سول ایوی ایشن اتھارٹی

FLIGHT STANDARDS DIRECTORATE
HQs CIVIL AVIATION AUTHORITY
JINNAH INTERNATIONAL AIRPORT
KARACHI – PAKISTAN

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Dear All,

FLIGHT STANDARDS INFORMATION BULLETIN

1. Enclosed please find Information Bulletin on Concept of mental workload and its relationship to flight operations and safety briefing note suggesting ways to improve the process.

2. This information is being provided in the continued effort of improving upon our concepts and skills towards safe flight operations.

Happy Landing and Safe Flying.

Yours Sincerely,

03/08/09

(CAPT. NAVEED AHMED AZIZ)
Director Flight Standards

Encl: ***As Stated***

See distribution list overleaf

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INFORMATION BULLETIN

CONCEPT OF MENTAL WORKLOAD

FLIGHT STANDARDS DIRECTORATE

This paper deals with the

Concept of mental workload and its relationship to flight operations and safety, it will be useful for designers as well as for operational personnel.

1. Introduction:

Cockpit design has evolved dramatically over the past 30 years. Increasing automation on the flight deck has added an important systems management function to stick-and-rudder flying. As a result, the mental workload of aircrews and air traffic controllers has received increased attention. Workload is an important focus because errors can be induced if mental task demands exceed the capabilities of the human operators. In turn, the consequences of these errors might be critical and detrimental to safety. To respond to the increased automation, the mental demands imposed by a human-machine interface must be considered as well as the physical task load it creates. Therefore, a psycho physiological approach (called “psycho physiological engineering”) to the evaluation of human-machine interaction has been developed with a particular emphasis on the mental workload of pilots.

1.1 General definition:

Workload might simply be defined as the demand placed on the human operator. This definition, however, is overly limiting because it only includes the requirements generated by external sources (e.g. task difficulty). In order to address workload completely, it is also necessary to consider demands generated internally that compete for an operator’s resources. Therefore, an appropriate human factors definition of workload is:
“Workload is the demand placed on an operator’s mental resources used for attention, perception, reasonable decision-making and action”.
Because human resources are limited, the level needed for a specific task can exceed the amount available. Under these circumstances, workload can also be defined as the ratio of the resources required by the task to the amount of available resources. Inherent in this definition is the notion of resource differences among operators since each person will have a differing amount and nature of resources to apply to a task. Because of these differences, a given task will not produce the same workload level for all operators. Rather, workload depends on the operator’s experience with the task, training and relevant skill levels. A task can even produce different workload for the same operator at a different time depending on his or her state when the task must be performed. Therefore, workload is an individual experience, and workload measurement methods must take into account human variability.

1.2 Workload and Time on Task:

Task demand is not the only factor that can affect the effort required by a task. Time on task for a given task demand will also affect the performance and workload of the operator workload increases as a function of time, even if the task load is stable. After a variable threshold of time, resources are exhausted and an increase in workload and breakdown in performance are likely to occur. This is because the operator gives up or “sheds” the least significant parts of the task in order to make workload more manageable.

1.3 A Multiple Resource Theory of Workload:

Another fundamental concept is the multiple resource theory of workload, which defines workload as the demand for resources. Thus poor performance in situations deemed to impose "high workload" is explained in terms of excess demands for specific resources. In this theory, resources are related to each of our senses such as sight and hearing and to our brain's central processing that is involved in many kinds of tasks. The multiple resource theory is especially relevant to predict workload in a multi-tasking environment. For example, it explains why tasks that require different resources (e.g., a visual task combined with an auditory task) will not directly interfere with each other. The performance of each of the unlike tasks can remain unaffected provided there is no performance decrement caused by excessive brain use. For example, it is often easier to detect a sound while performing a visual task than to detect two competing sounds at the same time.

2. Measures of Workload:

Three types of workload measurements have been widely used to assist human-machine interface design: performance, subjective ratings and physiological parameters.

2.1 Aircrew Performance Measures:

Direct measures of performance on criterion tasks are one measure of workload. However, they are not necessarily good predictors at the extremes of the task demand scale where high effort is associated with low performance. Therefore, performance measures of workload are often supplemented by other types of measures as part of the evaluation of human-machine systems. There are three performance measurement techniques that are widely used to assess workload:

- Primary-task measures can be used in either a laboratory or field setting. They address the specific criterion performance of interest such as tracking performance, number of errors, and speed of performance or reaction time). When measured in the field, primary-task performance must be very task specific. It might include such measures as deviations from the localizer and glide slope during an instrument approach or counts of control input reversals.
- Secondary-task measures use an added task, the performance of which is assumed to degrade as workload increases and the operator devotes more of his or her spare capacity to the primary task. The secondary task must be sufficiently demanding in order to ensure that performance on it is indicative of "spare capacity". A criticism of this method is the possible interference of the secondary task with the primary task.
- Reference tasks are standardized laboratory tasks measured before and after the task under evaluation. They mainly serve as a technique for assessing trends in primary task performance. The change of performance on the reference task over time indicates the effects of the mental load produced by the primary task. If subjective and physiological measures are added to the reference task, the effort needed to maintain performance on the primary task could also be inferred, particularly when the operator's state is affected. The use of standard reference task batteries is very common in organizational and occupational psychology.

2.2 Subjective Measures:

Self-reported judgments made by human operators are another type of workload measure. The most frequently used self-reports of mental workload in aviation are the Subjective Workload Assessment Technique and the NASA-Task Load Index. The primary advantages of self-reports are that they are provided directly by the operator involved, they can be collected after the task is done, and they are relatively simple and inexpensive to collect. The disadvantages of self-reports are that the operators are sometimes unaware of their own internal changes, and results can be biased by factors other than workload (e.g. psychosocial environment). These disadvantages can often be overcome if subjective measures are supplemented by one of the other workload measurement approaches.

2.3 Physiological Measures:

Physiological measures of workload are derived from the operator's bodily functions. Probably, the most frequently used measure in applied research is the Electrocardiogram (EKG). Several relevant measures derived from the EKG have been used in workload evaluation studies including:

- Heart rate (HR). This measure has been used in several aviation-related evaluations either in a simulator or in actual flight operations. These studies show that heart rate tends to increase in the most demanding phases of flight.
- Heart Rate Variability (HRV) over time is also used as a measure of mental workload. The basic assumption is that the higher the workload the lower the HRV. Stated differently, the more the operator exerts an effort the more regular the heart rate. In recent years, studies have begun to use the spectral analysis of HR as a measure, and therefore express the HRV in the frequency domain. A decrease in power in the mid-frequency band, also called the 0.10 Hz component, has been shown to be related to mental effort and task demand. One of the main limitations of heart rate spectral measures is that they can be only used in association with a detailed task observation and analysis because these measures are very sensitive to slight variations in workload.
- Other physiological measures based on respiration, electro-encephalography and ocular parameters have also proved to be sensitive to mental demand. Their main limitation is the difficulty of collecting them. This makes their use in operational settings doubtful.

3. Key Points:

- From a human factors perspective, workload is the mental demand placed on an operator. It is often thought of as the extent to which spare capacity to handle an additional task has been used up or as the ratio of required to available mental resources.
- The ideal situation is when performance is maximized at a minimum level of effort. As task demand increases beyond certain limits, performance will suffer even though effort increases.
- There are three primary types of workload measures that can be used alone or in combination

    - Performance
    - Subjective
    - Physiological

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