# CONSTRAINTS and NEEDS in the Auditory and Vocal Environment of Modern Air Combat

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## *PREAMBLE*

*As far as allied operations had occurred around the world during the last 15 years, many lessons learned appeared to the fighter pilot's unity. Among them, one might be the most important to bear in mind. The faster we exchange data between aircrafts, the best we coordinate our simultaneous actions. However, human ability to understand and manage a flow of information is limited. To improve the efficiency of communications, modern technologies are to be used, to reduce pilot's workload.*

*I personally experienced some scientific studies about Vocal Command and 3D Sound. THALES Company and the Defence Science and Technology Organization (Australia) have formed a group to study these technologies in Modern Air Combat. In France, the simulation means were a single seat Rafale cabin integrated in a 10m diameter combat dome and managed from a development and monitoring room.*

## 1. ENVIRONMENT CONSTRAINTS

In addition of the classical ambient noises existing in a fighter cockpit, numerous sounds are implemented into modern combat aircrafts. It allows pilots to minimize their visual checking onto the main control panel. According to the extreme cost of new generation aircrafts, any loss of aircraft in combat is to be considered as a heavy failure. Consequently, the coordination between aircrafts must be as efficient as possible, to build a common situation awareness (SA) and avoid any unexpected enemy shot.

### 1.1 The aeronautical environment

#### 1.1.1 Load factor

*Modern aircrafts can reach easily strong load factors up to 10 g. Their manoeuvrability is much more important than in the past. Experiencing heavy load factor during combat shows that a pilot loses his hearing capacity as long as g's are pulled. Furthermore, his analysis capacity can be reduced. There, we understand the difference between to hear and to listen to.*

*In a dog fight combat, a pilot is concentrated on keeping in sight his enemy, managing the energy, the trajectory and the system of his aircraft. Under load factor, vision and hearing are decreasing insidiously. Therefore, coordination between aircraft can be dangerously affected.*

### 1.1.2  Noise due to aero dynamical rubbing

*With the emergence of long range active missiles (AIM 120, MICA, AA12), modern combat is become a "beyond visual range" (BVR) combat. The sooner you shoot the sooner you can escape to the enemy shooting envelope. Escaping manoeuvres might be done at high speed and low altitude.*

*On the other hand, flying at high speed and low altitude may generate heavy aero dynamical noise in the cockpit. This can affect the quality of transmissions and often reduces the understanding ability of the pilot*

### 1.1.3   Engine and air conditioning noise

*Without a huge thrust, a fighter aircraft is not efficient. Most of the time, the engine is located just in the pilot's back. It also generates vibrations, heavy noise and roaring.*

*Air conditioning is mandatory but not discrete The ventilation blows regularly and noisily. It doesn't really trouble the pilot but adds yet a constant noise into the cockpit.*

## 1.2   The tactical context

### 1.2.1 Number of participants

*Since the beginning of the Aviation, aircrafts involved in the air warfare had always been numerous. Composite Air Operations, heavy strike deep inside the enemy lands, air combat between tens of aircrafts lead officials to solve problems of communication and coordination. Therefore, the audio environment may be fully confused and disorganized, causing misunderstandings and fratricide shots!*

*So far, cockpit sounds must be relevant, discrete but efficient, and give place to information about the SA. Overloading hearing pilot's capacity with lots of specific sounds is not appropriate. The pilot must be able to catch any vital data on the radio frequency to prevent him from unexpected threats.*

### 1.2.2 Radio jamming (TRANSEC)

*During the fight, radio exchanges might be scrambled by enemy jamming stations. Generally, the noise level is pretty high and frankly disturbing for pilot's mind..*

### 1.2.3 Radio cryptology (COMSEC)

*To avoid enemy intrusion in allied communications, a secured radio is employed ("Secure Voice"). Encrypted transmissions are not as clear as expected and may slightly trouble pilot's understanding.*

### 1.3    The aircraft weaponry system

*1.3.1 Two radio transmitters*

*Two radio transmitters are commonly used onboard. The pilot may simultaneously hear to two different talks and may be confused or miss any vital information about his safety, regarding the SA, the controller orders, or any threat calls.*

*1.3.2 Weaponry system alerts (RWR, Missile head)*

*In Modern Air Combat, two main equipments are employed by the fighter pilot. Firstly, the radar gives the pilot the capacity to build his own SA, completed by the controller or the wingies. Secondly, the Radar Warning Receiver (RWR) consists in alerting pilot to enemy radar pointing over 360° around him. The alert is given visually on a screen associated with specific sounds.*

*In BVR combat, the visual information shown on the screen in 2D dimension is widely sufficient to build the SA.*

***However, in "Within Visual Range" (WVR) combat like dog fights, the aircraft attitude may be unusual, troubling the pilot's analysis about the incoming threat. It is generally hard to locate any other threat while being upside down, head up and eyes turned to the enemy to keep visual on! At that time, 2D visual information on the RWR screen is hard to analyse. Moreover, keeping visual contact on the enemy prevents the pilot from glancing at the RWR screen regularly. Therein, audio alert may be a significant help.***

*1.3.3 Aircraft system alerts (failure, altitude, fuel, Auto Pilot)*

*Modern aircrafts are comprised of many audio alert devices like failure warning, crossing altitude warning, minimum fuel warning or Auto Pilot disconnection warning. It causes sometimes a bit of confusion when all these sounds get tangled in the pilot's mind.*

## 2.    NEEDS FOR AN EFFECTIVE SYSTEM

### 2.1  Auditory needs

Because audio information can be caught at any time, head up, it is the best way to alert the pilot of a warning situation.

*2.1.1 Quality of the radio transmitters*

*Both radio transmitters quality must be as good as possible to minimize noise interference and cluttered voice. It appears obvious that the clearer the radio transmission can be the better the coordination is achieved on a battlefield.*

*2.1.2 Radio hearing level presets*

*As two radio boxes are implemented on a fighter aircraft, one of them should be called the "Main Box", and the other the "Secondary Box". Usually, the Main Box's listening level is upper than the secondary one in order to distinguish one from the other. The pilot does regularly change the noise levels when switching boxes.*

*A system that could preset automatically both noise levels when switching channels would be relevant. It would improve the safety and the aircraft's ergonomics.*

*2.1.3 Advanced Electronic Noise Reduction System*

*Civilian aviation companies suggest its customers some noise reduction headsets during long haul flights. The technology is easy to implement and cheap. Reducing the noise inside the cockpit would improve quickly the pilot's comfort and exchanges' efficiency.*

*2.1.4 3D Sound System in WVR combat (RWR, IR missile lock on)*

*As told previously, keeping full SA during a Dog Fight is not an easy job. Analysing the RWR screen when pulling g's and keeping visual contact with the enemy is not that easy. However, an option to visual information on a screen is available.*

***3D sounds technology makes all that easier during WVR combat. Two major positive points might be underscored:***

    ***❶ During WVR combat, 3D sounds system offers the pilot the possibility to build the SA instinctively and surely. Locating any threat direction quickly while keeping in sight his bandit, makes the pilot more efficient in his combat and more aware of the SA.***

    ***❷ 3D sounds system may be used as an indicator of Electronic Warfare density. Not having the capacity to locate the threats reveals the presence of multi directional threats and can be alarm.***

*2.1.5 Audio failure warning*

*Every sound should be appropriate and representative of the type of information delivered. Failure warnings are generally associated with a light button on the failure panel. The pilot must analyse this panel to take a proper action.*

*Following the first warning alarm, a synthetic voice announcing the type of the failure would sometimes make the analysis easier during particular phases (night, sun reflection on the panel, air refuelling process, close formation in the clouds, landing and take off).*

## 2.2 Vocal needs

During overload flight phases, the pilot's resources might be fully used. Studies tend to prove that the Vocal Command could free some resources in order to use them to other tasks. In fact, once the overload is present, there is a little use of vocal command.

In a modern combat aircraft, the most difficult automatism to acquire is the voice. It needs a long and tedious training to be fully operational. Talking during a fight, as a danger is imminent, requires lots of mental resources. The resources consumption is all the more important than the vocal command phraseology is long or complex.

*2.2.1 Radio equipment (HQ radio and Secure Voice Radio)*

*To avoid enemy intrusion on the tactical frequency, it is mandatory to use HQ radio. This equipment allows the pilot to avoid radio jamming and also improves the exchanges' quality. However, efforts must be done to improve the reliability of this type of equipment which sometimes goes wrong due to problems of time reference between aircrafts.*

*Encrypted voice is often a bit confused and requires a minimum of attention by the pilot. It would be interesting to improve this technology to protect the pilot from difficulties to understand some exchanges.*

*2.2.2 Vocal Command (FQ changes)*

*Numerous studies have been achieved to determine the benefits of a vocal command in a fighter aircraft. This technology appeared to be very useful in some specific situations. HOTAS commands are generally the best way to improve the cockpit ergonomics. However, some functions are not always available via HOTAS command, either due to their specificity (i.e. radio control panel), or to the overloaded HOTAS commands' availability. Most of the time, pilot has to switch frequency onto the radio control panel, away from the stick and the throttle. Having the opportunity to do it vocally would be such a huge improvement for ergonomics and safety considerations.*

*Vocal command must be declined into three major features:*

**❶ It must be used quietly, without haste. Talking in combat is the most difficult automatism to get and to keep. A long training is necessary to be on top. Gestures appear much easier and faster to execute than the voice. Vocal command also requires time and mental resources to be used correctly. Consequently, the Vocal Command syntax must be short and easy to pronounce, perhaps as tactical codewords are chosen.**

**❷ During hot combat, pilots need a complete availability of the radio transmitter to listen to the situation awareness and to order any emergency call. No time for pronunciation efforts and hazardous results!**

**Vocal command is also useful when time is free, danger is out and any HOTAS command is not available (i.e. radio frequency switches, navigation waypoints management, weapon selection …etc, in close formation or at night).**

**❸ Vocal command technology is efficient but system misunderstandings may regularly occur. The reliability of this function is not complete. A validation process must be added to confirm the command and to avoid wrong vocal orders.**

## 3.   CONCLUSION

Today's missions become more and more complex. It is also mandatory to improve the ergonomics of the modern combat aircraft in order to minimize the pilot's workload.

A good ergonomics must be :

- intuitive

- simple

- reliable

Modern technologies bring military aviation the opportunity to improve the building of the Situation Awareness and the fighter aircraft cockpit's ergonomics. 3D sounds and vocal command technologies appear to be relevant as the complexity of the weapon system increases regularly. As a matter of fact, they must be implemented in the modern combat aircrafts.