MODELING AND SIMULATION
POSIBILLITIES RELATED TO ERGONOMIC FEATURES OF THE ARMOURED VEHICLE SYSTEMS

Dorel BADEA*
dorel.badea@yahoo.com
Mihai STOICAN**
mihaitza_stoican92@yahoo.com
Marian COMAN***
coman.marian@gmail.com

* “Nicolae Bălcescu” Land Forces Academy, Sibiu, Romania
** “Mihai Viteazul Tanks and Automobiles Training Center”, Pitești, Romania
*** “Getica” Land Forces Combat Training Center, Cincu, Romania

ABSTRACT
This article investigates by means of a specialized software few ergonomics characteristics of the operator in a man-machine system with special destination. The results (anthropometric conditionings) argue the practice of the field, such research contributing to optimizing the using of armored vehicles through human reliability issues improvement.

KEYWORDS: ergonomics, armoured system, modeling and simulation

1. Introductory Theoretical Elements
Modeling and simulation are important methods to optimize organizational capabilities, with significant benefits for organizations budgets. Although these concepts are applicable in a wide range of domains, it is necessary to note that there are, in many cases, the approach differences and even the concepts describing differences. In a broad way, modeling performs synthesis of the system. In other words, based on known components (I), the situation must be configured to show how to do in order to influence the making of the wanted elements (E) [1].

Describing all aspects of state and human behavior in the use of any kind of military technology, for instance, human factors, have become a major aspect of interest and at the same time a study subject by itself, aimed at improving performance and reducing risks in different professional fields, a particular interest in this regard for military domain is manifesting also within NATO, within a specialized structure, Human Factors & Medicine. Basically, the human factors’ model has as a fundamental
aim the explanation of the ability of a human-machine system to achieve its goals, and this general goal can be described by two fundamental issues [2]: the extent to which the technical component, both in terms of construction and in terms of mode of operation is consistent with the basic features of the human operator; the extent to which human component with respect to the physical potential, the skills, knowledge, abilities and so on, is consistent with the requirements of the technical component and the nature of the environment. In this context, ergonomics is a science that has its own subject, methods and research techniques. The research subject of ergonomics consists of organizing the human activity in the labor process by optimizing the relationship of man-machine-environment system, aimed at improving the technical and economic efficiency, optimization of satisfaction, motivation and results of the work, while maintaining and fostering good physiological personality development [3].

2. Research Methodology and Main Results

The main goal of this article is to verify the essential ergonomic working conditions for the driver of the amphibious armored carrier (BTR/APC) by utilizing the Ergo-Easer software which can simulate a wide variety of types of these conditions (in an office, in a vehicle, in front of a computer).

The parameters introduced in the Ergo-easer were obtained by measuring the driver’s seat-conductor (Figure no. 1), the distance from seat to pedal system until the windshield visor. Distances obtained from measurements within amphibious armored transporter model 77 for this study are: back support (26 cm), tilting backrest (20°), surface length for seating (33 cm), tilt of the seat surface (5°), the distance from the seat to the armored floor (35 cm), the dimension of a pedal (5 cm), the slant of the pedals (30°), the distance from the seating to the pedal system (63 cm).
After the measurements obtained from the inside of the armored carrier, the parameters were input in the Ergo-Easer software in accordance with Figure no. 2 in order to setup the driver’s seat parameters.

![Fig. no. 2 Setting Up of the Driver’s Seat](image)

Three basic existing dimensions are used by Ergo-Easer for modeling and simulation of the appeared tensions on the driver-conductor and subsequent corrections of his seat: a small man, a medium man and a large man (Table no. 1).

**The Three Basic Dimensions Offered by the Software**

<table>
<thead>
<tr>
<th>No.</th>
<th>Basic Dimensions Measured</th>
<th>A Small Man</th>
<th>A Medium Man</th>
<th>A Large Man</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Popliteal height</td>
<td>39 cm</td>
<td>44 cm</td>
<td>49 cm</td>
</tr>
<tr>
<td>2.</td>
<td>Eye height (sitting)</td>
<td>73 cm</td>
<td>79 cm</td>
<td>84 cm</td>
</tr>
<tr>
<td>3.</td>
<td>Elbow to fingertip</td>
<td>44 cm</td>
<td>48 cm</td>
<td>52 cm</td>
</tr>
<tr>
<td>4.</td>
<td>Elbow rest height</td>
<td>19 cm</td>
<td>24 cm</td>
<td>29 cm</td>
</tr>
<tr>
<td>5.</td>
<td>Elbow to elbow</td>
<td>34 cm</td>
<td>41 cm</td>
<td>50 cm</td>
</tr>
<tr>
<td>6.</td>
<td>Buttock to popliteal</td>
<td>44 cm</td>
<td>51 cm</td>
<td>55 cm</td>
</tr>
</tbody>
</table>

The running of the software for a small size man under the conditions described above analyzing his position in the seat is shown in Figure no. 3.
The result is that of a little discomfort in the back, hip and eye viewfinder. To decrease or even eliminate this uncomfortable position the seat must be adjusted as follows (Figure no. 4): decrease backrest 16 cm, increasing from floor to seat height 39 cm, move the seat to the front by 9.5 cm, and creating a support arms.

**Analysis Summary**

Based on current research, this workstation configuration will eventually result in discomfort to the operator. To minimize the risk of injury to the operator, make the following adjustments to the workstation:

- **The Chair**
  - Redesign workstation to include an ARM SUPPORT
  - Lower the BACK SUPPORT HEIGHT to 16 cm
  - Increase the SEAT PAN HEIGHT to 39 cm
  - Reduce the ARM SUPPORT HEIGHT to 17 cm
  - Reduce the FOOT REST DISTANCE to 61.5 cm

The running of the software for a medium sizeman under the conditions described above analyzing his position in the seat is shown in Figure no. 5.
This time the result is a greater discomfort for a medium size man than a small size man and it is extending also to the rear of the body, its reduction could be achieved by adjusting the seat as follows (Figure no. 6): decrease backrest to 18 cm, height increasing from floor to seat to 43 cm, moving with 4.5 cm the seat to the front, and creating a support arms.

The running of the software for a large size man under the conditions described above analyzing his position in the seat is shown in Figure no. 7.
The result is that of a more discomfort than for the two previous simulations. The discomfort was intensified to the back’s driver and his spine and shoulder problems have emerged, and the discomfort relief could be achieved by adjusting the seat as follows (Figure no. 8): decreasing the angle between the backrest and seat to 8°, increasing the height from the floor to the seat to 48 cm, moving the seat to the front with 1.5 cm, and creating a support arms.

Simulating the ergonomic conditions with QEC software was achieved by fulfilling the existing questions in the questionnaire after conditions’ assessment within BTR 77 and also based on the driver’s interview (Figure no. 9).
The result also obtained by using this software shows that this working position as a driver requires more effort in achieving the focus and driving a BTR 77 in these conditions, and the body suffers discomfort on several parts as of the scoring displayed by QEC software (Figure no. 10). The scoring indicates an exposure of that part of the body and it leads us to a classification of the parts subject to vibrations and discomfort: shoulder/arm (the obtained scoring was 34), wrist/hand (the obtained scoring was 30), driver’s back (the obtained scoring was 26), and neck (the obtained scoring was 16).

A feature of the software used in this study is that it classifies using a simulated scoring between 0 and 100 the body parts after emerging health problems and by knowing the previous classification, it can be achieved some improvements of the working environment in order to raise ergonomic level inside of the equipment or machinery subject to study.
3. Conclusion

These types of software can be useful in the military domain on a wide range of work stations, and in addition QEC can be used in the military units for analyzing a large number of drivers to collect data on ergonomic conditions within armored combat vehicles for improving these working conditions. Ergonomic factors as were those studied in this paper, also essential for developing a man-machine-environment system, have direct influences on human subsystem, which in terms of the use of military equipment, namely the relationship between the human body movement and the economy movements principles, their anthropometric and ergonomic value, work capacity and operational fatigue. The development of databases with such results is useful in the design phase of the equipment to reduce tensions on the armored vehicle driver. Of course, it would be ideal to be able to adapt the cockpit in accordance with each user but the spreading of sizes and lengths of body segments is one which can introduce design constraints (e.g. elimination of extreme sizes/lengths).

REFERENCES