HFI CMM Study
Definition of Competence Requirements for Assessors

HFI CMM Study - Work Package 4

March 2001

1 Summary

This note discusses the subject of competence in relation to a Capability Maturity Model for Human Factors Integration (HFI CMM). The maturity model in question has the working title of the Human-System Lifecycle (HSL) process model, using maturity assessments e.g. based on ISO 15504. An HFI CMM maturity assessment of a project has the working title of an HFI Process Risk Assessment (HFI PRA) (based on the work of Jokela at Oulu University). Assessments can range from formal large-scale exercises conducted as a Pre Contract Award Evaluation (PCAE) through to small informal activities for Process Improvement (PI). Required competence is defined, together with an outline process for staff development and accreditation. Two scenarios have been appended to start to provide case study material for competence development and assessment.

Document Details

Format - Internal Working Paper.
Author Brian Sherwood Jones,
V1c issued as draft 28 Feb 01 BSJ
Comments by J Earthy, 2001-03-10
Changes made by BSJ 11/3/01, and up-issued to V1d.
Discussion on competence requirements at LR 21/3/01
para. 5.2.7 added up-issued to v1e
Discussed at DERA CHS 26/4/01. Glossary added, generic introduction added. Scenarios added.
Last edit BSJ 30/4/01. Up-issued to Issue 1.

The document contains information supplied by Lloyd's Register of Shipping
under MOD/DERA Contract Number CU0050000001056
The relevant passages, which are identified as subject to DEFCON 90 and are made available to MOD with that right for use only.

2 The need for a statement on assessor competence

2.1.1 A statement on competence is required because it is recognised by almost all forms of process assessment that assessor competence is an essential element of a valid assessment. It may seem premature to discuss assessor competence when there is, as yet, no formal requirement for a statement of competence for HFI practitioners, or for many other key roles in MoD projects. This is recognised as being anomalous, but accepted, because without some form of statement on assessor competence, HFI Process Risk Assessment (HFI PRA) could get off to a bad start, or indeed be discredited on these grounds. It is also recognised that statements on competence are likely to become much more widespread in the future. Although this note has been written in the context of the UK Ministry of Defence (MoD), it is hoped that it may contribute to the current discussions on HF competence (e.g. within the Ergonomics Society), and may contribute to filling the current shortfall in the professionalisation of human aspects of safety. It is also hoped that the note may supplement consideration of the draft Human-System Lifecycle (HSL) model by ISO TC159.

2.1.2 A statement on competence is also required because an HFI PRA has consequences. AN HFI PRA conducted as a Pre Contract Award Evaluation (PCAE) has major financial consequences for tendering companies (and for the client). Where an HFI PRA is being undertaken for a PCAE involving the expenditure of public funds, then there is a clear obligation (by extrapolation of requirements in SEI CMM and ISO 15504) for assessor competence to be formally considered. Apart from the case based on professionalism, there is the need here to make the assessment lawyer-proof. The losing companies may not just appeal the finding, they may sue, and it is necessary to demonstrate that the decision to spend public funds with a different company meets criteria for probity, accountability etc. Assessor competence considers training and competence for the assessment team as a whole, and for the Lead Assessor in particular.

2.1.3 HFI PRA may well be done in the context of a system where human error is significant and is likely to form part of the relevant safety case. It would require SQEP (Suitably Qualified and Experienced Personnel) assessors as well as validated procedures.

2.1.4 Even an in-house Process Improvement (PI) programme has associated costs, and significant lost opportunity costs if conducted inappropriately.

2.1.5 It is particularly important to have a statement of competence in the field of HF and HFI because of the multiplicity of informal career paths and lack of a single recognised form of certification or accreditation of individuals or organisations. The consequence of this diversity of personnel is that the interim arrangements proposed here may remain in place indefinitely. Whilst the general requirements for competence can be identified, it is recognised that flexibility in the way that the requirements are met will be required in any proposed competence scheme.

2.1.6 Whilst this note refers to the generic requirements of a competence scheme (recognising the International approach being adopted in the HFI CMM study), the focus in this note is strongly on the needs of the UK MoD.

2.1.7 [As an aside, the importance of competence in system development is becoming more widely recognised. Given the huge potential leverage of good HFI in improving Value For Money, this may well be worth further investigation on a more general basis. There are now on-line software programmer productivity tools that are becoming widely used.

"Good tools typically increase productivity by 25%-35% and good processes can increase productivity by 50%-100%; but the best people are typically 10-20 times more productive than the average, and as much as 100-200 times better than the worst." Analysis from "The Yourdon Analysis," August 1995, Edward Yourdon, Compuserve: 71520,2322, Yourdon@acm.org .]

2.2 Structure of this note

2.2.1 This note:

- Identifies the requirements for a scheme to produce statements of assessor competence, and describes the types of scheme in operation.
- Identifies the various roles for which a competence statement might be required and indicates how this might be approached.
- Discusses the possible control over quality, and the business case.
- Examines the knowledge and skill requirements for assessors.
- Sets out a proposed scheme.
- Identifies proposed competences and training for assessors.

2.2.2 An annex presents a review of selected competence schemes and training courses that have formed the background to the proposed scheme.

3 Assessment and competence scheme requirements

3.1 Background

3.1.1 To make a supportable statement about professional competence, it is necessary to have some clear criteria for what this constitutes. There are a number of levels of formality with which a statement of competence can be made. At the most informal level, a candidate assessor could provide a CV to the client. This offers no protection to anybody and would be open to abuse. The next step in formality is for the client to review the candidate assessor against an externally defined set of criteria. This is the basis on which ISO 15504 is written, and presumes that the client is sufficiently well informed to conduct such a review. For any more formal arrangements than this, an external body is required to make a statement of assessor competence. In the limiting case, it would be necessary for this external body to have some form of accreditation itself.

3.2 Existing scheme structures

3.2.1 There are a number of existing schemes that provide assessor competence statements of one form or another. Perhaps the major split between them is whether the scheme is based in the public domain, or is a proprietary scheme.

3.2.2 In the public domain scheme for ISO 15504, the criteria for certification of assessors is left to the client or the management of the assessing organisation, although a framework is provided. The assessment of competence is restricted to the assessor, and does not extend to the accreditation of assessing organisations, instructor training, etc. Historically, many of the people working with ISO 15504 to date will have been involved with a proprietary scheme such as the Software Engineering Institute's Capability Maturity Model (for software) (SEI CMM) or BOOTSTRAP and will have

obtained formal training. How software or system competence assessment will evolve is unclear, particularly as regards the convergence of SEI CMM, ISO 12207 ISO 15288 and ISO 15504.

3.2.3 SEI set the criteria for a Lead Assessor, which includes attendance at their training. For a CMM project assessment to receive certification from SEI, it must use a qualified Lead Assessor. However, it is not essential that a) the training provider is the same body as that approving assessors or b) the body approving assessors is that approving project assessments.

3.2.4 In a full scheme for certification, there is a need for certification bodies with accreditation in accordance with the EN45011/ISO Guide 65.

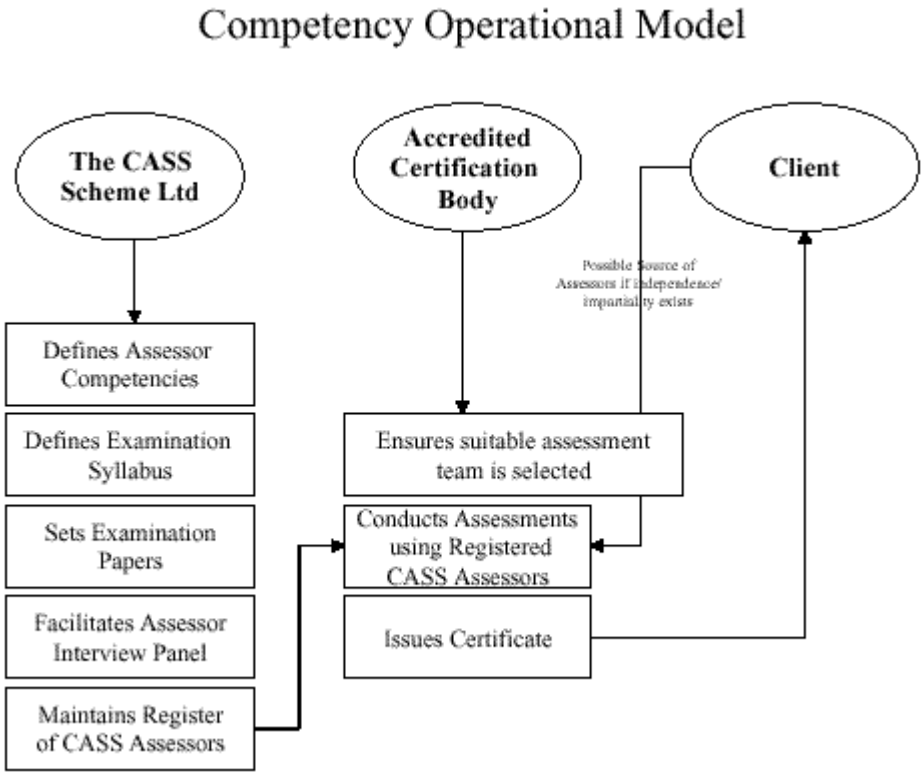


Figure 1: The role of assessor competence statements in system assessment - the CASS Scheme

3.2.5 The role of a certification body in a proprietary scheme (CASS) is shown in Figure 1. The scheme has been designed to meet the assessment requirements of IEC 61508 *Functional safety assessment*, with all the implications of safety-critical system assessment. (So far as the author can ascertain, IEC 61508 itself makes no statements about competence, but it is fairly clear that competence for design, assessment and operation needs to be considered - on liability grounds alone).

3.2.6 Where an HFI PRA is being undertaken as part of a safety case, then there is a need to establish assessor competence to meet the needs of the Design Authority, the Regulator and the Independent Safety Authority. It is likely that an accredited certification body will be involved (albeit indirectly), and that they may set generic criteria to be met. (It is also possible that the HFI manager will need to be able to demonstrate competence in safety-related aspects of HFI and be able to meet SQEP criteria).

3.2.7 Where an HFI PRA is being undertaken as part of in-house Process Improvement (PI), then demonstrable assessor competence is prudent a) for the expenditure of company

resources and b) to ensure that when an external assessment is sought or required, the necessary elements are in place.

3.3 Roles to consider

3.3.1 There are a number of roles to consider as regards competence and training. The key features of each of these roles are summarised in this section.

3.3.2 Lead Assessor: The Lead Assessor is the principal interest as regards competence. A statement of competence will be required. The requirements are discussed below.

3.3.3 External assessor: Members of the assessment team brought in from outside the project will require evidence of training in assessment, some familiarity with the project subject matter, and some familiarity with the HSL model. Given a suitable mix of people in the team (discussed at 5.3 below), it is likely that most training could be given as Pre Joining Training rather than anything more substantial. The most likely shortfall would be a short HFI course introducing the content of the HSL model. The major concerns are going to be bringing in in-depth expertise in HFI, or in assessment. Where specialists are brought in for these purposes, then the shortfall in the knowledge of the specialist is likely to be in the area of project application. This can be made up by other members of the team and familiarisation in the work up to the assessment.

3.3.4 Internal assessor: Members of the project team co-opted for the assessment will be in much the same position as external assessors.

3.3.5 PI champion: Where a Process Improvement (PI) programme is being put in place, the PI champion will need to have had training in a) PI and b) the HSL model. It is a reasonable assumption that a project PI champion role would be taken by an existing HFI person.

3.3.6 Host project sponsor: The project will need a briefing on the assessment process, and how it is to be directed to reach a valid and useful conclusion. There is no requirement for any competence assessment in this context. Given the emphasis on training IPT leaders and other key members of the project, some acquaintance with process assessment in general would be appropriate as part of their career training.

3.3.7 Assessee: The organisations need to be briefed as to what to expect. No formal competence is required, but knowledge of the application area and project procedures is expected, i.e. people new to the project may not be the best assessees.

3.3.8 Instructor: Training courses in HFI, the HSL model, assessment and team facilitation will need to receive some level of scrutiny as part of the competence assessment. Instructor credentials would form part of the material scrutinised.

3.4 General assessor competence requirements

3.4.1 The frameworks reviewed identify three areas for consideration of assessor competence; subject matter knowledge and experience, personal qualities, and assessment knowledge and experience. The approach taken is generally to place the onus on a Lead Assessor to have considerable competence in all three, with greatly reduced requirements for other members of the assessment team.

3.4.2 ISO 15504 recognises the distinction between the personal qualities required for Process Improvement and those required for assessment.

3.4.3 Most schemes seek a degree in a relevant subject and considerable subject matter experience. Some schemes provide case by case assessment of candidates without a relevant degree or professional qualification. The clearest scheme in terms of professional experience is ISO 15504, which seeks a log of experience by process. Some schemes seek personal qualities principally as regards probity, and obtain references. The ISO 15504 scheme sets out the specific attributes that are considered to apply, and obtains ratings against them. All schemes examined require some previous assessment experience and have some form of provisional qualification for Lead Assessors. The proprietary schemes examined require formal training and examination by the scheme administrator. (The importance of this revenue scheme to the administrator should be noted).

3.4.4 In terms of the competence requirements for other members of an assessment team, this seems to be generally left to the Lead Assessor. Legacy Marconi Electronic Systems insisted on formal training (at Dunchurch) for all CMM assessment team members, event though this is not required by SEI. The team training scheme run by new DERA SEC is probably one of the more advanced schemes. Team training starts with a team dynamics day and also includes 3 days on the model and 3 days on assessment, and 4 days working as a team developing the assessment material and timetable.

3.4.5 A factor that needs to be considered in the development of a competence framework is the diversity of HFI subject matter, when compared to software engineering or most forms of engineering. It will almost certainly be necessary to provide some matching of background to type of assessment.

3.5 Control over quality

3.5.1 An informal approach is not viable for PCAE, and some clear evidence of control over assessor quality is required.

3.5.2 It is proposed that for internal Process Improvement (PI) activity using the HSL model, a structure similar to that of ISO 15504 would be appropriate. However, for assessments with safety implications and for PCAE or similar assessments, competence statements should be made by an external body. This would apply to the Lead Assessor and to the assessment team as a whole.

3.5.3 As noted in Annex A, the state of professional accreditation relevant to HFI CMM is still at an early stage, but changing. Developments in more general professional accreditation may simplify matters considerably.

3.6 Business factors

3.6.1 Training, and assessor examination, form an important revenue stream for the developers and maintainers of proprietary schemes. A scheme costs a considerable amount to maintain to a proper standard, and while some money can be made from publications, this is at risk from piracy, so some form of finance from training becomes a necessary form of income. SEI CMM training becomes very expensive if taken all the way to Lead Assessor. ISO makes its money from publications rather than training, but it is surprising that there is no reference in ISO 15504 to accreditation to EN45011/ISO Guide 65 as an anchor point.

3.6.2 Any form of proprietary accreditation that depends on expensive training raises accusations of a closed shop. Schemes that use external accreditation to

EN45011/ISO would claim that this avoids vested interests. Given the importance of training revenue to proprietary schemes such as SEI CMM, the business aspects cannot be ignored. This is particularly true in a small discipline such as HFI. Whilst training from proprietary schemes or other commercial sources can be considered for the proposed scheme, a closed proprietary scheme - or any scheme that depends on a single commercial source - is unlikely to be considered for determining or assessing the disbursement of public funds.

3.6.3 The number of recognised CMM Lead Assessors is still small, even given the figure of 500, 000 people involved in some way with software CMM, and about 350 companies with recognised SEI CMM levels. Setting up a sophisticated infrastructure for the much smaller numbers likely to be involved in HFI needs to be considered carefully from a business angle to ensure the viability of any scheme proposed.

3.6.4 The implementation strategy of the HFI CMM study established that UK Defence Industry would not initiate activity, but would only respond to MOD initiatives. In this situation the initial costs would accrue to MOD projects or customer friend roles, developing an assessment capability that would act as an incentive (or threat) to industry. Once established, then the number of people involved in competence accreditation and training would increase significantly.

4 Assessor knowledge and skill requirements

4.1.1 This section concentrates on the knowledge and skill requirements of the Lead Assessor, but also identifies requirements for other assessors. Lloyd's Register work on the SPICE (ISO 15504) trials led to the conclusion that more junior staff may work as assessors as part of career development, provided that the leader and supporting materials (checklists and procedures) are strong.

4.2 HFI knowledge and experience required

4.2.1 HFI domains and HSL Processes

4.2.2 The scope of HFI domains is very wide. Within the Ergonomics community there has been discussion as to whether it is possible to give professional accreditation across the whole breadth of the subject, or whether claims should necessarily be circumscribed. For the purposes of assessment, it is proposed that the breadth of experience required should be judged on a case by case basis. It is proposed that the HFI domains are re-aggregated somewhat to define areas of experience, and that the experience required for a specific assessment can be classified into levels. The experience to be considered is practitioner experience rather than teaching. Research experience would need to be judged on a case by case basis. There will be instances when research (say on a Technology Demonstrator) is directly applicable. However, a Lead Assessor will need ten years experience as a practitioner on practical projects. For the (possibly indefinite) transitional period envisaged, it is proposed that the Lead Assessor requirements are expressed in terms of Figure 2 below, and that other experience in the team is also plotted on the figure to fill in shortfalls.

4.2.3 The Lead Assessor should have a professional qualification related to HFI. Given the diversity of career paths associated with HFI, and the likely continuation of this, it is proposed that at least one member of the assessment team should have such a qualification. It is also proposed that the Lead Assessor should have sufficient relevant

experience in terms of Figure 2 to enable the assessment to be conducted in a professional manner. Note that DERA SCE (with dual-qualified Lead Assessors) software and system assessments review the total and average experience for the team, and would expect to find 25 - 30 years collective experience in the team.

HFI Domain	Interpreted domains for defining HFI experience.	Experience required and available			
		Expert (10 yrs +)	Experienced (5 yrs +)	Familiarity (< 5 yrs or professional training)	No experience
Manpower, Personnel, Training (MPT)	Training Needs Analysis (TNA) experience (accreditation)				
	System interaction with MPT constraints				
	Organisational Development, Change Management (the HSL Human Resources process)				
Human Factors Engineering	Physical aspects				
	Cognitive aspects, HCI				
System Safety	Fault Tree Analysis etc, HRA etc.				
Health Hazards	Occupational Health etc.				

Figure 2: HFI experience requirements for Lead Assessor and assessment team.

4.2.4 Subject matter knowledge and experience required

4.2.5 Subject matter addresses the type of system being procured, the context of use, the user requirements. It may well not be possible to have all of these in the same person. Knowledge of the context of use mandates that some relevant real user experience exists within the team, i.e. a recent or current operator is included in the assessment team. However, there will be many instances when a current user will be unfamiliar with the type of system being procured (e.g. a software system with extensive digitisation) and the usability issues associated with it, and such knowledge will need to be provided by someone else. The Lead Assessor needs some familiarity with all the areas of subject matter, to the point where (s)he can ask appropriate questions to elicit detailed knowledge from within the team.

4.2.6 Commercial and project knowledge required

4.2.7 It is necessary for the Lead Assessor to be able to translate between commercial, contractual project decisions and technical issues. It is considered that such experience of major projects is necessary in the Lead Assessor (rather than within the team) because it will drive the focus of the assessment.

4.2.8 Skills required

4.2.9 This section is a very preliminary attempt to identify the skills required by a Lead Assessor at each stage of a large-scale full assessment. It may well be the case that

much more detailed analysis has been done in the context of software process assessment (the very extensive SEI CMM training material appears to reflect such an analysis), but it has not been found by the author.

4.2.10 **Obtaining agreement to conduct an assessment** on the basis of a reasoned proposal; consultancy skills, experience in planning and budgeting, credibility in HFI.

4.2.11 **Tailoring the assessment** to match the purpose (e.g. risk assessment PCAE); subject matter knowledge of similar systems and projects, and how risks occur and are mitigated, detailed understanding of HSL model, and elements of other models that might be brought to bear (e.g. elements of ISO 15288), understanding of time and effort involved (e.g. numbers of people to be interviewed, evidence to be sought, numbers of processes to be assessed), understanding of how assessment findings will be used and therefore the nature of information required (e.g. is it the intention to examine only discriminators between suppliers, or to assess the likely level of risk, including common risks).

4.2.12 **Selecting and building an assessment team**; understanding of competence issues (individual and collective) as applied to the specific situation, understanding of team working criteria and team building methods. (DERA SCE use the Tom Kayser approach).

4.2.13 **Running the team** to plan the assessment in detail; management experience and team building expertise, detailed knowledge of how to conduct process assessment.

4.2.14 **Liasing with assessee organisations**; interpersonal skills with senior management, planning skills for overseeing domestic arrangements. Arranging/giving training and briefing to the assessee organisation. Resolving differences in terminology between process assessment (model, process and scales) and the assessed projects/organisation (technology, methodology, sector, culture and language).

4.2.15 **Running the assessment**; experience in evidence gathering and interpretation using the HSL model, technical (HFI and system application) experience to support data gathering (e.g. follow-up questions) and interpretation (against the model), physical stamina, team management skills, experience in spotting team and schedule problems early.

4.2.16 **Presenting the findings to the assessee**; presentation skills, probity, full understanding of the HSL model and the assessment process.

4.2.17 **Interpreting the findings** with the sponsor; experience of major procurement decision-making, probity, HF and system application experience to interpret risk assessment and mitigation.

4.2.18 **Monitoring Process Improvement** programme; project management experience, understanding of specific risk mitigation required and of connections between activities and outcomes.

5 Proposed scheme

5.1 Scheme Structure

5.1.1 This section outlines the structure and staffing of the proposed scheme.

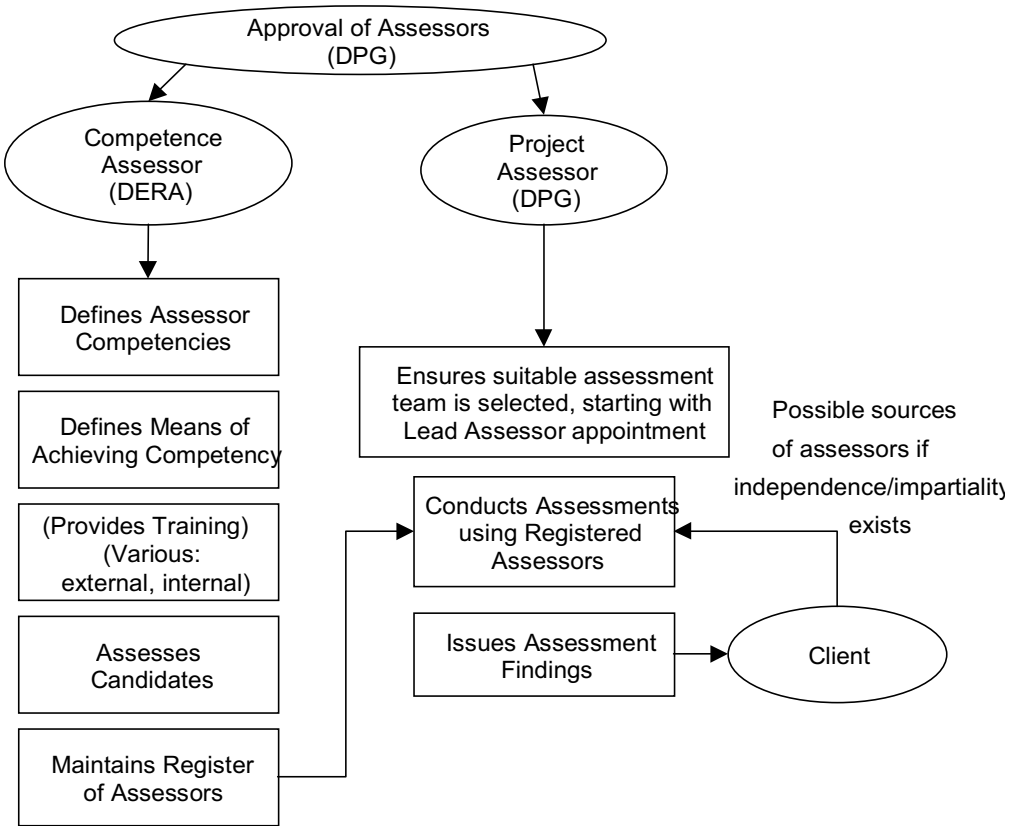


Figure 3 Proposed Scheme Structure

5.1.2 For the MoD, the obvious approach is to build on what exists. Thus, ownership of the assessment process would reside with the Defence Procurement Group (DPG). This group could take on the role of a scheme operator (cf. CASS Scheme Ltd

can be achieved by relatively simple means such as a) SEC personnel attending a course on HFI and b) HFI practitioners being part of an assessment team.

5.1.4 Sources of development and training

5.1.5 The main form of training not in existence already is a short course on HFI based around the HSL model. Possible candidates have been reviewed in Annex A. The most promising starting point is the DERA SEC System Engineering course material; an understanding of System Engineering is a pre-requisite to understanding HFI, and the course already includes some material on HFI. It would be quite possible to build a suitable HFI course, teaching HFI based around the HSL model in the right system engineering context from this baseline.

5.1.6 Training in assessment is available from a number of sources, based on CMM or ISO 15504. DERA SEC are well-placed to provide such training for MoD, but external providers are likely to have some form of accreditation. Training material in Process Improvement and informal self-assessment is likely to increase considerably following the publication of ISO 9000:2000, which introduces Continuous Improvement to a wide community.

5.1.7 Team training and facilitation skill development courses are widely available. Some training or professional experience in this sort of role is required for the Lead Assessor. Where the Lead Assessor is not the principal holder of assessment expertise, then it is necessary for the person bringing that expertise to also have some facilitation expertise.

5.2 Likely scale of training and competence development

5.2.1 A rudimentary projection of training throughput for a short HSL-based HFI course is as follows:

5.2.2 147 HFI foci changing once every 3 years, with 1 in 2 getting training leads to 24 places a year - presumably currently taken up by the SEA/DNV or Shrivenham short courses, or courses such as the Ergonomics course at the Robens Institute. The assumption here is that the proposal above would replace most of these courses.

5.2.3 147 IPT's each make a major procurement decision every 5 years. 1 in 5 have big HFI risks, and of these 1 in 10 do an HFI Capability Evaluation. This gives an assessment every 7 months. Say 2 non-HFI people on the assessment team need a short course; say 12 places a year.

5.2.4 Say 147 ongoing streams of HFI with an HFI focus; 1 in 5 considered risky. Say one in 5 of these does an internal Process Risk Assessment and puts a proper PI activity in place. Each PI programme requires 3 people to get a bit of training. 17 places, say spread over 5 years, gives 4 places a year.

5.2.5 This gives a total of 40 places a year. This excludes training related to practitioners working on the projects themselves. If we ignore the HFI specialists, and consider the ex-operator/ ex-control engineer/ ex-programmer who moves into HFI (to the discipline's benefit). It is hard to make an estimate of the numbers involved, but it ought to bring the total places per year up to say 80-100.

5.2.6 The medium-term hope is that the International approach adopted, the compatibility of the HSL model with ISO 12207 and (hopefully) ISO 15288, there will be sufficient interest outwith the MoD to make short courses viable.

5.2.7 The training objectives for the short course are as follows. The short course would enable the attendee:

- To initiate a quick self-assessment using HFI PRA resources.
- To identify HFI risks, using HFI PRA process risk resources, DPA risk management resources and EHFA resources.
- To develop a risk-based HFIP using the HSL model and the HFI Guides.
- To recognise when expert help is required for any of the above.

5.3 Nature of assessor competence statement and form of accreditation

5.3.1 At a team level, it is proposed that collective competence is reviewed by the Lead Assessor, with visibility given to DPG, using the structure in Figure 4. Collectively, in-depth expertise is desirable for all headings, and some experience is required for all headings. Collective experience of HFI, the type of system, and the user role should total 25 years. The Lead Assessor has the responsibility to say whether the team structure will work, or whether additional (or different) people need to be brought in.

Competence required	Level of collective competence available		
	In-depth (>10 yrs)	Some experience (> 5 yrs)	Limited or no experience (< 5 yrs)
HSL Model, or related model assessment			
HFI (summarising Figure 2)			
Process assessment experience			
User experience (e.g. context of use)			
Project, commercial framework			
Type of system			
Team facilitation			

Figure 4: Collective competence assessment

5.3.2 Individual competence records would contain the information from Figures 2 and 4 as applicable to the individual, together with a CV and training record. Assessment experience under the scheme would also be logged.

5.4 Continuing development, monitoring, surveillance

5.4.1 There would need to be intermittent reviews held to assess the extent to which the scheme was working. This is probably best done by a small exercise using people closely associated with the scheme, an audit or assessment professional body and people with experience of professional accreditation in a different context (e.g. The Ergonomics Society Professional Affairs Board, or other such body).

6 Annex A Relevant competence frameworks

6.1.1 This annex identifies possible contributions from existing (or emerging) frameworks. Assessment and logging of competence, together with maintenance and review of training records, is undertaken as a personnel function in many organisations and can appear as an element in an ISO 9000 Quality System. Such a scheme would be a suitable resource to carry out much of the mechanics of the material discussed here, but would not be in a position to set out the criteria. The safety community has perhaps given the most thought to competence, and has been drawn on as background.

6.2 Programme and Policy Evaluation

6.2.1 As yet, there is no such person as a professional evaluator. Evaluation (of say Value For Money, or programme effectiveness) is conducted by specialists in the subject area. This may continue to be the case indefinitely. However, the various evaluation societies around the world are considering whether such a person might - or should - exist. A recent paper (Maynard, R.A. (2001) 'Whether a Sociologist, Economist, Psychologist or Simply a Skilled Evaluator' Evaluation Vol. 6(4): 471-480.) identified a plausible set of requirements for an effective evaluator. These are:

- Familiarity with the policy issues and the relevant political, social and economic contexts.
- Understanding of the information needs to guide effective policy making and/or operational decision making.
- Skill in translating information needs into researchable questions and appropriate evaluation methodologies.
- Strong evaluation design skills, including the ability to define the range of policy options to be evaluated, specify the relevant target population and interventions or policy options to be examined.
- Determine the procedures for enrolling sample members and allocating them to treatments; and define the data needs and sources to carry out the evaluation.
- Commitment and ability to implement strong evaluation designs.
- Follow through on conducting analysis, including performing the statistical analysis and supporting qualitative research.
- Skill in communicating evaluation findings to programme staff, policy partners and sponsors.

6.2.2 She points out that graduates are only taught a sub-set of the necessary abilities, and that the current pool of evaluation expertise was developed under circumstances very different to those now prevailing.

6.2.3 Whilst there are many differences between programme or policy evaluation and capability evaluation, there are also many aspects in common. The extensive use of a task-based approach (such as one would do in a Training Needs Analysis) in the list above is also worth noting.

6.3 SCE (CMM & SPICE, SCOPE)

6.3.1 One of the objectives of the HFI CMM study was to provide compatibility with existing Software Capability Evaluation frameworks. The existing training schemes for

assessors, such as the ESSI and Compita courses, therefore provide the appropriate training in assessment. In the case of ISO 15504, should a course be run to meet the requirements of a provisional competent assessor, it may well be possible to negotiate agreement as to the subject matter qualifications, since ISO 18529 is recognised as being compliant with the standard. Bootstrap courses (Bootstrap Institute, Oulu University) may also be suitable training for "naked model" assessments)

6.3.2 In the case of SEI CMM, it may be more difficult to obtain a waiver to the subject matter experience requirements (although the SEI view on this has not been obtained). Even though much of the SEI training material could be abstracted from the subject matter, all the supporting examples and case studies are related to software process maturity, and really could only be used by an HFI person who also had had close involvement with software development.

6.3.3 Capability Maturity Model (CBA)-Based Appraisal Lead Assessor Training for the SEI CMM is geared toward participants who have assessment experience and wish to become authorised Lead Assessors in the SEI Appraiser Program. The course focuses on the SW-CMM®-Based Appraisal for Internal Process Improvement (CBA IPI) and prepares participants to become leaders in appraisal technology within the software community. CBA IPI is an SEI method for conducting software assessments. The method contains understandable, efficient, and effective rules for collecting information, assessing the reliability of the information, making judgments about the current state of the process, and reporting the results.

6.3.4 The course teaches individuals how to appraise software processes based on the Capability Maturity Model for Software v1.1. Participants learn how to:

- Build and train teams for each activity in the CBA IPI assessment method.
- Lead teams in the execution of the method.
- analyse and present findings from the assessment.
- Identify an organisation's strengths and weaknesses in order to build an improvement program action plan.

6.3.5 After completing the course, being observed by a current Lead Assessor, and receiving a satisfactory recommendation, participants may:

- Become Lead Assessors authorised to implement the CMM-Based Appraisal for Internal Process Improvement (CBA IPI).
- Perform assessment services for their own organisations or other organisations.
- Teach CBA IPI Team Training to their assessment teams, using SEI materials.

6.3.6 CBA Lead Assessor Training is a five-day course. Participants must meet the following prerequisites:

6.3.7 Verified participation as an assessment team member in at least two CBA IPIs within two years prior to applying to the program (SEI verifies from the Process Appraisal Information System (PAIS)).

- A minimum ten years of software engineering experience in software development or maintenance in an appropriate technical area, e.g., software design, software quality assurance, requirements analysis, configuration management, and testing.
- A minimum two years of experience managing software development personnel.
- An advanced degree or equivalent experience in an appropriate technical area.

- Successful completion of the SEI course Introduction to the CMM.

6.3.8 It should be noted that the SCOPE project (concerned with software acquisition in local authorities) was proposing to provide a half-day workshop as assessment training to support their tool and model. It is presumed that the audience has a large element of pre-selection e.g. the use of experienced ISO 9000 assessors.

6.4 BCS CPD, BCS SCS

6.4.1 The BCS runs the PDS, a CPD scheme, in a manner similar to other professional bodies. The only Human Factors module in the PDS relates to usability evaluation. Despite the importance of preventing and mitigating against human error, the Safety Critical Systems competence scheme (and training course) treats human error expertise as optional, so there does not appear to be any relevant material to be used or adapted. Furthermore, it means that human error aspects of software-intensive systems will need to be addressed by Human Factors people with minimal support from the system developers.

6.4.2 Given the number of potential HCD assessors (and indeed HSL assessors) who are in the BCS HCI community, the situation is unfortunate, and there appears to be little prospect of support to professional accreditation. It is to be hoped that the HCD model (ISO 13407, ISO 18529) will gain sufficient presence to change the situation.

6.5 Safety competence (CASS, SSMO, IEE, SQEP in general)

6.5.1 The increasing interest in defining competence requirements for safety professionals offers support to the development of competence schemes in related areas. The IEE competency guidelines for safety-related system practitioners has over 140 specific competencies arranged under 12 safety functions. One of the functions is called 'Human Factors Safety Engineering'. This has not been examined further, but may offer an important reference point for assessor competence in safety-related systems.

6.5.2 The MOD Ship Safety Management Office runs courses that are required for safety professionals concerned with ship safety, but this is not relevant to HSL training.

6.5.3 The requirements for CASS assessors do not appear to include any specific HF material, but the (still evolving) scheme is representative of a proprietary scheme, and the general approach has been considered in the proposals below.

6.5.4 To be registered as a CASS Assessor, an individual must have:

- Attended the CASS Assessor Training Course
- Passed the CASS Assessor Examination
- Passed the CASS Assessor Interview

6.5.5 The examination and interview addresses the following requirements which each applicant shall be required to demonstrate:

- An Understanding of the principles of IEC 61508
- Demonstrable evidence of implementation of relevant phases of IEC 61508
- A thorough understanding of the CASS technical schedules and how they should be applied

6.5.6 There will be one grade of CASS Assessor. The scope of registration of the CASS assessor will be defined by their:

- Competence in IEC 61508
- Experience of the CASS Scheme and supporting technical schedules
- Experience of IEC 61508 lifecycle phases
- Appropriate SIL level
- Industry sector experience e.g. railways, process industry etc.

6.5.7 Non-mandatory supplementary information may include:

- Evidence of audit management capability
- Registration as assessor for other schemes, and grade if applicable

6.5.8 The CASS Scheme Ltd will recognise and endorse appropriate commercially available training courses and shall define the course syllabus.

6.5.9 The HSE competency study formed a starting point for competency definition in the CASS scheme. It stated that assessment personnel competence assessment criteria should include:

- personal attitude;
- maturity;
- integrity;
- the ability to communicate;
- technical knowledge;
- product knowledge;
- application knowledge;
- openness;
- work to professional standards;
- possess professional recognition;
- appropriate experience;
- be capable of attention to detail and inquisitiveness;
- the level of awareness of the safety environment;
- knowledge of one's own limitations;
- the SIL level or safety criticality of the plant;
- and include the ability to operate reliably under stress and under adverse technical and managerial situations.

6.5.10 Competence criteria should include management competence and technical competence; the degree to which each skill is required will depend on the team composition and size and the task type.

6.6 Ergonomics Society, Eur Ergs, BCHF, BPS

6.6.1 The US BCHF certification scheme is of interest as it asked for evidence of competence by type of activity (analysis, design, test and evaluation) rather than a subject matter breakdown. [Historical note: the author took these headings and added management to provide the framework for the Total System Maturity Index - one of the inputs to ISO TR 18529]. Other schemes are concerned with subject matter and evidence of time spent in the profession, together with training. Clearly a person with FErgs or EurErgs is going to be knowledgeable about much relevant subject matter, but there is no guarantee that they will have practical experience of the processes being assessed, or

of the type of system being developed. A way ahead in the longer term might be to include some equivalents to the ISO 15504 elements in the Ergonomics Society CPD log book. The author has contacted the organisers of the proposed log book to this end.

6.6.2 The BPS runs schemes through to Charter status and beyond. However, the Engineering Psychology Branch is relatively new, and has yet to establish a clear identity (in contrast to the Occupational Branch). Should the Engineering Psychology initiative succeed, then this could offer a route to establishing assessor competence. At the time of writing, the boundaries between the HSL model and the Human Resources process have yet to be set; should an inclusive approach be adopted, then the BPS offers the potential (in time) for professional accreditation capability across the whole model.

6.7 EUSC

6.7.1 The Usability Support Provider Accreditation Scheme provides criteria for assessing whether a usability support provider possesses core competencies in: usability consultancy, planning user centred design, and evaluation and testing, and optional competencies in requirements engineering, product design support, training and technology transfer. Organisations wishing to be accredited are either visited by an auditor, or provide an auditor with examples of their work which demonstrate their competency. The scheme is described in the following document. Proposed Usability Engineering Assurance Scheme (INUSE Deliverable D5.2.3), by N. Bevan, N. Claridge, J. Earthy and J. Kirakowski (1998).

6.7.2 The investigation into competence by the INUSE project was focused on organisational competence rather than individual competence. This may be of value at some point in assessing organisations as certification bodies. However, there are elements in the USP scheme that could be mapped directly onto the core competences required for an assessor. The elements include competence in processes that are of the same type as those in the HSL model (cf. ISO 15504 process requirements), and consultancy skills (which *may* be part of the personal qualities required).

6.8 Training in HFI

6.8.1 It is assumed that for an HSL Lead Assessor with HFI background, several years of appropriate HFI-related work, qualifications etc. would be required, whether or not this competence is recorded in a process framework. There is also the need for non-HFI specialists on an assessment team to have a recognised understanding of HFI. In the case of systems with a safety concern (and this must be a large proportion of MOD systems), this will need to include those aspects of HFI related to health hazards and system safety (at least to the point where they are able to ascertain whether the right processes are in place). Thus some form of appropriate short course in HFI is likely to be required.

6.8.2 The state of HFI training is still immature. There is a 2-day course in HFI run for MOD by SEA and DNV. This operates almost entirely at the level of *techniques* (see Figure 5), and gives very little attention to the integration aspects of HFI. Although aimed at the DPA HFI focus, it does not address his/her task as set out in the Guides. The guidance on techniques such as Human Reliability Analysis may be useful, but are of limited value in developing competence for non-HFI specialists in an HSL assessment. The short course offered by Shrivenham is of similar limited value to the conduct and management of HFI, concentrating on the aims and ideas behind HFI.

Form of specification	Format requirements	User	Usability examples	Non Usability examples
Process statement	Outcome, goals, activities, work products	Assessor, process architect, planner	ISO TR 18529	ISO 15504, EFQM (ISO 12207, 15288)
Generic lifecycle statement	Activities, inputs, outputs	Project manager	UPA lifecycle, MUSE	Information Engineering, SSADM, Yourdon
Corporate lifecycle statement	Activities, inputs, outputs	Project manager	HFI Guides	AMS, BAE Systems Engineering Lifecycle
Project plan	Activities, dependencies, resources, timing	Project manager	HFIP	Project Plan
Project activity (techniques)	Activities, tools, resources, procedures, inputs, outputs	Specialist	EHFA, SSP10, 11, Stakeholder workshop, Task Analysis, Prototyping	Systems Analysis, HAZOP, Factory Testing

Figure 5 Levels of specifying project activity

6.8.3 In the field of HF for safety-related systems there are two specialist courses; one is a short course run by the CAA (see below), and one is the MSc run by Cranfield. However, neither of these address the full scope of HFI as set out in the HSL model, and they have very specific transport safety concerns.

6.8.4 Part of the MOD project management training material gives a good introduction to HFI , but this is quite short and would need expanding considerably.

6.8.5 The HSL model builds on ISO TR 18529, itself based on ISO BSEN 13407. These existing statements of best practice should have an impact on training course design. The curricula for courses in Design, Systems and Software Engineering, Human Factors and HCI need to take account of the existence of an authoritative standard for human-centred design. However, HCI training material that gives due recognition to the European Display Screen Equipment Directive (European Commission, 1990) such as in Hill (HILL, S., (1995). A Practical Introduction to the Human-Computer Interface, London: DP Publications. ISBN 1 85805 119 3) is the exception rather than the rule. Indeed, a recent UK Government publication on 'best practice' in user-centred design (CCTA (2000). User-centred Design. Business Systems Development with SSADM. London: The Stationery Office ISBN 0-11-330873-6.), which ignores the Directive and resulting legislation, the standards under discussion here, and those in Bevan (BEVAN, N., (2001). 'International Standards for HCI and Usability', International Journal of Human Computer Studies, Special Issue from HF 2000 (in press), may well be putting both its readers and its authors in harms way.

6.9 CAA

6.9.1 The CAA run a two-day course on Human Factors for a wide range of their safety staff (concerned with aircraft rather than ATC). This is very specifically tailored to their needs. It concentrates on developing inspection and interpretation skills, to help staff identify situations where there may be human error potential. It is not a training course in the processes related to JAR 25 or the FAA iCMM Human Factors elements.

7 Annex B Civilian (fictional) Case Study

7.1.1 This scenario is based on one published by the author in BCS HCI 'Interfaces' as a means of evaluating the potential usefulness of HF tools and methods.

7.2 Background

7.2.1 The Ambridge Building Society (ABS) has become a bank. In order to raise the revenue needed to pay for the windfall handouts, the board has decided to sell personal pensions. Following the board meeting there are the following centres of activity:

7.2.2 The business development group is defining a set of products, deciding suitable launch dates and marketing. Projections of market share, numbers of sales and customer profiles are being made. They have decided to sell them over the counter at branches rather than direct sales or over the internet. The group has brought in MAMMON management consultants to help with the business planning and product development. MAMMON were involved in the flotation and know that ABS need to lose 20% of their counter staff to meet financial predictions.

7.2.3 The compliance group is devising a strategy to avoid mis-selling in the light of the damage to Prudential and others from mis-selling personal pensions. They were concerned at the complexity of personal pensions compared to building society products and that counter staff would be unable to cope with this. However, they have been assured that the new computer system will supply the necessary support, backed up with the open learning resources coming on stream. (One of the compliance group used to work for CIS and has a fair idea of how long it takes to complete a personal pension sale in the client's home).

7.2.4 The human resources department is considering a range of new terms and conditions of employment with a big move to performance related pay. If pensions sales meet the business development department projections, then 25% of counter staff take-home pay will be a function of successful pensions selling. They realise that both technical and personal development training will be required and have contracted Row and Holdall (R&H) to conduct a corporate training analysis and plan.

7.2.5 The IT department was considering a new infrastructure as part of the move to a bank; the choice was between Java and thin clients or NT LANs and a separate WAN structure. They would like to make the pensions applications the lead item on the new computer system while they solve the problems of transferring legacy software. Either way, the user interface will be windowing and therefore easy to use. The IT department knows it is under some threat of outsourcing. Partly to counter this it is talking to John Wayne Facilities (JWF) with the intent of placing and managing a sub-contract on them for the supply of the new infrastructure, and possibly the pensions software.

7.2.6 The union, BIFFO, has its mind firmly fixed on avoiding redundancies and negotiating satisfactory conditions of employment. It had an unfortunate run-in with ABS some years back on working conditions and is disinclined to consider IT-related stress. Further, it is aware that the CEO of the HSE has said that they will not be policing the Display Screen Equipment Regulations.

7.2.7 There are a number of ways that this scenario could evolve. Please consider how HFI PRA would be used by each of the above stakeholders for each of the following options

(add your own options as you see fit). Make sure that its use has commercial benefits to those who are to use it.

7.3 Option A - business-led IT change

7.3.1 The board has considered a number of papers by the ABS centres of activity and have opted to place a performance-related Business Process Re-engineering (BPR) programme with MAMMON who will supply the necessary IT applications to support this. The leading application will be pensions. The IT department has decided to go with Java, and JWF will be installing the infra-structure (only). The legacy ABS software will be treated as 'middleware'. Database development and updating will be done by the IT department, MAMMON will do the user interface and any front-end development. Quotes from R&H and MAMMON(Training) both proved too expensive for the implementation of the training plan, and so training requirements will be specified in-house, as will the development of classroom courseware. Video training material will be sub-contracted to Fawlty Towers Video (FTV). CBT and on-line help will be done as part of the MAMMON IT contract.

7.4 Option B - Learning organization

7.4.1 Mrs Archer has decided that IT is too central to the future of financial services to be handed out to greedy contractors and consultants. She has given the go-ahead for NT based LANs to be set up in each major branch, and appointed IT gurus to each branch for applications development. The IT department will develop the WAN, and be responsible for software engineering aspects such as version control. Training requirements will be defined by the human resources department working with the local branches. Training material development will be done by R&H. Branches have been given tight personnel budgets which will be difficult to meet with early retirement, but natural wastage might just do it. The Borchester branch will lead the development of pensions software. The legacy software will be re-written from new at a number of branches because it was getting out of date anyway.

7.5 Option C - Major subcontracting

7.5.1 JWF have been given the contract to put in a Java-based intranet and develop pensions software as the lead application. They are basing the application on a US savings and loan software product. MAMMON will be providing the bulk of the resources for pension product development and planning the marketing material. R&H will be sub-contracted to implement the training plan.

8 Annex C Military (fictional) Case Study

8.1 Introduction to case study

8.1.1 The pilot is intended principally as an educational exercise in the use of the HSL model.

8.1.2 The fictional project selected has an IT bias. It is NOT a reflection of the HFI CMM project, where the model and assessment methods are intended to cover all types of project.

8.1.3 The assumption in writing the fictional project is that a 360 degree assessment is to be conducted at the request of the NAO. However, a Pre Contract Award Evaluation of the likely supplier could also be conducted.

8.2 BRIEF ON PROJECT

8.2.1 This section of the document provides some background on a fictional project. At this stage of a project of this complexity there would be a considerable quantity of documentation. The main points have been summarised with the hope that a short document can provide enough colour to allow people to extrapolate where necessary.

8.3 CONCEPT OF OPERATIONS - CURRENT

8.3.1 Gathering up to date information on current or likely hostile forces has always been important to military operations. The high level tasks involved are shown in Figure 1 below. Current operations use existing sensors and forces (perhaps with special fits) for data gathering. Specialist analysts in secure establishments then conduct detailed analysis of enemy equipment and tactics and advise the front line forces of relevant updates to threats (e.g. threat radar frequencies) and tactics.

Figure 1 - application of new data on hostile forces

8.3.2 The functional data flow of current operations is shown in Figure 2 below.

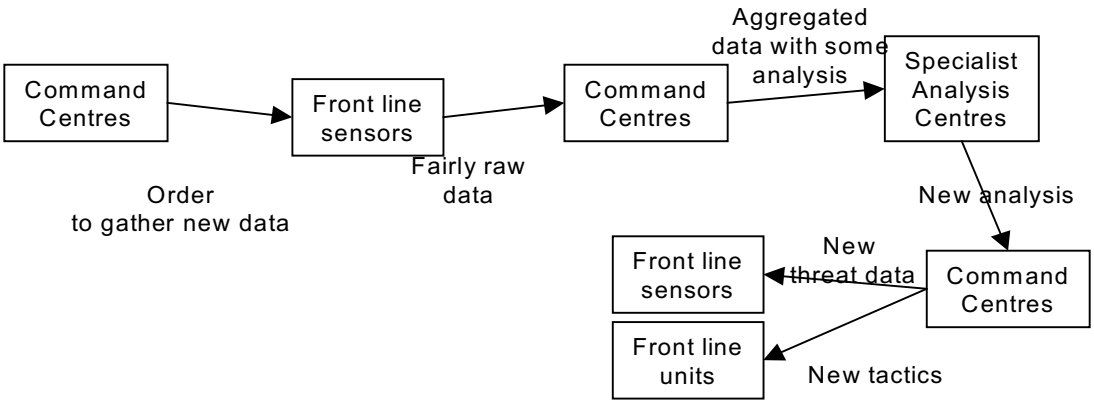


Figure 2 - Functional information flow for current operations

8.3.3 The justification for new equipment (Project PIGEON, after the use of Pigeons by

Rothschilds at the battle of Waterloo) is principally the elapsed time to complete the information flow. Modern warfare is conducted at a high tempo, with the aim of getting inside the enemy decision cycle.

8.3.4 IN-SERVICE ASSESSMENT OF OPERABILITY

8.3.5 Users of current equipment were surveyed as part of the HFI analysis during the concept and assessment stages (Extravagance on this scale is only possible in fictional examples). The following comments emerged.

8.3.6 Front line sensor operators: Gathering the data for analysis is difficult as it often involves lots of fine tuning that weren't in the training course and aren't normally used. The facilities for data recording are very variable in quality (depending on equipment), frequently badly designed, laid out and not user-friendly. Updating threat information on older equipment involves lots of typing and the facilities for error checking or correction are poor. Usually all this happens just when you are trying to get ready for some operation, and you have two workload peaks combining. Sometimes you go to great lengths (and some risk) to gather data, and nothing happens. You get no feedback.

8.3.7 Local Command Posts: We get lots of material sent in - in no particular sequence, in lots of different formats, with lots of duplication. We have to try and rationalise this lot, to reduce the amount of duplicate traffic we send back to HQ, and there is no obvious way of doing it. When we send out updates, it is sometimes very hard to know where we are, because you don't know if everyone has got everything, whether they have updated their equipment correctly, or whether they are just out of contact. All of this happens just as we are planning the next operation; I know it has to be done, but it is a drain on resources we don't have. We don't have the specialists here to do the job properly, and quite often we are guessing as to what data HQ and the analysts really need.

8.3.8 Central Command Posts: The system is just hopelessly out of date. It can't cope with the demands of modern warfare at all. The turnaround time is a major constraint on our operations, and we usually end up playing second fiddle to the US as a consequence. Making sure that everyone follows the right procedures is a drain on scarce resources here. If the communication links go down, it can take days to sort out where we are.

8.3.9 Analysis specialists: You should see some of the rubbish we get. I don't know where they get these sensor operators from - some of them can't have had any training at all. The local command posts are supposed to filter out duplicates - well it just doesn't happen. Tying in particular data to where it comes from so that we can determine its importance is very time consuming, and not a good use of our resources. Doing the analysis itself is an extremely difficult specialist task and takes some days. The HQ command people are always changing their mind, but don't tell us till we have done most of the work, so when we send them back the results and the updates, they want something different by yesterday.

8.3.10 PHYSICAL DATA FLOW IN CURRENT SYSTEM

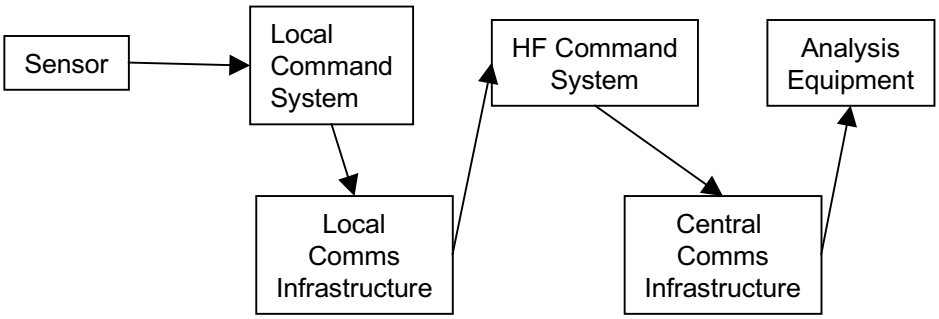


Figure 3 - Data flow for sensor data in current operations

8.3.11 Figure 3 shows the flow of data from sensors to analysis specialists in current operations. The sensor parameters are recorded by the sensor operator, coded into signal format and sent to the local command post. The local command post aggregates data from its area of operations and sends them to HQ which relays them to the analysis specialists. [This exercise does not address security issues]. There are concerns over the number of links (with consequent time delays) and the quality of data aggregation. Also the traffic is significant and disrupts other traffic over the same channels.

8.4 CONCEPT OF OPERATIONS - OPTIONS FOR PROJECT PIGEON

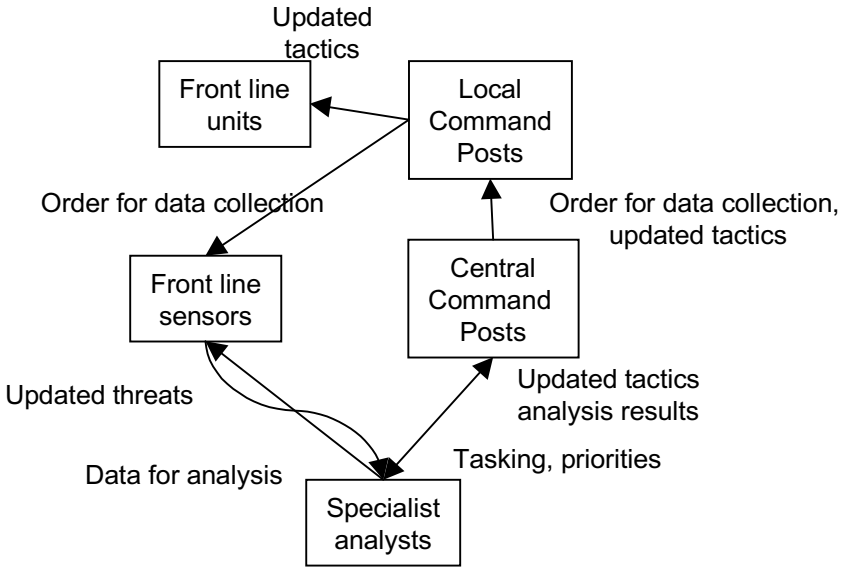


Figure 4 - CONOPS for PIGEON at Concept - functional information flow

8.4.1 The principal feature of the PIGEON Concept of Operations was the proposal to introduce a direct link from the sensor equipment to the analysis facilities, whilst retaining the existing chain of command for tasking and for tactical updates. This would reduce the time delays and would also reduce the workload involved imposed on the command chain. It was anticipated that the information flow through the command chain would be improved (in speed and capacity) by Project STOVEPIPE.

8.4.2 A complete dependency on this wide bandwidth was considered unacceptable, and fallback arrangements would be required. However, it was considered appropriate to consider the fallback arrangements as part of the equipment studies, as they would be principally determined by the local sensor equipment. A uniform approach to fallback operation was not considered appropriate.

8.4.3 OPTIONS REJECTED AT CONCEPT

8.4.4 During the concept stage of the study, a number of options were rejected. This section describes these rejected options briefly. The option that was clearly not viable was to put all the detailed analysis at the front line (shown below in Figure 5). The reasons for that were:

- Excessive cost (the numbers of new equipments would be vast - one per sensor), and the numbers of new operators and/or additional training would also be considerable.
- Inability to compare different data sources; the analysis would be done independently at each sensor, without the benefit of being able to use data from a number of sensors.
- Lack of control; the updates could well become driven by the local analysis rather than a central decision.

8.4.5 On the other hand, the benefits were:

- Lack of communications demands - no additional comms would be required.
- Resilience: the system would operate regardless of comms restrictions or delays with command and control.

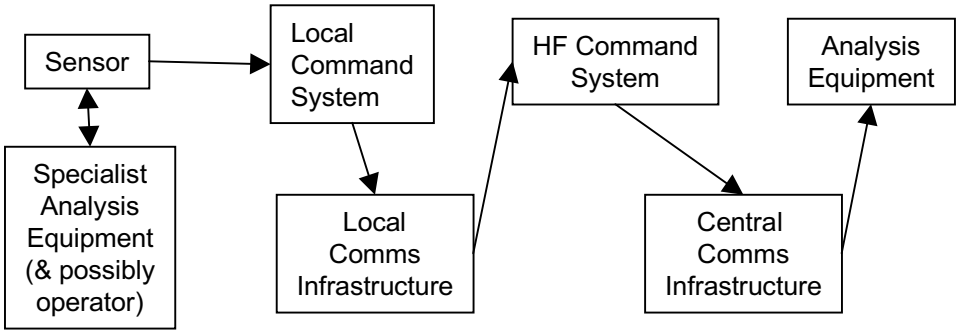


Figure 5 - Local Analysis option (Option A).

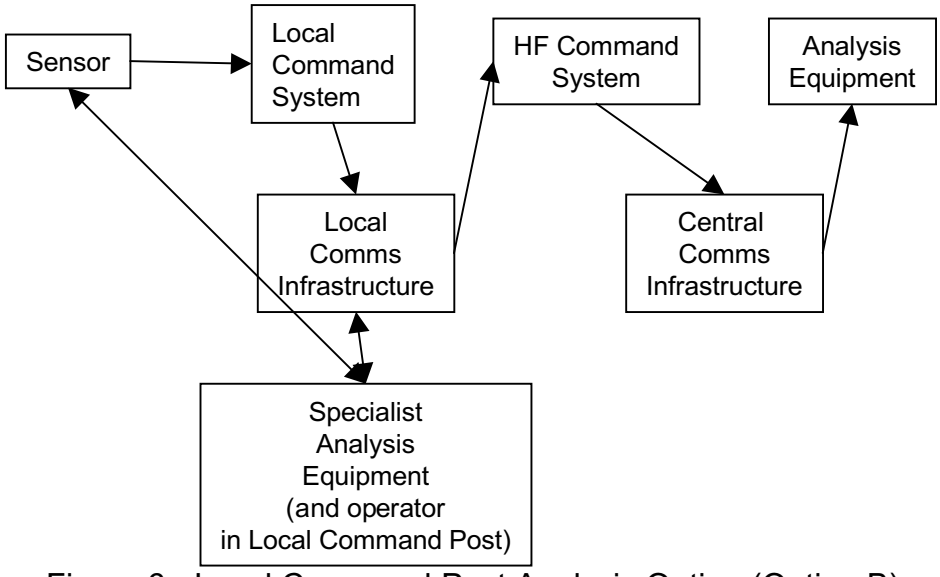
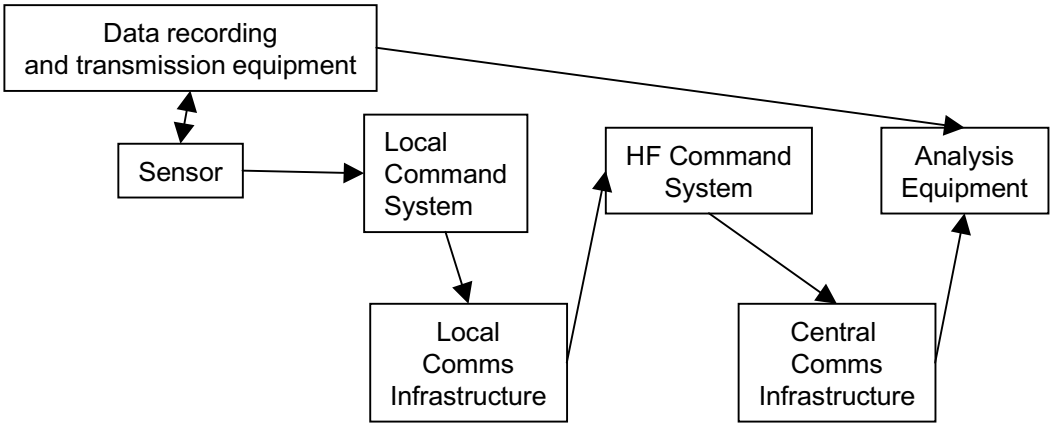


Figure 6 - Local Command Post Analysis Option (Option B).

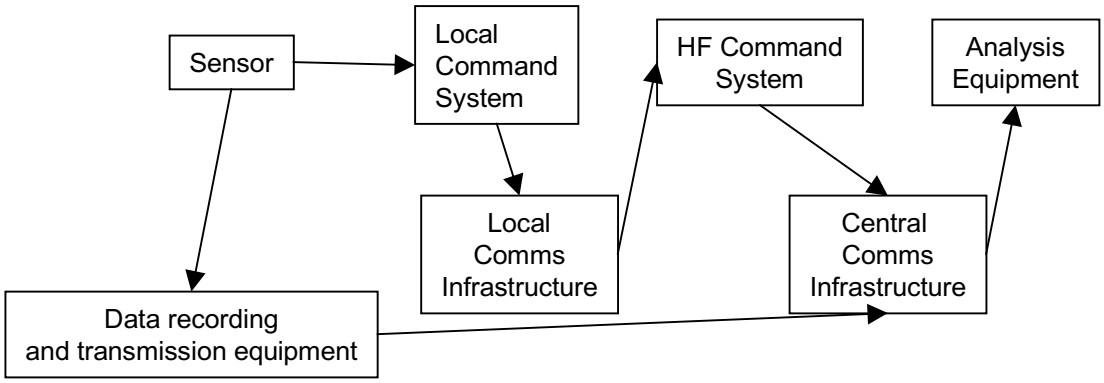
8.4.6 The other option rejected during concept phase was to conduct analysis at the Local Command Post (LCP). Although less expensive than Option A, it was still considered to be too expensive, and demanding in specialist manpower.

8.4.7 OPTIONS CONSIDERED AT ASSESSMENT

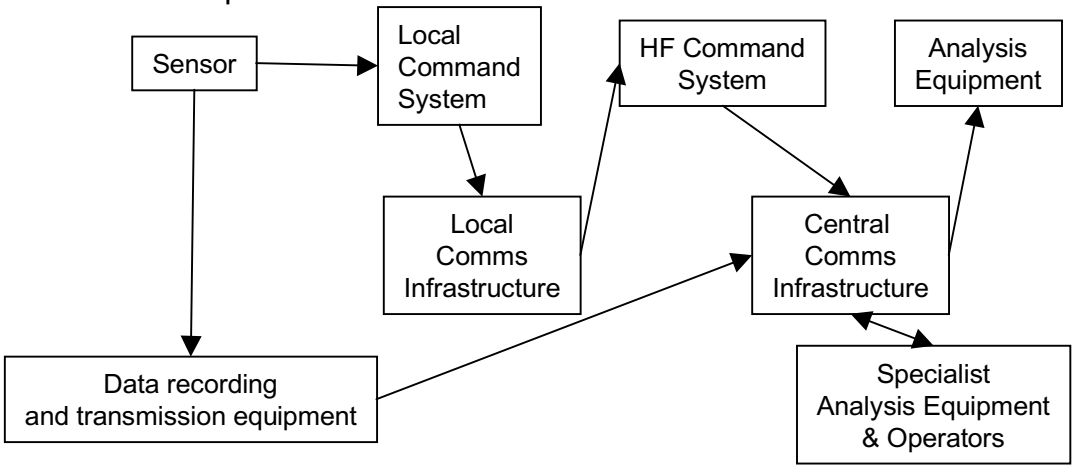
8.4.8 Several options were carried through into the Assessment Phase. Although a preferred option has been selected, the other options will not be eliminated formally until the between-phase COEIA (Combined Operational Effectiveness and Investment Appraisal) at Main Gate. However, the partnering arrangements with industry mean that candidate suppliers are aware of the preferred option, and would expect to offer variants around that, rather than against the other options discussed in this section. It should be noted that the options are closer to each other in concept, than those rejected at Concept, and all match the CONOPS. The differences are in the communications paths, and the location and nature of the analysis staff.



Option C - Direct communications to analysis centres



Option D - Communications via Central Comms



Option E (Preferred) - Communications via Central Comms, and co-located analysis

8.4.9 Option C offered the shortest communication paths, and therefore minimum delay. However, it would require considerable investment in communications facilities at the analysis centres. In addition, the analysis centres would have the task of all aggregation of data. There were questions over what (if any) new analysis equipment would be required at the analysis centres.

8.4.10 Option D is actually the lowest cost option; the main cost would be introducing additional land lines from the comms infrastructure to the analysis centres, and any additional analysis equipment that might be required at the centres. Additional comms delays over Option C were considered minimal, but there may be occasions when there would be disruption to other activity on the same channels.

8.4.11 Option E introduced the idea of a new analysis centre, co-located with the comms infrastructure. Although this would appear to introduce additional cost, it was considered to be lower cost risk, and offered the potential for a) greater overall effectiveness and b) better staff career progression, hence better retention and lower manpower costs.

8.5 PREFERRED OPTION

8.5.1 This section describes the equipment at the sensor end for the preferred option, and identifies some aspects of a) reversionary operation and b) inter-service differences. It also discusses the new analysis centre (JRDATUC - Joint Rapid Data Analysis and Tactical Update Centre).

Air equipment options: separate recording controls not possible.
Pre-program sensor recording as part of mission planning system.
Communications options: In-flight upload not possible. Sensor recordings to be sent from from mission planning system as part of de-brief.
Operators are Pilots in single seat aircraft, Navigators in 2 seat aircraft, and Ground Crew.
Update to threat data: done as part of data load from mission planning system.
Fallback mode: use mission planning system to do local analysis (add KBS to assist operator) and send results via Command chain.
Conclusion: Normal operation has little impact on operators.

Land equipment options: Can add recording and analysis facilities, and if necessary, additional sensor controls and refinements.
Communications options: Add satellite dish, but use buffer recording and data compression first.
Operators are members of Signals Regiments and should be able to do additional analysis, and operate additional equipment with minimal training.
Fallback mode: Use additional equipment to do local analysis (with KBS) and send results via Command chain.

Naval equipment options: Add recording and analysis equipment in vicinity of sensor. For newerequipments incorporate control from sensor.
Communications options: Use satellite communications with buffer recording and data compression first. Under restricted communications, or reversionary operation, operators do analysis using guidance sent with tasking (and KBS support). Operators are skilled sensor operators, and additional training should not be a problem.

JRDATUC

8.5.2 The rationale for introducing JRDATUC is as follows:

- It is likely that additional staff for rapid response analysis would be required, together with new specialist equipment. The options that depended on using existing analysis centre staff and facilities were considered to be high risk. It was likely that existing staff would be unsuitable and already busy, the centres may be re-located (negating the comms investment) or outsourced, and the current equipment is near-obsolete and is oriented towards slow-time detailed analysis rather than rapid response to operational circumstances.
- The comms infrastructure centres have spare space due to the replacement of large obsolete comms equipment with modern miniature sets, so no additional accommodation costs are incurred.
- The comms centres are staffed by high-grade personnel who could be trained to support specialist analysis, and trained to move into specialist analysis posts as a career progression.
- No additional comms facilities will be required, and existing links can be used.
- The comms centres are generally co-located with HQ's offering the potential for ease of tasking, rapid interpretation of analysis and further staff reductions with more automation.

8.6 KEY USER REQUIREMENTS (for preferred option)

8.6.1 The sensor operator shall be able to:

- Operate the additional recording equipment
- Set up the sensor and the recording equipment in accordance with the tasking order
- Transmit the data according to the communications order
- Update the sensor equipment in accordance with the update order.
- Perform reversionary operation.

8.6.2 The local commander shall be able to:

- Convert a tasking order to individual tasking orders for the sensor equipment in his/her command.
- Convert a communications order to individual communications orders for the uplink communications equipment in his/her command.
- Manage reversionary operation in response to standing operational priorities.
- Maintain training records and standards.

8.6.3 The HQ command shall be able to:

- Generate tasking orders for data gathering in response to operational priorities and existing threat analysis.
- Generate communications orders using current COMPLANS and analysis of communications intercept threats.
- Supervise training standards and change them in the light of any shortfalls that are deemed to occur.
- Generate a baseline plan for data aggregation.
- Set analysis priorities by region, sensor type, threat type.

8.6.4 The analysis supervisor shall be able to:

- Convert analysis priorities into individual work instructions for the analysts.
- Sort data using the baseline plan into analysis lists for the analysts.
- Maintain training standards for analysts.
- Resolve conflicting priorities.
- Decide when particular analysis should be stopped.
- Decide when particular analysis should be referred to the off-line analysis centres.

8.6.5 The analysts shall be able to:

- Confirm which data from a list should be analysed in detail, and which data are duplicates or too poor to be analysed.
- Perform a detailed analysis of the data and determine what updates to the hostile force tactical data are required.
- Perform a detailed analysis of the data and determine what updates to each applicable type of sensor are required.

8.7 STAKEHOLDERS

8.7.1 The MOD stakeholders involved in the project are identified here, and the main points from the stakeholder analysis are presented.

8.7.2 Front line operators and their local command: These come from all the services, but are fairly consistent in their views. The existing system doesn't work. Rapid response time

is vital. The front line operators cannot do the detailed analysis required. Older equipment is difficult to use in this context, and detailed analysis, recording and updating facilities have been dropped from most current procurement on cost grounds, so the difficulties will continue. Reversionary operation looks like being window dressing. They couldn't have supported Options A or B as things stand, but have grave doubts about the ability of HQ to do sensible aggregation, or to respond to current military timescales ("we won't be able to take any initiatives at the weekend if we have to rely on that lot"). The plan to introduce graduate sensor operators might have meant that Options A or certainly B might have been on with some KBS operator support. It isn't obvious why PIGEON and STOVEPIPE each need their own communications links.

8.7.3 HQ command: They see having to give detailed instructions on aggregation, and on analysis priorities as being a sizeable additional task, and would like JRDATUC to be able to take this on with a knowledge of the current operations. They do not see a problem with this given the co-location. JRDATUC could get a feed from STOVEPIPE and should be able to operate from that.

8.7.4 Intelligence staff (who run the existing analysis centres): Mixed reactions. On the plus side, JRDATUC relieves them of a lot of grief, and they can concentrate on the long-term analysis that is their core business. However, they do not believe that non-Intelligence staff could possibly do any useful analysis. In the longer term, they are concerned that JRDATUC could expand at their expense. This is particularly of concern because at the moment the centres are a) becoming Joint (rather than individual service) with the redundancies and moves that this involves and b) their equipment management is being outsourced, which is considered quite inappropriate given its sensitive and specialist nature. At the moment, they get all the data sent to them and they can choose what they analyse. It looks likely that they may only be sent what the JRDATUC supervisor chooses to send them, which would represent a major threat to their data integrity.

8.7.5 Training staff: They could not support Options A or B. The introduction of data analysis to the comms centres represents a major new training load. The additional tasks are considered very unlike their comms tasks. Even though the operators have the same initial training, the training gap is huge.

8.7.6 Personnel organisation (2SL etc.): They are planning to turn the comms centres into an agency with civilian (ex-military) staff, and this new tasking represents considerable confusion to the plan. They are also considering a combined analysis centre with the US, and the loss of data integrity would damage those aspirations.

8.7.7 Comms staff: This represents a good way to build up the empire, and to fight off the agency threat. However, STOVEPIPE looks like having a completely different HCI to PIGEON options, and so operators will continue to have to learn multiple separate equipments. The analysis task looks demanding, and the current retention rate of senior NCO's is dreadful, so it is not obvious that there will be the people to do the task. The new comms equipment was intended to be largely automated, and so the recruiting standards have been lowered, so while there might be a career path in theory, in practice it might not work without a change in entry standards and a lot more training. Because the comms centres are Joint, it is very hard to predict who is going to be coming into it, and career paths are still single service, which will be difficult to manage. The aggregation and prioritising tasks look dreadful however they are carved up. Given they are essentially operational, they should stay with the HQ staff and not come to the comms centre staff with JRDATUC.

8.8 RISKS FOR PREFERRED OPTION BY DOMAIN/STAKEHOLDER

8.8.1 The Early HF Analysis identified a great many concerns, many issues, but the following were considered sufficiently important to be entered into the project risk register.

MANPOWER

8.8.2 There is the risk that JRDATUC will not have enough people available to it to provide sustainable resources.

PERSONNEL

8.8.3 There is the risk that the skill demands at JRDATUC will be beyond the available personnel.

8.8.4 There is the risk that front line operators will be unable to perform reversionary operation.

TRAINING

8.8.5 There is the risk that the pre-joining training time required for analysis tasks at JRDATUC will leave only a short time for operational duties before being moved on to another assignment.

8.8.6 There is the risk that the lack of command experience in staff joining JRDATUC will mean that aggregation and priority-setting tasks will require uneconomic levels of training.

HFE

8.8.7 There is the risk that the HCI for analysis tasks will be very difficult to design for JRDATUC operators.

8.8.8 There is the risk that the KBS for front line operators will prove impossible to realise.

8.8.9 There is the risk that the incompatibility of PIGEON and STOVEPIPE HCI's will lead to excessive error rates.

SYSTEM SAFETY

8.8.10 There is the risk that operator error leads to a hazardous situation for front line troops. [subsequently considered an HFE risk rather than a safety issue].

HEALTH HAZARDS

8.8.11 There is the risk that the front line satellite dishes will expose front line staff to excessive dose rates.

8.9 THROUGH LIFE MANAGEMENT PLAN (TLMP)

8.9.1 The plan shows the development of an Initial Capability (IC) by 2003 for specific sensors. For the next 3 years, further capability will be phased in as new units are supplied with their recording and transmission equipment.

8.9.2 The RAF will supply User Requirements Owners. These will be a mix of specialist analysts and aircrew.

8.9.3 Interim prototype evaluation/demonstration will be conducted at the JWID annual exercise.

8.10 CANDIDATE SUPPLIER CAPABILITY STATEMENTS

8.10.1 The leading candidate supplier is offering a COTS integration approach. The leading company has a background in supplying complex radio equipment and is a leader in antenna design. Within the consortium are companies with software development experience and network management experience. Target analysis consultants have been retained. The COTS products come from UK, US and France.

8.10.2 Training equipment is the subject of a separate contract. The approach that has been preferred on the basis of a separate COEIA is to upgrade the existing target identification CBT package. Although the mechanics of the HCI are different, and only simple target analysis will be possible, it is considered that this is the most cost-effective option.

8.11 FEATURES OF TENDER

8.11.1 Data recording and transmission equipment: A standard PC package is being written for all equipments, which will be ported to Unix for the aircraft mission planning systems. The satellite dishes and transmission equipment are being bought from the US.

8.11.2 JRDATUC equipments: The message handling aspects (dealing with aggregation, prioritisation, and sending out tactical updates) will be a tailored version of a French intelligence system. The analysis aspects will use software developed for satellite imagery analysis at MIT Research Center, which has also been used by NASA. The user interface will be customised specifically for PIGEON (and ported from Unix to NT).

9 Glossary

AMS	Acquisition Management System
ATC	Air Traffic Control
BCHF	Board of Chartered Human Factors
BCS	British Computer Society
BPS	British Psychological Society
CAA	Civil Aviation Authority
CASS	CASS Scheme Ltd - an organisation to promote and support the use of IEC 61508 in the UK
CBA	Capability Based Appraisal
CCTA	Central Computers and Telecommunications Agency
CMM	Capability Maturity Model
CV	Curriculum Vitae
DCIS	Defence Computers and Information Systems
DERA	Defence Evaluation and Research Agency
DNV	Det Norske Veritas
DPA	Defence Procurement Agency
DPG	Defence Procurement Group
EHFA	Early Human Factors Analysis
ESSI	European Software Systems Institute
EUSC	European Usability Support Centres
FAA	Federal Aviation Authority
HCD	Human Centred Design
HCI	Human Computer Interface
HF	Human Factors
HFI	Human Factors Integration
HFIP	Human Factors Integration Plan
HSL	Human-System Lifecycle
IEC	International Electrotechnical Commission
IEE	Institution of Electrical Engineers
IPI	Initial Process Improvement
IPT	Integrated Project Team
ISO	International Standards Organisation
JAR	Joint Airworthiness Regulations
LR	Lloyd's Register of Shipping
MoD	Ministry of Defence
MPT	Manpower, Personnel and Training
NAO	National Audit Office
PAIS	Process Appraisal Information System (at SEI)
PCAE	Pre-Contract Award Evaluation
PDS	Professional Development Scheme
PI	Process Improvement
PRA	Process Risk Assessment
SCE	Software Capability Evaluation
SEA	Systems Engineering and Assessment Ltd
SEC	Software Engineering Centre
SEI	Software Engineering Institute (at Carnegie Mellon University)
SPICE	Software Process Improvement and Capability Evaluation
SQEP	Suitably Qualified and Experienced Personnel
SSADM	Structured System Analysis and Design Methodology
SSMO	Ship Safety Management Office
SSP	Sea Systems Publication
TNA	Training Needs Analysis
VFM	Value For Money