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NATO ARMY ARMAMENTS GROUP (NAAG)

LAND CAPABILITY GROUP DISMOUNTED SOLDIER SYSTEM

Human Systems Integration (HSI) Workshop Report

Note by the NATO Staff Advisor

LAMP Reference DSS-001

1. The Human Systems Integration (HSI) Workshop was held in October 2016, in Prague, Czech Republic, in the margins of the LCGDSS Meeting. The workshop was led by Dr. Nicholas Stanbridge (UK), who also prepared this report.

2. The HSI Workshop Report is now published as an official LCGDSS document for reference.

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1 Enclosure

NATO LCG DSS SCAG

Human Systems Integration (HSI) Workshop Report

Prague, Czech Republic

October 2016

Executive Summary

This document reports the Human Systems Integration (HSI) workshop held in October 2016. Representatives from twelve nations met over two days to identify the requirements of an HSI capability. rate the key characteristics of HSI assessment and determine the success criteria for an HSI facility.

While much commonality in requirement has been identified, it was noted that differences in national approaches to funding, governance and science and technology provision would preclude the development of a single solution. Regardless of specific function and tasking, the requirement for a core team of military, scientific and engineering leads was identified. The core team should be permanent, preferably co-located and with easy access to training areas and trials subjects, and ideally would be supported by experts in a number of identified disciplines, in order to deliver access to a range of different techniques.

Strong, clear delegated authority is required, since any integration facility by definition must cross boundaries between project, programmes and users, each of whom might be funded by, and report to, different stakeholders. The management of this stakeholder community is key to the ongoing success of any facility. The facility must be backed by suitable levels of funding and strong governance, so that appropriate research can be delivered, and where necessary, prioritisation between tasks made and direction given to associated projects and programmes.

It is considered anomalous that there is no formal grouping with Human Systems Integration responsibility in the Dismounted Soldier Systems Land Capability Group. Therefore it is recommended that a Human Systems Integration Team of Experts (HSI ToE) be established under the auspices of LCG DSS. This ToE should be charged with continuing to define best practice for HSI assessment, liaising with more specialised NATO fora as appropriate, sharing knowledge and information, and identifying opportunities for collaboration between nations.

1. Introduction

1.1 Background

Human Systems Integration (HSI) has been identified by the Dismounted Soldier System (DSS) Soldier Capability Advisory Group (SCAG) as one of the primary enablers for success on the battlefield.[1] Successful integration of soldier system components will allow the dismounted soldier to conduct his task more effectively since he will be less burdened and the equipment will be more tailored to his current mission. Furthermore, he will be able to access more of the equipment's capability, spiral acquisition will be easier, and he is less likely to suffer longer term issues[2].

Integration activities are sometimes viewed as adding unnecessary complexity and cost into the early stages of soldier system development, especially when the reversionary model – deployment of individual components with no designed integration – is known to work, albeit poorly. Quantification of the benefits of integration can be problematic, especially in areas which do not manifest for several years. Several nations have started to address this paucity in knowledge by developing integration testing and assessment facilities and protocols. This DSS SCAG activity is aimed at sharing information and establishing best practice in this area, and at identifying opportunities for further collaboration.

The perceived benefits of integration can be categorised into three broad areas[3]:

- Physical /physiological / cognitive: that the system components fit together in an ergonomic, fashion, reducing burdens on the individual.
- Technical (including procurement): that the system components share common services (e.g., power and data) and architectures, reducing duplication of provision and logistic and other burdens. This will also assist spiral acquisition – both for rapid fielding and testing, and to allow technology refresh - within nations, and potentially equipment interoperability between nations.
- Operational: that the individual and the formed unit can operate more efficiently and for longer on the battlefield, and that the individual is less likely to suffer chronic injury.

Physical and electronic integration of system's components and their integration with the human were perceived as being of similar interest, as were the methods by which integration could be governed, measured and researched.

[1] NATO LCG DSS SCAG Minutes, March 2016.
[2] Mostly due to chronic musculo-skeletal injuries caused by excessive and poorly integrated load.
[3] There is potential for cost saving as well, as poorly integrated equipment is more likely to be discarded by the user, and post integration could be more expensive. However, this was considered to be outside the scope of this task.

1.2 Aim, Objectives and Outcomes

The aim of this work is:

> *"to identify the requirements of a successful Human Systems Integration capability[4]."*

This aim will be achieved through the following objectives:

- the identification of best practice and lessons learnt;
- the sharing of knowledge from existing HSI capabilities;
- the promotion of opportunities for collaboration.

The definition and development of best practice for human systems integration was recognised as a large task that was unlikely to be completed in a single workshop. Therefore, an acceptable outcome was seen as formalised greater understanding of the issues associated with generating successful HSI capability. The outcomes of this work will be:

- a report outlining the characteristics of a successful HSI capability;
- a recommendation on whether a formal HSI Team of Experts be established;
- an informal network for sharing information and experience on HSI.

1.3 Method and Attendance

A two day workshop was held under the auspices of DSS SCAG, facilitated by the UK and Australia, in Prague in October 2016. A variety of standard workshop methods, detailed in Annex B were used to elicit opinion and achieve consensus. The workshop findings were then interpreted and presented back to the attendees for discussion and endorsement. This report presents the outcome of that workshop and subsequent discussions.

The workshop was structured around the following questions:

- What is the working definition of Human Systems Integration?
- What types of data should be collected?
- What techniques are available for collecting the most important data types?
- What capability aspects are important?
- What are the success criteria?
- What are the hurdles to success?

The workshop was attended by representatives from the following nations; more details on attendees can be found in Annex A:

Australia	Belgium	Canada	Denmark
France	Germany	Hungary	Netherlands
Norway	Sweden	United Kingdom	United States

Table 1: Nations represented.

[4] Capability is defined as the abilities and functions required. A facility is defined as a specific instantiation which delivers capability. Depending on set up, a facility might own or have access to, or contract for different sets of capability, depending on circumstance.

2. Results

2.1 Q1. Human Factors / Ergonomics Definition:

The Discipline of Human Factors (aka Ergonomics) is a sub-component of Human Systems Integration (HSI). Both are defined below:

Human Factors, as defined by the International Ergonomics Association (IEA) is "…*the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance".*[5]

The IEA also points out that HF professionals aid in the design and evaluation of tasks, jobs, products, environments and systems. It should be noted that the Human Factors domain is a multi-disciplinary in nature, with input from numerous scientific fields, including psychology, engineering, biomechanics, industrial design, physiology, and anthropometry. Physical, cognitive, social, organizational and environmental factors are considered in HF assessments.

Human Systems Integration Definition

Within HSI support to Defence the assessment of individual equipment is secondary to HSI's main goal of assessing the larger system.

As it relates to defence procurement HSI can be defined as "…*the process of integrating the domains of human factors engineering, system safety, training, personnel, manpower (crewing), health hazards and survivability into each stage of the defence systems capability life cycle*".[6]

According the UK MoD HSI is concerned with "…*providing a balanced development of both the technical and human aspects of equipment procurement. It provides a process that ensures the application of scientific knowledge about human characteristics through the specification, design and evaluation of systems*"[7]

2.2 Q2 What type of data should be collected?

This task elicited the type of data that a HSI capability should be collecting to enable analysis of the soldier / section performance when introducing or considering new equipment. Working in two groups, participants were asked to identify topics or areas that could be investigated in the context of the human system. Thirty three areas were originally identified and these were ranked according to their overall importance to the understanding of soldier system performance, recognising that investigation of specific items might alter this ranking, in the second part of the task. Finally, a post workshop assessment was made on whether the area was more applicable to the component, the system or both. The twenty five areas presented in **Error! Reference source not found.** are those where there was agreement regarding high, medium and low importance ranking.

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[5] International Ergonomics Association (http://www.iea.cc/whats/index.html. Accessed 28 FEB 2017)
[6] Burgess-Limerick, R., Cotea, C., Pietrzak, E., & Fleming, P. (2011). *Human Systems Integration in Defence and Civilian Industries*. Australian Defence Force Journal, 186, 51-60
[7] MoD (2000) Human Factors Integration: An Introductory Guide. London. HMSO.

Importance	Title	Description	Component[8]	System[9]
High	Does it do what it should?	Does the component or system function to the levels stipulated in the requirement when used in representative situations?	Y	Y
	Usability (Efficiency)	Is the component or system designed to minimise the users interaction with the system, e.g., fewest clicks / button presses, presentation of information through the medium reduces interaction time.	Y	Y
	Usability (Acceptability) User Acceptance perception of benefit[10]	User Acceptance involves testing the system to ensure it meets the stakeholders requirements. Testing can and should take place at the different stages of the product development life cycle	Y	Y
	Cognitive Workload	Mental effort being used in the working memory.	Y	Y
	Trust in the system	Ensuring a system's behaviour is consistent, transparent and can be relied upon.	Y	Y
	Personal Physical Limitations	The operator is physically unable to complete a task due to their / our biomechanics / musculoskeletal design	Y	
Medium	Situational Awareness	The ability to identify, process, and comprehend the critical elements of information about what is happening to the team with regards to the mission.		Y
	Flexibility – Range of movement	Testing the users range of movement to ensure they are free to complete their tasks in an acceptable manner.		Y
	Measurement of emotional response (User Experience)	User experience is the measure of how a user feels towards / about a system / brand after using it.	Y	Y
	Durability / Robustness	Will the equipment continue to function correctly while used in the range of environments seen by the DCC soldier.	Y	
	Comfort	Does the equipment introduce discomfort into the soldiers task	Y	Y
	Energy cost (human)	The metabolic cost to the individual when conducting a series of tasks while equipped with the soldier system and/ or other components.		Y
	Energy Cost (Electric)	Power consumption of the equipment.	Y	Y
	(Ability) Physical balance	The ability of the individual to maintain balance when conducting a series of tasks while equipped with the soldier system, compare to the same activities when unencumbered.		Y
	Stability of capability	Does the system "fall over".	Y	
	Influence of mass	Affect the new system mass has on movement, balance, agility, human energy expenditure.		Y

	Bulk	Affect bulk has on task completion, signature , agility, balance, movement through mouse holes / into and out of vehicles etc.		Y
	Impact of stress on decision making	Affect new system has of decision making.		Y
	Equipment performance WRT Stressors	How the performance characteristics might change given exposure to likely battlefield and environmental stressors, such as humidity, dust, etc		Y
	Modularity	Is the system scalable depending on mission profile or does the whole system need to be carried when only part of its functionality will be used.	Y	
Low	Data entry errors	Number of errors made while interacting with the system, e.g., erroneous button presses, input of incorrect data.	Y	
	Capture Alternative Use	Is the equipment used outside of its original design requirements	Y	
	User Purchases (Amazon)	Monitoring what soldiers bought for themselves to use in theatre the feeling was additional user needs or dislikes with existing equipment could be identified to help with requirement generation.	Y	
	(Equipment) Use Profile (Critical vs Enduring)	How and for how long the equipment is used: continuously or in discrete phases, and whether its use is critical to the mission at the point of use.		Y

Table 2: HSI capability areas ordered by importance.

Clear agreement could not be reached between the two groups on the ranking in some areas, reflecting difference experiences and interpretations. These areas are discussed below.

1. Field of view: Group A gave this a high importance, the opposite of Group B's conclusion. They reasoned that "field of view" was to be considered as a function of "does it do what it should". The example given was, "imagine you are designing a sight, vision block or binoculars, field of view would be important". Group B felt that because field of view was trial / equipment specific it was not consistently of high importance, or rarely of high importance and therefore gave it a low importance classification.
2. Intuitiveness: Group A saw Intuitiveness as a function of Usability, which both groups scored high; there rationale was if something was intuitive it was easy to use. Group B reasoned[11]

[8] Particular relevance of the data category to the assessment of individual system components, such as a thermal sight.
[9] Particular relevance of the data category to the assessment of the system as a whole.
[10] Group B removed this from their list of areas as they felt it was equal to the "Usability Acceptability" heading
[11] Group B's perspective can be explained through the example of learning to drive a manual car, many people do not find it intuitive (ie it is difficult to do initial without instruction); however, once they are sufficiently trained and experienced, the car is usable.

that once trained it didn't matter if equipment was intuitive as the users' performance could still meet the task success criteria.

3. Shooting Performance: Originally was given low importance by Group A, but after a brief discussion the group decided that shooting performance degradation was a fundamental measure and should be considered of higher importance.
4. "Chronic health effects" were seen, by Group A as not being a measure that could be captured in one-off assessments. However, this would need to be considered during the risk assessment / hazard analysis, before user testing starts, and possible assessed by subject matter expertise during any trial.
5. "Compatibility", "Modularity" and "Impact of environment on user's kit performance": Were grouped together by Group A and classed as important when designing any user testing; for example it's important to ensure all configurations of the equipment (its modularity) being tested, are tested in all relevant environments and against all possible kit configurations to test its compatibility. It is clear that Group B also grouped; "Compatibility", "Modularity" and "Impact of environment on users kit performance" but considered them slightly lower importance as other items.
6. User Experience (UX): Group A felt the user's experience and emotional response of using the equipment was important in a military environment, for a number of reasons, some rational. The other group considered that capability would ultimately triumph over personal perception and acceptance.
7. Time to train: it was considered that this would vary widely between equipment, and in some cases it might only need a short time to train with an equipment (ie to gain proficiency in its use) but longer to train with it in a collective sense, especially if its full benefit could only be realised with changes to Tactic, Training and Procedures.

2.3 Q3: What techniques are available for collecting data for the more important categories?

The facilitators identified three sets from the above areas, covering equipment, cognitive and physical effects. The participants were split into two (different) groups and asked to consider what techniques or methods were available to gather information on the relevant areas.

Equipment use effects:
- 1.1 Trust in system
- 1.2 User acceptability
- 1.3 Usability / efficiency
- 1.4 Stability of capability

Cognitive Effects:
- 2.1 Impact of stress on decision making
- 2.2 Cognitive workload
- 2.3 Situational awareness

Physical Effects:
- 3.1 Comfort
- 3.2 Influence of mass
- 3.3 Physical balance
- 3.4 Bulk
- 3.5 Flexibility – range of movement

The discrete techniques identified are presented in table 3, together with a brief description.

Technique	Description
CAD Packages	Tools for modelling the physical space that allow for human maniquins to be placed into the physical space and manipulated to examin the potential impact on the human. Examples include; JACK, SAMMIE, SANTOS.
EEG (electroencephalogram)	Used to explore brain activity to provide indications of attention, workload, task engagement, sleep.
3D Scanning	Used to capture profile outlines and measurements. For example 3D scanning has been used to gather anthropometric measurements, clothing modifier profiles.
Simulations	Simulated environments and situations that allow for increased control over variables to be measured.
Red team method	Is a family of methods that helps analysts and decsion makers avoid pitfalls of poor decision making and challenges there thinking. The group felt this technique could be used to help elicit user requirements.
Task Analysis	Structured elicitation, decomposition and recoding of tasks. Examples include Hirerrachical Task Analysis, Cognitive Task Anlysis.
Delphi Method	A communication technique used to converge group opinion. The group felt it could be used to develop user requirements
Physiology (HR, GSR)	Physiological response (Heart Rate, Galvanic Skin Responce) can be used to provide objective feedback relating to the systems impact on the user.
Primary and Secondary tasks	A secondary task is introduced while the subject is asked to maintain performance of the primary task. Performance in the secondary task measured as an indicator of cognitive workload in the primary task.
Sensors (Pressure, Temp)	Sensors can be placed around the subject to measure core body temperature / temperature generated by equipment. Sensors can also be placed under / inside equipement (shoulder straps, hip belts, boots) to measure presure
Personas Method	Personas are profiles describing a type of user of the system being designed. Their purpose is to aid the designers understand the Target Audiance.
Encumbered Anthropometry	Refers to understanding the clothing modifiers that should be added to the soldier‘s nude measurement. This facilitates the design of vehicles and platforms.
Goniometry	The measurement of joint angles. This method can be used to help assess / explain postural comfort due to equipment design / constraints. Additionally an assessment of longer term musculaskeletal issues can be made.
Situational Awareness Global Assessment Technique (SAGAT)	Is a methodology for assessing Situational Awareness. It is one of many techniques available.
Obstacle course	Can be used to assess the impact of system changes over a selection of represent generic physical tasks seen in theater.

Eye tracking	Equipment that will follow the gaze of the subject. Assessments of workload, distractions, menu use are a few of the benefits of using this technique.
Balance plate	Experimental apparatus used to measure the effect of load carriage on stability and balance.
Contextual Equiry / Third party observations	Contextual Equiry is a technique involves an initial semi structured interview to understand the subjects tasks and then a period of observations where the experimenter watches and asks questions as the subject undertakes their work. Contextual Equiry can be used to gather requirements, identify issues, oportunities start a task analysis. (3rd Party observations is a variant of the contextual enquiry).
Embedded Task	This is often used to test task demand on working memory. The subject is asked to carry out a task and then complete an embedded task (similar to the primary / secondary task above). The more demanding the tasks the more they interfere with each other leading to poor performance.
NASA TLX (Task Load Index)	This technique is a subjective measure of cognitive workload and can be used to measure a task, system or team's effectiveness.
User Experience Questionaires	Generic term used to cover all questionnaires that measure user experience.
Objective Performance measures (errors over time)	Objective performance meaures can include, number of errors, time to complete task, number / quantity completed in set time.
Usability Questionnaires	There are a number of validated usability questionnaires including: System Usability Scale (SUS), Software Usability Measurement Inventory (SUMI)
Anthropometrics (including reach / distance / grip strength)	Is the measurement of the human. It is often refered to when determining the ergonmic design / requirements of a system / equipment

Table 3: Techniques for assessing HSI areas of importance, and their descriptions

A number of the techniques are preceded by numbering where the groups linked the technique to the data on the slide for which it was suggested. It should be noted that the list of techniques elicited do not cover all those available for a data item as the knowledge was elicited over a small period of time and relied on memory as none of the participants used reference material to explore what other techniques may be available.

The techniques and methods generated were ranked in terms of easy-of-use and comprehensiveness. Having done this initial sort, the workshop participants, as a whole, were asked to classify the data collection techniques based on the following criteria, which is presented in table 4[12]:

- Core Methods - Which of the techniques / methods identified would be core to a Human System Integration capability?
- Difficult - Which of the techniques / methods identified are difficult to implement?
- Easy - Which of the techniques / methods identified are easy to implement?
- Time Consuming - Which of the techniques / methods identified are time consuming to implement? (Indicated in the table with an asterisk.)

	Core	Non Core
Easy	Range of motion Embedded Tasks Decision making Obstacle course	Grip strength Usability Questionnaire (pre defined standard) Third Party observations Reach (distance) Objective performance metrics *errors over time Primary and secondary tasks NASA TLX
Difficult	*Task analysis *Anthropometrics *Encumbered Anthropometry Likert Scales (Questionnaires) *Sensors (Pressure / Temp)	Designing Surveys / questionnaires *EEG *Personas Method *Simulations *Physiology (HR, GSR) Eye Tracking *Goniometry *CAD Packages (3D Modelling)

Table 4: Rating of HSI Techniques by importance and ease of implementation.

2.4 Q4. What components are important to a successful HSI facility?

Hitherto, this report has considered the data, techniques and tools required for a HSI capability in the round. Attention is now focussed on the governance, skillset and infrastructure requirements of a facility that would provide those capabilities. Clearly, the choice of which components are required in a facility depend on the tasks which need to be completed. However, certain general principles were identified in the workshop, and are discussed below.

A successful HSI facility requires access to a range of skills and infrastructure, and must be governed in a strong but flexible fashion. Depending on the requirement, all these components might not

[12] The participants were asked to identify the core techniques; after the workshop the assumption has been made that all other techniques are non-core. The participants were also asked to identify those techniques that were particularly easy or difficult, meaning that not all the items will be found amongst the sum of the easy and difficult techniques.

need to be available or staffed full time, nor necessarily co-located. For the purposes of this work, governance, skill set and infrastructure sub-questions were posed as follows:

- Governance and execution: how should the facility be organised, run and funded?
- Skillset: what type of workforce /roles and skillset is required, and how should that workforce be recruited (post duration, etc)?
- Infrastructure: what physical and virtual facilities are required?

Governance: The level and style of governance necessary will be determined by the role fulfilled by the integration facility. A role covering the definition and maintenance of integration standards, for instance, provides and requires a different type of governance than one which solely conducts integration investigations determined by an external organisation. The following discussion considers how a HSI facility could be run and interactions it needs to establish and maintain.

The preferred business model for the facility is to some extent agnostic of precise tasking of the facility. It should be under the authority of a Steering Committee which would determine and hold the terms of reference for the facility and prioritise the work which it conducts. The facility should provide scrutiny of the work which it commissions, and subject its own output for appropriate independent scrutiny.

The Steering Committee will have the responsibility for endorsing the authority of the facility and mandating its use to industry and other providers as appropriate. This could include the development, maintenance and possibly even the enforcement of policies, standards and architectures pursuant to human systems integration.

On receipt of its tasking from the Steering Committee, the core team will need to determine the skillset (see table 6) and effort required to discharge its responsibilities, which includes liaison with the external actors noted below (table 5). It will also need to include the training of new personnel should any of the posts within the facility or on the Steering Committee be subject to rotation or short term appointment.

The funding model for the capability will be entirely dependent on local financial control regulations and financial strategy. Some nations will want to keep the majority, if not all, of the provision within government, while other nations would seek to push as much out to the private sector as possible, possibly only retaining control of the Steering Committee.

In a similar fashion to the running of the facility, the type and extent of external interactions is in part dependent on the nature of the work conducted. Broadly speaking though, interactions with the user community, the research supplier community, and the wider defence community are essential regardless of specific remit. These interactions should be maintained and managed by the facility, on behalf of the Steering Committee.

Defence Community	User Community	Research supplier community
Customer hierarchy	Troops / User	Industry
Procurement		Research institutes / academia
Other nations (Interoperability)		Other nations (Science and technology)
		Other UK Programmes

		(UK equipment interoperability)

Table 5: Facility stakeholders

Skillset: the multi-disciplinary nature of HSI demands an interconnected team at the core of any facility. The depth of specialism required depends on whether the capacity intends to commission, monitor, advise or conduct low level research. At the very least, the facility must be able to state the high level requirements for the work to be conducted, and to determine whether those requirements have been met by received work. Central to the facility is the requirement for strong scientific and engineering guidance. This, coupled with military user experience will ensure that the facility is rooted in firm principles.[13] As the facility is likely to have an important information storage and exploitation role, the role of information manager is key, as is that of an administrator to ensure that the facility is run efficiently and that its interactions with the wider community are managed appropriately. The amount of effort required by these roles will depend on the maturity of the initial setup and the extent to which the facility is being used.

Core skillset	Task dependent skillset	
Military user	Physiology	Nutrition
Scientist	Ergonomy	Cognitive pyschology
Engineer	Statistics	Sub system SME
Knowledge manager	Trials design	Behavioural science
Administrator	Trials conduct	Technicians
	Operational analysis	Designers
	Project management	CAD Modelling
	Industrial design	

Table 6: Core and task dependent skillset requirements.

The ‘Task dependent’ skillset requirement will be heavily dependent on the tasks that are conducted by the facility. If certain tasks, such as anthropometric measurement or combat effectiveness assessment, are routinely conducted physiology, trials design and conduct, and operational analysis become part of the core requirement. National differences will dictate the range and depth of work conducted within a HSI facility, and therefore other than the core skillset, no further categorisation of skills is possible.

A balance needs to be struck between short term appointments and secondments, ad hoc contracts, and permanent positions. Permanent staffing gives stability and continuity, which is especially important if the nature of the work is unlikely to be routine. Short term placements (two years or less) bring valuable fresh ideas and currency into the organisation, while ad hoc contracting makes specialist expertise available when required. Therefore, having the core skillset (possibly less the military user who would benefit from maintaining currency) on a permanent, but necessarily

[13] It is not suggested that military experience and scientific or engineering knowledge need to be provided by the same individual. Indeed, it is probably beneficial to have these roles separately delivered, although some appreciation of the other’s knowledge area is clearly advantageous.

fulltime, arrangement is beneficial, ideally with postings lasting at least three years and not simultaneously refreshed.

Infrastructure: the infrastructure requirements were relatively straightforward, consisting in the main of standard office based facilities, but with dedicated storage areas for trials and demonstration equipment, workshop and / or laboratory areas if the facility conducted its own research, and deployable office facilities should it conduct fieldwork. Regardless of role, data storage was seen as essential to provide easy access for documentation; the capacity required would increase markedly if the facility was required to store raw data from self or contractor run trials and experimentation for potential future analysis.

Easy access to current and historic equipment and configurations was seen as highly desirable since it would inform ongoing research and enhance general systems education. Permanent displays would enhance the corporate identity of the facility, which would be further enhanced and communicated by the use of deployable displays to units, conferences and customer sites.

The requirement for workshops and laboratories would clearly depend on the nature of the work and whether it was conducted 'in house' or contracted out. Work could be conducted using owned and managed facilities, in third party facilities by integration facility staff, or by third parties in their own facilities. In the most extreme case this would include provision of manufacturing workshops (eg tailoring, 3D printing, machining) and specialist laboratory space (eg climatic chamber, instrumented scanning studio).

Access to suitably representative training areas, which were reasonably accessible by both staff and trials troops, was essential, as was the deployable infrastructure necessary to support power and data hungry trials. The need for rapid and high capacity data transfer and storage, and battery recharging should not be overlooked.

The ability to conduct standardised, repeatable tests in a variety of locations was considered advantageous, especially by nations with more highly dispersed forces. The potential for sharing these equipment or data was also deemed beneficial.

2.5 Q5. What are the success criteria?

Ultimately, the success of a soldier system and its components can be gauged by the demonstration of capability benefit, user acceptance, and reputational success. By these metrics, an HSI facility can prove it is successfully delivering a service and providing a positive impact on Defence acquisition.

User Acceptance: The majority of HSI assessments focuses on, or at least considers, the level of user acceptance of the item or system under review. The subjects undertaking the assessments must be representative in demographic, experience and role, of the end user.

The level of acceptance by users is assessed in a number of ways, though the focus is typically on the acceptance of the equipment for its intended use in an environment/circumstance in which it is typically employed (which is rarely an air-conditioned laboratory). The item or system may still have specific limitations, but the assessment of acceptance is a balance between the capability provided and the physical cost of the provision. For example, night vision goggles are considered cumbersome and uncomfortable, but the capability advantage they offer the user is so large as to eclipse any criticism, generating a high acceptance level overall.

Beyond the formal evaluation of user acceptance (e.g. during a field trial), indirect means of determining acceptance come from a lack of complaints received after delivery of the new item or system. Problems with systems are often heard informally about before they are formally 'written up' as issues. A third means of user acceptance feedback is by knowing the participant has taken enthusiastic ownership of the item or system. This includes using the item due to its obvious benefits instead of only using it because the user is told to. Good indicators of taking ownership may be as small as re-naming the device, being an advocate of it to other user groups, or providing unsolicited feedback on ways to further improve the device's utility.

Deliver Capability Benefit: The extent to which an item or system provides a capability improvement to the end user group is a significant measure of the success of an acquisition program. The contribution of HSI to this success will vary, but may be critical to the decision to procure one product type over another. HSI input into a program that fields reliable equipment (i.e. does what it was intended for without failure) that is easy to use is a sign of a successful program.

- Mission success
- Resolution of known issues
- Re-usable facility

Reputational Success: A positive reputation for success held by a HSI facility helps add weight to any findings it delivers, helps it maintain a flow of 'customers', or even helps HSI to be formally included in the acquisition process chain.

HSI input into an acquisition process is most beneficial when it begins as the 'user needs' for the item or system are being considered. A measure of reputational success is when the project specifically requests involvement from the facility in the early stages of a study, rather than asking it just to endorse any outcomes towards the end of the study.

Independently generated reviews, comments or articles relating to the facility's work are possibly the most public indication of reputational success, especially if freely available, for instance referenced on the facility website. Positive press articles are a good indicator of reputational success. Positive experience of participants and Project Managers who have interacted with the facility.

2.6 Q6. What are the hurdles to success?

The hurdles to a successful HSI program or facility were discussed and captured during the workshop. They can generally be divided into two groups; poor governance and insufficient resourcing.

Poor governance: Although the definition of governance is far-reaching, in this context consideration is given of Governance as the development and management of process within a program or facility. Ineffective governance is where a process is not followed, to the detriment of the deliverable. Examples include unnecessary time delays in proceeding with the work, especially due to bureaucracy and administration overheads (anticipate this additional time and plan it into the timeline for the program). Similarly a failed trial, either due to poor planning or execution will result in unacceptable results, as well as the potential to bruise the Programme or Facility's reputation. This is an example of poor governance, not at the highest level (e.g. Facility Director) but at the level of the practitioner. Mitigation includes independent assessment of the trial plan, including logistics, and timing, not just data collection methods. Poor governance will also be manifest in wasted effort (repetition of work), naivety (enthusiasm damaging relationships), and poorly planned / executed trials, through lack of appropriate and timely review.

Insufficient / inappropriate resourcing: appropriate funding, scaled to the facility demand, is essential in maintaining output and hence reputation. Arguably, failure to deliver to previous high standards is as difficult to recover from as initial poor output. Regardless of how well planned and which business model is used, any facility will have set up or maintenance costs; clearly, these are going to be of a higher proportion overall 'turnover' in the early stages of the facility, or if it is underused. Maintaining a critical mass during these stages is key to ongoing and future success.

Should demand outstrip resources and funding available, attempts to conduct a cursory or light touch assessment should be resisted unless it can be demonstrated that it won't affect the fitness for purpose of the output. In particular, access to the appropriate expertise, both in terms of discipline and experience should be maintained. If necessary the Steering Committee should prioritise tasks for the facility, and champion the requirement for additional funds should it be considered that failure to meet particular demand would harm the provision of equipment to the user.

3. Discussion

The capability required to conduct investigations into human systems integration, and especially the facility to deliver that capability, requires careful specification, and will depend on national policies and constraints. However, certain characteristics can be considered common, regardless of any constraints. It terms of manning, it is clear that a core skillset of military user, physical scientist, and engineer are needed. Ideally, the personnel filling these roles should have a breadth of experience, and be able to contribute outside the narrow confines of their particular discipline. These personnel should be supported by an administrator and a knowledge manager, to ensure continuity of function as other staff members are rotated through the organisation. These core personnel should ideally be permanent posts, although some level of part time posting allowing the staff to maintain their currency within their discipline might be beneficial.

The other skillsets required will depend on nation priorities and constraints, and the amount of effort required will depend on the anticipated workload. Regardless of workload though, it is likely that the core function will require access to at least physiology, statistics, trials design and conduct, and operational analysis expertise. Depending on the volume of work, these skills could be taken into the core function and provided on a permanent basis. The business model through which the facility is provided will be subject to national constraints, although the flexibility of having the main skills and methods under immediate call off (and command) should not be underestimated. It is likely that this arrangement would ultimately, given suitable levels of work, prove to be more cost efficient and agile than any service provision contractual arrangement.

Teamwork, a common goal and 'branding' are essential to success. Wherever possible, the core members of the team should be co-located with other team members and facilities within easy travelling distance. Ideally, the main location should be at or near suitable training areas to facilitate trialling, at both the individual and collective levels. The facility should have a virtual presence, through a website and possibly other social media, so that the user and supplier communities can have easy access to the team. Further, this will provide the integration facility with a 'grass roots' understanding of perceptions and issues associated with the equipment. These feeds need to be monitored and responded to regularly to maintain credibility and currency.

A large number of techniques and methods have been identified, such that it is unlikely, unnecessary, and probably prohibitively expensive to actively maintain all of them. A primary requirement of the core engineer and scientist roles is to maintain a network of experts such that they can give appropriate advice and drawn on the relevant technique or discipline, should the need arise. The facility can fulfil the important role of guardian of definitive baseline reference data relating to current soldier systems and components, the performance of the soldier when thus equipped, representative test procedures and vignettes in which that performance can be assessed, and the standards to which future developments must adhere,. Furthermore it should curate knowledge of relevant research such that it is available for all legitimate users.

Finally, the development and use of standards, be they local, commercial (eg IEEE) or international (eg NATO) will ensure the dissemination of best practice and common approaches. This will facilitate collaboration on projects between nations and instil greater confidence in the use of data and findings from other nations, a factor of increasing importance as research budgets diminish.

4. Conclusion and Recommendation

It was clear that there is considerable interest in human systems integration development and assessment within the participating nations, and a genuine desire to share knowledge and experience. The workshop recognised that while it had identified the scale of the issue, and provided some outline guidance, it had by no means completed a full definition of nor established a procedure for running an HSI facility.

It was also clear that while the benefits of human systems integration are recognised, if not fully understood, it is a very wide, multi-disciplinary subject which any one individual nation is unlikely to cover in its entirety. A facility would have to be specifically tailored to meet the particular needs of the individual nation, and to fit within their prevailing financial and governance models. Regardless of national styles and constraints, a successfully facility was deemed to need strong governance and appropriate delegated authority. A multi-disciplinary approach is critical to success, and a single solution will not be applicable across all nations.

Since human systems integration, and human factors in general, is fundamental to the provision of dismounted capability, it is considered anomalous that there is no formal grouping with this responsibility in the Dismounted Soldier Systems Land Capability Group. Therefore it is recommended that a Human Systems Integration Team of Experts (HSI ToE) be established under the auspices of LCG DSS. This ToE should be charged with continuing to define best practice for HSI assessment, liaising with more specialised NATO fora as appropriate, sharing knowledge and information, and identifying opportunities for collaboration between nations.

Annex A: Workshop attendees and affiliations.

Attendee	Affliation	Nation
Dr Chris Brady	Defence Science Group	Australia
Dr Nick Stanbridge	Defence Science and Technology Laboratory, MoD	United Kingdom
Ben Leonard	Defence Science and Technology Laboratory, MoD	United Kingdom
Maj Alex Rabbitt	Capabiltiy Combat, Army Headquarters	United Kingdom
Mark Richter	Gruntworks, USMC	USA
Emma Moon	Integrated Soldier Systems Project, DND	Canada
Maj Magnus Halberg		Sweden
Maj Torstein Johnson	Norwegian Army Land Warfare Centre	Norway
Maurice van Beurden	TNO	Netherlands
Maj Z Hommersom	TNO	Netherlands
Maj Shelia Howell	PEO Solider, US Army	USA
Kristin McKenna	PEO Soldier, US Army	USA
Maj Jenny Gustafsson	Swedish Defence Materiel Administration	Sweden
Maj Soren Strunge	Danish Army	Denmark
		France
		Germany
		Hungary
		Belgium