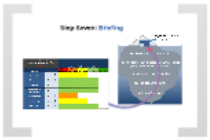
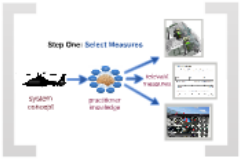
Toward a Framework for Assessing
Human Systems Integration Efficacy

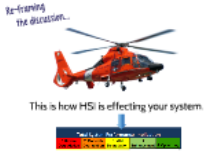
HSI balances human capabilities and limitations with the
affordances and constraints presented by system technology
to accomplish systems goals.

"The Coast Guard relies on cutters, boats, and aircraft to operate in the maritime
environment, but it is our people who deliver truly unique capabilities to the
Nation."
– ADM Paul Zukunft, Commandant's Direction (2014)

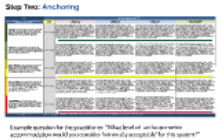
Start:


Step Seven: Briefing


Step One: Select Measures
system concept
practitioner knowledge


Re-framing the discussion...
This is how HSI is effecting your system

Step Six: Analysis
MANPOWER
PERSONNEL
HFE


Step Two: Anchoring

MFE Measure 1
MFE Measure 2
MFE Measure 3
MFE Measure 4

Step Five: Collection and Assessment

Step Three: Calibration

Step Four: Socialization
Awareness & Buy-in
Framework for and onboarding HSI
Overview of HSI measures
Rubric of acceptable performance

What's next?
thesis / initial concept (FY 14)
conceptualize domain scales (FY 15)
draft domain criteria & TSP scale
calibration / TTX (FY16)
brief to program (FY 16)
beta test (FY 16)
automation / software
scaling

Toward a Framework for Assessing Human Systems Integration Efficacy

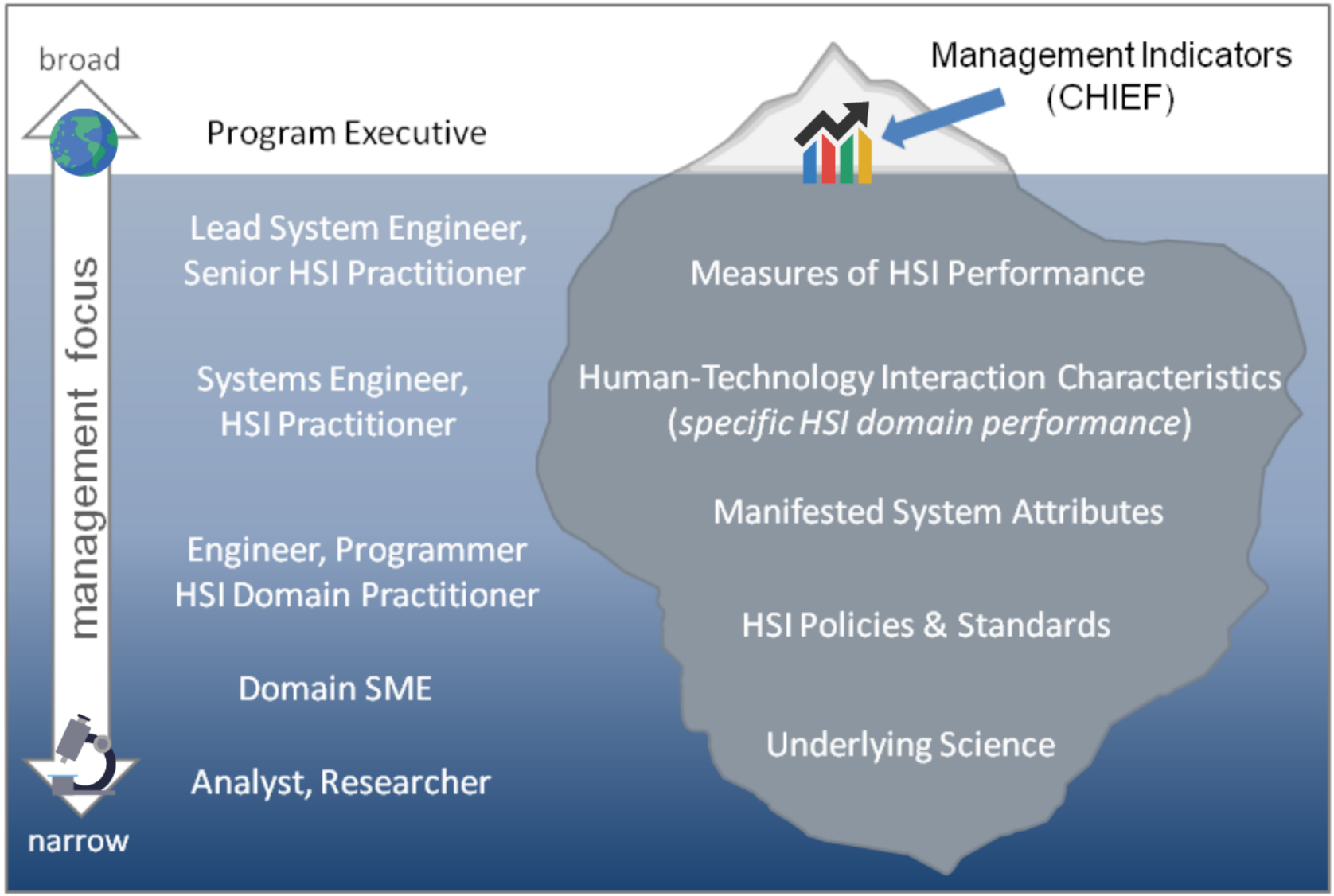
NDIA Human Systems 2016
Springfield, VA

CDR Mike O'Neil
U.S. Coast Guard
HSI Division (CG-1B3)

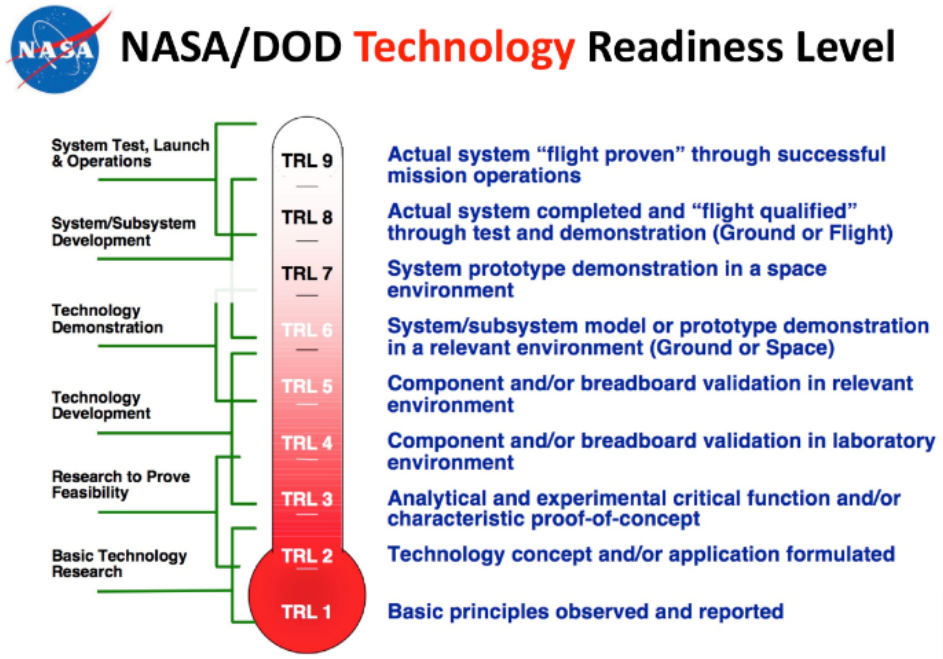
"The Coast Guard relies on cutters, boats, and aircraft to operate in the maritime environment, but it is our people who deliver truly unique capabilities to the Nation." *- ADM Paul Zukunft, Commandant's Direction (2014)*

HSI balances human capabilities and limitations with the affordances and constraints presented by system technology to accomplish system goals. *(Shattuck, O'Neil & Sciarini 2014)*

How do we place humans on par tech during system development?


broad
management focus
narrow
Program Executive
Lead System Engineer,
Senior HSI Practitioner
Systems Engineer,
HSI Practitioner
Engineer, Programmer
HSI Domain Practitioner
Domain SME
Analyst, Researcher
Management Indicators
(CHIEF)
Measures of HSI Performance
Human-Technology Interaction Characteristics
(specific HSI domain performance)
Manifested System Attributes
HSI Policies & Standards
Underlying Science

Selective borrowing from TRL



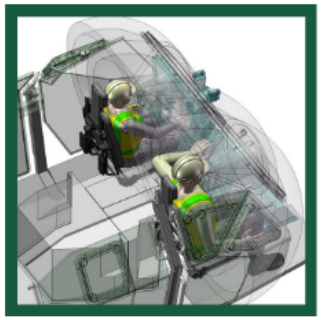
- ✓ simple language
- ✓ discipline independent
- ✗ uni-variate scale for multiple HSI domains

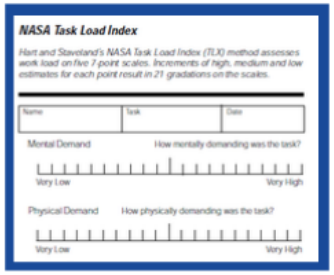
Re-framing
the discussion...

This is how HSI is effecting your system.

Total System Performance Implication				
1.Severe Degradation	2. Moderate Degradation	3. Mild Degradation	4. Enhancement	5. Optimizing

Basic idea...





selected measures

HFE Evaluation Criteria

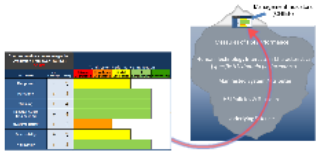
	TSPI	Analyze/Select (Preliminary Design)
5	Optimizing	
4	Enhancement	
3	Minimal Degradation	anthro TLX eye track
2	Moderate Degradation	
1	Severe Degradation	

unifying scale for each HSI domain

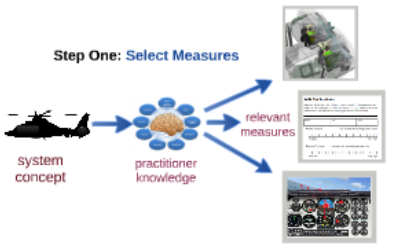
Comprehensive Human Integration Evaluation Framework (CHIEF) DRAFT			Total System Performance Implication				
HSI Domain	HSI Glideslope	Rating	1.Severe Degradation	2. Moderate Degradation	3. Mild Degradation	4. Enhancement	5. Optimizing
Manpower	-	3					
Personnel	+	4					
Training	+	4					
Human Factors Engineering	+	4					
Systems Safety	+	2					
Survivability	+	3					
Habitability	+	4					

integrated HSI assessment

Step Seven: Briefing



Step One: Select Measures

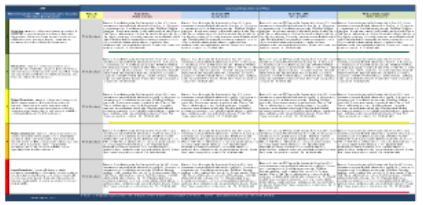


Re-framing the discussion...

This is how HSI is effecting your system.

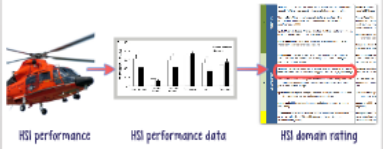
Step Six: Analysis

Step Two: Anchoring

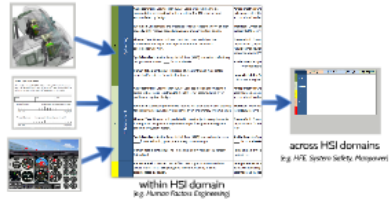


Example question for the practitioner: "What level of anthropometric accommodation would you consider 'minimally acceptable' for this system?"

Step Five: Collection and Assessment



Step Three: Calibration



Step Four: Socialization

Awareness & Buy-in:

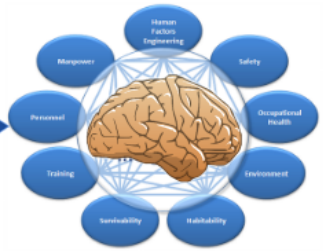
- ✓ Framework for understanding HSI
- ✓ Overview of HSI measures
- ✓ Range of acceptable performance

Start:

Entering Arguments: Users, Work Context, System Config

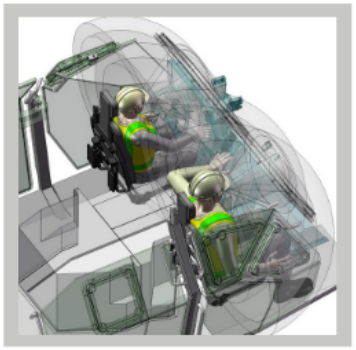
Step One: Select Measures

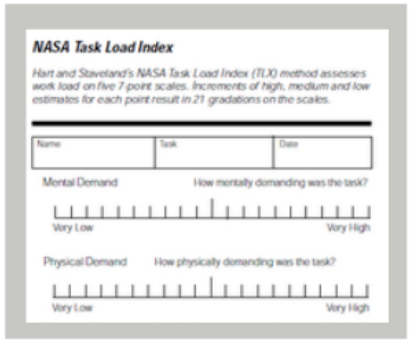
system concept



practitioner knowledge

relevant measures





Step Two: Anchoring

CHIEF		Coast Guard Acquisition Lifecycle Phase				
What is the implication of HFE on total system performance given what we know about the system?		Project ID (Needs)	Analyze/Select (Preliminary Design)	Obtain (pre CDR) (Detailed Design)	Obtain (Post CDR) (Prototype/LRIP)	Produce, Deploy, Support (Full-rate Production)
5	**Optimizing:** Impacts on total system performance are consistently positive with no exceptions predicted or observed. Engineering changes driven by inadequate human system integration are very unlikely given current system configuration. Human-system performance is at or above objective-level requirements.	[To be Developed]	Based on the preliminary design: [Anthropometrics] At least 99% of users accommodated across all critical tasks modeled; less than 1 in 100 users are not accommodated in the preliminary system design. [Workload] Workload insignificant. Enough spare capacity for all desirable additional tasks. [Time on Task] Time on task is predicted to be less than specified objective value (better than objective requirement) for requisite manpower, across all mission-critical tasks. [Spatial Analysis] No measurable performance degradation noted for either non-critical or mission-critical tasks due to workstation layout, workspace design, system physical configuration. [Human error] Human error predicted to occur in 1 in 100 critical tasks.	Based on the detailed design: [Anthropometrics] At least 99% of users accommodated across all critical tasks modeled; less than 1 in 100 users are not accommodated in the preliminary system design. [Workload] Workload insignificant. Enough spare capacity for all desirable additional tasks. [Time on Task] Time on task is predicted to be less than specified objective value (better than objective requirement) for requisite manpower, across all mission-critical tasks. [Spatial Analysis] No measurable performance degradation noted for either non-critical or mission-critical tasks due to workstation layout, workspace design, system physical configuration. [Human error] Human error predicted to occur in 1 in 100 critical tasks.	Based on the prototype/LRIP system: [Anthropometrics] At least 99% of users accommodated across all critical tasks modeled; less than 1 in 100 users are not accommodated in the preliminary system design. [Workload] Workload insignificant. Enough spare capacity for all desirable additional tasks. [Time on Task] Time on task is predicted to be less than specified objective value (better than objective requirement) for requisite manpower, across all mission-critical tasks. [Spatial Analysis] No measurable performance degradation noted for either non-critical or mission-critical tasks due to workstation layout, workspace design, system physical configuration. [Human error] Human error predicted to occur in 1 in 100 critical tasks.	Based on the production system: [Anthropometrics] At least 99% of users accommodated across all critical tasks modeled; less than 1 in 100 users are not accommodated in the preliminary system design. [Workload] Workload insignificant. Enough spare capacity for all desirable additional tasks. [Time on Task] Time on task is predicted to be less than specified objective value (better than objective requirement) for requisite manpower, across all mission-critical tasks. [Spatial Analysis] No measurable performance degradation noted for either non-critical or mission-critical tasks due to workstation layout, workspace design, system physical configuration. [Human error] Human error predicted to occur in 1 in 100 critical tasks.
4	**Enhancement:** Impacts on total system performance are net positive with rare or insignificant exceptions. Engineering changes driven by inadequate human system integration are unlikely. Human-system performance is well above threshold-level requirements, but has not met objective-level requirements.	[To be Developed]	Based on the preliminary design: [Anthropometrics] At least 95% of users accommodated across all critical tasks modeled; less than 1 in 50 users are not accommodated in the preliminary system design. [Workload] Workload low. Ample spare capacity for additional tasks). [Time on Task] Time on task is predicted to meet objective requirement for requisite manpower, across all mission-critical tasks. [Spatial Analysis] Rare or insignificant performance degradation of critical/non-critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in 5 in 100 critical tasks.	Based on the detailed design: [Anthropometrics] At least 95% of users accommodated across all critical tasks modeled; less than 1 in 50 users are not accommodated in the preliminary system design. [Workload] Workload low. Ample spare capacity for additional tasks. [Time on Task] Time on task is predicted to meet objective requirement for requisite manpower, across all mission-critical tasks. [Spatial Analysis] Rare or insignificant performance degradation of critical/non-critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in 5 in 100 critical tasks.	Based on the prototype/LRIP system: [Anthropometrics] At least 95% of users accommodated across all critical tasks modeled; less than 1 in 50 users are not accommodated in the preliminary system design. [Workload] Workload low. Ample spare capacity for additional tasks. [Time on Task] Time on task is predicted to meet objective requirement for requisite manpower, across all mission-critical tasks. [Spatial Analysis] Rare or insignificant performance degradation of critical/non-critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in 5 in 100 critical tasks.	Based on the production system: [Anthropometrics] At least 95% of users accommodated across all critical tasks modeled; less than 1 in 50 users are not accommodated in the preliminary system design. [Workload] Workload low. Ample spare capacity for additional tasks. [Time on Task] Time on task is predicted to meet objective requirement for requisite manpower, across all mission-critical tasks. [Spatial Analysis] Rare or insignificant performance degradation of critical/non-critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in 5 in 100 critical tasks.
3	**Minimal Degradation:** Impacts on total system performance trend slightly toward degradation. Engineering changes driven by inadequate human system integration may emerge during sustainment to remedy minor system performance deficiencies. Human-system performance (time on task, error rates, availability, etc.) is marginally meeting threshold requirements.	[To be Developed]	Based on the preliminary design: [Anthropometrics] At least 90% of users accommodated across all critical tasks modeled; roughly 1 in 20 users are not accommodated in the preliminary system design. [Workload] Workload comfortable. Reduced spare capacity for additional tasks. [Time on Task] Time on task is predicted to meet threshold requirement for requisite manpower, across all mission-critical tasks. [Spatial Analysis] Minimal performance degradation noted of critical/non-critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in 10 in 100 critical tasks.	Based on the detailed design: [Anthropometrics] At least 90% of users accommodated across all critical tasks modeled; roughly 1 in 20 users are not accommodated in the preliminary system design. [Workload] Workload comfortable. Reduced spare capacity for additional tasks. [Time on Task] Time on task is predicted to meet threshold requirement for requisite manpower, across all mission-critical tasks. [Spatial Analysis] Minimal performance degradation noted of critical/non-critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in 10 in 100 critical tasks.	Based on the prototype/LRIP system: [Anthropometrics] At least 90% of users accommodated across all critical tasks modeled; roughly 1 in 20 users are not accommodated in the preliminary system design. [Workload] Workload comfortable. Reduced spare capacity for additional tasks. [Time on Task] Time on task is predicted to meet threshold requirement for requisite manpower, across all mission-critical tasks. [Spatial Analysis] Minimal performance degradation noted of critical/non-critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in 10 in 100 critical tasks.	Based on the production system: [Anthropometrics] At least 90% of users accommodated across all critical tasks modeled; roughly 1 in 20 users are not accommodated in the preliminary system design. [Workload] Workload comfortable. Reduced spare capacity for additional tasks. [Time on Task] Time on task is predicted to meet threshold requirement for requisite manpower, across all mission-critical tasks. [Spatial Analysis] Minimal performance degradation noted of critical/non-critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in 10 in 100 critical tasks.
2	**Moderate Degradation:** Impacts on total system performance are consistently degrading with measurable affect on critical mission performance. Engineering changes driven by inadequate human system integration are likely to emerge during early prototype testing or very early in the sustainment phase. Human-machine performance (time on task, error rates, availability, etc.) are appreciably below threshold requirements.	[To be Developed]	Based on the preliminary design: [Anthropometrics] At least 85% of users accommodated across all critical tasks modeled; roughly 3 in 20 users are not accommodated in the preliminary system design. [Workload] Very high workload with very little spare capacity. Difficulty in maintaining level of effort. [Time on Task] Time on task is predicted to exceed *threshold* requirement for one or more mission-critical tasks by up to 10%. [Spatial Analysis] Measurable performance degradation noted for critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in 15 in 100 critical tasks.	Based on the detailed design: [Anthropometrics] At least 85% of users accommodated across all critical tasks modeled; roughly 3 in 20 users are not accommodated in the preliminary system design. [Workload] Very high workload with very little spare capacity. Difficulty in maintaining level of effort. [Time on Task] Time on task is predicted to exceed *threshold* requirement for one or more mission-critical tasks by up to 10%. [Spatial Analysis] Measurable performance degradation noted for critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in15 in 100 critical tasks.	Based on the prototype/LRIP system: [Anthropometrics] At least 85% of users accommodated across all critical tasks modeled; roughly 3 in 20 users are not accommodated in the preliminary system design. [Workload] Very high workload with very little spare capacity. Difficulty in maintaining level of effort. [Time on Task] Time on task is predicted to exceed *threshold* requirement for one or more mission-critical tasks by up to 10%. [Spatial Analysis] Measurable performance degradation noted for critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in 15 in 100 critical tasks.	Based on the production system: [Anthropometrics] At least 85% of users accommodated across all critical tasks modeled; roughly 3 in 20 users are not accommodated in the preliminary system design. [Workload] Very high workload with very little spare capacity. Difficulty in maintaining level of effort. [Time on Task] Time on task is predicted to exceed *threshold* requirement for one or more mission-critical tasks by up to 10%. [Spatial Analysis] Measurable performance degradation noted for critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in 15 in 100 critical tasks.
1	**Severe Degradation:** Unacceptable impact on mission performance. Accomplishment of key mission functions or tasks are severely degraded or precluded due to an unsafe or operationally ineffective system configuration. Engineering changes driven by inadequate human-machine integration are required for continued program viability.	[To be Developed]	Based on the preliminary design: [Anthropometrics] Less than 85% of users accommodated across all critical tasks modeled; roughly 3 in 10 users are not accommodated in the preliminary system design. [Workload] Excessive workload. Unable to apply sufficient mental effort. No spare capacity. [Time on Task] Time on task is predicted to exceed threshold requirement for multiple mission-critical tasks, or by more than 10%. [Spatial Analysis] Severe performance degradation noted for one or more mission-critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in more than 15 in 100 critical tasks.	Based on the detailed design: [Anthropometrics] Less than 85% of users accommodated across all critical tasks modeled; roughly 3 in 10 users are not accommodated in the preliminary system design. [Workload] Excessive workload. Unable to apply sufficient mental effort. No spare capacity. [Time on Task] Time on task is predicted to exceed threshold requirement for multiple mission-critical tasks, or by more than 10%. [Spatial Analysis] Severe performance degradation noted for one or more mission-critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in more than 15 in 100 critical tasks.	Based on the prototype/LRIP system: [Anthropometrics] Less than 85% of users accommodated across all critical tasks modeled; roughly 3 in 10 users are not accommodated in the preliminary system design. [Workload] Excessive workload. Unable to apply sufficient mental effort. No spare capacity. [Time on Task] Time on task is predicted to exceed threshold requirement for multiple mission-critical tasks, or by more than 10%. [Spatial Analysis] Severe performance degradation noted for one or more mission-critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in more than 15 in 100 critical tasks.	Based on the production system: [Anthropometrics] Less than 85% of users accommodated across all critical tasks modeled; roughly 3 in 10 users are not accommodated in the preliminary system design. [Workload] Excessive workload. Unable to apply sufficient mental effort. No spare capacity. [Time on Task] Time on task is predicted to exceed threshold requirement for multiple mission-critical tasks, or by more than 10%. [Spatial Analysis] Severe performance degradation noted for one or more mission-critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in more than 15 in 100 critical tasks.
Form V4 - Updated 1/19/16		Instructions: For the appropriate acquisitions phase, select the block that describes the current state of performance for the selected HFE measures. If all performance criteria are not met, select the next lower block.				

Example question for the practitioner: "What level of anthropometric accommodation would you consider 'minimally acceptable' for this system?"

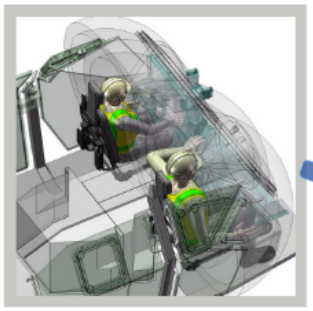
3

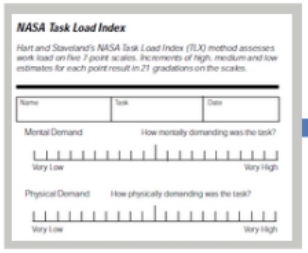
Minimal Degradation: Impacts on total system performance trend slightly toward degradation. Engineering changes driven by inadequate human system integration may emerge during sustainment to remedy minor system performance deficiencies. Human-system performance (time on task, error rates, availability, etc.) is marginally meeting threshold requirements.

Moderate Degradation: Impacts on total system performance are

e	degradation of critical/non-critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in 5 in 100 critical tasks.	de de to
ot on	Based on the detailed design: [Anthropometrics] At least 90% of users accommodated across all critical tasks modeled; roughly 1 in 20 users are not accommodated in the preliminary system design. [Workload] Workload comfortable. Reduced spare capacity for additional tasks. [Time on Task] Time on task is predicted to meet threshold requirement for requisite manpower, across all mission-critical tasks. [Spatial Analysis] Minimal performance degradation noted of critical/non-critical tasks due to workstation layout, workspace design, system physical configuration. [Human Error] Human error predicted to occur in 10 in 100 critical tasks.	Ba ac ac co Ti ma pe lay Hu
not	Based on the detailed design: [Anthropometrics] At least 85% of users accommodated across all critical tasks modeled; roughly 3 in 20 users are not accommodated in the preliminary system design. [Workload] Very high	Ba ac ac

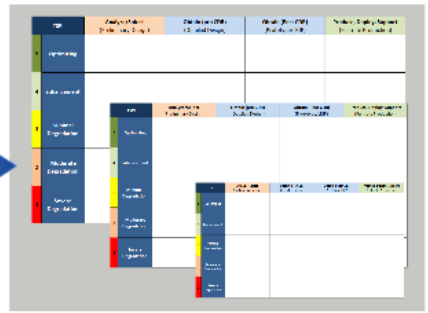
Step Three: Calibration





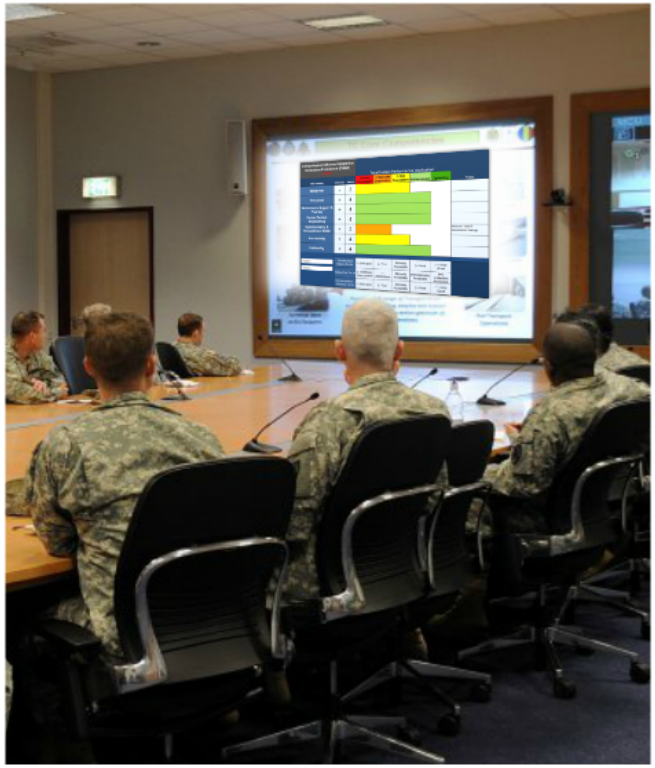
5	Optimizing	**Antropometrics:** Greater than 99% of users are predicted to be accomodated across critical tasks; less than 1 in 100 users are not accomodated by design. **Workload:** Critical tasks are predicted to require less than 80% of user capacity (20% reserve capacity) given preliminary system design. **Time on Task:** Time on task are predicted to exceed objective requirement for requisite manpower limitation (reference spec/manpower KPP). **Spatial Analysis:** Spatial Analysis Link Tool (SALT) scores for preliminary design do not exceed ____ for critical tasks. **Human Reliability Rating:** HRR score of greater than 96 % or better modelled/predicted for critical systems.	**Antropometrics:** Gre to be across all critic accomodated by det **Workload:** Critical ta capacity (20% reserv **Time on Task:** Time requirement (requir requisite manpower spec/manpower KP **Spatial Analysis:** Spa ____ for critical tasks **Human Reliability Ra** critical systems give
4	Enhancement	**Antropometrics:** Greater than 98% of user population acoomodated across critical tasks; less than 2% (1 in 50) is not accomodated given preliminary system design. **Workload:** Workload predicted to require less than 90% of user capacity for critical tasks (10% reserve capacity) given preliminary system design. **Time on Task:** Time on task predicted to meet objective requirements for requisite manpower mix (reference spec/manpower KPP) given preliminary system design. **Spatial Analysis:** Spatial Analysis Link Tool (SALT) scores do not exceed ____ for critical tasks, given preliminary system design. **Human Relaibility Rating:** The Human Reliability rating of 96 percent (objective)	**Antropometrics:** Gre accomodated across accomodated by des **Workload:** Workloa tasks (10% reserve c **Time on Task:** Time requirements for re KPP) **Spatial Analysis:** Spa ____ for critical tasks **Human Relaibility Ra** (objective)
		Antropometrics: Greater than 95% of user population accomodated across critical tasks; 15% (roughly 1 in every 20 users) are not accomodated by design.	**Antropometrics:** Gre across critical tasks; accomodated by des

within HSI domain
(e.g. Human Factors Engineering)



across HSI domains
(e.g. HFE, System Safety, Manpower)

Step Four: Socialization

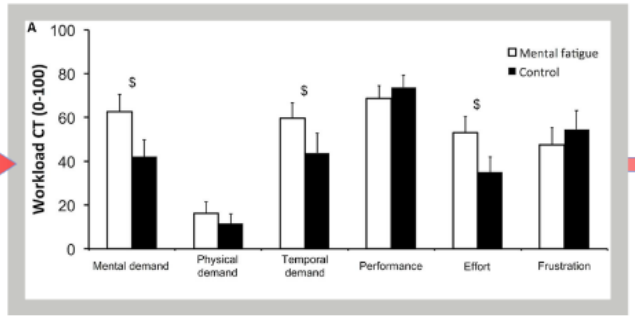


Awareness & Buy-in:

- Framework for understanding HSI
- Overview of HSI measures
- Range of acceptable performance

Step Five: Collection and Assessment

HSI performance

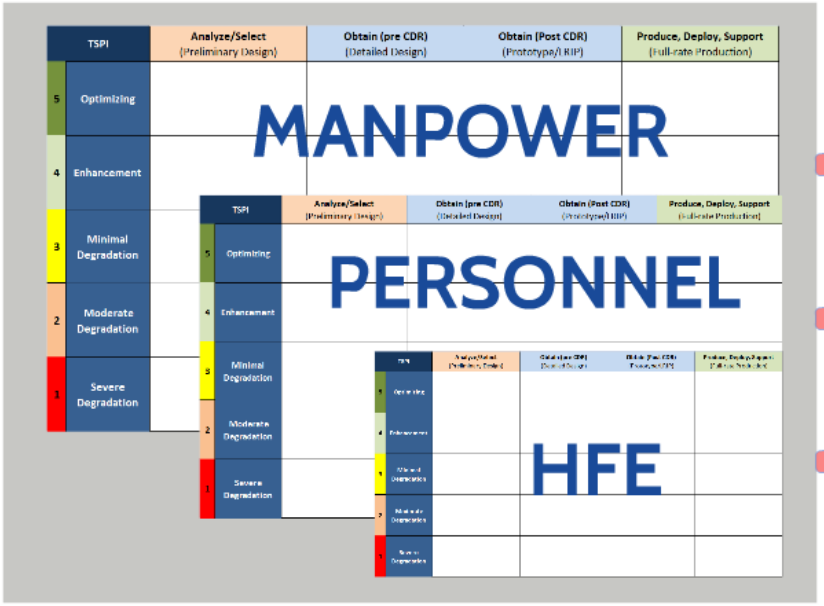


HSI performance data

5	Optimizing	**Workload:** Critical tasks are predicted to require less than 80% of user capacity (20% reserve capacity) given preliminary system design. **Time on Task:** Time on task are predicted to exceed objective requirement for requisite manpower limitation (reference spec/manpower KPP). **Spatial Analysis:** Spatial Analysis Link Tool (SALT) scores for preliminary design do not exceed ____ for critical tasks. **Human Reliability Rating:** HRR score of greater than 96 % or better modelled/predicted for critical systems.	**Workload:** Critical ta capacity (20% reserv **Time on Task:** Time requirement (requir requisite manpower spec/manpower KP **Spatial Analysis:** Spa ____ for critical tasks **Human Reliability Ra** critical systems give
4	Enhancement	**Antropometrics:** Greater than 98% of user population acoomodated across critical tasks; less than 2% (1 in 50) is not accomodated given preliminary system design. **Workload:** Workload predicted to require less than 90% of user capacity for critical tasks (10% reserve capacity) given preliminary system design. **Time on Task:** Time on task predicted to meet objective requirements for requisite manpower mix (reference spec/manpower KPP) given preliminary system design. **Spatial Analysis:** Spatial Analysis Link Tool (SALT) scores do not exceed ____ for critical tasks, given preliminary system design. **Human Relaibility Rating:** The Human Reliability rating of 96 percent (objective)	**Antropometrics:** Gre accomodated across accomodated by des **Workload:** Workloa sks (10% reserve c **Time on Task:** Time requirements for re KPP) **Spatial Analysis:** Spa ____ for critical tasks **Human Relaibility Ra** (objective)
		Antropometrics: Greater than 95% of user population accomodated across critical tasks; 15% (roughly 1 in every 20 users) are not accomodated by design.	**Antropometrics:** Gre across critical tasks; accomodated by des

HSI domain rating

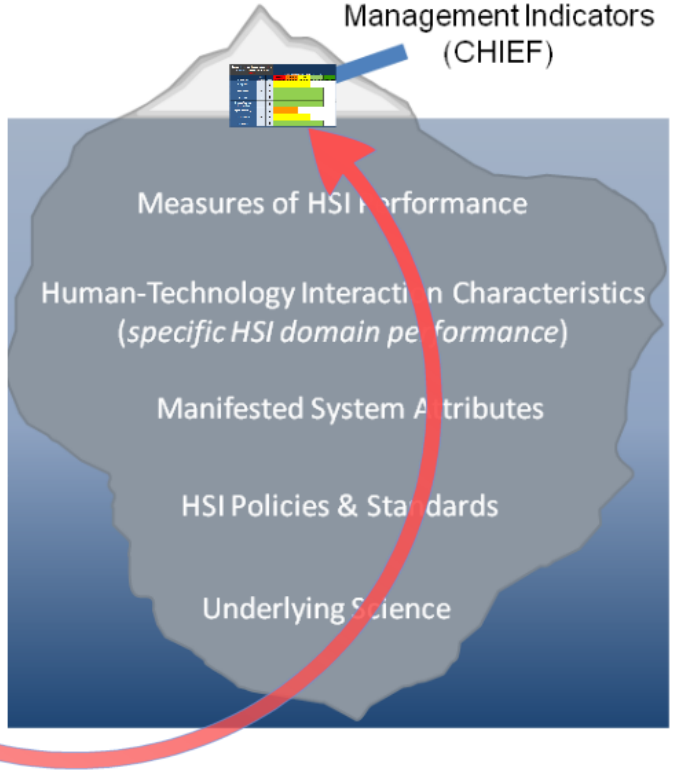
Step Six: Analysis



Comprehensive Human Integration Evaluation Framework (CHIEF) DRAFT			Total System Performance Implication				
HSI Domain	HSI Glideslope	Rating	1. Severe Degradation	2. Moderate Degradation	3. Mild Degradation	4. Enhancement	5. Optimizing
Manpower	-	3					
Personnel	+	4					
Training	+	4					
Human Factors Engineering	+	4					
Systems Safety	+	2					
Survivability	+	3					
Habitability	+	4					

Step Seven: Briefing

Comprehensive Human Integration Evaluation Framework (CHIEF) DRAFT			Total System Performance Implication				
HSI Domain	HSI Glideslope	Rating	1.Severe Degradation	2. Moderate Degradation	3. Mild Degradation	4. Enhancement	5. Optimizing
Manpower	-	3					
Personnel	+	4					
Training	+	4					
Human Factors Engineering	+	4					
Systems Safety	+	2					
Survivability	+	3					
Habitability	+	4					



what's next?

- ✓ thesis / initial concept (FY 14)
- ✓ conceptualize domain scales (FY 15)
- ✓ draft domain criteria & TSP scale
- ➡ calibration / TTX (FY16)
- ◎ brief to program (FY 16)
- beta test (FY 16)
- automation / software
- scaling

Contact: CDR Mike O'Neil

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HFE Measure 1

HFE Measure 2

HFE Measure 3

HFE Measure 4

HFE Evaluation Criteria

TSPI		Analyze/Select (Preliminary Design)	Obtain (pre CDR) (Detailed Design)	Obtain (Post CDR) (Prototype/LRIP)
5	Optimizing			
4	Enhancement		criteria 1	
3	Minimal Degradation		criteria 2 criteria 3 criteria 4	
2	Moderate Degradation			
1	Severe Degradation			

Comprehensive Human Integration Evaluation Framework (CHIEF)
DRAFT

Total System Performance Implication

HSI Domain	HSI Glideslope	Rating	1.Severe Degradation	2. Moderate Degradation	3. Mild Degradation	4. Enhancement	5. Optimizing
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