

## Human Factors Assessment of the Future Soldier Vision 2 Combat Clothing

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## Executive summary

A concept set of combat clothing; entitled Future Soldier Vision 2 (FSV2) combat clothing has been developed under the Close Combat Systems Engine Room task [1] to inform future procurement. The future combat clothing would be issued alongside the current Personal Clothing System (PCS), but worn on operations. FSV2 has been designed by the Royal College of Art (RCA) and contains several innovative design features such as three way entry pockets, the use of compression material and silent Velcro®. Over the past 18 months the initial FSV2 clothing design has undergone several design iterations.

In order to inform the DE&S led Combat Clothing System Requirements Document (SRD), a Level 2<sup>1</sup> Human Factors (HF) assessment of the FSV2 clothing was conducted. This compared the FSV2 clothing to the current PCS clothing using defined Human Factors (HF) assessment techniques.

11 subjects were recruited to take part in the HF assessment. These comprised the following three cohorts:

- 4 male subjects recruited from the 1<sup>st</sup> Royal Anglian Regiment (infantry).
- 3 female subjects recruited from the Intelligence Corp and Royal Artillery., (military females).
- 4 male subjects recruited from the 3<sup>rd</sup> Battalion (3 Para) the Paratrooper Regiment., (Paratroopers).

Two main test conditions were assessed; comparing the FSV2 combat clothing against the PCS. Each type of combat clothing was worn with one of three protective equipment ensembles; these were Mk. 4 OSPREY, VIRTUS and Enhanced Combat Body Armour (ECBA). This resulted in six discrete experimental conditions; PCS with OSPREY, VIRTUS and ECBA and FSV2 with OSPREY, VIRTUS and ECBA. A within subject, repeated measures experimental design was used. Each subject wore each of the six experimental configurations. Configuration allocation to each subject was randomised and a Latin Square design was used to balance order effects across conditions.

Subjects then underwent a series of range of movement tasks, HF relevant military tasks e.g. patrolling, leopard crawling; and selected Common Battlefield Test Facility (CBTF) obstacles. These tasks and obstacles were designed to test and challenge the clothing conditions. This will allow designers to assess the affect that the FSV2 clothing has on individual combat and military performance, to examine whether the functionality provided by the FSV2 combat clothing improves or hinders physical performance and to identify any further design changes that may benefit the clothing and which would be recommended to the combat clothing System Requirement Document (SRD).

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<sup>1</sup> Section 2.2 defines a level 2 Human Factors Assessment.

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Subjects had their task performance rated. After each experimental run, they completed a questionnaire to provide subjective feedback on how they felt the clothing had performed.

Data from the HF relevant military tasks, CBTF obstacles and the majority of subjective questionnaire questions/comments, demonstrate that there is no difference between clothing conditions, in other words, the PCS and FSV2 combat clothing perform equally well across a wide range of assessment criteria. Nor does either clothing system negatively impact on task performance.

Qualitative data from subjects (written and verbal comments and opinion), as well as written comments from investigators, has highlighted issues and concerns for both the PCS and FSV2 clothing systems. Used in conjunction with the rating data sets, these led to suggested design improvements (referred to as observed requirements) to the FSV2 combat clothing. These enhancements have been described in terms of 14 suggested additions to the SRD to aid the procurement of future combat clothing.

These design improvements are:

- **Observed requirement 1:** Combat shirt collar. The shirt collar should prevent straps e.g. the weapon strap, from irritation of the wearer's skin.
- **Observed requirement 2:** The positioning of arm pockets should allow for easy access and to minimise snags when donning load carriage equipment.
- **Observed requirement 3:** Arm pockets should allow for the storage of defined equipment e.g. a tourniquet.
- **Observed requirement 4:** The closing system on the combat shirt should be low profile so as to prevent it from being pushed into the wearer's chest by worn body armour.
- **Observed requirement 5:** An integral elbow protector should be included within the combat shirt.
- **Observed requirement 6:** The attachment system for the Tier II pelvic protection should allow easy attachment by the unaided wearer.
- **Observed requirement 7:** External trouser pockets should have a three way entry system.
- **Observed requirement 8:** External trouser pockets should be positioned to allow easy access in a number of postures and should be large enough to hold a military map.
- **Observed requirement 9:** Internal trouser pockets should be made from robust reinforced material to prevent holes from developing.
- **Observed requirement 10:** External facing material at the knee should provide a degree of additional traction/grip when kneeling or crawling.

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- **Observed requirement 11:** The internal knee pad should be anchored in position so that, once adjusted to a comfortable position, it remains in position.
- **Observed requirement 12:** Ankle adjustment should allow the ankle cuff to be pulled and secured so that it is tight around the ankle/boot interface.
- **Observed requirement 13:** The palm area of the gloves should provide good abrasion protection.
- **Observed requirement 14:** The palm area of the glove should provide a good level of traction/grip.

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**1 Aim of the work**

A concept set of combat clothing; entitled Future Soldier Vision 2 (FSV2) combat clothing has been developed under the Close Combat Systems Engine Room task [1] to inform future procurement. The future combat clothing would be issued alongside the current Personal Clothing System (PCS), but worn on operations. FSV2 has been designed by the Royal College of Art (RCA) and contains several innovative design features such as three way entry pockets, the use of compression material and silent Velcro®. Over the past 18 months the initial FSV2 clothing design has undergone several design iterations.

In order to inform the DE&S led Combat Clothing System Requirements Document (SRD), a Level 2<sup>2</sup> Human Factors (HF) assessment of the FSV2 combat clothing was conducted. This compared the FSV2 combat clothing to the current PCS clothing using defined Human Factors (HF) assessment techniques.

This will allow designers to assess the affect that the FSV2 combat clothing has on combat and military performance, to examine whether FSV2 improves or hinders physical performance and to identify any further design changes that may benefit the clothing.

This report outlines the Level 2 HF assessment of the FSV2 combat clothing.

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<sup>2</sup> Section 2.2 defines a level 2 Human Factors Assessment.

## 2 Introduction

Over the past decade Dismounted Close Combat (DCC) clothing and equipment has benefited from substantial investment throughout Ops TELIC and HERRICK, with Urgent Operating Requirements (UORs) overcoming historical deficiencies in capability. However, piecemeal acquisition of new equipment to meet specific UORs has resulted in poor integration, increased burden (e.g. physical weight and thermal burden) and ineffective mobility solutions for the soldier.

The MOD now faces a key risk, namely, that future under-investment in DCC clothing and equipment could lead to a tactical disadvantage when compared to potential adversaries. Additionally, UORs have not yet been fully delivered into the core programme, which risks a reversion to pre- Op TELIC levels of capability. In order to address and potentially avert this risk, the MOD has embarked upon an Integrated Soldier System (ISS) Programme.

The vision for the ISS<sup>3</sup> is to transform the soldier into an effective and deadly combat platform, equipped and trained to operate in all land environments/environmental conditions and capable of conducting effective tactical actions as a member of a dismounted platoon. The ISS will be able to defeat adversaries at 600m and suppress them at 1000m, giving the UK military a significant tactical advantage in the near future. In addition the ISS will be protected against the most likely threats whilst enhancing mobility i.e. being able to self-move up to 20km in a 24-hr period and with the agility to cross natural and man-made obstacles.

### 2.1 Future Soldier Vision 2 background

A subset of the wider ISS project is the Future Soldier Vision (FSV). This is a physical concept for the UK Dismounted Soldier in 2024 based on current military research and emerging commercial technology. The background to and requirement for the FSV and its first and second iterations (FSV1 and FSV2) have been reported by Lowe *et al* [1].

The FSV2 upgrades were driven by the FSV1 design brief and drew upon specific research in Dstl and Industry, together with Commercial Off-the-Shelf (COTS) and other developing technologies from 'Best Athletes' (Companies and Organisations at the leading edge of research in their specialist fields). SEA Ltd led the initial systems incorporation of the elements from each of these best athletes, specifically:

- Clothing – Royal College of Art
- Body armour, ballistic plates and power architecture – Source, Morgan and Intelligent Textiles
- Helmet / Head Sub System – Revision Military
- Dismounted Situational Awareness (DSA) - QinetiQ

The FSV2 showcases what is technologically feasible while being cognisant of military need. This was engendered in the FSV using a design brief which specifically drew from extant MoD research such as that from Dismounted Protection.

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<sup>3</sup> Integrated Soldier System Programme Mandate: APFO/Portfolio Management/Governance/382. Version 1.0 2016

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FSV2 brought together output from several research programmes (current military research and emerging commercial technology) to produce a physical concept to help visualise the principle of an integrated soldier system which could be delivered as the future Dismounted Soldier System (DSS) in 2024.

The FSV2 is designed to be exploited to promote discussion amongst the stakeholder community, highlight areas of potential integration issues and to showcase technologies as they mature within Dstl as well as wider industrial and academic partners. There is also the opportunity to test and evaluate different areas of the FSV2.

The areas addressed in the FSV2 were as follows;

- Clothing
- Helmet
- Body armour and load carriage
- Weapon system including surveillance and target acquisition
- DSA device

Figure 1 shows examples of the FSV2 equipment.



Figure 1; The Future Soldier Vision 2

This report will focus on a Human Factors evaluation of the FSV2 clothing, establishing whether the FSV2 clothing offers any performance benefit over the current PCS. Whilst PCS has performed adequately during recent operations, it is not

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specifically designed to be used in combat, under varying environmental conditions, or integrate with VIRTUS or the wider Integrated Soldier System (ISS).

The MODs combat clothing requirement is a clothing system that affords protection against all environmental conditions and reduces the dismounted soldier's signature. Additionally, it will increase basic armour coverage across vulnerable essential areas of the torso, and provide durable and combat effective trousers with integrated ballistic and non-ballistic protection, enhanced durability and flame resistance. It will also assist in reducing the soldier's physical burden, and increase mobility and agility.

The FSV2 clothing aims to address these issues and has been modified in the following way to achieve this:

- The fit of the shirt and trouser has been improved from the in-service Combat Clothing design. This has been achieved through changing the cut of the clothing to provide a closer fit to the body, using four-way stretch fabrics on the chest and bringing the waist of the trouser higher so it sits better when wearing body armour or load carriage.
- The pocket on the trouser has three points of entry to assist the wearer's access to the pocket when standing, prone or kneeling.
- The Under Body Armour Combat Shirt (UBACS) pockets are designed to have a bellowing action and additional eyelets added to improve the flow of air around the torso to keep the wearer cool when moving.
- A range of different sleeves have been integrated as part of the clothing to explore options for how a wrist mounted display might be worn and still be able to interact with the wearer's skin for biometric sensing and not compromise the protection afforded by the Combat Clothing.
- Protection has been integrated into the clothing. The armpits and shirt collar have been lined with ballistic silk to add to the overall survivability and integrated floating knee pads added to the trousers as well as padding added to the shoulders.

Figure 2 illustrates these design changes.

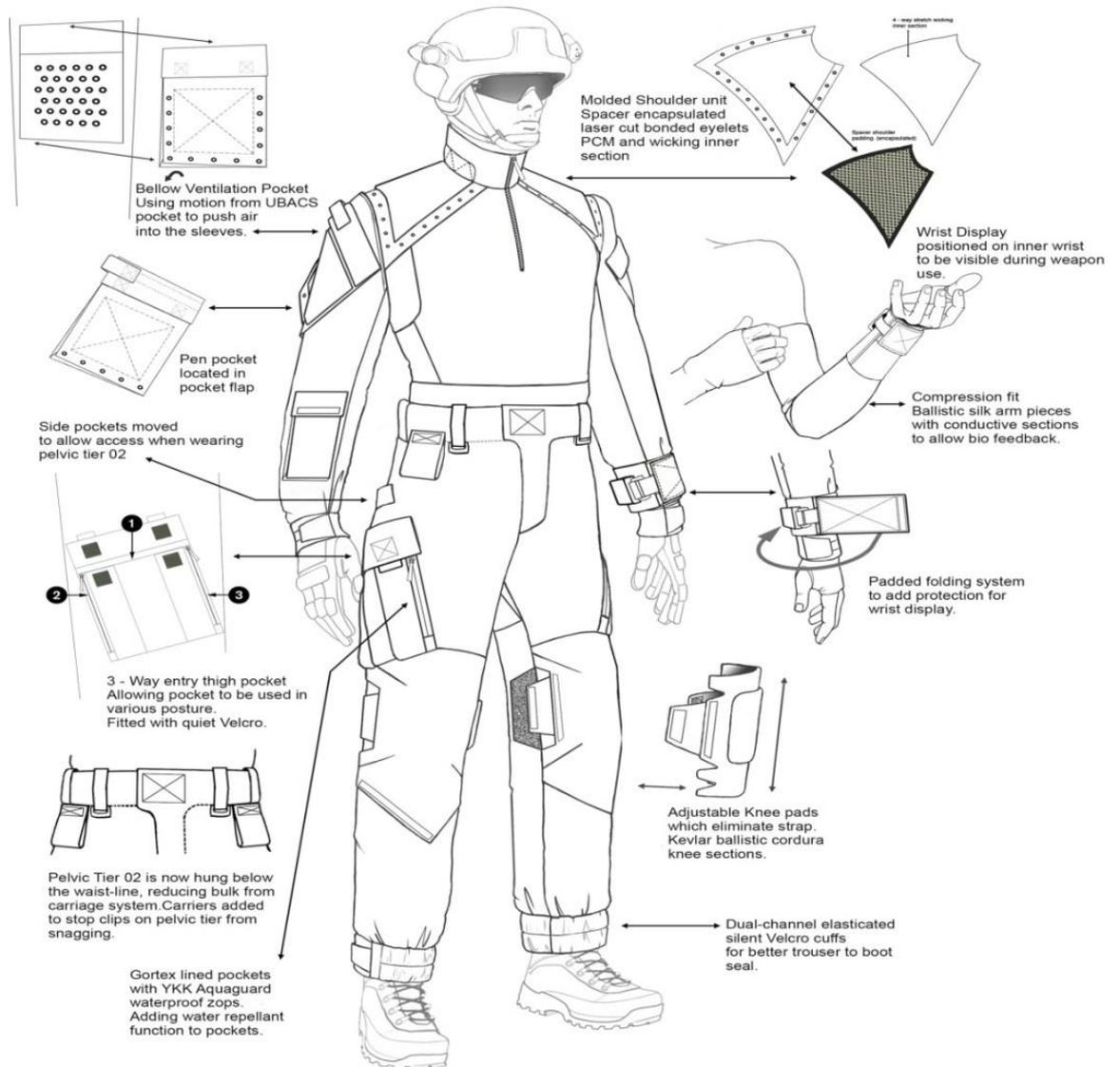


Figure 2: FSV2 combat clothing design features

## 2.2 Human Factors assessment of the FSV2 combat clothing

The DCC Human Factor Assessment Framework [2] provides a high level technical approach for HF Practitioners to gather HF data needed to support DCC Systems capability management, design and system analysis as well as Human Factors Integration (HFI) activities. The HFAF has been developed to provide HF practitioners with a robust and auditable way of gathering data on the people-related aspects of a system/capability. It is the intention that the HFAF will enable better discrimination between proposed systems/capabilities through a progressive iterative scientific approach. Applying the HFAF as part of research/acquisition programmes will improve the ability to provide advice and aid decisions through well designed, standardised and repeatable data collection activities.

The HFAF uses a three level approach designed to provide a structure against which the most suitable assessment method is selected.

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- **Level 1:** Initial HF Assessment - Specification or parameter paper-based review, visual inspection and / or functional assessment.
- **Level 2:** Functional Performance Assessment - Assesses the function and performance of a system for a number of users during a range of simulated military tasks, using standardised HF data collection methods.
- **Level 3:** Controlled Environment Assessment - A lab-based assessment which ensures a controlled environment. Used where high confidence, reliable physiological, psychological or performance related data is required to answer a specific question.

Selection of the appropriate level of the HFAF depends on the context of the assessment in which HF data is required. The HFAF allows for a risk-based approach to assessment to be taken, which considers the required validity and confidence of the outputs, whilst also taking into consideration some of the principle constraints of available time, cost, resource and personnel. Table 1 illustrates this principle.

	Level 1	Level 2	Level 3
<b>Time</b>	Increasing time requirement →		
<b>Cost</b>	Increasing cost →		
<b>Resource</b>	A non-representative / non-military like setting may be sufficient.	A representative setting should be utilised to enable understanding of the user in a more dynamic and integrated environment.	Highly specialised facilities are required in order to enable control over the environment and take appropriate measures.
<b>Users</b>	Increasing numbers of end-users / Subject Matter Experts (SMEs) →		
<b>Technology Maturity</b>	Applicable at all stages of technology maturity.	Consider the implications and validity of output if technology maturity is low.	Low technology maturity is unlikely to warrant a Level 3 assessment.
<b>Validity of Output</b>	← increasingly subjective data      Increasingly objective data →		

Table 1: HFAF variables within each level of assessment

For the purposes of this assessment it was appropriate to undertake a Level 2 HF assessment of the FSV2 combat clothing.

### **3 Methodology**

#### **3.1 Subjects**

In total 12 subjects were recruited to take part in the HF assessment. These comprised the following three groups:

- 4 male subjects recruited from the 1<sup>st</sup> Royal Anglian Regiment (Infantry)
- 3 female subjects recruited from the Intelligence Corp and Royal Artillery (Military females)
- 4 male subjects recruited from the 3<sup>rd</sup> Battalion (3 Para) the Paratrooper Regiment. (Paratroopers)

During the conduct of the trial two of the infantry soldiers were withdrawn from the trial. One subject developed a swelling on his knee, whilst the second suffered from mild heat stress. Both subjects completed only five of the six experimental conditions.

One of the military female subjects failed to attend the trial due to her vehicle breaking down.

The demographic and anthropometric characteristics of the remaining eleven subjects whose data were used for analysis were as follows:

	<b>Infantry</b>	<b>Military females</b>	<b>Paratroopers</b>
<b>Mean age (± standard deviation)</b>	24 (6.5)	29 (4.6)	26 (3.5)
<b>Mean weight (± standard deviation)</b>	79.2 (5.2)	66.9 (4.6)	81.2 (6.3)
<b>Mean height (± standard deviation)</b>	171.7 (4.6)	168 (5.9)	180.1 (6.7)

Table 2: Demographic and anthropometric data for subjects

Each subject was fully briefed on the aims and purpose of the trial and was asked to either self-certify that they were fit to attend or provide a medical certificate, signed by their Medical Officer, to confirm their fitness. Consent to allow photography was taken. Subjects were then shown and practised the military tasks that formed part of the HF assessment. This included being shown and practising the Common Battlefield Test Facility (CBTF) obstacles under the supervision of a CBTF certified Physical Training Instructor. Images of the CBTF can be found in APPENDIX C.

Finally, subjects were sized and issued all the combat clothing and protective equipment they would require during the assessment. This included:

- FSV2 combat clothing (trousers and shirt)
- VIRTUS body armour containing surrogate ballistic plate inserts
- VIRTUS webbing
- Mk. 4 OSPREY body armour containing surrogate ballistic plate inserts
- Personal Load carriage Equipment (PLCE)

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- Tier II pelvic protection
- Mk. 7 helmet/Cobra helmet
- Day sack
- PCS issue gloves/Armour Gel gloves
- Hearing protection
- Personal role radios
- Eye protection
- Dummy SA 80 rifle

Subjects provided their own PCS combat trousers and UBACS.

## 3.2 Ethics

Participants were asked to wear a maximum load of 30kg whilst conducting a series of military tasks, representative of current and future training and operations, at self-paced speed. In consultation with Dstl physiologists, the proposed physical strain was assessed as low. It was therefore agreed that there was not a requirement for physiological monitoring from a health and safety or data gathering perspective. Soldiers were doing tasks that are expected of them for their peace time role and they had plenty opportunity to rest between activities.

Dr Paul Rice (Dstl, Chief Medical Officer) confirmed that the assessment approach did not contravene the allowed exemptions within Joint Service Publication (JSP) 536 'Ministry of Defence Policy for Research Involving Human Participants<sup>4</sup>' and was therefore considered an equipment trial and did not need formal ethical approval through the MoD Research Ethics Committee (MoDREC) process.

## 3.3 Experimental test conditions and experimental plan

The trial was conducted over ten days in September 2016 at the Infantry Trials and Development Unit, Land Warfare Centre, Warminster. The environmental conditions in terms of Wet Bulb Globe Temperature (WBGT) were taken at regular intervals throughout each test day. A WBGT of 26° was the temperature at which work would have had to stop due to the risk of heat illness. APPENDIX A contains the environmental data recorded for each test day.

Two main test conditions were assessed; comparing the FSV2 combat clothing against the PCS. Each type of combat clothing was worn with one of three protective equipment ensembles; these were OSPREY, VIRTUS and Enhanced Combat Body Armour (ECBA). This resulted in six discrete experimental conditions; PCS with OSPREY, VIRTUS and ECBA and FSV2 with OSPREY, VIRTUS and ECBA. Table 3 shows the different conditions for each combination of combat clothing with protective equipment.

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<sup>4</sup> Ministry of Defence Research and Ethics Committee (MODREC). MODREC v1.0 – 23 March 2006 JSP 536: Ethical Conduct and Scrutiny in MOD Research involving Human Participants.

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Condition		Combat clothing	Body armour	Load carriage	Helmet	Gloves	Forearm protection
1	PCS/ OSPREY	PCS	OSPREY	PLCE	Mk. 7	Issue	None
2	PCS/ VIRTUS	PCS	VIRTUS	VIRTUS	Cobra+	Issue	None
3	PCS/ ECBA	PCS	ECBA	PLCE	Mk. 7	Issue	None
4	FSV2/ OSPREY	FSV2	OSPREY	PLCE	Mk. 7	Armour Gel	Yes
5	FSV2/ VIRTUS	FSV2	VIRTUS	VIRTUS	Cobra+	Armour Gel	Yes
6	FSV2/ ECBA	FSV2	ECBA	PLCE	Mk. 7	Armour Gel	Yes

Table 3: Experimental conditions

In all conditions subjects wore the Tier II pelvic protection, personal role radio headset, eye protection, their personal issue combat boots and carried a dummy SA 80 rifle.

Subjects also wore a day sack, loaded with military equipment to a weight of 10kg. The PLCE and VIRTUS webbing contained three dummy magazines, two dummy grenades and additional weights to bring the weight to 10kg. **Error! Reference source not found.** shows photographs of each of these experimental conditions.

A within subject, repeated measures experimental design was used. Each subject wore each of the six experimental configurations. Configuration allocation to each subject was randomised and a Latin Square design was used to balance order effects across conditions. Table 4 shows the experimental design.

Subject no.	Test run					
	1	2	3	4	5	6
1	PCS/ OSPREY	PCS/ VIRTUS	PCS/ ECBA	FSV2/ OSPREY	FSV2/ VIRTUS	FSV2/ ECBA
2	PCS/ VIRTUS	PCS/ ECBA	FSV2/ OSPREY	FSV2/ VIRTUS	FSV2/ ECBA	PCS/ OSPREY
3	PCS/ ECBA	FSV2/ OSPREY	FSV2/ VIRTUS	FSV2/ ECBA	PCS/ OSPREY	PCS/ VIRTUS
4	FSV2/ OSPREY	FSV2/ VIRTUS	FSV2/ ECBA	PCS/ OSPREY	PCS/ VIRTUS	PCS/ ECBA

Table 4: Latin Square experimental design

### 3.4 Human Factors relevant military tasks

Subjects were asked to carry out a number of simple, representative military tasks, whilst wearing each of the test conditions. These tasks fell into one of several categories, which included:

- Donning/doffing the clothing
- Operation of/access to equipment
- Range of movement
- Patrolling
- Dynamic tasks and CBTF obstacles
- Engaging the enemy
- Vehicle tasks

Each of the tasks associated with each category is described below in APPENDIX C. The CBTF obstacles are described in detail in the management protocol [3].

Subjects were paired with a HF investigator, who guided the subject through the tasks in a consistent manner. Upon completion of each of the tasks, the investigator rated the task in terms of how successfully the task had been completed (task success rated as ‘Yes’, ‘Partially’ or ‘No’) and if they perceive it to have been completed to an acceptable level of military performance (task acceptability rated as ‘Acceptable’, ‘Acceptable with concerns’ or ‘Not acceptable’). Table 5 shows the task success and acceptability ratings used by investigators.

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<b>Can you successfully complete the task?</b>	
<b>1. Yes</b>	Task is completed with: <ul style="list-style-type: none"> <li>– Normal timings</li> <li>– No modifications to drills and procedures</li> <li>– No modification to equipment</li> </ul> Overall performance as expected
<b>2. Partially</b>	Task is completed with some or all of these changes: <ul style="list-style-type: none"> <li>– Extended timings</li> <li>– Modifications to drills and procedures</li> <li>– Modification to equipment</li> </ul> Overall performance less than expected
<b>3. No</b>	Task is completed with: <ul style="list-style-type: none"> <li>– Extended timings</li> <li>– Modifications to drills and procedures</li> <li>– Significant modification to equipment</li> </ul> Overall performance much less than expected
<b>Acceptability levels</b>	
<b>1. Acceptable</b>	Accident unlikely Combat performance unlimited No increased risk to military users
<b>2. Acceptable with concerns (modifications desirable)</b>	Accident likely Combat performance limited, but tolerable Risk acceptable to military users
<b>3. Not acceptable (modifications essential)</b>	Accident unlikely Combat performance limited, but tolerable Risk unacceptable to military users

Table 5: Task success and acceptability ratings

The percentage task success and acceptability ratings were calculated for all tasks for each of the three cohorts (infantry, military females and Paratroopers). This percentage data is tabulated in APPENDIX D. If there was a task that was consistently failed or was judged militarily unacceptable, the reasons for this were highlighted.

Investigators also made notes on task performance, highlighting where the clothing was judged to either negatively or positively affect the task performance. These notes

were analysed for patterns or repeated occurrences across subjects in order to assess clothing performance.

**3.5 CBTF assessment**

In addition to the HF investigator assessments, the four CBTF obstacles were assessed in terms of task performance by a validated CBTF assessor. A five point scale was used to assess the quality of the task conducted for each of the CBTF obstacles; this five point scale is shown below in Table 6.

<b>CBTF task rating</b>	<b>Description</b>
1	Catastrophic degradation of task performance
2	Severe degradation of task performance
3	Noticeable degradation of task performance.
4	Minor degradation of task performance
5	No degradation of task performance

Table 6: CBTF task rating scale

The CBTF task ratings for each CBTF task for each of the three cohorts (infantry, military females and Paratroopers) are tabulated in APPENDIX A. If there was a task that was consistently failed or was judged unacceptable, the reasons for this were highlighted by the CBTF assessor in his notes.

The CBTF assessor also made notes on task performance, highlighting where the clothing was judged to either negatively or positively affect the task performance. These notes were analysed for patterns or repeated occurrences across subjects in order to assess clothing performance.

**3.6 Subjective questionnaire data**

Following completion of each test run of the HF tasks, a subjective evaluation questionnaire was administered to each subject. Subjects was shown the questionnaire and instructed in how to complete it. The questionnaire covers the following aspects and can be seen at APPENDIX A :

- Clothing adjustability
- Comfort

- Thermal comfort
- Equipment/clothing integration
- Hindrance
- Mobility
- Weight
- Bulk
- Satisfaction and
- Confidence in the clothing

Subjects were also asked for their feedback on each question and to list 'Likes', 'Dislikes' and 'Changes' they would suggest for the clothing. Responses to the questions were recorded on a subjective rating scale, i.e. Visual Analogue Scale ranging from 0 – 10 (the lower the number the better the rating). Figure 3 shows an example of this scale.

**5 If at all, how much did the clothing hinder your ability to complete the military tasks?**



Figure 3: Example of the visual analogue scale

Individual responses for each test condition were tabulated and are presented in APPENDIX A.

**3.7 Subjective comments and opinion**

Subjects provided subjective data on the performance of the PCS and FSV2 combat clothing; this was provided in either written form as part of the subjective questionnaire or in verbal comments made to investigators during each experimental run. These subjective comments were analysed for patterns or repeated occurrences across subjects in order to assess clothing performance. A thematic analysis was conducted on all subjective data to pull out the key themes and issues surrounding the combat clothing and its performance. APPENDIX H contains this subjective data which is summarised within the results and discussion sections.

In addition, the HF investigators and the CBTF assessor made notes of where they considered the clothing was helping or hindering the military tasks and CBTF obstacles. These notes will inform the discussion section of this report.

**3.8 Limitations of the methodology**

Prior to and during the conduct of the trial several restrictions or conditions were imposed on the trial conduct which affected the quality or amount of experimental data that could be collected. Each of these is listed below with its potential impact.

<b>Limitation/Restraint</b>	<b>Impact</b>
<p>Due to contractual reasons, the Royal College of Art was unable to provide a full range of FSV2 clothing sizes for either combat shirts or trousers. Only two sizes of trousers were available (waist sizes 28" and 34"); and only two sizes of combat shirt (small or large). As a result two subjects had inappropriate sized FSV2 clothing, specifically, one female subject had a large combat shirt instead of a medium and one male subject wore size 28" waist trousers when a size 30/32" would have produced a better fit.</p>	<p>The quality of the data collected for these two subjects may have been compromised i.e. they may have had a less favourable opinion of the clothing than should have been the case. These two subjects subjective data was assessed against others for any outlying comments or opinions. The incorrect fitting clothing <u>has</u> affected their subjective questionnaire results and comments and they have given less favourable comments as a result to the FSV2 clothing.</p>
<p>The Paratrooper cohort was not issued with ECBA. As a result these two experimental conditions could not be run as part of this trial.</p>	<p>One data set comparing PCS/ECBA with FSV2/ECBA was not conducted.</p>
<p>Although the WBGT never approached the safety critical level of 26 degrees, it became apparent during the first day of the trial that the infantry subjects were finding the physical tasks extremely arduous. This was due to the high temperature and relative humidity. The decision was taken by the Trial Manager (on safety grounds) to remove the second patrol task (patrolling at a brisk pace) to mitigate any heat illness risk. This was removed for all subsequent cohorts.</p>	<p>One HF task was removed resulting in less data being collected. However, as percentage task success/acceptability is calculated for all tasks this is judged to have had a minimal impact on the quality of the data.</p>
<p>Two subjects were withdrawn from the trial for medical reasons. This resulted in two experimental runs not being conducted and one, only partially completed.</p>	<p>Lack of a full data set for the infantry cohort.</p>

<p>The 'quick' release mechanism for the VIRTUS webbing broke on both webbing sets during four infantry cohort runs. Causing the webbing to fall off the subject or drop down the subjects thighs. This caused frustration and annoyance to the subjects and caused the trial to stop whilst repairs were made. The VIRTUS webbing was repaired for subsequent cohorts.</p>	<p>The quality of the data collected for these four runs may have been compromised i.e. they may have had a less favourable opinion of the clothing than might have been the case if no breakage had occurred. It is not possible to assess these subjects subjective data against others as all four subjects suffered the same problem.</p>
<p>Armour gel gloves were supplied in only 2 sizes (Medium and Large). One female subject had small hands so these gloves did not fit her well.</p>	<p>The quality of the data collected for this subject may have been compromised i.e. she may have had a less favourable opinion of the clothing than should have been the case. Her subjective data was assessed against others for any outlying comments or opinions related to gloves. The incorrect fitting gloves do not appear to have affected her subjective questionnaire results or comments.</p>

Table 7: Limitations imposed upon trial conduct

**3.9 Statistical analysis**

No statistical analysis will be performed on any of the data. The three cohorts were treated as separate groups due to their diversity in terms of gender and physical fitness. With a maximum population sample size of 4, the use of statistical analysis tools becomes invalid. For this reason individual data will be presented in mainly tabulated formats. Comparison between experimental conditions will be made referring to individual data.

## 4 Results

### 4.1 Test completion

Two of the Infantry subjects were withdrawn from the study. Of these, one subject developed a swelling on their right knee, whilst a second suffered from mild heat stress. This resulted in two test runs not being completed and one test run partially completed. One of the military female subjects did not attend; as a result this cohort consists of three subjects only.

### 4.2 HF relevant military tasks, percentage task success and acceptability

The percentage HF task success and acceptance data is tabulated in APPENDIX D. Figure 4 to Figure 11, shows this data in a graphical format (showing percentage task success for all subjects and then for each cohort). The percentage task success for both combined (all subjects) and for male and female cohorts is consistently of the order of about 90%, for all subjects and each cohort the range of percentage task success were:

- All subjects: 82% - 98%
- Infantry: 82% - 95%;
- Military females: 88% - 93%
- Paratrooper: 95% - 98%.

Analysis of the 'partial' and 'failed' tasks shows that occasionally subjects could not fold their arms across their chest, climb over the 5 foot wall or get through the high window, as part of the CBTF obstacles. Subjects could rarely touch the top of their day sack. These four tasks account for the majority of the 'partial' and 'failed' ratings.

The Paratrooper cohort have a slightly higher task success percentage than the other two cohorts, this is because they were more successful at the 5 foot wall climb and the high windowed obstacles.

Percentage task acceptability for infantry and military female cohorts were both of the order of 85% acceptable, the Paratrooper cohort had a marginally higher percentage task acceptability of about 95%. The range of percentage task acceptability for all subjects and each cohort were:

- All subjects: 80% - 97%
- Infantry: 80% - 93%
- Military females: 80% - 94%
- Paratrooper: 94% - 97%.

Analysis of the 'partial' and 'failed' tasks mirrored that for the task success reported above. Subjects, occasionally, could not fold their arms across their chest, climb over

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the 5 foot wall or get through the high window, as part of the CBTF obstacles. Subjects could rarely touch the top of their day sack. These four tasks account for the majority of the 'with modifications' and 'not acceptable' ratings. The Paratrooper cohort have a slightly higher task acceptability percentage than the other two cohorts, this is because they were more successful at the 5 foot wall climb and the high windowed obstacles.

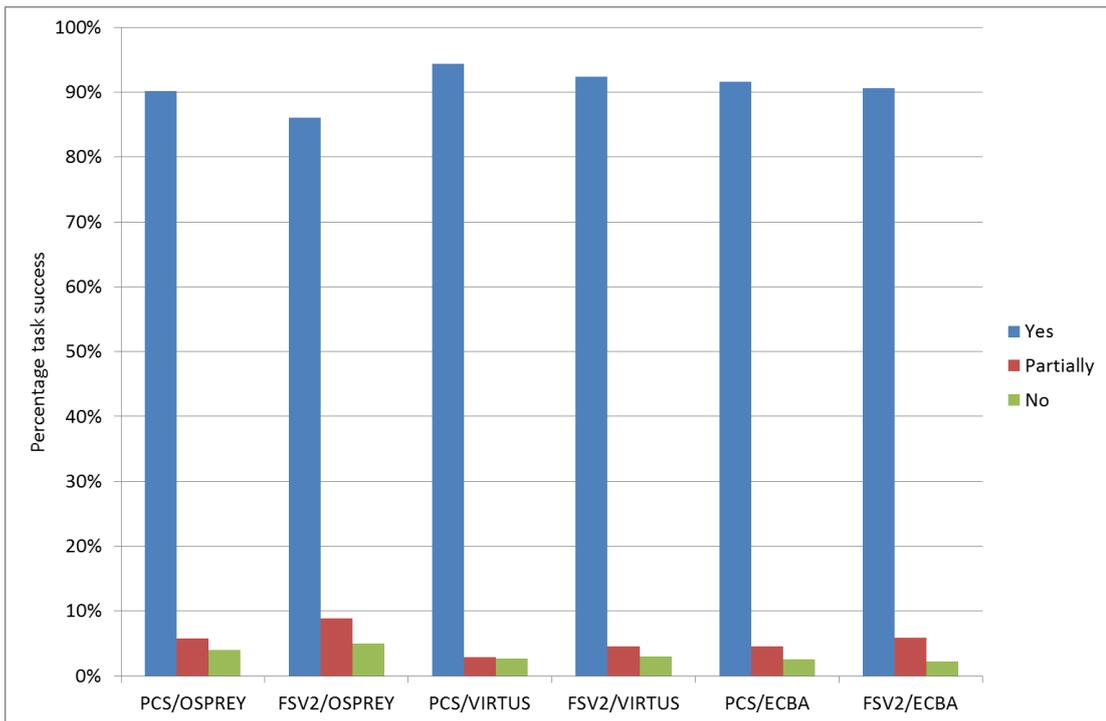


Figure 4: Percentage task success for all subjects

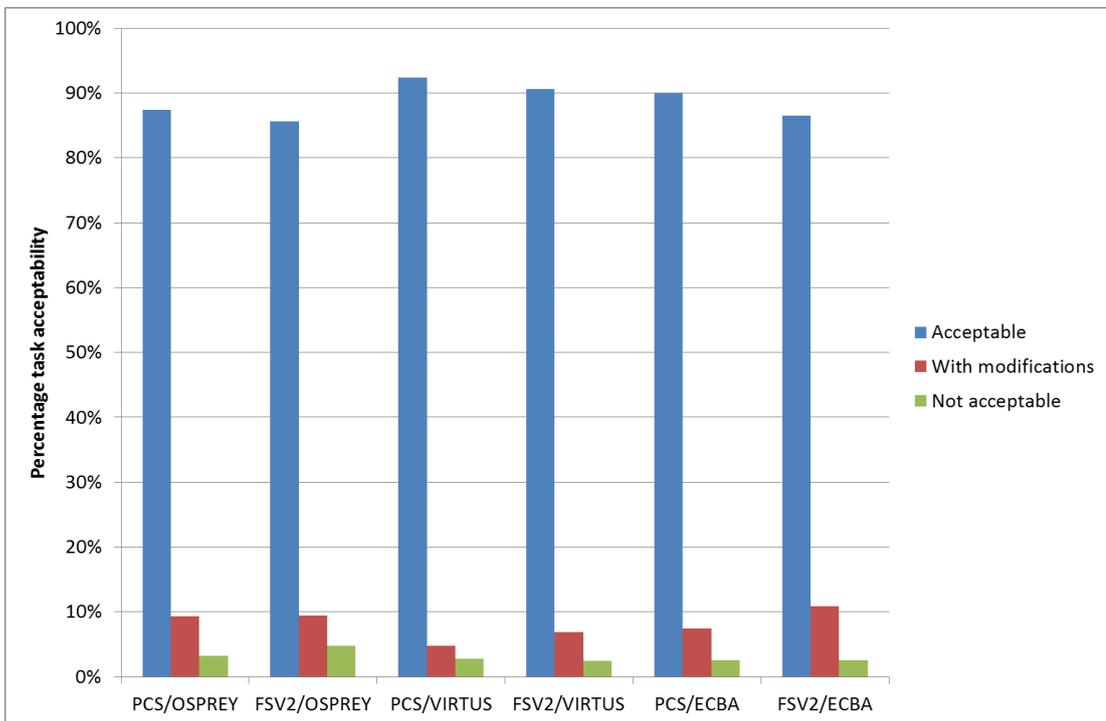


Figure 5: Percentage task acceptability for all subjects

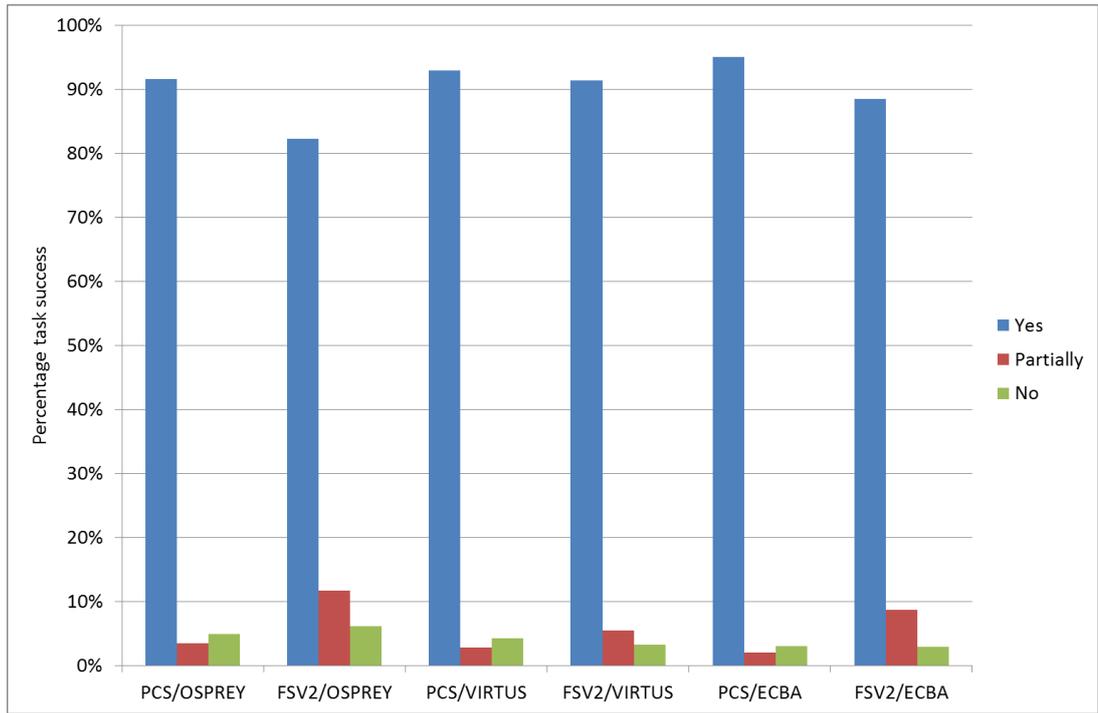


Figure 6: Percentage task success for the infantry cohort

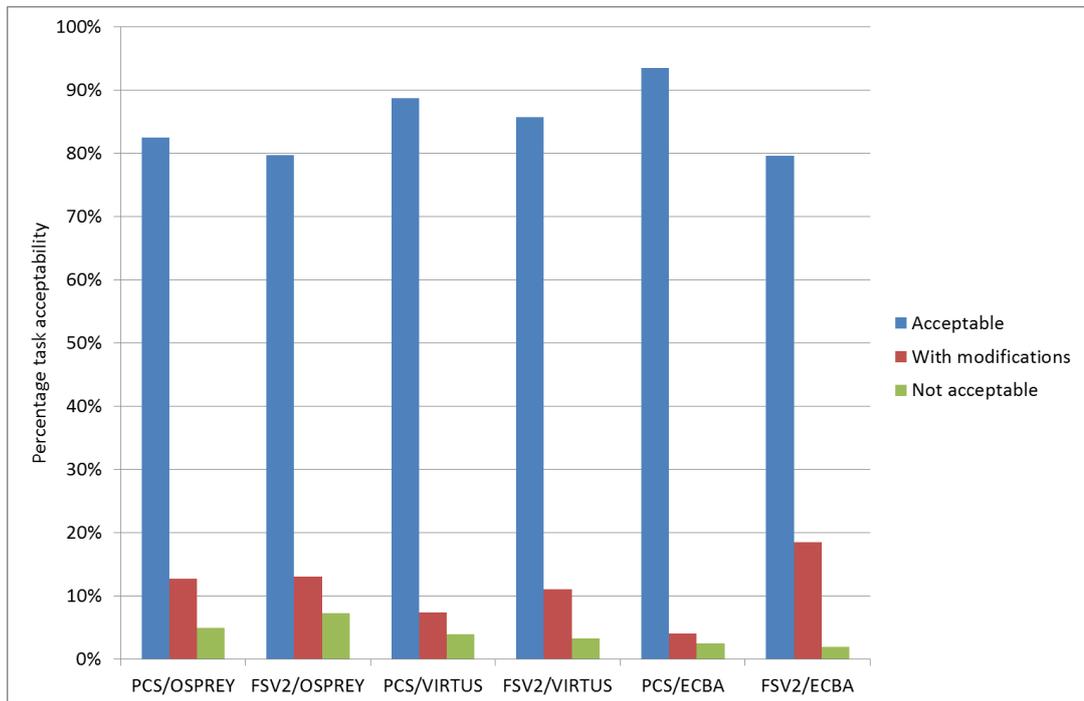


Figure 7: Percentage task acceptability for the infantry cohort

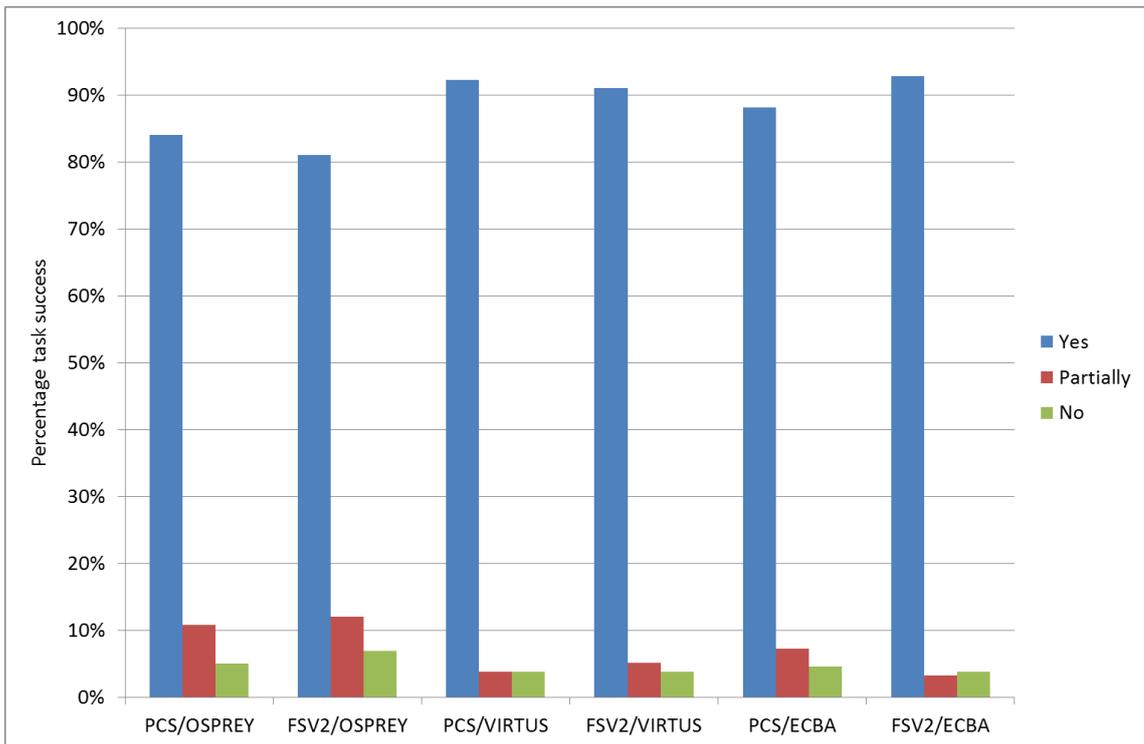


Figure 8: Percentage task success for the military female cohort

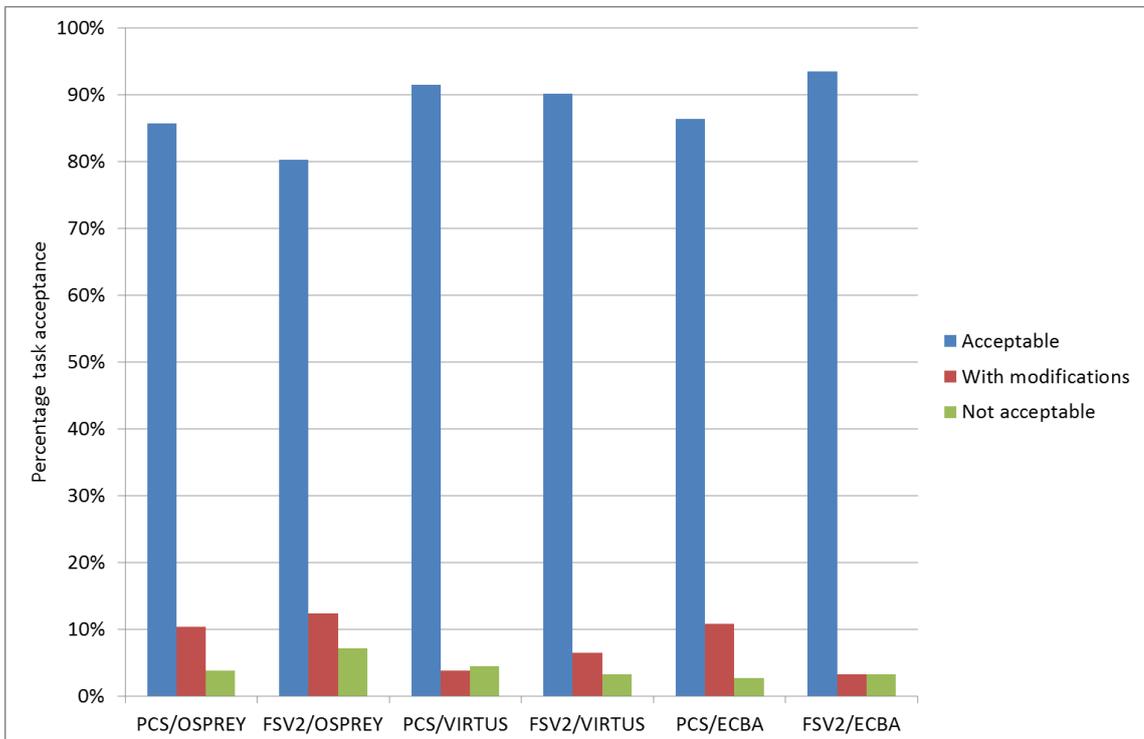


Figure 9: Percentage task acceptability for the military female cohort

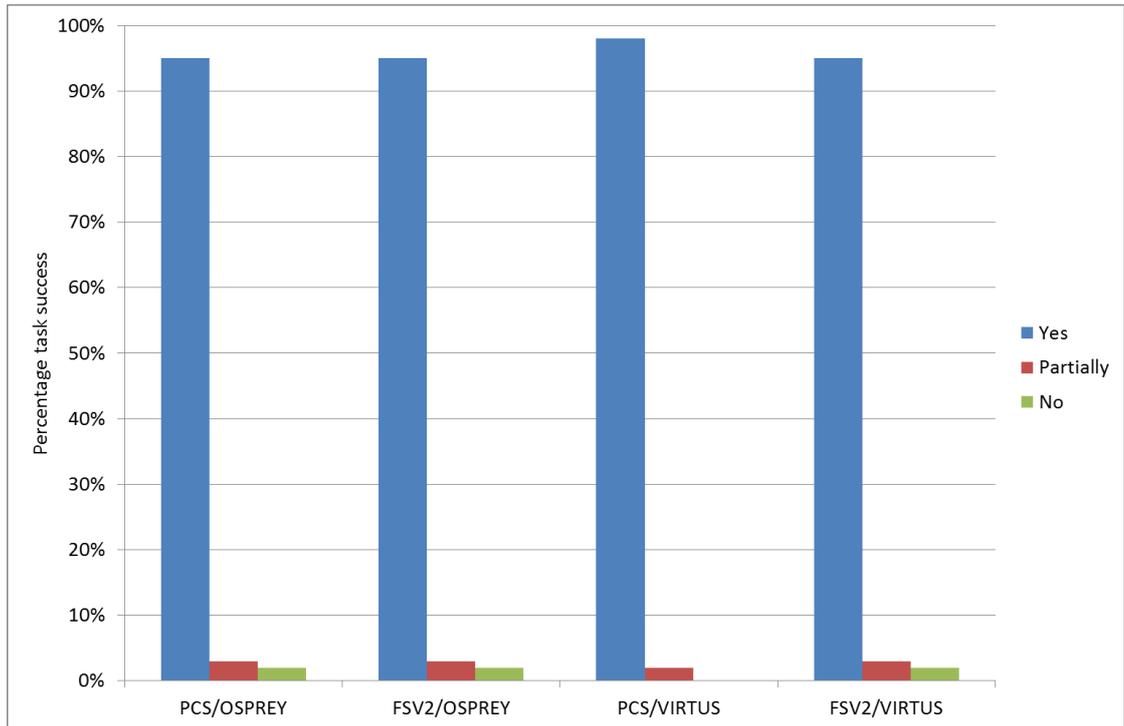


Figure 10: Percentage task success for the Paratrooper cohort

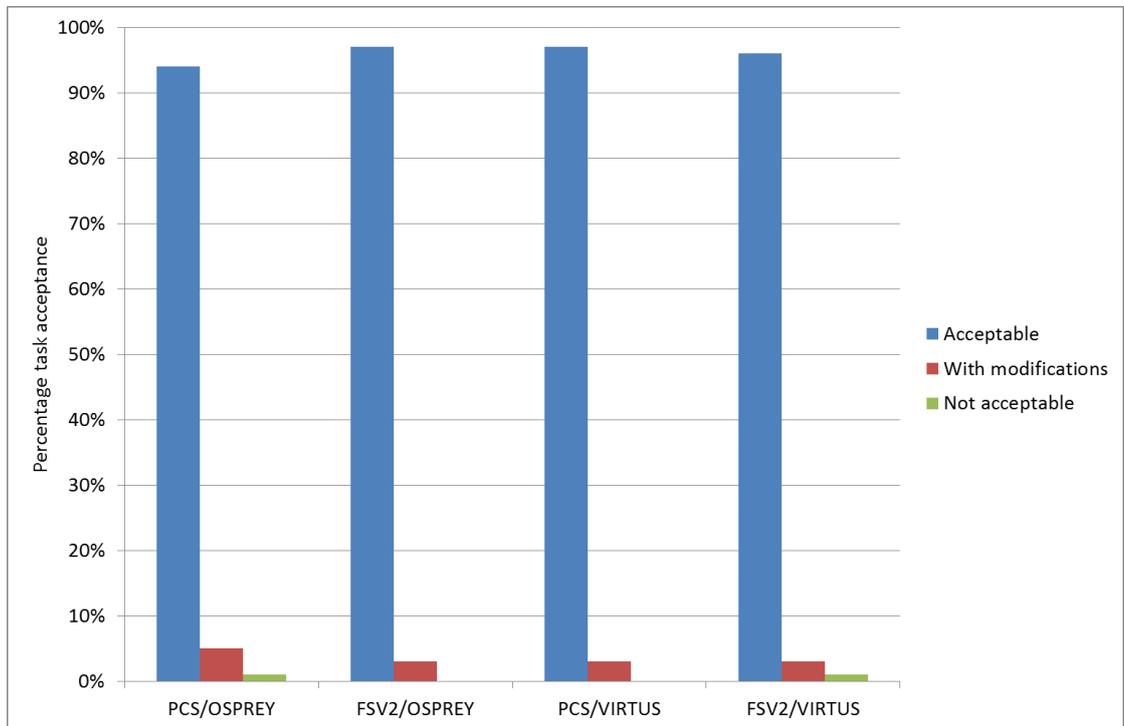


Figure 11: Percentage task acceptance for the Paratrooper cohort

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## 4.3 CBTF task performance<sup>5</sup>

The CBTF rating data for task performance is tabulated in APPENDIX E. Two subsets of this data have been extracted and are shown below in Table 8 and Table 9.

Subject	Stairs and ladders		Window and mouse hole	
	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
5	3	5	1	1
6	4	5	1	1
7	---	---	---	---
8	3	4	1	1

Table 8: CBTF ratings for two obstacles, military female cohort

Subject	Stairs and ladders		Window and mouse hole	
	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
9	5	5	4	3
10	5	4	3	5
11	4	5	4	4
12	4	5	4	4

Table 9: CBTF ratings for two obstacles, Paratrooper cohort

<sup>5</sup> Task ratings are shown in Table 6. They are 1: Catastrophic degradation of task performance. 2: Severe degradation of task performance. 3: Noticeable degradation of task performance. 4: Minor degradation of task performance. 5: No degradation of task performance

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These two subsets are consistent with the larger set of data for CBTF ratings. Comparing the PCS/VIRTUS with the FSV2/VIRTUS clothing conditions for these two CBTF obstacles for both cohorts shows very little difference. The 'stairs and ladders' obstacle, when undertaken by the military female's shows rating of 3, 4, 3 for PCS/VIRTUS, compared to 5, 5, 4 for the FSV2/VIRTUS clothing condition. The 'window and mouse hole' obstacle show identical ratings for both clothing conditions.

This pattern is the same for the Paratrooper cohort, with the 'window and mouse hole' obstacle having ratings of 4, 3, 4, 4 for the PCS/VIRTUS clothing condition compared to 3, 5, 4, 4 for FSV2/VIRTUS.

## 4.4 Subjective questionnaire data<sup>6</sup>

APPENDIX G tabulates all the data from the subjective questionnaires. It is not possible to present all this data in the results section, therefore, two of the main questions have been extracted and are shown below. Table 10, shows the data for question 2, relating to subjects qualitative view on how comfortable the clothing was during the functional assessment. This is shown for the PCS/VIRTUS and FSV2/VIRTUS clothing conditions only.

Subject number	Infantry cohort	
	PCS/VIRTUS	FSV2/VIRTUS
1	6.2	4.1
2	2.9	5.5
3	4.5	4.7
4	2.9	2.4
	Military female cohort	
	PCS/VIRTUS	FSV2/VIRTUS
5	4.5	4.5
6	5.0	4.0
7	---	---
8	2.5	0.8
	Paratrooper cohort	
	PCS/VIRTUS	FSV2/VIRTUS
9	4.8	3.5
10	5.0	2.5
11	1.8	2.5
12	2.0	3.0

Table 10: Subjective questionnaire ratings for the question 'How comfortable was the clothing during the functional assessment?' PCS/VIRTUS compared to FSV2/VIRTUS

<sup>6</sup> Figure 3 shows the visual analogue scale and APPENDIX F shows the subjective questionnaire. Dark and light green indicate positive responses, dark and light red indicate negative responses.

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There is little difference in how subjects rated the comfort between these two clothing conditions.

Table 11 shows the data for question 8.1, relating to subjective feedback on how mobility was affected during the functional assessment. This is shown for the PCS/VIRTUS and FSV2/VIRTUS clothing conditions only.

<b>Infantry cohort</b>		
<b>Subject number</b>	<b>PCS/VIRTUS</b>	<b>FSV2/VIRTUS</b>
1	2.6	3.4
2	1.1	1.0
3	4.0	4.0
4	2.0	1.0
<b>Military female cohort</b>		
	<b>PCS/VIRTUS</b>	<b>FSV2/VIRTUS</b>
5	5.5	4.0
6	4.0	2.0
7	---	---
8	3.0	1.0
<b>Paratrooper cohort</b>		
	<b>PCS/VIRTUS</b>	<b>FSV2/VIRTUS</b>
9	---	3.0
10	1.0	1.1
11	1.2	2.0
12	2.0	0.5

Table 11: Subjective questionnaire ratings for the question 'The mobility was?' PCS/VIRTUS compared to FSV2/VIRTUS

There is little difference in how subjects rated the mobility between these two clothing conditions.

This pattern, showing little, if any difference, between PCS and FSV2 clothing conditions is repeated for almost every question apart from two exceptions. Firstly, the responses to the question relating to the integration of the knee pads with the clothing, this consistently rates the PCS external knee pads worse than the FSV2 internal knees pads. This is supported by the subjective qualitative data discussed below (see section 4.5).

Secondly, the military females rated their confidence and satisfaction with the FSV2 clothing worse than for the PCS clothing. This may reflect the fact that the FSV2 clothing was incorrectly fitting for two of the female subjects.

**4.5 Subjects qualitative data**

APPENDIX H lists the qualitative comments captured by the comments boxes on the subjective questionnaire, highlighting if they are positive or negative and indicating how many times a type of comment or opinion was expressed. More negative comments were expressed about the FSV2 clothing than for the PCS clothing (27 compared to 41 respectively). However, the negative comments made regarding the FSV2 clothing are more diverse, covering many more aspects of the clothing design, whereas for the PCS clothing, the majority of negative comments relate almost solely to the external knee pads. Both PCS and FSV2 clothing receive a similar type and number of positive comments relating to adjustability and comfort.

The notes made by the HF investigators and the CBTF assessor also add to the subject's qualitative data and inform the discussion section.

## **5 Discussion**

### **5.1 Overall**

The range of movement, CBTF obstacles and HF relevant military tasks provided a realistic and robust physical test for the combat clothing. If one set or item of clothing caused a physical restriction or imposed a specific burden on the wearer then the quantity or quality of the task would have been impaired and showed up in either the task rating data or the subjects/investigators subjective comments and notes.

Each of the parts of the assessment is discussed in turn below.

### **5.2 HF relevant military tasks, percentage task success and acceptability**

The percentage task success and acceptance ratings provide a sensitive metric for assessing the performance of clothing and equipment. There is, however, no difference between the PCS clothing and the FSV2 clothing conditions for any of the three sets of protective equipment worn with it.

Analysis of the 'partial' and 'failed' tasks does show that certain tasks proved more difficult to complete for all three cohorts. Subjects consistently failed at 'touching the top of the day sack'. The day sack sat too low on the subjects back for it to be accessed from the top whilst it was being worn, so the failure to complete this task reflects the poor integration of the day sack with the body armour and webbing rather than any restriction imposed by the combat clothing. The same is true for the task of 'crossing your arms across your chest', where the body armour and not the clothing prevented subjects achieving this task.

The second main area of 'partial' or 'failed' tasks related to the CBTF obstacles, subjects in both the infantry and military female cohorts struggled to complete both the 'mouse and window' obstacle and the 'high window' obstacle. This was due to lack of physical strength for both cohorts and the fact these two cohorts tended to be shorter in height, both of which made it more difficult for them to climb through the windows and 5 foot wall. The Paratrooper cohort was able to complete these tasks, reflecting their greater physical strength, level of fitness and greater height.

In total these four tasks account for the majority of tasks rated as 'partial', 'failed', 'required modification' and 'not acceptable'.

Overall, the percentage tasks 'completed' and 'acceptable' were high, indicating that both PCS and FSV2 clothing conditions did not impair the ability of subjects to complete the range of movement, CBTF and HF relevant military tasks. The reasons for task 'unacceptability' or 'failure' were due to reasons unrelated to the clothing.

### **5.3 CBTF task performance**

The clothing condition did not affect CBTF task performance. However, there were subtle differences captured by the CBTF assessor. These centred on the knee pads and gloves. The PCS external knee pads would slide down the leg during the tunnel crawl task. Subjects would come out of the tunnel with the external knee pads either

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half way down the shin or round the ankle. Figure 12, shows two examples of PCS knee pads falling down the leg after the tunnel crawl.



Figure 12: PCS external knee pads after the tunnel crawl

As the knee pads fall down they stop providing protection and made the tunnel crawl task more difficult.

The PCS external knee pads also acted as a snag hazard when subjects attempted the two window tasks, with the knee pads snagging on the lip of the window and slowing progress through it.

The FSV2 Armour Gel gloves were reported to provide inadequate protection to the palms of the hands and to be too 'slippery', when crawling through the tunnel crawl task. Conversely, some subjects 'monkeyed' through the tunnel i.e. made a fist and used their knuckles to crawl. The Armour Gel gloves provided good grip and protection to facilitate this type of crawling.

### 5.4 Subjective questionnaire

Subjects rating of the PCS and FSV2 clothing were, overall, positive. The vast majority of ratings for adjustability, comfort, hindrance, mobility, weight, bulk, satisfaction and confidence were rated as less than 5 (a positive rating and showing as dark and light green in APPENDIX G). Again, there is no difference in subjective ratings for these factors between the PCS or FSV2 clothing conditions.

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The questions relating to integration show more variability (the number of colours is more varied for these questions in APPENDIX G) and this is most likely due to the fact that subjects were also rating the protective equipment they wore. It is likely that when asked to rate how the body armour integrated with the clothing that subjects conflated their feelings about wearing the body armour with the clothing and as a result overall ratings became more negative.

However, there are two clear issues that subjects rated as more negative. The first relates to the question about integration of the knee pads with the clothing. This consistently rates the PCS external knee pads worse than the FSV2 internal knee pads. As discussed above for the CBTF tasks, the PCS knee pads fell down the leg during tasks e.g. leopard crawl, CBTF tasks and sometimes during the patrol task. In addition to this subjects complained of 'pinching', 'pain' and 'irritation' caused by the external PCS knee pads as they worked their way through the functional tasks. And several subjects developed abrasions on the back of their knees, caused by these knee pads (see Figure 13). Their ratings reflect these problems.



Figure 13: Example of an abrasion on rear of knee after wearing external knee pads.

The second issue concerns the ill-fitting FSV2 clothing issued to the military female cohort. The military females rated their confidence and satisfaction with the FSV2 clothing worse than for the PCS clothing. This undoubtedly reflects the fact that the FSV2 clothing was incorrectly fitting for two of the female subjects. The two male cohorts did not mirror this negative outcome.

### 5.5 Overall rating data

The three sets of rating data (percentage task success and acceptability, CBTF task performance and the subjective ratings) all strongly suggest that there is no difference between the PCS and FSV2 clothing conditions. And this is irrespective of which set of protective equipment is worn with it.

## 5.6 Qualitative data and suggested design changes

The subjects own comments and opinion of the clothing systems under evaluation, coupled with investigator notes allow for issues and concerns with the clothing design to be examined in detail. This analysis can suggest design changes to the FSV2 clothing to enhance its usability, function and comfort. In addition, these suggested design changes can inform system requirements for any future clothing procurement.

This next part of the discussion will examine the qualitative data for the combat shirt, combat trousers and other design issues.

## 5.7 FSV2 combat shirt

**Combat shirt collar:** The PCS UBACS collar has no rigidity to it, as a result, when worn the collar will fall down and it is then possible for the weapon strap to rub on the wearers neck causing irritation and abrasion. The FSV2 combat shirt collar is more rigid but it was noted by investigators that the weapon strap forced the collar down. There is a fine balance to be struck here, make the collar too rigid and it will become a source of irritation in its own right, however, the collar should provide a barrier to straps that have to worn and which can cause irritation to the wearer's neck.

- **Observed requirement 1:** Combat shirt collar. The shirt collar should prevent straps e.g. the weapon strap, from irritation of the wearer's skin.

**Arm pockets:** The size and positioning of arm pockets could be altered to enhance accessibility and prevent snagging. The positioning of pockets on the upper arm was considered to be difficult to get to with the opposing arm. And it provided a snag hazard when donning the day sack. Bringing the pockets down the arm and slightly towards the front would aid access and also reduce the snag hazard. The pen pocket in this position was considered of little use, being in the wrong position for easy access to pens.

- **Observed requirement 2:** The positioning of arm pockets should allow for easy access and to minimise snags when donning load carriage equipment.
- **Observed requirement 3:** Arm pockets should allow for the storage of defined equipment e.g. a tourniquet.

**Combat shirt zip:** Several subjects reported that the zip on both the PCS and FSV2 combat shirt was pushed into the chest by the body armour, thus causing discomfort. A low profile zip would prevent this from occurring.

- **Observed requirement 4:** The closing system on the combat shirt should be low profile so as to prevent it from being pushed into the wearer's chest by worn body armour.

**Elbow protection:** Subjects reported that they did not like the elbow protection within the PCS UBACS. Stating that the protection pads became creased within their pockets and that when removed for washing, were not replaced. There was little appetite for a similar design within future clothing but the FSV2 clothing was thought

to offer no elbow protection and subject's opinion was that some elbow protection would be of benefit.

- **Observed requirement 5:** An integral elbow protector should be included within the combat shirt.

## 5.8 FSV2 combat trousers

**Tier II pelvic protection integration:** The attachment buckles for the Tier II pelvic protection were too narrow which caused difficulty when sliding the pelvic protection webbing through the buckle to attach it to the FSV2 trousers. This would be solved by making the gap on the buckle wide enough to easily slide the webbing through.

- **Observed requirement 6:** The attachment system for the Tier II pelvic protection should allow easy attachment by the unaided wearer.

**Trouser pockets:** Subjects stated that the three way entry pockets were considered to be a significant advantage over one way access pockets, allowing easy access to the pocket when in the seated driving position of a vehicle or when reaching for the pockets in a prone or kneeling posture.

The size and positioning of the external thigh trouser pockets could be altered to enhance accessibility and usability. The size of the external thigh pockets was considered too small for a map to easily fit into, whilst moving the pocket slightly upwards and towards the front of the thigh would aid access.

The top internal front trouser pockets were considered to be too flimsy and would quickly develop holes. Reinforcing these internal pockets would prevent this.

- **Observed requirement 7:** External trouser pockets should have a three way entry system.
- **Observed requirement 8:** External trouser pockets should be positioned to allow easy access in a number of postures and should be large enough to hold a military map.
- **Observed requirement 9:** Internal trouser pockets should be made from robust reinforced material to prevent holes from developing.

**Knee pads:** The PCS external knee pads were reported as uncomfortable, constantly slipped and provided a snag hazard when navigating tasks. The internal FSV2 knee pads were viewed as solving these problems and were reported to offer good protection and comfort. However, the external knee pads had a textured surface which provided a degree of traction/grip which was absent from the FSV2 knee pads. Subjects reported that the FSV2 knee pads were more slippery in the tunnel crawl than the PCS knee pads. The provision of a texture or rubberised surface on the external knee material would aid traction/grip at the knee when subjects were crawling.

- **Observed requirement 10:** External facing material at the knee should provide a degree of additional traction/grip when kneeling or crawling.

Subjects also reported that although they liked the adjustment system for the FSV2 knee pads (held in place by Velcro® on either side of the knee), they found that the knee pads would often slip within the knee pad pocket and had to be readjusted. A more robust anchoring system for the internal knee pads would solve this issue.

- **Observed requirement 11:** The internal knee pad should be anchored in position so that, once adjusted to a comfortable position, it remains in position.

**Ankle cuff fastening:** The FSV2 ankle cuff adjustment did not allow subjects to tighten the cuff sufficiently. The Velcro® did not extend around the ankle enough for the cuff to be pulled tight.

- **Observed requirement 12:** Ankle adjustment should allow the ankle cuff to be pulled and secured so that it is tight around the ankle/boot interface.

## 5.9 Other design issues

**Silent Velcro®:** The silent Velcro® used in the FSV2 clothing did not work well; it became undone on numerous occasions. Figure 14 shows an example of the silent Velcro® failing at the ankle cuff. However, the silent Velcro® also failed on the pockets, during the tunnel crawl, leopard crawl and mouse hole and window tasks. Pockets would be easily opened if they rubbed against an object.



Figure 14: Silent Velcro® failing to remain fastened at the ankle

**Armour Gel gloves:** Subjects considered the Armour Gel gloves to be an improvement over the issue combat gloves, most especially in terms of the protection on the back of the hand which allowed a ‘monkeying’ type of crawling. However, subjects also reported that they viewed the material on the palm to be too thin and therefore to not offer enough protection, and also that this palm material was too slippery, especially through the tunnel crawl task. Other types of gloves have a textured rubber impregnated into the palm material to aid traction/grip.

- **Observed requirement 13:** The palm area of the gloves should provide good abrasion protection.
- **Observed requirement 14:** The palm area of the glove should provide a good level of traction/grip.

## **6 Conclusions**

In terms of overall task performance there is no difference between the PCS combat clothing and the FSV2 combat clothing. Both clothing conditions (regardless of protective equipment worn with it) have similar percentage task success, task acceptability, and CBTF task performance.

Subjects own ratings of clothing performance are also very similar. Overall, both clothing conditions were viewed positively in terms of comfort, hindrance, mobility, weight, bulk, satisfaction and confidence. Subjects did differ in their opinion in terms of how they viewed the knee pads between the two clothing conditions. Here subjects preferred the FSV2 internal pads to the PCS external knee pads. The internal FSV2 knee pads were judged more comfortable and less of a hindrance to completing tasks.

Qualitative data from subjects (coupled with investigators notes) highlighted issues and deficiencies with the current FSV2 clothing design. The qualitative data has also been used to suggest enhancements to the FSV2 combat clothing design. These enhancements have been described in terms of Observed requirements to aid the procurement of future combat clothing.

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- [2] TIN 3.082. Human Factors Assessment for Land Systems. Developing the Human Factors Assessment Framework (HFAF) into a Technical Guide and Complementary Training Package: Technical Guide.
- [3] Armstrong, N and Paris, H. (2013) Data capture and management protocol for the CBTF. DSTL/TR76187 1.0

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## APPENDIX A Environmental conditions on each test day

Test day	WGBT @ 09:30 am	WGBT @ 11:00 am	WGBT @ 12:30	WGBT @ 14:00
5 <sup>th</sup> September	19.5	18.2	---	19.5
6 <sup>th</sup> September	17.7	---	18.8	---
7 <sup>th</sup> September	19.5	20.4	---	---
8 <sup>th</sup> September	17.0	16.9	16.8	---
9 <sup>th</sup> September	14.9	17.3	---	---
12 <sup>th</sup> September	17.1	17.3	---	---
13 <sup>th</sup> September	18.5	19.3	19.5	20.1
14 <sup>th</sup> September	21.3	21.9	---	---
15 <sup>th</sup> September	19.7	20.3	---	---
16 <sup>th</sup> September	No experimental runs			

Note: Timing of measurement is approximate.

APPENDIX B Photographs showing each of the experimental clothing conditions



Figure 15: PCS/OSPRESY clothing condition



Figure 16: FSV2/OSPREY clothing condition



Figure 17: PCS/VIRTUS clothing condition



Figure 18: FSV2/VIRTUS clothing condition



Figure 19: PCS/ECBA clothing condition

**Note: Photography of the FSV2/ECBA clothing condition is not available**

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## APPENDIX C HF relevant military tasks and four CBTF obstacles

Task category	Task description
Donning/doffing clothing and protective equipment	Don/doff combat shirt
	Don/doff combat trousers and knee pads
	Adjust clothing to fit
	Don/doff body armour
	Don/doff helmet, comms and hearing protection
	Don/doff belt order and load carriage
	Don/doff Tier II pelvic protection
Operation of/access to equipment	Simulate operating your comms and radio
	Access and load upper limb pockets
	Access and load lower limb pockets
	Access med pouch
Range of movement	Facing forward, over left and right shoulder, look up and down
	Touch the top of your day sack, touch the bottom of your day sack
	Fold your arms across your chest
	Take an extended stride across a 1m gap
	Obtain a squatting/kneeling position
	Rotate at the waist to the left and right as far as you can go
	Sit on a chair with back pushed to against the backrest and stand up

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Patrolling	At patrol pace, walk a specified distance (approx. 700 m) whilst observing arcs
	Conduct a 50m zig/zag run
Dynamic tasks and Common Battlefield Test Facility (CBTF) obstacles [3]	Use a pick axe and shovel, prepare a defensive position
	Conduct a 10 m leopard crawl
	CBTF: Tunnel crawl
	CBTF: Stairs and ladder climb
	CBTF: Window and mouse hole
	CBTF: High window
Engaging the enemy	Adopt a standing position. Simulate loading your rifle, make ready, take aim, unload your rifle
	Adopt a kneeling position. Simulate loading your rifle, make ready, take aim, unload your rifle
	Adopt a prone position. Simulate loading your rifle, make ready, take aim, unload your rifle
Vehicle tasks (repeated for a Land Rover and a 6 Tonne lorry)	Ingress driver/passenger door, sit in seat and secure seat harness
	Sitting in driver/passenger seat, attempt to access controls, mirror etc.
	Sitting in driver/passenger seat, access upper and lower limb pockets on clothing
	Undo seat harness, egress driver/passenger door
	Load and unload the Bergen onto the back of the 6 tonne lorry

The four CBTF obstacles.



Figure 20: The tunnel crawl



Figure 21: Stairs and ladders



Figure 22: Mouse hole and window



Figure 23: High window

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**APPENDIX D Percentage task completion and acceptability data**

	<b>Clothing configuration</b>					
<b>Task completion</b>	<b>PCS/ OSPREY</b>	<b>FSV2/ OSPREY</b>	<b>PCS/ VIRTUS</b>	<b>FSV2/ VIRTUS</b>	<b>PCS/ ECBA</b>	<b>FSV2/ ECBA</b>
<b>Yes</b>	92	82	93	91	95	88
<b>Partially</b>	3	12	3	5	2	9
<b>No</b>	5	6	4	3	3	3

	<b>Clothing configuration</b>					
<b>Task acceptability</b>	<b>PCS/ OSPREY</b>	<b>FSV2/ OSPREY</b>	<b>PCS/ VIRTUS</b>	<b>FSV2/ VIRTUS</b>	<b>PCS/ ECBA</b>	<b>FSV2/ ECBA</b>
<b>Acceptable</b>	82	80	89	86	93	80
<b>Acceptable with modifications</b>	13	13	7	11	4	18
<b>Not acceptable</b>	5	7	4	3	3	2

Table 12: Percentage task completion and acceptability for the 1 Royal Anglian infantry (cohort 1)

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<b>Clothing configuration</b>						
<b>Task completion</b>	<b>PCS/ OSPREY</b>	<b>FSV2/ OSPREY</b>	<b>PCS/ VIRTUS</b>	<b>FSV2/ VIRTUS</b>	<b>PCS/ ECBA</b>	<b>FSV2/ ECBA</b>
<b>Yes</b>	84	81	92	81	88	93
<b>Partially</b>	11	12	4	5	7	3
<b>No</b>	5	7	4	4	5	4
<b>Clothing configuration</b>						
<b>Task acceptability</b>	<b>PCS/ OSPREY</b>	<b>FSV2/ OSPREY</b>	<b>PCS/ VIRTUS</b>	<b>FSV2/ VIRTUS</b>	<b>PCS/ ECBA</b>	<b>FSV2/ ECBA</b>
<b>Acceptable</b>	86	80	92	90	86	94
<b>Acceptable with modifications</b>	10	12	4	7	11	3
<b>Not acceptable</b>	4	8	5	3	3	3

Table 13: Percentage task completion and acceptability for the military females (cohort 2)

**OFFICIAL**

Clothing configuration						
<b>Task completion</b>	<b>PCS/ OSPREY</b>	<b>FSV2/ OSPREY</b>	<b>PCS/ VIRTUS</b>	<b>FSV2/ VIRTUS</b>	<b>PCS/ ECBA</b>	<b>FSV2/ ECBA</b>
<b>Yes</b>	95	95	98	95	---	---
<b>Partially</b>	3	3	2	3	---	---
<b>No</b>	2	2	0	2	---	---
Clothing configuration						
<b>Task acceptability</b>	<b>PCS/ OSPREY</b>	<b>FSV2/ OSPREY</b>	<b>PCS/ VIRTUS</b>	<b>FSV2/ VIRTUS</b>	<b>PCS/ ECBA</b>	<b>FSV2/ ECBA</b>
<b>Acceptable</b>	94	97	97	96	---	---
<b>Acceptable with modifications</b>	5	3	3	3	---	---
<b>Not acceptable</b>	1	0	0	1	---	---

Table 14: Percentage task completion and acceptability for the Paratroopers (cohort 3)



APPENDIX ECBTF task rating data

CBTF task rating	Description
1	Catastrophic degradation of task performance
2	Severe degradation of task performance
3	Noticeable degradation of task performance.
4	Minor degradation of task performance
5	No degradation of task performance

Table 15: CBTF task rating scale

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CBTF obstacle								
Tunnel crawl		Stairs and ladders		Window and mouse hole		High window		
Subject	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY
1	3	4	4	5	1	1	3	4
2	---	4	4	4	---	1	---	1
3	4	4	4	4	4	1	5	4
4	3	4	4	4	1	1	4	4
CBTF obstacle								
Tunnel crawl		Stairs and ladders		Window and mouse hole		High window		
Subject	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
1	4	5	4	3	1	4	4	1
2	4	4	4	4	1	2	3	4
3	4	5	4	4	4	1	5	4
4	3	4	4	4	1	2	5	3
CBTF obstacle								
Tunnel crawl		Stairs and ladders		Window and mouse hole		High window		
Subject	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA
1	4	---	4	---	4	---	4	---
2	4	---	4	---	1	---	3	---
3	4	5	4	5	4	4	5	5
4	4	5	4	5	3	4	5	4

Table 16: CBTF rating data for the infantry cohort

**OFFICIAL**

CBTF obstacle								
Subject	Tunnel crawl		Stairs and ladders		Window and mouse hole		High window	
	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY
5	4	4	4	4	1	1	1	1
6	5	4	4	5	1	1	4	3
7	---	---	---	---	---	---	---	---
8	4	4	4	4	1	1	1	1
CBTF obstacle								
Subject	Tunnel crawl		Stairs and ladders		Window and mouse hole		High window	
	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
5	3	4	3	5	1	1	1	1
6	---	5	4	5	1	1	3	4
7	4	---	---	---	---	---	---	---
8	4	4	3	4	1	1	1	1
CBTF obstacle								
Subject	Tunnel crawl		Stairs and ladders		Window and mouse hole		High window	
	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA
5	4	5	4	4	1	1	1	1
6	4	5	4	5	1	4	4	4
7	---	---	---	---	---	---	---	---
8	4	4	4	4	1	1	3	1

Table 17: CBTF rating data for the military female cohort

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CBTF obstacle								
Subject	Tunnel crawl		Stairs and ladders		Window and mouse hole		High window	
	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY
<b>9</b>	4	4	4	4	4	4	5	4
<b>10</b>	4	5	5	5	4	5	5	5
<b>11</b>	4	5	5	4	4	4	5	5
<b>12</b>	4	5	4	5	5	5	4	4

CBTF obstacle								
Subject	Tunnel crawl		Stairs and ladders		Window and mouse hole		High window	
	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
<b>9</b>	4	5	5	5	4	3	5	5
<b>10</b>	4	5	5	4	3	5	5	5
<b>11</b>	4	5	4	5	4	4	5	5
<b>12</b>	4	5	4	5	4	4	4	5

Table 18: CBTF rating data for the Paratrooper cohort

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## APPENDIX F Subjective questionnaire

### FSV2 / Combat Clothing HF Assessment

#### Subjective Evaluation: Questionnaire

Date	
Participant number	
Configuration	
Investigator	

**Size** (mapped to Personnel, Training and Protect against Environment Human Factors (HF) System Requirements (SRs))

1.1.	<b>Were you provided with the correct clothing size?</b>  Y/N	If no, explain why:
1.2.	<b>Did the clothing fit you?</b>  Y/N	If no, explain why not:
1.3.	<b>Did you have to routinely readjust the clothing throughout the tasks to ensure correct positioning?</b>  Y/N	If yes, what needed adjusting and when in particular?
1.4.	<b>Did the clothing prevent dirt, dust, etc. entering at openings (i.e. cuffs)?</b>  Y/N	If no, during which tasks was this particularly obvious?

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For all questions, as appropriate, answer by **scoring a mark** through the top line in the place which best describes your experience.

## 2.0 How easy was the clothing to adjust to fit (i.e. was it intuitive)?

\_\_\_\_\_

Very Easy	Easy	Difficult	Very Difficult
-----------	------	-----------	----------------

Additional Comments:

## **Comfort** *(mapped to Comfort and Protect against Environment HF SRs)*

### 3.0 How comfortable was the clothing during the functional assessment?

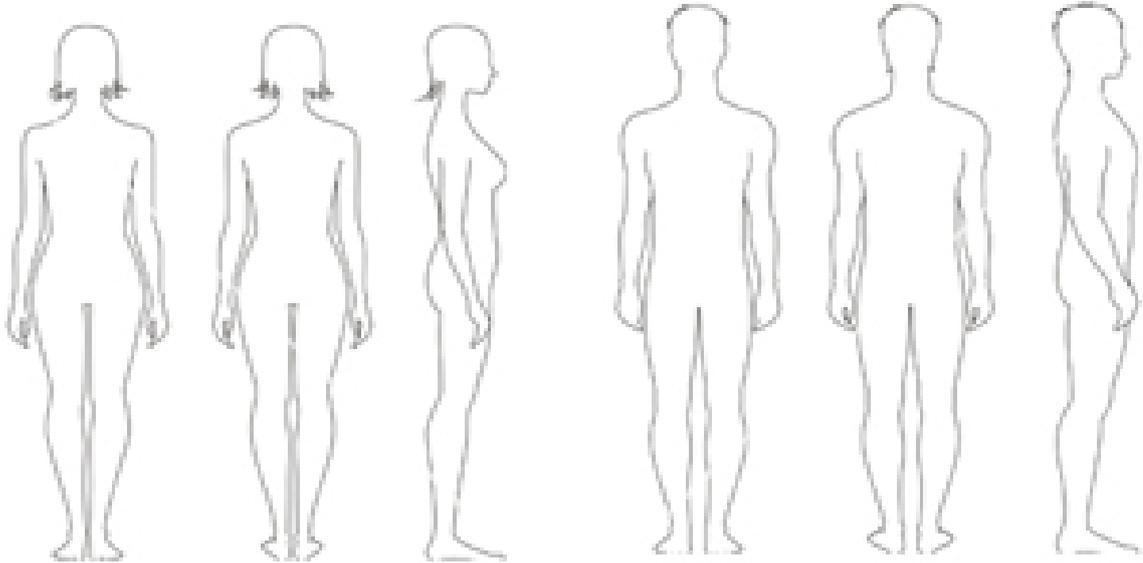
\_\_\_\_\_

Very Comfortable	Comfortable	Uncomfortable	Very Uncomfortable
------------------	-------------	---------------	--------------------

Additional Comments (please detail any particular tasks that caused discomfort, especially whether the knees and elbows were sufficiently protected):

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**4.1 If you associate the clothing with any Discomfort please use the numbered discomfort scale to indicate where you and to how severe it was (Mark the numbers on the diagram)**



## **Discomfort Scale**

1. Slightly uncomfortable
2. Uncomfortable
3. Very uncomfortable
4. Unacceptably uncomfortable

No Discomfort

**4.2 Please write next to each number the type of discomfort you experienced. Use the below criteria to describe the type of discomfort (Mark the letters on the diagram)**

- |                          |             |                |
|--------------------------|-------------|----------------|
| a) Pressure              | e) Numb     | i) Annoying    |
| b) Pinching              | f) Sore     | j) Restrictive |
| c) Stiff                 | g) Chaffing | k) Hindrance   |
| d) Tingling              | h) Sweaty   |                |
| i) other, please specify |             |                |

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## **Thermal Comfort** *(mapped to Comfort HF SRs)*

5.1 Please **CIRCLE** on the scale below how you felt **DURING** the exercise:

9	Very Hot
8.5	
8	Hot
7.5	
7	Warm
6.5	
6	Slightly warm
5.5	
5	Neutral
4.5	
4	Slightly Cool
3.5	
3	Cool
2.5	
2	Cold
1.5	
1	Very Cold

5.2 Please **CIRCLE** on the scale below how you feel **NOW**:

9	Very Hot
8.5	
8	Hot
7.5	
7	Warm
6.5	
6	Slightly warm
5.5	
5	Neutral
4.5	
4	Slightly Cool
3.5	
3	Cool
2.5	
2	Cold
1.5	
1	Very Cold

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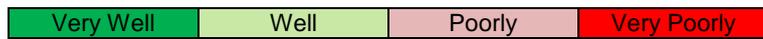
**Integration** (mapped to Integration HF SRs)

6 How did the Clothing **Integrate** with other clothing and equipment and did it impact on your task performance? *Integrate – the 'fit' and interaction with other equipment*

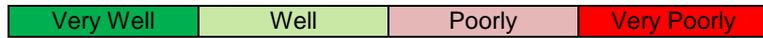
**Clothing** \_\_\_\_\_



**Knee Pads** \_\_\_\_\_



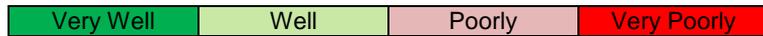
**Extremity Protection** \_\_\_\_\_



**Pelvic Protection** \_\_\_\_\_



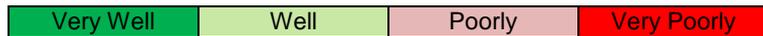
**Webbing / Belt Order** \_\_\_\_\_



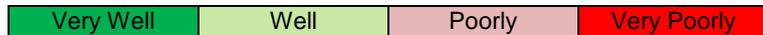
**Day Sack** \_\_\_\_\_



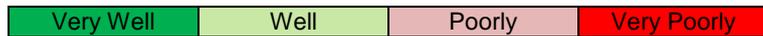
**Helmet** \_\_\_\_\_



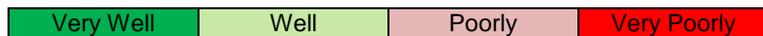
**BA** \_\_\_\_\_



**Rifle** \_\_\_\_\_



**Other** \_\_\_\_\_



**Task Performance** (mapped to Mobility and Agility HF SRs)

7 If at all, how much did the clothing hinder your ability to complete the military tasks?

\_\_\_\_\_

Minimally	Moderately	Severely	Extremely
-----------	------------	----------	-----------

Additional Comments (please include any tasks / positions that were particularly effected):

8 The impact of the clothing on military task performance:

8.1 The **Mobility** was:

*Mobility - The ability to move physically or adopt natural body positions*

\_\_\_\_\_

Minimal	Moderate	Severe	Extreme
---------	----------	--------	---------

Additional Comments:

8.2 The **Weight** was:

*Weight – How heavy the clothing feels*

\_\_\_\_\_

Minimal	Moderate	Severe	Extreme
---------	----------	--------	---------

Additional Comments:

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## 8.3 The **Bulk** was:

*Bulk – the size of the clothing*

Minimal	Moderate	Severe	Extreme

Additional Comments:

## 9 How **satisfied** are you with the clothing? (incl. aesthetics)

Very Satisfied	Satisfied	Dissatisfied	Very Dissatisfied

Additional Comments:

## 10 How **confident** would you be using the clothing in theatre?

Very Confident	Confident	Unconfident	Very Unconfident

Additional Comments:

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11 Please indicate any Likes, Dislikes or Changes you would make to the clothing:

Likes	Dislikes	Changes

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**APPENDIX G Subjective questionnaire data<sup>7</sup>**

Comfort						
	How easy was the clothing to adjust to fit		How comfortable was the clothing		Thermal rating during the exercise	
Subject number	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY
1	6.3	3.7	6.3	2.5	7.5	7.0
2	0.3	6.2	0.7	0.2	7.0	8.0
3	4.4	3.4	8.3	3.7	6.0	5.0
4	2.2	3.7	1.4	5.0	7.0	8.0

Comfort						
	How easy was the clothing to adjust to fit		How comfortable was the clothing		Thermal rating during the exercise	
Subject number	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
1	2.6	3.8	6.2	4.1	7.5	7.5
2	2.0	5.9	2.9	5.5	8.0	8.0
3	3.6	3.6	4.5	4.7	7.0	7.0
4	0.1	2.2	2.9	2.4	7.0	7.0

Comfort						
	How easy was the clothing to adjust to fit		How comfortable was the clothing		Thermal rating during the exercise	
Subject number	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA
1	3.7	---	8.6	---	---	---
2	6.2	---	1.5	---	7.0	---
3	3.4	5.0	4.9	5.0	7.0	7.0
4	3.7	3.2	2.1	4.3	9.0	7.0

<sup>7</sup> APPENDIX F shows the visual analogue rating scale for each question.

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Integration (How did the clothing integrate with other clothing and equipment)						
Subject number	Clothing		Knee pads		Extremity protection	
	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY
1	3.8	3.7	10.0	3.9	---	---
2	1.4	0.2	4.5	---	---	4.7
3	5.5	4.7	8.1	2.1	5.6	4.7
4	1.3	0.2	6.2	3.2	2.8	1.0
Subject number	Pelvic protection		Webbing/belt order		Day Sack	
	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY
1	7.7	2.5	6.3	5.0	10.0	7.6
2	3.7	5.8	5.0	3.9	---	5.9
3	5.6	5.7	8.2	5.7	9.8	6.1
4	4.7	5.6	5.4	5.6	7.8	3.0
Subject number	Helmet		Body Armour		Rifle	
	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY
1	5.0	5.0	5.0	5.0	5.0	5.0
2	---	---	2.0	2.5	2.5	5.2
3	4.7	4.4	10.0	8.1	5.7	5.6
4	0.3	0.0	4.1	5.9	2.6	5.3

**OFFICIAL**

Integration (How did the clothing integrate with other clothing and equipment)						
Subject number	Clothing		Knee pads		Extremity protection	
	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
1	5.0	3.7	10.0	3.7	---	3.7
2	1.9	5.6	6.6	5.0	5.4	0.6
3	5.0	4.5	10.0	4.4	4.9	3.8
4	0.0	1.9	7.0	2.4	2.9	0.7
Subject number	Pelvic protection		Webbing/belt order		Day Sack	
	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
1	3.6	3.8	10.0	6.3	6.1	6.2
2	6.9	4.0	3.9	3.0	4.0	3.8
3	5.0	6.2	10.0	4.5	10.0	5.6
4	0.6	3.0	1.9	3.8	9.1	5.3
Subject number	Helmet		Body Armour		Rifle	
	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
1	0.0	2.5	5.0	3.9	5.0	5.0
2	2.8	---	2.5	0.2	3.6	4.6
3	4.0	3.6	10.0	5.0	6.5	6.3
4	0.0	0.1	2.9	0.2	2.2	0.3

**OFFICIAL**

Integration (How did the clothing integrate with other clothing and equipment)						
Subject number	Clothing		Knee pads		Extremity protection	
	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA
1	3.7	---	8.8	---	---	---
2	0.6	---	7.1	---	4.7	---
3	4.6	5.0	9.0	3.7	---	5.0
4	0.2	0.2	7.2	0.2	2.1	0.2
Subject number	Pelvic protection		Webbing/belt order		Day Sack	
	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA
1	7.6	---	8.9	---	6.0	---
2	5.7	---	5.7	---	6.7	---
3	2.9	7.5	5.3	10.0	5.7	10.0
4	6.6	0.2	2.2	0.2	4.7	2.5
Subject number	Helmet		Body Armour		Rifle	
	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA
1	5.0	---	0.1	---	5.0	---
2	3.8	---	4.1	---	---	---
3	1.2	3.7	4.1	5.0	3.8	5.0
4	0.2	0.0	0.0	0.0	5.0	0.0

**OFFICIAL**

Task performance (The impact of the clothing on)								
How much did the clothing hinder		Mobility		Weight		Bulk		
Subject Number	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY
1	0.0	1.5	0.0	3.9	2.5	3.7	0.0	5.0
2	0.0	1.0	0.0	1.0	1.0	3.0	1.0	4.0
3	3.0	5.0	2.0	4.0	2.0	5.0	3.0	6.0
4	3.0	2.0	2.0	0.0	0.0	2.0	2.0	5.0
How much did the clothing hinder		Mobility		Weight		Bulk		
Subject Number	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
1	1.3	3.7	2.6	3.4	2.5	2.5	2.5	4.0
2	0.0	1.0	1.1	1.0	0.6	1.0	0.7	4.0
3	3.0	2.0	4.0	4.0	1.0	5.0	1.0	5.0
4	3.0	2.0	2.0	1.0	3.0	1.0	3.0	3.0
How much did the clothing hinder		Mobility		Weight		Bulk		
Subject Number	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA
1	8.3	---	3.6	---	0.0	---	0.0	---
2	1.0	---	1.0	---	0.0	---	0.0	---
3	2.0	4.0	4.0	5.0	1.0	6.0	1.0	6.0
4	0.0	0.0	2.0	2.0	0.0	3.0	0.0	2.0

**OFFICIAL**

Acceptability				
How satisfied are you with the clothing			How confident would you be using the clothing	
Subject Number	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY
1	3.8	2.6	3.6	2.5
2	0.0	3.0	0.0	1.0
3	5.0	6.0	4.0	6.0
4	1.0	4.0	0.0	5.0

Acceptability				
How satisfied are you with the clothing			How confident would you be using the clothing	
Subject Number	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
1	3.8	3.7	3.7	3.7
2	3.0	2.0	2.7	1.0
3	4.0	6.0	3.0	5.0
4	1.0	2.0	0.0	5.0

Acceptability				
How satisfied are you with the clothing			How confident would you be using the clothing	
Subject Number	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA
1	4.1	---	3.6	---
2	1.0	---	0.0	---
3	4.0	6.0	4.0	6.0
4	0.0	1.0	0.0	0.0

Table 19: Subjective rating data for infantry cohort

**OFFICIAL**

Comfort						
	How easy was the clothing to adjust to fit		How comfortable was the clothing		Thermal rating during the exercise	
Subject number	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY
5	5.5	5.3	2.5	4.5	8.0	9.0
6	3.0	3.8	4.0	7.7	8.0	9.0
7	---	---	---	---	---	---
8	0.0	0.1	2.5	3.9	6.0	8.0

Comfort						
	How easy was the clothing to adjust to fit		How comfortable was the clothing		Thermal rating during the exercise	
Subject number	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
5	4.5	4.5	4.5	4.5	8.5	8.0
6	4.0	3.7	5.0	4.0	8.0	6.0
7	---	---	---	---	---	---
8	0.0	0.4	2.5	0.8	7.0	8.0

Comfort						
	How easy was the clothing to adjust to fit		How comfortable was the clothing		Thermal rating during the exercise	
Subject number	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA
5	4.0	4.5	2.5	4.0	7.5	7.5
6	4.0	4.0	9.1	4.0	6.0	8.0
7	---	---	---	---	---	---
8	0.0	1.0	5.0	0.0	6.0	7.0

**OFFICIAL**

Integration (How did the clothing integrate with other clothing and equipment)						
Subject number	Clothing		Knee pads		Extremity protection	
	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY
5	4.1	4.0	6.0	6.5	2.0	1.1
6	5.0	4.1	9.0	7.0	---	---
7	---	---	---	---	---	---
8	0.8	3.0	10.0	8.5	---	---
Subject number	Pelvic protection		Webbing/belt order		Day Sack	
	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY
5	2.5	2.0	3.5	4.5	8.4	4.0
6	3.0	7.0	4.0	6.0	9.0	9.0
7	---	---	---	---	---	---
8	7.5	5.0	7.5	5.0	7.5	10.0
Subject number	Helmet		Body Armour		Rifle	
	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY
5	3.7	7.0	2.8	8.0	6.4	4.0
6	4.0	4.0	9.0	5.0	4.0	6.5
7	---	---	---	---	---	---
8	5.0	7.5	10.0	7.5	9.0	10.0

**OFFICIAL**

Integration (How did the clothing integrate with other clothing and equipment)						
Subject number	Clothing		Knee pads		Extremity protection	
	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
5	5.3	5.5	4.0	6.0	1.0	1.0
6	3.0	4.0	8.7	5.1	1.5	---
7	---	---	---	---	---	---
8	2.5	1.3	10.0	6.4	---	---
Subject number	Pelvic protection		Webbing/belt order		Day Sack	
	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
5	5.0	0.5	7.0	5.0	9.0	6.5
6	7.0	4.0	8.2	4.0	9.4	6.0
7	---	---	---	---	---	---
8	5.0	2.5	5.0	6.3	8.8	6.4
Subject number	Helmet		Body Armour		Rifle	
	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
5	1.0	0.5	6.5	4.0	7.0	4.5
6	0.5	0.5	1.0	0.5	4.0	4.0
7	---	---	---	---	---	---
8	0.0	1.4	2.5	3.7	10.0	9.4

**OFFICIAL**

Integration (How did the clothing integrate with other clothing and equipment)						
Subject number	Clothing		Knee pads		Extremity protection	
	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA
5	4.0	3.0	6.0	8.0	0.5	3.0
6	9.0	4.0	7.2		---	4.0
7	---	---	---	---	---	---
8	7.5	0.0	10.0	4.5	---	---
Pelvic protection						
Subject number	Pelvic protection		Webbing/belt order		Day Sack	
	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA
5	1.0	2.0	4.8	3.5	8.0	5.5
6	1.0	4.0	7.5	4.0	4.5	7.0
7	---	---	---	---	---	---
8	10.0	5.0	5.0	7.5	7.5	8.7
Helmet						
Subject number	Helmet		Body Armour		Rifle	
	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA
5	5.2	8.0	5.0	5.3	7.1	4.0
6	4.0	4.0	4.0	2.1	4.0	4.0
7	---	---	---	---	---	---
8	5.0	5.0	3.8	2.5	10.0	10.0

**OFFICIAL**

Task performance (The impact of the clothing on)								
How much did the clothing hinder		Mobility		Weight		Bulk		
Subject Number	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY
5	4.0	8.0	4.8	6.0	6.5	9.0	2.5	4.5
6	2.0	7.0	2.0	7.0	1.0	9.0	1	5.0
7	---	---	---	---	---	---	---	---
8	2.0	2.0	3.0	0.0	3.0	0.0	3.0	0.0
How much did the clothing hinder		Mobility		Weight		Bulk		
Subject Number	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
5	6.1	3.5	5.5	4.0	8.5	5.0	4.6	6.0
6	7.0	2.0	4.0	2.0	1.0	2.0	1.0	2.0
7	---	---	---	---	---	---	---	---
8	3.0	1	3.0	1.0	0.0	1.0	0.0	1.0
How much did the clothing hinder		Mobility		Weight		Bulk		
Subject Number	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA	PCS/ECBA	FSV2/ECBA
5	6.5	2.0	4.5	3.0	2.0	4.5	5.0	4.5
6	9.0	2.0	2.0	2.0	2.0	4.0	2.0	5.0
7	---	---	---	---	---	---	---	---
8	5.0	0.0	0.0	4.0	0.0	3.0	0.0	1.0

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<b>Acceptability</b>				
<b>How satisfied are you with the clothing</b>			<b>How confident would you be using the clothing</b>	
<b>Subject Number</b>	<b>PCS/OSPREY</b>	<b>FSV2/OSPREY</b>	<b>PCS/OSPREY</b>	<b>FSV2/OSPREY</b>
5	5.0	5.5	6.0	10
6	3.0	9.0	3.0	9.0
7	---	---	---	---
8	3.0	2	1	1

<b>Acceptability</b>				
<b>How satisfied are you with the clothing</b>			<b>How confident would you be using the clothing</b>	
<b>Subject Number</b>	<b>PCS/VIRTUS</b>	<b>FSV2/VIRTUS</b>	<b>PCS/VIRTUS</b>	<b>FSV2/VIRTUS</b>
5	5.0	4.8	5.5	5.5
6	3.0	3.0	1.0	3.0
7	---	---	---	---
8	2.0	1.0	0.0	1.0

<b>Acceptability</b>				
<b>How satisfied are you with the clothing</b>			<b>How confident would you be using the clothing</b>	
<b>Subject Number</b>	<b>PCS/ECBA</b>	<b>FSV2/ECBA</b>	<b>PCS/ECBA</b>	<b>FSV2/ECBA</b>
5	7.0	3.5	10	4.5
6	2.0	4.0	9.0	4.0
7	---	---	---	---
8	3.0	0.0	0.0	0.0

Table 20: Subjective ratings data for military female cohort

**OFFICIAL**

<b>Comfort</b>						
	<b>How easy was the clothing to adjust to fit</b>		<b>How comfortable was the clothing</b>		<b>Thermal rating during the exercise</b>	
<b>Subject number</b>	<b>PCS/OSPREY</b>	<b>FSV2/OSPREY</b>	<b>PCS/OSPREY</b>	<b>FSV2/OSPREY</b>	<b>PCS/OSPREY</b>	<b>FSV2/OSPREY</b>
<b>9</b>	3.4	3.0	4.8	3.0	3.0	8.0
<b>10</b>	3.9	1.3	3.9	1.9	6.5	7.0
<b>11</b>	2.5	2.3	2.5	2.4	8.5	8.0
<b>12</b>	2.0	2.0	2.0	2.0	6.0	5.0

<b>Comfort</b>						
	<b>How easy was the clothing to adjust to fit</b>		<b>How comfortable was the clothing</b>		<b>Thermal rating during the exercise</b>	
<b>Subject number</b>	<b>PCS/VIRTUS</b>	<b>FSV2/VIRTUS</b>	<b>PCS/VIRTUS</b>	<b>FSV2/VIRTUS</b>	<b>PCS/VIRTUS</b>	<b>FSV2/VIRTUS</b>
<b>9</b>	4.9	3.0	4.8	3.5	8.0	8.0
<b>10</b>	4.9	2.5	5.0	2.5	5.0	7.0
<b>11</b>	2.0	3.9	1.8	2.5	7.5	8.5
<b>12</b>	4.0	3.5	2.0	3.0	4.5	5.0

**OFFICIAL**

Integration (How did the clothing integrate with other clothing and equipment)						
Subject number	Clothing		Knee pads		Extremity protection	
	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY
9	4.8	3.3	7.8	2.0	6.5	2.6
10	3.7	1.3	5.6	1.3	5.1	3.7
11	2.5	4.5	6.8	5.2	3.2	2.9
12	2.0	2.0	7.0	4.0	5.0	4.0
Subject number	Pelvic protection		Webbing/belt order		Day Sack	
	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY
9	5.9	4.0	3.5	4.7	3.5	4.7
10	3.1	3.7	5.5	9.8	5.1	7.4
11	2.5	1.7	9.9	7.8	3.8	3.8
12	3.0	4.0	3.0	3.5	2.5	3.0
Subject number	Helmet		Body Armour		Rifle	
	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY
9	4.5	4.0	3.4	4.2	3.9	---
10	5.1	1.5	5.0	1.4	7.6	8.8
11	3.0	1.9	1.5	1.9	1.3	1.9
12	1.0	2.0	3.0	4.0	2.5	2.0

**OFFICIAL**

Integration (How did the clothing integrate with other clothing and equipment)						
Subject number	Clothing		Knee pads		Extremity protection	
	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
9	---	3.4	---	2.4	---	4.9
10	5.0	2.5	8.0	3.6	7.0	3.7
11	2.3	2.7	10.0	2.8	2.5	2.8
12	5.0	2.0	7.0	3.0	5.0	2.0
Subject number	Pelvic protection		Webbing/belt order		Day Sack	
	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
9	---	4.5	---	4.3	---	4.3
10	3.0	2.5	10.0	6.3	7.0	6.3
11	2.6	2.8	9.7	9.9	5.4	6.3
12	2.0	6.0	4.0	6.0	4.0	4.5
Subject number	Helmet		Body Armour		Rifle	
	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
9	---	3.4	---	3.4	---	2.8
10	1.0	3.7	5.0	6.2	9.0	7.6
11	1.7	2.5	1.7	2.5	0.9	2.5
12	1.0	2.5	2.0	1.0	8.0	2.0

**OFFICIAL**

Task performance (The impact of the clothing on)								
Subject Number	How much did the clothing hinder		Mobility		Weight		Bulk	
	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY	PCS/OSPNEY	FSV2/OSPNEY
9	5.5	4.7	4.8	4.6	3.0	2.5	6.9	2.5
10	2.5	1.0	1.5	1.3	1.4	1.2	1.3	2.5
11	0.7	1.3	0.9	1.6	0.6	4.3	1.3	1.4
12	2.0	2.5	2.5	2.5	4.0	2.0	5.0	4.0

Subject Number	How much did the clothing hinder		Mobility		Weight		Bulk	
	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
9	---	3.5	---	3.0	---	2.5	---	2.5
10	2.0	1.2	1.0	1.1	1.0	1.2	1.0	2.5
11	1.9	2.3	1.2	2.0	1.4	2.2	1.3	2.5
12	2.0	4.0	2.0	0.5	2.0	2.0	2.0	4.0

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Acceptability				
	How satisfied are you with the clothing		How confident would you be using the clothing	
Subject Number	PCS/OSPREY	FSV2/OSPREY	PCS/OSPREY	FSV2/OSPREY
9	4.9	3.0	4.9	2.5
10	5.0	1.5	5.4	1.4
11	1.2	2.3	1.0	1.3
12	5.0	2.1	3.5	2.0

Acceptability				
	How satisfied are you with the clothing		How confident would you be using the clothing	
Subject Number	PCS/VIRTUS	FSV2/VIRTUS	PCS/VIRTUS	FSV2/VIRTUS
9	4.8	3.3	4.3	3.2
10	5.0	1.2	5.0	1.2
11	2.3	2.5	1.8	1.7
12	2.5	2.0	3.0	3.0

Table 21: Subjective rating data for the Paratrooper cohort



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## APPENDIX H Subjective comments and opinion

PCS clothing		
Comment number	Issue/comment or opinion expressed (green is a positive/red is negative)	Number of times comment/opinion expressed
1	The PCS clothing was stated as being comfortable.	4
2	The PCS clothing was stated as being lightweight.	4
3	The PCS clothing was stated as being flexible.	2
4	The PCS clothing was easy to adjust	1
5	Knee pads uncomfortable/slipping	17
6	Arm pockets provide a snag hazard to day sack	3
7	Trousers being pulled down by Tier II pelvic protection	2
8	Wicking ability of UBACS material considered poor	1
9	Chaffing under armpits	1
10	UBACS collar does not prevent weapon sling rubbing on neck	1
11	Too few pockets on trousers	1
12	Issue glove provide poor grip	1

Table 22: Comments and opinions relating to the PCS

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<b>FSV2 clothing</b>		
<b>Comment number</b>	<b>Issue/comment or opinion expressed (green is a positive/red is negative)</b>	<b>Number of times comment/opinion expressed</b>
1	The FSV2 clothing was stated as being comfortable.	4
2	Internal knee pads considered good, protective and comfortable.	4
3	Three way zip pockets allowed better/easier access	4
4	The FSV2 clothing was easy to adjust	1
5	Silent Velcro® came undone on either leg cuffs or pockets	9
6	Trouser material considered too thick/heavy/sticking	6
7	Trouser material considered too restrictive	4
8	Suggested better design of knee pads so they hold position better	4
9	Adjustment for leg cuffs was inadequate	3
10	Arm pockets provide a snag hazard to day sack	3
11	Positioning of arm and trouser pockets should be adjusted	2
12	Armour gel glove palms considered too thin to give good protection	2
13	Armour gel glove palms considered too slippery	1
14	Chaffing under armpits	1

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15	Forearm protection uncomfortable	1
16	Too few pockets on trousers	1
17	Trouser pockets are not large enough to hold a map	1
18	UBACS shoulder pads rucked up causing discomfort	1
19	Inadequate elbow protection	1

Table 23: Comments and opinions relating to the FSV2 combat clothing

## Subjective comment/opinions related to non-clothing equipment

During the course of the trial subjects expressed comment and opinion about the protective equipment they were wearing. These are summarised below in terms of equipment worn.

### OSPREY body Armour:

Subjects voiced overwhelmingly negative opinions with regard to the OSPREY body armour, reporting that it was too heavy, restrictive and bulky. It was reported that the OSPREY body armour did not integrate well with the helmet. In the prone firing position the body armour prevented the person from lifting their head due to clashes between the helmet and the top of the body armour.

### VIRTUS body armour:

Subjects voiced positive comments about the VIRTUS body armour, describing it as comfortable, well-fitting and lightweight. One negative comment centred on the lack of a shoulder pad for the butt of the rifle. On the OSPREY body armour there is a shoulder pad that provides 'grip' for the rifle butt, preventing it slipping. Subjects would like to see this feature as part of the VIRTUS body armour.

### OSPREY and VIRTUS webbing:

Both sets of webbing received poor comments and opinions from subjects. It was judged that the webbing integrated poorly with both sets of body armour, and pelvic protection. The webbing was unstable, moving around too much during tasks such as the leopard crawl, which made the task harder to complete. Every male subject reported that they would not use either set of webbing and instead, bought their own from a commercial supplier. Of particular note the 'quick release' mechanism on the VIRTUS webbing came undone several times during the trial. This slowed the trial conduct and in response the 'quick release mechanism was 'taped up' to prevent this

from happening again, however, even the 'taped' mechanisms came undone on two occasions, see Figure 24.



Figure 24: VIRTUS webbing 'quick release' mechanism failure

**Day sack:**

Subjects voiced overwhelmingly negative opinions with regard to the day sack. The shoulder straps were too thin and did not integrate with either body armour type, constantly slipping off the shoulders and having to be readjusted. There was no hip belt to facilitate load distribution or chest strap to stabilise the day sack. During tasks subjects mentioned that the day sack moved too much, 'swaying' left and right, causing subjects to be unsteady and slowing their ability to do the task.

**Cobra+ helmet:**

Subjects voiced positive comments with regard to the Cobra+ helmet, describing it as comfortable and lightweight with good balance.

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## Initial distribution

1.	KIS	Dstl	electronic
2.	Lorna Thompson	DE&S STSP	electronic
3.	Maj. Simon Farley	DE&S STSP	electronic
4.	Col. Phil White	Army Sp-Integ. Cbt	electronic
5.	Lt. Col. Iain Moodie	Army CapCbt-DCC-Delivery-SO1	electronic
6.	Mr. Richard Leigh	Dstl	electronic
7.	Mr. Scott Bell	Dstl	electronic
8.	Mr. Colin Skelton	Dstl	electronic



**Report documentation page**

**v5.0**

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<b>7a. Abstract: *</b> A new set of combat clothing, called Future Soldier Vision 2 (FSV2) is being proposed for adoption by the UK military. This report describes a Human Factors (HF) assessment of the FSV2 clothing, comparing it to the current Personal Clothing System using defined HF assessment techniques. 11 subjects took part in the assessment and completing a series of range of movement tasks, relevant military tasks and a Common Battlefield Test Facility (CBTF) series of obstacles. Subjects had their task performance independently rated and then completed a subjective questionnaire on clothing performance. Data from the HF tasks, CBTF assessor and the subjective questionnaire demonstrated no difference between clothing conditions. The PCS and FSV2 combat clothing perform equally well across this range of assessment criteria. Qualitative data from subjects (written and verbal comments/opinion), highlighted issues and concerns for both the PCS and FSV2 clothing systems. Used in conjunction with the rating data, these led to suggested design improvements to the FSV2 clothing. These design improvements have been described in terms of 14 suggested additions to potential System Requirements Document (SRD) to aid the procurement of future combat clothing.	
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<b>7c. Abstract national caveats: *</b> NONE	
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