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MEASURING AIRCREW WORKLOAD:
PROBLEMS, PROGRESS, AND PROMISES

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An overview of the problems of defining, quantifying, and measuring mental workload during aircrew tasks is given based on our work in the areas of aircraft handling qualities, pilot model measurement and prediction, multi-display scanning, and psychophysiological correlates of workload. The continued promise and problems with psychophysiological measures is assessed and the importance of some new multidimensional workload rating techniques is emphasized. The lack of unifying theoretical approach is identified as the main impediment to progress, and an approach is suggested, that can handle both continuous and discrete task loads. A review is given of some new workload measurement concepts such as Non-Invasive Pilot Identification Program, the "imbedded surrogate" auxiliary task method, and the measurement of workload margin via the Cross-Coupled-Instability Task (CCIT).
THE PROBLEM:

BLOCK DIAGRAM SHOWING INTERACTIONS AMONG MAN-MACHINE
STABILITY, PERFORMANCE, AND WORKLOAD

MAN-MACHINE SYSTEM

PERCEPTUAL SYSTEM
Monitor, scan, sample, reconstruct

META-CONTROL SYSTEM
Copes with interacting goals, strategies, task variables, subroutine delegation, margins

SENSORIMOTOR CONTROL SYSTEM
Sensors, C.N.S., N.M. System

CONTROLLED ELEMENT
Displays and Control

Performance Margins
Performance Requirements (mission criteria, goals, priorities)

Stability Margins
Stability Requirements

Indifference Thresholds

Workload Margin (excess control capacity)

Achieved Stability

Achieved Performance

Achieved Workload

Motivation

Psychophysiological Measures

Subjective Ratings

Measures:
Perceptual-Motor Task Loading

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CRITERIA FOR WORKLOAD MEASURES

1. RELEVANT:
   TO PROBLEM & SOLUTION

2. SENSITIVE:
   MONOTONIC W.R.T SUBJECTIVE WL. HIGH "TEST-POWER" WRT WL VARIABLES, INSENSITIVE TO OTHER VARIABLES

3. CONCORDANT:
   UNIVERSAL EFFECTS IN TARGET POPULATION

4. RELIABLE:
   TEST-RETEST
   "DIFFERENTIAL STABILITY" WRT PRACTICE
   VALIDATED; WITH NORMS

5. CONVENIENT:
   PORTABLE
   EASY TO LEARN
ELEMENTS OF THE CROSS-COUPLED INSTABILITY TASK (CCIT)

INPUT → PRIMARY ERROR \( e_1 \) → OPERATOR \( Y_{p_1} \) → SECONDARY TASK \( Y_2 = \frac{X}{s-X} \)

ATTENTION-SHARING; ADAPTATION

CROSS-COUPLING ALGORITHM

FILTERING, INITIALIZING, COMPARING, ADJUSTING, TIMING, AND SCORING

\( \lambda \text{ instability level} \)

ERROR-INCREASE CRITERION (1.0 ≤ \( E_c \) ≤ 14)
CROSS ADAPTIVE MEASURE OF EXCESS CONTROL CAPACITY FOR
SEVERAL EXAMPLES OF PRIMARY CONTROLLED ELEMENTS

\[ 1 - \left( \frac{\lambda_X}{\lambda_C} \right) \] Attentional Workload

\[ \frac{\lambda_X}{\lambda_C} \] Excess Control Capacity

Day to Day Range of \( \lambda_C \),
The Critical, Limiting Score

Controlled Elements:

- \( K/s \)
- \( K/\left[s^2 + 2(0.7)(16)s + (16)^2\right] \)
- \( K/\left[s^2 + 2(0.7)(7.8)s + (7.8)^2\right] \)
- \( K/s(s+4) \)
- \( K/s(s+2) \)
- \( K/s(s+1) \)
- \( K/s^2 \)
- \( K/(s-2) \)
TYPICAL APPLICATION OF ADAPTIVE-WORKLOAD TESTING

Performance Penalty = \( f(\text{Error} + \text{Workload}) \)
\[
P = \frac{\sigma_e}{\sigma_i} + \frac{\lambda_c}{\lambda_x}
\]

- Subject A Data; Bars = Means
- Workload Data from McDonnell: AFFDL TR 68-76

Workload: \( \frac{\lambda_c}{\lambda_x} \)

Error: \( \frac{\sigma_e}{\sigma_i} \)

Portion Due to:

Display Quanta Level (cm):
- 0.
- 0.254
- 0.508

Operator Lead Req't:
- None
- Some
- Much

Workload Data from McDonnell: AFFDL TR 68-76

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