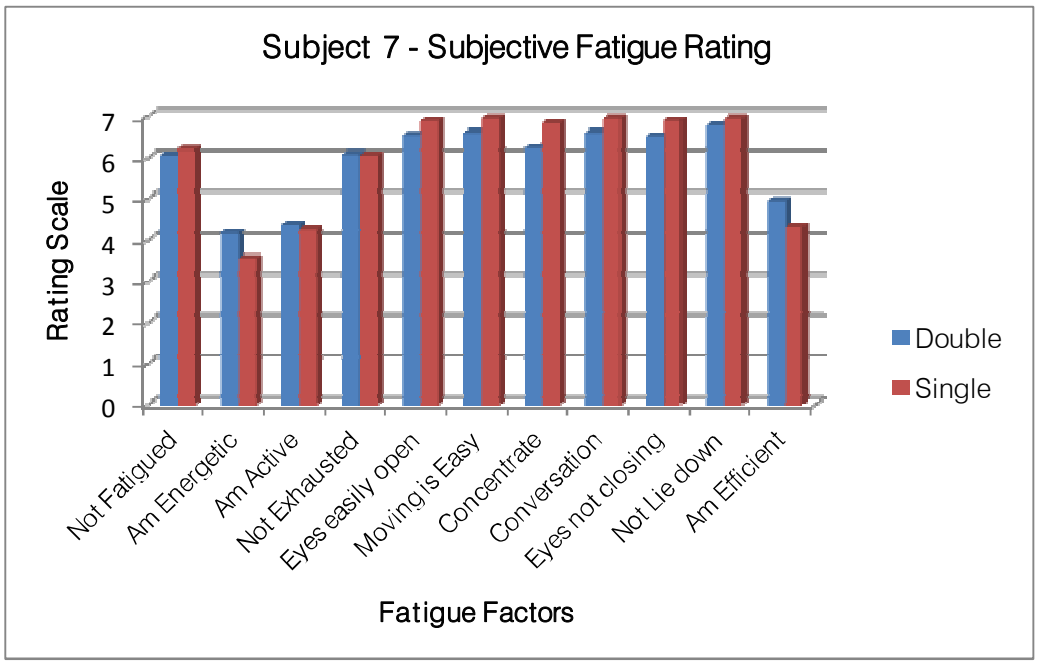


Figure 5.16: Subject 7 fatigue scores

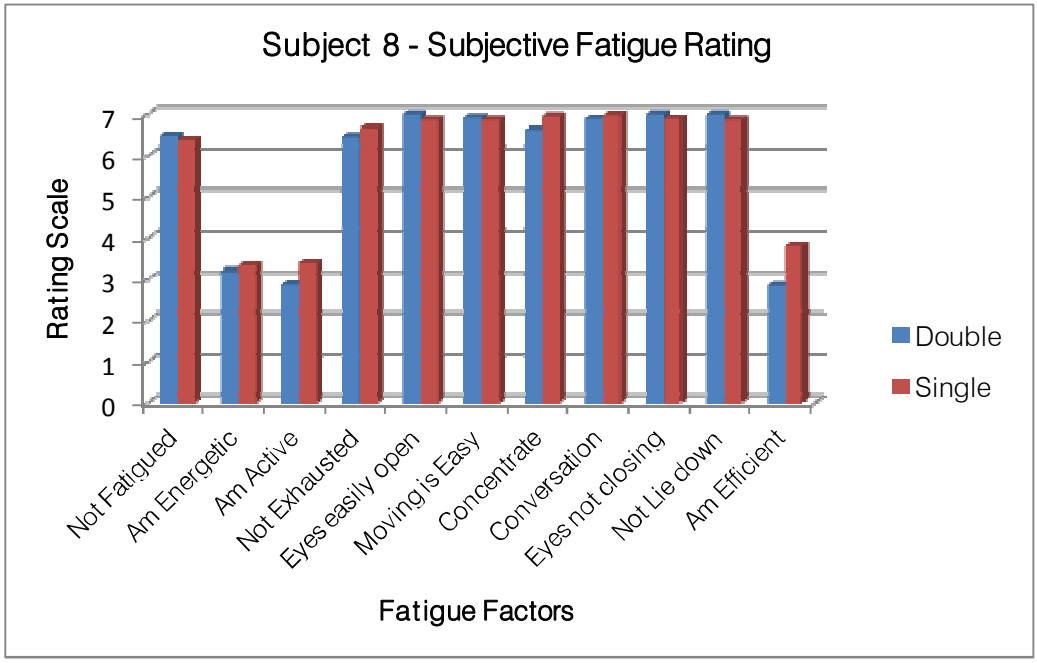


Figure 5.17: Subject 8 fatigue scores

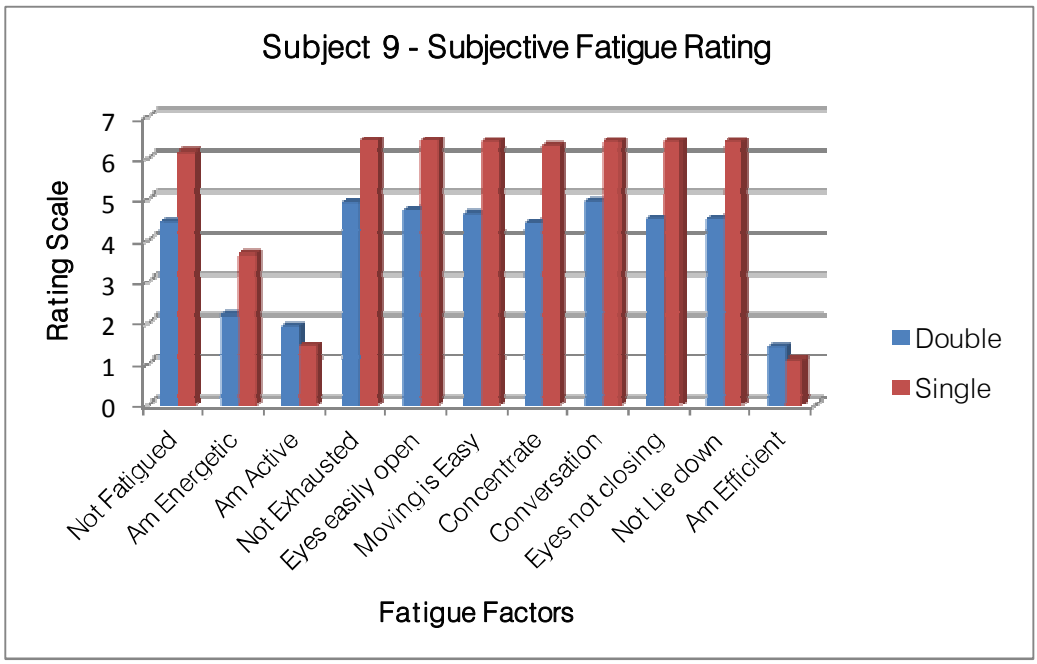


Figure 5.18: Subject 9 fatigue scores

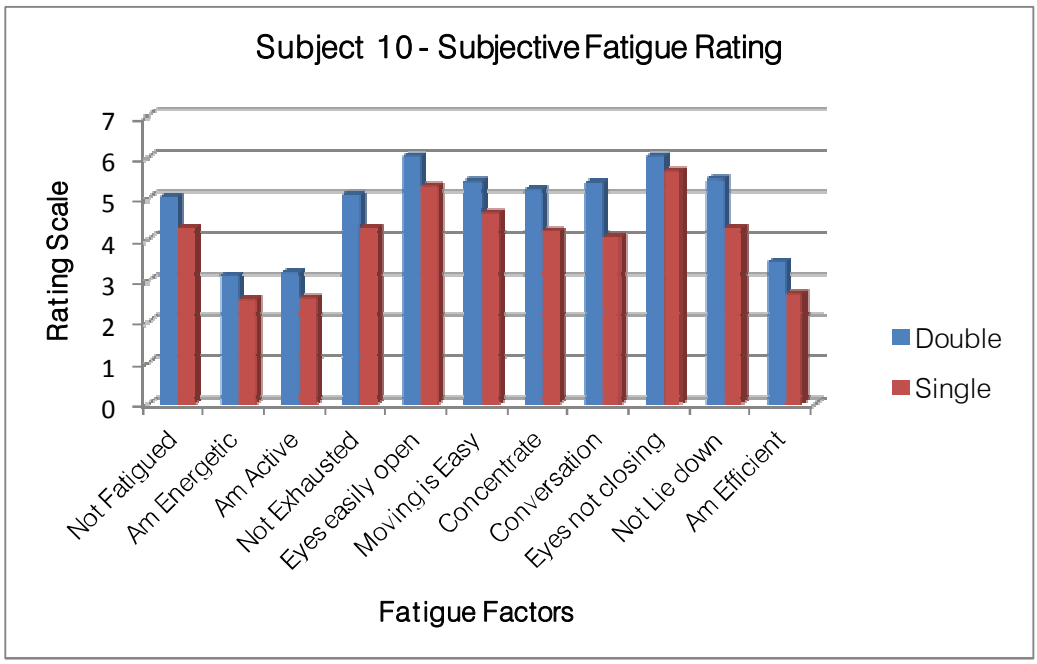


Figure 5.19: Subject 10 fatigue scores

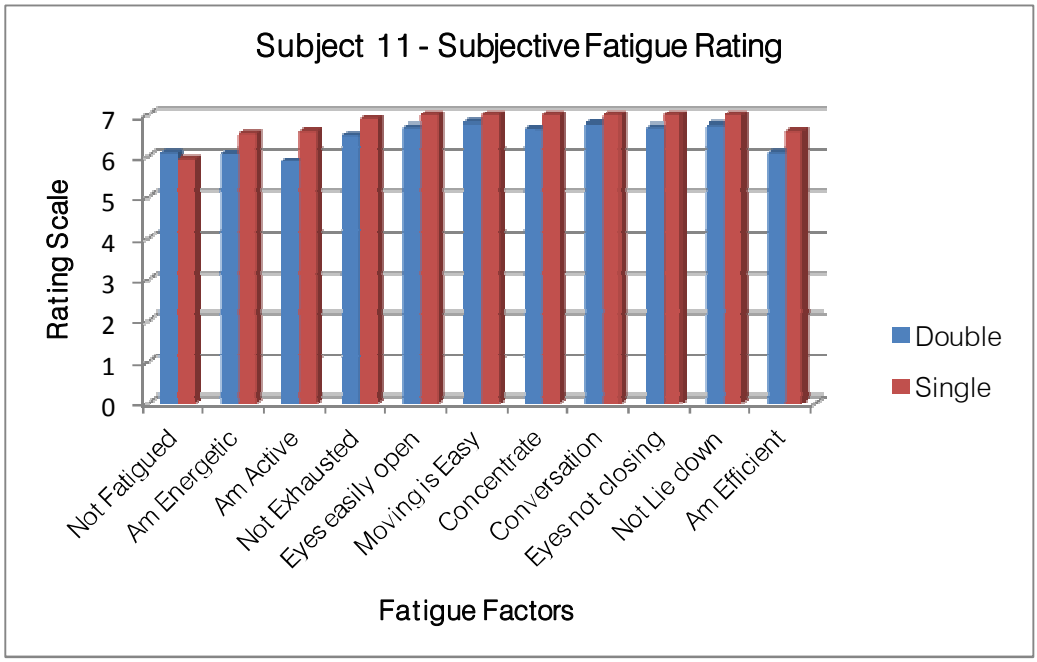


Figure 5.20: Subject 11 fatigue scores

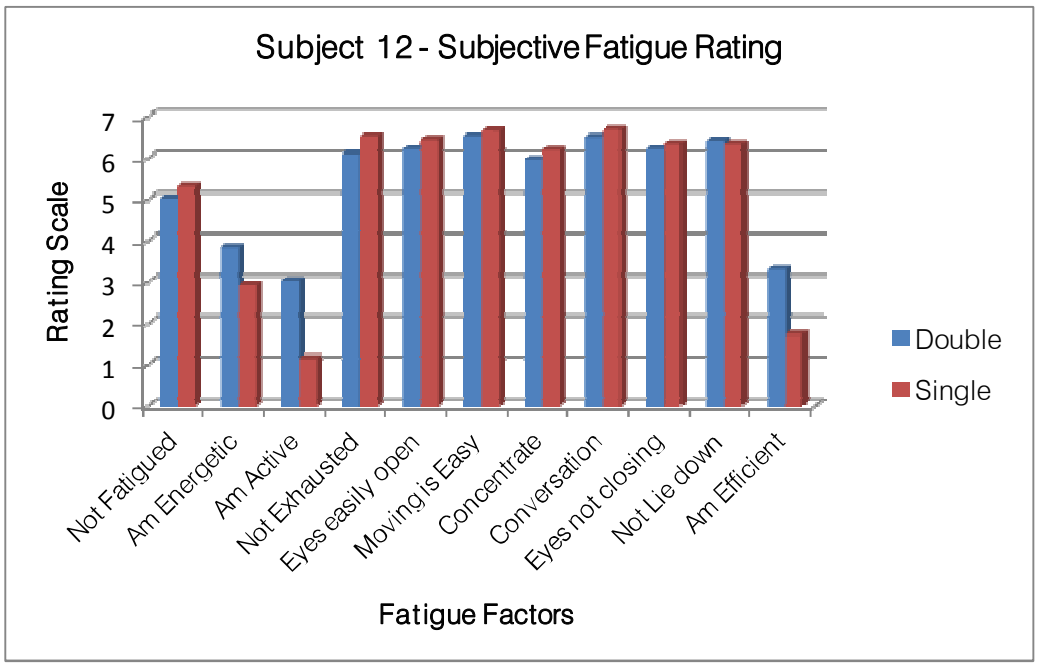


Figure 5.21: Subject 12 fatigue scores

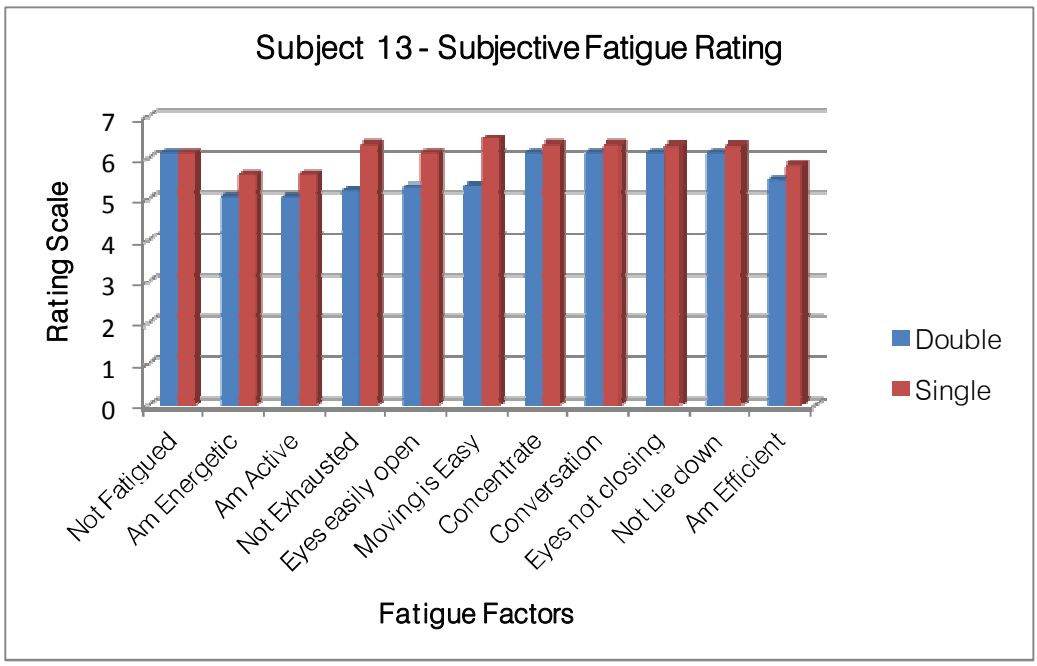


Figure 5.22: Subject 13 fatigue scores

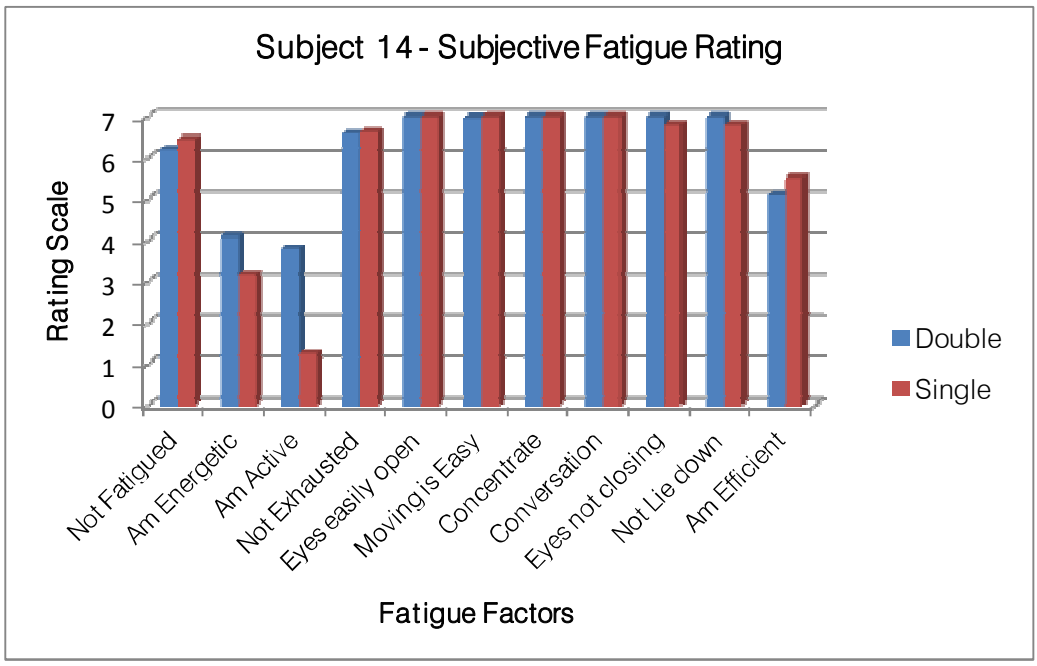


Figure 5.23: Subject 14 fatigue scores

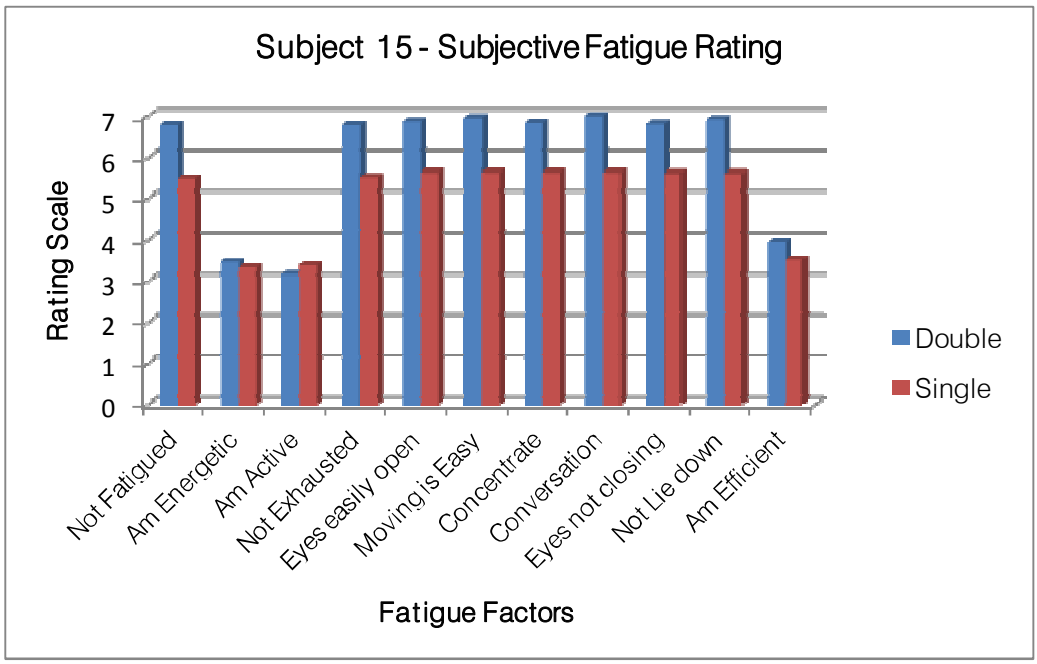


Figure 5.24 - Subject 15 fatigue scores

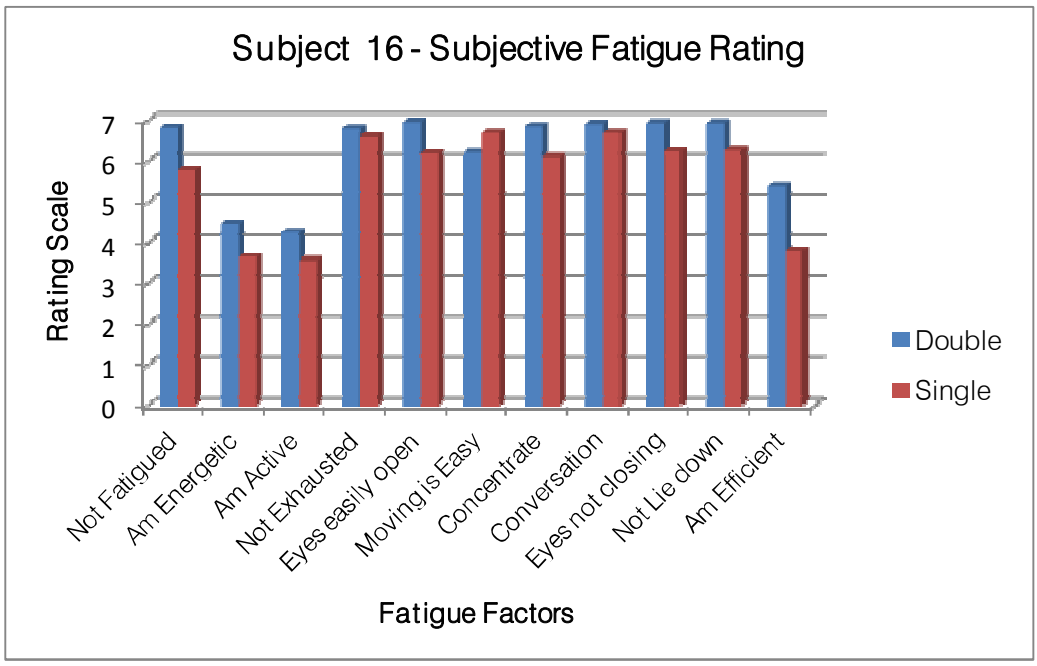


Figure 5.25: Subject 16 fatigue scores

5.11.5 The results indicate firstly that subjects did not, on average, experience high levels of fatigue in either double or single crewing mode. The majority of scores in either case for most factors are above level 4 (i.e. mid-point of the rating scale). There were individual variations across different days and shifts and across different factors, indicating that subjects do experience fatigue at different times of the day or on different shift days, but generally this is neither sustained (over hours or days) or at a high level.

5.11.6 Secondly, the results indicate that:

- Subjects tended to rate single crewing slightly more negatively than double crewing
- Five subjects rated double crewing more negatively than single
- The remaining six rated both modes approximately equally (i.e. found each mode equally fatiguing).

5.11.7 It is notable that the differences between the various ratings for either crewing mode are typically small; there is no discernable pattern to suggest fatigue is likely to be worse under one crewing mode or the other. It is also notable that there is no consistent pattern amongst the different fatigue factors, typically if a subject found one mode more or less fatiguing than another, they did so for all factors and largely to a similar degree.

5.11.8 It is perhaps worth noting that the lowest scores were consistently given to the factors “Energetic”, “Active”, “Efficient”, by all 16 subjects. This indicates a common tendency to not rate their state as being highly and positively energetic, even though they typically did not feel fatigued. It was noted that many lower ratings for these factors were recorded when few incidents occurred and / or the subjects were not actively occupied, especially so on night shifts

5.11.9 In order to determine whether fatigue varied between crewing modes over time, a fatigue index was created by summing scores for each of the 11 factors. Again the ratings were normalised such that the lower the score, the

higher the level of fatigue: a graphical representation of this can be seen below.

Figure 5.26 – Fatigue Index

5.11.10 Figure 5.27 to Figure 5.42 displays the fatigue level index scores for each subject comparatively for both double and single over the course of a full six day shift.

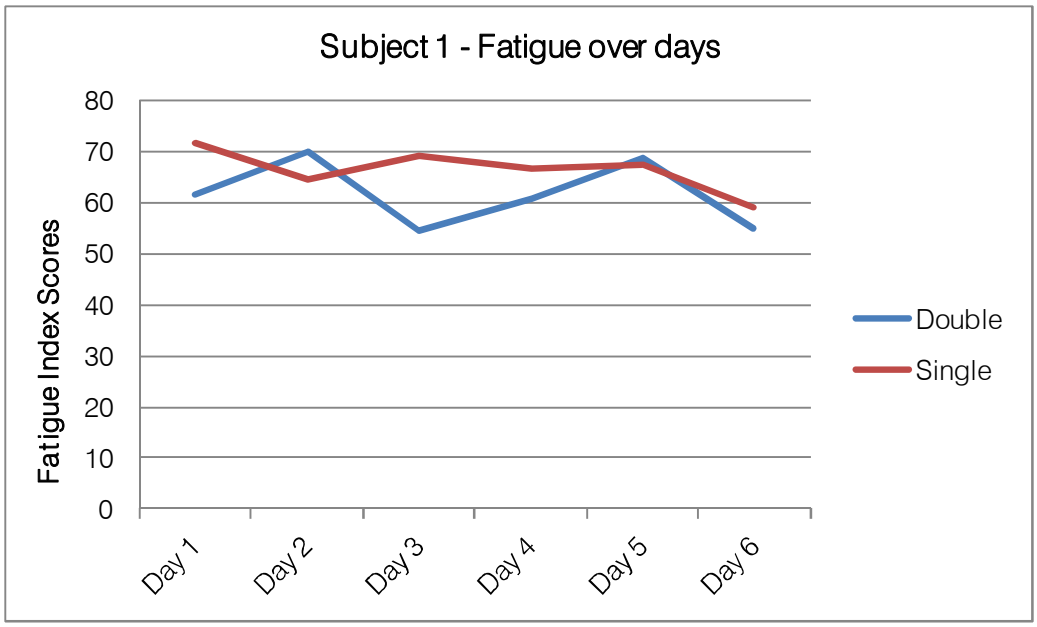


Figure 5.27: Subject 1 fatigue index score

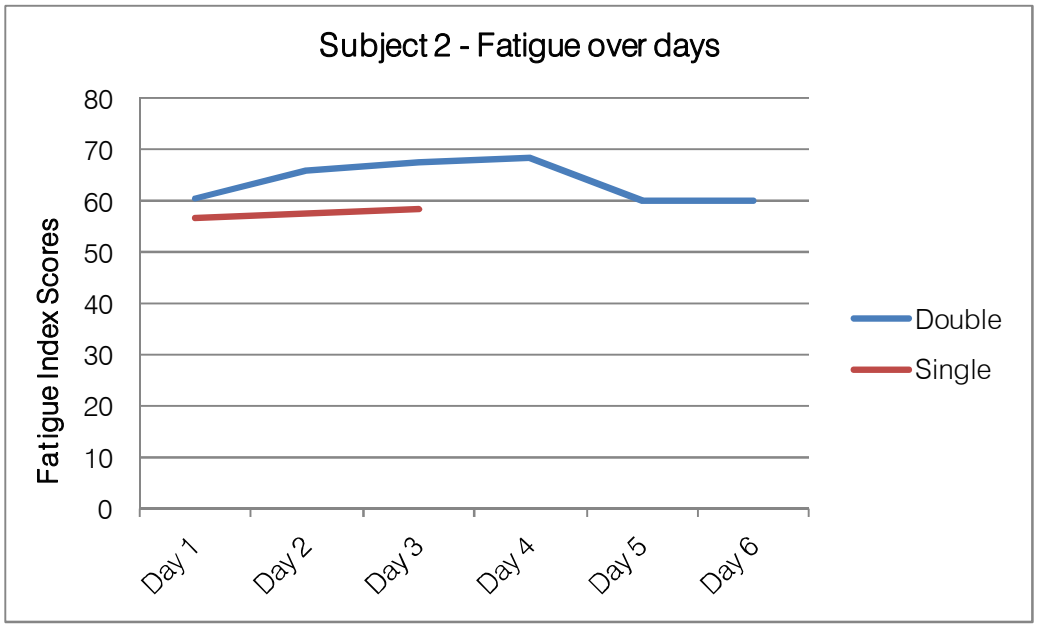


Figure 5.28: Subject 2 fatigue index score

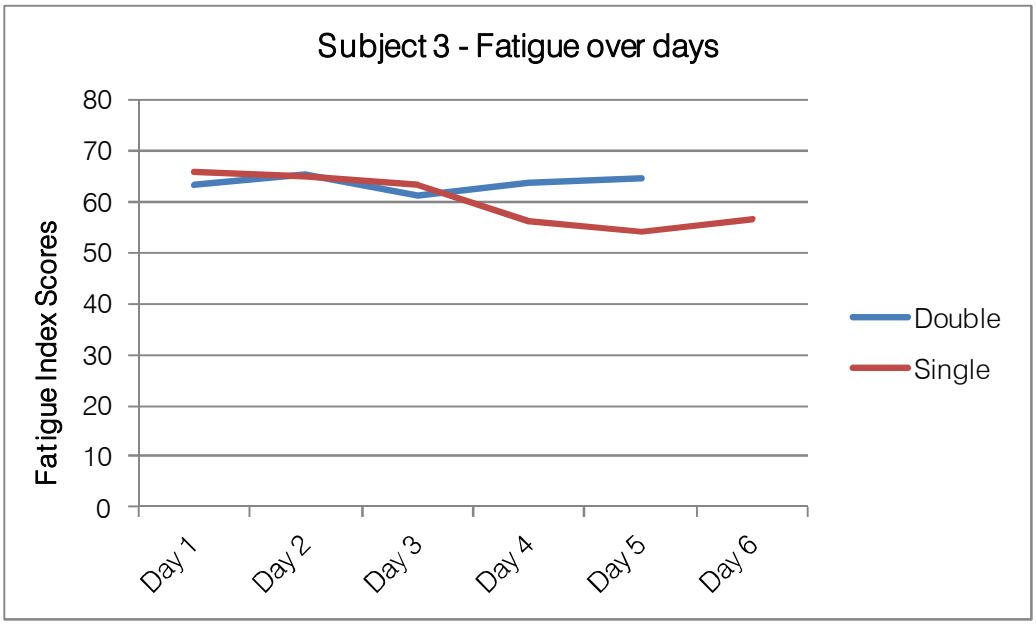


Figure 5.29: Subject 3 fatigue index score

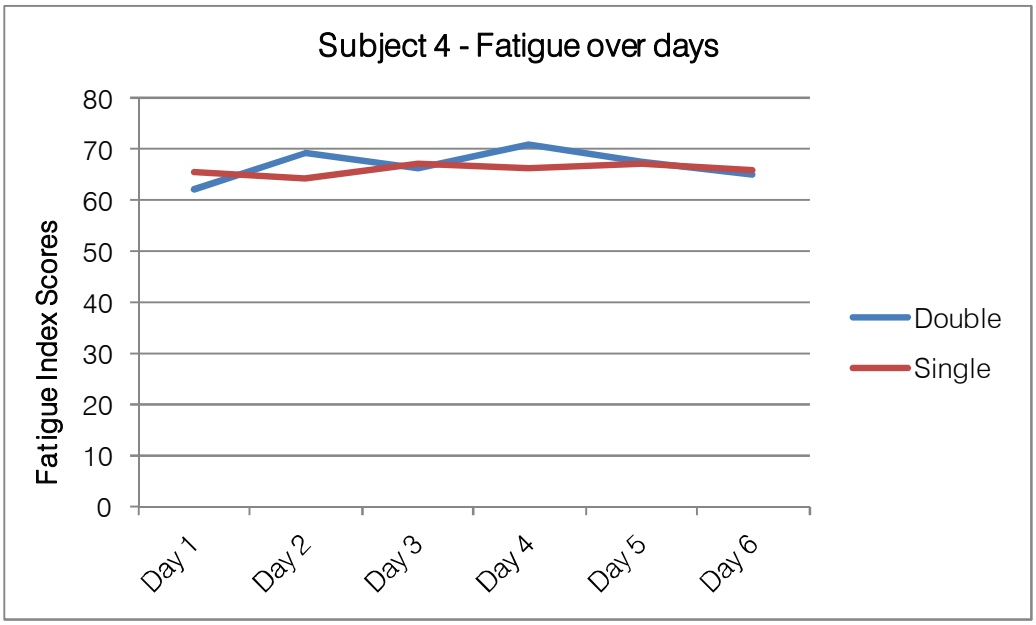


Figure 5.30: Subject 4 fatigue index score

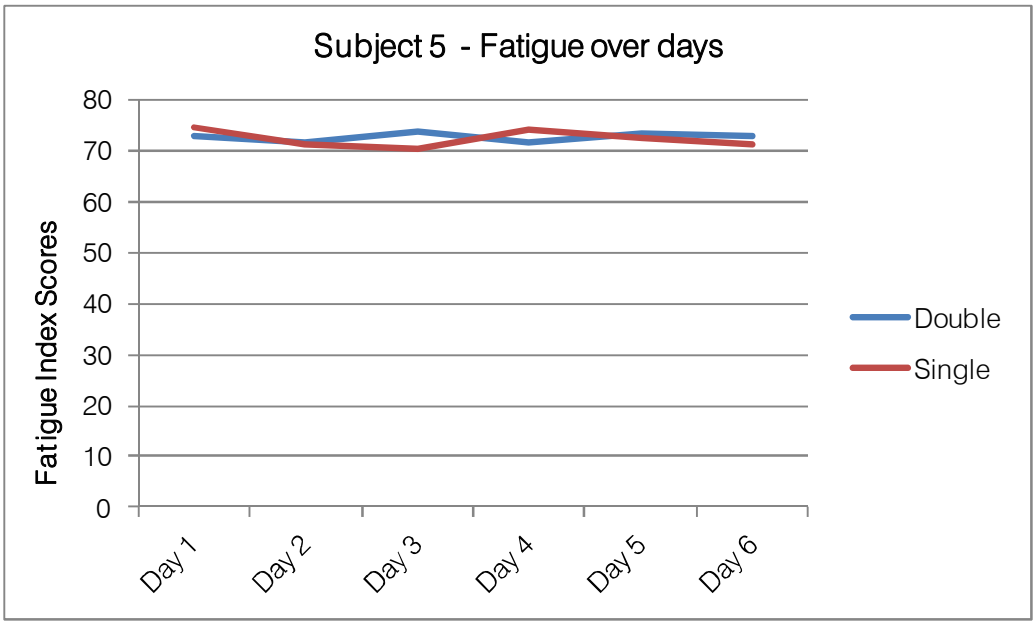


Figure 5.31: Subject 5 fatigue index score

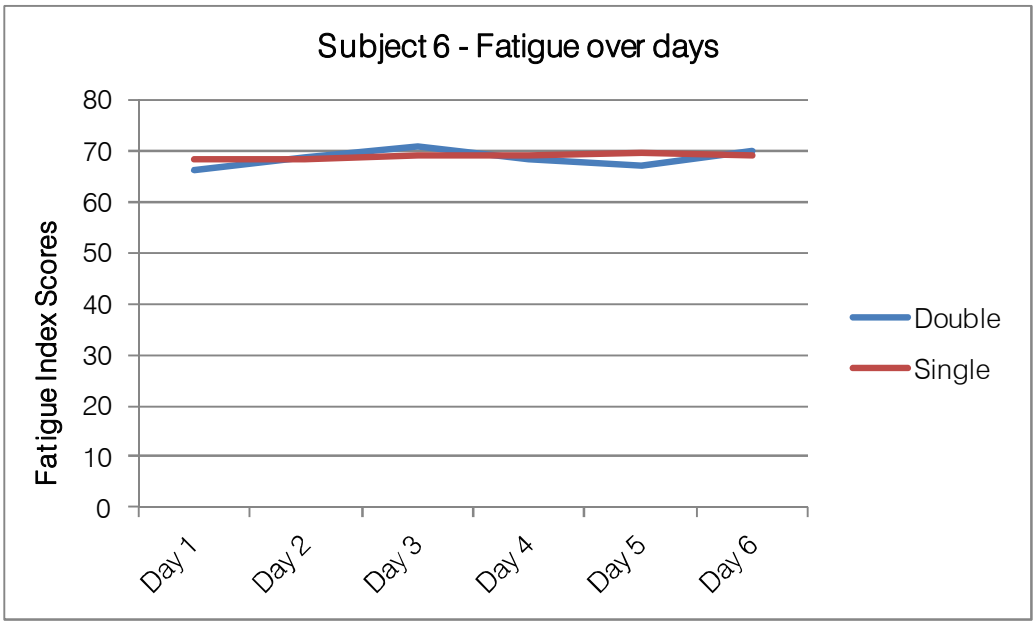


Figure 5.32: Subject 6 fatigue index score

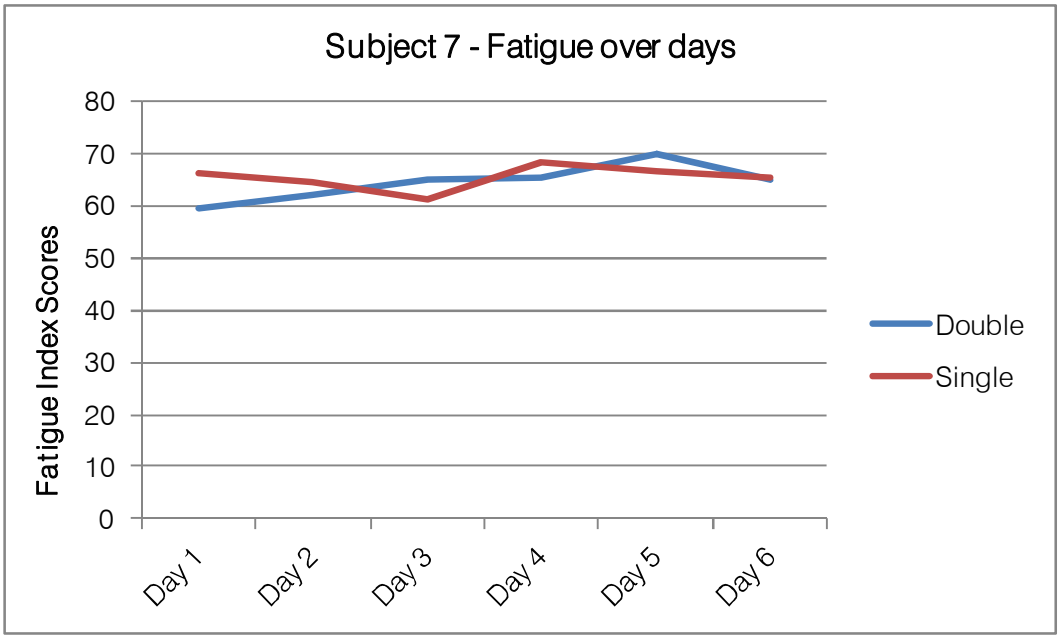


Figure 5.33: Subject 7 fatigue index score

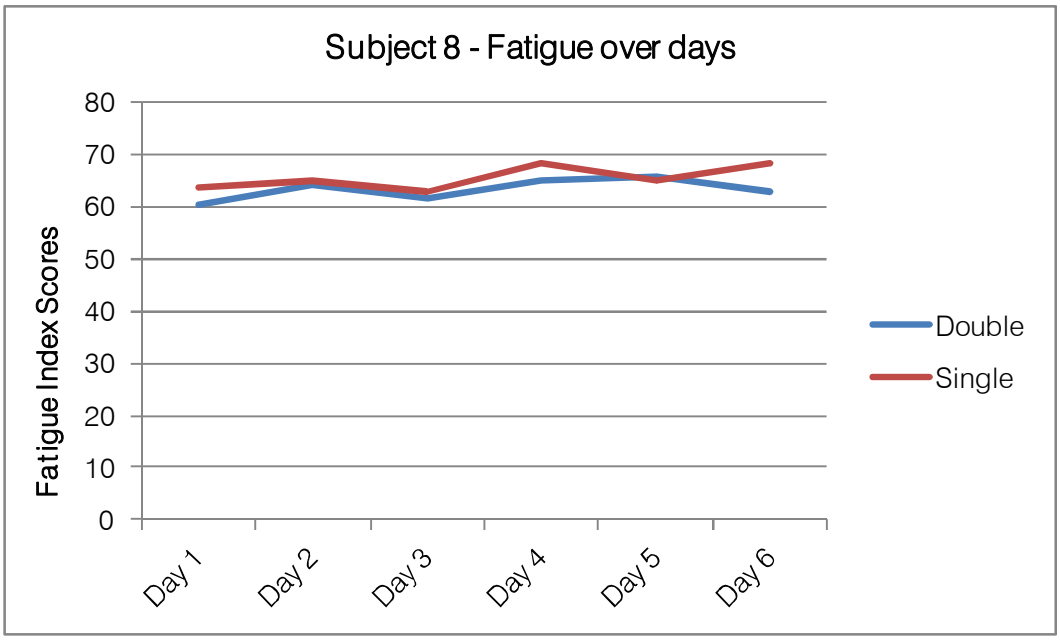


Figure 5.34: Subject 8 fatigue index score

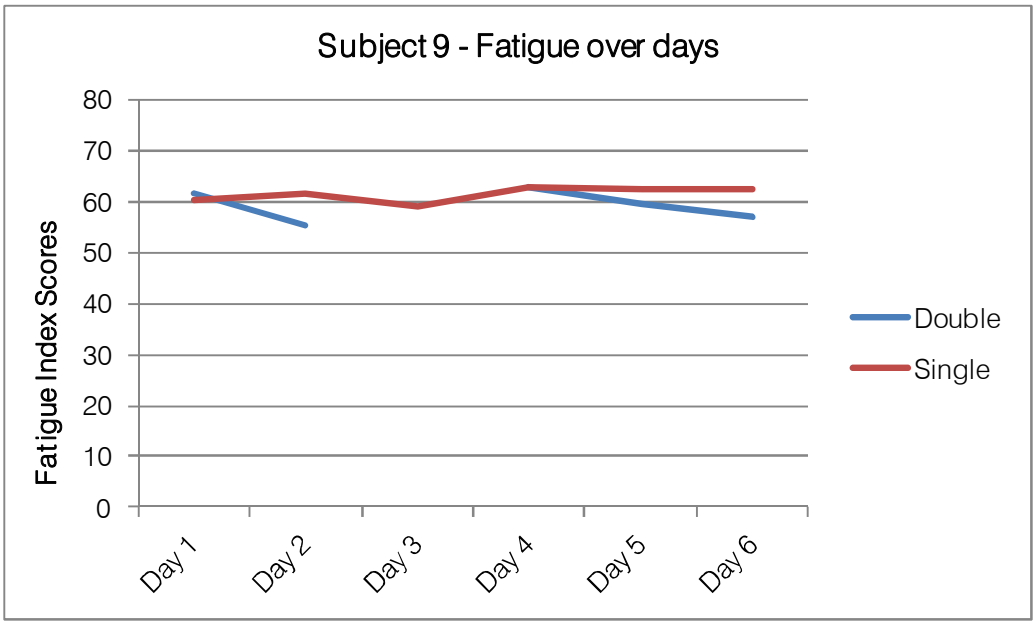


Figure 5.35: Subject 9 fatigue index score

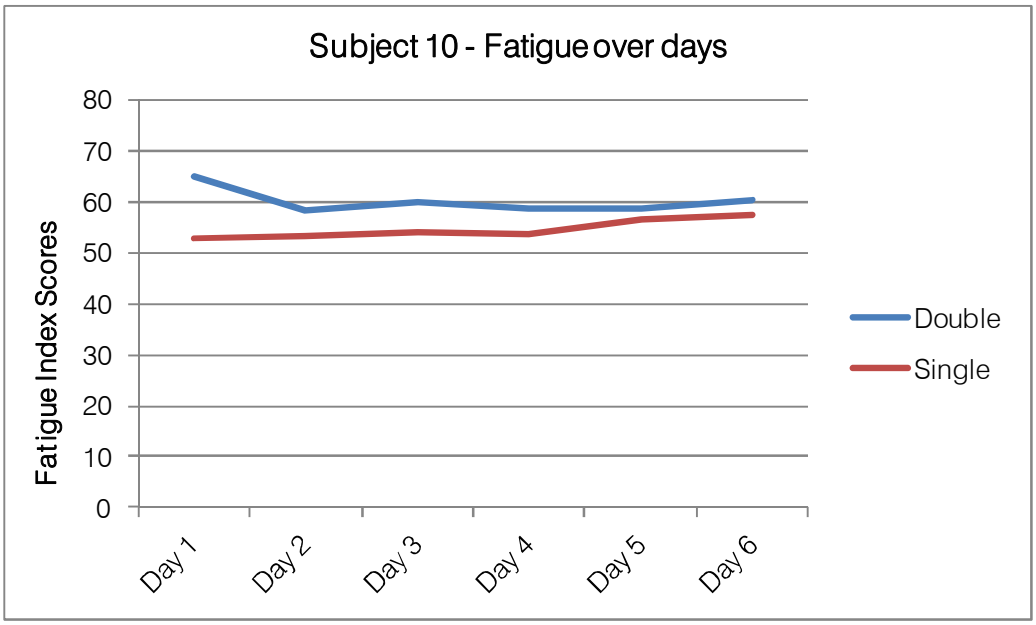


Figure 5.36: Subject 10 fatigue index score

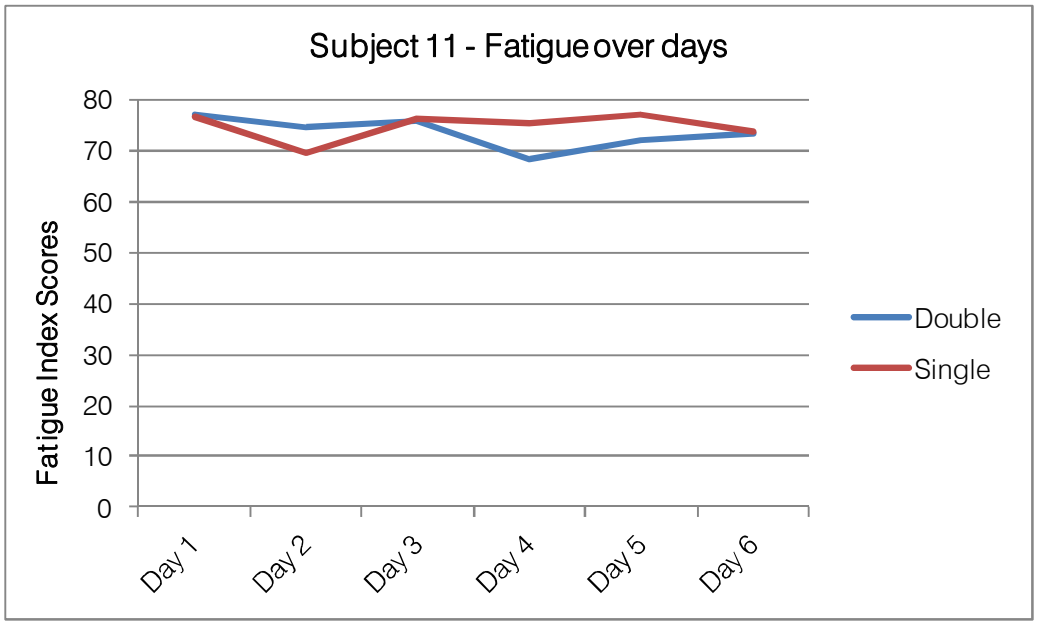


Figure 5.37: Subject 11 fatigue index score

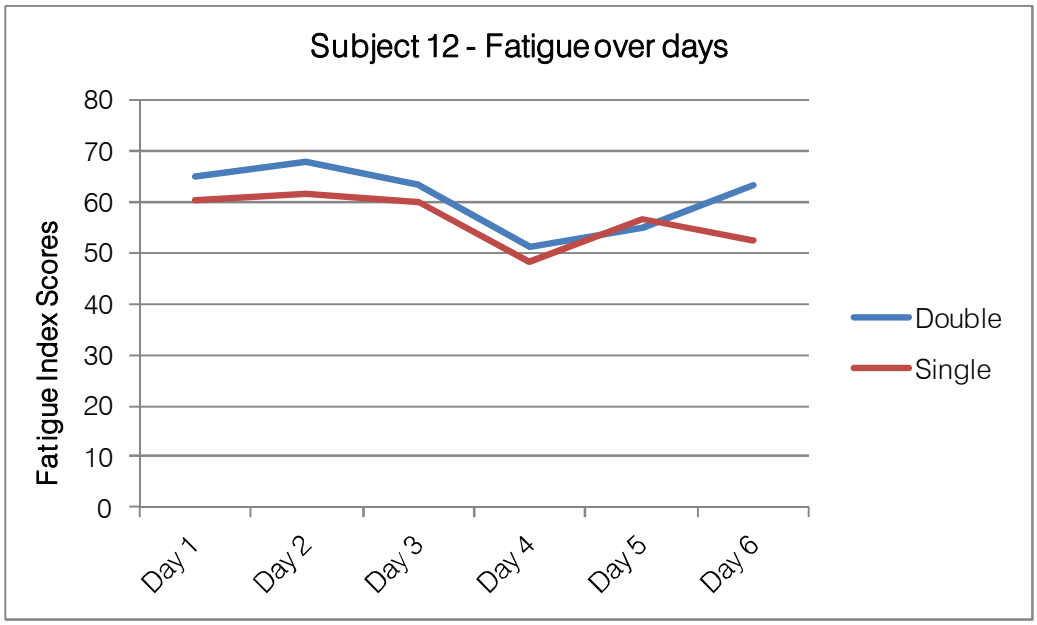


Figure 5.38: Subject 11 fatigue index score

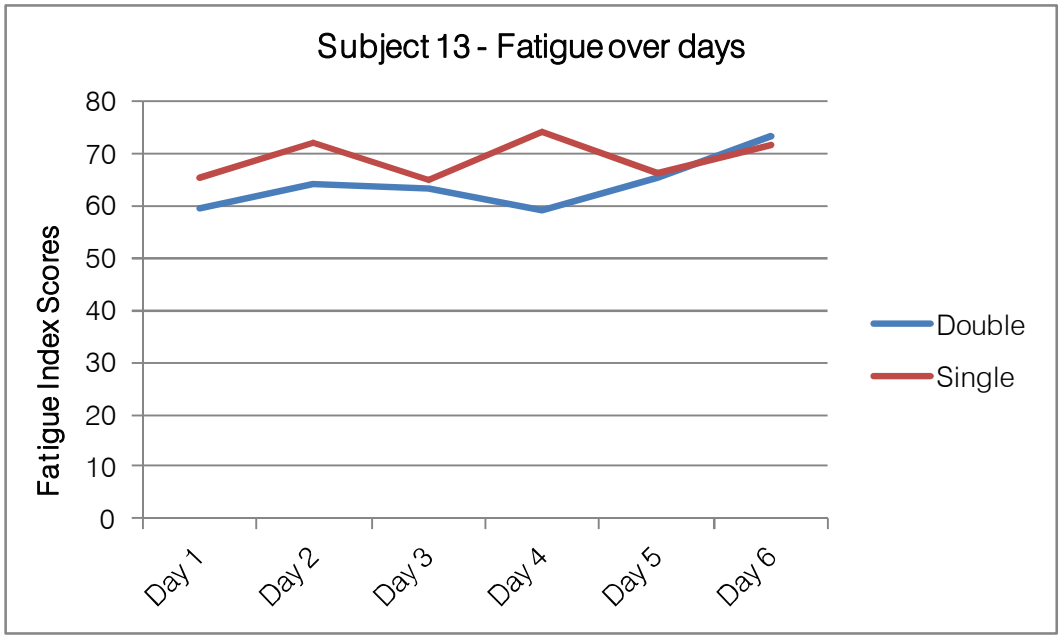


Figure 5.39: Subject 13 fatigue index score

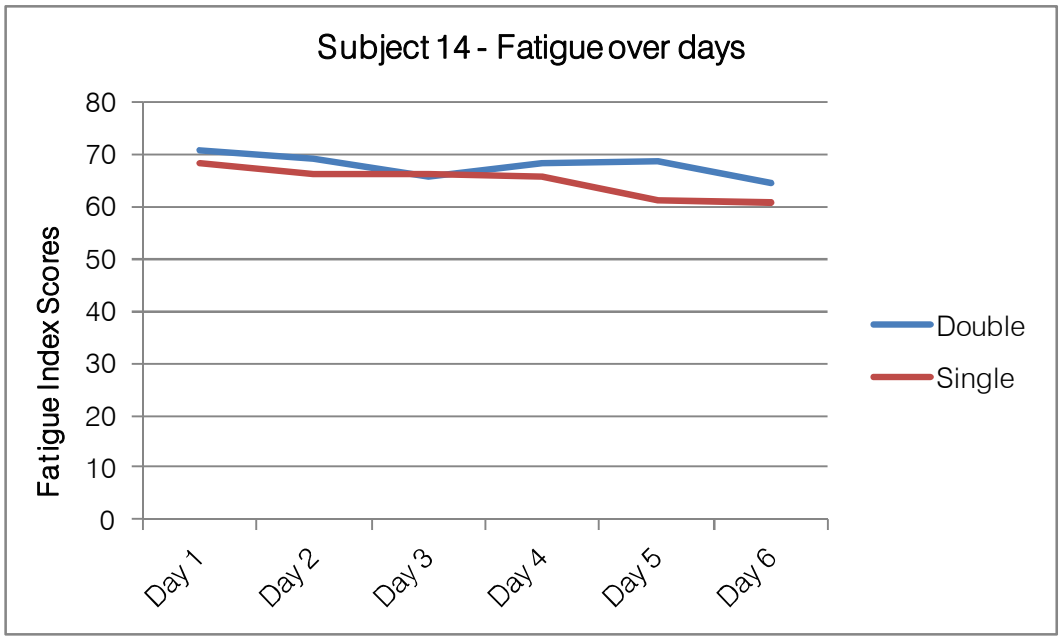


Figure 5.40: Subject 14 fatigue index score

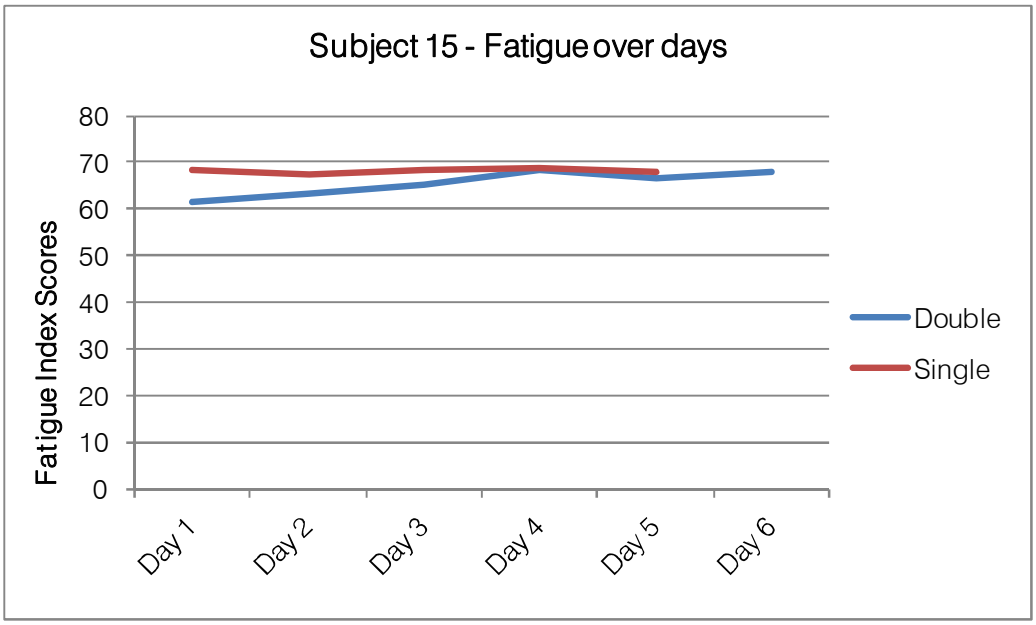


Figure 5.41: Subject 15 fatigue index score

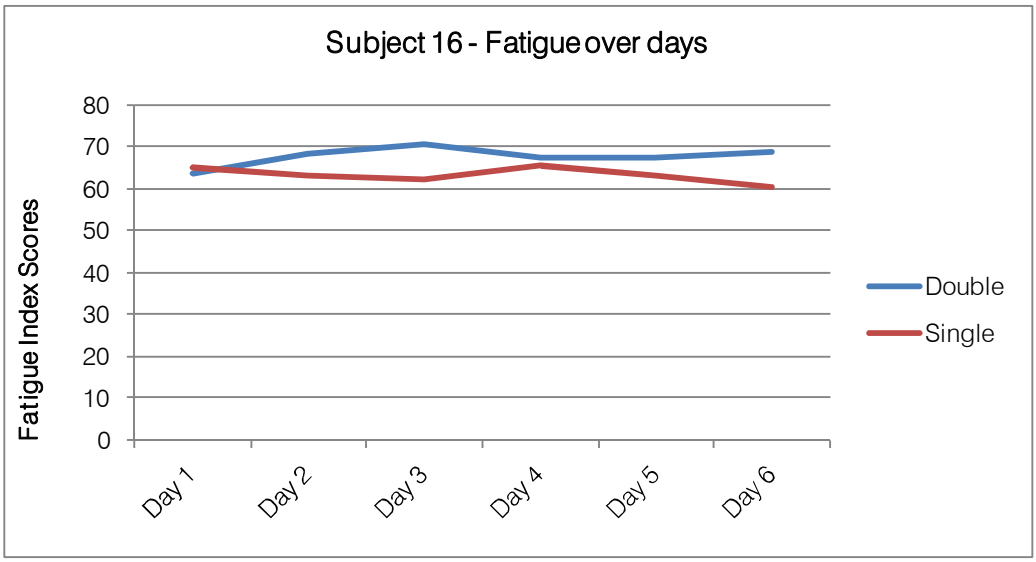


Figure 5.42: Subject 16 fatigue index score

5.11.11 The fatigue index scores fluctuate largely between 60 and 70, again indicating that overall fatigue levels remained fairly low across each shift. The majority of graphs (8) are fairly flat for both double and single crewing modes, indicating that fatigue did not increase over the period of the shift for these subjects.

5.11.12 There are four graphs which indicate an overall downward trend (subjects 1, 3, 12 and 14) where subject's fatigue did get slightly worse over successive days in both crewing modes. Subject 12's graph is interesting with a dip in the middle, indicating that the subject's level of fatigue increased between days 3 and 4 for both crewing modes, but improved (i.e. the subject was less fatigued) over days 5 and 6.

5.11.13 There are three graphs (subjects 7, 8 and 13) where the overall trend is upward, showing that fatigue levels decreased for these subjects over successive days, again for both crewing modes.

5.11.14 Comparing fatigue levels between modes, eight subjects (2, 4, 5, 6, 7, 11, 13 & 15) end the six day shift by rating their fatigue at the same level for both single and double crewing. There were three subjects (1, 8 and 9) whose level of fatigue was marginally worse at the end of the six days in double crew mode and five subjects (3, 10, 12, 14 and 16) whose level of fatigue was marginally worse under single crew mode.

5.11.15 Subject 3 displays higher levels of fatigue on days 3 to 6 when single crewed. The same shift pattern was worked during double shifts (EEE/LLL) and incident levels and type were similar on both double and single tests. This would indicate that, for this subject being single crewed was generally slightly more fatiguing.

5.11.16 The index scores for Subject 10 in single crew are slightly lower than in double. This individual worked night shifts as a single crew which might account for the marginal increase in reported fatigue levels for single mode.

5.11.17 Subject 12 shows similar patterns of fatigue working as a double and single crew, with slightly higher levels of fatigue during single crewing. In both double and single testing fatigue levels peaked on Day 4 when the Subject completed his first night shifts after 3 early shifts. The subject's fatigue levels improved thereafter, although less so when in single crewed mode.

5.11.18 It is interesting that the only subject to record maximum scores for any fatigue factors (subject 1) did so for the last two hours of the day on the last day of the shift cycle for both double and single crewing modes. The subject reported being "exhausted" in both cases.

5.11.19 In addition to the fatigue scales, TO test participants were asked to rate how sleepy they felt on the Stanford Sleepiness Scale. Subjects responded at the start, middle and end of each shift.

5.11.20 This scale uses 8 points where 1= feeling active/wide awake and 8 = Asleep. Figure 5.43 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. 1, 2 or 3; these are classified as:

1 = Feeling active, vital, alert or wide awake

2 = Functioning at high levels, but not at peak

3 = Awake, but relaxed; responsive but not fully alert

5.11.21 There were no discernable differences in feelings of sleepiness scores over the duration of each shift or between double and single crews.

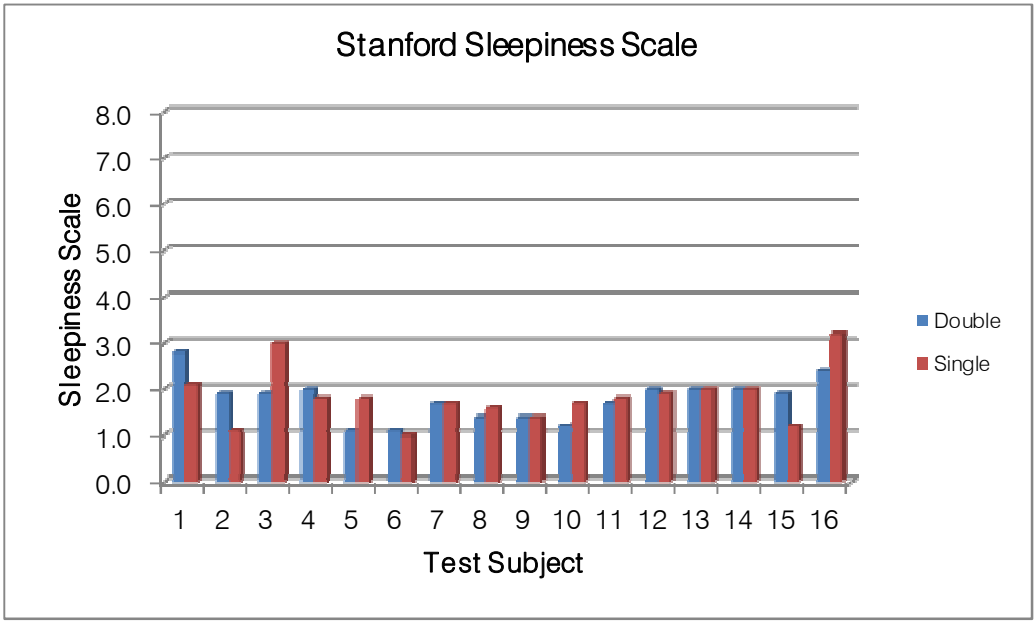


Figure 5.43: Rating scores on the Standard Sleepiness Scale

5.11.22 **Qualitative Data**

5.11.23 The subjective scales show that the test subjects tended to rate themselves as being alert and awake over the whole test period. However, some subjects did comment that the level of sleepiness they experienced depended upon the type of shift they were on and on the day. For example Subject 3 rated himself as being more awake on the first early shift than on the third early shift. By comparison, Subject 4 rated themselves higher i.e. more sleepy, on the first early shift and lower by the third shift. There is a risk that the test presented itself as something new and exciting to the usual job role and therefore skewed the fatigue ratings.

5.11.24 Subject 1 recorded high scores i.e. 5, 6, of fatigue on the last day of single crewing and stated that single crewing had “left me exhausted”. They believed that their increased fatigue was mainly due to having the sole responsibility of driving; in a double crew it is usual for the TOs to switch role between Driver and Observer every other day. Subject 9 also stated that they had found driving for six continuous shifts to be fatiguing.

5.11.25 Interestingly, most subjects stated that they actually feel less fatigued during busy shifts than quieter ones. Most raised the concern that if they were single crewed on quiet shifts that they may find this more fatiguing as they would not have a partner to talk to. One Subject admitted that he had deliberately patrolled to certain locations when in single crew as he knew that other TOs would be there to converse with.

5.11.26 The patrolling strategy on nights has recently been changed in the NW region which means that officers are now expected to remain in the outstation and respond to incidents as they occur instead of completing routine patrols. During the test period on night shifts often the TOs did a loop of their designated area of the network and then returned to the outstation for the remainder of the shift. It was observed that the test subjects, and other officers on duty, tried to remain alert and awake; however some officers did go to sleep for periods of time. It is not thought that this new strategy will have a direct affect on the sleepiness of single crew officers because they are likely to be sitting in the outstation with others; however the strategy may

affect how sleepy TOs are in general and, in turn, their response rates and efficiency.

5.11.27 From a welfare perspective, the outstations are not designed for TOs to be stationed there for long periods of time and they are not comfortable; for this reason some TOs choose to spend the majority of the night sitting the patrol vehicle in the outstation yard. If TOs are expected to remain alert and responsive then the outstation environment should be conducive to this.

5.12 Mood

5.12.1 The BMIS (Brief Mood Introspection Scale) was used as a comparative tool to understand if a test subject's mood altered negatively when single crewing. 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 etc. .

5.12.2 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:

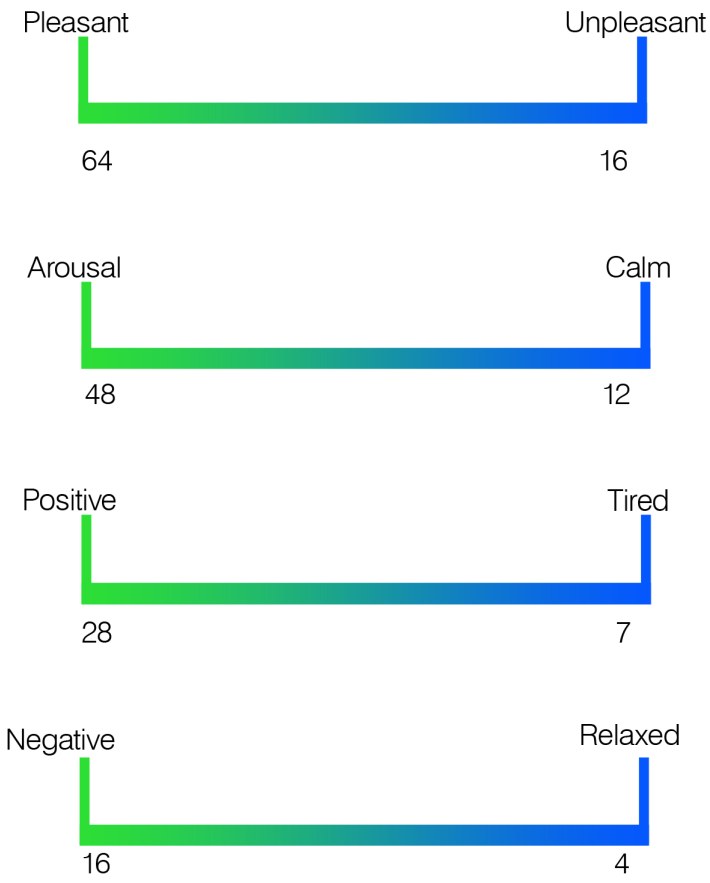


Figure 5.44 – Mood Scales

5.12.3 Table 5.6 shows the average scores relating to all mood scale scores for each test subject in double and single crew tests, illustrated further in Figures 5.45 to Figure 5.48.

		Test Number																
Scale	**Test Type**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**Total Av.**
P-U	Double	52.9	52.6	34.0	50.3	59.0	61.2	55.8	54.9	42.6	51.8	60.2	48.4	55.6	53.2	53.2	54.8	52.5
	Single	55.3	24.3	42.6	53.9	58.7	61.0	55.8	49.6	53.2	51.7	58.2	49.4	59.2	52.8	27.8	51.6	51.6
A-C	Double	23.7	23.8	19.1	28.1	26.4	28.5	26.8	24.8	20.7	26.9	27.9	22.1	27.2	22.6	25.2	25.3	24.9
	Single	25.7	12.0	21.9	25.3	26.2	28.6	26.8	24.1	25.6	25.2	26.4	21.1	27.6	21.0	22.4	23.1	24.3
P-T	Double	19.1	19.3	12.3	21.2	24.2	26.1	22.8	21.3	16.7	21.7	25.7	18.2	23.1	19.8	21.1	21.8	20.9
	Single	21.4	8.7	14.8	22.3	23.7	25.8	22.8	18.2	21.2	20.4	24.2	24.7	25.4	18.8	19.8	18.8	20.3
N-R	Double	7.1	7.3	8.7	10.1	6.2	6.5	7.6	7.2	7.1	9.5	6.1	7.6	7.7	6.4	7.6	12.3	7.8
	Single	7.4	4.2	9.6	8.1	6.4	6.8	7.6	9.1	9.8	8.7	6.2	7.1	6.7	6.1	5.8	7.4	7.6

Table 5.6: Average mood scale scores for each test subject in double and single crews

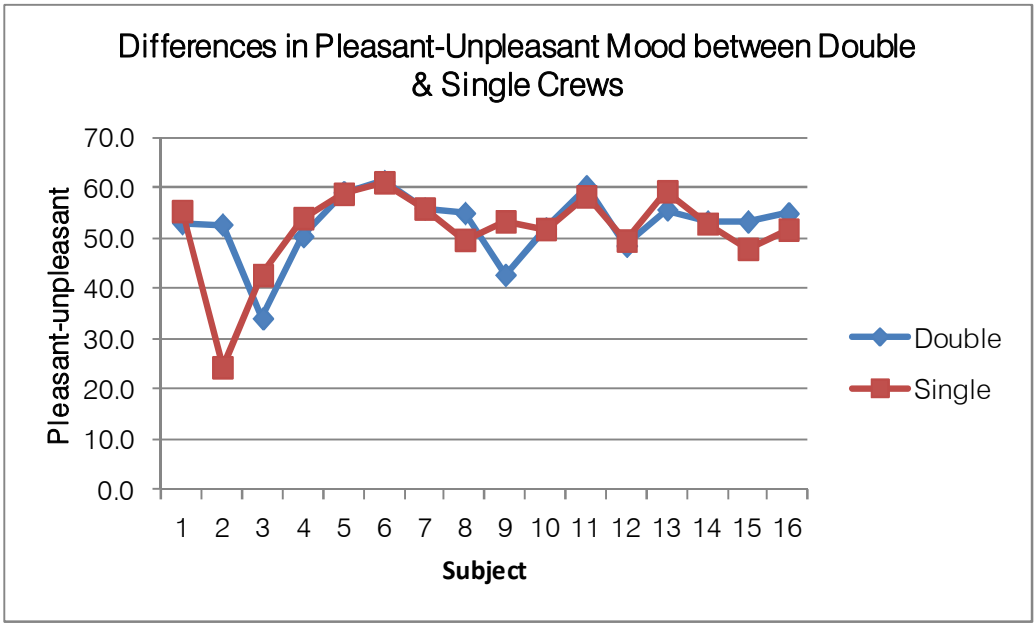


Figure 5.45 Averages for Pleasant-Unpleasant scale

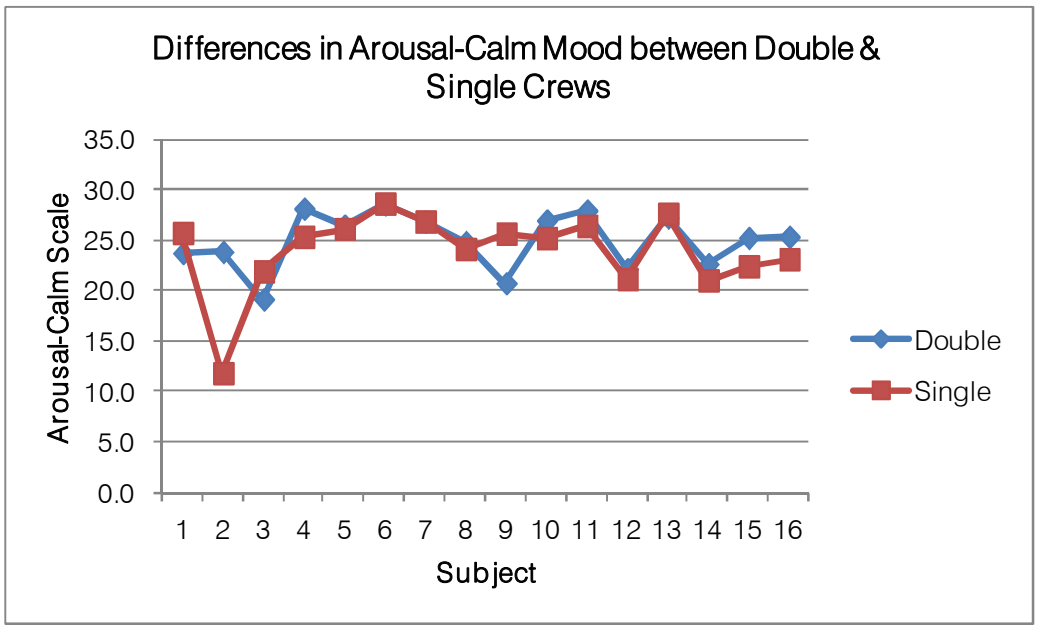


Figure 5.46: Averages for Arousal-Calm scale

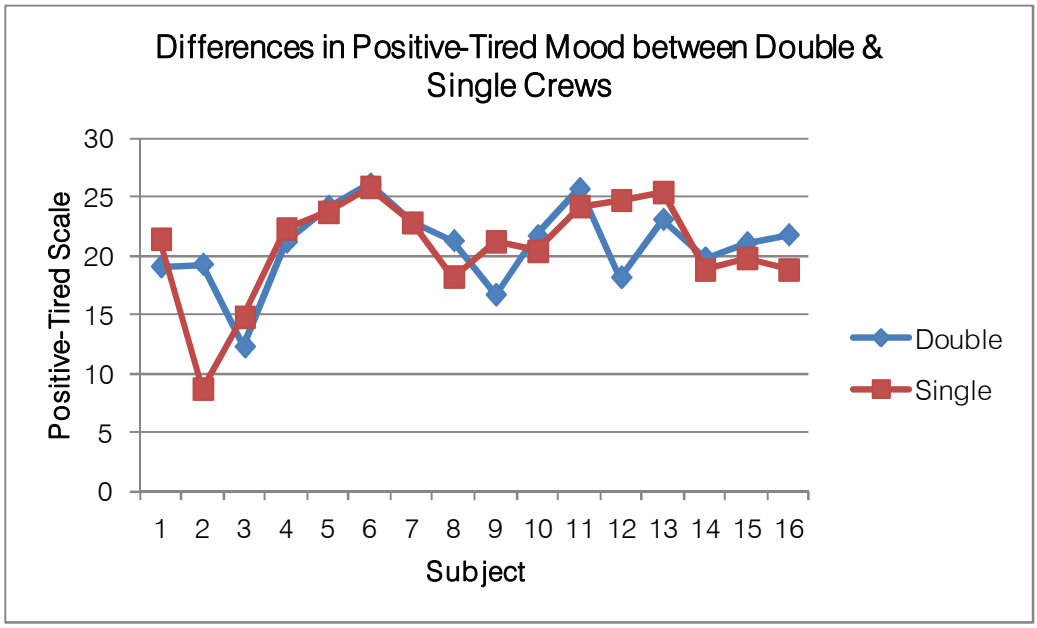


Figure 5.47: Averages for Positive – Tired scale

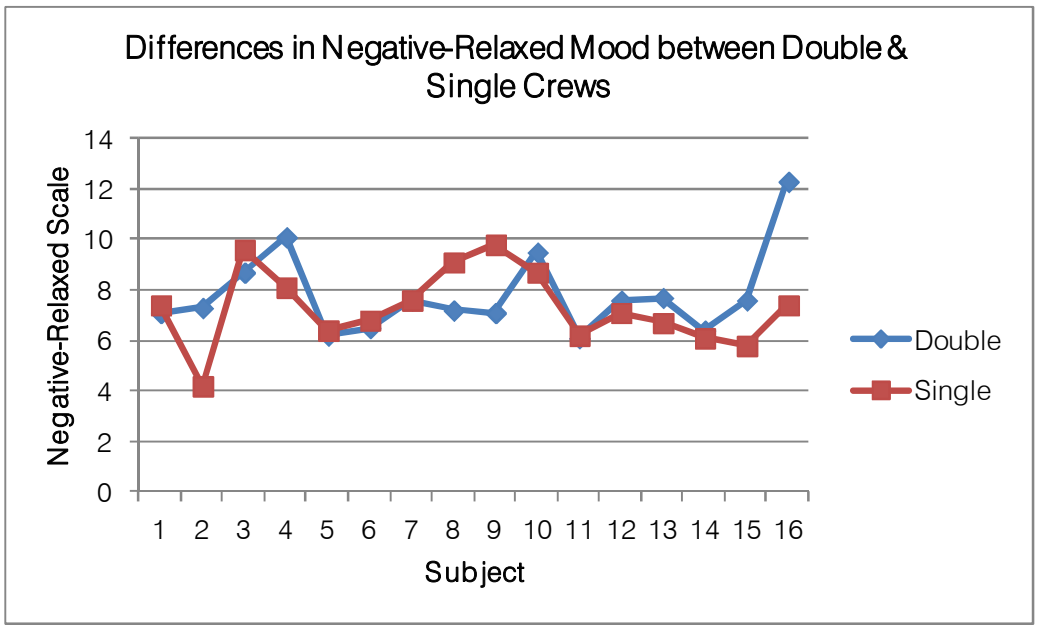


Figure 5.48: Averages for Negative – Relaxed scale

5.12.4 The data shows that, overall, there was minimal difference between Subjects moods in double and single crew tests. Subjects were generally in positive, alert but relaxed moods.

5.12.5 The most noticeable differences in all four graphs are the ratings for Subject 2. They consistently rated themselves less pleasant, calm and positive in a single crew than all other test Subjects. This is perhaps not unexpected however, as Subject 2 was taking part in Test 1 when it was cancelled on health and safety grounds, which appears to have had an adverse affect on their mood.

5.13 Performance

5.13.1 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/feelings of stress, both of which could influence how the subject performed. These were completed on separate scales where 1=Not demanding and 7=Very demanding. Figure 5.49 displays the average temporal demand ratings and Figure 5.50 shows rating scores for frustration.

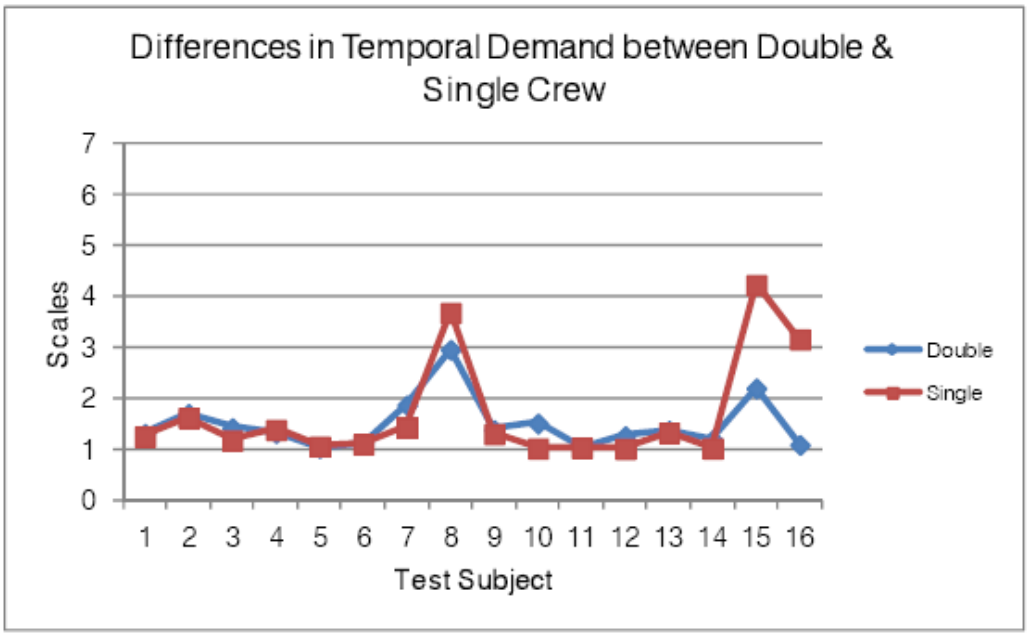


Figure 5.49: Temporal demand scores

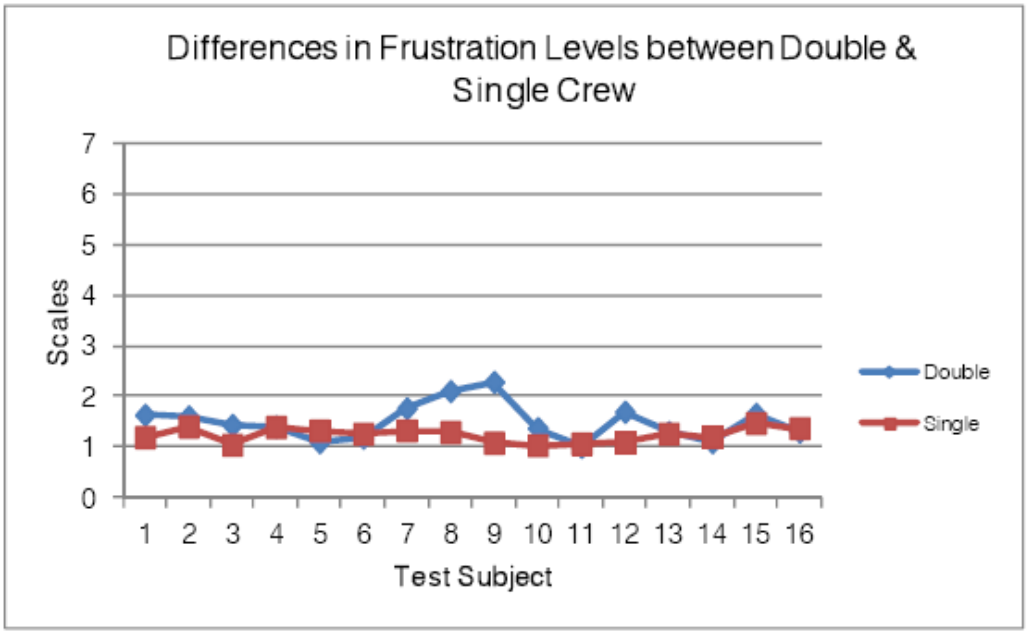


Figure 5.50: Frustration rating scores

5.13.2 Overall, test subjects recorded low levels of temporal demand and feelings of frustration with scores of 1 to 3. There were no discernable differences between double and single crewing data apart from for the temporal demand scores for Subject 15. This individual had to manage a live lane 3 RTC and sheep on the carriageway, both of which received higher temporal scores. Timeline information indicates that these higher scores seem to be because neither incident was straightforward and given that they involved working in live lane, added to the temporal demands felt by the subject.

5.14 SME Assessment

5.14.1 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

5.14.2 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. For driving and task performance, these scores were then considered as part of an overall assessment, based on the same scales.

5.14.3 A total of 349 SME assessments were completed for significant incidents; 136 in double crew and 213 in single. A cumulative total of 58 minus scores were recorded in double crew and 85 in single. It should be noted that some subjects received scores of above, below or expected within the same incident (the SME may have scored different elements or activities differently within one incident). 56% of subjects in double crew and 31% of subjects in single received minus SME scores relating to driving and/or task performance.

5.14.4 Figure 5.51 displays the percentage of cumulative SME minus and plus scores for driving performance in double and single crew. It clearly shows that a greater number of minus scores were given in single crew (49%) than in double crew (20%), but equally a higher number of plus scores were awarded in single (21%) than double (10%).

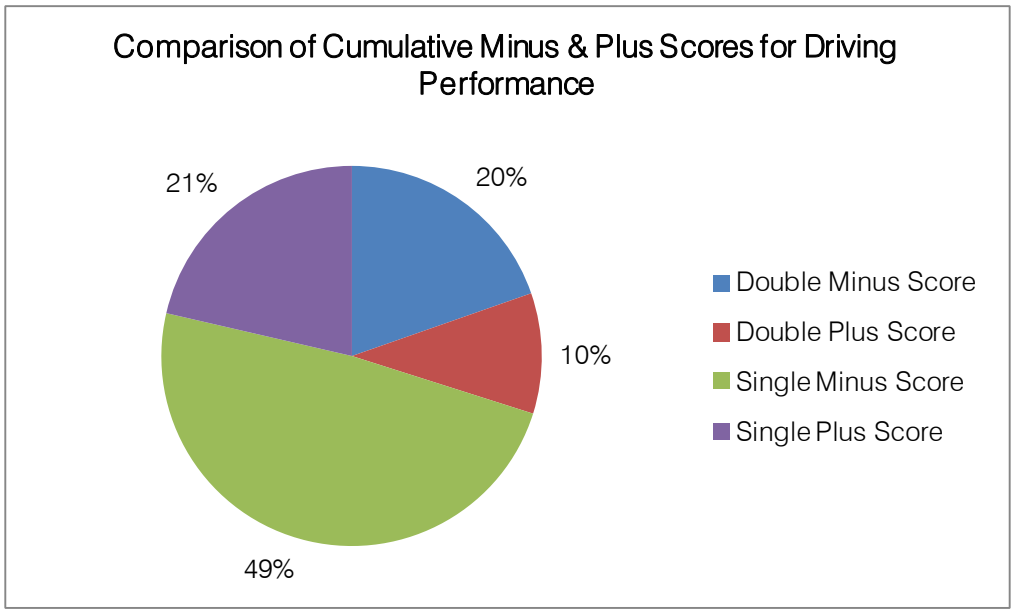


Figure 5.51: Percentage of minus and plus scores for driving performance

5.14.5 Figure 5.52 displays the percentage of cumulative SME minus and plus scores for task performance in double and single crew. It shows that a greater number of minus scores were given in double crew (36%) than in single crew (28%). A higher number of plus scores were awarded in single (30%) in compassion to double (6%).

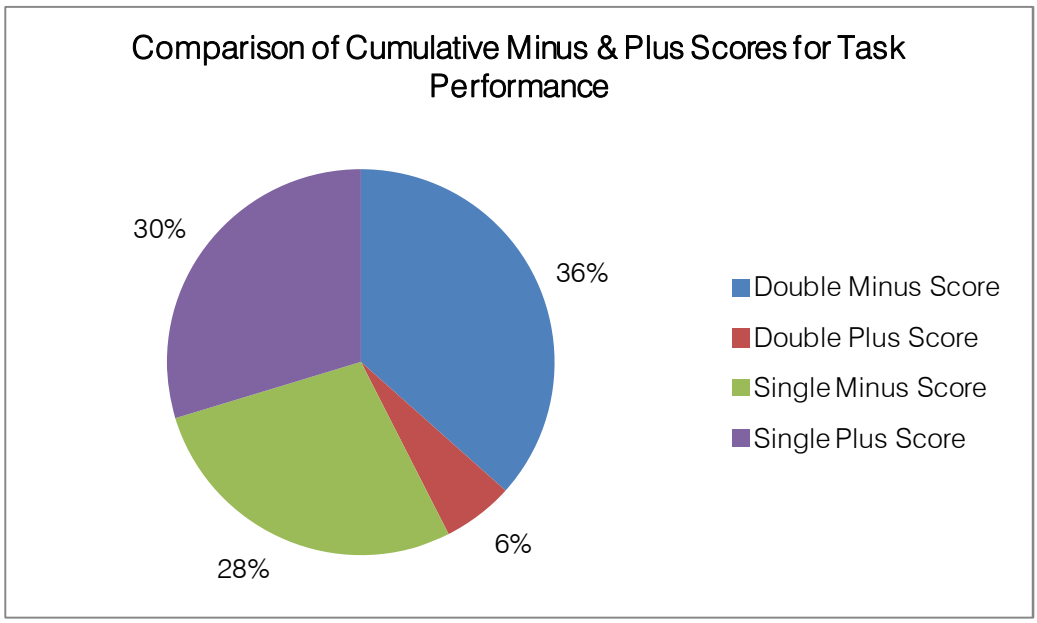


Figure 5.52: Percentage of minus and plus scores for task performance

5.14.6 Figure 5.53 shows each of the elements of driving performance that were rated by the SME and the cumulative scores in both double and single crews. The most marked difference between driving performance relates to elements of judgement, awareness/planning and compliance with operational guidelines. There is marginal negative change for single crewing in relation to entering/exiting the hardshoulder, steering, reversing and compliance to ops guidelines. Examples of SME reasoning for the driving performance minus scores can be seen in Table 5.7.

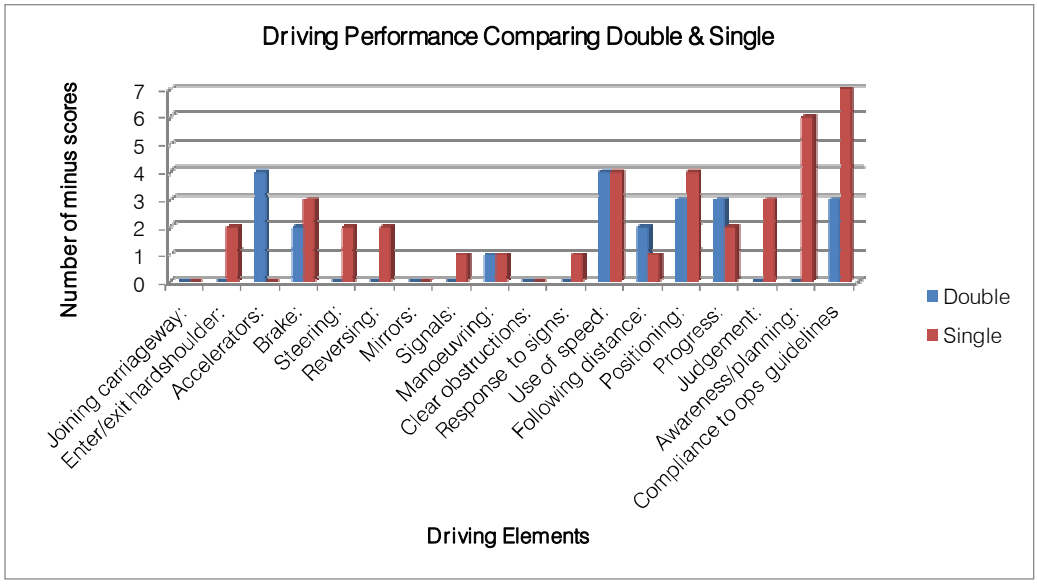


Figure 5.53: Comparison of driving performance

Category	Example of Reasons for Minus Score
Compliance to ops guidelines	*Responded at 60mph, should have been at 70mph* *Used light bar pad on entry to H/S instead of rocker switch.*
Awareness/planning	*Following a car trailer too close, missed observation of 2 vehicles on H/S*
Judgement	*Due to lack of forward observations, overshot incident and stopped in L3.*

Table 5.7: Reasons for minus scores

5.14.7 Interestingly, the elements of driving performance given the higher percentage of minus scores was different in Test B than in Test A which saw steering, entering/exiting hard shoulder and use of speed attracting the greater number of minuses, with supporting information indicating that, in some cases, use of the light control pad was to blame. It is likely that the introduction of the rocker switch in Test B had an effect on the driving performance of the Test Participants; however it is unclear whether this was overall positive or negative.

5.14.8 During the Test, the SME was required to complete an overall assessment of the driving and task performance of the test participants, in addition to the individual performance aspects listed within the questionnaire (See Appendix A).

5.14.9 Figure 5.54 shows the overall driving performance assessment for each subject in relation to safety and efficiency. Analysing 'Efficiency', although there is a difference between double and single, it is marginal given that out of 213 single crew incidents for example, there are only 5 occasions (2%) were a subject received a more negative mark than in a double crew.

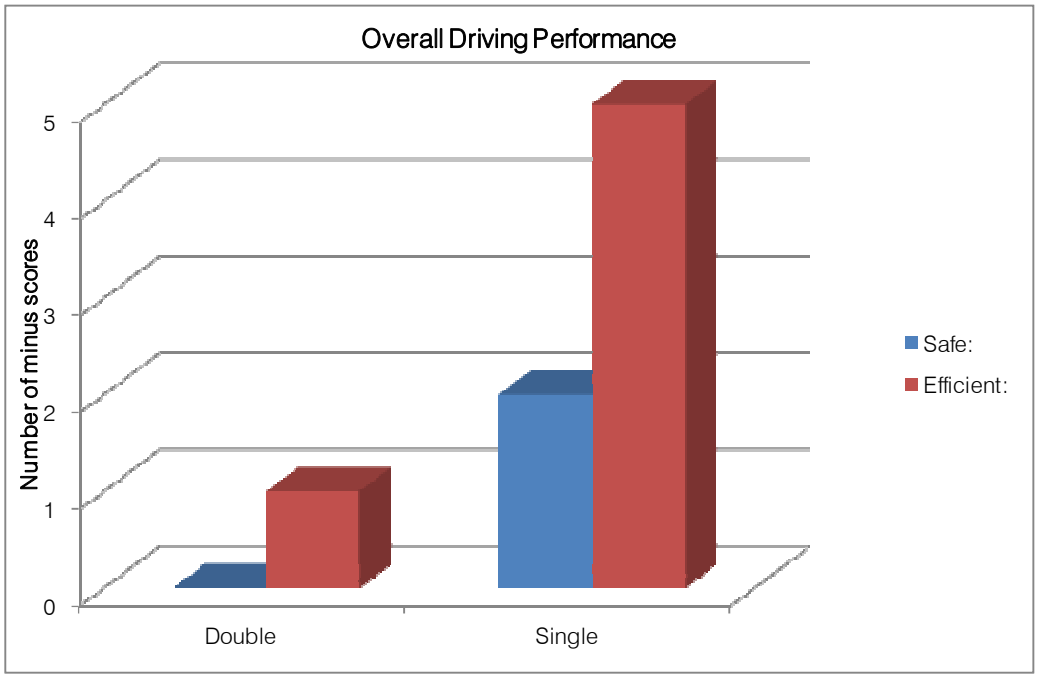


Figure 5.54: Overall safety and efficiency rating for driving and performance

5.14.10 Figure 5.55 shows each of the elements of task performance that were rated by the SME and the cumulative scores in both double and single crews. There was no real marked difference between scores in double and single crewing, but most minus scores related to the use of VMP and signals. Examples of SME reasoning for the task performance minus scores in relation to VMP and signals can be seen in Table 5.8.

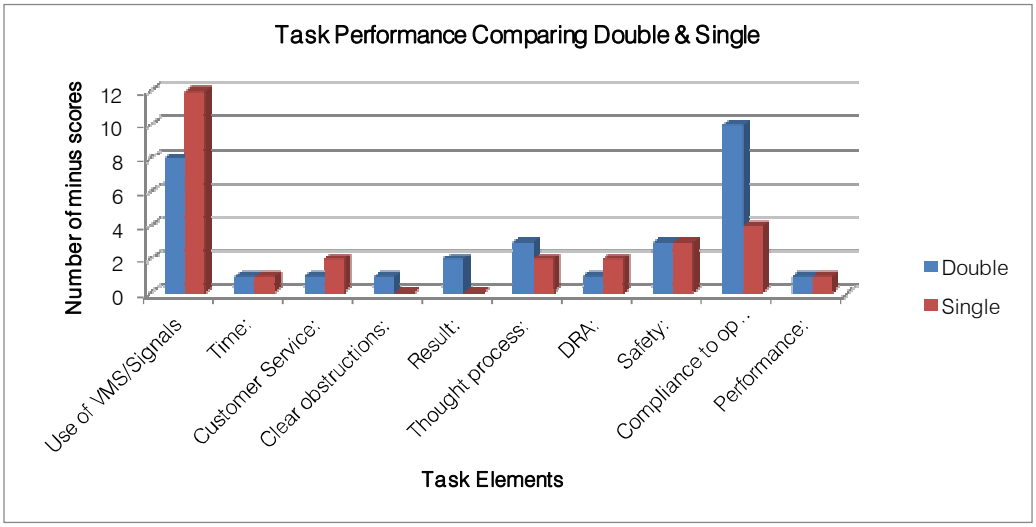


Figure 5.55: Comparison of driving performance

Category	Example of Reasons for Minus Score
Use of VMP/Signals	*VMP not turned off after RRB* *Rear reds not displayed when in live lane* *Rear reds left on whilst on H/S* *Rear reds and 'Keep Right' VMP arrows left on whilst on H/S*

Table 5.8: Reasons for minus scores

5.14.11 Figure 5.56 shows the overall task performance assessment for each subject in relation to safety and efficiency. The change between double and single crewing is trivial with a small reduction in the number of minus scores awarded.

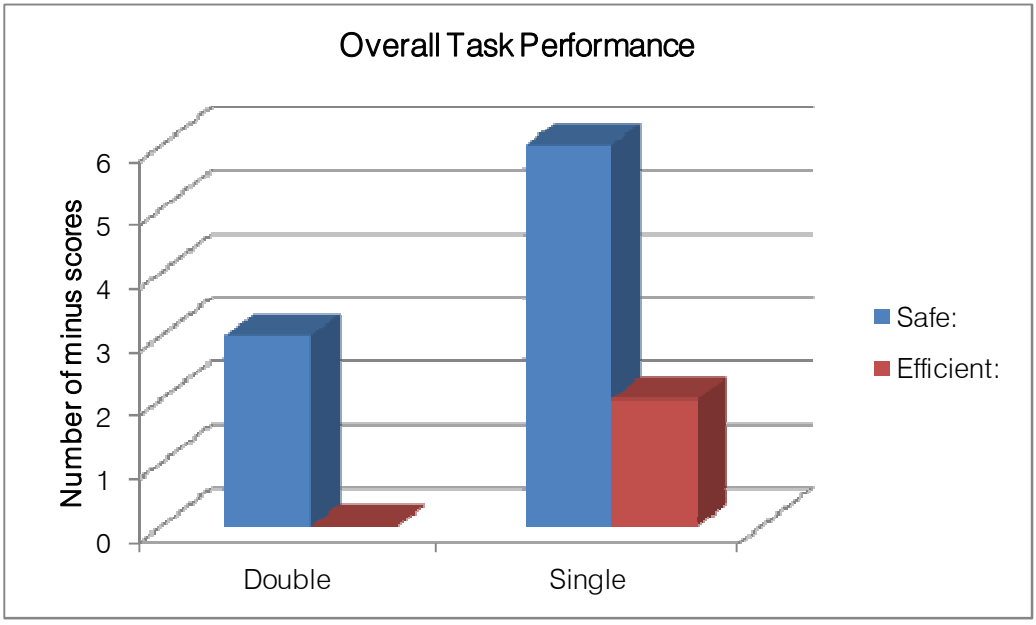


Figure 5.56: Overall safety and efficiency rating for driving and performance

5.14.12 These results indicate that during single crew, there were a greater number of incidents where the test subject was awarded scores which were below expected levels of performance. However, a larger number of incidents were attended to by single crews.

Qualitative Data

5.14.13 One Subject was given a minus score when working as a single crew because they overshot a car in the central reservation that had been involved in an RTC. The Subject was concentrating on another vehicle in L3 which had ignored the signs and signals that had been set and was trying to overtake the patrol vehicle. This resulted in the subject having to reverse back up L3. It is difficult to say if this would have occurred in a double shift, but perhaps with the presence of the second TO they may have observed the L3 vehicle sooner and steps could then have been taken to block it.

Rolling Road Block (RRB)

5.14.14 The completion of RRBs in a single crew during Test A was prohibited. The HA were keen to understand any potential implications for single crewing and approved the completion of RRBs by single crews in Test B. Furthermore, to ensure that adequate data was gathered to draw conclusions, it was agreed that simulated RRBs (know in test as GRRB) could be completed. Subjects were authorised to perform up to two GRRBs per shift. The number of RRBs and GRRBs for the test period can be seen in Table 5.9.

	Double Crew	Single Crew	Total for Test
RRB	11	28	39
GRRB	26	30	56

Table 5.9: Number of RRB's and GRRB's

5.14.15 Overall the RRBs and GRRBs were completed safely and accurately. There were no instances where a real RRB had to be aborted in a single or a double crew during the test period. There were only two instances where a GRRB

had to be stopped and these were both in a double crew: once when there was a fault with signs and signals and another when the Observer spotted an ambulance approaching.

5.14.16 Subjects stated that, overall, they felt comfortable completing the RRB procedure in a single crew and any issues raised relating to feasibility or safety of blocks were primarily concerned with the suitability of using the VMP and rocker switch and these are discussed in more detail in Section 5.14.

5.14.17 There were no discernable differences between double and single crewed RRBs and GRRBs in the mental demand scores nor was there an increase in minus scores for the SME performance scales.

Data Logger

5.14.18 A data logger device using GPS tracking was temporarily installed into two of the test patrol vehicles to record speed, acceleration and lateral deviation during each Test session in the hope of capturing some objective measures of driving performance and determining if performance deteriorated in single crew. The two small cameras attached to the logger provide video imagery which can be used in conjunction with the data to offer contextual information regarding prevailing road, traffic conditions, environmental conditions and the actions of the patrol vehicle.

Figure 5.57 – Video imagery provided by data logger

5.14.19 The logger was used in Test A, but without the CCTV cameras and the information recorded did not provide any useful information to help explain SME driving performance scores and observations. The HA wished to use the logger and cameras for Test B to provide context to any issues or problems identified during procedures such as RRBs. The loggers were installed into two vehicles: the Mitsibushi Shogun used for the Knutsford outstation Tests 1 and 5 and the Land Rover Discovery used for the Milnrow outstation Test 2.

5.14.20 A total of 392 hours data was recorded. The CCTV images along with the logger information for significant incidents were all analysed against time line information, specifically comparison of RRB performance in double and single crews and general driving performance on approach to an incident.

5.14.21 The data captured typically shows that subjects drove at relatively stable speed, between 50 and 60mph where the TO vehicle is travelling on the motorway interspersed with some spikes of increased speed (70mph) when travelling on route to an incident. Not surprisingly, speed and lateral acceleration variation increases markedly when the TO vehicle is travelling off motorway, particularly in and around service areas and on the urban road network.

5.14.22 Overall, the logger information and CCTV footage show that there was no consistent difference between the driving performance of the test subjects whilst driving in a double and single crew. Single crew tests did not demonstrate any obviously greater frequency or level of variation in speed or lateral acceleration.

5.14.23 All of the RRBs and GRRBs completed in Tests 1, 2 and 5 were analysed. The data indicates that there were no discernable differences between the speed and lateral acceleration during tests either when double or single crewed. Any differences that were found were as a result of the block that was being carried out.

5.14.24 Figure 5.58 shows a RRB for the purpose of debris collection carried out in a double crew on a Tuesday, around mid-day; the environmental conditions were good and the traffic flow medium. In comparison, Figure 5.59 shows the same test subject completing a RRB in a single crew. The purpose of a block was also due to debris in the carriageway. The environmental conditions were good and the traffic flow medium. In both graphs, Arrow A shows the start of the block and Arrow B denotes the end. On the graph, the red line denotes speed and the grey line lateral acceleration.

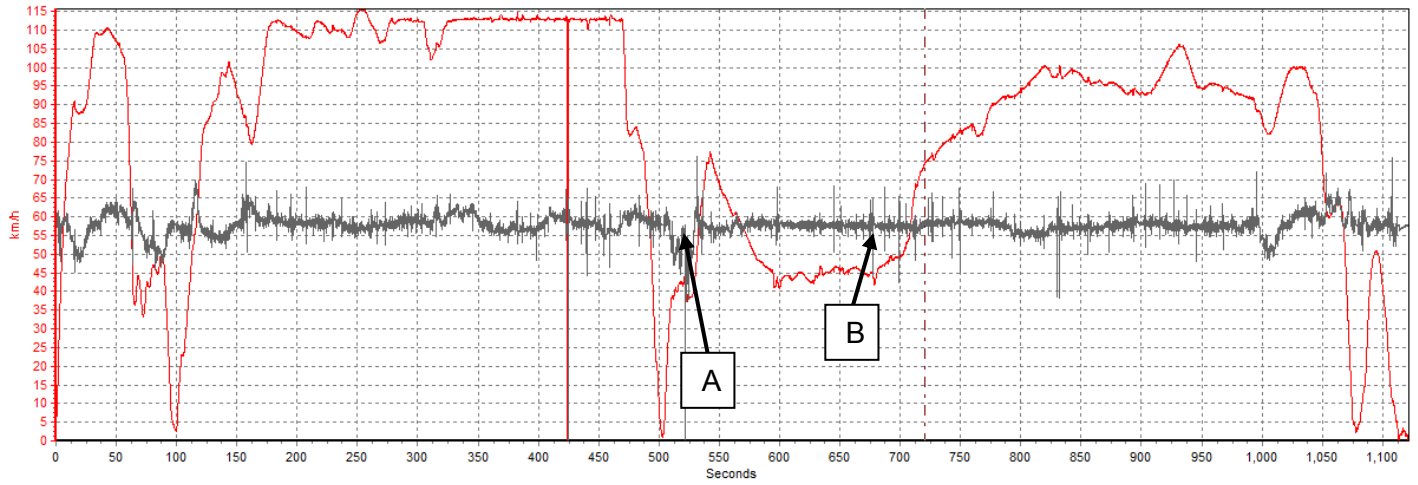


Figure 5.58: RRB for debris collection in double crew

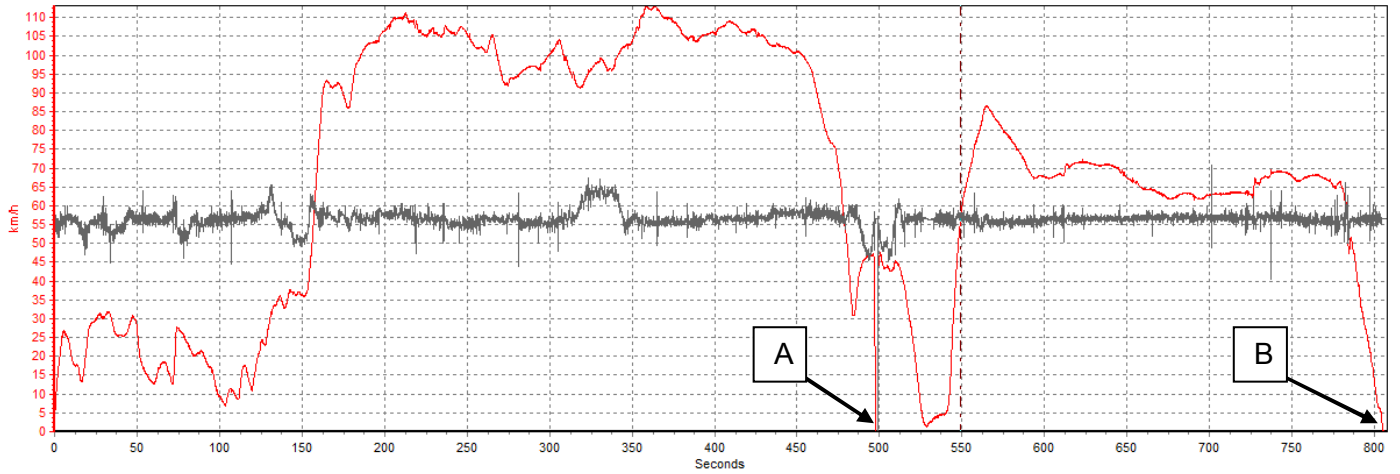


Figure 5.59: RRB for debris collection in a single crew

5.14.25 The graphs show a difference in speed over the duration of the block, but this is perhaps to be expected and will be influenced by the flow of the traffic and the reason for completing the block. There appears to be very little difference in lateral acceleration between the two graphs and any spikes can be accounted for by slight movement between lanes 1 & 2 to ensure compliance as observed on the CCTV footage.

5.14.26 Figure 5.60 displays the logger data for an RRB required for debris retrieval. This block was completed by a double crew on a Friday afternoon. The traffic was light and the environmental conditions clear. Conversely, Figure 5.61 shows an RRB completed by a single crew subject on a Sunday afternoon, to control the traffic ahead of a LL RTC. The traffic flow was medium to and environmental conditions good. In both graphs, Arrow A shows the start of the block and Arrow B denotes the end.

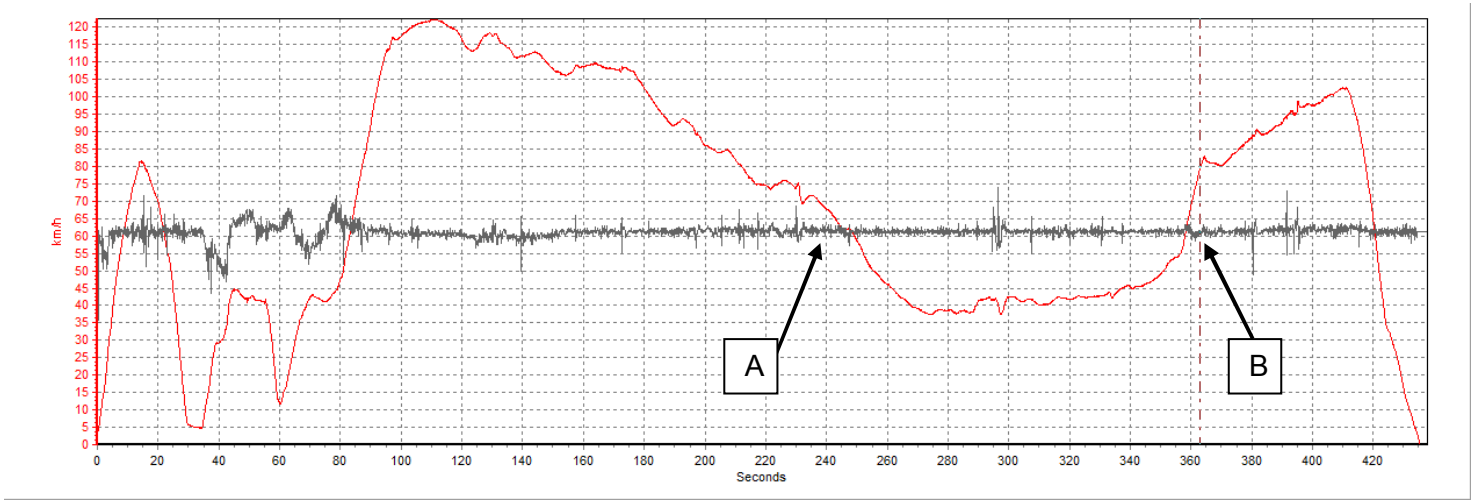


Figure 5.60: RRB for debris collection in double crew

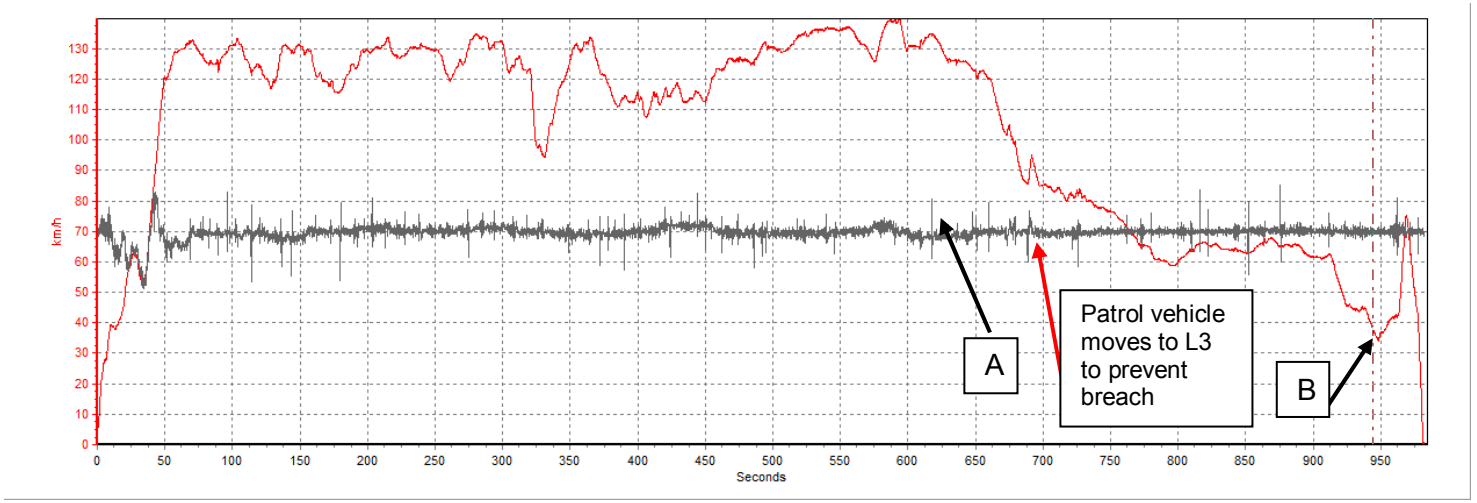


Figure 5.61: RRB for traffic flow ahead of RTC in single crew

5.14.27 Again, the graphs show that whilst there are some speed variations, they are not likely to be because the subject is working as a double or single crew but more due to traffic conditions and the requirements of the block. The lateral acceleration is marginally different and more frequent in the graph in Figure 5.61 than in Figure 5.60, but from CCTV it can be seen that the block was over a longer duration and required fairly regular, but minor, movements between the lanes of traffic to ensure compliance. The red arrow in Figure 5.61 indicates where the patrol vehicle had to sharply pull over to lane 3 to prevent a breach. The CCTV footage shows that this was done quickly and safely without the block being compromised.

5.14.28 The near miss resulting in Test 1, Subject 2, single shifts being cancelled was analysed. The subject submitted the near miss after coming across a big foot cone in LL1 on an unlit section of motorway at night. The subject could not find the rocker switch and averted his eyes from the road to operate the light bar control pad. Figure 5.62 shows an overview of the data logger output recorded prior to, during and after the near miss: the start is signified by Arrow A. Figure 5.63 shows an enlarged version of the near miss incident. Using the CCTV information, it can be reported that arrow A shows the time when the subject noticed the cone and B to C is the patrol vehicle moving onto the hard shoulder and coming to a stop.

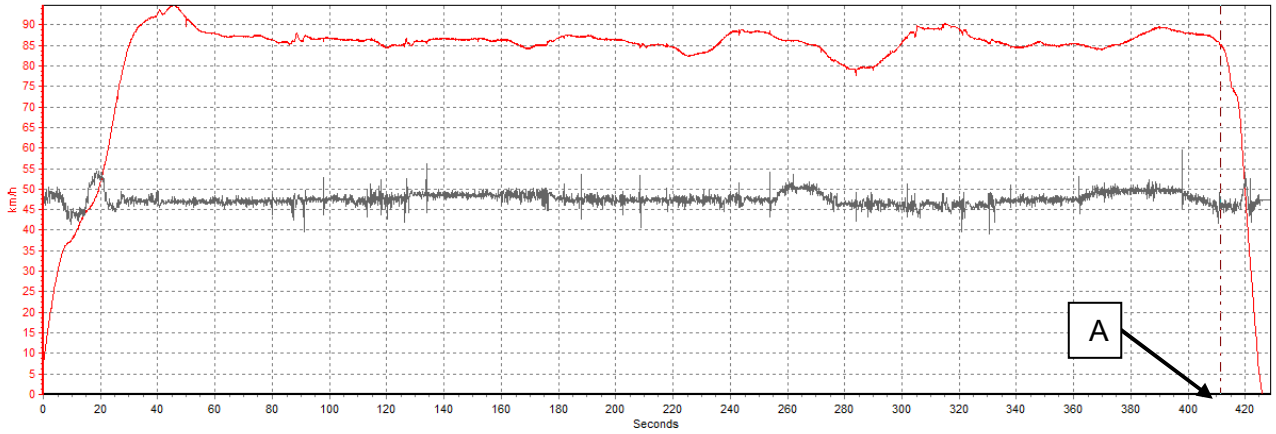


Figure 5.62- Overview of near miss incident

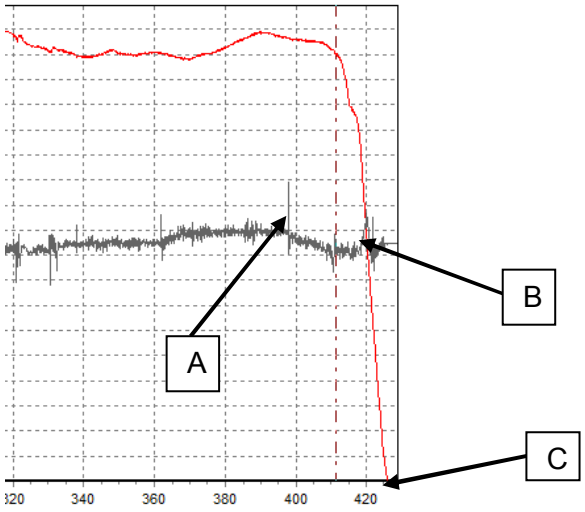


Figure 5.63- Detailed graph of near miss incident

5.14.29 The output shows that whilst there is some lateral acceleration between points B to C, these are not especially remarkable. This indicates that whilst the subject perceived the car to have swerved, there was only minor lateral acceleration which was similar to that as seen during RRBs.

5.15 Operational Issues – Equipment

Rocker Switch and Light Control Panel

5.15.1 The rocker switch, as explained in Section 4.6.5, was installed for Test B to provide primary light bar control to a TO in a single crew. It meant that the TO would not have to avert their eyes from the road to operate the light control pad currently located in the central console which was a highlighted as being a problem in Test A. During Test B, overall, most subjects found it relatively easy to use and became accustomed to the location of the rocker switch, however some limitations were identified:

The switch is not back lit

5.15.2 During hours of darkness, and especially on unlit sections of motorway, the switch could not be clearly seen by the TO. As described in Section 5 this was the primary reason why the remaining shifts for Subject 2, Test 1, were cancelled. The subject could not easily locate the rocker switch in the dark and had to avert his eyes from the road to look for the control pad instead resulting in a minor vehicle swerve. Figure 5.64 and Figure 5.65 show images of the rocker switch during daylight hours and in darkness on a lit carriageway. The switch has limited functionality.

Figure 5.64: Rocker switch clearly visible during daylight (Land Rover)

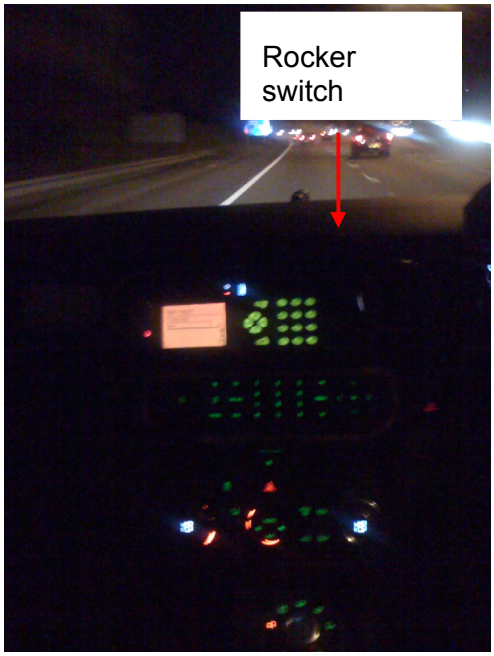


Figure 5.65: Rocker switch undetectable during darkness on a lit carriageway (Land Rover)

5.15.3 Pressing the red switch is supposed to imitate selecting the 'Arr' on the control pad which would activate the rear ambers and reds. Similarly the amber switch would only enable front and rear facing amber lights (no rear reds). There is no opportunity to enable any further lights. This was cited as being a particular problem during RRBs when another patrol vehicle or ISU

required visuals that the block was approaching. Pressing the red switch cancels the front amber lights and pressing the amber switch removes rear reds.

5.15.4 During Test A the light control pad remained in its location in the central console and it was recorded that there were five occasions where an SME reported that the test subjects driving had deteriorated because of interacting with the pad. During Test B there was only one occurrence of the driving being compromised when using the rocker switch. This suggests that having the controls closer to the driver and within their relative line of sight is an improvement.

5.15.5 After the cancellation of Test 1 and to ensure that Test 5 would go ahead, the rocker switch was removed from the test vehicle and the light control pad re-located to the left of the steering wheel. The Test 5 subjects reported that they thought this location was suitable and that they could easily see the buttons and activate the relevant functions without distraction.

VMP

5.15.6 The VMP allow for the TO to display a message on the back of the patrol vehicle e.g. 'Don't pass', 'Thank-you', scrolling right and left arrows etc. They are predominantly used during live lane incidents and RRBs and are a secondary tool to inform and direct traffic used in conjunction with gantry signs and signals.

5.15.7 The VMPs have recently been upgraded (this action was not related to the results of Test A or requirements of Test B). Figure 5.66 shows the new VMP used during Test B.

Figure 5.66: VMP display

5.15.8 During Test B four near misses were reported and a further twelve individual comments were recorded by the TOs or SMEs directly related to the poor design and operability of the new VMP. The main design flaws were identified as follows:

The on/off switch, enter button and function buttons are not back lit

5.15.9 The on/off switch, enter button and function buttons on the panel are not back lit which makes operability difficult in the dark. Figure 5.67 shows the VMP in decreased daylight. As part of the single crew procedures the TOs should pre-set the required message when stationary before attending an incident. However, in reality this is sometimes not possible, especially if the TO happens upon an incident without warning. In this scenario it requires the TO

to have to operate the VMP on the move and if the buttons are not visible and difficult to locate this could cause a distraction.

Figure 5.67: VMP panel in decreased daylight.

There is no status feedback i.e. is the VMP on or off?

5.15.10 There is no feedback to the TO on the display as to whether the message is still showing on the back of the vehicle. It relies on the TO to remember to turn off the message; this was not an issue during Test B but it was observed that several officers repeatedly checked the panel to ensure that the message was off.

The display screen is too bright in darkness

5.15.11 Several test subjects stated that they found the display too bright in darkness. Some subjects chose to turn the panel off but they would prefer not to have to do this so that they could access it easily in an emergency.

It is not possible to pre-set more than one message at a time

5.15.12 On the old panels it was possible to pre-set more than one message, for example in RRB, a TO may wish to use 'Don't Pass' during the block and then 'Thank-You' to help confirm that the block has been released. This could be activated by pressing one button. The new panels do not have this function and the test subjects spoken with did not consider it safe to be scrolling through the messages to find the one that is needed whilst driving/controlling traffic. In fact, during one single crew test it was noted by the SME that the subjects driving performance was compromised because they were scrolling through the messages on the VMP. On a further eight occasions subjects reported that the VMP was not suitable for the RRB requirements and they would have like to be able to easily change the message to help signify that the RRB was over.

5.15.13 The location of the VMP was suitable for the subjects in Test B to access, but in general some subjects stated that it would be beneficial to be able to angle or orientate the panel to the driver's seat when in a single crew.

5.15.14 Whilst these issues can also affect TOs in a double crew, they are exacerbated in a single crew scenario because there is no Observer dedicated to taking control and operation of the VMP.

5.16 Other Issues

Lack of Social Interaction

5.16.1 Whilst the role of a TO can be varied and interesting there are also extensive periods of time when there is little to do. New patrol strategies for early and late shifts have recently being brought in which stipulates that vehicles be strategically parked and await calls from the RCC. The strategy on nights is to remain in the outstation. Prior to this TOs could patrol their designated path regularly and this often generated some work for them, e.g. hard shoulder breakdown or debris. In double crew there is at least another person to speak to, in a single crew this is obviously lost. For some people this lack of interaction will not be taxing and will have little effect on them, but for others it could have a profound effect on their mood, levels of fatigue, frustration and stress. Test B examines this only to a limited extent given the presence of the SME and HFO.

Safety

5.16.2 Safety implications for TOs working alone is being addressed by the HA ahead of any single crew roll out programme and was not assessed in Test B given the presence of the SME and HFO. This aspect of single crewing was discussed with some subjects during the test and the main concern was how to respond to pedestrians, especially at night. This was discussed at length during the briefing days with no clear outcome other than to 'use your judgement' and to call for back up as required. It is anticipated that further clarification will be given ahead of any potential roll-out.

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, there do not appear to be any appreciable or consistent differences from a physical perspective when working in a single crew. Dependent upon the type of incident that they attend, a TO working alone may experience an increase in physical activity, e.g. putting out and collecting in all ETM, but the test subjects did not perceive this to be a particular problem. Any increase in activity is also likely to be for short periods of time with adequate rest and recovery in between. For example, putting out ETM for lane closure to assist a tyre fitter may require increased physical activity but after this has been completed, the TO may then be standing stationary on the H/S for sometime whilst the fitter completes the task. Furthermore, at serious or multiple RTCs it is unlikely that the single crew TO will be on scene alone and if they are first arrival, a back-up crew is usually close behind so there is an opportunity to share any of the physical tasks.

6.1.3 There does not appear to be a generally consistent or appreciable increase in mental demands when working in a single crew. However, after some of the more challenging incidents (e.g. LL3 RTC) or when having to attend to multiple members of the public (e.g. RTC on the hardshoulder) the relevant test subjects did tend to report higher levels of mental demand when working alone. They stated that this is because they no longer had the support of an additional TO and were responsible for completing all of the tasks as well as keeping vigilant over the safety of others on the network. Additionally there were some instances when the subjects forgot to turn off red lights when at scene on the hard shoulder and had to be prompted by the SME, or failed to respond the first time to radio updates from the RCC. These omissions though are likely to be because subjects are not used to completing all of the tasks required and it is a change to the way that they would normally complete their tasks. It is likely that this will lessen with appropriate training and experience.

6.2 Fatigue Levels

6.2.1 Overall fatigue levels do not differ dramatically or consistently between double and single crewing, although over a 6 day shift, a minority of subjects did feel more fatigued towards the end of their single shifts. One test subject who showed increased levels of fatigue stated that he found driving every day to be particularly tiring. He was an older subject who had a commute of an hour in each direction; both of these factors could have contributed to his higher levels of fatigue. However, other test subjects that completed single crewing on early and late shifts also commented that driving for 6 days consecutively was arduous and that not being able to converse with a second TO could be fatiguing when truly alone in the vehicle (i.e. when the SME and HFO are not present). Therefore, consideration of how single crewing might fit into the current rostering schedule might be needed to allow for TO's to have a break from driving. This of course would be different on night shifts, when often the vehicles do not leave the outstation.

6.3 Task and Driving Performance

6.3.1 The performance data shows that the SMEs reported more under performance for driving in single crew mode, including judgement,

planning/awareness, compliance to operational procedures and use of VMS/signals. The reasons for the associated errors could be attributed to lack of familiarity when working alone and losing the second TO as an Observer. Information provided by the SME's supports this as elements of tasks which would ordinarily be discussed with the second TO, e.g. ensuring that a procedure is correct or discussing what actions will be taken when arriving at scene, are no longer possible. Again, with training and familiarity a single crew TO should be able to maintain an appropriate standard of driving.

6.3.2 The data logger information that was analysed did not reveal any discernable difference in overall driving performance of subjects when double and single crewed and when completing RRB's. The data recorded was limited however given that the equipment was only used in three out of eight tests. Whilst the subjects using the vehicles with the data loggers attended some interesting incidents, it is known that on other tests which used vehicles without the logger, there were more challenging incidents which would have been helpful to analyse and compare.

6.3.3 The issue of the position of the in vehicle control pads still needs to be fully addressed. Whilst the rocker switch was adequate in some instances, there are limitations to its design. During Test 5, the light control pad was re-located close to the steering wheel and the subjects were able to easily use this. This indicates that a permanent solution is feasible.

6.4 RRB

6.4.1 The perception that Rolling Road Blocks were deemed to be of particular risk to a single crew TO appear to be unfounded on the results of Test B. Out of all of the RRB and GRRBs undertaken during the test only two were abandoned, both whilst double crewed and both in relation to external factors.

6.4.2 Any conclusions drawn from the results of Test B should however be read in context with the limitations set out within this report. It is the responsibility of the HA to decide whether the RRB procedure sits within their corporate risk tolerance when singly crewed.

6.5 Other Factors

6.5.1 The subjective data shows that there was no noticeable negative impact on mood or frustration when in single crew mode.

6.5.2 People's working environments can influence levels of frustration, irritability and stress which in turn can affect work performance. The original purpose of the outstations was to provide a place for TO's to convene before and after a shift and to offer basic welfare facilities during break times; they were not designed for continuous and sustained use. Outstation welfare arrangements should take account of the change in patrol strategies on nights and the change in TO requirements.

6.6 Safety

6.6.1 Figure 6.0 below is an illustration of an injury pyramid which shows that for each death/RIDDOR there are many more lost days and accidents that require treatment. This is mainly due to the fact that most accidents share the same root causes.

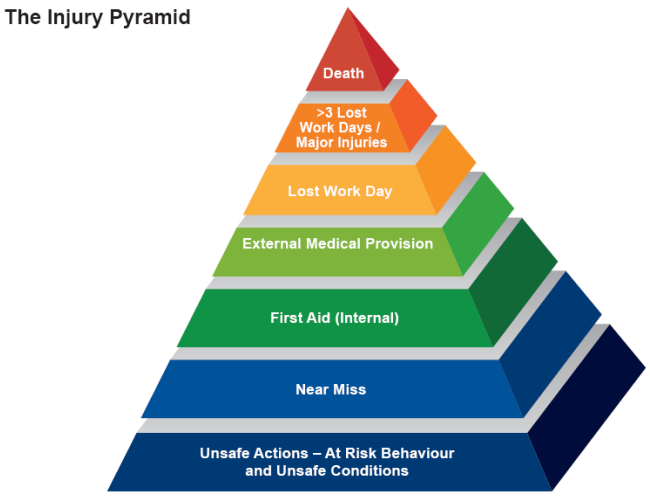


Figure 6.0: Injury Pyramid.

6.6.2 A commonly applied measure of workplace safety is the Accident Frequency Rate (AFR) which Number of accidents x 100000/No of hours worked. This attempts to express the number of RIDDOR reportable accidents that an employee is likely to receive during the course of a typical career.

6.6.3 Therefore a high AFR, which is based on the number of reported RIDDOR accidents, would suggest that there is a heightened probability of a fatality occurring.

6.6.4 Table 6.0 below shows the RIDDOR data for the HA TMD, alongside the number of hours worked in order to calculate an AFR.

TMD Area	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Grand Total
East	1	2	0	1	0	0	1	0	0	2	2	0	**9**
East Midlands	1	0	0	0	0	0	0	0	0	0	0	0	**1**
North West	0	0	1	0	0	0	0	0	1	0	0	1	**3**
South East	0	1	0	2	0	2	0	1	0	0	1	0	**7**
South West	0	1	1	0	0	0	0	0	1	0	0	0	**3**
West Midlands	0	1	0	0	0	2	0	0	0	0	1	0	**4**
Yorks & North East	0	1	0	0	0	0	0	0	0	0	0	0	**1**
	2	6	2	3	0	4	1	1	2	2	4	1	**28**

TMD Area	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Grand Total
East	40,623	35,598	43,283	36,882	20,648	43,547	49,393	47,470	48,472	47,306	44,453	35,139	**457,675**
East Midlands	16,023	13900	16,876	14,298	7,989	17,317	19,983	19,504	19,977	19,951	18,585	15,106	**184,403**
North West	32,950	26,471	37,718	31,771	17,458	38,266	43,590	42,505	42,126	41,138	37,797	29,148	**391,790**
South East	38,728	31,808	42,314	35,837	18,664	43,224	48,688	46,626	47,506	47,437	44,095	34,320	**444,927**
South West	21,658	17,190	22,796	19,610	10,546	23,120	26,940	25,884	26,061	25,798	24,127	19,274	**243,730**
West Midlands	26,678	22,018	28,413	24,884	13,699	29,332	33,809	32,254	32,573	31,992	29,444	23,685	**305,096**
Yorks & North East	24,454	22,277	28,021	23,488	14,710	28,614	32,627	31,368	32,377	31,332	28,876	23,564	**298,144**
	201,114	**169,262**	**219,421**	**186,770**	**103,714**	**223,420**	**255,030**	**245,611**	**249,092**	**244,954**	**227,377**	**180,236**	2,325,765
								Accident Frequency Rate (AFR)				**1.12**	

Table 6.0 – Accident Frequency Data for TMD

6.6.5 Figure 6.1, below, shows a monthly breakdown of the AFRs within the HA TMD for 2010/11.

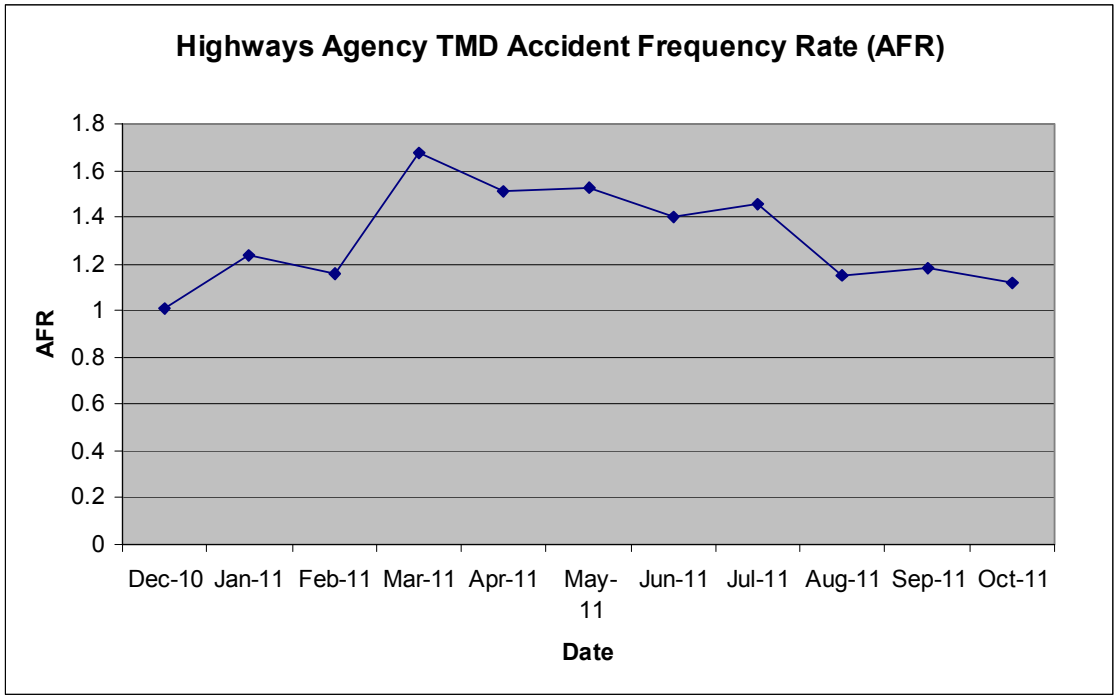


Figure 6.1 – Monthly HA TMD Accident Frequency Rate for 2011

6.6.6 The AFR of the TMD can be compared against other industries generally regarded as high risk, such as the construction industry. Figure 6.2 below illustrates the AFR of four randomised construction contractors with the HA TMD.

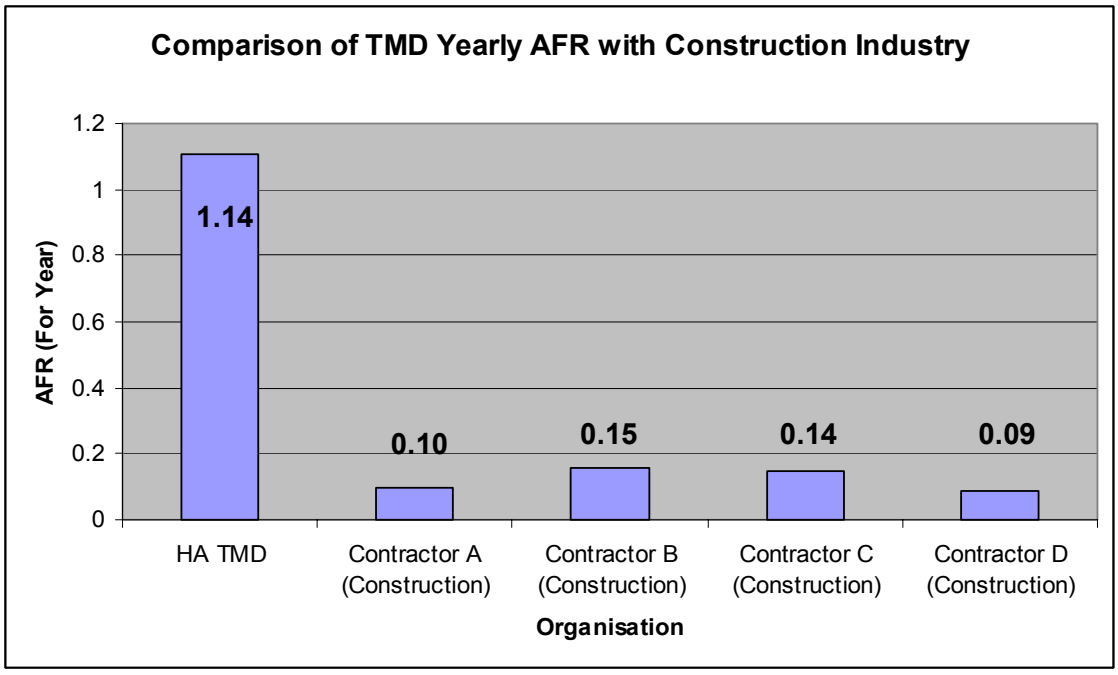


Figure 6.2 – Comparison of TMD AFR with Construction Industry

6.6.7 Figure 6.2 above demonstrates that the construction firms (selected at random) have a much lower AFR than that of the TMD. This offers context as to the relatively high AFR of the TMD.

6.6.8 The AFR of the TMD can also be compared against the HA's own Motivating Success Toolkit (MST). Within this toolkit there is a section for safety, and one of the assessed areas is a suppliers AFR. A supplier to the HA would be scored zero out of ten for any AFR that exceeds 0.3. Therefore by the HA's own standards, the AFR of the TMD is not acceptable.

6.6.9 Any future rollout of single crewing should carefully consider the impact it may have on the AFR and the HA should consider whether this is within their acceptable corporate risk tolerance. The AFR of the TMD should also be reviewed against the HA `Aiming for Zero' programme to determine whether additional measures are required to reduce the reportable accidents reported within the TMD.

7 LIMITATIONS

7.1 Test 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 only a few serious or complex incidents (i.e. multiple injury or fatal 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 complex or serious incidents or, indeed, if there would be any safety implications.

7.1.3 The number of incidents, on average, that Test subjects attended was lower during double crewing than when compared with single crewing. This is expected as for every double crew test there were two single crew tests. The number of incidents attended during Test B would appear to be representative of the incidents attended within the North West region over the same timeframe of the test. However, it is not known to what extent the North West region is representative of the TO experience in other regions in England. It is possible that single crewing might prove more onerous in other regions, such as Cumbria, if the number or range of incident types were markedly different.

7.1.4 Furthermore it is known that other regions and outstations follow different shift patterns: Test B tested a pattern of 'six on, three off', so the conclusions drawn from the subjective scales are only valid for this. If the test were to be completed in regions with a different shift pattern, TO's ratings of various test factors may be different. Rob Lane was excluded from Test B as a result of operating a different shift regime to those of other outstations within the North West region.

7.1.5 The demographic of the test subjects was predominantly male, with an average age of 43 years, in good health and relatively fit. Perhaps the low fatigue scores reflect this. Other TO's who are older and/or less active may find the experience of single crewing more arduous, dependent on the incidents that they attend.

7.1.6 Whilst every effort was made to test all subjects following the same shift patterns on double and single, this was not possible for six out of the sixteen subjects due to rostering requirements. This makes it more difficult to accurately do a direct comparison of the subjective scales.

7.1.7 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 maybe skewed by the enthusiasm of the test subjects. It is therefore possible that some current TOs

would find single crewing much more challenging and fatiguing than the test subjects did.

7.2 Lone Workers

7.2.1 The Health and Safety Executive (HSE) have published guidance for Employers who are involved in lone working (See Appendix B). The guidance outlined below is not compulsory, but it should help the HA decide what they need to do to comply with their legal duties towards lone workers under the Health and Safety at Work etc Act 1974 and the Management of Health and Safety at Work Regulations 1999.

7.2.2 The guidance describes lone workers, and includes in the definition those who work alone outside of normal hours and mobile workers who work away from their fixed base, such as vehicle recovery and maintenance work. It is clear that a singly crewed TO would fall into this definition.

7.2.3 The law requires that the HA consider the H&S risks that people will be exposed to prior to them working alone, and take appropriate action. The importance of this is emphasised by the current Accident Frequency Rate in the service.

7.2.4 The HA should carefully consider the risks associated with lone working, including the guidance set out by the HSE. During Test A and Test B there were a number of risks that were identified, as shown in Table 7.0 below:

Lone Worker Risks
Communication
Particularly during Test A and occasionally during Test B there have been problems with the Airwave communication system, with instances of dropouts and delays in relaying information to and from the RCC. The communication equipment and protocols currently used by the TOs may not be appropriate for a single crew.
Currently mobile phone communications are used as a backup to Airwave. However, the HA should assess the suitability of using a mobile phone in relation to single crewing.
There is a risk that the current equipment relied upon for communication is not sufficient to raise the alarm in an emergency, either manually or automatically.
Training and Behaviours
There is a risk that staff are not adequately trained to single crew. This applies to both the RCC and the TOs. There is a range of capability within the TOS and certain individuals may not be suitable or may require extensive training. The staff tested were either picked from a group of the best officers, or were volunteers. Less confident, or less capable, TO's may not be included in these groups.
There is a risk that TOs will not be sufficiently experienced to fully understand the different risks and changed precautions associated with lone working. It is likely that at some point a single TO will be called on to act in relation to an incident which is outside their training and experience. There is a risk that they will not respond appropriately.
There is a risk that the rollout of single crewing is not supervised sufficiently to identify health and safety issues or risks associated with single crewing.
There is a risk that instances of violence, aggression and attack could increase as a result of single crewing. The HA should consider conflict management training for its employees ahead of any rollout of single crewing.

Lone Worker Risks
The HA should consider the effects of lone working in light of the AFR. The HA should review the incidents for trends and assess if the likelihood would increase as a result of single crewing. There is a possibility that the current poor performance is as a result of cultural issues which will be difficult to address where staff do not work in teams.
Equipment
The equipment used by the TOs should be reviewed to ensure that it can be safely handled by a single crew. The types and range of equipment used should also be reviewed, as a single crew should not be issued with equipment that they cannot safely use alone. In addition, there is anecdotal evidence to suggest that the 610 signs are not fit for purpose and should not be used in either crew state.
The layout and types of equipment used within the cab of the TO vehicle should be reviewed to support safe and efficient single crewing. The primary task while driving is control of the vehicle. The equipment should support this.
Procedures
Any lone working should be approved based on a risk assessment. Whilst it may be appropriate to be alone in low risk areas, there may be times and places where this not deemed suitable, such as in areas know to have large numbers of drunken individuals using the Motorway as a short cut, or remote areas where support may be slow in arriving.
The TO procedures should be comprehensively reviewed to assess compatibility with single crewing. There is a risk that the current procedures do not have sufficient control measures in place to cater for single crewing.
The procedures should be amended to include suitable emergency procedures that are required for lone working. There is a risk that the current procedures do not fully cater for an emergency, with particular reference to lone working.
The RCC procedures should be reviewed for their compatibility to single crewing. There is a risk that staff will not be able to assist the TOs adequately when singly crewed as a result of not having a risk based approach to the deployment of single crews. The RCC was not considered as part of Test B.

Table 7.0 – Lone Worker Risks

7.3 Feedback

7.3.1 Both Test A and Test B was useful in gaining qualitative feedback from the TOs in relation to their job roles.

7.3.2 There was feedback that in some outstations there is a perception amongst employees that TOs are not properly consulted about, or involved in, decisions that directly affect them. There is a risk that any potential rollout of single crewing is met with resistance should there not be an adequate means of communication and a training programme which allows input from employees.

7.3.3 There was feedback during both Test A and Test B that the signs carried onboard the TO vehicles are not fit for purpose and cause issues when attending to incidents. This feedback was further reinforced during the single crewing element of the tests. There is a risk that the current equipment is not adequate for single crewing and a thorough review of the need for each item and its design should be undertaken ahead of any rollout.

7.3.4 There has been feedback from the TOs that the aspect of their job which makes them most nervous is dealing with pedestrians who are not associated

with a vehicle. Anecdotal feedback suggests that the TOs feel they are at risk of malicious accusation, and are not confident of their Employer's support. This risk can only be heightened when single crewed. However, the TO has a duty to protect the public, and this may on occasion extend to allowing pedestrians into the vehicle. The HA should consider any solutions that may better protect the TO in this situation, such as use of CCTV within the patrol vehicle, or the use of an open communication channel to the RCC while pedestrians are on board.

7.3.5 Changes to the patrol strategy during the currency of the test meant that during night shifts TOs now spend extended periods of time in the outstations. The outstations were not designed or equipped with this use in mind, and there are reports that some TOs find it more comfortable to pass time sat in vehicles rather than in the outstation. The installation of comfortable seating and facilities to help keep TOs alert, such as entertainment or exercise systems, should be considered.

7.3.6 There was an instance during the test where a test participant swerved to avoid a traffic cone within a live lane (See Paragraph 5.3.2). The test participant did not notice the cone, as they were attempting to locate the rocker switch used to control the vehicle lights. It is not possible to be definitive, but it seems likely that the driver had failed to prioritise the most safety critical item, which in this case was driving.

8 CONCLUSIONS

8.1 Conclusions

8.1.1 The conclusions of Test A and Test B are documented in the following text. Table 8.0 below summarises the conclusions of Test A and assesses their validity for Test B, whilst taking into account the limitations of the test. See Test A Feasibility Report for detailed conclusions.

Test A Conclusion	Changed or Reinforced in Test B?
There does not appear to be any appreciable difference in physical demand between double and single crewing	Reinforced
There does not appear to be any appreciable difference in mental demand between double and single crewing	Reinforced
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	Changed
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	Reinforced
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	Reinforced
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.	Reinforced

Table 8.0 – Test A and Test B Conclusion Comparison

8.1.2 The conclusion founded in Test A that "*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*" has changed when looking at the results for Test B. Test Participants for Test B did not suffer from high levels of fatigue routinely in either crewing mode; however, a minority of subjects found that they were marginally more fatigued in single crew towards the end of a six day shift block. Test A participants were not tested over a six day cycle, therefore it is unsurprising that this marginal fatigue was not apparent the Test A results.

8.1.3 The conclusions of Test A that have been reinforced within Test B cover such things as physical and mental demand, driving performance and task performance. This includes the expanded elements of Test B, such as RRB's and working six day shift cycles.

8.1.4 From the results of the Test B Live Network Test it can be concluded, subject to the limitations set out in Section 7, that for the sample of TO's tested:

- Single crewing does not appear to cause greater levels of frustration or adversely affect mood
- The current facilities at the outstations do not provide adequate provision for continuous or sustained use
- Driving performance overall was found to be somewhat worse when single crewed, specifically for elements of judgement, planning/awareness and compliance to operational guidelines
- The task performance, overall, was found to be better when single crewed. Elements of poor task performance are related to use of the VMP and light bar controls via the rocker switch. This is likely to be improved by better design of equipment and positioning within the vehicle
- The RRB procedure appears to be feasible in single crew mode; however the design of the current VMP and limitations of the rocker switch have the potential to make the procedure difficult to execute safely
- The design of the latest VMP is not fit for purpose. Elements of functionality from the previous version are missing
- The rocker switch modification used during the test has limited functionality. A permanent solution with full functionality should be found, and the design should be carried out with the involvement of suitably qualified individuals
- Some TO's may find single crewing socially isolating which may impact on their work performance
- From the incidents attended during the trial period, single crew operation appears likely to be feasible, but will be better supported by improvements to the design and layout of the VMP and light bar control to support operation whilst driving; and by consideration of shift patterns as a single crew to reduce the likelihood of fatigue and monotony.

8.2 Driving Performance

8.2.1 Driving performance deteriorated while single crewed. It is understood that as in Test A, contributing factors are difficulty in operating the controls whilst driving (especially during darkness), the need to take on more mental and physical demands, 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.

8.2.2 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. Furthermore, there was an instance during the test where a test participant swerved to avoid a traffic cone within a live lane (See Paragraph 5.3.2). It is likely that the test participant failed to prioritise the most safety critical item, which in this case was driving.

8.2.3 As with Test A, there were problems with the layout and use of the in vehicle equipment during Test B. The layout of the vehicle should be assessed in detail, with the involvement of a range of users, installers and suppliers of in vehicle equipment, a professional in the field of vehicle ergonomics and any other stakeholders, such as the vehicle lease company.

8.3 Training

8.3.1 A comprehensive training programme is required ahead of a rollout of single crewing in order to meet the required standard of care for employees. It would be beneficial to train the TO's in prioritisation whilst driving, so the probability of them concentrating on the most safety critical item, and discarding those items that can wait, is increased. Even after mitigation, an elevated risk as a result of undertaking a second task while driving remains.

8.3.2 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 the public. This adverse impact has not been quantified.

8.4 Summary

8.4.1 Single crew operations within the limitations of Tests A and B appear to be feasible. However, 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. The HA need to be satisfied that the changed risks remain within the HA's corporate risk tolerance.

8.4.2 The tests did not address the safety of a lone TO involved in a personal injury accident in the course of their work.

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 We recommended that a suitable mechanism is developed, trialled and subsequently implemented allowing for the light control pad to be re-located closer to the steering wheel when working as a single crew. If this can be achieved and the TO's are satisfied then the benefits of using the rocker switch are negated. If re-location is not possible then redesign of the rocker switch will be necessary, including backlighting and improved functionality, allowing for control of the front rear and ambers to be compliant with current operating procedures.

9.1.3 The new VMP are not considered fit for purpose and adaptations are required to make them suitable for single crewing. All subjects stated that the inability to pre-set more than one message was frustrating, especially during RRB's, and that the lack of lighting of the controls was a retrograde step. If the new VMP cannot deliver this functionality alternative devices may need to be sought, or a reversion back to the old VMP.

9.1.4 There should be adequate visual feedback to the TO on the currently displayed message on the VMS. This has safety implications, especially during RRB's, if the VMS is displaying an incorrect message. It should be investigated if this feedback is possible with the current VMP and if not, an alternative is recommended.

9.1.5 All switches and buttons should be backlit so that they can be readily seen in dim environments. The level of light from the main display should be reduced to lessen the potential effects of glare when working at night.

9.1.6 It may also be beneficial to position the VMP, and potentially other controls, on an adjustable bracket so that the screen could be angled more towards the driver when double crewed. Any adjustments would need to be simple and quick to do e.g. a ball and socket joint.

9.1.7 Further live testing or a wider trial within the TOS is recommended to ascertain whether single crewing is suitable for all TOs. It is recognised that during the tests subjects were never alone, as the SME and HFO were present. An assessment of staff regarding their suitability for lone working is also recommended by the HSE Lone Worker guidance (See Section 7 and Appendix B).

9.1.8 Contingency procedures for responding quickly to the personal injury of a TO should be reviewed. In particular, communication protocols should be reviewed to minimise the added risk from not having a companion to summon help quickly in dangerous situations.

9.1.9 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.

9.1.10 Consideration needs to be given to the frequency and duration of single crewing for an individual. Some subjects found driving for six shifts in a row

arduous and tiring, and actively sought out other patrols so that they could engage in conversation to alleviate monotony. This could be mitigated by TO's not completing six single shifts in a row, but perhaps following a pattern of 3 days single, then 3 days double crewed. This would give them a break from driving and an opportunity to return to a double crew for social interaction.

9.1.11 The welfare facilities and arrangements at the outstations should be assessed to determine what changes are needed given the alterations to patrol strategies and the increased amount of time that TO's are based in the outstation. For example, some comfortable chairs and entertainment or exercise facilities could be provided.

9.1.12 Prior to a national rollout 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 may have greater exposure to more serious incidents and, as previously explained; subjects in this test did not attend these.

10 RISKS

10.1.1 Both Test A and Test B have highlighted areas of the TO's operational performance that represent a risk, that should be considered ahead of any potential rollout of single crewing. These risks that are related to single crewing should be carefully considered by the HA as to whether they are within their corporate risk tolerance.

10.1.2 Table 10.0 below details the risks that have become apparent during Test A and Test B:

Single Crewing Risk
There is a risk that the modification of the TO vehicles is undertaken without the consideration of the relevant stakeholders (See Paragraph 8.2.3), resulting in a cab layout that is not optimised for single crewing.
There is a risk that the change in strategy for night patrols results in a high level of boredom for the TO. The effects of this on a single crew have not formed part of either Test A and Test B.
The patrolling strategy on nights has resulted in the TOs spending extended periods at the outstation. There is a risk that any rollout of single crewing does not include the effects that this may have on the TO. There is also a risk that the outstation does not have the required facilities for a TO to remain occupied during night patrols.
There is a risk that single crewing will result in an increase of accusation of wrong doing when dealing with pedestrians on the network, with particular reference to those pedestrians who are not associated with a vehicle. This risk is especially heightened at night.
There is a risk that any potential rollout of single crewing does take into account regional variations that exist within the TOS. It is possible that single crewing may not be suitable for certain regions as a result of these variations.
There is a risk that the results of Test A and Test B contain an element of optimistic bias as the test participants may have found the tests new and exciting, influencing such factors as mood. The performance of the TO may also have been affected with the knowledge of having an SME and HFO present in the vehicle, this could also have affected how they answered questionnaires.

Table 10.0 – Single Crewing Key Risks