Human-System Interaction Standards for Robotic, Intelligent, Autonomous Systems

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ABSTRACT

ISO TC159/SC4 Ergonomics of human-system interaction is developing Technical Report (TR) ISO 9241-810 Human-system issues of robotic, intelligent and autonomous systems to address product development involving Robotic, Intelligent, Autonomous Systems (RIAS). This TR will review the human-system issues for a range of RIAS, describe the ergonomics risks that have to be considered in the application of these technologies, and identify priorities for future standardisation work. The focus of the TR is breadth not depth and issues not answers. This paper presents the approach ISO TC159/SC4 Working Group 6 is using to identify and develop the list of issues and priorities for future standardisation work regarding RIAS. Categories of issues that highlight the significant ergonomics challenges RIAS present and the ramifications for the practice of Ergonomics/Human Factors Engineering will be discussed.

1.0 INTRODUCTION

Product development of systems with robot, intelligent and autonomous characteristics is rapidly progressing. Given the human-system issues unique to systems with these characteristics, timely guidance covering these issues is necessary to help all sectors of industry to design, field and operate first-time quality RIAS, and build appropriate trust in such systems.

The paradigm behind human-systems interaction standards so far has been that of tool use. The current 9241 series of standards are for interactive tools and the physical environment within which they are used. RIAS necessitate a new paradigm. Agents developed using these technologies will be more connected, complex, probabilistic, social, and augment human capabilities. Interaction with these agents could become a relationship, their interface a personality, and users and agents may form complex human machine teams, working together towards a shared goal.

There is an urgent need for a Technical Report from ISO explaining the existing, emerging and potential human-system issues and consequences for use and users associated with systems that have robotic, intelligent and autonomous characteristics. The scope of RIAS addressed includes:

- Physically embodied RIAS, such as robots and autonomous vehicles with which users will physically interact
- Systems embedded within the physical environment with which users do not typically interact, but which collect data and/or modify the environment within which people live or work (e.g. smart buildings)
- Intelligent software tools and agents with which users actively interact through some form of user interface

- Intelligent software agents which act without active user input to modify or tailor the system to the users behaviour, task or some other purpose (e.g. providing context specific content/information, tailoring adverts to a user based on information about them, "ambient intelligence", etc.)
- The effect of interaction of several RIAS on users
- The impact on the wider system of systems / socio-technical systems on which the use of RIAS will impact.

It is not intended to explore the philosophical, ethical or political issues surrounding robotics, artificial intelligence, machine learning, and intelligent machines or environments. These concerns are addressed in BS 8611:2016 Guide to the ethical design and application of robots and robotic systems and IEEE project P7000 Model process for addressing ethical concerns during system design. However, the study identifies where and why ethical issues need to be taken into account for a wide range of systems and contexts, and as such it provides information relevant to the broader debate regarding RIAS.

The target audience for the report is the standards development community and ergonomists involved in developing, acquiring and/or commissioning RIAS. Designers and engineers who have to consider the ergonomics point of view, futurists, researchers, technology developers, regulators and legislators may also find the document useful.

Although the report addresses a wide range of technology applications, and sector and stakeholder views on the issues, the treatment of each may not be complete. The report will list the areas of concern that remain to be investigated.

2.0 METHOD

Boundaries were not set for this study beyond analysis by example. These will come from other work (e.g. robotics, Artificial Intelligence (AI), safety) and lack of representation for some areas of application. Figure 1 presents the space explored, including the scale of system, the ramifications of the complete product lifecycle, and the maturity of application in relation to the scope of ergonomics. RIAS can be located in these dimensions. The location prompts consideration of particular use/user issues/problems. Because of the possible interpretation of "issue" as meaning a known topic for a specific project that is to be addressed by a particular Ergonomics method or technique, the combined phrase issue/problem was introduced to indicate a more general area of concern requiring further consideration.

The analysis projected forwards from current applications of technology to more connected, complex, probabilistic and non-deterministic social systems/entities/agents and human augmentation. Social in this context also included physical interaction. Applications the team considered included robots, intelligent systems and environments, and autonomous agents/systems. The range of users for each was explored. The futurology literature, as well as reports of current and planned products was considered. The range of published sources and other expertise considered was broad, and included extensive discussions and analysis by the project team. A bibliography of key/interesting sources is therefore provided in lieu of references.

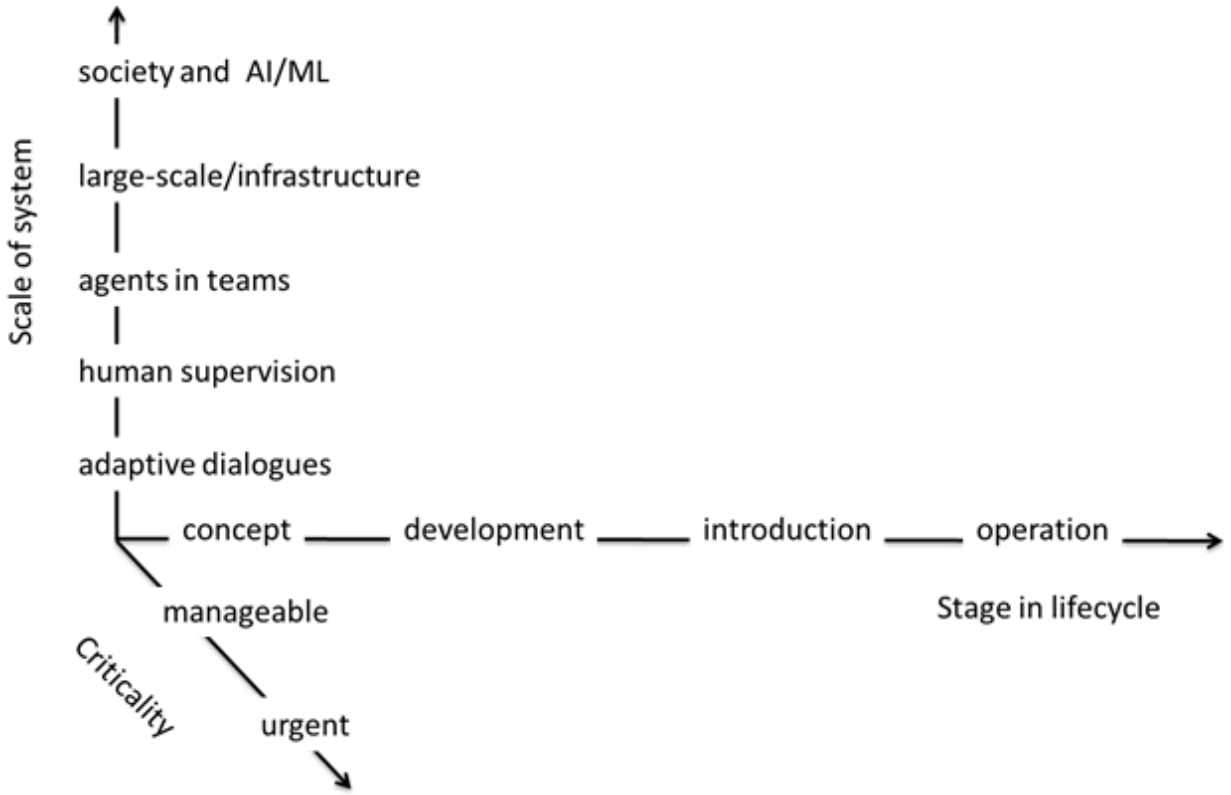

Figure 1: Dimensions considered in the review of RIAS issues/problems.

Human-system issues or problems were assessed at each level/context from society's relationship to large-scale AI (e.g. being kept as pets or not; employee, colleague, independent agent), through large-scale systems such as autonomous transport, through autonomous entities within teams, through human supervision of autonomous systems, to the details of adaptive dialogues. These analyses were based on existing research where available. The stage in the lifecycle where the issues/problems emerged and could be addressed was considered. The current level of maturity of addressing issues/problems and the urgency of addressing them were also considered.

The team considered views and concerns of users of RIAS and other stakeholders including industry sector, roles, visibility, trust, rights and culture. The limits for ergonomics were considered, with some attempt to identify areas of change. Regulatory work and astute observers were also considered.

An example of highly social interaction with autonomous entities was explored. Particular emphasis was placed on identifying what was of interest to ergonomics. The team was encouraged to go beyond the current assumed scope of ergonomics, considering what ergonomics absorbed from psychology, sociology, anthropology, and engineering. Cockpit resource management and how ergonomics contributed is an example of a successful application of domain knowledge and techniques that had not previously been considered by ergonomics. Verbal and chat interfaces, and physical interactions between people were explored, including how these interfaces change between a person and an artificial intelligence.

The issues identified were grouped under the minimum set of categories described in Section 3. The hazards and possible harm that could result were identified and are described in Section 4. The ergonomics aspects addressed by standards are described in Section 5. The necessary extensions to the scope of ergonomic analysis are explored in Section 6.

3.0 CATEGORIES

The identified human-RIAS issues/problems fall into six categories. These are summarised in Figure 2 and described in the following sub-sections.

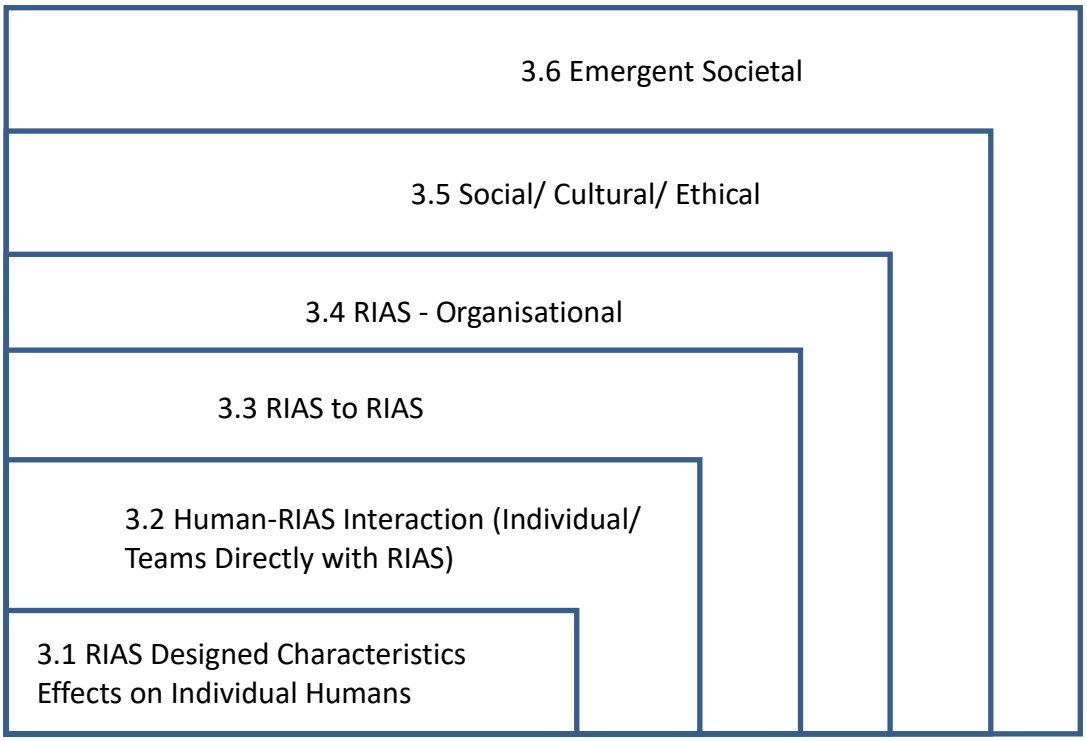

Figure 2: The six categories of RIAS issues identified.

3.1 RIAS designed characteristics effects on individual humans

This first category represents the impact that the characteristics of RIAS have on individual humans who are in the environment where it is operating. This includes physical, cognitive, affective, behavioural, and motivational responses.

3.2 Human-RIAS interaction issues (individual/teams interacting directly with RIAS)

Unless a RIAS is completely autonomous, humans interact with it directly at some level, or to some degree. The humans in this category constitute users of the RIAS. The issues in the category specifically cover the consequences and impact of the design of the user interface on user interactions with the RIAS.

1.3 RIAS to RIAS issues

One can anticipate that the time will come when multiple RIAS operate within the same environment, if it has not happened already. It is difficult to predict exactly what issues may arise, but compatibility and communication issues between one RIAS and another are, perhaps, foreseeable, and can be expected to affect users, as well as with the humans present in environments where multiple RIAS are operating.

3.4 RIAS – organisational issues

The RIAS is apt to affect the activities (e.g., work) that occurs in the organization, organizational processes, and the roles that people in the organization play. These issues raise the question of how we might optimise the existing organisational structures/working practices etc. to make best use of a new RIAS into an existing organisation. Although the issues in this category may not arise for every RIAS, they are likely to arise for any RIAS that is implemented at the level of an organization.

3.5 Social/cultural/ethical issues

A RIAS does not operate in isolation, but within a social and cultural context. To be effective, it must be seamlessly integrated within that context, as a member of the “team” or a “cooperating entity". The issues in this category describe how the design of the RIAS can impact the social interactions, group attitudes and motivation, collective group behaviours positively or negatively, depending on how seamlessly the RIAS “fits” within the social and cultural context.

3.6 Emergent societal issues

Issues will emerge during or soon after a new scientific or technological development is applied. These issues generally involve society as a whole, and are dealt with via policies, standards, regulations, and procedures. Thus, although human factors/ergonomics specialists may have a role to play in addressing some of these issues, many other types of professionals, as well as the general public, are apt to work together in addressing these issues.

4.0 HAZARD FROM RIAS TECHOLOGY IF ERGONOMICS ARE NOT ADDRESSED

4.1 The benefits of a human-centred approach to RIAS

Human interaction with RIAS agents can be predicted to take a variety of formats and, perhaps, even more that cannot be predicted. Regardless, it must be expected that many of these, if not all, will require a relationship with humans as individuals or with society as a whole. Some might even form complex human machine teams, working together towards a shared goal. Highly usable systems and products tend to be more successful both technically and commercially. RIAS developed following human-centred principles will offer several more benefits. These include:

- Improved ability for user/human to take control when required
- Increased accessibility for people with a limited range of capabilities
- Improved user experience
- Improved acceptance and integration of RIAS in human teams
- Improved integration and support of human tasks and activities
- Improved system performance across all system states (primary/normal, degraded, emergency, and reversionary (when the RIAS is unavailable)) and during the transitions between these states where particular issues can arise.

That can lead to:

- Increased product/system/service acceptance
- Increased product/system/service confidence and trust

- Reduced supporting costs
- A competitive advantage
- Reduced risk of human/human machine teaming errors and systems performing sub-optimally or entering unsafe or undesirable modes of operation.

4.2 The risks of not addressing RIAS human-system issues/problems

Not considering the human element in the design of a RIAS carries significant risks. The potential is high for negative impacts on the performance of individuals using the system and the behaviour of those otherwise affected by the RIAS. These include such things as:

- Inappropriate levels of trust/confidence in the system (having the correct level of trust or confidence in a RIAS is important. This is task, context and situation dependent, i.e. a RIAS may be more reliable in some situations than others and the ability of a user to understand this is critical, through transparency/predictability of system behaviour, etc.):
  - Under-trust can lead to: increases in workload due to additional checking and supervisory activities, users not adopting the system (if they have a choice) and anticipated benefits of the RIAS not being fully realized
  - Over-trust can lead to errors being made or missed, task disengagement and dissatisfaction with the RIAS when it doesn't perform as expected.
- Loss of situational awareness and disengagement with a task
- Over-reliance on the RIAS to complete tasks
- Increases in mental workload
- Degradation of knowledge, skills and abilities which may be required in reversionary, emergency and degraded system states or in the absence of the system
- Increases in training needs
- Perceived loss of control over one's work or one's environment, which may impact on job satisfaction and staff retention
- Ambiguity or loss of accountability and responsibility
- Poor usability impacting on sales and customer satisfaction.

These factors, in turn, can compromise safety by:

- Increasing human error, leading to accidents and injuries
- Increasing the time taken for users to reengage with a task (re-entering the loop) when they are required to do so, potentially delaying corrective action in time to prevent an unsafe state or action from occurring
- Causing people to deliberately (or unknowingly) develop ways of working around the RIAS and violating processes in order to complete tasks satisfactorily.

Similarly, when the human element is not sufficiently considered, there are negative social impacts for groups of people using the RIAS or functioning within the context of a RIAS. These include:

- General dissatisfaction with the social aspects of the environment
- Disruptions in the functioning of teams using a RIAS, or aberrations in social interactions due to the presence or functioning of a RIAS

- General diffusion of responsibility in the case of negative events related to the RIAS
- Perceived invasion of privacy by social groups and/or user teams
- Perceived decrease in security by social groups and/or user teams
- Generalized stress due to uncertainty created by the presence of the RIAS.

These things, in turn, can result in rejection of the RIAS, negatively impacting both the RIAS company's reputation and its bottom line. They can also serve to create a dysfunctional workplace, with all the difficulties this entails.

Therefore it is essential that a human-centred approach (human enhancement) be considered at all levels (of a system, organisation and scale of system), where RIAS and overall system design is focused around the decisions and tasks that must be retained by the human user (across all potential use cases: optimal, degraded, reversionary and emergency) with the RIAS supporting these. The human must be kept in the loop to the extent that is needed to achieve required levels of performance and safety across all system states. This is particularly important when systems transition between states, e.g. normal operation into an emergency state. Determining the needed extent is part of system risk assessment.

Similarly, it is critical to seamlessly integrate the RIAS with the social context in which it operates, to ensure that its operation does not unintentionally disrupt the social and cultural fabric of the environment. Thus, it is important that effect change management procedures are implemented whenever a RIAS is introduced into an environment that includes teams or other groups of people whose social interactions could be affected. Although change management is important during the introduction of any new or modified system, it is especially important for these systems to help ensure their acceptance, and minimize disruptions of group activities in the environment.

5.0 AREAS OF RIAS ERGONOMICS ADDRESSED BY STANDARDS

Standards for ergonomics already address many of the issues described in Section 3 and hazards described in Section 4, particularly those related to user interface, organisational issues and lifecycle processes. This section summarises how these standards can be used to address RIAS.

5.1 Principles of Ergonomics

ISO 26800:2011 *Ergonomics – General approach, principles and concepts.*

ISO 26800 describes the general ergonomics approach and specifies basic ergonomics principles and concepts applicable to the design and evaluation of tasks, jobs, products, tools, equipment, systems, organizations, services, facilities, and environments. The underlying principles of ergonomics remain the same, although the relative emphasis placed on them will vary. The principles and concepts described in this standard are fundamental to the design process wherever human involvement is expected, in order to ensure the optimum integration of human requirements and characteristics into a design.

There are a number of standards on ergonomics and human factors based on these principles and concepts which can be used by managers, engineers, and designers in selecting, designing, and managing systems and equipment to ensure that they are effective, efficient, and satisfying to use. These are outlined below.

ISO 27500:2016 *The human-centred organization – Rationale and general principles.*

This International Standard draws on that extensive body of ergonomics and human factors knowledge and presents the rationale and general principles of human-centredness in a concise form for *inter alia* executive board members. It explains the principles which characterize a human-centred organization. These

principles are as follows:

- Capitalize on individual differences as an organizational strength
- Make usability and accessibility strategic business objectives
- Adopt a total system approach
- Ensure health, safety, and well-being are business priorities
- Value employees and create a meaningful work environment
- Be open and trustworthy
- Act in socially responsible ways.

These provide a framework for organisational behaviour when RIAS are considered or implemented.

5.2 Human-Centred Design Process

ISO 9241-210:2010 *Human-centred design for interactive systems*.

ISO/FDIS 9241-220:2018 *Processes for enabling, executing and assessing human-centred design within organisations*.

ISO/TS 18152:2010 *Specification for the process assessment of human-system issues*.

Human-centred design is an approach to interactive systems development that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, and usability knowledge and techniques. This approach enhances effectiveness and efficiency, improves human well-being, user satisfaction, accessibility and sustainability; and counteracts possible adverse effects of use on human health, safety and performance.

ISO 9241-210 provides requirements and recommendations for human-centred design principles and activities throughout the life cycle of computer-based interactive systems. It is intended to be used by those managing design processes, and is concerned with ways in which both hardware and software components of interactive systems can enhance human–system interaction. The approach described complements existing systems design approaches. It can be incorporated in approaches as diverse as object-oriented, waterfall and rapid application development.

The principles and activities of a human-centred approach to design are elaborated in two human-centred design process models. 9241-220 describes the processes that ensure human-centred quality of interactive systems and 18152 describes the processes that address human-system issues in the engineering of systems. The processes in these standards go a lot further than the current norm in HCD practice (e.g. saying that HCD people must get involved early, defining the user requirements and then drive the system/technical/platform level requirements) and will apply to RIAS as much as to other types of system and any set of human-systems issues.

5.3 Interaction and Interface

ISO 9241-110:2006 *Dialogue principles*.

ISO 9241-112:2017 *Principles for the presentation of information*.

ISO 9241-13:1998 *User guidance*.

ISO 9241-129:2010 *Guidance on software individualisation*.

These parts of ISO 9241 set general design principles the ergonomic design of interactive systems and information presented without reference to situations of use, application, environment or technology. They

provide a framework for applying those principles to the analysis, design and evaluation of interactive systems. While they are applicable to all types of interactive systems, they do not cover the specifics of every context of use (e.g. safety critical systems, collaborative work). The principles are generally independent of any specific design style or application. Part 129 specifically addresses adaptive dialogues. Other parts address novel and multiple modalities.

A dialogue is the "*interaction between a user and an interactive system as a sequence of user actions (inputs) and system responses (outputs) in order to achieve a goal*", where user actions include not only entry of data but also navigational and other (control) actions of the user. Principles relating to dialogue and individualisation help prevent usability problems such as:

- Additional unnecessary steps not required as part of the task
- Misleading information
- Insufficient and poor information on the user interface
- Unexpected response of the interactive system
- Navigational limitations during use, and
- Inefficient error recovery.

Principles related to information and guidance provide a variety of benefits to users including improvements in speed, accuracy, mental effort, and user experience. They also help prevent users from experiencing usability problems with presented information. Examples of such problems include the following:

- Not detecting information despite it being present
- Other information distracting from information they are focusing on
- Not discriminating between pieces of information, since they appear to be identical
- Misinterpreting information, since the meaning of the information is ambiguous
- Expending unnecessary time in understanding information, since the information is presented is unnecessarily lengthy
- Unknown conventions leading to lack of understanding information.

5.4 Workspace and Workload

ISO 6385:2016 *Ergonomics principles in the design of work systems*.

ISO 9241-2:1992 *Guidance on task requirements*.

ISO 10075 *Ergonomic principles related to mental workload (Parts 1-3)*.

These standards provide ergonomic principles for the design of tasks, work and work systems intended to encourage balanced attention on human, social and technical requirements in a balanced manner during the design process.

"Work system" covers a large variety of working and leisure situations, including permanent and flexible work places. Work systems involve combinations of people and equipment, within a given space and environment, and the interactions between these components within an organization. Work systems vary in complexity and characteristics.

The principles specified in these standards support design of optimal working conditions with regard to task performance, workload, human well-being, safety and health; including the development of existing skills and the acquisition of new ones - while taking into account technological and economic effectiveness and

efficiency.

Technological, economic, organizational and human factors affect task performance, behaviour and well-being of people as part of a work system. Applying ergonomic knowledge in the light of practical experience in the design of a work system is intended to satisfy human requirements including changes to type and measurement of workload.

The systems approach in these standards assists in both existing and new situations, such as introduction of RIAS. Ergonomic evaluations of existing or new work systems will show the need for, and encourage attention to, workload and the role of the worker with/within those systems. Following the principles and requirements described in these standards will support management in making better decisions, for instance related to the sustainability of investments in RIAS and work system innovation.

5.5 Context and Environment

ISO 9241-11:2018 *Usability: Definitions and concepts*.

ISO 11064 *Ergonomic design of control centres (Parts 1-7).*

Standards from TC159/SC5 *Ergonomics of the thermal/physical environment*. For example, ISO TR 15742 *Determination of the combined effects of environmental components on people*; ISO/DTS 16418 *Mathematical model for predicting and evaluating the dynamic human physiological responses to the thermal environments*; ISO 28803 *Application of international standards to people with special requirements*.

ISO 9241-11 provides a framework for understanding the concept of usability and applying it to situations where people use interactive systems (including RIAS), and other types of systems (including built environments), and products (including industrial and consumer products) and services (including technical and personal services). Usability is a scalable, task-based measure of the degree to which users are enabled to achieve goals effectively, efficiently and with satisfaction, taking account of the context of use. 9241-11 explains how usability can be interpreted in terms of user performance and satisfaction, and emphasizes that usability is dependent on the context of use, the specific circumstances in which a system, product or service is used.

Control and control centres present an early and widespread application of RIAS. The overall strategy for dealing with user requirements in control centres is presented in ISO 11064-1. ISO 11064-2 provides guidance on the design and planning of the control room in relation to its supporting areas. Requirements for the layout of the control room are covered by ISO 11064-3. Ergonomic requirements, recommendations and guidelines for the design of workplaces in control centres are established in ISO 11064-4. Displays and controls, human computer interaction and the physical working environment are presented in ISO 11064-5 and ISO 11064-6. Evaluation principles are dealt with in ISO 11064-7.

Standards for modelling, measuring and assessing the impact of properties of the physical and thermal environment are defined by ISO TC159/SC5. As RIAS increase their presence in environments, in particular controlling dynamic integrated environments, personal capability, comfort and safety will increasingly depend on machine application of these standards and correct interpretation of the integrated effect of environmental factors.

6.0 CHANGES REQUIRED FOR ERGONOMICS TO BETTER ADDRESS RIAS TECHNOLOGY

Ergonomics involves the design and evaluation of the user interface and its context. The ergonomist develops and studies the concept of operations for a system, defines the tasks to be performed, and allocates

those tasks to the user, the machine, or some combination of user and machine. The physical presentation and layout of controls, the content and format of information displayed to the user, and the physical workspace are of interest to the ergonomist.

The toolbox of principles and techniques applied by the ergonomist to develop user interfaces in a system has evolved to support systems that function according to inputs provided by the user in context with engineered models of the environment in which the system is to be operating. Automation runs on such models, often following scripted logic for performing tasks the user would have otherwise had to perform.

The toolbox of principles and techniques applied by the ergonomist will need to be modified to address the unique interaction challenges autonomy presents. As automation extends to become more autonomous, dynamic, probabilistic behaviours that are more adaptive to the operational needs of a system, merely concerning ourselves with the design and layout of control panels will be insufficient to define the user interaction with the system. That is we need to use human-centred design approaches that are consistent and linked to the wider systems engineering and design processes for RIAS (HF requirements identification, architecting, modelling, design, human in the loop test and acceptance processes etc.). Integration with engineering, management and design are already addressed in ISO TS 18152 and ISO 9241-220.

With advanced autonomy that functions like another person or team of people might when performing the same task, collaborative awareness and crew resource management are examples of constructs and techniques from teaming and supervisory command and control that may apply. Likewise, abnormal situation management may also provide relevant guidance.

Like the use of stereotypes and affordances, biases in social expectations and social contracts of a specific user population will be essential for the developers of autonomy to consider and control for in their designs. This may be as simple as ensuring the proper use of turn signals in an auto-driving car, or as complex as deciding the level of medical care to be given to an elder.

These are just a few examples of areas of interest that may be important to the ergonomist dealing with RIAS analysis and design. Our consideration of issues, principles, and techniques that may be relevant to ergonomists dealing with the development of autonomy needs to include that middle ground between what we know about how to design effective interfaces between people and automatic systems, and the industrial and social psychology of teaming and supervisory command and control. Other domains like sociology and anthropology might have principles and techniques that could prove useful to ergonomists dealing with autonomy, as could computer science.

The areas in which Ergonomics will need to develop are listed below:

- Social aspects of RIAS and effects on society:
  - Highly social interaction
  - Cultural ergonomics
  - ISO personality dimensions for RIAS
  - Organisational psychology/ergonomics
  - Management of emergent behaviour.
- Human State Measurement and models:
  - Human State Measurement
  - Human Models

- General models of humans
- Models of specific users/user groups.

- Human machine teaming
  - Who is the user?
  - Dynamic function allocation between humans, machines
  - Dynamic Goal Setting
  - Dynamic task allocation between human team members
  - Dynamic task allocation between humans and machines
  - Dynamic task allocation between machines
  - Transparent interaction and transparent users
  - Knowledge acquisition/management
  - Small data *vs* big data – learning / evolving systems vs models.
- Guidance and RIAS:
  - Transparent systems
  - Automated education
  - Training users of RIAS systems
  - Design of systems for zero training.
- Principles for RIAS ergonomics.

7.0 DISCUSSION AND CONCLUSIONS

7.1 Human Autonomy Teaming in this context

Table 1 assigns Symposium presentations to the RIAS human-system issue categories. The purpose is to illustrate the categories using the terminology and concepts of human autonomy teaming.

This distribution is not surprising, being close to that seen in the source literature studied in our analysis. The focus of ergonomics seems to be on the things that we can address in a physical and engineering context, and to dabble a bit with regard to organisation and teaming, but the vast body of social science is not applied by ergonomists. The analysis of human-system issues and consequential risks reported above indicates that this approach will not suffice for RIAS. Examples include: requiring workers to collaborate with robots in the workplace, or development of collaborative robots; the changes to pedestrian behaviour and transport infrastructure required by self-driving cars; changes in the construction of personal privacy and security brought about by the internet; changes in human behaviour with increasing ambient intelligence.

Table 1: Symposium papers by RIAS issue category.

Issue category	Symposium paper number
1. RIAS designed characteristics effects on individual humans	2, 4, 10, 11, 12
2. Human-RIAS interaction issues (individual/teams interacting directly with RIAS)	1, 3, 5, 6, 7, 8, 9, 13, 16, 23, W2

Issue category	Symposium paper number
3. RIAS to RIAS issues	21
4. RIAS – organisational issues	K1, W1, W3
5. Social/cultural/ethical issues	14, 15, 20, 22
6. Emergent societal issues	

7.2 Conclusions

This paper has described the scope and methodology employed by ISO TC159/SC4 Working Group 6 to identify established, emerging, and potential human-system issues with the introduction and use of RIAS technologies. Summaries of the categories of these issues, and benefits and hazards for use and users associated with systems that have RIAS characteristics were also described. An alignment of these categories to this symposium's papers was presented to demonstrate the broad and deep relevance of the issues to the wider community of practitioners and researchers. Likewise, existing ISO standards that may address the RIAS ergonomics issues were identified.

Working Group 6 has identified a number of issues and categories of issues that will likely require that HFE and the greater HSI community extend the principles and techniques they have become comfortable with if the study and practice of ergonomics is to remain relevant for future RIAS technologies. To name a few, methodologies in social and organizational psychology, sociology, anthropology, and computer science may prove useful in defining the interaction requirements for RIAS' connected, complex, probabilistic, social, and human augmentation characteristics across the international stage.

Next steps for Working Group 6 include exploring the degree to which existing ISO standards address the issues, and how the standards may need to be updated or new standards defined. The characteristics and ramifications of an ISO standard personality for RIAS will continue to be explored. Publication of a technical report detailing the group's findings will then follow. Wide dissemination of the findings is required to notify the existence of human-systems issues in relation to RIAS, and to demonstrate the existence of available solutions. At the same time the Ergonomics community have to be persuaded of the need to extend the scope of practice to address a new scope of interaction.

8.0 ACKNOWLEDGEMENTS

Standards are team efforts, but traditionally anonymous. The contributions of the 9241-810 project team within ISO TC159/SC4/WG6, and the new members and liaisons that joined for this work are gratefully appreciated.

The authors thank their respective organisations for their support in ISO work. This paper presents the personal opinions of the authors and not those of their respective organisations or of ISO as an organisation. This document is not an ISO International Standard. It is made available for review and comment. It is subject to change without notice and may not be referred to as an International Standard.

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Section 2 outlines the information meta-analysis applied during the study and why references are not cited. A bibliography of key documents and other information items is provided instead for interested parties.

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