

A Summary of the Development and Validation of the Scale for Habitat Usability (SHU)

Usability is an important concept to consider when designing space habitats/vehicles. In addition to objective outcomes (success rate, net habitable volume etc.), collecting users' subjective judgments via comments and questionnaires can provide valuable data for evaluating conceptual designs, identifying potential layout issues, improving concept of operations, substantiating design changes, or selecting between competing mockups. Historically at NASA, there has been no "gold standard" questionnaire for capturing users' subjective viewpoint regarding habitat design. To address this gap a Human Research Program (HRP) study was conducted to create a new measurement tool: the Scale for Habitat Usability (SHU).

Development of the SHU

The SHU was developed using an iterative process. In the first year of the project, a literature review was conducted to identify constructs and methods applicable to habitat/vehicle usability. Additionally, relevant (e.g., spacecraft designers) subject matter experts (SMEs) were consulted to identify additional methods and constructs of interest. The candidate item pool was formed by adapting items from existing usability and habitat assessment tools, and items were generated to address any perceived gaps in construct coverage. The items were further refined through a card sort by SMEs at NASA, first in an open sort and then a closed sort, to identify the underlying constructs within the item pool. The card sorting study yielded the following factors which were used to form the SHU subscales.

SHU Scales and Descriptions

Scale	Description
Intuitiveness	Users' judgment of how well the habitat leverages users' prior knowledge and common design practices to create effective interaction(s).
Labels	Users' judgment of the quality of labels/signage in the habitat and how well they supported task completion.
Layout	Users' judgement of how the volume, configuration, and co-location of task and related areas/items impacted task performance.
Lighting	Users' judgment of how appropriate the lighting level was for the completion of the task.
Satisfaction	Users' judgment of how pleasant it was to complete the task within the habitat.
Situation Awareness	Users' judgment of how well the environment supported their ability to understand what was going on during the task and how elements of the environment related to the task.
Workload	Users' judgment of how much effort it took to complete the task.

Validation of the SHU

The validity (extent to which a scale measures the target construct) and internal reliability (tendency of the items on a scale to covary) of the SHU and its subscales have been supported across a series of studies. In the first study, all seven SHU scales were found to meet the recommended criterion of internal reliability (Cronbach's $\alpha > .70$). In another study, the SHU was used to compare two configurations of a mockup used in a previous NASA evaluation. The mockup was intentionally manipulated in three important ways: the lighting levels, the quality of stowage labels, and the orientation of the user while completing the task. Three of the SHU scales (Labels, Layout, and Lighting) were found to be able to detect between the two configurations differences, a form of scale validity commonly referred to as known-groups

validity. In the same study, and in the evaluation of another mockup, the validity of the other scales (Intuitiveness, Satisfaction, Situation Awareness, and Workload) has been supported via correlations with corresponding measures of the same constructs (convergent validity).

SHU Overview and Administration

The SHU consists of 7 scales and 28 items. Responses to each item are captured by a five-point anchor ranging from 1 “Strongly disagree” to 5 “Strongly agree.” Each SHU scale is scored separately by averaging the corresponding items. Scores closer to 1 can be interpreted as undesirable and scores closer to 5 can be interpreted as desirable. The SHU should be administered after the task of interest has been completed within the habitat being evaluated.

SHU Scales, Items, and Scoring Instructions

Intuitiveness = (INT1 + INT2 + INT3 + INT4)/4	
INT1	It was easy to learn how to perform the task within this habitat.
INT2	Completing the task came to me naturally.
INT3	I was able to anticipate what the next part of the task would be.
INT4	Using the habitat to complete the task was intuitive.
Labels = (LAB1 + LAB2 + LAB3 + LAB4)/4	
LAB1	Symbols, signs, and labels were adequate for the performance of this task.
LAB2	Symbols, signs, and labels were easy to understand.
LAB3	Symbols, signs, and labels throughout the habitat were consistent.
LAB4	The labeling throughout the habitat was helpful to me.
Layout = (LAY1 + LAY2 + LAY3 + LAY4 + LAY5)/5	
LAY1	The habitat is organized well.
LAY2	It was easy to access the items I needed for the task.
LAY3	The habitat layout made the task easy to accomplish.
LAY4	The habitat design made good use of available volume.
LAY5	The habitat provided adequate space to perform the task.
Lighting = (LIT1 + LIT2 + LIT3 + LIT4)/4	
LIT1	I could see well enough to complete the task.
LIT2	The habitat was well lit.
LIT3	Lighting was sufficient to perform the task.
LIT4	Overall, the lighting was comfortable.
Satisfaction = (SAT1 + SAT2 + SAT3 + SAT4)/4	
SAT1	I am satisfied with the ease of completing the task in this habitat.
SAT2	I like how this habitat enabled me to perform my tasks.
SAT3	I felt very confident performing the task within the habitat.
SAT4	Overall, I am satisfied with this habitat.
Situation Awareness = (SIT1 + SIT2 + SIT3 + SIT4)/4	
SIT1	I was able to understand how my surroundings (areas and objects) related to the task.
SIT2	I was able to anticipate how my surroundings (areas and objects), as they related to the task, were changing over time.
SIT3	I was consistently aware of all the habitat attributes that were necessary to complete the task.
SIT4	The environment helped me identify task-critical information.
Workload = (WRK1 + WRK2 + WRK3)/3	
WRK1	It was easy to maintain the mental effort required to complete the task.
WRK2	It was easy to maintain the physical effort required to complete the task.
WRK3	I was able to complete the task without too much effort.