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ADAPTIVE PILOT PERFORMANCE OPTIMIZING: VALIDATION AND HUMAN BEHAVIOR ADJUSTMENT

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Abstract: *This paper will present the final preliminary stage of validation results and human behaviour adjustment build on data acquired during pre-production use of an intelligent system able to improve assessments of aircraft piloting abilities. Optimized components of these abilities are provided, along with the base for decision making process concerning the pilots' and candidates' hierarchy and their admittance in specific flight training programs. Data analyzed and results emerge from the system recorded performance parameters based on measuring the differences between ideal trajectories according to assigned missions and the real trajectories in simulated flights. These differences were measured in 3D space (on each axis: Ox – longitudinal axis, Oy – transversal axis, Oz – vertical axis). The data acquisition stream rate is 2 samples per second. Each of these variables is afterwards processed so that a set of performance data can be synthesized (e.g.: average values, symmetry and form of distributions). All results are thoroughly analyzed, as well as their psychological meanings and consequences for final release of intelligent system.*

Keywords: *flight simulators, pilot assessment, intelligent systems, aviation*

1. GENERALITIES

The main goal of this paper is to present the final preliminary stage of validation results build on data acquired during pre-production use of an intelligent system able to improve assessments of aircraft piloting abilities. Optimized components of these abilities are provided, along with the base for decision making process concerning the pilots' and candidates' hierarchy and their admittance in specific flight training programs. Also, the specialized staff involved in decisional processes of flight personnel selection will widen the support requested by this more and more demanded activity.

2. GLOBAL ASSESSMENT AND SESSION FRAMEWORK

The main framework is related to subject assessment session, stages structured:

- subject identification;
- subject accommodation with session requirements;
- theoretical training;
- theoretical knowledge assessment;
- simulator controls training;
- main simulation;
- optimization;
- data processing;
- decision.

The environment where the subjects fly is a virtual one, populated with specific visual, sound and tactile information, in a cockpit specific form. Complex scenarios are provided, as well as an effective tool for developing particular ones based on a set of primitive trajectories. Different flight simulations may also become available by gathering together the considered stimulus hierarchies, focusing on a stimulus category at one time (visual, flight, navigation and environment integration).

All these are supported by a simulation sub – system for the virtual environment generation and dynamics, a main flight simulation system, a multi-stream data acquisition sub – system (data integration in simulated flight, physiological data and behavior data) and a structured processing and correlative analysis sub – system. Beside these, the decision making sub – system acts as a whole data integrator.

The acquired data processing complex models are statistic, presuming a minimum and maximum distribution analyses, an average data analyses, respectively kurtosis and skewness, which are applied at specific deviations level to each candidate, deviations acquired in the simulated flight process. In analyzing the candidate behaviour related to the statistical group to whom he belongs, specific box-plot representation analyses can be performed. Also, three – dimensional viewing models of the real and imposed trajectories are implemented, the deviations in focus being displayed and the statistic analyzing models being applied to all candidate controls (stick, pedals and throttle).

The acquired information is reported against the results of the theoretical knowledge exam applied during the assessment session time.

Technologically speaking, high tech computers, networks and software with distributed information share the huge amount of data processed. Over all, the system integrates a package of equipments able to deal with acquisition, processing and making available the volume of information requested for quantizing the subject’s panel. Only data showing strong predictive character is extracted and passed on efficiently to the component responsible with optimizations.

At a national scale, this approach is absolutely new, coming to lead the decision system on a new level of performance and to optimize the subjects` behaviour regarding the following of imposed flight mission and his behaviour from physiologic viewpoint. This intelligent system presents interests in priority domains of aeronautics and medicine.

By using this system the level of subjects’ safety, the flight security level, the pilot’s training level increase, simultaneously with decreasing the training and license maintenance costs.

3. METHOD USED AND RESULTS

The current release used is the final preliminary operational stage of intelligent system for pilot performance assessment in a standard flight scenario: climbing or descending flight, with fixed flight path data (initial flight altitude, final flight altitude, glide/slope angle, indicated speed). As many as 65 pilot students (among them 19 from Air Forces Academy) voluntary passed thru the flight program at the simulator. All subjects hold the same experience on training aircrafts. There also exist recordings of pilot performance assessments in real flights for each one.

The system recorded the performance by measuring the differences between ideal trajectories according to assigned missions and the real trajectories in simulated flights. These differences were measured in 3D space (on each axis: Ox – longitudinal axis, Oy – transversal axis, Oz – vertical axis). The data acquisition stream rate is 2 samples per second. Each of these variables is afterwards processed so that a set of performance data can be synthesized (e.g.: average values, symmetry and form of distributions).

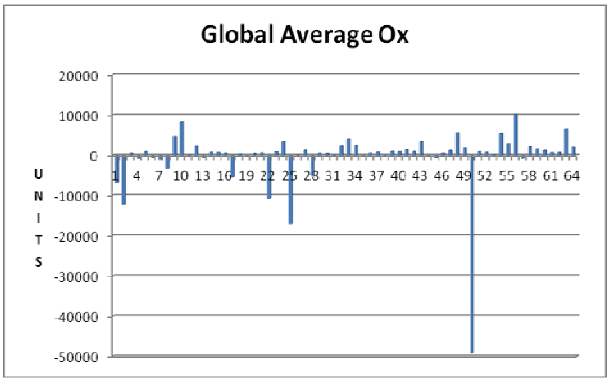

Fig. 1: Global Average Deviations: Ox

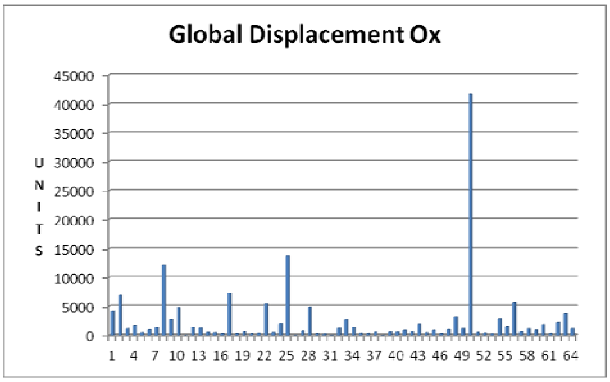

Fig. 4: Global Displacement Ox. Absolute values

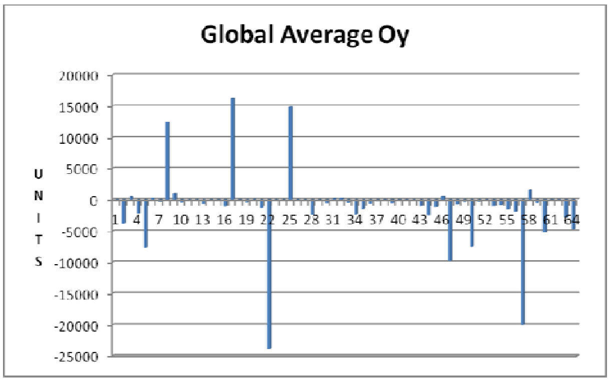

Fig. 2: Global Average Deviations: Oy

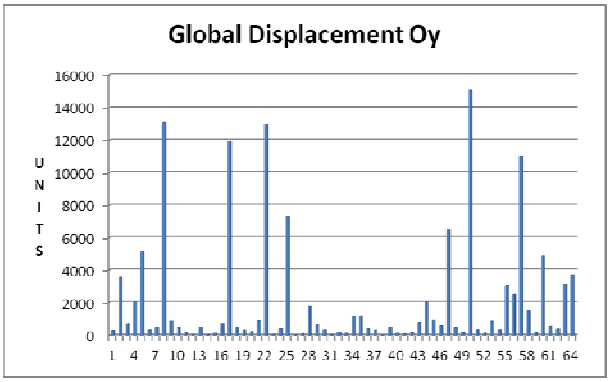

Fig. 5: Global Displacement Oy. Absolute values

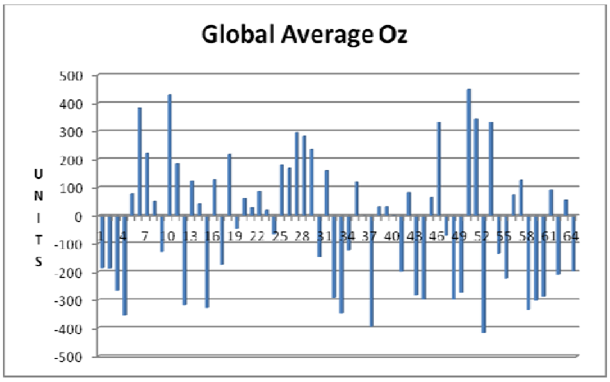

Fig. 3: Global Average Deviations: Oz

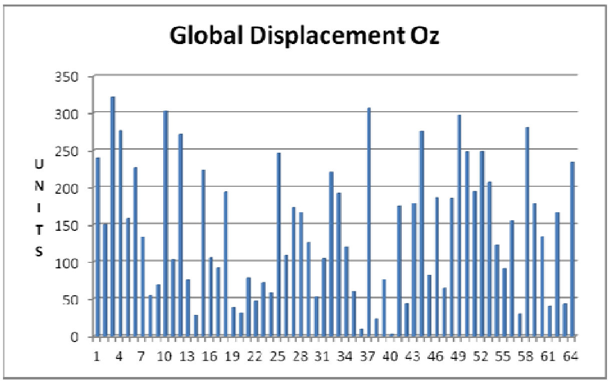

Fig. 6: Global Displacement Oz. Absolute values

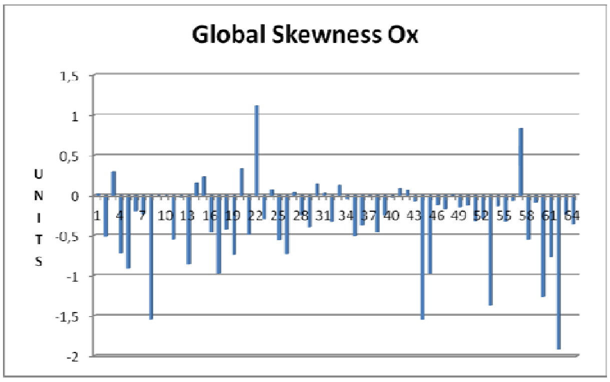

Fig. 7: Global Skewness: Ox

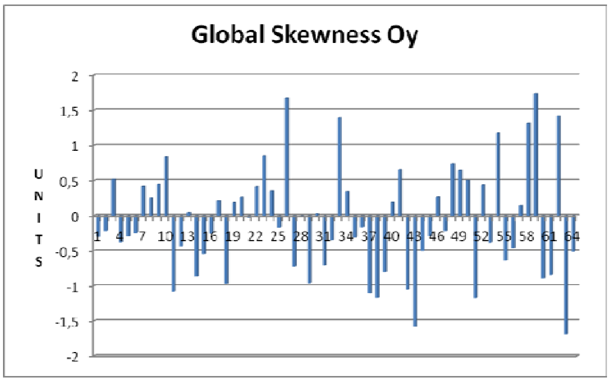

Fig. 8: Global Skewness: Oy

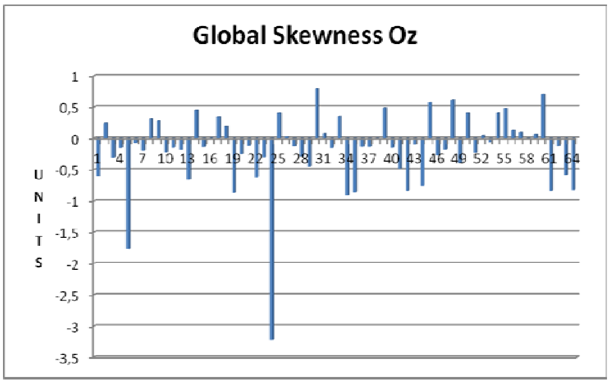

Fig. 9: Global Skewness: Oz

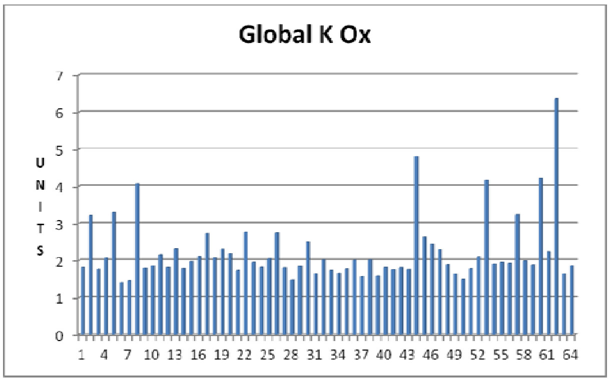

Fig. 10: Global K: Ox

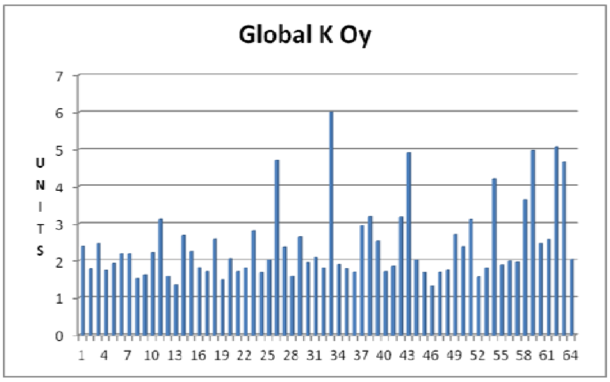

Fig. 11: Global K: Oy

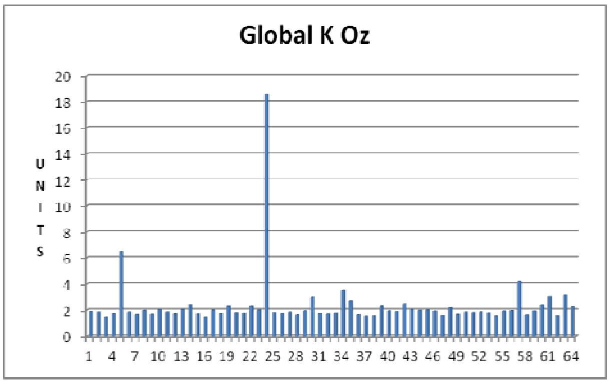

Fig. 12: Global K: Oy

4. CONCLUSIONS

The performance parameters exposed by intelligent system indicators were correlated with real in flight performance and with the results of coordination in multi-tasking test (Double Maze Bonnardel).

The results of Kendall correlations confirmed a significant association for differences between ideal and real trajectories on Oy axis (differences in horizontal plane), in all three stages of flight: first third (r = +0.40, p = 0.023), middle third (r = +0.50, p = +0.004) and final third (r = +0.62, p = +0.001). Also, the average global variation on Oy axis positively correlated with real in flight performance (r = +0.60, p = +0.0005). The multiple regression coefficient calculated for the four predictors is R = 0.82 (F = 7.69, p = 0.002).

The correlation with performance in Bonnardell shows moderate associations, taking values around 0.3÷0.4, with the ones between performance at simulator indicators and the number and duration of test errors.

All results are thoroughly analyzed, as well as their psychological meanings and consequences for final release of intelligent system.

REFERENCES

1. Adams, C.. The Avionics Behind the Avionics. *Avionics Magazine*. July (1998).
2. Evans, B.. Cockpit Automation: The Good, the Bad and the Ugly. *Avionics Magazine*. May (1998).
3. Matei, P.G., *On Board Equipment: Navigation, Gyro and Data Processing Systems*. Bucharest: MTA Press (2010).
4. Matei, P.G.. Integrated Flexible System for Flying Profiles Assessment. *Aerospace Science Conference „Aerospace 2008"*. October (2008).
5. Popa, M., Matei, P.G., Radu, V., Merode, C., Panțîru, S., Ionescu, V.. Flying Capabilities Assessment System in Virtual Environment: Preliminary Validation. *International Conference "Psychology and Society: Applied Psychology"*. September (2007).
6. Matei, P.G., Popa M.. Flight Performance Optimizing System by Improving Pilot – Aircraft Coupling. *National Conference „Aerospace 2005 – Aerospace Science Symposium"*. October (2005).
7. Racoveanu, N., Stoica, A.. *Aircraft Automation*. Bucharest: EDP (1990).
8. Wensley, J.H.. Error Tolerance Implementation. *Fall Joint Computers Conference*. Montvale: AFIPS Press (1995).