Need for Atmanirbharta in Human-centred Design, Human Factors and Human Systems Integration in Indian Defence

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How can Indian defence engineers reduce training time for soldiers through the design of human-centred technologies? How can Indian defence engineers reduce time for technology adoption of novel technologies? How can Indian defence engineers support the military end -user in all phases of design, deployment, operation, maintenance and decommissioning of Indian defence technologies and systems? How can Indian military decision-makers ensure that the soldiers involved in combat are not let down by difficult-to-use technologies? How can programme managers ensure that the technological cost is reduced by finalising on human-centric design aspects during the design phases of the project, rather than waiting for the technology to be developed resulting in a decrease in design flexibility?

In light of India's progressive initiatives, like 'Make in India' and 'Atmanirbhar Bharat', it is necessary to include human-centred design (HCD), human factors engineering and human systems integration for atmanirbharta (self-reliance) in the defence sector of India. This commentary

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emphasises the necessity of considering aspects of human contribution along with technological advancements in the defence sector, thereby improving combat capability and efficiency of operations. The aim is also to shed light on end-user challenges and long-term adaptation issues among defence personnel arising from technology-centric design. In addition, the significance of designing technology that is user-centric and adaptable throughout its life-cycle, along with technical proficiency, is highlighted.

The commentary also discusses the lack of awareness regarding HCD in the defence sector and the undervaluation of HCD's contributions at the expense of technological aspects of systems design. Design is not colour, paint, drawing or even the pejorative use of the term 'aesthetics' applied at any project's end. Unfortunately, this is the popular understanding of civilian design. In contrast to this understanding, HCD, as an encompassing term, considers human factors engineering and human systems integration, and is a vital aspect to be considered by the defence sector in India.

There is a gap due to HCD and human factors-oriented education and design in the defence sector in India. In different countries—for example, the United Kingdom (UK)[1] and the United States (US)[2]—where human factors, HCD and human systems integration have matured in a better manner, the need for these three thrust areas is unequivocal. Hence, to overcome the challenges, the commentary proposes policy changes in terms of developing an institutional base for supporting HCD in the defence sector. Further, it is important to engage various stakeholders through collective efforts to ensure improved application and inclusion of human-centric design principles.[3]

The commentary is divided into four sections. After the introduction, the next section highlights the basis of HCD, Human Factors and Human Systems Integration. The following section identifies barriers to the incorporation of HCD in the Indian defence sector. Finally, the last section concludes with policy recommendations. In summary, the focus is on human needs, along with technical advancements, to improve combat experience, national productivity and international competitiveness by application of an efficient HCD ecosystem.

Current State of HCD, Human Factors and Human Systems Integration in the Indian Defence Sector

The HCD is a branch of design that emphasises the use of human-centric principles for the design of products, service and systems. Human factors engineering and human systems integration are closely related to this area and

bring about a close coupling of the human and technology along with systems engineering processes. While Indian defence has created an institutional basis for physical ergonomics[4] as well as cognitive requirements for selection of various personnel,[5] along with medical science-enabled ergonomics,[6] there is still a pressing need for human-centric design in the weapons life-cycle. Also, HCD related to operation and maintenance are yet to be institutionalised in a systematic manner, which includes both manned and unmanned systems. In other words, there are also human factors engineering based design in unmanned systems in terms of design, deployment, operations and maintenance. Unfortunately, this understanding has not percolated in the Indian defence sector yet. Therefore, HCD, human factors and human systems integration need to be incorporated in the Indian defence sector; and these aspects need to be incorporated at all levels starting from policy considerations.

The defence sector demands specialised personnel and specific operational needs as compared to civilian sectors.[7] Presently, the engineering designers in the defence sector focus mainly on technology-centric design of weapons and equipment, rather than accommodation of human-centric design principles in the design process. The HCD incorporates the existing technology-centred approaches and design principles along with human factors and systems engineering for better design outputs. The role of HCD must be included strategically so that this shift in cooperation of private and government participation can be utilised for better prospects. Considering global HCD developments and ongoing transformation of the Indian defence industry, the commentary emphasises a sectoral approach to the implementation of HCD in the defence sector.

Barriers to Incorporating HCD in the Indian Defence Sector

After discussing the need and basis of HCD in defence, this section sheds light on the barriers to incorporating HCD that limit the growth of usability, productivity, safety and international competitiveness in the defence sector.

HCD is 'Obvious': Lack of Awareness or Understanding of the Approach to User Engagement and Academic Institutionalisation

The undervaluation of the importance of design and human factors is due to the perception of sophistication of science and technology education in the Indian education system. This is because of lower prominence of design (arts and crafts) discipline and education in the education system. The perception

of design output as 'obvious' after creation, as also the lack of acceptance of the creative envisioning process, is similar to the attitude towards human factors as being obvious. In both the cases, the theoretical and scientific basis is neglected and traded-off with what can be created by anyone.

In addition, human factors engineering still remains unknown in the country. Human factors is often a branch of industrial and systems engineering (at times mechanical engineering) in American universities. In addition, it is also found as part of applied psychology programmes, or even as separate departments of ergonomics. Unfortunately, in India, it has not moved beyond its physical and physiological dimension. In India, 'ergonomics' as a label is more widespread. However, 'ergonomics' is equated to 'physical ergonomics' at the expense of its cognitive and organisational dimension. As a result, ergonomics also remains underdeveloped and lacks the quality of change required for developing human-centric weapon systems that involve information design and crew-centric requirements.

The over significance of technological aspects of engineering products in the defence sector undermines the importance of HCD principles. The HCD, in the form of human–machine interaction design or industrial design, is often considered an afterthought. Thus, engineers end up working on end-user interaction design with a vague understanding of HCD. This phenomenon is manifested in the Indian defence sector, where engineers are leading prominent design work focused on humans without a proper understanding of HCD.

The lack of awareness about the fundamental aspects of HCD and understanding of its practical applications for the end-users is a big challenge to overcome. Various design analysis techniques, like user studies and work analysis, help to understand the mental model and perspectives of the user qualitatively, compared to the casual inquiry of 'asking the users' as it lacks the creative and lateral thinking skills required for designing.

The differences between HCD and engineering design programmes offered in civilian educational institutions have resulted in the lack of institutional basis for HCD in defence systems. The HCD education is offered in India through certain design schools like the National Institutes of Design (NIDs), and design departments of various institutions, including some Indian Institutes of Technology (IITs). At the same time, engineering design is specifically taught in engineering departments of IITs, as in 'design engineering'. Human factors programmes that address technology in its totality are missing. Fragmented programmes, such as physical ergonomics, are well-developed in India. Systems engineering, in its entirely, is missing

from the academic sector in India. Hence, the gap is evident between HCD, human factors engineering and engineering design, especially for large-scale systems design for defence, and is not coherently addressed by academic institutions.

Since the defence sector is dominated by technology, the recognition and institutionalisation of HCD still remains a gap to be filled. Therefore, the necessity to acknowledge and integrate HCD into the Indian defence sector is important to unleash the full potential of the defence sector and avoid allowing technologists to masquerade as HCD practitioners without proper design training in HCD techniques.

Lack of Understanding of HCD and its Impact on Innovation and International Competitiveness

The underutilisation of HCD in the defence sector is primarily due to the lack of awareness and understanding of its potential and capabilities. While the sub-disciplines of design, like service design and strategic design, are assimilated and practised internationally, it is still a challenge to overcome in the practice of the disciplines in the Indian defence laboratories. The gap between the users of these products and those who commission these products attracts a lot of 'low-cost' designs than products with better usability and user satisfaction. The Indian defence sector needs to create a better understanding of HCD practices, prospects and return-on-investment opportunities.

The lack of HCD leads to international incompetency and compromise on innovation. The reliance on defence imports and international training of the defence personnel can bring better perspectives on the adaptation of various features in native designs, but it raises the challenge of adding new features only when other designs evolve. Consequently, this results in lagging behind in innovation and the inclusion of necessary updates in design. The HCD is not just about an on-screen interface but also involves holistic engagement of human–technology interaction. Therefore, the lack of HCD development results in a compromise in the quality of design and limits international competitiveness.

Lack of Understanding of Basic Knowledge-based Concepts (crucial for the defence sector) and their Application to Achieve Value from HCD

The incorporation of human factors concepts into the existing design professions in India still remains a challenge. Product design utilises the concepts of physical and physiological ergonomics, but the aspects of cognitive human factors, like Situation Awareness (SA), are known but

underutilised. The lack of inclusion of these concepts in the education of designers in the defence sector often leads to lack of adoption of crucial HCD concepts. The understanding and application of fundamental human factors principles, like SA, in defence applications ensure user-centric design and maintain international competitiveness. While the concept of SA is widely used in the defence community, its origins and applicability from a human-centric perspective may remain obscured.

The focus on creating working prototypes and scaling them up for development, by the engineers dominating the systems development, in the Indian defence sector, results in less attention given to the incorporation of HCD prototypes and confusion about HCD principles and tools. This is due to the confusion of perceiving learning tools, like computer-aided design (CAD) software or graphical user interface (GUI) programming frameworks, with core principles and methodologies of HCD. In order to rectify this, there is a need to disambiguate design from development with the consideration of end goals without decoupling them in the long run.

Two main issues are raised from the focus on technological development and the delay in HCD considerations of the design project. First and foremost, budget overruns from multiple human interface design iterations are caused by delayed iterations and inadequate accounting of human hours for HCD activities. Second, HCD offers better design flexibility and reduces system development costs. Hence, the efficiency of project management and cost effectiveness are achieved through the effectiveness of the relationship between HCD and the systems development life-cycle.

The necessity for specifically designed usability metrics for the operator experience is lacking in the Indian defence sector. The prevailing metrics that could be adopted are oriented towards civilian applications (user experience [UX]/user interface [UI]) and, therefore, may not be able to completely understand the sophistications of defence systems. Understanding human interaction in complex systems is done by adaptation of cognitive engineering, a sub-field of human factors, which provides suitable heuristics and metrics. Utilisation of existing usability scales helps to evaluate, verify and validate defence systems for the optimisation of human use.

Engineered systems in the defence sector involve consideration of technical reliability, ease of maintenance, availability and safety. The HCD can improve ease of maintenance; utilise ergonomics to reduce fatigue and musculoskeletal disorders; and improve productivity and comfort in workspaces for the end-users. The adaptation of effective information design in HCD, enabling better analytics and insight discovery through Health

and Usage Monitoring Systems (HUMSs), can improve user satisfaction. However, HCD principles are yet to be utilised in the Indian defence sector.

Policy Suggestions for Atmanirbharta in HCD, Human Factors and Human Systems Integration

The recommendations covering various aspects, including the formation of HCD design teams and the incorporation of HCD in a strategic way, are presented through a few suggestions for changes at the policy level for 'atmanirbharta' in terms of a human-centred approach in the defence sector.

1. There is a need to create awareness about the importance of HCD in the defence sector. The decision-makers in defence must be made aware of benefits of incorporating HCD principles. The strategic level of decision-making in defence agencies should adopt HCD principles and enable their growth throughout their organisations.
2. Representation of dedicated HCD designers in multifunctional teams and end-user involvement should be present in the entire systems life-cycle. Usability, productivity and safety should be evaluated using HCD-based metrics.
3. Defence educational institutions should introduce HCD courses; and civilian institutions should establish design and human factors courses oriented towards defence.
4. Research and development (R&D) should be promoted on HCD with funding; defence agencies should establish specialised HCD laboratories; Defence Research and Development Organisation (DRDO)–Industry–Academia (DIA) Centres of Excellence should incorporate HCD support.
5. Project formulation should include HCD experts and project methodologies should incorporate HCD criteria. Technical and HCD design activities should be optimised jointly.
6. Systems integrator, start-up and micro, small and medium enterprise (MSME) budgets should provision for HCD and human factors efforts. Further, defence companies should establish R&D facilities based on HCD, human factors and human systems integration.
7. Next-generation defence products should involve HCD-based concept design at the beginning of the project. Prior to starting development, the HCD-based design concepts should be completed and tested.
8. A shared vision of HCD should be developed in Indian defence. The HCD, human factors and human systems integration should be implemented in defence forces by developing joint roadmaps and

systemic policies. Policy documents, trade studies and roadmaps in the aforementioned areas should be commissioned for this inclusion.

Conclusion

A need exists to incorporate HCD principles into the Indian defence sector. It requires comprehensive understanding of HCD, including design, human factors and human systems integration. The HCD should be incorporated at all operational levels. The value of HCD for defence must be recognised by all stakeholders, including end-users, programme managers and decision-makers, thereby ensuring a human-centric approach in India's defence sector.

Notes

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