Symposium Paper

AERO MEDICAL ASSESSMENT OF FLYING PERSONNEL

Human Engineering Problems

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Introduction

AIRCRAFT to be an effective weapon system, flown with efficiency and safety need proper Man-Machine matching. The need is highest degree of co-ordination of physical, mental and psychophysiological attributes of the flier and systems/sub systems of the aircraft. Human abilities under various flight conditions need to be understood and quantified to define limits of acceptable ranges. Potentialities and limitations of the human operator should be understood to the fullest extent and should form the key note in aircraft design criteria. To fulfill the aim of assessment, namely to ensure efficiency and safety in operation and conservation of trained man power, the norms laid down should cater for basic limitations, ageing, and acquired primary and secondary disabilities inherent as occupational hazards. Assessment criteria should be based on sound knowledge, with adequate flexibility to meet the requirements of varied conditions.

The basic concepts of Human Engineering design of aircraft vis-a-vis aeromedical assessment of aircrew are :—

(*a*) Man-Machine dynamics		(*a*) Human capabilities
(*b*) Layout of cockpit area		(*b*) Human abilities
(*c*) Design of instruments and controls	*vis-a-vis*	(*c*) Reaction time lag
(*d*) Display pattern and position		(*d*) Anthropometric variability

The category of personnel assessed are :—

(*a*) New entrants to IAF Flying branch both direct entry and NDA cadets,

(*b*) Serving aircrew on change over to new type/high performance aircraft,

(*c*) Aircrew with disability (congenital/acquired) after the condition has reached medical finality.

Pattern of Assessment

Human engineering assessment involves physical, physiological and psycho-physiological evaluation. Physical evaluation consists of Static Anthropometric measurements of body dimensions like stature, sitting height, shoulder height, arm length, fore-arm length, arm reach, thigh length and leg length. It also includes assessment of neuromuscular integrity of limbs and muscle power. Morant's board is used for physical measurements.

Dynamic anthropometric measurements in universal cockpit consist of assessment of reach by upper and lower limbs. The primary and secondary controls are duplicated in the universal cockpit with respect to their location and loading as close to as they are in the aircraft. The controls are coupled with electronic load cells to assess loads pulled, pushed or operated as the case may be for a particular control. Simultaneous muscle strain is also monitored by obtaining EMG tracing of the groups of muscles involved in a particular control operation. The subject is fully clothed, seated and harnessed as he would be in the cockpit during flight.

In border line cases and to cross-check the findings of static and dynamic anthropometric findings a practical cockpit trial on ground is given. Assessment is done both by the Medical Officer and a qualified flight instructor on the type.

In certain specific cases individuals who are

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marginal are also given inflight assessment by a qualified pilot on type. Inflight assessment would be the best way to evaluate efficiency and safety.

In spinal orthopedic disabilities like old healed fracture of vertebrae, slip disc, low backache, osteo-arthritic changes and cervical rib syndrome, other flight simulators like Human Centrifuge are made use of to impose suitable 'G' stresses for evaluation.

Major Human Systems involved and Functions evaluated

The major systems involved and functions evaluated are :—

Systems	Functions Evaluated
Central Nervous System	Psychophysiological task load, Sensory channels monitoring, Perception, Recognition, Decision, Utilisation of full capacity of brain.
Auditory System	Sound level and frequency range for input of information. Good air-to-air and air-to-ground communication. Monitor audio warning system.
Visual	External: Navigation, Target acquisition, avoid mid-air collisions. Internal: Map reading, Monitoring flight instruments and displays. These functions are dependent upon :— (i) Eye datum line and seating (ii) Display method and positioning.
Skeletal System	Layout of work space (cockpit), Positioning of controls, Range of required/permissible movements, Ejection and escape path clearance.
Muscular System	Force required to operate controls, Operator's Max Power. Assessed under all conditions of flight.

Review of Work done

Individuals are first assessed by specialist Medical Officers of various medical disciplines. The final assessment to decide fitness to undertake/resume flying is done by Human Engineering Specialist. During the period 1968-1979 a total number of 190 cases were evaluated by the Human Engineering department at the Institute of Aviation Medicine, IAF. The details are as follows :—

Details of cases evaluated by the Human Engineering Department, I.A.M., IAF

I.	Total number of cases evaluated		...	190
II.	Congenital abnormalities		...	89
	(*a*) Scoliosis	67		
	(*b*) Vertebral	16		
	(*c*) Others	6		
III.	1. Traumatic disabilities		...	103
	(*a*) Single	60		
	(*b*) Multiple	43		
	2. Vertebral fractures		....	38
	(*a*) Single	17		
	(*b*) Multiple	21		
	3. Upper limb fractures		...	34
	4. Lower limb fractures		...	39
IV.	Miscellaneous cases		...	24
V.	Burns		...	2

Majority of cases were congenital abnormalities and traumatic orthopedic disabilities.

Current Problems

Assessment of Anthropometric Variables: I.A.F. has in its fleet a large number of aircraft of foreign design in which design criteria have been based on the needs of pilot population of the design country. Hence the requirement of human engineering assessment of such aircraft and pilots who are going to fly them, is critical.

Work space layout and location of primary and secondary controls are mapped out based on measurements obtained by use of cockpit caliper. Based on this data, acceptable safe limits and Max/Min of various body dimensions are laid down. Static anthropometric measurements and body dimensions of individuals are done on Morant's Board. Those within the range laid down are considered fit while marginal cases are given practical cockpit trial. Practical cockpit trial is however, not possible in all cases as all types of aircraft are not readily available for assessment.

Assessment of Orthopaedic Disabilities: Orthopaedic disabilities both congenital and traumatic can be grouped into three categories for discussion viz. spinal, upper limb and lower limb.

Spinal Group: For assessment of this group of disabilities, sound guide lines, formulated on the basis of our own experience and current practice in other Air Forces have been laid down. Scoliosis of more than 7° (by Cobb's method), Ankylosing Spondylitis, spondylolisthesis, compression fractures causing symptoms, spinal tuberculosis and prolapsed intervertebral disc will be causes for rejection from flying. Congenital abnormalities of the vertebral column like spina bifida except for S1 and unilateral sacralisation of LV5 often result in disabling symptoms later on in life and hence are causes for rejection at initial examination.

Clinical/radiological findings, residual functional disability and neurological deficits if any need critical evaluation of risk factors in assessment of serving aircrew. These cases are also subjected to exposure to +Gz in the Human centrifuge. Any recurrence or aggravation of symptoms is cause for rejection from flying duties.

Upper limb disabilities: Assessment of upper limb disabilities is streamlined. It is both subjective as well as objective. Static anthropometric measurements are done on Morant's board and dynamic assessment is done in universal cockpit. Location of stations for various controls in different aircraft as determined by cockpit caliper are duplicated in the universal cockpit. Adequacy or otherwise of reach, range of movements and muscle power are measured and recorded. Electronic load cells and recorders are utilised. Simultaneous muscle strain is also recorded as integrated EMG.

Loss of any finger or fingers or parts thereof excepting terminal phalynx of little finger, Ankylosis of joints and recurrent dislocation of shoulder will be cause for rejection. Painless limitations of the wrist movements need careful evaluation. Loss of dorsiflexion is more critical functionally than loss of palmar flexion. Loss of terminal phalynx of Rt Index finger in a serving aircrew, excision of a Lunate bone, Polydactyly surgically treated, are few examples of cases which were evaluated and declared fit in keeping with the objective of conservation of trained man power.

Lower limb disabilities: Assessment of lower limb disabilities is still restricted to static measurements, clinical evaluation, subjective assessment and executive reports on performance in flight. Work is in progress to set up facilities for objective assessment of lower limb.

Loss of toes or part of the foot needs critical evaluation. Flat foot needs special consideration not only for flying duties but also duties involving normal defence service. Congenital abnormalities like cavus and talipes are not acceptable. Acquired disabilities like genu valgum/genu varum/recurvatum, traumatic disabilities of knee and ankle joints including disparity in the length of two limbs need careful functional evaluation and guidelines for acceptance or rejection have been laid down.

Other types of disabilities : At present assessment of other human systems is done by the respective clinical specialists. Facilities for assessment of cases with disabilities of sensory input, namely visual, auditory and assessment of psycho-physiological work load from Human Engineering angle are being set up. A sophisticated flight simulator will be needed for this purpose.

Future Problems

The exciting advancements in the field of Electronics, Computer Technology and Contol System have totally changed the concepts of information display, "Analog to digital", and control system "Fly by Wire" in design of current generation of aircraft. The profile of the pilot flying a modern aircraft is shifting from an active participant to that of an ever vigilant monitor and error corrector. The mental attributes required and task demands will radically change. This changed profile of the pilot required to meet the demands of a modern aircraft will necessitate a total re-orientation of recruitment policy and training methods. In Human Engineering assessment, the emphasis will also shift from musculo-skeletal system to sensory input and monitoring and cognitive functions of central nervous system. The assessment facilities, procedures and disposal policies need to be re-oriented to the changed task demand.

Conclusions

Human Engineering assessment needs specialised equipment and specifically trained personnel. These assessments should be done at specialised centres till such time we accumulate our own data and standardise the disposal policies. Assessment by clinical specialities is a must but overall assessment by Human Engineering Specialist would ensure efficiency and safety in flight. Availability of different types of aircraft for inflight trials will help to a large extent. A flight simulator will help in conducting further research in this field.