NEED FOR UPDATING WORKSYSTEM MODEL

Roli Dave, National Institute of Industrial Engineering, Mumbai
Vivek Khanzode, National Institute of Industrial Engineering, Mumbai
Rauf Iqbal, National Institute of Industrial Engineering, Mumbai
Vikram Neekhra, Armoured Static Workshop, Ahmednagar

ABSTRACT

Worksystem in human factor and ergonomics comprises of 'Human', 'Machine' and 'Work Environmental' components, its associated subsystems, and their interactions. The purpose of worksystem design (WSD) is to addresses design issues of worksystem, Leamon's Human-machine worksystem model is the fundamental conceptual framework to design and analyze the worksystem. ER-14786:2002 to an extent had updated Leamon's model, with thrust on factors affecting machine, environment, and human dimensions of work systems. With technological advancement and increasing automation, the worksystems are undergoing major transition, and becoming more and more complex. The dimension of human, machine and environmental component in the worksystem is also undergoing change in the process. The current conceptual human-machine worksystem frameworks stands true for linear systems, but are inadequate to explain automated complex worksystem.

This study examines the transition in components of existing worksystem and its connotations.' It delineates the need to update Lemon's worksystem model, in the light of increasing transition towards automation.

Keywords: Complex Worksystems, Industrial Ergonomics, Leamon's Model, Worksystem Design, Automation, Coupling.

INTRODUCTION

Human-machine worksystem is an analytical concept, defining all determinants (components and their interactions) involved in the execution of desired task. According to Wieringa & Stassen (1999), it refers to all the conditions where humans uses, controls or supervises tools, machines or technological systems. Human-machine worksystem is the building block of every technological domain and its application is multidisciplinary (medical technology, transport, defense, shipping, aviation) etc. (De Winter & Dodou, 2014). In order to achieve higher economic benefits and increase productivity, advanced technology is used in worksystem design (WSD) of all domains (Westin et al., 2016). The engineering system have become more complex and technology savy (Caple, 2007).

Industrialization and technological advancements have forced worksystem to undergo major transition. The changing worksystem is characterized by increased machine work content and diminished human work content (Onnasch et al., 2014). The jobs previously performed by human are taken over by machine and systems are becoming more and more automated. Automation is most often defined as *"device or systems that accomplishes (partially or fully) a function that was previously, or conceivably could be, carried out (partially or fully) by a human*

Citation Information: Dave, R., Khanzode,V., Iqbal, R., & Neekhra, V. (2023). Need for Updating Worksystem Model. *Journal of Management Information and Decision Sciences, 26* (S5),1-12.

operator"(Parasuraman et al., 2000). Automation in worksystem has caused paradigm shift in human role from physical to cognitive (Endsley, 1997), and we argue that the role is now changing from cognitive to digital. This change has resulted in new dimensions of interactions (Onnasch, 2015). Worksystem have transformed from simple and loosely coupled to complex and tightly coupled. Automation and complexity of worksystem has yield a plethora of different interactions. In critical conditions, there may be series of inevitable and unexpected interactions, which might escalate rapidly into unobstructed system failure (Sarter & Woods, 1997).The existing worksystem models are inadequate in explaining complex and automated worksystems of modern world. Newer technology and interactions in complex and automated systems delineate the need of updating current worksystem model.

This paper explains the traditional worksystem concept and model, examines the changing dimensions of worksystem and need for better worksytem model, that will explain worksystem, with varying degree of automation and complexity.

Worksystem

'Worksystem' is a loosely used word in many areas, meant to explain a work process. In each context, it has specific vocabulary of its own. In human factors and ergonomics, it represents a worksystem comprising of workers and work equipment acting together to perform the system function in the workspace, in the work environment, under the conditions imposed by work tasks. For example, in an automobile manufacturing unit, a car assembly station is the worksystem. The term *'worksystem'* was first noteworthy used in (Johannsen, 1982).

The most recent definition of worksystem is by ISO 2016 and was revaluated in 2020 and no change was made. According to it, worksystem is defined as a *"system comprising one or more workers and work equipment acting together to perform the system function, in the workspace, in the work environment, and under the conditions imposed by the work tasks"*. This is similar to definition given by Bridger (2003), which states that worksystem is *"a system designed to carry out value-added work, that consists of human (H) and machine (M) component embedded into local environment (E). This includes work space, work environment and work organization. Elements of worksystem interact with each other and six directional interactions are possible (H>M, H>.E, M>H, M>E, E>H, E>M)".* Four of these interactions involve human component (Bridger, 2003)

The human factor and ergonomics worksystem approach uses 'worksystem' as basic analytical concept (Margulies & Zemanek,1983). And the worksystem design is a flexible and iterative process De la Garza et al. (2012) that includes system components and interdependencies between system components. (e.g., machine, work organization, work environment). This indicates that worksystem is more than the sum total of its parts (Ottino, 2004).

After a detailed search of literature and comparative analysis of various worksystem models and theories, we believe that Leamon's 'Human-Machine model' is the most rightful and near accurate model, that explains all components of worksystem, with clear boundaries. It has the potential to explain process flow as well as inter-component interactions (Leamon, 1980). This model described the components of the worksystem as Human, Machine, Workspace, Environment and Organization. Human and machines are placed at the core of the worksystem

Citation Information: Dave, R., Khanzode,V., Iqbal, R., & Neekhra, V. (2023). Need for Updating Worksystem Model. *Journal of Management Information and Decision Sciences, 26* (S5),1-12.

(Figure 1). Sensory mechanism, processing, effectors and control, control process, display are described as primary components of humans and machines respectively in the model (Leamon, 1980).

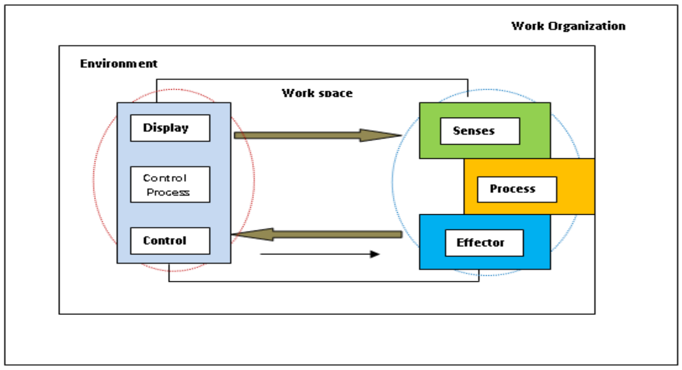

FIGURE 1
HUMAN MACHINE SYSTEM: A MODEL (ADOPTED FROM LEAMON,1980)

Leamon's Human-Machine System Model

Environment component of worksystem

(a) Workspace: It is three dimensional spaces, where the work is carried out at any point in time, as the human moves from one place to other. Design issues like anthropometry of human, dimensions of space required for human and machine are related to it (Martin et al., 1990).

(b) Physical Environment: Many aspects of environmental factor like noise, vibration, lighting, climate etc. affect the human functioning. Leamon (1980) states that contamination and pollution are the crucial environment variables dealt by industrial hygienist, since they have direct effect on the health of human component of system, which also has impact on human abilities and motivation.

(c) Work Organization: It is the work organizational structure, where the work activity is embedded with support of social and technically system. It is an immediate organization of human machine interaction, which refers to the rate of work, human working alone or as a dependent, activity as a group or machine is deciding the pace of work etc.

Machine Component of worksystem

(a) Control: Human interaction with machine is via suitable controls, which are used by the effectors. In the simple technology, tool or equipment acts as control. Controls are also an important source of feedback, during execution of control action. Few examples of control are switches, joy stick, steering wheel, handle lever.

(b) Display: Display is the action of machine on its local environment. Sometime process itself acts as display (cutting of steel rods in small pieces). With technological

Citation Information: Dave, R., Khanzode,V., Iqbal, R., & Neekhra, V. (2023). Need for Updating Worksystem Model. *Journal of Management Information and Decision Sciences, 26* (S5),1-12.

advancement, the gap between the controlled process and human component have increased; and so, the role of artificial display is important. When the operator has no direct access to the process, he has to interact with the machine via artificial display (screen, colored bulbs).

(c) Controlled process: This is the basic operation of the machine that ranges from a machine tool to an automatically controlled process.

Human component of worksystem

(a) Senses: These are the mechanism by which man are made aware of surroundings. The senses are being used in varying degrees, by human operator to gather information about the state of system, the changes brought about by its controlling action (Leamon, 1980). Vision is the dominant sense in the human, followed by hearing. Design of control is dominated by these two senses. Sometime smoke and chemical of different odor is used as warning signal.

(b) Effectors: There are three main effectors: hand, feet and voice, through which the information is fed into the control. It may be voice command.

(c) Processing: It is that part of human component, which is responsible for perception of process, registering the information gained by senses, decision making, and selecting/ordering the alternatives needed to adapt or control the process.

Advanced Human Machine Interface Model (PR EN: 14386: 2002)

Over a period, the Leamon's Human Machine model evolved into Advanced Human Machine interface model (Figure 2). This has incorporated, few important factors, having direct effect on the worksystem. Human component in this model includes factors like age, training, and motivation, physical and mental workload (Bridger, 2003). Age has direct relations to the human performance, as the senses, effectors and metal process capacity may differ with the age, directly affecting the worksystem. It has been proved that with motivation and training, the performance of human component will increase. The motivation enhances the performance of human mind and physiological process. Mental and physical load are also identified as factor affecting the human performance.

In the machine component, display is in the form of gauges and meters etc. (Mason, 1990); but there are few processes, where the process itself can be seen happening e.g. cutting of rod into small pieces , which act as real display of process itself and does not require any gauges or meter for display. This real display gives direct feedback to senses of human component, for further required control of process. In this process, the senses of human component (i.e., senses) can also have direct feedback from the control of machines actuated by effectors. Environment component has identified few factors such as noise, vibration, thermal conditions (heat or cold) and adequate lighting, having major impact on the work system. These environment components affect the performance of human and machine both, and have overall impact on performance of worksystem and productivity. Workplace design, which was identified as workspace by Leamon,

Citation Information: Dave, R., Khanzode,V., Iqbal, R., & Neekhra, V. (2023). Need for Updating Worksystem Model. *Journal of Management Information and Decision Sciences, 26* (S5),1-12.

here is categorized as immediate environment, where design of workplace is in accordance to the job, e.g. working posture of person while working and convenient location of control and display are important, while studying work system.

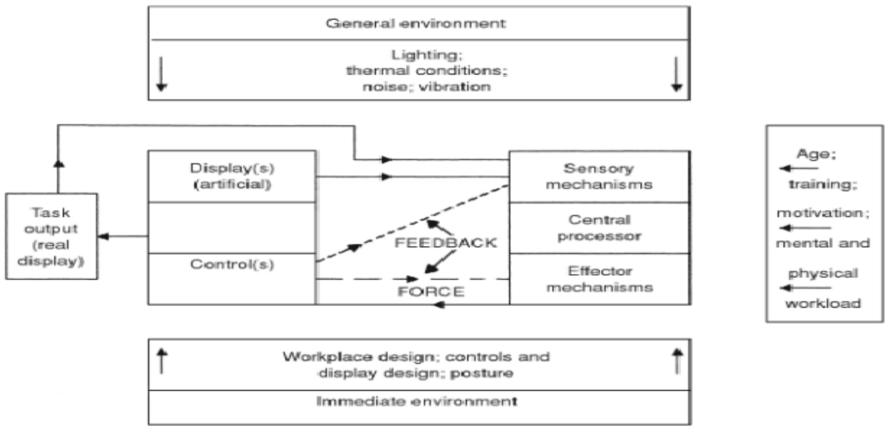

FIGURE 2
ADVANCED HUMAN MACHINE INTERFACE MODEL (ADAPTED FROM BRIDGER 2003)

(*Source : German Version Pren 14386:2002)*

Changing Worksystem

Industrial revolution and technological advances have brought new system designs, with use of computers, robotics, sensors etc. to sustain with industrial rapid growth. Significant changes have taken place in worksystems. Traditional worksystems, which were simple and involved manual work by operator, has evolved into more complex, mechanized, and automatic in nature figure 3. The work of the operator is eased and performed by the machines. There is significant change in worksystems across the dimensions of complexity, coupling and automation (Dave & Khanzode, 2023).

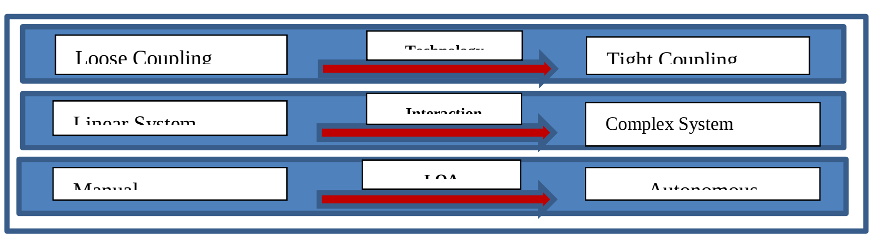

FIGURE 3
WORKSYSTEM TRANSITION

Citation Information: Dave, R., Khanzode,V., Iqbal, R., & Neekhra, V. (2023). Need for Updating Worksystem Model. *Journal of Management Information and Decision Sciences, 26* (S5),1-12.

(a) Level of Complexity

The worksystem change has occurred due to rapid increase in size and complexity of technical system, flexibility and capacity of digital labor and dynamics of human machine interface (Chapanis, 1961). The new system have multiple interface with unpredictable multiple interactions (Kaber et al., 2006). Hence the worksystems are becoming increasingly complex. Based on the design, worksystems are classified as: (i) linear worksystem and (ii) Complex worksystem. Linear system has spatial segregation of components and limited inter-dependencies of subsystem or components (Endsley, 1997). The chances of common mode failure of entire system are limited. When one subsystem fails, it can be separated from entire worksystem, repaired or replaced, without hindering other part functions of system (Johannsen, 1982). Example is a simple assembly line or packaging unit. Whereas, the key feature of complex systems is the cooperative interactions of many individual components, in order to get desired outcome. The complex work systems may have many autonomous sub-systems, with complex and shared interfaces, and so their boundaries are hard to pin down (Hoc, 2000). Failure or little change in one component may have far reaching consequences for the entire system.

(b) Coupling

Coupling in a system is an engineering term and it means the amount of slackness or buffer betweeen two components or subsystem, that are interdependent and so whatever happens in one directly affects the other. It is broadly stated that if there is neither reposnsisveness nor distinctiveness, the system is not really a system, and it can be called as an uncoulped system (Rijpma, 1997). If there is responsiveness without distinctiveness, the system is tightly coupled . if there is distinctivness without reponsiveness, the system is decoupled. If there is both distinctiveness and reposnsiveness the system is loosely coupled (Firestone, 1984). Loosely coupled systems preserve the identity, uniqueness, and separateness of elements in their working; whereas tightly coupled systems work on interconnectivity and inter-processing of two or more sub-system simultaneously. It has complex interdependencies between two or more components in terms of internal state, data, and function. In tightly coupled complex systems, the adverse impacts of a failure in one engineered system may propagate, and possibly amplify, through several other connected systems (Firestone, 1984). Tightly coupled system have little slackness, as against loosely coupled systems.

Perrow has explained the effect of technology and complexity in worksystem design by Interaction and Coupling Model. This model analyzes the various systems in the light of WSD i.e., linear or complex, application of technology i.e., loosely coupled or tightly coupled and assesses the catastrophic potential of system. Loosely coupled system can incorporate shocks, failure and pressure of change without destablization, while tightly coupled system will respond more quickly to these perturbations, but the response may be disasterous.

Citation Information: Dave, R., Khanzode,V., Iqbal, R., & Neekhra, V. (2023). Need for Updating Worksystem Model. *Journal of Management Information and Decision Sciences, 26* (S5),1-12.

(c) Automation

The term '**automation'** was introduced in mid-19th century, which represented the function execution by machine agent, that was previously performed by human (Albus et al., 1998). Automation denotes both automatic operation and the process of making things automatic (Diebold 1952 cited by Vagia et al., 2016). On one side, some functions of human are completely allocated to machine (like elevators) and are not considered as automation; while on another side, functions/devices like flight management system, teller machine, cruise control or cars etc. which human perform, qualify as automation. This shows that automation does not supplement human activity, rather it changes the nature of human work. This change has resulted in saving of manual labor, increase in productivity, improvement in quality, precision and accuracy. The automated systems have replaced human manual control, planning and problem solving by automatic devices and computers. In automated system, human and machine work together in varying degree of capacity and control; and this has been expressed by many researchers as different level of automation (Sheridan, 1997).

Worksystem Transition

The degrees of complexities in the systems are increasing along with technological coupling. These highly complex and tightly coupled system pose critical and greater challenge to human, So the automation in the systems is introduced to compliment the human effort, Hence to match up with the pace of global trends, productivity, and cost effectiveness, we see that the level of automation (LOA) in the systems is increasing (Parasuraman et al., 2000). All this has led to continuous transition in worksystem from linear to complex, loosely coupled to tightly coupled and from manual to automatic and autonomous worksystem (Beer et al., 2014). To explain this transition, we drew a continuum of worksystem as explained in Figure 4.

This continuum of worksystem transition is divided into three regions, where the worksystem is transiting from manual to automatic and autonomous, with increasing level of automation. Automation of machine component has in-turn changed the human role. The human role has changed from being a direct performer (no automation) to the manual controller (operator perform decision-making activities) to the supervisory controller (operator can override a machine-made decision), and then the executive controller (operator enables or disables execution of fully automated system). The term performer implies that operator directly performs a function, whereas the term controller implies, to control and supervise machine components. Manual controller and supervisory controller are in line with automatic worksystem in the continuum. With increasing level of automation, the machine work content is continually increasing and human work content is diminishing. However, human work content will never diminish completely, even in fully automated worksystem (Caple, 2007). This is because, human is expected to take over the control during unusual operating conditions and emergencies, to stabilize worksystem and prevent failures. This makes human work content very critical. Designing worksystems is a challenge with increasing level of automation due to issues in complacency, situational awareness and human machine compatibilities (Onnasch et al., 2014).

The use of computers and information technology in worksystem had shifted the focus of ergonomics from physical (when worksystems were manual) to cognitive ergonomics (automatic

Citation Information: Dave, R., Khanzode,V., Iqbal, R., & Neekhra, V. (2023). Need for Updating Worksystem Model. *Journal of Management Information and Decision Sciences, 26* (S5),1-12.

worksystems). Now with the introduction of robots, sensors, and smart machines, we foresee a paradigm shift in ergonomics from cognitive to digital ergonomics (Pacaux-Lemoine & Millot, 2016). The footprints of digital ergonomics are being observed in aviation, aerospace, nuclear plant, and defense sectors. We expect digital ergonomics to soon appear in manufacturing and service worksystems.

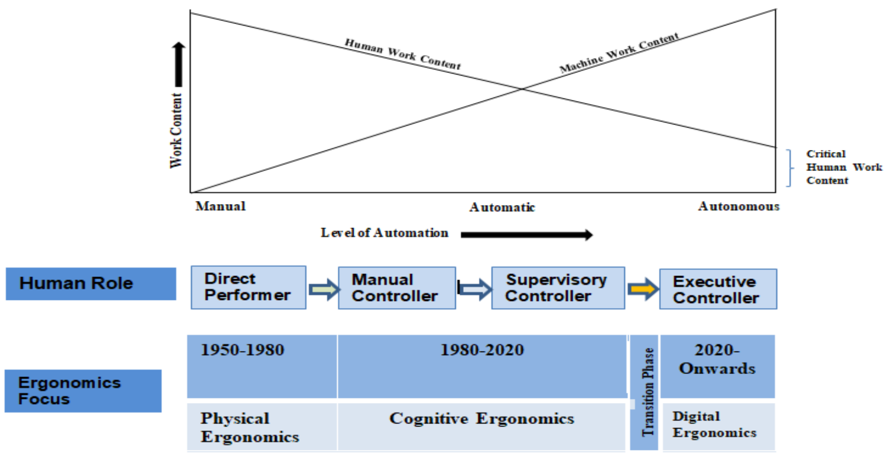

FIGURE 4
CHANGING WORK CONTENT, HUMAN ROLE AND ERGONOMIC FOCUS ON AUTOMATION CONTINUUM

Varying Role of Human in Worksystem

Figure 4 explains that with increase in mechanization and automation, human role in worksystem has undergone paradigm shift. There are different modes of human functioning (human-machine interaction) in worksystem (Wieringa & Stassen, 1999). They are:

(a) **Direct Control/ direct performer:** when work is done using tools and gadgets, human was ‘direct performer/controller of worksystem. There is a physical contact between human The human motor skills, and equipment are important characteristics of worksystem. The mechanical tool serves as extension of human effectors, e.g surgical equipment, hammer, bicycle etc. The human is continuously ’in-the-loop’ of work action and so the performance of worksystem is dependent on his capabilities.

(b) **Indirect/ Manual control:** When worksystems became more mechanized, the technological advancements were used to assist human in functions beyond their capacity. Here, human acts as manual controller, e.g., use of cranes or mechanical lifts to transfer heavy stuff or driving a vehicle. The human motor skills, sensory and cognitive capabilities are important characteristics of such worksystem, but human is not

Citation Information: Dave, R., Khanzode,V., Iqbal, R., & Neekhra, V. (2023). Need for Updating Worksystem Model. *Journal of Management Information and Decision Sciences, 26* (S5),1-12.

continuously 'in the loop'. They act as intermittent controller, adjusting and waiting for machine response. The machine response can be fast, but is at low conscious level and in control of operator

(c) **Supervisory control:** When worksystem becomes more automated and machine performs most of manual work, human manual work decreases as seen in the figure 4. He becomes the supervisor of system, and his task is to start/stop operations, to change set-points, monitor system performance and product quality and to perform fault diagnosis (Inagaki, 2003). Human can still interfere and modify the process, but is dependent on complexity and coupling status of worksystem. The more complex and automated is the worksystem, lesser is the human control. Here, the human is 'outside of the loop', for most of the part. The performance of automated system depends on proper human-machine interface design, operational procedures and training, human cognition, monitoring, situational awareness and learning skills.

(d) **Executive controller:** With further automation in worksystem, such that systems have become autonomous; like with use of robots, artificial intelligence (AI) and smart machines, it is generally believed that human role is restricted to designing such systems, starting, and switching off the system. However, we argue, that his role becomes more important, when he has to intervene, to stabilize the worksystem during critical juncture (unexpected negative interactions). Human cognition, decision, and quick reaction capabilities, as well as smart human machine interfaces are of paramount importance. There is lot of controversary among researchers and stakeholders, relating role of human in worksystem. Some believe that automation with AI has made human a subordinate of machine, while others believe that human is still the boss of worksystem, as he has the power to design and dictate the worksystem. Both human and automated machine can work as team and augment each other's role, in making the worksystem more robust.

Redefining Worksystem

Different definations of worksystems are given in literature (Bridger, 2003; Leamon, 1980), which more or less are similar. However, technology driven culture has immensely changed worksystem design. With this, not only human and machine is undergoing change, but even the dimensions of workspace and environment are changing (Wilson & Carayon, 2014). Worksystem which were confined static spaces, have become dynamic, and spatially and temporally segregated (Ottino, 2004), e.g., remotely operated unarmed vehicle (UAV). Human is remotely operating machine, in the extended dimension of workspace and both human and machine are operating in the varied work environment, posing requirement to changes work organization dimensions (HocrafferN& Nam, 2017; Isermann, 2011). Human and machine components, which are the core of worksystem have already transitioned (Debernard et al., 2016; Yin et al., 2015).

Citation Information: Dave, R., Khanzode,V., Iqbal, R., & Neekhra, V. (2023). Need for Updating Worksystem Model. *Journal of Management Information and Decision Sciences, 26* (S5),1-12.

On basis of these change in worksystem, we propose a modified definition of worksystem – Worksystem is a human-machine system performing tasks within the physical or virtual workspace, work environment and work organization through human-machine interaction using information and technology. This definition is relevant to complex and automated worksystems, where human may operate machine in or beyond anthropometric limits, and machine includes artificial intelligence component.

Epilogue

Leamon's Human-Machine Model (Fig 1), so far is the most fundamental model, explaining worksystem, because it illustrates all the essential components of worksystem (Human: senses, process, effectors; Machine: display, machine process, control; Environment: workspace, physical environment, work organizations) with clear boundaries (Dave & Khanzode, 2023; Leamon, 1980). It explains the process flow and some inter-component interaction. As can be seen from Figure 1 human and machine are core components of worksystem design.

When Human-Machine model (Leamon,1980) was formulated, machine and technology in the worksystem were at its nascent stage. Most ergonomics researches then focused on work space, work environment and work organization related issues. Stringent norms and regulations have since strengthened the work environmental and work organization components (Milczarek et al., 2010). However, human-machine interactions are least addressed in the literature. Its apparent, that core of worksystem is undergoing significant transition, as machine component is becoming more automated and complex and thereby, changing human role in worksystem. Complex and automated worksystem may have new components and elements. The inter/intra component and element level interaction need to be analyzed and mapped. For capturing interactions, illustrating the functioning, and analyzing complex and automated worksystems, the existing Human-Machine model is deficient. It needs to be updated and validated in several worksystems.

REFERENCES

Albus, J., & Antsaklis, P. J. (1998). Panel discussion: Autonomy in engineering systems: What is it and why is it important? Setting the stage: Some autonomous thoughts on autonomy. In *Proceedings of the 1998 IEEE International Symposium on Intelligent Control (ISIC) held jointly with IEEE International Symposium on Computational Intelligence in Robotics and Automation (CIRA) Intell*, 520-521. IEEE.

Beer, J. M., Fisk, A. D., & Rogers, W. A. (2014). Toward a framework for levels of robot autonomy in human-robot interaction. *Journal of human-robot interaction, 3*(2), 74.

Bridger, R. (2003). *Introduction to ergonomics*. Crc Press.

Caple. (2007). Ergonomics-future directions. *Journal of human ergology*, *36*(2), 31-36.

Chapanis, A. (1961). Men, machines, and models. *American Psychologist*, *16*(3), 113.

Dave, R. and Khanzode, V. (2023). "Mapping Of Human-Centric Worksystem Interactions In Industrial Engineering, 27, 3.

De la Garza, C., Labarthe, J. P., & Graglia, L. (2012). The contribution of ergonomics to risk analysis in the design process: the case of a future control room. *Work*, *41*(Supplement 1), 730-736.

Citation Information: Dave, R., Khanzode,V., Iqbal, R., & Neekhra, V. (2023). Need for Updating Worksystem Model. *Journal of Management Information and Decision Sciences, 26* (S5),1-12.

De Winter, J. C., & Dodou, D. (2014). Why the Fitts list has persisted throughout the history of function allocation. *Cognition, Technology & Work*, *16*, 1-11.

Debernard, S., Chauvin, C., Pokam, R., & Langlois, S. (2016). Designing human-machine interface for autonomous vehicles. *IFAC-PapersOnLine*, *49*(19), 609-614.

Endsley, M. R. (1996). Automation and Situation Awareness. Parasuraman, R.; and Mouloua, M.(Eds.), Automation and Human Performance.

Endsley, M. R. (1997). Situation awareness, automation and free flight. In *USA/Europe ATM R&D Seminar*.

Firestone, W. A. (1984). The study of loose coupling: problems, progress, and prospects.

Hoc, J. M. (2000). From human–machine interaction to human–machine cooperation. *Ergonomics*, *43*(7), 833-843.

Hocraffer, A., & Nam, C. S. (2017). A meta-analysis of human-system interfaces in unmanned aerial vehicle (UAV) swarm management. *Applied ergonomics*, *58,* 66-80.

Inagaki, T. (2003). Automation and the cost of authority. *International Journal of Industrial Ergonomics*, *31*(3), 169-174.

Isermann, R. (2011). Perspectives of automatic control. *Control Engineering Practice*, *19*(12), 1399-1407.

Johannsen, G. (1982). Man-Machine Systems - Introduction and Background", IFAC Proceedings Volumes, Elsevier,15, 6.

Kaber, D. B., Perry, C. M., Segall, N., McClernon, C. K., & Prinzel III, L. J. (2006). Situation awareness implications of adaptive automation for information processing in an air traffic control-related task. *International Journal of Industrial Ergonomics*, *36*(5), 447-462.

Leamon, T. B. (1980). The organisation of industrial ergonomics—A human: machine model. *Applied Ergonomics*, *11*(4), 223-226.

Margulies, F., & Zemanek, H. (1983). Man's role in man-machine systems. *Automatica*, *19*(6), 677-683.

Martin, T., Kivinen, J., Rijnsdorp, J. E., Rodd, M. G., & Rouse, W. B. (1990). Appropriate automation–integrating technical, human, organizational, economic, and cultural factors. *IFAC Proceedings Volumes*, *23*(8), 1-19.

Mason, S. (1990). Improving plant and machinery maintainability. *Applied Ergonomics*, *21*(1), 15-24.

Milczarek, M., Kosk-Bienko, J., Muylaert, K., Op te Beeck, R., Royo, S., Grusenmeyer, C., ... & De Norre, B. (2010). Maintenance and Occupational Safety and Health: A statistical picture. *European risk observatory EA-OSHA, Luxembourg*.

Onnasch, L. (2015). Crossing the boundaries of automation—Function allocation and reliability. *International Journal of Human-Computer Studies*, *76*, 12-21.

Onnasch, L., Wickens, C. D., Li, H., & Manzey, D. (2014). Human performance consequences of stages and levels of automation: An integrated meta-analysis. *Human factors*, *56*(3), 476-488.

Ottino, J. M. (2004). Engineering complex systems. *Nature*, *427*(6973), 399-399.

Pacaux-Lemoine, M. P., & Millot, P. (2016). Adaptive Level of Automation for risk management. *IFAC-PapersOnLine*, *49*(19), 48-53.

Parasuraman, R., Sheridan, T. B., & Wickens, C. D. (2000). A model for types and levels of human interaction with automation. *IEEE Transactions on systems, man, and cybernetics-Part A: Systems and Humans*, *30*(3), 286-297.

Rijpma, J. A. (1997). Complexity, tight–coupling and reliability: Connecting normal accidents theory and high reliability theory. *Journal of contingencies and crisis management*, *5*(1), 15-23.

Sarter, N. B., & Woods, D. D. (1997). Team play with a powerful and independent agent: Operational experiences and automation surprises on the Airbus A-320. *Human factors*, *39*(4), 553-569.

Sheridan, T. B. (1997). Eight ultimate challenges of human-robot communication. In *Proceedings 6th IEEE International Workshop on Robot and Human Communication. RO-MAN'97 SENDAI* (pp. 9-14). IEEE.

Vagia, M., Transeth, A.A., & Fjerdingen, S.A. (2016). A literature review on the levels of automation during the years. What are the different taxonomies that have been proposed?. *Applied ergonomics*, *53*, 190-202.

Westin, C., Borst, C., & Hilburn, B. (2016). Automation transparency and personalized decision support: Air traffic controller interaction with a resolution advisory system. *IFAC-PapersOnLine*, *49*(19), 201-206.

Wieringa, P. A., & Stassen, H. G. (1999). Human-machine systems. *Transactions of the Institute of Measurement and Control*, *21*(4-5), 139-150.

Wilson, J. R., & Carayon, P. (2014). Systems ergonomics: Looking into the future–Editorial for special issue on systems ergonomics/human factors. *Applied Ergonomics*, *1*(45), 3-4.

Citation Information: Dave, R., Khanzode,V., Iqbal, R., & Neekhra, V. (2023). Need for Updating Worksystem Model. *Journal of Management Information and Decision Sciences, 26* (S5),1-12.

Yin, Y. H., Nee, A. Y., Ong, S. K., Zhu, J. Y., Gu, P. H., & Chen, L. J. (2015). Automating design with intelligent human–machine integration. *CIRP Annals, 64*(2), 655-677.

Received: 23-Feb-2023, Manuscript No. JMIDS-23-13681; **Editor assigned:** 25-Feb-2023, Pre QC No. JMIDS-23-13681(PQ); **Reviewed:** 22-Mar-2023, QC No. JMIDS-23-13681; **Revised**: 16-June-2023, Manuscript No. JMIDS-23-13681(R); **Published:** 23-June-2023

Citation Information: Dave, R., Khanzode,V., Iqbal, R., & Neekhra, V. (2023). Need for Updating Worksystem Model. *Journal of Management Information and Decision Sciences, 26* (S5),1-12.