

## Military Pilot's Emotional Stress Analysing

**Jiri Millek**

Military Technical Institute  
CZECH REPUBLIC

[jiri.millek@vtusp.cz](mailto:jiri.millek@vtusp.cz)

**Jaromir Cmiral**

Military Technical Institute  
CZECH REPUBLIC

[zdena.cmiral@seznam.cz](mailto:zdena.cmiral@seznam.cz)

**Ferdinand Tesar**

Military Technical Institute  
CZECH REPUBLIC

[ferdinand.tesar@vtusp.cz](mailto:ferdinand.tesar@vtusp.cz)

### **ABSTRACT**

*In the Department of Human Factors in Military Aviation, the military pilot's emotional stress is one of the fields which we are interested in. During last decade, the interest has been focused to the following areas:*

- a) *The impact of emotional stress caused by high informational load on tactical decision of Air Force supersonic fighter pilots during simulated combat missions was tested.*

*Experimental testing was made in pilot tactical simulator during the simulation of air combat between two pilot's groups (four pilots on each side).*

*The pilot's physiological activities during the whole mission were monitored. It was analysed, that the moment, when pilot made the incorrect tactical decision was the point when the emotional stress was detected.*

- b) *The possibility of increasing the tolerance of Air Force supersonic fighter pilots classified on level "Combat Ready" to psychological stress caused by high informational load was verified.*

*Experimental testing was again made in pilot tactical simulator during the simulation of air combat between two pilot's groups (for pilots on each side). Each pilot during several experimental measuring was tested and the trend of his physiological reactions among individual measuring was analysed. The pilot's monitoring during highly demanding tasks and assess their physiological resistance level was the aim of our work.*

- c) *The possibility of increasing the tolerance of Air Force subsonic fighters classified on level "Combat Ready" to the high information load resulted from the insufficiently trained situation was tested.*

*Experimental testing was made in pilot simulator during the simulation of attack by two subsonic combat aircrafts to ground targets. The special scenarios of missions, in which the pilots were not trained sufficiently yet, for our experimental measurements were prepared. Each pilot was tested*

*during several experimental measuring and the trend of his physiological reactions among individual measuring was analysed. The scenarios were not the same but in similar difficulty. The pilot's monitoring during solving these situations and assess their tolerance level was the aim of our work.*

*During testing mentioned above, the level of the physiological activation of body organism was objectified by physiological values, concretely by the heart rate analysing, the voice record analysing and by the eye-tracking analysing.*

*The results of projects solving in mentioned fields to optimizing personal training were focused.*

**Keywords:** *pilot's emotional stress, tactical decision, tolerance to emotional stress*

### 1.0 INTRODUCTION

This paper describes achieved results of the applied research in the Military Technical Institute, department of Human Factors in Military Aviation focused to the military pilot's emotional stress analyses during combat simulation training. The interest has been focused to the following areas:

- a) The impact of emotional stress on tactical decision of the Air Force combat supersonic fighter pilots (2013-2015).
- b) The tactical training effectivity increasing for the Air Force combat supersonic fighter pilots in the tactical simulator due to their resistance to the high information load (2016-2018).
- c) The training effectivity increasing for Air Force subsonic fighter pilots in the simulator from the unexpected situation point of view (2018-2020).

### 2.0 THE IMPACT OF EMOTIONAL STRESS ON TACTICAL DECISION OF AIR FORCE COMBAT SUPERSONIC FIGHTER PILOTS

#### 2.1 Description of Experimental Testing

Experimental measurement was made in the pilot tactical simulator during the simulation of air combat missions (Air-to-Air) between two pilot's groups (four pilots on each side).

The pilot's physiological activities during the whole mission were monitored.

#### 2.2 Tactical Simulator – Description

The measurement was provided in tactical simulation centre that contain the following parts:

- Four pilot's cockpits with power projection systems
- Four pilot's cockpits with simplified projection systems
- Two workplaces for Ground Controlled Interception (GCI)
- One workplace for Forward Air Controller (FAC)
- Workplace for instructor
- System for exercise evaluation

- Briefing rooms for blue and red teams
- HW support technologies

### 2.3 Applied Additional Information Loads

- Radio Interference
- Radio interruption – pilot is without radio connection with other pilots and with GCI
- Partial interruption of radio connection – pilot after some special activity makes the connection again
- Radar is out of activity – technical fault in radar imitation during mission
- Technical fault in weapons – missiles were impossible to launch
- Loss of radar information from GCI in complicated situations
- Tactical switch on of Air Defence system
- Air defence system moving to the position where it is not expected

All added information loads correspond with the real situations that can come in the real missions.

### 2.4 Description of Missions

The experimental testing was made in pilot tactical simulator during the simulation of air combat missions between two supersonic fighter groups (four fighters on each side) in mission type BVR (Beyond Visual Range). The missiles air to air were used.

One pilot's group was the enemy group that made the air support for the group of bomber aircrafts. The primary task was to shoot down the supporting supersonic aircrafts and secondary task was push up the enemy bomber aircrafts from active zone.

The added information load was started by instructor from control PC console (in the simulator this solution is enable) in the moment when he recognises as the suitable moment.

### 2.5 Description of Pilot's Evaluation

The pilot's physiological activities during the whole mission were monitored by his Heart Rate. The ratio between actual Heart Rate and the median of the Heart Rate measured before the mission (throughout 3 minutes) was used.

The pilot's behavior during the solution of the individual tasks throughout the mission was analyzed by instructor. He analyzed the following facts:

- manner of communication (continuity, completeness, etc.)
- reaction to events (good, slow, impetuous, adequate, inadequate, bad)
- quality of activity in the whole group
- aircraft handling
- command in the group

The results of the Heart Rate testing from mission were compared with the instructor's results.

Additionally, the pilot's subjective evaluation by psychological questionnaire was used.

### **2.6 Results of Evaluation**

From the psychological point of view the tested pilots were the homogeny group.

For our project it was analysed, that the moment, when pilot made the incorrect tactical decision was the point when the emotional stress was detected.

The obtained results of the relative Heart Rate is closed with the emotional stress.

The obtained results show that the changes of relative Heart Rate are possible to distribute in the following three levels:

- The relative Heart Rate was lower or equal the value 1,3. The results show that in these cases the pilot was not concentrated (in most cases he was shot down).
- The relative Heart Rate was in the range between values 1,3 and 1,5. The results show that in these cases the pilot was in right tension, fully concentrated.
- The relative Heart Rate was higher than value 1,5. The results show that in these cases the pilot was in the appreciable emotional stress. In the most cases the pilots made mistakes (e.g. correct decision but noncorrect provided or impetuous reaction). The increased level of the stress was seen also in the nervous communication.

It is necessary to say that our results are possible to interpret carefully and focus them to the simulated tactical training for the Czech supersonic fighter pilots only.

The results of our research (for relative Heart Rate higher than 1,5 means that pilot is probably in stress) correspond with FHFLEX developed by Spurr [1].

### **3.0 THE TACTICAL TRAINING EFFECTIVITY INCREASING FOR THE AIR FORCE COMBAT SUPERSONIC FIHTER PILOTS IN THE TACTICAL SIMULATOR DUE TO THEIR RESISTANCE TO THE HIGH INFORMATION LOAD**

#### **3.1 Description of Experimental Testing**

The possibility of increasing tolerance of Air Force supersonic fighter pilots classified on level "Combat Ready" to psychological stress caused by high informational load was verified.

Experimental testing was made in the pilot tactical simulator during the simulation of air combat between two pilot's groups (four pilots on each side). It was the same as in the previous project mentioned above.

The adding information loads were also the same as in the previous project.

For testing the following requirements were determinate:

- All evaluation will be provided for each pilot individually.
- The pilots will be measured always in the same position – either as the leader of group or as the member of group.
- The evaluation will be provided for the pilots who took more, then two measurements.

Eight pilots took more than two measurements.

### 3.2 Evaluation methods that were used

For the evaluation of the changes of the pilot's resistance to the high information load during suitable training were used the analysing of the following parameters:

- The coefficient of Heart Rate (the ratio between actual Heart Rate and the median of the Heart Rate measured before the mission - throughout 3 minutes without any action - so call relax time).
- The eye activity:
  - Saccade Average Speed [px/ms];
  - Blink Duration [ms];
  - Blinks Per second;
  - Fixation Duration [ms];
  - Fixations Per second;
  - Average Pupil Area [px].

The coefficient of Heart Rate and Average Pupil Area had the well correlation with events. The example of the coefficient of Heart Rate and individual parameters of the eye activity in the timeline during the mission is in the Figure 3-1.

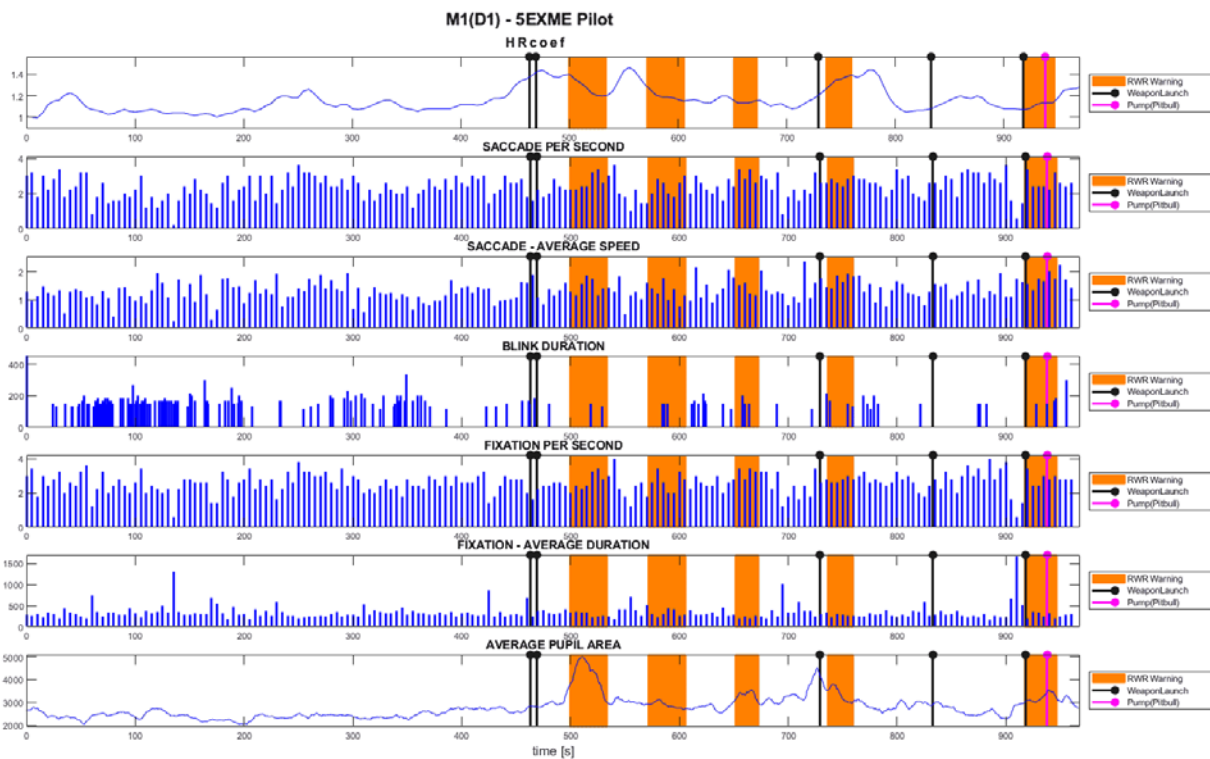


Figure 3-1: Physiological parameters in timeline

The results show that the assessment of mission, as a whole, has the sufficient information value. Therefore, the coefficient of the Heart Rate and Average Pupil Area were evaluated by box-plots of the whole mission. The trend of relative Heart Rate and Average Pupil Area evaluated by box-plots was similar - See Figure 3-2 and Figure 3-3.

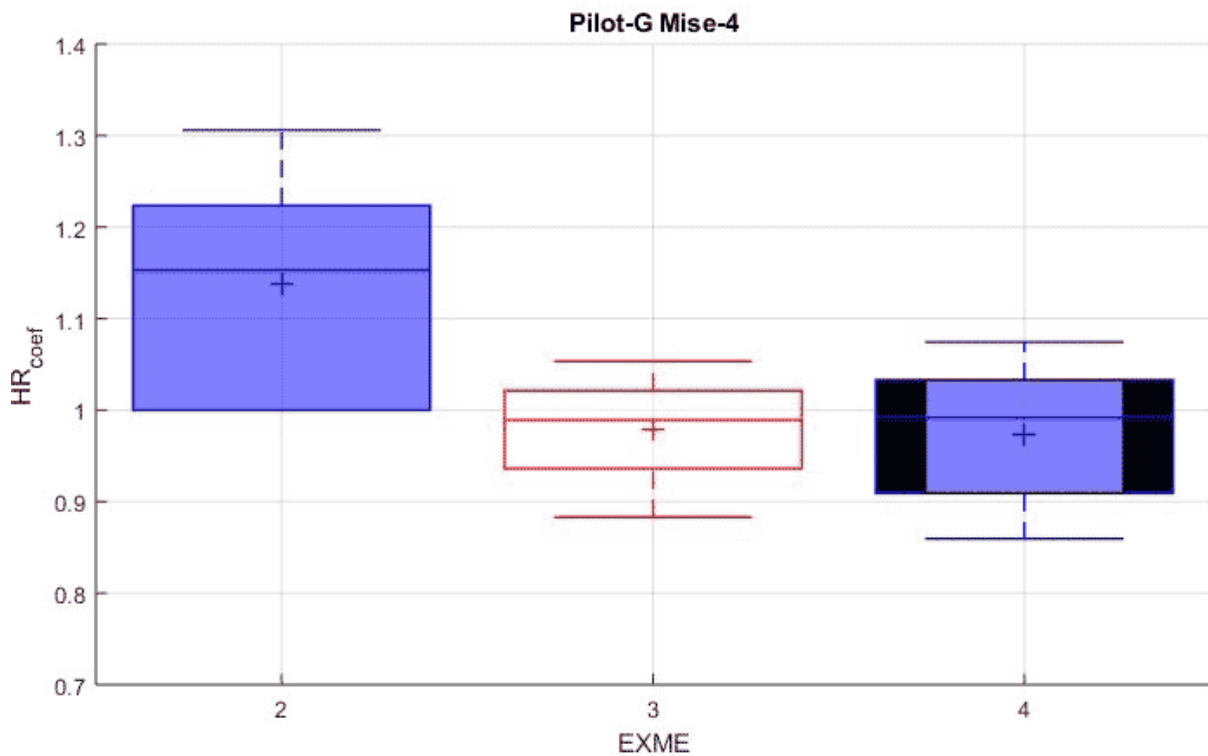


Figure 3-2: Trend of the relative Heart Rate

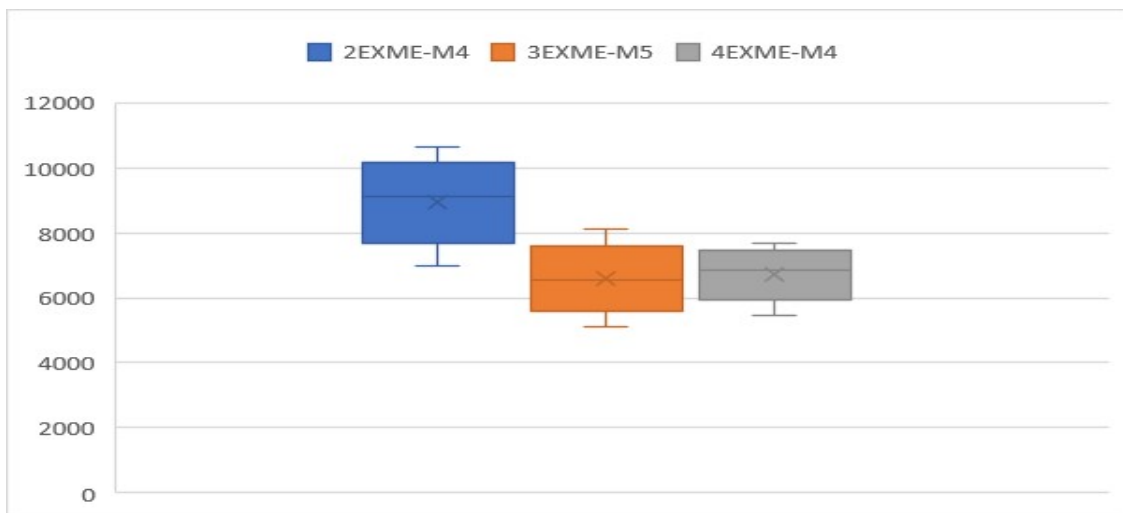


Figure 3-3: Trend of Average Pupil Area

### 3.3 Results of evaluation

Total eight pilots took more, then two measurements, especially three measurements in the same position (leader or wing man). There was the substantial decrease of the relative Heart Rate and also in Average Pupil Area in six pilots between the first and second experimental measuring (between second and third was the minimal change only).

In conclusion, it can be said that the tolerance to high information load can be increased by training exercises. The coefficient of Heart Rate and Average Pupil Area are the suitable instrument for emotional stress analysing.

#### **4.0 THE TRAINING EFFECTIVITY INCREASING FOR THE AIR FORCE SUBSONIC FIGHTER PILOTS IN THE SIMULATOR FROM THE NON-EXPECTED SITUATION POINT OF VIEW**

##### **4.1 Description of Experimental Testing**

The possibility of increasing the tolerance of Air Force subsonic fighter pilots classified on level "Combat Ready" to the high information load resulted from the insufficiently trained situation was tested.

##### **4.2 Tactical Simulator – Description**

The measurement was provided in tactical simulation system that contains the following parts:

- Two connected pilot's cockpits with projection systems
- One workplace for Airborne Early Warning and Control System (AWACS)
- One workplace for Forward Air Controller (FAC)
- Workplace for instructor
- HW support technologies

##### **4.3 Description of missions**

Experimental testing was made in pilot simulator system during the simulation of attack by two subsonic combat aircrafts to (against) ground targets. The five special scenarios of missions, in which the pilots were not trained sufficiently yet, for our experimental measurements were prepared. The scenarios were not the same but in similar difficulty. Each of these scenarios contains the different unusual elements. The sixth scenario was prepared as more difficult scenario. Each pilot was tested during several experimental measuring and the trend of his physiological reactions among individual measuring was analysed.

##### **4.4 Evaluation methods that were used**

The tolerance of Air Force subsonic fighter pilots classified on level "Combat Ready" to the high information load resulted from the insufficiently trained situation was analysed by following physiological parameters:

- The coefficient of Heart Rate (the ratio between actual Heart Rate and the median of the Heart Rate measured before the mission - throughout 3 minutes).
- The eye activity by Average Pupil Area
- The voice analysing

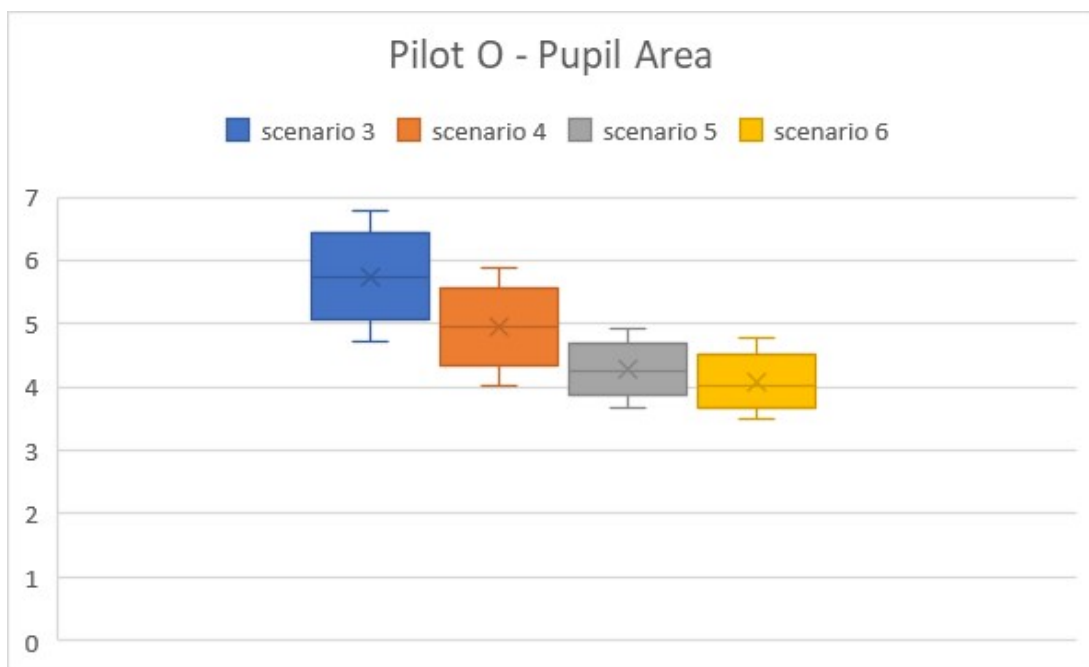
##### **4.5 Results of evaluation**

The initial assumption was to perform the measurements with eight pilots in all six scenarios. All six scenarios were successfully implemented but unfortunately due to the great busyness of the pilots only seven pilots completed more than two scenarios. All of these completed the sixth scenario. In six of these seven

pilots, there was a clear trend in both relative Heart Rate and Average Pupil Area. In the sixth scenario (more difficulty) the relative Heart Rate increased again. The Average Pupil Area did not increase - See Figure 4-1 and Figure 4-2. From this point of view it can be deduced that relative Heart Rate is more sensitive for stress testing than Average Pupil Area.



**Figure 4-1: Trend of the relative Heart Rate**



**Figure 4-2: Trend of Average Pupil Area**

Except the relative Heart Rate and Average Pupil Area we also used the voice analysis from recorded pilot



radio communication. The evaluation of the pilot's voice was used based on a well know fact, that the voice can identify the different emotional states. The digital record was analysed by Nemesysco's Layered Voice Analysis (LVA™). The results didn't correspond with the results of Heart Rate and Average Pupil Area.

Therefore, we have focused our interest to the application of the neural networks for the voice analysing. We are in the initial phase now, but the preliminary results achieved are promising.

## **5.0 FUTURE WORK**

Current results give us the focus for the analyses of recorded voice pilot communication by the neural networks as a supplement for emotional stress analysing.

## **6.0 CONCLUSIONS**

The results of our solved projects show that the relative Heart Rate and the Average Pupil Area are the suitable for emotional stress analysing. The relative Heart Rate seems to be as more sensitive for emotional stress analysing.

## **7.0 REFERENCES**

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### AUTHOR BIOGRAPHIES

**Jiri Millek, Ing.** graduated Czech Technical University, faculty of biomedical engineering in 2017; works as biomedical engineer in Military Technical Institute, department of Human Factors in Aviation; focused in heart rate data analyses and mathematical tools development and the ergonomic of pilot's workspace.

**Jaromir Cmiral, Ing., Ph.D., D.Sc.** graduated Czech Technical University in 1962, graduated Ph.D. study at Czech Technical University in 1969 and D.Sc. at Czech Technical University in 1990; works in the field of physiological signal analysing and military pilot's physiological reaction in specific loads for 44 years; currently works in Military Technical Institute, department of Human Factors in Military Aviation.

**Ferdinand Tesar, Ing., Ph.D.** graduated Czech Military Academy in 1979 as engineer of aircraft and aircraft systems, graduated Ph.D. study at Czech Military Academy in 2013; works as head of research and development in Military Technical Institute, department of Human Factors in Military Aviation focused on physiological signal analysing.