



**INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS**

Name of the Student : Amare Wibneh Mengistu
Roll Number : 166105010
Programme of Study : Ph.D.
Thesis Title: Study on Ergonomic and Crew Protective Interventions on Light Armoured Vehicles for Ethiopian Army
Name of Thesis Supervisor(s) : Dr. Sougata Karmakar
Thesis Submitted to the Department/ Center : Department of Design
Date of completion of Thesis Viva-Voce Exam : 16/10/2022
Key words for description of Thesis Work : ergonomic design; anthropometry; vehicle design; hull obliquity; digital mock-ups; physical trial; DHM, vehicular accommodation; comfort; crew protection; PCA

SHORT ABSTRACT

Light armored vehicles (LAVs) are multi-purpose type of vehicles. It can be used for reconnaissance activities such as patrolling and scouting activities, transporting and carrying troops, ambulance service, small and large scale combating activities in various army wings, and conflict cessation in streets and institutions of urban or city. From the design perspective, LAVs require maneuverability, survivability, off-road efficiency, and compact size, maintaining the adequacy of the space and comfort. Researchers have conducted various studies regarding its maneuverability, survivability/crew protection, and firing power in a compact interior space of the vehicle. However, ergonomics aspects are often overlooked while space compactness and crew protective aspects are considered. Therefore, the current research aims to investigate the design intervention of the ergonomic and crew protective aspects without affecting the space occupancy and mobility of the Ethiopian LAV to enhance crew comfort and safety.

Based on the fixed problems, various results and findings were established following different systematic approaches and procedures. The results of the comprehensive study come up with design procedures/guidelines for Ethiopian army vehicles were presented as follows:

1. The anthropometric database of 32 variables that were collected from 250 males and 60 females of Ethiopian army personnel in terms of range mean, standard deviation, and percentile values (5th, 50th, and 95th) was documented for ergonomic design of vehicular workspaces and other facilities as there is anthropometric variations comparing with other nationalities such as USA, Korea and India and as there is no reported similar database for army personnel in the Ethiopian context.
2. As there was an ergonomic mismatch of the existing vehicular workspaces, new proposed design dimensions were determined based on the predictive mathematical models which were formulated as a function of anthropometric dimensions and ROMs.

3. Due to the contradictory effects of the various desired constraints, an optimal design and analysis of the vehicle hull were performed to achieve the maximum crew protection capability without affecting the hull weight and space adequacy.
4. Validating the compatibility of predicted workspace dimensions of LAV employing digital and physical mockup evaluations was the part of the study to ensure the accuracy of the predicted design dimensions that comply with ergonomic principles early in the design of new LAVs.
5. Before physical mockup testing, identification of key anthropometric variables (the minimum data set) that represents the rest of required large variables for a PMU testing of LAV with limited source of users for trial was done as there is no sufficient human subjects for user trial in the institute where the physical mockup made.

The study's findings will be immensely useful to design a new or redesign an existing army vehicle to ensure better comfort and performance of the crew in working posture. Design of an obliqued hull of LAVs based on the anthropometric and ROM data for defining workspace design dimensions thereby the final proposed vehicle models would certainly reduce muscular discomfort and injury of the crew and troops from armor piercing rounds, and increase operating performances efficiency and safety of the crew during neutral posture sitting, firing, sighting and driving.

The development of the anthropometric database of the Ethiopian army personnel has been initiated to extend more number of variables and sample size for a complete reliable package of anthropometric database. It may also be considered for designing military equipment and workspaces until additional studies were conducted. It can be utilized as an ergonomic design guideline of Ethiopian army vehicle due consideration of Ethiopian anthropometric database. Fabricating LAVs considering the comfort and safety of the crew can enhance their operational performance and efficiency during military operations. Modernizing the defence vehicular technology by introducing scientifically proven better design concept according to the need of specific country is the global need. The design intervention considering both ergonomic and protection aspects avoids the uncertainty of the negative effect of hull obliquity on mass and space occupancy.

Furthermore, the major methodological protocols that can provide visible contributions for researchers in the process of anthropometric survey consist of sample size calculation, anthropometric measurement tools, procedures and techniques, selection of the required anthropometric variables for design of army vehicles, reliability assessment of measurements to avoid errors occurred by measuring instruments and observer, and techniques for data analysis. The match/mismatch analysis of existing vehicular workspace dimensions compared to predicted design dimensions (determined by predictive equations) is considered the novel methodological contribution of its kind. Predictive equations formulated as a function of anthropometric variables and ROMs can be utilized as a design standard globally and nationally. Design intervention of ergonomic issues and crew protective aspects (such as dimensions of occupant space, hull obliquity, geometric factors, and mobility aspects) of the vehicle was considered to be design constraints to enhance crew protection without affecting space occupancy and mobility/mass so that it helps to provide as a methodological basis. Digital human modeling has been used in many literature surveys to test digital mock-up. However, physical mock-up testing was also performed to use small sample sizes as needed to check the design intervention of both ergonomic and crew protective aspects.