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Air Force Human Systems Integration in Test and Evaluation

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This deliverable summarizes the completed task efforts to analyze current Test and Evaluation (T&E) processes and recommends ways and methods to insert Human Systems Integration (HSI) considerations within the T&E protocol/process to allow human aspects related to system design to be tested and evaluated.

15. SUBJECT TERMS
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Executive Summary

The study and findings described in this report are part of a larger effort that is focused on Human Systems Integration (HSI) in acquisition and was conceived and sponsored by the Air Force's 711th Human Performance Wing's Human Performance Optimization Division (711 HPW/HPO). Other projects in this effort include HSI in the Systems Engineering Plan, in the Life Cycle Management Plan, and in the Systems Requirements Document.

This study on HSI in Test and Evaluation (T&E) examined T&E processes, planning teams, guiding documentation, and roles to uncover opportunities for improving the visibility and treatment of HSI in T&E. The study team engaged Subject Matter Experts (SME) from the T&E and HSI communities in a one day workshop to identify focus areas for the project. The participants identified the following five areas as needing attention: 1) testable requirements; 2) guidance documents; 3) linkages with existing tests; 4) improved measurement methods; and 5) usability shortfalls.

The study team conducted focused interviews and performed document reviews to shape investigations for each of the five areas. The investigations generated recommendations for modifications to Air Force policy, instructions, and guidance for T&E. These are included as appendices to this report.

A key feature of the study was the development of 26 HSI-related sample entries for the T&E Top-Level Evaluation Framework Matrix (the "Framework"). The Framework is a required section of Test and Evaluation Strategy and Test and Evaluation Master Plan documents. The Framework displays the program's developmental and operational test process at a glance by tying together high-level user requirements (including Key Performance Parameters), key test measures, critical test parameters, and test methodologies. The Framework had been identified by workshop participants as a primary opportunity for including HSI in T&E processes, and thus will become a key enabler for better integration of HSI and T&E.

The HSI-related Framework examples developed during this task link HSI to existing tests and program decisions, describe measurement methods, and include testable requirements and several usability examples. Combined with the Air Force Instruction recommendations, these Framework examples address all of the five focus areas that had been recommended by SMEs. The 26 examples are included as an appendix to this report.

The study team recognized two key factors that have hindered better integration of HSI concepts into the T&E community. First, T&E in the Air Force is distributed over a number of organizations. While the same policy and guidance governs the distributed activities, the variation of roles and missions prevents complete standardization of practice from one group to another. Secondly, the understanding of the HSI concept is not strong within the T&E Community. Similar to many other Air Force communities, many individuals in the T&E Community still equate HSI with Human Factors Engineering (HFE). Quite a few individuals encountered were performing HSI-related testing without recognizing it as being HSI-related. T&E subject matter experts requested more information about HSI and the identification of HSI points of contact that they could draw upon for their day-to-day needs.

The Framework examples provide an opportunity to address both of these hurdles. As the study team was unable to discover previously developed examples, these--for HSI--may be the

first. By consolidating these examples into a single library, they will be readily available for use by the T&E Community for training purposes and for insertion into T&E guidance documentation. This will also raise Community awareness of the contributions of HSI to mission capabilities, and will facilitate a consistent understanding of HSI within the T&E Community.

Introduction and Background

The scope of this project was to analyze current Test and Evaluation (T&E) processes and to recommend ways and methods to insert Human Systems Integration (HSI) considerations within the T&E Community that would allow human aspects related to system design to be tested and evaluated. The intent was to identify and develop means for greater HSI integration into T&E activities and products that would result in capabilities that are more operationally suitable, safe and effective.

T&E covers the entire spectrum of the Department of Defense (DoD) acquisition life cycle. This SURVIAC task did not address laboratory testing during technology development, [operational] capability testing of already-fielded systems, systems deployed through rapid-response / prototyping processes, or the process for upgrades and modifications (aka 1067 process). These have been deferred for parallel or future study.

The Performance Work Statement (PWS) described the following areas of work:

1. Analyze Existing Test and Evaluation Process: determine the extent of HSI consideration within the T & E process and related requirements documents.
2. Identify HSI Personnel Involvement with T&E Process: identify current areas of opportunity where HSI personnel may become involved with the T & E process and determine how HSI personnel can become involved with the T & E process.
3. Identify T&E Personnel Involvement with HSI Process: identify current areas of opportunity where T & E personnel may become involved with the HSI process and determine how T & E personnel can become involved with the HSI process.
4. Identify Gaps Where T&E Personnel Can Influence Requirements Documents: identify areas for inserting HSI into T & E processes and requirements documents.
5. Identify Areas for HSI Requirements within T&E Processes / Documents: identify gaps where T&E personnel can assist in authoring HSI-related thresholds and objectives within requirements documents.
6. Provide Recommendation for HSI Metrics with T&E Processes / Documents: provide recommendations for inserting HSI metrics into T & E processes and related documentation in order to monitor the human related aspects for system development and design.

To address these work areas, the team adopted the following three courses of action:

SME Interactions. The study team was able to satisfy the first five work areas (as listed above) by conducting technical interchange meetings and structured interviews with SMEs from both communities. The interview plan included attending HSI and T&E conferences at which large numbers of those on the interview list were expected to be present.

Document Analyses and Recommendations. The study team was able to satisfy the first, fourth, and fifth work areas (as listed above) by reviewing acquisition and T&E policy and

guidance documents, and making recommendations for inserting language and guidance that would influence HSI's inclusion in T&E.

The study team, in collaboration with the government, identified the following three T&E policy and guidance documents as providing the greatest opportunity to improve the inclusion of HSI in acquisition:

1. **Air Force Instruction (AFI) 99-103, *Capabilities Based Test and Evaluation*.** This instruction is the primary policy document for T&E in the Air Force.
2. **Air Force Manual (AFMAN) 63-119, *Certification of System Readiness for Dedicated Operational Testing*.** This manual provides detailed guidance for ensuring a new or modified capability is ready for dedicated operational test and evaluation.
3. **The Air Force Test and Evaluation Guidebook.** This unofficial document provides detailed background on many facets of Air Force T&E. Since it is an unofficial Air Force publication, it has not been updated since 2007.

The study team recommended 86 specific HSI-related modifications to these documents based on extensive review and consultation with T&E and HSI SMEs. In addition, the study team recommended 97 specific HSI "touch points" to provide guidance when executing particular sections of these documents, based on extensive review and consultation with T&E and HSI SMEs.

HSI Measures. To satisfy the sixth work area, the study team investigated the T&E Top-Level Evaluation Framework Matrix (the "Framework") as a tool for documenting HSI measures. The Framework is a required section of Test and Evaluation Strategies (TES) and Test and Evaluation Master Plans (TEMP). The study team was unable to discover previously completed Framework examples because the policy was only recently implemented in late 2009. The development of a set of HSI examples was therefore considered a prime opportunity for interdisciplinary communication.

Framework categories comprise all of the attributes of a measure including the following: 1) the attribute to be measured; 2) the method of measurement; 3) the scale of measurement; and 4) the rule (threshold or objective) for assigning value or desirability of a given measurement. The study team produced 26 HSI-specific examples for the Framework that capture measurable, objective requirements for developmental and operational test and relate them to technical parameters and test methods. The 26 representative measures are intended for use by HSI and T&E personnel in crafting requirements and associated test parameters.

It should also be noted that the Framework is limited to "critical" test parameters due to the higher-level nature of TESs and TEMPs. While HSI test parameters are extremely important, they may not rise to the level of "critical" as the word is used in the context of the Framework. Early tester involvement during the development of requirements, as recommended in AFI 99-103, is a primary way to permit the thinking promulgated by the Framework to affect HSI without necessarily having HSI parameters in the Framework of any specific program.

Methodology

Test and Evaluation Workshop

On January 27, 2010, the Air Force Human Systems Integration Office (AFHSIO) hosted a one-day workshop that brought together twenty-six SMEs from the Air Force HSI and T&E communities. The number of representatives from the HSI community was approximately equal to the number who represented T&E. Some participants could represent both interests (e.g., human systems testers).

The objectives of the workshop were to bring the HSI and T&E communities together to accomplish the following: 1) achieve a better understanding of each other's' processes and of the participants' perspectives; 2) identify opportunities and methods that would enable representatives of the two communities to work closer together, to support one another, and to ensure HSI requirements can be effectively tested; and 3) define the path forward for the HSI in T&E project and for the HSI Assessment Project (being performed for AFHSIO). One of the AFHSIO assessment projects is the development of templates for the TES and TEMP, which will be used for reviewing HSI content in those two acquisition documents.

The workshop plan consisted of a series of presentations, facilitated discussions on targeted topics, and the collection of action items. The agenda included presentations by AFHSIO representatives, T&E representatives from the Policy and Programs Division of the Air Force Test and Evaluation Directorate (AF/TEP), the Air Force Flight Test Center (AFFTC), the Air Force Operational Test and Evaluation Center (AFOTEC), field test unit representatives, and Center Test Authorities (CTA).

Workshop Findings: A theme that was first raised at the workshop and continued throughout the study was a perceived lack of synergy among components of the T&E enterprise. It must be noted that due to the diverse nature of T&E across the Acquisition Life Cycle (e.g., munitions v. space v. command & control, or developmental testing v. follow-on operational testing), it may appear there is a lack of a coordinated approach to T&E.

Another concern first raised at the workshop was the consistency of representation by HSI domain representatives, such as Environment, Safety, and Occupational Health (ESOH) and training personnel, in T&E activities. For example, if a training issue is discovered in developmental testing, there is less confidence that this issue is communicated back to the program training representative(s).

These both can contribute to a situation in which HSI does not appear to be comprehensively tested. Again, early tester involvement during the development of requirements can help to mitigate this. SMEs interviewed during this study indicated that human factors and ESOH should be tested as part of developmental testing. However, ESOH testing has not been institutionalized in the Air Force. Manpower, personnel, training/training support, and human-machine interfaces may be tested as part of logistics T&E.

HSI Awareness: The aforementioned diversity within the T&E Community means there will not be a singular point of interface for HSI with T&E. HSI representatives will need to align with the test organizations, or with test managers at program offices and with major commands (MAJCOMs), air logistics centers, detachments, product centers, and field test units which also

have test-coded positions. The only Air Force T&E organizations with an organic HSI presence (primarily human factors) are the AFFTC and AFOTEC.

The T&E Community asked for help in becoming better informed about HSI issues so they could make improvements in this area. They recommended HSI involvement in Integrated Test Teams (ITTs) and ITT subgroups as a conduit for raising HSI issues. This would allow HSI to maintain persistent visibility throughout the life cycle. ITTs should be formed in the Materiel Solution Analysis phase, but this does not consistently occur. Even at that point in acquisition, it is considered too late. The Aeronautical Systems Center's Center Test Authority's (ASC/AQT) "Test Early-Start and Issues" initiative calls for a test-stakeholders meeting to consistently occur immediately after the Materiel Development Decision. ASC/AQT representatives suggested that HSI participate as an early stakeholder.

There was an attempt to find goal alignment between the HSI and T&E communities. Participation by T&E and HSI representatives in High Performance Teams (HPT) that develop operational requirements, and HSI participation in ITTs are ways to achieve goal alignment.

HSI in Requirements: Many of the T&E SMEs that were interviewed recognized the importance and relevance of HSI requirements. The T&E Community emphasizes that it does not write requirements; testers provide help and advice. This is consistent with an important aspect of T&E – impartiality. They can ensure that the requirements that are brought forward by users are stated in testable forms, if that is possible. This is one of the reasons that the philosophies of "early tester involvement" and "up front and early" are strongly promoted by the T&E Community. It was noted that not all requirements are testable; for example, lethality is measurable but sometimes not testable in a cost-effective manner, so modeling and simulation are used as alternatives.

HSI in requirements writing is supported by HSI representatives at both the MAJCOMs and at the AFHSIO. The T&E voice at the HPT can help ensure that human-related requirements are supported by appropriate testable or measurable criteria. The T&E Community knows how to test these HSI relevant requirements and does so routinely. The T&E representatives who are familiar with these methods can help HSI representatives in crafting these requirements. The advocacy for the voice of HSI on the HPT lies with the user and with the AFHSIO.

Operational Concepts: Operational concepts are specifically documents that provide a system's operational context; i.e., how a system will be used (this is in contrast with the more formally defined concepts of operations (CONOPS)). They are one of the foundations for designing operational tests and are very helpful for designing developmental tests. They should help to define test planning and help to form the basis of operational tests. Customarily, however, they are received too late by the operational test team. HSI task and work analysis techniques are suited to operational concept development. This is an area where HSI practitioners can help warfighters write better concepts for T&E.

Testing HSI Requirements: Getting requirements into test was identified as another issue. For example, ESOH compliance is required by regulation; ESOH requirements are written, but ESOH is rarely tested in the developmental test phase. One workshop participant stated that it is considered difficult to measure "safety-ness," but there are measurable hazards. Operational T&E looks at meaningful, mission-level outcomes. The human element is not separable in this view, but if there is a deficiency, testers will try to assess what caused the deficiency. The difficulty with this approach is that finding an HSI- related requirement that was missed does not equate with fixing the deficiency. In many cases budget limitations might prevent addressing

that one missed requirement. In cases such as this, questions of verification and validation and compliance remain unanswered.

One approach suggested for institutionalizing the treatment of requirements is to return to the practice of putting standards on contract. This practice would require contractors to include the cost of doing standards-related work in their proposals and make it more likely that the work is accomplished.

HSI Deficiencies: The attendees discussed the use of deficiency reports for tracking HSI issues and for identifying lessons learned. The attendees expressed concerns that HSI deficiencies may be getting closed without appearing to be sufficiently addressed. This could be the result of a lack of funding, advocacy, or established requirements. While this may have been the case in the past, recent changes to the technical manual that governs deficiency reporting for the Air Force should help strengthen this process and ensure that deficiencies are not closed without being addressed and reviewed by the appropriate organizations.

SMEs suggested that the Joint Deficiency Reporting System (JDRS), which is replacing the Air Force Deficiency Reporting Information System (DRIS), could be used to identify common problems and to generate statistics on design performance with respect to HSI. For those few deficiencies that meet the necessary criteria, it would be appropriate to categorize and track them as safety deficiencies via safety engineering processes.

Workforce Development: Initiatives, such as "Test Early-Start and Issues," demand additional test-coded positions if they are to spread throughout the Air Force. Building up the T&E workforce is a major concern of the Community. New T&E courses are being developed and existing courses are being improved. Opportunities exist to insert relevant HSI content into Air Force Institute of Technology, Defense Acquisition University and even Naval Postgraduate School T&E courses.

Workshop Issues: At the conclusion of the presentations and discussions, the important findings were collected and prioritized. Additionally, a substantial list of action items was developed from attendee notes. The list highlighted questions and opportunities to be addressed by the study team.

The attendees were able to categorize the concerns raised during the Workshop into 15 issues. The attendees were asked to vote on which of the issues provided the greatest opportunity for improving HSI practice in T&E. The issues were then ranked by number of votes received. The 15 issues were as follows:

1) Requirements
2) Guidance Documents
3) Linking HSI to Other Tests
4) Measurement Methods
5) Usability Shortfalls
6) HSI Expertise on Integrated Test Teams (ITTs)
7) HSI in Acquisition Contracts
8) Deficiency Reports
9) Careers
10) Institutionalization
11) Culture
12) Infrastructure

13) HSI Key Performance Parameters (KPPs), Critical Operational Issues (COIs), Operational Concepts
14) Enterprise-Level Assessments
15) Early Systems Engineering / Rapid Prototyping

Workshop "Top Five List:" The day following the workshop, the study team met with representatives from the 711 HPW/HPO and AFHSIO to debrief workshop findings. The group determined that the study team should focus on the top five issues that were identified in the workshop. Each of these five issues satisfies at least one of the six areas of work identified in the performance work statement:

1) **Guide the development of testable requirements.** HSI relevant requirements are perceived to be vague and subjectively evaluated. In part, this is due to training shortfalls – there may be a general lack of familiarity in many communities with quantitative methods and how qualitative methods are quantitatively assessed. Through closer collaboration of T&E and HSI practitioners, HSI requirement statements can be made more complete, clear, and more fully testable.
2) **Insert HSI into T&E guidance documents.** Several documents were identified by the attendees, the primary ones being AFMAN 63-119, AFI 99-103, and the AF T&E Guidebook.
3) **Link HSI to other tests.** Dedicated HSI testing is rare. HSI testing is almost always embedded in other types of suitability testing without being identified as a separate test. It is important to identify opportunities to test human-related requirements as part of customary testing.
4) **Improve measurement methods and incorporate HSI.** Workshop attendees stated that T&E is on a cusp of being able to objectively test HSI-related parameters. Methods for collecting data, such as for ESOH and usability, need to be strengthened and the knowledge of their use promulgated.
5) **Establish approaches that address usability shortfalls.** Quantitative usability measurement methods are in common use. Usability requirements can be easily derived from operational suitability. However, requirements that drive usability testing are often absent or poorly stated. Additionally, the mathematical methods to be used in usability evaluations are not well understood, especially for small samples. Workshop attendees expressed a desire to improve usability verification and validation. It is unlikely that usability will rise to the level of a Key Performance Parameter (KPP) but many considered it vitally important to the achievement of many existing KPPs and Key System Attributes (KSAs).

During the debrief, emphasis was placed on requirements as represented by the T&E Evaluation Framework Matrix, HSI recommendations for T&E documentation (including operational concepts), and how to link or embed HSI to existing tests.

Post-Workshop Focus Areas: The study team took the "Top Five List" and developed three courses of action to help resolve these five issues. The three courses of action were as follows:

1) Conduct interviews of SMEs in the HSI and T&E communities.
2) Review T&E policy and guidance in order to provide recommendations for insertion of HSI language.
3) Directly apply HSI by developing HSI-relevant examples for the T&E Framework (although unstated, the intent of the workshop attendees was in reality to influence Joint Capabilities Integration and Development System (JCIDS) documents, system

specifications, contract requirements documents, TEMPs, and test plans, all of which "connect" to the Framework).

The remainder of this report and associated appendices align with the three courses of action described above.

SME Interactions

Approach and Purpose

After the January workshop, the study team planned to further explore issues related to the Top Five List and action items with HSI and T&E SMEs. The team compiled a list of representatives from Air Staff, the operational MAJCOMs, Air Force Materiel Command (AFMC) headquarters, AFMC product, air logistics, and test centers, AFOTEC, the Air Force Research Laboratory, and the Air Force Institute of Technology. The intent was to find at least one HSI SME and one T&E SME in each of these Air Force organizations who could speak authoritatively for that organization regarding their observations of the relationship between HSI and T&E in their organization.

The study team developed a detailed list of questions to guide interviews. This discussion guide addressed demographic information (e.g., the interviewee's role in T&E, the interviewee's T&E responsibilities, in which weapon system domain the interviewee primarily worked, the interviewee's HSI experience / exposure), followed by a series of questions in each of the following areas: Testable Requirements Development, Test Strategy, Test Planning, Test Execution, Test Reporting, and Contractor Documentation. This discussion guide is included as Appendix C of this report.

Interviews were conducted in face-to-face settings, when possible, or by telephone, over a six-week period. Face-to-face settings included several HSI and T&E conferences that were scheduled to occur during the interview period. The study team planned to conduct interviews in conjunction with the following conferences:

- Department of Defense (DoD) Human Factors Engineering (HFE) Technical Advisory Group (TAG) meeting, Mesa, AZ
- Air Force Test Policy Conference, Peterson AFB, CO
- DoD Test Week, Huntsville, AL

After the first guide-driven interview, which occurred at the DoD HFE TAG, study team members determined that the interviewing process was too lengthy to fit with conference agendas and attendee priorities at those events. The study team used these conferences as opportunities to identify additional opportunities for HSI -T&E interaction, to establish contacts, and to arrange post-conference interview appointments. The discussion guide was also streamlined for subsequent interviews.

After conducting several interviews, respondent answers were found to be repetitively consistent and in agreement with workshop findings and with information collected during the Air Force CTA Conference which preceded the interview period; these findings are summarized below. The study team concluded that additional interviews would have diminishing returns; therefore, no further interviews were conducted and plans to attend DoD Test Week were abandoned.

Findings

There were numerous and diverse comments presented by the interview respondents. Many of the comments could be categorized according to the Workshop's "Top Five List". Those comments that did not fit into these five categories fell into a general category of institutionalizing HSI within the T&E culture. The specific findings are summarized and grouped in the following sections.

Guide the Development of Testable Requirements:

- **Writing HSI Requirements:** Respondents noted a void in the area of requirements criteria for human performance, making it difficult to write good requirements. In addition, quantifiable human reliability measures are needed. Standards call for modeling of human reliability, but this is not done well, particularly for end-to-end timelines (sensor-to-shooter). Operators, in order to be effective in stating user-driven requirements, need to attend requirements classes. Respondents also noted that non-mandatory/non-required[1] KPPs are not frequently seen in JCIDS documents, due in part to the "premium" placed on KPPs within the process for DoD acquisition programs. Finally, the back-end processes – supply chain, logistics tail, parts required, ability to repair – affecting availability have much HSI content and should be considered as valuable source material when developing HSI requirements.
- **Manpower, Personnel, Training:** Respondents noted that workload baseline studies are usually not performed in support of manpower estimates. Also, automation is sometimes used to artificially suppress manpower numbers, but can ultimately result in substantial increases in individual workloads.
- **Operating Concepts:** At least one respondent identified an OV-5 representation as the operating concepts of greatest tester interest. Operating concepts and enabling concepts, those required by operational testers, are equivalent to day-in-the-life (DITL) scenarios. DITL scenarios are useful because they help to execute "Test Like You Fly." They tell testers what people need to do on a daily basis to make the system work.
    - DITL scenarios are also used to develop evaluation questionnaires for HFE and logistics testing.

  Human-in-the Loop testing is used. Design engineers are replaced with a representative from a pool of actual users. This requires procedures that cover task performance time, errors, etc – non-functional requirements.
- **Outcomes:** It is possible to do a good job with requirements and a bad job with implementing them; the Space-Based Infrared System's ground segment was given as an example. Respondents also noted that a crew system can be barely effective but not suitable.

Insert HSI in T&E Guidance Documents:

- **Requirements Documents:** Testers verify and validate the requirements found in the JCIDS capability documents. They particularly need a solid Capability Development Document.
- **Air Force Policy Documents:** Some HSI guidance should be included in AFI 99-103, AFPAM 63-119, and AFI 63-101 to trigger T&E and acquisition practitioners to review and enhance HSI content in acquisition programs.

[1] While all KPPs must be met, the JCIDS manual specifically refers to "mandatory" and "required" KPPs; the use of "non-mandatory" and "non-required" is merely to distinguish the "mandatory" and "required" KPPs from KPPs that are developed for a specific capability.

- **Contract Documentation:** Contract language should state that contractors are required to test derived requirements. One respondent noted that compliance standards have been used very effectively by the Space and Missile Systems Center (SMC) to ensure contractors consider and include human-related issues and requirements. Another very useful guide is *Incorporating Test and Evaluation into Department of Defense Acquisition Contracts*, published by the Office of the Secretary of Defense.
- **Test Planning:** It was noted that test planning by government organizations is only one piece of the total test planning process. Test planning and test requirements must also be captured in the appropriate contract documentation to ensure development contractors are adequately planning for contractor-led tests. HSI is reviewing Requests for Proposals, including HSI in data information documents and placing HSI in the Systems Requirements Document (SRD). Ensuring the participating of contractor test personnel on ITTs will further support the goal of thorough test planning by development contractors.
- **Test Reports:** There should be a separate section for HSI-related results in test reports. HSI is often piggy-backed onto software testing, and as a result, HSI issues will end up being included in the software test reports. The Army's HSI Office (aka MANPRINT) instituted a separate safety section. There is a separate section for human factors in logistics test and evaluation reporting.

Link HSI to Other Tests:

- **Test Planning Methods:** The C-130J program developed an extremely comprehensive (referred to as "giant" by one respondent) test matrix to determine what was tested in which tests. This helped to ensure HSI testing was conducted at every possible opportunity.
  SMC uses a Critical Report Matrix (CRM) which is similar to a Deficiency Report (DR), but is generated at the front end of the program life cycle. The CRM is used to coordinate testing and to ensure critical issues are tested.
- **HSI Test Time:** Gaining access to the system for testing can be an issue for HSI, but once again, early tester involvement to make him/her aware of HSI testing needs is key. Ensuring that HSI requirements are properly flowed down into lower level specifications (which should lead to corresponding lower-level test plans and procedures) is also important.
- **Specialized Testing:** It is difficult to piggy-back noise testing onto other tests; it cannot be done when the system is being used (tested) for other purposes.

Improve Measurement Methods and Incorporate HSI:

- **Contract Documentation:** Government data requirements are not well specified in contract documentation. HSI personnel have trouble getting access to raw contractor data.
- **Methodologies:** Study methods, such as the Bedford or Modified Cooper, that were used for workload in the past, are not being used today. Interviewees also clarified qualitative vs. quantitative measures. People tend to equate subjective with qualitative measures and objective with quantitative. However, subjective measures can be quantified using human factors techniques. Larger sample sizes also help with quantifying subjective data. Following up questionnaires with interviews is a method of using quantified subjective data to identify actionable root causes. Finally, statistical analysis, to include use of scientifically based test design techniques such as Design of Experiments, is important to validate results.

- **Developmental Test:** Traditionally, developmental testing is rarely performed with real operators, particularly when fundamental system principles are being tested early in a test program. Integrated testing can provide an avenue to obtain real operators for more mature developmental test activities and to bring in experienced system operators from operational units for what may normally be characterized as developmental test events. It can also embed some variation from test to test when using multiple operators who each have particular preferences.
- **Operational Test:** There was disagreement about methods that could be used during operational test. At the workshop, it was asserted that operators (pilots) could not be instrumented, but interviews provided examples to the contrary. In one example, privacy and data security of pilot instrumentation results were key to operator acceptance of the instrumentation. It is not enough to have only the primary system operator representing the operational user when testing. For adequate testing, other crew positions should be included, as well as maintainers and other support personnel. Training is required on experimental psychology techniques that support shadowing operators during operational test.

Establish Approaches That Address Usability Shortfalls:

- **Suitability:** Operational suitability is evaluated in all operational testing. Some respondents said all testing was testing of suitability. Others said suitability was really tough to test. An October 29, 2009 meeting of senior acquisition personnel asserted that operational suitability is their biggest problem, but there is no Suitability or Usability KPP. Respondents said there would be except that suitability is difficult to measure quantitatively.
- **Ease of Test:** Some interviewees asserted that usability was routinely tested. Others said requirements were never written to drive usability testing. Some said usability was one of the toughest things to test. The study team concluded that usability was poorly understood. Usability of knobs and dials is hard for software and computer test people to address.

Institutionalizing HSI: Findings that did not clearly fit any of the five major categories previously identified are presented in a broader category of institutionalizing HSI within the T&E culture.

- **HSI Awareness:** Interviewees (both T&E and HSI SMEs) were generally unaware of the alignment between Air Force HSI organizations (the 711th HPW and AFHSIO) and their own organizations. For example, there were product center organizations that did not understand how the 711th was organized. Those interviewed expressed a desire to better understand what comprised HSI, what Air Force HSI resources were available, and how their organizations could better align with those resources.
- **Breadth of HSI Domains:** Organizations tended to address some of the HSI domains and not others. HFE was routinely addressed; the HFE person was customarily the one that integrated the other HSI domains. Treatment of Training, Personnel, Manpower and ESOH was organization-dependent. Few respondents mentioned Survivability and Habitability.
- **HSI Presence:** Within AFRL, HSI exists in the 711th HPW; there is no HSI presence in the other directorates. Sometimes it does not take much of a review to determine whether there are human issues, but the review needs to be conducted. It was asserted that this should be a 711th HPW function. Personal networking plays a strong role in HSI effectiveness. One respondent leveraged contacts in the two-letter organizations.

Standards tended to be associated with government two-letter organizations and each standard has a subject matter expert as a point of contact.

- **HSI in Deficiency Reporting:** There should be an HSI representative on Deficiency Review Boards (DRBs). Interviewees reported giving post-test briefs to DRBs; HSI inputs were ignored. It is possible DRB participants are not familiar with the performance and cost implications and so are not as comfortable with assessing the consequences of a human-related deficiency as they are a technology deficiency.
- **Training Requirements:** Maintainers should receive training in engineering terminology and processes so they are able to engage with engineers on common ground. A real training plan specific to HSI testing also needs to be developed. HSI testing is intangible and hard to do. The content should include small sample statistical methods, ESOH testing, questionnaire development, how to ask questions at test event debriefs, documenting the value of HSI and logistics testing, and how to "market" HSI and logistics testing to government and contractor program offices.

These bulleted findings were used to guide recommendations for including HSI in T&E policy and guidance documents and for selecting and populating examples for the Framework.

HSI in Test and Evaluation Documentation

During the initial workshop, it was determined that a highly effective way to include HSI guidance into existing T&E processes would be to review T&E policy and provide recommendations for HSI-related guidance in those documents. The workshop attendees identified this as the second highest priority issue after the need to guide the development of testable HSI requirements. Recommendations developed under this study would be submitted for the next update cycle of each of the impacted T&E documents.

At the recommendation of several T&E SMEs at the initial workshop and in other venues, the study team reviewed three particular T&E policy documents in which the inclusion of HSI would potentially have the greatest impact with regard to T&E processes.

Air Force Instruction (AFI) 99-103, Capabilities Based Test and Evaluation

This instruction is the primary policy document for T&E in the Air Force. It encompasses the entire T&E process across the acquisition life cycle. Figure 1 shows how T&E should start with early tester involvement even prior to the Materiel Development Decision that officially begins the acquisition life cycle. Testers are expected to be members of HPTs that meet to develop capabilities documents under the JCIDS process. These capabilities documents, the Initial Capabilities Document (ICD), the Capabilities Development Document (CDD), and the Capabilities Production Document (CPD) are used to guide the development of the technical requirements in the acquisition cycle. Early tester influence in developing these JCIDS documents helps ensure requirements are clear and testable, and can be effectively tested and evaluated throughout the acquisition process.

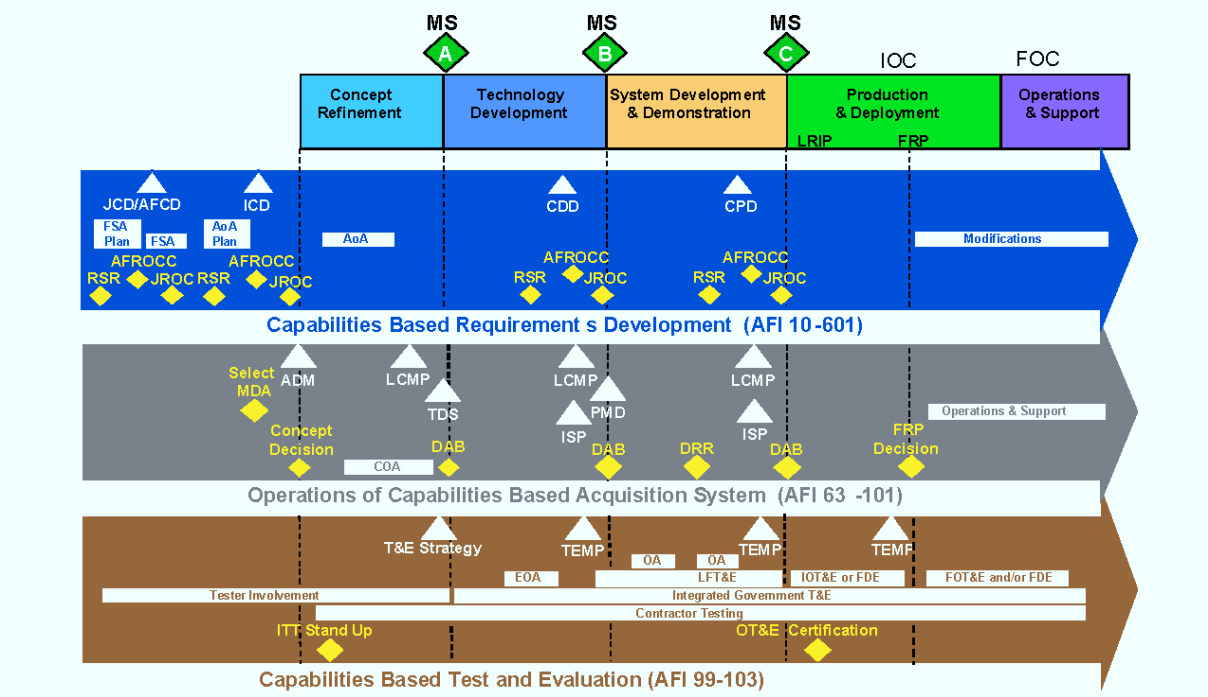

Figure 1. Integration of the Requirements, Acquisition, and T&E Processes

The study team recommended 24 specific insertions into the instruction that would strengthen HSI influence. Of particular note, the Air Force HSI Handbook is a recommended addition to the list of references, and the definition of HSI is a recommended addition to the "Terms." In addition, the study team provided 40 specific HSI "touch points" to provide HSI guidance when executing particular sections of the instruction. The complete list of recommended changes to AFI 99-103 is included in Appendix D of this report.

Air Force Manual (AFMAN) 63-119, Certification of System Readiness for Dedicated Operational Testing

This manual provides detailed guidance for ensuring a new or modified capability is ready for dedicated operational test and evaluation. AFMAN 63-119 contains a group of 32 different templates that address everything that is required in order to properly begin IOT&E. The templates are reviewed by a working group comprising personnel from the program office, the Operational Test Agency (OTA), the lead and supporting operational major commands, the prime contractor, and T&E oversight agencies. The series of template reviews culminates in a presentation to the Program Executive Officer (PEO) for him/her to accept the working group's recommendation that the program is ready to start IOT&E.

A Microsoft Excel workbook tool has been developed that permits the certification working group to assign a color code (red, yellow, or green) to each item in each template to graphically present the status of each template. This tool also recommends the responsible parties for each item. There is also a block for additional comments for each item.

The study team was able to make 50 specific recommendations for additional language in all but four of the 32 templates. The study team also recommended adding a specific HSI template to address those HSI-related issues that would not neatly fall into any of the other templates. In

addition, the study team provided 52 specific HSI "touch points" to provide HSI guidance when executing particular sections of the manual and templates.

Because AFMAN 63-119 focuses on a program's readiness to proceed into dedicated operational testing, there is a risk in relying on it as an all-inclusive assessment for a program's entire life cycle. For example, the training template addresses the training of the test team only. It does not provide an assessment of the complete training program for the capability. For instance, there may be cases in which the test team receives only that portion of the full training program which is required to successfully complete IOT&E. For these cases, the study team included a template item for the certification working group to clearly identify any gaps between the training requirements being assessed and the full requirements.

The complete list of recommended changes to AFMAN 63-119 is included in Appendix E of this report.

The Air Force Test and Evaluation Guidebook

This unofficial document provides detailed background information on the many facets of Air Force T&E. It is produced by AF/TEP. Detailed information has been segregated in the T&E Guidebook in order to keep T&E policy documents from becoming cumbersome and bogged down with information that is not directly relevant to the directives being presented. This detailed information is customarily referenced in T&E policy documents. The T&E Guidebook is an unofficial Air Force publication. It has not been updated since 2007.

The study team recommended 12 specific insertions into the Guidebook that would strengthen HSI influence. In addition, the study team provided 5 specific HSI "touch points" to provide HSI guidance when executing particular sections of the Guidebook to provide HSI guidance for reviewing acquisition programs. A complete list of recommended changes to the T&E Guidebook is included in Appendix F of this report.

HSI Touch Points in Other T&E Documents

The three T&E policy and guidance documents that the study team has impacted refer to other T&E policy and guidance documents. There are two particular references that bear additional consideration.

- The AF T&E Guidebook refers to the T&E Oversight List. Specifically, section 3.2.2 includes criteria for determining whether or not a program may be on the T&E Oversight List. The study team recommends adding a criterion for an "extremely high level of human-system interaction." Defining what is "extremely high" may be difficult to establish. In addition, concurrence from the Office of the Secretary of Defense would be required to add this criterion.

HSI T&E Touch Points in non-T&E Documents

The three T&E policy and guidance documents refer to several other policy and guidance documents that are not exclusively part of the T&E policy and guidance series.

- The integrated requirements, acquisition, and T&E process chart in Figure 1 includes events prior to the Materiel Development Decision (not shown in this version but prior to the Concept Refinement Phase in this figure). In order to fully impact what is sometimes referred to as "left of A", changes would need to be made to AFI 10-601, *Operational Capability Requirements Development*, and to the JCIDS process itself.

- Section 2.5 of AFI 99-103 refers to operational concepts. In the past eight to ten years, the definitions of operating concepts, operational concepts, concepts of operation, etc., have become clouded. While AFPD 10-28 (*Air Force Concept Development*) and AFI 10-2801 (*Air Force Concept of Operations Development*) have provided clarity for some of these definitions, some of the legacy definitions of an operating concept or concept of operations have continued to be referred to in the T&E processes. HSI mission task analysis techniques can contribute to generating operational concepts that supply the understanding, required for operational test, of how a capability is expected to be used and sustained.
- As previously mentioned in the introduction, this study was not able to address every area related to T&E. The following areas warrant additional attention because of their general importance to the T&E Community. The T&E Community collaborates with and influences these areas, but they are not under the T&E Community's control. These seven specific T&E related topic areas warrant additional attention:
    - AFI 99-103 refers to AFI 16-1002, *Modeling and Simulation (M&S) Support to Acquisition*. Because of the close relationship between T&E and M&S, the study team recommends an HSI review of this AFI and the parent DoD Directive 5000.59.
    - AFI 99-103 refers to AFI 63-104, *The SEEK EAGLE Program*. This program certifies the carriage of all non-nuclear internal and external stores on Air Force systems. Several HSI domains would be touched upon in the course of stores certification, recertification, and decertification. The study team recommends a more thorough HSI review of the SEEK EAGLE Program.
    - AFI 99-103 and the AF T&E Guidebook refer to Technical Order (T. O.) 00-35D-54, *USAF Deficiency Reporting, Investigation, and Resolution*. The deficiency reporting (DR) process was originally established to identify production and manufacturing defects in the field. It was not originally developed to capture deficiencies during early T&E stages, and it was especially not designed for software-intensive or HSI-related deficiencies. The study team recommends a thorough HSI review of the AF DR process, to include T. O. 00-35D-54, AFI 63-501 (*Air Force Acquisition Quality Program*), and T. O. 00-5-1 (*Air Force Technical Order Program*).
    - It is suggested in AFMAN 63-119 to use its templates in conjunction with DoD 4245.7M, *Transition from Development to Production*, aka "the Willoughby Templates". The study team recommends an HSI review of DoD 4245.7M.
    - There is a very close relationship between the Operational Safety, Suitability, and Effectiveness (OSS&E) process as defined by AFI 63-1201, *Life Cycle Systems Engineering*, and the T&E process, particularly during developmental test. The study team recommends an HSI review of AFI 63-1201 and the OSS&E process.
    - The AF T&E Guidebook refers to AFI 63-114, *Rapid Response Process*, and rapid acquisition process in general. The study recommends an HSI review of AFI 63-114 and the rapid acquisition process.
    - AFI 99-103 refers to AFI 63-103, *Nuclear Weapons Program Management*, and AFI 63-125, *Nuclear Certification Program*. The study team recommends an HSI review of both of these AFIs.

TES/TEMP/Defense Acquisition Guidebook (DAG) Chapter 9

The TES and TEMP have prominent roles in the T&E process. A related effort for the AFHSIO to provide recommended HSI guidance for developing a TES or TEMP includes detailed

comments. Making specific comments against the existing outlines for a TES or TEMP will require recommending updates to Chapter 9 of the DAG.

JCIDS Documentation

The study team initially considered reviewing samples of actual JCIDS capability documents to determine how well HSI-related language was being incorporated in capability statements. The study team concluded that examining this in the context of the third course of action (T&E Framework) would provide a larger return on investment.

The Test and Evaluation Framework

At the January 2010 Workshop, Mr. Chuck Triska (AF/TEP) unveiled the Top-Level [T&E] Evaluation Framework Matrix ("Framework") to the HSI community using the notional example shown in Figure 2.

Key Requirements and T&E Measures				**Test Methodologies/Key Resources (M&S, SIL, MF, ISTF, HITL, OAR)**	**Decision Supported**
Key Reqs	**COIs**	**Key MOEs/ MOSs**	**CTPs & Threshold**		
KPP#1:	**COI #1.** Is the XXX effective for…	**MOE 1.1.**	Engine thrust	Chamber measurement Observation of performance profiles OAR	PDR CDR
	COI #2. Is the XXX suitable for…		Data upload time	Component level replication Stress and Spike testing in SIL	PDR CDR
	COI #3. Can the XXX be…	**MOS 2.1.**			MS-C FRP
		MOE 1.3.			Post-CDR FRP
		MOE 1.4.	Reliability based on growth curve	Component level stress testing Sample performance on growth curve Sample performance with M&S augmentation	PDR CDR MS-C
KPP #2		**MOS 2.4.**	Data link		MS-C SR
KPP #3	**COI #4.** Is training….	**MOE 1.2.**		Observation and Survey	MS-C FRP
KSA #3.a	**COI #5.** Documentation	**MOS 2.5.**			MS-C FRP

Figure 2: Top-Level T&E Evaluation Framework Matrix – notional example.

The Framework has been a required section of TESs and TEMPs since 2009. The Framework's purpose is to show the correlation between the KPPs/KSAs, Critical Test Parameters (CTPs), key test measures (i.e., Measures of Effectiveness (MOEs) and Measures of Suitability (MOSs), planned test methods, and key test resources, facility or infrastructure needs. When structured this way, the Framework should describe the most important relationships between the types of testing that will be conducted to evaluate the JCIDS requirements and all other T&E methods. Only the top-level measures are listed.

At the Workshop, the Framework was identified as a primary opportunity for including HSI in T&E processes. It simultaneously addresses all of the Top Five issues listed in this report as it

captures requirements, is required for the TES and TEMP, links HSI to existing tests, and contains measurement methods that could include usability. Attendees at the Workshop debrief made the Framework an area of focus for subsequent study work.

The study team's goal was to first use relevant KPPs called out in the *Manual for the Operations of the Joint Capabilities Integration and Development System* to create HSI-related examples. Additionally, the study team set, as a goal, the development of at least one example for each of the nine HSI domains, plus at least one for the HSI integration function. Table 1 lists the KPPs that were used for example creation, the degree to which the KPP is required (e.g. mandatory, required or selectively applied), and the relevance of the KPP to HSI.

Table 1: KPPs used to Create HSI-related Framework Examples

JCIDS KPP	KPP Type	HSI Relevance
Survivability (of a manned system)	Mandatory	Survivability Domain: The characteristics of a system that reduce detection, and the probability of being attacked.
Force Protection	Mandatory	Survivability Domain: The characteristics of a system that reduce risk of fratricide, and that enable the crew to withstand man-made or natural hostile environments without aborting the mission or suffering acute and/or chronic illness disability, or death.
Sustainment – Includes:		
Availability KPP	Required	Availability of a materiel system relies not only on hardware and software readiness, but also on human readiness. Thus Availability relates to manpower, personnel and training as well as to occupational health and safety.
Reliability KSA	Required	Mean Time To Repair is a reliability measure that relates to designs that facilitate rapid access, understandability, parts manipulation and availability. These are enabled by good human factors engineering practice.
Ownership Cost KSA	Required	Manpower, personnel and training customarily represent the largest life-cycle expenditures. Additionally, medical care and personnel replacement costs associated with occupational health and accidents can represent a life-long Air Force investment. Finally, survivability and habitability failures result in workforce attrition from which recruitment and training costs will result.
System Training	Selectively Applied	Often the costs of design deficiencies are pushed out to the deployment and operations segment in the form of additional system-specific training. Training, as an HSI domain, must be integrated into the life-cycle management plan. For the ever more prevalent embedded training, the training system is an integral part of the core capability. HSI is required to integrate training expertise and balance training needs along with other mission requirements.

While the study demonstrated the applicability of the mandatory Net Ready KPP and selectively applied Energy Efficiency KPP, this exercise was completed once the examples were already being vetted by T&E and HSI SMEs. As a result, these two KPPs were not included for the examples created.

The study team produced 26 HSI-specific examples for the Framework that capture measurable, objective requirements for developmental and operational testing and relate them to technical parameters and test methods. Examples are contained in Appendix G of this report. The 26 representative measures are intended for use by HSI and T&E personnel for recording associated top-level test measures, parameters, and resources.

The examples were vetted with T&E and HSI community representatives. The T&E Community looked at the categorization of KPPs and KSAs, and also looked at the phrasing of COIs, MOEs, MOSs, and CTPs. These were judged as correct and representative. The HSI community reviewed the threshold values and the test methods for correctness. Comments from both communities were incorporated into the examples.

Concerns about the Examples

The 26 examples are considered realistic and representative but not comprehensive. They do not fit all HSI contexts and cannot be generalized to all systems or even system types. There may be key MOEs and MOSs that are not included in the examples.

A concern, shared by the project's government sponsor, was that programs would inappropriately cut and paste the framework examples listed in Appendix G, without the necessary tailoring, into program documentation and thus skew development and test outcomes such that weaker, not stronger, capabilities resulted. The examples are intended to help people from the T&E and HSI communities think through the requirements and T&E documentation process. The examples should be tailored by a program to fit their needs; they should not be adopted without analysis and consideration of context.

In response to this concern, a tentative decision was made to subsequently craft a more comprehensive library of Framework examples primarily for use by HSI practitioners. Because this follow-on work is anticipated, the next section describes the process by which the study team created the examples.

Finally, several T&E SMEs indicated HSI considerations should be captured in COIs, MOEs, or MOSs. However, there was concern about the number of COIs that will be permitted by the user commanders who define requirements. At the workshop, it was asserted that some commanders are limiting the number of COIs associated with a KPP, and the rule of thumb is to keep the number of COIs to a minimum. However, HSI issues would more likely be addressed below the COI level (probably as MOEs or MOSs).

Additionally, in discussions with logistics test representatives at Edwards AFB, occasions were noted when non-mandatory KPPs for Decontamination, Operability and RAM (reliability, availability and maintainability) were used. For the RAM KPP, supportability and deployability were COIs. Thus, it can be seen that the same term can serve several purposes in the framework.

The Process Used to Create the Examples

In order to create examples, a representative system needed to be used to help illustrate examples. Many times, the systems used were those that were recently and currently being developed by the Air Force. Doing so made it easier for the study team to devise COIs associated with the system. For example, the B-2, two-pilot manning example was used because it was familiar to study team members. Unmanned Aircraft Systems were selected because the issues were familiar, and the COIs were relevant.

Identifying the system and establishing the COIs were the most critical parts of the process. Once completed, the COIs, MOEs, and MOSs were stated in question form so that testers could answer the questions affirmatively or negatively at the conclusion of developmental or operational testing.

The MOEs and MOSs were explored to develop the more detailed CTPs. While some HSI-related parameters are qualitative in nature, and even though the T&E Community readily understands that many system attributes are qualitatively evaluated, the study team determined that quantifiable examples were preferred for the audience that the study team intended to reach. This was the audience of stakeholders which was wont to assert that HSI-related requirements were not testable.

The CTPs selected were, for the most part, those that resulted in hard numbers being generated from accepted measurement methods and testing devices. Usability CTPs were included in multiple examples in order to address top issue number five from the workshop, "improve usability testing." Included in this group was an intuitive user interface parameter which required comparison of human performance between trained and untrained users; the interface was judged intuitive if it could be successfully used to satisfy mission requirements in the absence of system-specific training.

Presentation of the Examples

Initial versions of the examples were indexed by HSI domain and KPP. These appeared in two additional left-hand columns not found in Figure 2 (adding columns was strictly for the benefit of comprehensibility of the examples – there is no recommendation to formally change the Framework structure). The capability (or system) type was not included in the presentation.

Reviewers found it difficult to make sense of the examples in the absence of a system context. The Framework was subsequently modified (again for the purposes of these examples only) to add a third column on the left which gave the system type. In the opinion of reviewers, this increased the comprehensibility of the examples.

When the examples were shown to HSI representatives, there was disagreement on the HSI domains that were used to index specific examples. The study team believes this illustrates the synergistic quality of the domains which are relevant to definition, but perhaps less so to practice. There is a good deal of overlap between occupational health risk and human factors designs, for example. The disagreements on attributed domains inhibited review of the rest of the table. It was subsequently postulated that removing the domains and indexing the examples by system type would facilitate understanding and streamline review. This inference turned out to be true.

The set of examples sent out to the communities including a column for KPP/KSA and a second column for system type. The remainder of the Framework was as it is shown in the notional example in the figure above.

Feedback on the Examples

In the table above, HSI relevance to JCIDS KPPs was shown. While these relationships are demonstrable from the definitions of the KPPs and the HSI domains, the traditional interpretations of the Survivability and Availability KPPs, as examples, do not include HSI as the study team related it. Discussions with ASC/AQT representatives acknowledged the relationship, but suggested that an explanation of the relevance of the examples provided to the KPPs in question would serve to make those examples more useful.

It should be emphasized that the importance of the measures in the Survivability and Availability examples was not questioned, merely the names of the KPPs that were used to create those examples. These examples were modified to include footnotes explaining the use of the terms "Survivability" and "Availability" in this context. Additionally, some terms used as KPPs were thought instead to be KSAs by reviewers, and the supported decisions in the final column were corrected by reviewers in some cases.

After the review by ASC/AQT, all of the examples were reordered to de-emphasize the Survivability and Availability examples prior to sending them out to a broader T&E audience. This was done so that traditional understanding of these KPPs would not cause reviewers to reject them out of hand. KPPs that were not defined as "mandatory" were re-labeled as KSAs. Decisions supported were reviewed and changed as recommended.

Feedback was also received on the CTPs and test methods from the HSI community. Representatives of the AFFTC rigorously scrutinized the examples, corrected several of the CTPs and added both qualitative and quantitative test methods. These recommendations were also incorporated. This feedback increased the study team's confidence in the examples.

Value of the Examples

The study team was unable to discover previously completed Framework examples. The HSI Framework examples developed by the study team may be the first to exist anywhere. This situation provides an opportunity for HSI to deeply penetrate the T&E Community. This was illustrated by the ASC/AQT representatives who were encouraging the study team to work with training and community of practice representatives to embed the examples in the material of those organizations.

Recommendations and Conclusions

The study team collected numerous and diverse findings throughout the course of this study. Many of the findings have been already presented throughout this report.

- The study team took the findings of the January Workshop and, with the help of the Workshop attendees, was able to develop them into five major issues (testable requirements; guidance documents; linkages with existing tests; improved measurement methods; and usability shortfalls) and three focus areas.
    - Interviews with T&E and HSI SMEs resulted in numerous issues that continue to need attention by the T&E Community.

  - Review of primary T&E policy and guidance resulted in nearly 200 recommendations for specific HSI guidance in T&E policy as well as "touch points" for HSI awareness while executing T&E policy (see Appendices D, E, and F).
    - Each T&E policy document follows a rigorous change process. SURVIAC recommends continual client involvement in this change process to ensure the recommendations of this study provide the optimal HSI guidance within T&E policy. Barring full incorporation of the recommended policy changes, SURVIAC recommends publishing these recommended changes in a Guidebook. In addition, SURVIAC also recommends the development of a suggested HSI template for AFPAM 63-119 to be presented to AF/TEP.
    - As this study effort was unable to sufficiently address many topic areas sharing common ground with the T&E Community. Such topic areas where overlap occurs are: foreign materiel testing, modeling & simulation, stores carriage certification, deficiency reporting, transition to production, OSS&E, rapid acquisition, and nuclear weapons life cycle management. SURVIAC recommends further HSI focus on these topic areas to ensure complete coverage of HSI in these areas related to T&E.
  - Development of HSI-specific examples for the new T&E Framework was able to address all five major issues identified at the January Workshop.

The study team also concluded there were three themes that were broader than the initial areas of work, January Workshop findings, or findings from the three focus areas.

- **HSI Integration with T&E Process:** The Air Force T&E process is distributed over a number of organizations. While there is a centralized policy office, application of that policy is decentralized. Furthermore, missions vary from organization to organization, which necessitate differences based on test phase (DT, OT, sustainment), acquisition phase, product domain (aircraft, armament, Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance, space), and other categorizations. This has made it more challenging to develop a standardized approach to integrating HSI in T&E.
  - SURVIAC recommends that the HSI community increase its network of contacts within the T&E Community at every opportunity. This will include not only links between the 711th HPW and test organizations, but will also include creating connections between HSI domain practitioners and the T&E Community.

- **HSI Awareness:** Awareness of HSI within the T&E Community is weak. Most personnel with whom the study team interacted had heard the term HSI, but equating HSI with Human Factors Engineering remains prevalent. The T&E Community, both AFMC and SMC, are working to rebuild their workforce. The human factors presence, once a strong link to HSI, has become depleted as well. Training courses are being developed and modified for test managers. There is an opportunity to incorporate HSI into these courses.
  - SURVIAC recommends supporting AFHSIO education and training initiatives, some which are already ongoing, to include more HSI in T&E training, and more T&E in HSI training, and to support that initiative with materials and findings from this study as required.

- **T&E Framework:** The recent introduction of the T&E Framework has provided HSI with a key opportunity to address many of the issues raised at the January Workshop (including each issue on the Workshop "Top Five List"). It is necessary to remember that while these T&E Framework examples are realistic and representative, they are still contrived and cannot be over-generalized; they must not be lifted directly into a TEMP without significant amounts of situational-specific analysis.
    - SURVIAC shares the recommendation of this project's government sponsor to create a library of Framework examples for HSI SMEs to use as guidance while working with the T&E Community.

Appendix A: Glossary of References and Supporting Documentation

Air Force Human Systems Integration Handbook, http://www.wpafb.af.mil/shared/media/document/AFD-090121-054.pdf.

Air Force Instruction 10-601, *Operational Capability Requirements Development*, 12 July 2010.

Air Force Instruction 16-1002, *Modeling and Simulation (M&S) Support to Acquisition*, 1 June 2000.

Air Force Instruction 63-101, *Acquisition and Sustainment Life Cycle Management*, 17 April 2009.

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Air Force Instruction 63-104, *The SEEK EAGLE Program*, 21 January 2005.

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Air Force Instruction 63-501, *Air Force Acquisition Quality Program*, 31 May 1994.

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Defense Acquisition Guidebook, https://dag.dau.mil/Pages/Default.aspx.

Department of Defense 4245.7M, *Transition from Development to Production*, September 1985, with Change 1, 13 February 1989.

Department of Defense Instruction 5000.02, *Operation of the Defense Acquisition System*, 8 December 2008.

Manual for the Operations of the Joint Capabilities Integration and Development System, 31 July 2009.

Appendix B: Glossary of Abbreviations and Acronyms

711HPW/HPO	Air Force 711th Human Performance Wing/Human Performance Optimization Division
AF	Air Force
AF/TEP	Air Force Test and Evaluation Directorate, Policy and Programs Division
AFHSIO	Air Force Human System Integration Office
AFI	Air Force Instruction
AFMAN	Air Force Manual
AFMC	Air Force Materiel Command
AFPAM	Air Force Pamphlet
AIAA	American Institute of Aeronautics and Astronautics
ANSI	American National Standards Institute
ASC	Aeronautical Systems Center
ASC/AQT	Aeronautical Systems Center/Center Test Authority
CDD	Capabilities Development Document
CDRL	Contract Data Requirements List
CLIN	Contract Line Item Number
COI	Critical Operational Issue
CPD	Capabilities Production Document
CTA	Center Test Authority
CTP	Critical Test Parameter
DAG	Defense Acquisition Guidebook
DoD	Department of Defense
DoDI	Department of Defense Instruction
DR	Deficiency Report / Deficiency Reporting
DRB	Deficiency Review Board
ESOH	Environment, Safety, and Occupational Health
HFE	Human Factors Engineering
HPW	Human Performance Wing
HSI	Human Systems Integration
ICD	Initial Capabilities Document
IOT&E	Initial Operational Test and Evaluation
ITT	Integrated Test Team
JCIDS	Joint Capabilities Integration and Development System
KSA	Key System Attribute
KPP	Key Performance Parameter
MOE	Measure of Effectiveness
MOS	Measure of Suitability
OTA	Operational Test Agency
OV	Operational View
PEO	Program Executive Officer
SME	Subject Matter Expert

SURVIAC	Survivability and Vulnerability Information Analysis Center
TAG	Technical Advisory Group
T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
TES	Test and Evaluation Strategy
T.O.	Technical Order

Appendix C: Interview Discussion Guide

The Air Force Human Systems Integration Office and the 711th Human Performance Wing are interested in the amount of interaction of human systems integration (HSI) in the DoD acquisition cycle. The following questions specifically deal with the interaction of HSI with test & evaluation (T&E). Unless otherwise stated, please relate these questions to your current work assignment.

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YOUR HSI-in-T&E BACKGROUND

What is your primary role in the T&E process?

a. Capability Requirements Definition
b. T&E Policy
c. Verification Planning – during requirements development
d. T&E Planning
e. T&E Execution
f. T&E Verification and Validation
g. Other: _____

Please briefly describe your primary T&E responsibilities:

In which weapon systems domain do you primarily work?

a.	Aeronautics	☐	Product	☐	Logistics	☐	Technology Dev.
b.	Armament	☐	Product	☐	Logistics	☐	Technology Dev.
c.	C2ISR	☐	Product	☐	Logistics	☐	Technology Dev.
d.	Space	☐	Product	☐	Logistics	☐	Technology Dev.
e.	Nuclear Weapons	☐	Product	☐	Logistics	☐	Technology Dev.
f.	Personnel Equipment*	☐	Product	☐	Logistics	☐	Technology Dev.

g. Other: _____

*e.g., night vision goggles, etc.

If you are an HSI professional, in which domains do you routinely work? (check all that apply)

☐ Manpower
☐ Personnel
☐ Training

☐ Environment

☐ Safety
☐ Occupational Health

☐ Human Factors Engineering
☐ Habitability

☐ Survivability

☐ Others? _____ _____ _____

- How do you reach out to the HSI domains in which you have less expertise?

In your experience, who brings the considerations of the domains together?

- What is the process for making this happen?

If you are not an HSI professional, with which HSI domains do you routinely work? (check all that apply)
☐ Manpower
☐ Personnel
☐ Training

☐ Environment
☐ Safety
☐ Occupational Health

☐ Human Factors Engineering
☐ Habitability

☐ Survivability

☐ Others? _____ _____ _____

- How do you reach out to the other HSI domains?

In your experience, who brings the considerations of the domains brought together?

- What is the process for making this happen?

How does including HSI in test contribute to confidence in a system's mission effectiveness?

YOUR ROLE IN TESTABLE REQUIREMENTS DEVELOPMENT
Are you currently, or have you in the past been, involved with requirements development for

☐ Initial capability documents (ICDs)?

☐ Capability development documents (CDDs)?
☐ Capability production documents (CPDs)?

☐ System Requirements Documents (SRDs)?
  ☐ Requirements Development?
  ☐ Documenting Verification and Validation Approaches?
☐ Source Selection Reviews?

☐ Review of Contractor-Developed Specs?
☐ Participation in Design Reviews?

☐ Others? _____ _____ _____

What resources do you routinely use when developing requirements?

- Specific Documents?
- Specific Web Sites?
- Specific Organizations?
- Specific Personnel?
- Other?

- Have you ever served on a High Performance Team (HPT)? ☐ Yes ☐ No ☐ Don't know what an HPT is.
  - If yes, what mechanisms did you use to "reach back" to others in your profession?

- Are you a certified requirements manager? ☐ Yes ☐ No
  i.e., Passed DAU CLM 041 and RQM 101?

- Have you ever known of a T&E professional who has supported an HPT? ☐ Yes ☐ No
  - If yes, what mechanisms did they use to "reach back" to other T&E professionals?

- Have you ever known of a HSI professional who has supported an HPT? ☐ Yes ☐ No
  - If yes, what mechanisms did they use to "reach back" to other HSI professionals?

What do you believe is the most appropriate role for an HSI professional on an HPT?

How do you believe the T&E professional on an HPT should reach out to HSI domain experts?

How do you believe the HSI professional on an HPT should reach out to other HSI domain experts?

Example for Discussion Leaders:
- Well-defined requirements are:
  - Specific
  - Measurable
  - Achievable
  - Traceable to user need
  - Testable

- How can well defined and testable HSI requirements be included in ICDs, CDDs, or CPDs?

- Mandatory KPPs, as defined in the July 2009 MANUAL FOR THE OPERATION OF THE JOINT CAPABILITIES INTEGRATION AND DEVELOPMENT SYSTEM (JCIDS), are listed below.
  - Survivability
  - Force Protection
  - Sustainment
    - Availability
    - Reliability
    - Ownership Cost
  - Net Ready
  - System Training
  - Energy Efficiency

- Have you seen mandatory KPPs used to motivate HSI in requirements documents?

Mandatory KPP
Survivability? ☐ Yes ☐ No How? _____

Force Protection? ☐ Yes ☐ No How? _____

Sustainment? ☐ Yes ☐ No How? _____
Availability? ☐ Yes ☐ No How? _____
Reliability? ☐ Yes ☐ No How? _____
Ownership Cost? ☐ Yes ☐ No How? _____

Net Ready? ☐ Yes ☐ No How? _____

System Training? ☐ Yes ☐ No How? _____

Energy Efficiency? ☐ Yes ☐ No How? _____

Others? _____ _____ _____

- Have you seen cases when HSI requirements were motivated by – KPPs that are not on the mandatory list? ☐ Yes ☐ No
  How? _____

- What is the relationship between KPPs, KSAs, APAs and critical operational issues (COIs)? For example, are KPPs used directly to develop COIs?

- How can HSI be included in critical operational issues, measures of effectiveness, measures of suitability, and measures of performance?

- What is the relationship between measures of effectiveness, measures of suitability, and measures of performance and critical test parameters? For example, does each measure of effectiveness map directly to a critical test parameters? multiple critical test parameters?

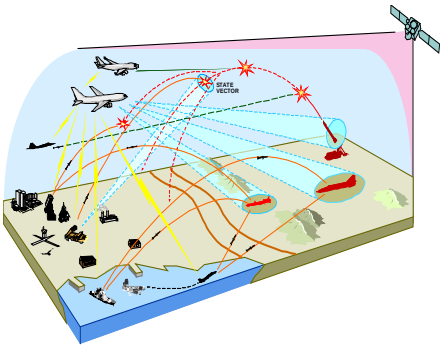
- How do you personally review candidate requirements to assure they are testable? What do you look for? Think about?

Many HSI requirements are derived from "operating concepts". What is your understanding of what an "operating concept" is?

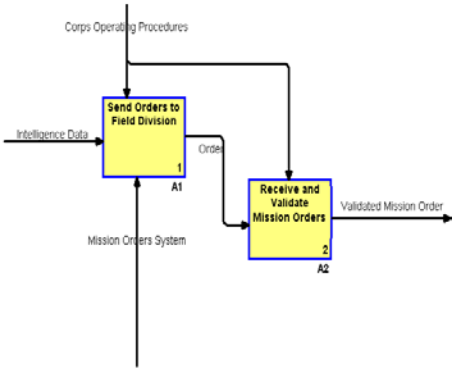
How do you obtain "operating concepts"? Who creates them?

Are DoDAF architecture products, such as the High-Level Operational Concept Graphic (OV-1) or the Operational Activity Model (OV-5b) used to support test requirements development?

Illustrative example for discussion leaders to use if needed.



OV-1 Example



OV-5 Example

Some HSI requirements are dismissed by HPT members because they're not considered testable. HPT members seem to be unfamiliar with human systems test and measurement techniques. Can you think of a way this could be addressed?

- What test measures would you recommend to satisfy these concerns?

What specific programs (name, series) with which you're familiar did a good job of crafting testable HSI requirements?

ALIGNING HSI WITH T&E

How are HSI people contacted for support to T&E activities?

- Given the breadth of the nine HSI domains, how are you assured you will have the "right" HSI person for each task?

What qualifications should an HSI professional possess in order to successfully participate in the T&E process?

What techniques should be used to maintain the "visibility" of HSI throughout the life cycle?

TEST PLAN DOCUMENTATION – STRATEGIES AND MASTER PLANS

Are you currently or have you in the past been involved with developing ☐ Yes ☐ No

test strategy and test master planning?

What resources do you routinely use when developing strategies and master plans?

- Specific Documents?
- Specific Web Sites?
- Specific Organizations?
- Specific Personnel?
- Other?

Have you ever served on an Integrated Test Team (ITT)? ☐ Yes ☐ No

If yes, what mechanisms did you use to "reach back" to others in your profession?

Have you ever known of a T&E professional who has served on an ITT? ☐ Yes ☐ No

If yes, what mechanisms did they use to "reach back" to other T&E professionals?

Have you ever known of an HSI professional who has served on an ITT? ☐ Yes ☐ No

If yes, what mechanisms did they use to "reach back" to other HSI professionals?

What do you believe is the most appropriate role for an HSI professional on an ITT?

How do you believe the HSI professional on an ITT should reach out to other HSI domain experts?

Which HSI tests should be performed in Developmental Test & Evaluation (DT&E)?

What HSI tests can be performed in Operational Test & Evaluation (OT&E)?

What are the constraints?

How do HSI tests break out between tests of mission effectiveness and logistics tests?

In which tests are HSI attributes customarily included?

Which HSI attributes are generally tested in performance tests?

Which HSI attributes are generally tested in logistics tests?

What programs with which you're familiar did a good job of crafting strategies and master plans that effectively incorporated HSI requirements in big-picture testing plans?

TEST PLAN DOCUMENTATION – TEST EXECUTION PLANS AND PROCEDURES

Are you currently or have you in the past been involved with developing test plans and procedures? ☐ Yes ☐ No

What resources do you routinely use when developing test plans and procedures?

- Specific Documents?
- Specific Web Sites?
- Specific Organizations?
- Specific Personnel?
- Other?

Have you successfully included HSI requirements into test plans and procedures? ☐ Yes ☐ No

Have you successfully included HSI metrics into test plans and procedures? ☐ Yes ☐ No

Have you interacted with human factors engineers in developing test plans and procedures? ☐ Yes ☐ No

What do you believe is the most appropriate role for an HSI professional in developing test plans and procedures?

How do you believe the T&E professional involved in developing test plans and procedures should reach out to HSI domain experts?

How do you believe the HSI professional who is involved in developing test plans and procedures should reach out to other HSI domain experts?

Does HSI T&E ever occur before milestone B?

What language have you used to specify test criteria so the human is included (human-in-the-test-loop) in the performance requirement being tested (e.g., timing a test to include user understanding of situation and subsequent execution of keystroke)?

Do you use or know of a resource or repository that lists and describes tests related to human performance and suitability? ☐ Yes ☐ No

What resources exist?

What objective HSI measures can be collected during flight test (DT&E or OT&E)?

Have you ever used the SWOT method (**S**trengths, **W**eaknesses, **O**pportunities, and **T**hreats) for workload measures? ☐ Yes ☐ No ☐ Never heard of

Have you applied SWOT results to test? ☐ Yes ☐ No

- DT&E? ☐ Yes ☐ No
- OT&E? ☐ Yes ☐ No

Are you familiar with the Design of Experiments (DOE) process? ☐ Yes ☐ No ☐ Never heard of

Have you ever participated in a DOE analysis? ☐ Yes ☐ No

Was the DOE related to test design? ☐ Yes ☐ No

How is logistics suitability evaluated?

How can HSI attributes of cross-platform interoperability (e.g., usability) be measured?

What programs with which you're familiar did a good job of crafting execution test plans and procedures that effectively incorporated HSI requirements in big-picture testing plans?

TEST EXECUTION

Are you currently or have you in the past been involved in conducting tests and/or analysis of test data? ☐ Yes ☐ No

How would you generally characterize the types of T&E you perform?

Have you interacted with human factors engineers in conducting tests and/or analysis of test data? ☐ Yes ☐ No

What do you believe is the most appropriate role for an HSI professional involved in test execution and/or analysis of test data?

How do you believe the T&E professional involved in test execution and/or analysis of test data should reach out to HSI domain experts?

How do you believe the HSI professional involved in test execution and/or analysis of test data should reach out to other HSI domain experts?

What qualifications should testers have in order to successfully conduct tests with HSI implications?

If users are used to evaluate HSI implementations (e.g., human-system interfaces), how have you avoided having the design being skewed by single-user preferences?

How are human test participants selected?

What processes are used to qualify system operators as test subjects?

What processes are used to qualify system maintainers as test subjects?

What infrastructure tools are missing for human performance measurement?

- In DT&E?

- In OT&E?

Have you ever used small end statistical methods? ☐ Yes ☐ No ☐ Never heard of

When?

How do you factor system safety (what has been designed into the system) into test planning and execution?

Do HSI concerns factor into the OT&E readiness certification? ☐ Yes ☐ No

Are HSI reps ever involved? ☐ Yes ☐ No

TEST REPORTS AND DEFICIENCY REPORTING

Where are HSI-related test results documented?

Are you currently or have you in the past been involved with deficiency reporting? ☐ Yes ☐ No

How can users be included in acceptance review of watch list items prior to conversion to deficiency reports?

How can HSI be considered during Deficiency Review Board (DRB) deliberations?

What do you believe is the most appropriate role for an HSI professional on a DRB?

How do you believe the T&E professional on a DRB should reach out to HSI domain experts?

- How do you believe the HSI professional on a DRB should reach out to other HSI domain experts?

CONTRACTOR DOCUMENTATION

Have you ever supported definition of contractor documentation? ☐ Yes ☐ No

Request for Proposal (RFP)? ☐ Yes ☐ No

Statement of Work (SOW)? ☐ Yes ☐ No

Data Information Documents (DIDs)? ☐ Yes ☐ No

Contract Data Requirements Lists (CDRLS)? ☐ Yes ☐ No

Contract Line Item Numbers (CLINS)? ☐ Yes ☐ No

System Requirements Document (SRD)? ☐ Yes ☐ No

Have you been successful in inserting HSI considerations into these documents ☐ Yes ☐ No

Why?

Can you think of programs which did a good job of incorporating HSI into contractor documents? ☐ Yes ☐ No

Please provide program names if possible.

Name some ways in which you think HSI incorporation in contractor test could be improved.

PROCESS IMPROVEMENT

If you can, name a mechanism, repository or tool that would provide the HSI community with insight into human interface issues that are being found on systems during development or operations?

Appendix D: Recommendations to AFI 99-103, Capabilities-Based Test and Evaluation

This appendix contains recommendations for modifications to AFI 99-103. Recommended additions or modifications are in red. Because the study sought interaction points between the HSI and T&E processes, the "HSI Touch Point" column is included to indicate HSI activities associated with those described in the AFI that would improve HSI's treatment in T&E or, more generally, in acquisition. Red indicates additions to existing text.

Section	Section Title	As Is	Recommended	HSI Touch Point
1.1	Purpose of Test and Evaluation	-	-	HSI is strongly related to OSS&E (mission capability). Incorporate HSI into T&E to identify HSI-related risks.
1.1.1	-	-	-	Collaborate with T&E personnel.
1.1.2	-	-	-	Provide test results to HSI Status Board.
1.1.3	-	Help manage risks during engineering, acquisition, fielding, and sustainment by accurately characterizing system technical and operational performance throughout the system life cycle.	Help manage risks during engineering, acquisition, fielding, and sustainment by accurately characterizing system technical, human and operational performance throughout the system life cycle.	-
1.1.4	-	Help the acquisition and sustainment communities acquire and maintain operationally effective, suitable, survivable, and secure systems for Air Force operators.	Help the acquisition and sustainment communities acquire and maintain operationally effective, suitable, safe, survivable, and secure systems for Air Force operators.	-
1.1.5	-	-	-	Support refinement of Tactics, Techniques and Procedures.

Section	Section Title	As Is	Recommended	HSI Touch Point
1.2.2	Collaborative Concepts and Processes	-	-	In order to be able to impact "Left-of-A", AFI 10-601 and the JCIDS Process must be impacted.
1.3	Seamless Verification	-	-	Integrate HSI tests with other T&E efforts via the TES, TEMP and test plans. Ensure T&E databases are configured to include HSI-related parameters.
1.3.2	-	Refocuses T&E of materiel solutions on capabilities-based requirements and operational mission needs instead of traditional pass-fail measurements of specification-like requirements.	Refocuses T&E of materiel solutions, including the human elements, on capabilities-based requirements and operational mission needs instead of traditional pass-fail measurements of specification-like requirements.	Help to define operating concepts for systems.
1.4	Integrated Test Team	ITT membership will include representatives from the responsible test organization (RTO), operational test organizations, participating test organizations (PTO), system contractors, and the acquisition, requirements, intelligence, operations, and support communities.	ITT membership will include representatives from the responsible test organization (RTO), operational test organizations, participating test organizations (PTO), system contractors, and the acquisition, requirements, Human Systems Integration (HSI), intelligence, operations, and support communities.	Have HSI representation on ITT. Set up a reachback network for ITT HSI rep to enable lifeline contact with domain specialists for detail questions.
1.5.1	Tailoring	-	-	Contribute to identify operators' requirements prior to the Material Development Decision.
1.5.3	Early Deficiency Resolution	-	-	Contribute to identification of human-related deficiencies.

Section	Section Title	As Is	Recommended	HSI Touch Point
1.5.5	Inclusion of HSI in Operational Suitability Evaluations	-	Operational Suitability evaluations should include HSI attributes (environment, safety, occupational health, human factors, usability, habitability, manpower, personnel, natural environment effects and impacts, and training) as appropriate, in accordance with AFI 10-601, when determining the degree to which a system can be placed and sustained satisfactorily in field use.	-
2.2.1	-	Assesses the technological capabilities of systems or concepts in support of requirements activities described in AFI 10-601 …	Assesses the combined technological and human capabilities of systems or concepts in support of requirements activities described in AFI 10-601 …	The usefulness, understandability, usability, safety and suitability of the capabilities must be assessed.
2.2.7	-	Characterizes system performance, military utility, and determines system safety.	Characterizes system performance, military utility, and determines system safety and usability.	Usability is a key element of operational suitability. It supports capability availability.
2.2.10	-	-	-	OSS&E has a strong relation to HSI. Systems that are suitable conform to user needs. Safety is an HSI key interest. Effective systems are ones that enable forces and warfighters to meet operational goals.

Section	Section Title	As Is	Recommended	HSI Touch Point
2.2.11	-	-	-	As with OSS&E, Reliability, Availability and Maintainability (RAM) has a strong relation to HSI. Reliable systems are those that do not induce human errors. System availability is improved when human safety, occupational health, protection and survival are assured. Maintainability is another facet of usability and understandability.
2.4.1	-	Provide information to decision makers on potential operator casualties, system vulnerabilities, lethality, and system recoverability while taking into equal consideration the susceptibility to attack and combat performance of the system.	Provide information to decision makers on potential operator casualties, operator survivability, force protection, system vulnerabilities, lethality, and system recoverability while taking into equal consideration the susceptibility to attack and combat performance of the system.	Addresses two KPPs that relate to HSI.
2.4.2	-	-	-	HSI analysts help to define realistic conditions from the human standpoint.
2.4.3	-	-	-	“Repair capabilities” have usability implications just as maintainability does.

Section	Section Title	As Is	Recommended	HSI Touch Point
2.5	Operational Testing	Operational testing may also look at doctrine, operational concepts (as described in AFPD 10-28, *Air Force Operational Concepts)*, system performance, TTPs, logistics support elements, intelligence support elements, system interoperability and security, materiel issues, safety, training, organization, human systems integration (HSI), and personnel.	Operational testing may also look at doctrine, operational concepts (as described in AFPD 10-28, *Air Force Operational Concepts)*, system performance, TTPs, logistics support elements, intelligence support elements, system interoperability and security, materiel issues, usability, safety, training, organization, human systems integration (HSI), and personnel.	Each of the listed items has human dimensions.
2.6.1	Initial Operational Test and Evaluation	AFOTEC determines the operational effectiveness and suitability of the items under test…	AFOTEC determines the operational effectiveness, safety and suitability of the items under test…	HSI analysts help to characterize representative personnel.
2.6.9	Operational Assessment	They provide early operational data and feedback from actual testing to developers, operators, and decision makers.	They provide early operational data and feedback from actual testing to developers, operators, sustainers, and decision makers.	-
2.6.9.3	-	Identify deficiencies or design problems that can impact system capability to meet operational requirements, the mission, and/or employment concepts.	Identify deficiencies or design problems including operator and maintainer workarounds that can impact system capability to meet operational requirements, the mission, and/or employment concepts.	Workarounds are clear sign that the user interface is inadequate to satisfy requirements and operational needs. Workarounds may also be responses to modified operating concepts or new threat environments that need to be incorporated into product definitions (see 2.6.9.4).
2.6.9.5	-	-	-	Prototype demonstrations provide opportunities to improve user interfaces.

Section	Section Title	As Is	Recommended	HSI Touch Point
2.6.10	Early Operational Assessments	EOAs are similar to OAs, except they are performed prior to MS B to provide very early assessments of system capabilities and programmatic risks.	EOAs are similar to OAs, except they are performed prior to MS B to provide very early assessments of system capabilities, ~~and~~ programmatic risks, and OSS&E.	-
2.6.12	Sufficiency of Operational Test Review	…The SOTR may not be used for acquisition milestone decisions associated with OSD OT&E Oversight programs unless approved by DOT&E. See paragraph **7.5.5**.	…The SOTR may not be used for acquisition milestone decisions associated with OSD OT&E Oversight programs unless approved by DOT&E. SOTRs should include any human-related findings and conclusions as appropriate. See paragraph **7.5.5**.	-
2.9	Joint Test and Evaluation	The JT&E Program focuses on evaluating current equipment, organizations, threats, doctrine, TTPs, test methodologies, and system interoperability in realistic environments.	The JT&E Program focuses on evaluating current equipment, organizations, team design, usability, threats, doctrine, TTPs, test methodologies, and system interoperability in realistic environments.	Non-materiel capabilities nevertheless have implications to workflow and the usefulness and usability of the capability; HSI contributes to a complete evaluation.
3.4.6	-	-	Ensure that HSI is addressed in test planning.	
3.5.6	-	-	Ensure that HSI is addressed in test planning.	Section parallels 3.4, but for space systems.
3.8.6	-	-	-	Points to AFI 16-1002 – M&S must consider all HSI aspects.
3.8.14	-	-	-	Points to AFI 63-104 – all aspects of HSI should be considered within the SEEK EAGLE program.
3.8.16	-	-	-	Deficiency reporting process must take HSI into consideration.

Section	Section Title	As Is	Recommended	HSI Touch Point
4.2	Early Tester Involvement in Requirements Development	-	-	Testers can help to ensure HSI-related requirements are not thrown out by the HPT for being perceived as "untestable."
4.4.3	ITT Membership	The ITT should include expertise from organizations such as the SPO (or initial SPO cadre), AFOTEC, and/or MAJCOM operational tester (as appropriate), SAF/AQ or SAF/US, HQ USAF/TE, HQ USAF/A3/5, SAF/XC, JITC, OSD, ALCs, product centers, contractor, developer, science and technology, intelligence, developmental testers, requirements sponsors, test facilities, and other stakeholders as needed during various test program phases.	The ITT should include expertise from organizations such as the SPO (or initial SPO cadre), AFOTEC, and/or MAJCOM operational tester (as appropriate), SAF/AQ or SAF/US, HQ USAF/TE, HQ USAF/A3/5, SAF/XC, JITC, OSD, ALCs, product centers, contractor, developer, science and technology, intelligence, developmental testers, requirements sponsors, test facilities, HSI, and other stakeholders as needed during various test program phases.	ITTs have been identified by the T&E community a high-payoff activities for incorporating human considerations into system performance testing.
5.3	Critical Test Parameters	CTPs should be developed to address all major areas of system performance and should correlate to all key requirement areas, to include all KPPs.	CTPs should be developed to address all major areas of system performance, including human, and should correlate to all key requirement areas, to include all KPPs.	While personnel are mentioned in the following list, explicit inclusion of humans removes techno-centric bias that may exist in planning, and supports the total system approach called out in 5000 series documents.
5.5	Common T&E Data Management	Operational testers must allow open data sharing and non-interference observation by all other testers, the system developer, contractor, operators, DOT&E, and the PM.	Operational testers must allow open data sharing and non-interference observation by all other testers, the system developer, contractor, operators, DOT&E, HSI personnel, and the PM.	HSI-related data in the common database should be severable to support evidence-based practice.

Section	Section Title	As Is	Recommended	HSI Touch Point
5.10.8	Warfighter Survivability	-	-	HSI engineers shall be involved in the planning for, conduction of and evaluation of warfighter survivability assessments.
5.11.1	Early Operational Assessments	-	-	EOAs are opportunities to assess usability, understandability and usefulness.
5.11.2	Operational Assessments	-	-	OAs are opportunities to assess the human considerations of OSS&E.
5.14.2.1	-	-	-	SAF/AQ AFHSIO should be on the TEMP coordination list. (Review 99-103, Attachment 2, Information [coordination] Requirements.)
5.14.2.2	-	-	-	SAF/AQ AFHSIO should be on the TEMP coordination list.
5.14.2.3	-			An HSI cell representative should support the Service Acquisition Executive or designated representative in the TEMP approval process.
5.14.3	Multi-Service TEMPs	-	-	The lead service should ensure that its HSI office has coordinated on the TEMP.
6.3.1	-	-	-	HSI engineers must make sure COIs, MOEs and MOSs capture human considerations related to operational capabilities and CONOPS.
6.4	Realistic Testing	-	-	HSI analysts should participate in test scenario development, so they are realistic from a human perspective.

Section	Section Title	As Is	Recommended	HSI Touch Point
6.5	Integrated Technical and Safety Reviews	-	-	Safety integration is part of total life cycle systems management per DODD 5000.01 section E1.1.29.
6.5.2	Safety Review Board	-	-	Environmental safety and occupational health hazard mitigation is part of total life cycle systems management per DODD 5000.01 section E1.1.29.
6.7.1	Operational Test Concept Briefings	-	-	SAF/AQ HSIO should be part of Air Force-level reviews and multi-service review teams.
6.7.2	Operational Test Plans and Test Plan Briefings	-	-	SAF/AQ HSIO should be part of Air Force-level reviews and multi-service review teams.
6.9.1	Joint Reliability and Maintainability Evaluation Team	-	-	HSI needs to be represented on the Joint Reliability and Maintainability Evaluation Team because of the linkage between RAM and human safety and performance.
6.10	Deficiency Reports	-	-	HSI needs to have a voice in making the “nice to have” decision as the designation may have manpower, personnel or training cost implications.
6.10.4	Tracking and Closing DRs	-	-	HSI should participate in the decision to close a DR.
6.13.1	-	-	-	HSI should participate in Capabilities and Limitations (C&L) Report generation due to OSS&E links with HSI.

Section	Section Title	As Is	Recommended	HSI Touch Point
7.5.2	Final Reports	Reports must address each of the COIs, the system's operational effectiveness, suitability, additional information on operational capabilities, and include an assessment of operational mission impacts.	Reports must address each of the COIs, the system's operational effectiveness, suitability, safety, usability, additional information on operational capabilities, and include an assessment of operational mission impacts.	Safety is an HSI cost driver. Usability is a specific attribute identified by test community as a priority for evaluation.
7.5.6	Capabilities and Limitations Reports	…The level of detail provided will vary depending on the amount of preexisting information available, the warfighter's need for technical information, and the amount of time and resources available to conduct additional testing before the fielding decision. The C&L Report should not make specific recommendations concerning the system fielding decision or release for training purposes…	…The level of detail provided will vary depending on the amount of preexisting information available, the warfighter's need for technical information, and the amount of time and resources available to conduct additional testing before the fielding decision. The C&L Report must include human-related findings, limitations, and conclusions. The C&L Report should not make specific recommendations concerning the system fielding decision or release for training purposes…	-
7.6	Operational Test Report Distribution	-	-	SAF/AQ AFHSIO should be included in the distribution.
7.9	Briefing Trail			SAF/AQ AFHSIO should be included in test report briefings.
8.4.2	Early Influence Team	-	-	HSI should be represented among the Early Influence Team subject matter experts to help author T&E measures, criteria and scenarios.

Section	Section Title	As Is	Recommended	HSI Touch Point
8.4.3	Integrated Test Team Formation	-	-	The ITT should include HSI representation.
8.5.3	Integrated Test Concept and TEMP Development	-	-	HSI should be represented on ITT to support scenario, COI, CTP, MOE and MOS development.
8.7.1	Integrated T&E Support to Consent to Ship and Launch Approval Decisions	-	-	HSI analysts should participate in OT&E Phase II testing to assess and evaluate the operations segment.
Atch 1	References	-	*Air Force Human Systems Integration Handbook*	-
Atch 1	Terms	-	Human Systems Integration (HSI)--A disciplined, unified and interactive systems engineering approach to integrate human considerations into system development, design, and life cycle management to improve total system performance and reduce costs of ownership.	-

Appendix E: Recommendations to AFMAN 63-119, Certification of System Readiness for Dedicated Operational Testing

This appendix contains recommendations for modifications to AFMAN 63-119. Recommended additions or modifications are in red. Because the study sought interaction points between the HSI and T&E processes, the "HSI Touch Point" column is included to indicate HSI activities associated with those described in the AFI that would improve HSI's treatment in T&E or, more generally, in acquisition. Red indicates additions to existing text.

Section	Section Title	As Is	Recommended	HSI Touch Point
1.4.2.1	-	Ensure a robust systems engineering process is the underlying foundation for systems development and for reviewing these templates.	Ensure a robust systems engineering process that includes human systems integration is the underlying foundation for systems development and for reviewing these templates.	HSI processes are integral to best systems engineering practice.
1.4.2.2	-	Ensure their system is mature and demonstrates stabilized performance in an operationally relevant environment prior to certification. Additionally, all necessary test support must be available and the system must have a high likelihood of a successful operational test.	Ensure their system is mature and demonstrates stabilized performance in an operationally relevant environment prior to certification. Operational relevance includes consideration of the target audience who will operate, sustain and threaten the system. Additionally, all necessary test support must be available and the system must have a high likelihood of a successful operational test.	The operational environment includes the blue and red forces that encounter the system.
2.6.1	Pre-Certification Reviews	-	-	HSI SMEs need to be review participants.

Section	Section Title	As Is	Recommended	HSI Touch Point
2.6.1.1	-	-	-	HSI SMEs need to be part of the assessment.
2.6.2.2	Develop Exit Criteria	-	-	HSI should participate in defining exit criteria.
2.7.1.7	-	-	-	Areas where HSI disagrees with the certification should be included.
2.7.1.8	-	-	Specifically provide details of HSI readiness, including system limitations due to HSI issues and system attributes not testable due to HSI issues.	-
3.3	Answering Template Line Items	The word “system” refers to software as well as hardware components of the program under review.	The word “system” refers to software as well as hardware and human elements ~~components~~ of the program under review.	-
Atch 1	References	-	*Air Force Human Systems Integration Handbook*	-
	Abbreviations and Acronyms	-	HSI – Human Systems Integration	-

Section	Section Title	As Is	Recommended	HSI Touch Point
	Terms	-	Human Systems Integration (HSI)--A disciplined, unified and interactive systems engineering approach to integrate human considerations into system development, design, and life cycle management to improve total system performance and reduce costs of ownership. Operational Concept – A plan for day-to-day operations that describes capability characteristics and goals, and explains the how the capability will be employed by defined operators to achieve operational objectives.	-
A2.2.1	-	-	Ensure significant HSI-related events (e.g., approval of Environmental Impact Statement, training events etc.) are included in the schedules (PM).	-
A3.2.1	-	All relevant costs must be identified, preferably using objective engineering and business estimates using accepted Air Force cost analysis principles and processes. (PM)	All relevant costs must be identified, preferably using objective engineering, ~~and~~ business, and human resource estimates using accepted Air Force cost analysis principles and processes. (PM)	Manpower, personnel and training costs must be included in cost estimates.

Section	Section Title	As Is	Recommended	HSI Touch Point
A3.2.2.1	-	-	Ensure that assumptions and constraints regarding manpower, personnel, and training are explicitly identified. (User)	Include specific goals to eliminate manpower authorizations, combine Air Force Specialty Codes (AFSCs), or merge training programs.
A3.2.2.2	-	-	Ensure that HSI-specific issues from the existing capability are explicitly identified so they are included in the trade space. (User)	-
A3.2.3	-	Acceptable ranges of performance must be established using rigorous cost-benefit, trade-off, and sensitivity analyses to show decision makers when and where certain degradations in system cost or performance yield outcomes that no longer satisfy the mission need. (User)	Acceptable ranges of performance must be established using rigorous cost-benefit, trade-off, and sensitivity analyses to show decision makers when and where certain degradations in system cost or performance yield outcomes that no longer satisfy the mission need. Ensure consideration for humans is factored into the overall trade space. (User)	-
A3.2.4	-	-	All nine HSI domains should be explicitly addressed in the AoA, and potential issues clearly identified (User).	-
A3.3	-	-	-	Refer to T&E Framework HSI examples for recommendations on how to develop HSI-related MOEs.
A4.1	-	-	-	Make sure HSI-related requirements are captured in the CBRD.

Section	Section Title	As Is	Recommended	HSI Touch Point
A4.8	-	-	-	Refer to T&E Framework HSI examples for recommendations on how to develop HSI-related MOEs.
A4.10	-	-	-	Refer to T&E Framework HSI examples for recommendation on how to develop HSI-related KPPs, KSAs, and APAs.
A4.10.1	-	-	Exemptions to mandatory KPPs must be explicitly stated. (User)	All mandatory KPPs directly or indirectly influence HSI requirements.
A4.10.2	-	-	An explanation for why the System Training KPP does not apply must be given (User).	Training is one of the nine HSI domains.
A5.4.5	-	-	Threats to humans must be explicitly identified (PM).	
A6.2.4	-	-	The ITT shall include a specific individual identified as an HSI subject matter expert who will have “reachback” to all HSI domains. (PM)	-
A6.3.1	-	-	For programs with high HSI interest, it is highly recommended to form an HSI subgroup to ensure proper attention to human-related T&E. (ITT)	-
A6.5.1	-	-	-	Incorporate standards for human-related measurements (formulas, definitions, and terms).

Section	Section Title	As Is	Recommended	HSI Touch Point
A6.6	-	-	Common means for successfully determining results of testing HSI requirements are clearly documented and approved. (ITT)	-
A7.2	-	(M&S, interoperability certification, Information Assurance testing, LFT&E, contractor testing, etc.)	(M&S, human-in-the-loop, interoperability certification, Information Assurance testing, LFT&E, contractor testing, etc.)	-
A7.4.1	-	-	HSI risks and mitigation methods and techniques are clearly identified. (PM)	-
A7.6	-	-	-	Refer to T&E Framework HSI examples for recommendation on how to develop HSI-related MOEs, MOSs, COI, and CTPs.
A8.1.2	-	-	Human interactions must be clearly identified within all concepts, strategies, methods, and tactics. (User)	-
A8.2	-	-	-	Human elements contribute to operational effectiveness.
A9.1.2	-	(such as long lead items, TOs, support equipment, training)	(such as long lead items, TOs, support equipment, training, workload and personnel skills and knowledge shortfalls)	-
A9.4	-	-	-	HSI should be involved in task analysis in support of suitability test scenario development.
A9.7	-	-	-	HSI should engage in DOTMLPF assessment due to HSI domain alignment with DOTMLPF constituents.

Section	Section Title	As Is	Recommended	HSI Touch Point
A9.9	-	-	-	HSI needs to be part of the reliability and maintainability growth plan and its coordination.
A10.1	-	-	-	Human information requirements flow from the NR-KPP.
A10.1.1.1	-	-	Ensure architecture views that call out humans are clearly detailed. (User.	-
A10.1.2	-	-	-	Human-to-human and human-to-machine interfaces are key interfaces.
A10.1.3	-	-	-	Human aspects of Information Assurance include interactions of facilities layouts and displays.
A10.2	-	-	-	HSI scope extends to nine of the thirteen steps required for Information Support Plan preparation.
A11.4.3	-	-	-	HSI M&S assets should be included.
A11.4.4	-	-	-	HSI M&S assets must be verified.
A11.5.1	-	-	-	Critical issues that must be addressed in OT&E must include human-related ones.
A12.2	-	-	-	HSI should review definitions, formulas and evaluation criteria in all test plans and T&E documents to ensure human-element contributions to OSS&E are consistently and completely represented.
A12.4.1	-	-	-	HSI must provide required inputs in agreed-upon forms.

Section	Section Title	As Is	Recommended	HSI Touch Point
A12.4.2	-	-	-	Human element test configurations must be also be controlled by HSI in order to contribute to reliability curve improvement.
A13.2.5	-	-	Ensure HSI implications have been addressed in the OPSEC plan. (PM)	-
A14.2.1	-	-	-	Inspection of HSI requirements flow down should be included in formal reviews.
A14.2.8	-	-	Ensure the contractor's test program gives full attention to verification and validation of human-related requirements. (PM)	-
A14.3.1	-	-	-	HSI is an essential component of systems engineering and should participate in test results analysis.
A14.6.3	-	-	-	HSI should participate in decisions to modify pass/fail values and document rationales for elections.
A15.2.1	-	-	Ensure that any trade-offs where human-related requirements are significant are reported and user concurrence is obtained. (PM)	-

Section	Section Title	As Is	Recommended	HSI Touch Point
A15.3.3	-	The system must demonstrate the capability to satisfy each of the 14 elements of operational suitability and the ten logistics support elements. (PM) (See A9, A25, A27, A30, A32, A33)	The system must demonstrate the capability to satisfy each of the 14 elements of operational suitability, the nine HSI domains, and the ten logistics support elements. (PM) (See A9, A25, A27, A30, A32, A33, A34)	-
A15.6.2	-	-	-	HSI must ensure environment is operationally relevant from the viewpoint of the system operators.
A15.10.1	-	If there are any incomplete test areas, explain why and give impacts on dedicated OT&E. (RTO)	If there are any incomplete test areas, explain why and give impacts on dedicated OT&E. Ensure that HSI-related impacts are clearly identified. (RTO)	-
A16.1.1	-	-	-	Human related aspects of interoperability (standardization of interfaces, safety, task interfaces) must be included in system-of systems test.
A16.2	-	-	-	Exit criteria must include usability and resilience studies.
A16.3	-	-	-	HSI should participate in tracing user interface and safety requirements as part of the measurement process.

Section	Section Title	As Is	Recommended	HSI Touch Point
A16.5.1	-	The software must be analyzed for safety critical functions and determined acceptable for operational use. (PM)	The software must be analyzed for safety critical functions and determined acceptable for operational use. The analysis shall consider the impact of multiple minor issues accumulating to become a major safety issue. (PM)	HSI should participate in safety critical analyses.
A17.9	-	-	Ensure that human survivability has been fully addressed throughout the LFT&E process. (PM)	HSI must make sure human survivability is in the test plan and analyze related test results.
Atch 18	Modeling and Simulation (M&S)	-	-	-
A18.1	-	-	-	-
A18.2	-	-	-	HSI M&S requirements should be incorporated into the MSSP.
A18.2.4	-	-	Ensure that humans are properly modeled throughout. (PM)	-
A18.2.5	-	-	Ensure that validated HSI models (e.g., Jack, IMPRINT) are being used for human related M&S. (PM)	-
A18.3	-	-	-	HSI should develop training for the M&S that will be used for T&E.
A18.4	-	-	-	Identify HSI M&S tools that have already been validated. Define how other HSI M&S tools will be verified and validated.
A18.4.1	-	-	-	HSI methods should be applied to scenario development.

Section	Section Title	As Is	Recommended	HSI Touch Point
18.4.4	-	-	Ensure that the results of human-based M&S are reviewed by appropriate subject matter experts. (PM)	-
A19.1.1	-	e.g., hardware, software, support equipment, spares, GFE	e.g., hardware, software, human, support equipment, spares, GFE	-
A19.2.3	-	-	Ensure that requirements for test subjects are defined within the parameters of all of the capability's human-related requirements and thoroughly documented. (PM)	-
A19.3.1	-	-	-	HSI needs to participate in the determination that form, fit and function are not adversely affected.
A19.3.2	-	-	-	HSI must execute trade-off studies to support assessment.
A20.4.2	-	-	Ensure that a qualified HSI subject matter expert is assigned to the DR Review Board (PM).	-
A20.5.2	-	-	-	HSI needs to participate in the determination that form, fit and function are not adversely affected.
A20.5.3	-	-	-	HSI techniques should be used to connect the operator and sustainer to DRs and impacts.

Section	Section Title	As Is	Recommended	HSI Touch Point
A20.8	-	-	-	HSI needs to be represented on the Joint Reliability and Maintainability Evaluation Team and the Board to review human-element impacts to Reliability, Maintainability and Availability.
A21.1	-	Test articles (to include support equipment, software, GFE) must be as production-representative as possible to support the dedicated OT&E and schedule.	Test articles (to include support equipment, software, GFE, and human elements) must be as production-representative as possible to support the dedicated OT&E and schedule.	-
A21.2.1	-	-	HSI issues must be clearly documented to ensure there are no limitations imposed on production representative articles that may drastically alter OT&E (PM).	
A22.1	-	-	-	HSI is integral to operational effectiveness and suitability and its products should help to define relevant scenarios and environment.
A22.3	-	-	-	Testing related to human-performance must be defined in order to ensure the integrated system allows operators to satisfy mission requirements.
A22.3.1	-	Integration among system components, subsystems, and external systems must optimize total system design and performance capabilities. (PM)	Integration among system components, subsystems, and external systems (including humans) must optimize total system design and performance capabilities. (PM)	Suboptimal solutions will result if human elements are not considered in the overall integration.

Section	Section Title	As Is	Recommended	HSI Touch Point
A22.4	-	If the system was planned with an evolutionary acquisition strategy, describe what capabilities are lacking at this time and when they will be implemented. (PM)	If the system was planned with an evolutionary acquisition strategy, describe what capabilities are lacking at this time and when they will be implemented. Clearly identify operator or maintainer capabilities that may be initially lacking due to an evolutionary acquisition strategy. (PM)	-
A22.5	-	-	-	Force protection issues need to be included in assessments of survivability and lethality achievement.
A23.1.1	-	-	-	HSI must participate in characterization of operations and support environments from the operator and sustainment personnel perspective in order to fully test operational suitability. To achieve this, HSI methods should be employed as part of test scenario development.
A23.1.2	-	-	-	HSI must participate in development of the Logistics Support Concept by performing task and workload analysis.
A23.3.1	-	-	-	HSI methods should be employed as part of test scenario development.
A23.3.2	-	-	-	Human-related COIs, MOEs, and MOSs must be derived from higher-level sources by HSI.

Section	Section Title	As Is	Recommended	HSI Touch Point
A23.3.5	-	-	-	HSI should review requirements, methodologies and MOEs.
A23.3.6	-	-	-	HSI M&S assets should be documented in the MSSP.
A23.6	-	(e.g., lack of test articles, time, system capabilities, insufficient realism)	(e.g., lack of test articles, time, system capabilities, insufficient realism, poor training of human subjects)	-
A24.8	-	-	Adequate training shall be provided for all test instrumentation, data analysis equipment, M&S assets, associated test assets prior to the beginning of each test phase. (PM / OTA)	-
A25.2.2	-	A25.2.2. All system-related ESOH risks have been accepted at the appropriate management level prior to exposing people, equipment, or the environment to known hazards. A safety release must be provided to the OTA before start of dedicated operational testing. (PM)	A25.2.2. All system-related ESOH risks, including those for support and packaging, handling and transportation equipment, have been accepted at the appropriate management level prior to exposing people, equipment, or the environment to known hazards. A safety release must be provided to the OTA before start of dedicated operational testing. (PM)	-
A26.4	-	-	Document all training that is required beyond that which is necessary to fulfill OT&E. (PM)	Training for OT&E may be a sub-set of the entire training requirement for the capability.
A27.6	-	-	Document all support equipment that may be required beyond that which is necessary to fulfill OT&E. (PM)	There may be support equipment that is not necessary for OT&E but that is required for the full capability.

Section	Section Title	As Is	Recommended	HSI Touch Point
A30.1.1	-	-	-	HSI should be involved in task analysis in support of maintenance test scenario development.
A30.5	-	OT&E test team maintenance personnel must be adequately trained. (PM)	OT&E test team maintenance personnel must be adequately trained (including safety training). (PM)	-
A31.1	-	-	-	HSI task analyses should be used to ensure all personnel and manpower requirements have been identified for operations and sustainment.
A31.1.1	-	-	Document all Air Force specialties that may be required beyond that which is necessary to fulfill OT&E. (PM)	The specialties required for OT&E may be a sub-set of that which is required for the full capability.
A33.1	-	Operator and maintainer technical data (i.e., TOs, engineering drawings, specifications, standards, process and user manuals, technical reports, catalog items) are available to support the OT&E plan and schedule. (PM)	Operator and maintainer technical data (i.e., TOs, engineering drawings, specifications, standards, process and user manuals, technical reports, catalog items, embedded training, diagnostics, prognostics and maintenance) are available to support the OT&E plan and schedule. (PM)	-
A33.1.4	-	-	Document all technical data that may be required beyond that which is necessary to fulfill OT&E. (PM)	The technical data required for OT&E may be a sub-set of that which is required for the full capability.
Atch 34	Human Systems Integration	-	-	-

Section	Section Title	As Is	Recommended	HSI Touch Point
A34.1	-	-	The integrated system consists of hardware, software and human elements. Require-ments related to the human elements of the system must be developmentally tested at the system level prior to starting dedicated OT&E. (PM)	Reference AFI 63-1201.
A34.1.1	-	-	All safety risks identified in developmental testing must be incorporated into the program risk matrix and assessed for risk level. (PM) (See A25)	-
A34.2	-	-	Developmental evaluation of operational effectiveness and suitability must incorporate representative personnel who will operationally employ, support and maintain the system. (PM) (See A15, A17, A25, A26, A31)	-
A34.3	-	-	CBRD mission-effectiveness requirements must be decomposed to include the interactions of representative personnel with the system that affect mission outcomes. (PM)	-

Section	Section Title	As Is	Recommended	HSI Touch Point
A34.4	-	-	Operationally relevant scenarios must introduce induced, operational stressors that would degrade mission performance at optempo. (PM) (See A22)	-
A34.5	-	-	DT&E must test conditions for usability (illumination, vibration, sound, in MOPP 4 gear; war, peace, standby conditions; transportation, access, maintenance, support, training modes) by representative personnel. (RTO)	-

Appendix F: Air Force Test and Evaluation Guidebook Recommendations

This appendix contains recommendations for modifications to the Air Force Test and Evaluation Guidebook. Recommended additions or modifications are in red. Because the study sought interaction points between the HSI and T&E processes, the "HSI Touch Point" column is included to indicate HSI activities associated with those described in the AFI that would improve HSI's treatment in T&E or, more generally, in acquisition. Red indicates additions to existing text.

Section	Section Title	As Is	Recommended	HSI Touch Point
2.2.2	Section 2366, Major Systems and Munitions Programs; -- Survivability Testing and Lethality Testing Required Before Full-Scale Production	-	[add new 2.2.2.x at end] While not explicitly cited in Title 10, survivability and lethality testing implicitly requires specific testing to ensure the survivability of crew members and required passengers. It is important when LFT&E is in the planning stages that survival of crew and passengers is considered.	-

Section	Section Title	As Is	Recommended	HSI Touch Point
2.2.3	Section 2399, Operational Test and Evaluation of Defense Acquisition Programs.	-	[add new 2.2.3.x at end] It is critical that OT&E provide as realistic an environment as possible for exercising new and upgraded capabilities. Those environments that cannot be completely replicated must be simulated in order to ensure that operators and maintainers will be able to carry out all capabilities in a fully operational environment and therefore be able to provide an accurate assessment of effectiveness and suitability.	
3.2.2	What Goes on OSD T&E Oversight List.	-	[add to bulleted list] Extremely high level of human-system interaction	Adding this would require concurrence from OSD
7.2	ITT Formation and Management	…specialists in financial management, contracting, safety, logistics, training, software development, etc.	…specialists in financial management, contracting, safety, logistics, training, software development, HSI, etc.	

Section	Section Title	As Is	Recommended	HSI Touch Point
7.3	Integrated Initial Test Design (IITD)		…The ITT uses a systems engineering approach to identify and de-conflict the initial COIs, CTPs, test objectives, MOEs, resources, and schedules. It is absolutely essential that HSI is considered throughout the IITD process through the development of the ITC. The IITD process culminates in an ITC that includes an initial description of test scenarios, test locations, exercises, T&E methodologies, operational impact assessments and issues, and projections for future increments….	
9.6.7	-	…developmental testers, OSD, requirements sponsors, test facilities, and other stakeholders as needed during various test program phases….	…developmental testers, OSD, requirements sponsors, test facilities, HSI, and other stakeholders as needed during various test program phases….	
12.1	Test Capabilities and Facilities	Additional facilities along this path are data measurement facilities, system integration laboratories, hardware-in-the-loop facilities, and installed system test facilities.	Additional facilities along this path are data measurement facilities, system integration laboratories, human-in-the-loop facilities, hardware-in-the-loop facilities, and installed system test facilities.	

Section	Section Title	As Is	Recommended	HSI Touch Point
Figure 12.1	T&E Resource Needs Through Program Development	-		Will need to update this figure to include human-in-the-loop facilities if the previous comment is accepted.
13	Deficiency Reporting	-	-	Recommend an HSI review of TO 00-35D-54, AFI 63-501, and TO 00-5-1
13.1	Accurate Categorization of DRs	-	-	The issue of how to address the generally subjective nature of HSI DRs needs to be presented.
14.1	Testing in Support of Rapid Response Process (RRP)	-	-	Recommend an HSI review of AFI 63-114 along with the entire rapid acquisition process.
14.2	Foreign Material Program (FMP)	-	-	Recommend an HSI review of AFI 99-114 (classified Secret) for differences from the basic T&E processes.
Attachment 1	References		[add new] *Air Force Human Systems Integration Handbook*	
Attachment 1	Abbreviations and Acronyms		[add new] HSI – Human Systems Integration	
Attachment 1	Terms	-	[add new] Human Systems Integration (HSI)--A disciplined, unified and interactive systems engineering approach to integrate human considerations into system development, design, and life cycle management to improve total system performance and reduce costs of ownership.	

Section	Section Title	As Is	Recommended	HSI Touch Point
A5.3.2	The Executive Level		[add new to end] The Air Force HSI Office, has an advisory role to SAF/AQ for HSI matters.	
A5.3.3	The Working Group Level		[add new at end] HSI subject matter experts should be part of the working level ITT.	
A5.3.4	Subgroups		[add new] **A5.3.4.3.** In order to ensure focused T&E attention on HSI, the ITT should create an HSI subgroup for any program that has extensive HSI requirements and/or high-level HSI interest.	

Appendix G: HSI Test and Evaluation Framework Examples

Row Number	System	Key Requirements and T&E Measures				Test Methodologies / Key Resources (M&S, SIL, MF, ISTF,HITL, OAR)	Decision Supported
		Key Requirements (KPPs, KSAs)	Critical Operational Issues (COIs)	Key MOEs/MOSs	Critical Technical Parameters (CTP) & Thresholds		
1	Long-Duration Bomber	**KSA: Sustainable Crew Workload**	Does the long-duration bomber system support operation by a two-person crew?	**Number of Crew:** Can two (2) crewmembers execute the full range of long-duration bomber missions and associated phases over a 24-hour period?	Crew exhibits signs of fatigue per FAA Minimum Flight Crew, AC 23.1523, Appendix 1. Number of missions and associated phases successfully accomplished in 24-hours with less than 3% errors.	NASA TLX Workload assessment of five crews executing mission scenario number one (1). Piece validation using flight trainer. Twelve (12) crew teams, randomly paired for 36 trials, four (4) trials per mission scenario (including rest-period scenarios).	MS B

Row Number	System	Key Requirements and T&E Measures				Test Methodologies / Key Resources (M&S, SIL, MF, ISTF,HITL, OAR)	Decision Supported
		Key Requirements (KPPs, KSAs)	**Critical Operational Issues (COIs)**	**Key MOEs/MOSs**	**Critical Technical Parameters (CTP) & Thresholds**		
2	**Unmanned Aerial System Operator Console**	**KPP: Sustainment** **KSA:** Reduced Manpower Costs	Can 1UOX (Air Force Specialty Code) personnel operate a single UAS in all phases without a rated 18X UAS pilot?	Can the operator console supply the piloting skills, knowledge and abilities lacking in 1UOX?	UAS manual control error: <7% from optimal trajectory (integrated spherical error). 1UOX / 18X Performance Ratio: Ratio of 1UOX control error performance to 18X control error performance > 95%. Average number of aircraft lost per 1000 missions. Constrained flight collision avoidance during operations: 99% confidence of greater than five-inch distance from any point on UAS surface to obstacle; integrated over all obstacles when in ISR mode.	Operator console engineering model with UAS simulator. Eight (8) subjects (two novice, two journeymen, two expert 1UOX, two 18x journeyman pilots) navigating through design scenario urban, mountain, rural waypoint courses. EMDD engineering model and instrumented UAS test model. Twelve (12) subjects navigating through AFOTEC Urban Flight Obstacle Course (straight, corner, necked pathway, dual balcony and laundry line cases). Simultaneous ISR collections of three by five inch (3 in x 5 in) ground targets during obstacle passes.	MS B LRIP

Row Number	System	Key Requirements and T&E Measures				Test Methodologies / Key Resources (M&S, SIL, MF, ISTF,HITL, OAR)	Decision Supported
		Key Requirements (KPPs, KSAs)	**Critical Operational Issues (COIs)**	**Key MOEs/MOSs**	**Critical Technical Parameters (CTP) & Thresholds**		
3	**Unmanned Aerial System Operator Console**	**KPP: Sustainment** **KSA:** Reduced Manpower Costs	Can 1UOX (Air Force Specialty Code) personnel operate a single UAS in all phases without a rated 18X UAS pilot?	**System Usability:** Does the operator console interface direct user attention to critical information and activation functions during Handover, Enroute, ISR, and Strike modes?	**Visual Attention Directivity Efficiency** Nominal: < two (2) second lag between screen presentation and visual lock on critical display Fatigue: < four (4) second lag between screen presentation and visual lock on critical display **Visual Attention Failure** Nominal: < 2% visual lock failure Fatigue: < 3% visual lock failure	Time-compressed demonstration of Scenario 2C screen progression. 15 subjects (five (5) novice, five (5) journeymen, and five (5) experts). Nominal taken during first watch by personnel serving first watch. Fatigue taken during third watch by personnel serving third watch. Eye-tracking computer platform including cameras and infrared emitters hidden behind small dark windows at the top and bottom of the monitor.	MS C

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4	Unmanned Aerial System Operator Console	**KPP:** **Sustainment** **KSA:** Reduced Manpower Costs	Can four UAS be operated by a crew consisting of two pilots and one sensor operator (SO)?	**Workload:** Does the crew have capability to perform the required tasks? Does the crew have enough spare capacity to take on additional tasks? Does the crew have enough spare capacity to cope with emergency situations?	Single UAS Workload (individual crew members) Gaining Handover Workload (single UAS): <20% Enroute Workload (Single UAS): <17.5% ISR Workload (Single UAS): <20% Strike Workload (Single UAS): <20% Losing Handover (Single UAS): <20% Concurrent Tasking (CT) Definitions 1) Two UAS in Strike; one gaining Handover, one Losing Handover 2) Two UAS in ISR; two in Strike 3) One UAS Gaining Handover, one Losing Handover, one in Strike, one Enroute Workload Concurrent Tasking (individuals) CT1: Pilot < 85%; SO <80% CT2: Pilot<80%; SO<90% CT3: Pilot<75%; SO<75%	IMPRINT Pro simulation of pilots and sensor operator performing all mission functions. DMO exercise at Air National Guard's Distributed Training Operations Center (DTOC) to validate simulation. Measures to include: • NASA TLX Workload assessment • Eye tracking and video taping of pilot and SO scanning during CT scenarios. • Graduated insertion of five stressor tasks into CT scenarios. • Measures of situation awareness. • Number of times actions were made for one plane but meant for a different plane. • Number of undo actions required during simulation.	PDR Operational Test Readiness

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5	Information System	**KSA: IA Situation Assessment**	Can system-specific training be eliminated?	Intuitive Usability: Can the system be used effectively by an untrained individual?	Successful exercise of core interface functionality.	Exercise of clickable prototype on Critical Mission Segment Scenarios (CMSS) 1-11. Minimum of 10 subjects pulled from AFSC OCYC apprentice pool.	MS C
					Percentage of time eye motion tracks to correct area of screen. Percentage of incidents where eyes stop and remain on correct area.	Eye-tracking computer platform including cameras and infrared emitters hidden behind small dark windows at the top and bottom of the monitor.	
					Numbers of induced keystroke errors and undo's: 85% reduction from the TD prototype.	Keystroke tracking during 10 hours of operation over two sessions for each of 10 subjects.	
					Facial expressions: Less than one instance of frustration per trial.	Webcam capture of user's facial expressions. Synchronized audio channel to capture subject vocalizations. All tests above simultaneously executed.	

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6	Airfield Operations	**KSA: Controlled Air Field Access**	Are aircraft protected from mobile, ground-based entities when on the flight line?	**Wildlife Exclusion:** Are aircraft protected from incursions of wild animals onto taxiways and runways?	Perimeter barrier height: 15 feet. Perimeter barrier spacing: No less than 90 feet from center line of taxiway or runway.	Inspection by base civil engineers.	Fielding MS C
				Vehicle Exclusion: Are measures in place to prevent unauthorized operators from driving vehicles onto the flight line?	Ignition Control: Air field vehicle ignitions controlled and activated with Common Access Card (CAC). CAC Driver Authorization: CAC cards encoded with driver authorization credentials.	Subsystem demonstration using engineering model. CASE testing of encoding module and software system. Laboratory encoding verification of eight (8) driver authorization codes using hand scanner.	

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7	Fighter Aircraft Crew System	**KPP: Force Protection**	Does the system enable crew members to sustain operation under rapid onset conditions?	Can crew members sustain safe and effective operations at up to 9 Gs rapid onset?	Pressure breathing for G (PBG): Provide a mean score of at least eighty-five (85) seconds in the weighted time and acceleration explores of a relaxed rapid onset series. Maximum possible score: 105 seconds. Time to experience 100% peripheral (or 50% central light loss): 15 seconds	Centrifuge tests of rapid onset series: 1. Plus (+) six (6) G per second to plus (+) three (3) Gs; hold for fifteen (15) seconds; two (2) minute rest period. 2-7. Incremental increases of plus (+) 1 Gs up to plus (+) 9 Gs. Subjects remain relaxed (no anti-G straining maneuver). Tests cease when subjects experience 100% peripheral or 50% central light loss. Light bar apparatus with button mounted on handlebar grip. Subjects squeeze grip, click the button on top in response to red lighting that moves from periphery to center of vision. Subject failure to press button once/second indicates narrowing of field of vision. Subjects signal test abort by releasing grip. Vital sign measures via chest, neck, and left wrist electrodes. Doppler sensor measure of velocity of blood flow to brain.	MS C

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8	Fixed-wing Aircraft	**KPP: Sustainment** **KSA:** Reliability	Does the performance of system maintenance tasks induce system failures?	**Design Vulnerability:** Is the engine pylon design vulnerable to maintenance damage? **BIT:** Does built-in test (BIT) notify flight and maintenance crews of maintenance errors (incomplete or incorrectly performed maintenance procedures)?	Human Error Probability (error occurrences / error opportunities): acceptance < 0.01	Validation of error analysis using subsystem (Pylon, Engine, BIT, and Ignition) and integrated system simulations. Ecological analysis of legacy system procedure to validate M&S error opportunities. Flight model test of procedure to identify previously missed error opportunities and catalog error occurrences. Three maintenance crews performing full engine change out.	MS B MS B MS C
9	Information System	**KPP: Materiel Availability**	Does the capability provide an unambiguous indication of instantaneous materiel availability?	**Availability Determination**: Can novice and experienced users rapidly determine the exact amounts of materiel available? Can novice and experienced users accurately identify the exact amounts of materiel available?	Rapid determination: Call up materiel availability display within two (2) seconds of voice command. Accurate identification: Vocally communicate the counts of 10 inventory items in eight (8) seconds with 99% accuracy over 25 trials.	Timed, live-virtual simulation of four candidate displays with 40 subjects using “Engagement 5.2B” scenario. Timed, live simulation of three candidate displays with 20 subjects. Vary ordering of items numerically, alphabetically, and categorically.	MS B

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10	Information system	**KPP: Sustainment** **KSA:** Reliability	Does the Data Collection, Analysis and Corrective Action System (DCACAS) support reliability growth throughout operations?	**Autonomous Collection:** Does the DCACAS autonomously collect success and failure data?	Subsystem success (completion) sensor activations: 100% Subsystem failure sensor activations: 100%	Human-in-the-Loop testing of subsystem maintenance procedures. One subject. Full demonstration of all maintenance procedures.	Test Readiness Review
				User Prompting: Does the DCACAS system effectively prompt flight, maintenance and logistics crews to record success and failure data?	Incident Recording Ratio (recorded/opportunity): 98% Time to prompt acknowledgment: < 5 seconds	Simulations of flight, maintenance and logistics crew procedures on legacy system with mountable PDA-based display/prompt system. Videotaped observations and digital timing of prompt acknowledgement.	MS C
				Availability and Usability: Are failure, analysis and corrective action data accessible to all sustainment and development personnel in usable form?	Time to access: < 5 seconds Time to correct input errors: < 8 seconds Post-processing conversion operations required: 0	Eye-tracking computer platform. Webcam/audio capture of user's facial expressions and vocalizations. Walkthroughs of stakeholder post-access information processing. Subjective usability rating questionnaire, Likert-scale evaluations.	MS B

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11	Maintenance Information Support System	**KSA: Accessible Procedures**	Are maintenance procedures available at point of application?	**Availability:** Are searchable, just-in-time procedures accessible to maintainers at the location where maintenance will be performed?	One-touch, biometric accessible: Procedures delivery system accessible from any unit via one-touch, biometric activation. Time to access correct procedure: < 5 seconds Language accessibility: Procedures available, including keyword searches, in American English, United Kingdom English, French, German, Polish and Arabic. Accessibility in Environment: All-conditions interface, including temperature, lighting, pressure, vibration, dust and vapor obscuration.	CASE testing of alphanumeric symbols with Latin, Cyrillic and Arabic alphabets. Usability tests prior to Coalition Warrior Interoperability Demonstration (CWID) Interoperability Trial (IT). Five (5) subjects from each nationality. Videotaped trials, questionnaire, Likert scale acceptance evaluations. Mockup display testing. Videotape of candidate display mockups with digital camera perpendicular to display field Environments tested in order of • Temperature – environment chamber from minus 20-plus120 degrees Fahrenheit • Lighting – bench test, dark to full-sun, fluorescent and incandescent white, blue, red, and green, hemisphere, 1.5 ft radius. • Pressure – environment chamber to two atmospheres • Vibration – shaker table , -0.5 dBg, 2300 RPM • Dust – Duration exposure at Yuma Test Center • Humidity - Condensing humidity tests.	Test Readiness Review Post Deployment Review MS B

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12	Manned Aircraft Crew System	**KSA: Personnel Survivability**	Can the crew expeditiously exit the vehicle?	**Tools:** Do support tools impede rapid evacuation of the vehicle?	Maximum time for crew exit: ten (10) seconds Tool access: Within arm length reach of personnel near the boundary conditions of the central 95% of the representative user population (MIL STD 1472).	Timed walk though of emergency egress tasks. Anthropometric model of full-scale mockup of all crew stations. Inspection of full-scale mockup of single seat using personnel near the boundary conditions of the central 90% (5^{th} to 95^{th} percentile) of the representative user population.	MS C

13	Passenger Transport Aircraft	**KSA: Passenger Load and Density**	Does the capability accommodate the required number of inhabitants?	**Dimensions:** Does the system accommodate linear spatial dimensions of central 95% of the representative user population, two carry-on items and two stowed cargo items?	Seat pitch: 37 inches Seat width: 21 inches Seated headroom: 37 inches Carry on one dimensions: 21.5 in x 9 in x 15.5 in Carry on two dimensions: 16.5 in x 6 in x 13 in Stowed cargo (each of 2): 62 linear inches (l + w + h)	Anthropometric model measured against bounding and mixed-complement scenarios. Have representative passenger pack for actual mission and attempt to stow cargo.	MS B
				Are stowed carry-ons within the non-extended reach of a 5th percentile female when motion restraints are in place?	Non-extended reach to carry-ons: 27.6 in.	Demonstration of full-scale mockup of compartment section. Have representative passenger pack for actual mission and attempt to stow cargo.	MS C
				Does the capability support the volumetric spatial dimensions of central 95% of the representative user population, carry-on items and stowed cargo items?	Small female plus carry-ons: 29,616.5 cu in. Large male plus carry-ons: 33,035.2 cu in. Stowed cargo: 510.8 cu ft	Lickert scale, user rating of space. Inspection of full-scale mockup of half-row. Lickert scale, user rating of space.	MS C

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14	Passenger Transport Aircraft	**KSA: Passenger Load and Density**	Does the capability accommodate the required number of inhabitants?	**Personal Amenities:** Does the system incorporate handicap-accessible, private lavatory facilities in sufficient numbers for the system's full 50-inhabitant complement?	Max wait time: 5 minutes Avg. wait time: ≤ 2 minutes Handicap stall width: 39 in. Handicap stall depth: 59 in.	Task network simulation Interior CAD model of stall employing "Jack" anthropometric model.	MS B
				Does the system supply personal video with audio to each seated inhabitant?	Controls reachable from vertical line from shoulder center to top of hip bone: Large male (24 in) to small female (27.6 in).	CAD models of single seat configuration employing "Jack" anthropometric models.	
					Eye-screen distance: between 45 inches away at horizontal eye level and 35 inches away at a 30-degree downward gaze angle. It shall not be closer than the resting point of vergence for any passenger in the small female through large male population.	CAD models of single seat configuration employing "Jack" anthropometric models.	
					Visibility in full sun: ability to discriminate all colors and contrasts.	10 user trials of single-seat, full-scale, mockup of color bars with grey scale and plunge patterns in hemispherical screen-impingement pattern of simulated, full sunlight.	
						Eight-hour, full scale trial of system with full 50-person complement.	MS C

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15	Training Information System	**KPP: System Training KSA:** Coordinate Civilian Personnel and Contractor Support	Does the capability meet prior-to-forward-deployment training objectives for civilians and contractors?	**Training Availability:** Does the capability support seamless civilian and contractor training at CONUS locations, when in transit and at the staging location?	User access: Secure access to login, course materials and trainer feedback from a) all Government Education and Training Network (GETN) sites; b) air, sea and ground transport systems; and in-theater housing. Progress handoff: Resume active training module from exact point of last trainee-to-training-system interaction with no more than a five-second handoff lag. Communication Audibility: Voice channel between trainers and trainees audible when trainee is in 85 dB noise floor environment. Distortion in voice channel <.0025% from 20 to 20kHz.	Assessment at 25 distributed sites using modified GETN automated software test cases. Three shifts tested on eight-hour centers from all test sites. White event C2-ground demonstration of capability at Air National Guard's Distributed Training Operations Center. Noise measurements taken from 20Hz to 20kHz in 10 Hz intervals in anechoic chamber. On-line computer-controlled acquisition and processing. Confirmation of anechoic findings using Modified Rhyme Tests of 20 human subjects in presence of increasing noise floor starting from measured ambient to induced 85 dB. Measurements of transmission to ear-piece, end-to-end signal using spectrum analyzer.	Service/ JROC Validation and Approval

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16	Training Information System	**KPP: System Training KSA:** Coordinate Civilian Personnel and Contractor Support	Does the capability meet prior-to-forward-deployment training objectives for civilians and contractors?	**Automated Training Assessment:** Does the capability accurately assess civilian and contractor preparedness for forward deployment?	Training Module Assessment vs. Simulation Score: Pearson correlation coefficient (r) of 90, with 95% regression confidence.	Pre-training *Full Spectrum Civilian* simulation scoring. Embedded training assessment Post-training *Full Spectrum Civilian* simulation scoring. Fifteen subjects. *Statistical* data reduction.	Service/ JROC Validation and Approval
17	Unmanned Aerial System Ground Control System	**KSA: Positive Indication**	Does the Ground Control System (GCS) provide Positive Indication of UAS states when transferred in?	**Unacknowledged Commands**: Does the GCS provide positive indication that unacknowledged commands from previously controlled UAS's have been cleared from the system prior to transfer in?	GCS command buffer flush: Within 25 ms of receipt of CTA (Command Transfer Acknowledgment) telemetry signal from UAS.	CASE test of algorithm. Built-in, timed test of full flush. GCS test equipment to include command buffer stored volume.	MS C
				Autopilot Engagement: Does the GCS provide continuous positive indication when autopilot is engaged?	Autopilot engagement display: All-conditions display within one-inch radius of autopilot switch. Autopilot engagement display: Line-of-sight visibility to seated pilot, all chair adjustments.	Inspection under all lighting conditions. JACK ergonomic model 5th percentile female to 95th percentile male.	MS B
				External Pilot Point of View: Does the EP controller provide positive indication of direction (forward, rear) when associating right-left controls with actuators?	EP POV Indicator: Zero-error left-flap, right-flap activation in all relative orientations.	Live-Virtual exercise with UAS trailer and engineering model of EP controller, randomized 15 deg increments for full 360 deg. horizontal coverage.	MS C

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18	**Unmanned Aerial System Maintenance Training System**	**KSA Rapid Sortie Turnaround**	Does the capability support rapid training of users?	**Amount of training time required:** Does system-specific training achieve required competence in accordance training plan and operational need?	**Number of repetitions required to satisfactorily achieve competence scores:** < 3 repetitions per embedded module. **Required Training Time:** < 1 hour of training spent on each embedded module. **Maintainers' reactions to training:** > 4.85 mean overall score**.** **Learning as a result of training:** 98% mission success rates; untimed. **Results:** 50% decrease in mean UAS return-to-service times at three, six and nine weeks.	Automated recording of trials by maintainers through nine weeks from IOC. Automated recording of time maintainers are logged into specific training module through nine weeks from IOC. Lickert scale, self-evaluation of training relevance to maintenance tasks. Increases in success rates on training scenarios for critical mission segment 4, 5 and 11 at three, six and nine weeks. Ecological observation of maintainers. Samplings taken at junctures of design-reference task-network model, all shifts, ten hours' of operation for each shift. Time measures beginning with handoff at model's upstream juncture through downstream juncture.	Test Readiness Review

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19	Vehicle Crew System	**KSA: Environ-mental Control**	Is the environment suitable for extended periods of human habitation in all modes of operation?	**Level of Humidity**: Does the level of humidity in the work environment remain at 50 +/- 20% when the capability is in operation?	Humidity level: 50 +/- 20%	Ambient (internal) humidity levels with calibrated electronic hygrometer.	MS C
				Operational Temperature: Is the temperature of the work area maintained in the range of 18-26°C (64-78°F) when external ambient temperature is between -20°F with minimum solar load and +115°F with maximum solar load?	Workspace ambient temperature: 71 +/-7°F External ambient temperature: -25°F to +140°F.	Dry bulb measures of internal ambient temperature. Stevenson screen measurements of external ambient temperature.	MS C
				Crew Core Temperature: Does the core body temperature of work area inhabitants remain between 95°F and 100°F when the capability is in operation?	Inhabitant core body temperature (rectal): 97.6 +/ - 2°F	Rectal temperature measurement with probe.	MS C
						All measures taken with representative crew members performing scenario 7 mission tasks. **Key Resources:** Workspace mockup; thermal chamber	

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20	Aircrew Kneeboard Laptop	**KSA: Personnel Survivability**	Can emergency egress occur via the ejection seat with a kneeboard laptop system in place?	**Obstruction:** Does the system obstruct the pathway for emergency egress?	Ejection position with kneeboard laptop system: Any position within 5 inches of vertical adjustment (MIL-DTL-9479E).	Task modeling and simulation to determine likelihood of hung jumper	MS B
					Accommodation of flight clothing and personal equipment: Seat Assembly with laptop kneeboard laptop operation without snag, jam or damage to clothing or equipment.	Monte Carlo Seat Assembly simulations with Draping and Aux Equip model engaged.	MS B
					Knee Room: No less than 25 inches high and 20 inches wide	Height measurement of crew compartment from interior floor at seat edge and at six inches forward of seat edge. Width measurements extending from seat edge to left and right panels perpendicular to floor at seat edge and at six inches forward of seat edge.	MS C
					Kneeboard laptop cannot interfere with ejection rails at any point.	Engineering model test of Seat Assembly with kneeboard mockup using representative crash dummies.	LRIP

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21	Aircrew Kneeboard Laptop	**KSA: Personnel Survivability**	Can emergency egress occur via ejection seat with kneeboard laptop system in place?	**Signal:** Does the kneeboard laptop emit a signal(s) that jams or interferes with the egress signal?	Audibility of emergency signal: audible to subject with H-1 hearing profile (per AFI 36-2108 *Airman Classification)* over 90 dB noise floor.	Helmet mounted audio measurement of emergency signal. Mannequin insert in helmet. Acoustic chamber with simulated noise floor. Subjective tests in acoustic chamber using pilots with representative hearing (H-1 to H-3 hearing profiles).	MS B
					Kneeboard laptop visual signal frequencies: 1.5 – 2.5 Hz.	Visual Signal Frequency measurement of kneeboard laptop displays.	MS B
					Kneeboard laptop visual signal discrimination: Differentiable from cockpit warning signal frequencies 3-5 Hz in all lighting conditions in frequency and color.	Subjective determination of conflicting and competing ranges. Blackout, twilight, full sun and glare conditions.	MS C
					Automatic kneeboard laptop auditory signal cutoff: At immediate onset of auditory egress signal; continuous thereafter.	CASE test of algorithm using cockpit system and engineering model of kneeboard.	MS C
					Kneeboard line-of-sight (LOS) obscuration of cockpit visual egress warning signals: 99% visible for each visibility square containing all or part of cockpit egress warning display.	Video files of representative target audience members in mock-up cockpit. Digitize into posture file for input into Classic JACK. Quantify LOS with the JACK Coverage Zone Tool (CZT). Origin location between virtual operator eyes; CZT resolution of 100 horizontal units and 100 vertical units.	MS B

22	Aircrew Kneeboard Laptop	**KPP: Survivability** [2] (of a manned system) **KSA:** Personal Locator EMI	Can crew members survive vehicle evacuation with the kneeboard laptop system?	**Personal Locator Device:** Does the kneeboard laptop system emit a signal(s) that jams or interferes with the personal locator device signal?	Allowed EMI Interference between 406 MHz emergency locator signal and kneeboard laptop system: None.	Test receiver measurements of locator signal in presence of engineering model of kneeboard laptop unit. Frequency start: 300 MHz Frequency stop = 1 GHz Resolution Bandwidth (RBW) = 120 kHz (6 dB) Step size = 60 KHz (1/2 RBW)	Operational Test Readiness
23	Aircrew Kneeboard Laptop	**KPP: Survivability**[1] (of a manned system) **KSA:** Detectability	Can crew members survive vehicle evacuation with the kneeboard laptop system?	**Detectable Signal:** Does the kneeboard laptop emit a signal or visually detectable light source that may alert the enemy/foe of emergency egress/distress?	Range of electromagnetic signals from kneeboard laptop: Undetectable outside of a sphere of two (2) foot radius centered on kneeboard. Simultaneous screen automatic shut-off with initiation of ejection.	Near-field test receiver measurements in free-field test range of kneeboard laptop engineering model. Frequency start: 9 KHz Frequency stop = 3 GHz Resolution Bandwidth (RBW) = 20 kHz (6 dB) Step size = 10 KHz (1/2 RBW) Subsystem testing of automatic shut-off circuit in simulated ejection scenario.	Operational Test Readiness
24	Fighter Aircraft	**KPP: Sustainment KSA:** Reduced Ownership Cost	Does the system create an environment that induces hearing loss that creates a permanent, debilitating impairment?	**Number of Personnel with time weighted average noise exposure in excess of 85 dB over a 12-hour period.** Do costs of compensating and treating airmen for permanent hearing loss exceed Surgeon General and Veterans Administration annual budget allocations for aircraft platform?	Number of air crew and ground crew members exposed to > 85 dB time weighted average equivalent sound level over a 12-hour work shift (annually): < 4	IMPRINT simulation of air crew performing missions I, II, IVC and VII. IMPRINT simulation of ground crew simultaneously readying four 4 aircraft. Quarterly audiometric testing of aircrew beginning at IOC.	PDR Post-Deployment Review

[2] Survivability attributes are those that contribute to the survivability of a manned system. This includes attributes such as speed, maneuverability, detectability, and countermeasures that reduce a system's likelihood of being engaged by hostile fire. These examples relate to the detectability or lack of detectability that would put the system at risk.

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25	Fighter Aircraft	**KPP: Sustainment** **KSA:** Availability[3]	Does air crew and maintenance crew noise exposure limit system availability for forecast levels of manpower?	**Noise exposure:** Do aggregate noise exposure levels constrain the flight time (range) of the aircraft? Do aggregate noise exposure levels increase the required manpower levels for the ground crew?	Time weighted average noise level (with hearing protection): 8-hour time weighted average equivalent sound level < 85 dB for any flight crew or ground crew member. Percent of ground crew that incorrectly implement and adjust hearing protection: <0.1%	Near Field Measures: Maintenance and operations personnel acoustics in dB. Military power and afterburner power. Stationary aircraft on the ground. Octave band sound exposure levels (SEL) in dBA at 500, 1000, 2000, 3000, 4000, 5000 and 6000 Hz at each crew position. Octave band measurements in dB at 500, 1000, 2000, 3000, 4000, 5000 and 6000 Hz at positions on a six (6) feet by six (6) grid within cone +/- 135° from aircraft nose. All equipment operating in normal mode. Form and custom mold ear protection testing. Twenty insertions, twenty subjects. Repeat at two hour intervals. Administered by AF Hearing Conservation Program designee.	MS C

[3] The Availability KSA for this example relates to the relationship between ground crew availability and the ability to field the fighter at optempo. Since there is a limit on the amount of exposure to individual ground-crew members, a significant number of ground crew members exceeding that limit, would place mission capability at risk. Ignoring the limit would drive up Air Force enterprise medical costs.

Row Number	System	Key Requirements and T&E Measures				Test Methodologies / Key Resources (M&S, SIL, MF, ISTF,HITL, OAR)	Decision Supported
		Key Requirements (KPPs, KSAs)	Critical Operational Issues (COIs)	Key MOEs/MOSs	Critical Technical Parameters (CTP) & Thresholds		
26	Fighter Aircraft	**KSA:** Noise Compatibility	Is the system suitable for CONUS basing?	**Far Field Noise:** Will relative geospatial positioning of required flight profiles, dominant weather patterns, frequency of flight operations and airfield acoustics combine with aircraft noise to result in noise contours that are unacceptably high to stakeholders in communities surrounding CONUS air bases?	Sound Exposure Levels: <100 dBA , 1000 ft flight level , minimum power <120 dBA, 100 ft flight level, mil power <125 dBA, 100 ft flight level, with afterburner	Field measures followed by M&S using Advanced Acoustics Model. **Far Field Measures:** Community acoustics, sound exposure levels (SEL) in dBA. Array of 170 microphones. Flight level (above- ground) measures: 0 to 300 ft Lateral measures: 25 to 7 miles 160 Knots true airspeed **Advanced Acoustics Model** applied to candidate CONUS basing. Flight level (above- ground) measures: 0 to 1000 ft Adjust to Standard Acoustic Day: International Standard Atmosphere + 18°F (ISA + 18°F)	Fielding