Symposium : Design of a Modern High Performance Aircraft

QUALITATIVE REQUIREMENTS OF A MODERN FIGHTER AIRCRAFT

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The topic 'Qualitative Requirements of a Modern Fighter Aircraft' is indeed vast, encompassing many disciplines and it is hardly surprising that it tends to mean different things to different people, depending on their own area of interest and speciality.

Future Combat Aircraft

Thanks to technological advances in materials, electronics and computers, both in aircraft and as an aid to design and simulation, we see future combat aircraft developing as highly potent multi-role weapon systems with a high degree of intelligence. This intelligence in the system will guide the pilot in taking correct decision through display systems. It is not good for the ego of a pilot to find a particular command in the cockpit not being obeyed because the computer senses it to be wrong. Instead of obeying, the display tells him to select again modestly implying that the previous action was wrong. In terms of physical performance, aircraft will have very high thrust-to-weight ratios, in excess of one, resulting in rapid accelerations, high rates of climb, high sustained G and so on. These are all going to make greater physical demands on the pilot. When we consider that a BVR supersonic interception at 13 Km may be completed in 4 min from the time the pilot was on the ground then we get an idea of the physical and mental demands on a pilot, all compressed in a short timeframe.

Aspects of Human Interface

The human requirements are less easy to define and are yet far more important in terms of ensuring that the total weapon system performs optimally. This calls for harmonious interface between the Pilot and the aircraft. Essentially, there is need to look at two areas :

- Establishing an effective rapport or interface between a fragile and fallible human being on the one hand, and an intelligent weapon system which absorbs and processes a large volume of sensor data on the other.

- Providing physical protection and comfort to the pilot to enable him to sustain peak efficiency.

Pilot-Vehicle Interface

Talking of the first item, it is obvious that attention should go to the cockpit or crew station since it is from here that an effective Pilot-Vehicle Interface (PVI) is to be achieved. Today this is a concept when Electronic Cockpits, Head Up Displays (HUD), Multi Function Displays, Hands on Throttle and Stick (HOTAS) layout, Voice Command Systems, Helmet - Mounted Sights and Touch Panels are all vying for a place. More important, computers will monitor many of the pilot's functions and reject wrong actions of the pilot. There will thus be a continuous realtime dialogue in the cockpit between the pilot and his weapon system.

Optimum solutions will vary with the aircraft's role, specific missions, ergonomics, pilot acceptance and many other factors. Perhaps it is worth sharing some thoughts on these aspects.

HUD: Head Up Displays are available in present day fighter aircraft. But much wider fields of view are becoming available with capability to project both Cursor and Raster symbology. We are already aware that decluttering of HUD symbology is becoming necessary to prevent saturating the pilot. How much information in a particular situation, whether take off, landing, navigation, or weapon aiming, can be absorbed efficiently by a pilot will depend on many factors including operation by night.

Multi Function Displays: Electroni Cockpit concept is to do away wit traditional instrumentation altogethe and have two or more Multi Functio Displays instead. The questions to b addressed and resolved are:

Will a totally electronic cockpit find universal pilot acceptance?

Is colour better than monochrome and if so, what information should have which colour priority?

What should be the data distribution format?

What data should be pilot selectable and what should be mode selectable?

HOTAS: This is basically an integrated approach at workload alleviation and a means of establishing better dialogue between the pilot and the weapon system. All real time controls for sensor operations and weapon management are located on the throttle and stick grips, obviating the need to move hands especially under G load conditions. Optimal switch locations and universal pilot acceptance will need studies.

Voice Command System:Voice actuated command system is no more in the realm of fiction.This approach still has some problems. While the words and sequence of words may be the same, the frequency of sound generated by different pilots would be different. Even for the same pilot, the frequency of output would never be the same through the G load spectrum. If to this is added the complexity of different English accents,the problems certainly get magnified. Notwithstanding these problems, there is very little doubt that voice command

systems hold immense potentialities in a fighter cockpit and will be used to full advantage in future.

In addition to the above, helmet-mounted sights and concept of touch panel will find wider use in future fighter aircraft. However,their utility for optimum human-vehicle interface will need extensive and careful studies.

Crew Comfort

To cope up with the multirole aircraft requirements where in a very high volume of information will be processed and displayed, a two crew concept may become necessary to maintain physical and mental alertness. If, indeed, this becomes necessary, the work sharing between the two will require careful study. Reclining seats and associated side stick controllers must be studied with specific reference to the cockpit environment. Quite apart from their apparent benefit, will they find pilot acceptance ? Opinions seem divided on this issue. At this juncture, it is worth noting that with the agility of modern fighters made possible by fly-by-wire controls, the pilot's 'seat of the pants' feeling has virtually been eliminated from the loop, and today one reads reports about the pilot not being able to withstand the rate of build up of G generated on aircraft like F-16. One also understands that there is work going on with partial pressure breathing to improve the G threshold of pilots. There is little doubt that today it is the human being who is becoming the limiting factor in expanding the performance envelope of combat aircraft.

Crew Protection

It is inescapable for future aircraft to have protection for the pilot in a nuclear biological and chemical environment. The aircraft airconditioning system will need to cater to part of the requirement. The rest perhaps will be the pilot's flying clothing, mask and oxygen system.

Coming to the crew survival, it is perhaps unfortunate that design envelope of fighter aircraft and ejection seats/safety equipment have not always been coincident. There is a crying need to devote as much attention to escape systems as it is to aircraft itself. Our aim should be to have a pilot back in operational flying very soon after an ejection. With costs of flying training soaring, there is need for greater R&D in this field. Simultaneously,there is need to somewhat harden the cockpit, with parasitic protection of the crew station, to ensure battle survivability against the ever increasing lethality of Air Defence Weapon.One cannot expect complete protection; and tradeoffs need to be studied.

Special Areas Needing Medical Inputs for Optimal Man-Machine Interface

So far the discussion has centred around Pilot-Vehicle Interface, increasing workload of a fighter pilot and the attempts at alleviating it. This paper will be incomplete without a few words on the demands being placed on the ground crew. All too often,in their enthusiasm to achieve high performance, the designers give the least priority to aspects of maintainability. For example, pre-flight engine check in a

typical fighter involves the technician crawling prone and head first into the intake with a torch. To expect optimum performance in an Indian summer while doing this check would be to overestimate human tolerance. A lot needs to be done during design phase to help air/ground crew to achieve task efficiency.

Conclusion

The quantitative requirements of future fighter aircraft are quite conceivable. However, to have effective and optimum pilot-vehicle interface in an operational environment, it is necessary to lay down the qualitative requirements of man-machine interface. To have adequate data for clearly defining these requirements it is necessary to have simulation and other research studies at well known Centres like Institute of Aviation Medicine, Aircraft Systems and Testing Establishment and Hindustan Aeronautics Ltd.