

# Human-System Interaction Design Requirements to Improve Machinery and Systems Safety

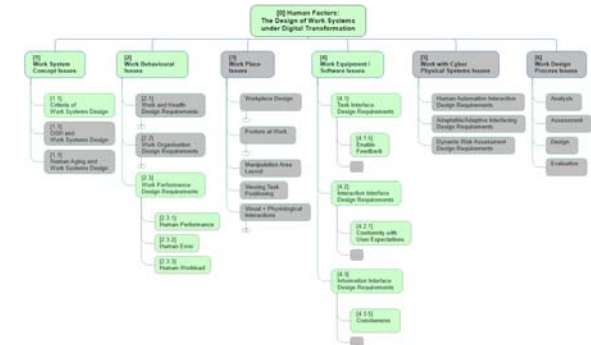
Peter Nickel, Peter Bärenz, Siegfried Radandt,  
Michael Wichtl, Urs Kaufmann, Luigi Monica,  
Hans-Jürgen Bischoff, Manobhram Nellutla



6th International Conference on Safety Management and Human Factors at AHFE 2019,  
July 24-28, 2019, Washington D.C., USA

# Agenda

- ISSA Section Machine and System Safety
- The Design of Work Systems
- Design Issues in Human-System-Interaction
  - Work behavioural issues
  - Work place issues
  - Work equipment/software issues
  - Work with cyber physical system issues
- Conclusions



## **ISSA Section Machine and System Safety**

### **■ Improve OSH Worldwide**

- Risk assessment and risk management at workplaces with machines and systems
- Guidelines for machinery safety in the EU


### **■ Project Groups**

- Control devices
- Explosion protection
- Stop defeating protective devices
- Human Factors, Ergonomics and Safe Machines  
[Human Factors]

### **■ Human Factors, Ergonomics, Safe Machines**

- Support manufacturers, designers and users (employers) of machinery
- HF/E design requirements and good practice in human-system-interaction
- Improve machine operator health, safety and security in analogue and digital environments

# ISSA Section Machine and System Safety



INTERNATIONAL SOCIAL SECURITY ASSOCIATION  
 ASSOCIATION INTERNATIONALE DE LA SÉCURITÉ SOCIALE  
 ASOCIACIÓN INTERNACIONAL DE LA SEGURIDAD SOCIAL  
 INTERNATIONALE VEREINIGUNG FÜR SOZIALE SICHERHEIT

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[www.issa.int/prevention-machines](http://www.issa.int/prevention-machines)

Section on Machine and System Safety




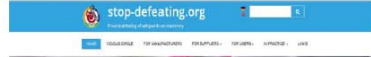

## ISSA-Section Machine and System Safety Activities and Projects

The Section is committed to improving safety and health at work in the field of machine and system safety worldwide.


- Core fields
  - Risk assessment and risk management at the workplace when using machines and systems
  - Guideline for machine safety in Europe (only in German) Summary in English and German

Project groups: in a specific but also integrative approach.

- “Control Devices”
  - Detect and consider developments in the field of control devices at an early stage concerning security of machines
  - Participate in the international standardization process
  - Present expert know how practice-oriented in => seminars => publications (safety flyers)
- “Explosion Protection”
  - Dust explosions in mills (1<sup>st</sup> example)
  - Using a modular approach
  - Modules: product acceptance, storage/ensilage, grinding/crushing, cleaning of the product, drying, packaging
  - Collecting examples
  - Taking into account sensor technology
- “Stop defeating of protective devices on machines”

International Section of the ISSA on Machine and System Safety  
 Comité international de l'AISS pour la sécurité des machines et systèmes  
 Comité Internacional de la AISS para la Seguridad de Máquinas y Sistemas  
 Internationale Sektion der IVSS für Maschinen- und Systemsicherheit



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Section on Machine and System Safety

- 5 important steps each for manufacturers, dealers, users
- Practical examples
- How does digital manufacturing influence safety + security of protective devices?

- “Human factor, ergonomics and safe machines”
  - Tasks and requirements from engineering for safe machines and healthy users
  - 1<sup>st</sup> part: ergonomic requirements for design of an ergonomic workplace with displays and control actuators
  - Next parts:
    - Software ergonomics
    - Work psychology – engineering psychology
    - Technological developments towards cyber physical systems (tasks and functions in process chain, machine (user) interface)
- “Digital Manufacturing”
  - Each individual element of the system Man - Machine - Environment may be the cause of system failure and thus lead to risks.
    - Digitization: chances + risks for safety and security, health at work
    - Classical risk assessment be extended => cyber risks
    - Develop practical examples from industry
    - Training for engineers, employees, prevention and IT-experts

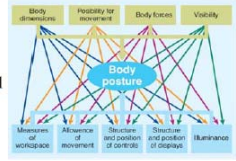




Photo: [www.issa.int](http://www.issa.int)

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Further information:  
<http://www.issa.int/de/web/prevention-machines/about>

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# ISSA Section Machine and System Safety



The screenshot shows the website's header with the ISSA logo and the title 'ISSA Section Machine and System Safety'. A navigation menu includes: Home, About us, Control Devices, Digital Manufacturing, Explosion Protection, Human Factors, Stop Defeating, Membership, and Useful Links. Below the menu are two columns: 'News' featuring a 'Welcome' article with a photo of a man at a presentation, and 'Events' featuring the 'Forum Prävention' event from May 20-23, 2019 in Vienna, Austria. A 'Project Groups' section follows, containing six cards: 'Control Devices', 'Digital Manufacturing', 'Explosion Protection', 'Human factors, ergonomics and safe machines', 'Stop defeating of safeguards on machinery', and 'General information'. Each card includes an icon, a brief description, and a 'Learn more' link. At the bottom of the website, the text 'Prevention. International.' is visible.

[www.safe-machines-at-work.org](http://www.safe-machines-at-work.org)

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- Support manufacturers, designers and users (employers) of machinery
- HF/E design requirements and good practice in human-system-interaction
- Improve machine operator health, safety and security in analogue and digital environments
- Internet platform on HF/E and OSH (selective, simple, suitable)

# ISSA Section Machine and System Safety

ISSA Section **Machine and System Safety**



## HUMAN FACTORS, ERGONOMICS AND SAFE MACHINES

[Home](#) | [About us](#) | [Control Devices](#) | [Digital Manufacturing](#) | [Explosion Protection](#) | **[Human Factors](#)** | [Stop Defeating](#) | [Membership](#) | [Useful Links](#)

[Home](#) | [Human Factors](#)

### Contact

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### News



### Welcome

Welcome to the new website of our ISSA-Section Machine and System Safety! Our aim is to improve safety and health at work in the field of machine and...

[Read more](#)  
27/07/2019



### Activities Human factors, ergonomics and safe machines

The working group reviews, selects, and presents design requirements and recommendations according to Occupational Safety and Health (OSHA) standards for Human Factors and Ergonomics. This is to inform about how to integrate Human Factors and Ergonomics into the design process of machines, construction, in workplace and equipment design and in human-system interaction.

Human Factors and Ergonomics in Occupational Safety and Health (OSHA) standards for Human Factors and Ergonomics. This is to inform about how to integrate Human Factors and Ergonomics into the design process of machines, construction, in workplace and equipment design and in human-system interaction as well as to optimise human workload, which in turn will contribute to the safety of the system.

With some future work systems remaining unchanged, others in the context of digital manufacturing may develop into new systems. For Human Factors

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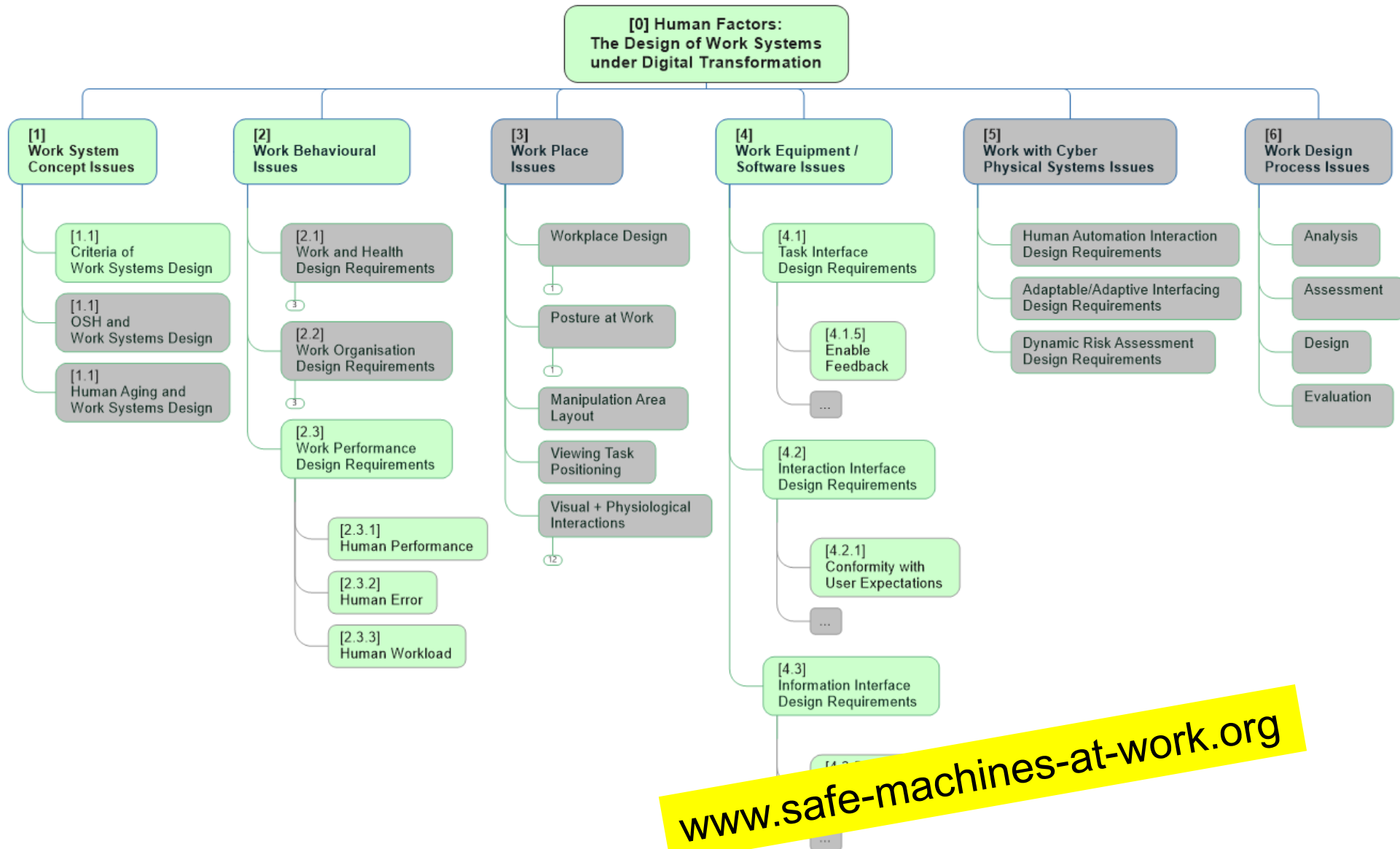
## ■ Conclusions

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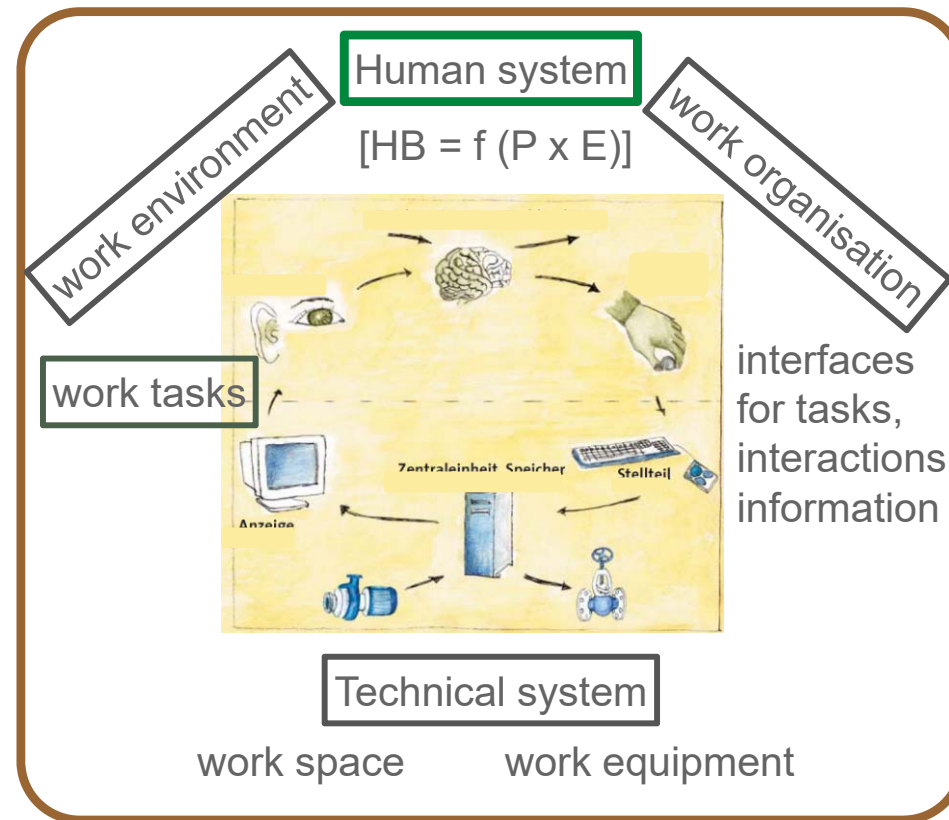
# ISSA Section Machine and System Safety – HF Structure



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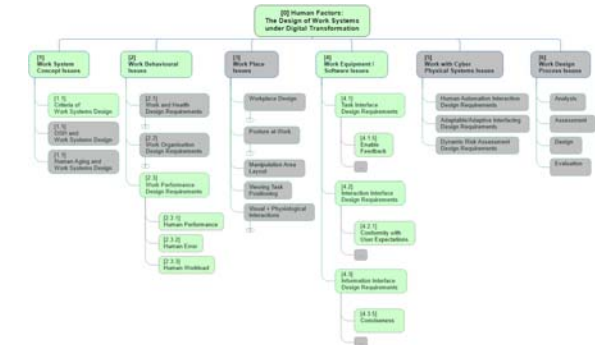
# The Design of Work Systems – The Concept

## Human-System Interaction



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(requirements for work and health, organisation, performance)
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(requirements for design, posture, layout etc.)
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(requirements for task, interaction and information interfaces)
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## Work Behavioural Issues – Human Workload

### ■ Definition

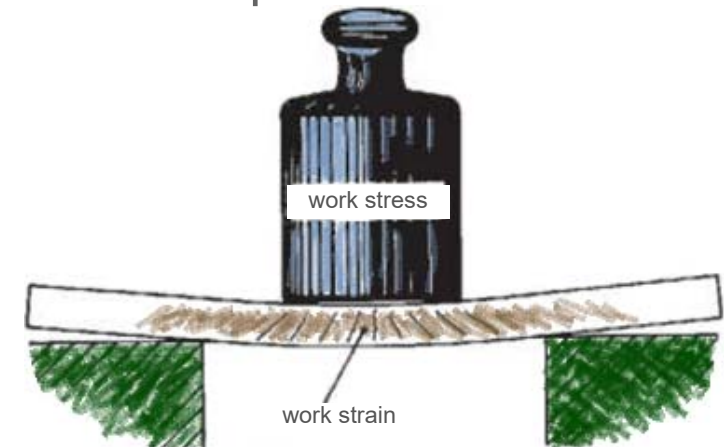
- Physical and mental stress is the total of all influences having an effect on a human being. Influences should be assessable from external sources and may affect physically or mentally.
- Physical and mental strain is the immediate effect of stress within the individual; moderated by their current condition.

### ■ Explanation

- Work stress and strain are crucial for assessments of work systems design quality. Multidimensional measurement and differentiation with regard to type, level and dynamics of work stress may be required.

### ■ Example

- Work stress (physical and mental) is synonymously used with the term external workload. The figure illustrates the stress-strain relationship.



### ■ References

- EN ISO 10075-1:2017. Ergonomic principles related to mental workload - Part 1. CEN.
- Hacker (1998). Mental workload. ILO Encyclopaedia of OSH.



# Work Behavioural Issues – Human Workload

## Human Workload

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Physical and mental stress is the total of all assessable influences impinging upon a human being from external sources and affecting that person physically and mentally.

Physical and mental strain is the immediate effect of physical and mental stress within the individual; with their current condition potentially having a moderating effect.

Work stress and work strain are crucial for assessments of work systems design quality. Multidimensional measurement and differentiation with regard to type, level and dynamics of work stress may be required.

Work stress (physical and mental) is synonymously used with the term external workload. The figure illustrates the stress-strain relationship.

### References:

- EN ISO 10075-1:2017. Ergonomic principles related to mental workload - Part 1: General issues and concepts, terms and definitions. Brussels: CEN
- Hacker (2011). Mental workload. In: Stellmann, J.M. (ed.) ILO Encyclopaedia of Occupational Health and Safety (vol. 1, 29.41-43). International Labour Office (ILO), Geneva.



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## Work Place Issues – Field of Vision

### ■ Definition

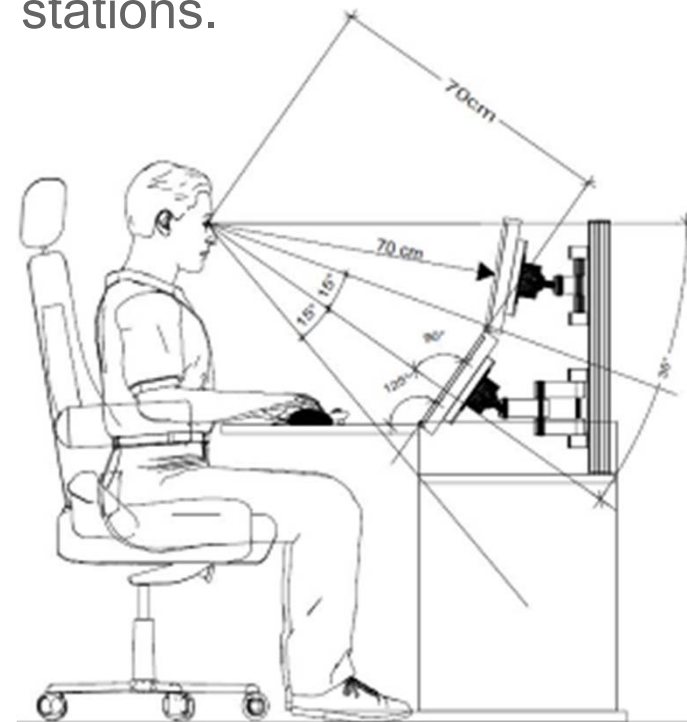
- Field of vision or line of sight is the location for displays and controls during task performance.

### ■ Explanation

- Displays and hand control actuators shall be placed at comfortable levels below the line of sight in order to reduce fatigue and to maintain high level of task performance (e.g. when operating machines).

### ■ Example

- Field of vision at sitting work stations.



### ■ References

- EN 894 Series (ISO 9355 Series): Safety of machinery – Ergonomics requirements for the design of displays and control actuators – Parts 1-4. CEN, Brussels (2010).

# Agenda

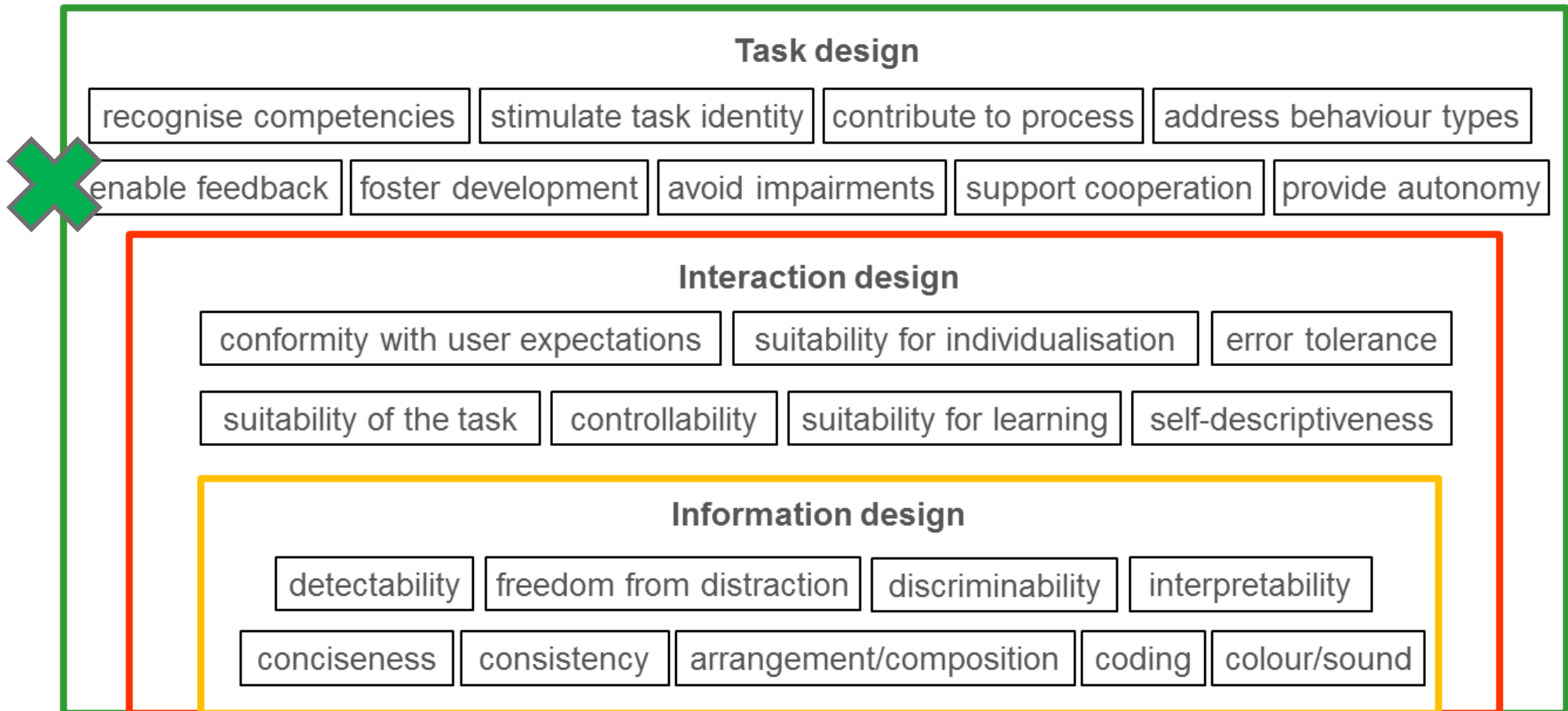
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# Work Equipment Issues – Interface Design Hierarchy



## Work Equipment Issues – Task Interface Design

### ■ Definition

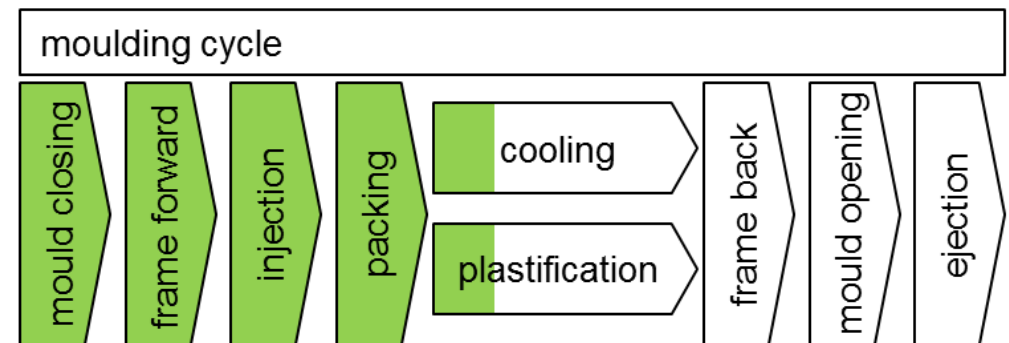
- Machinery should inform operator about operations available and provide feedback about operations currently applied in the work process.
- Operator decides whether systems task goals have been achieved and whether adjustments are required.

### ■ Explanation

- Operators require feedback about their own and the systems task to maintain job control, to coordinate interactions and to optimise workload.

### ■ Example

- Batch procedure of an injection moulding machine provides visual feedback to an operator about the production process.



### ■ References

- EN 614-2 Safety of Machinery – Ergonomic design principles – Part 2 – Task design. CEN.
- Kantowitz & Sorkin (1983). Human factors: Understanding people-system relationship.

# Work Equipment Issues – Task Interface Design

## Task Interface Design Requirements – Enable Feedback

Among the task interface design requirements "Enable Feedback" is important to allow the operator to perform his/her task.

Machinery should inform operator about operations available and provide feedback about operations currently applied in the work process.

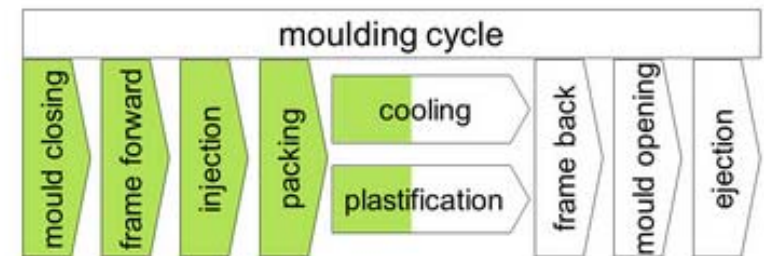
Operator decides whether systems task goals have been achieved and whether adjustments are required.

Operators require feedback about their own and the systems task to maintain job control, to coordinate interactions and to optimise workload.

Figure shows batch procedure of injection moulding machine that provides visual feedback to operator about production process.

### References:

- EN 614-2:2008. Safety of Machinery – Ergonomic design principles – Part 2: Interactions between the design of machinery and work tasks – Task design. Brussels: CEN
- Kantowitz, B.H., Sorkin, R.D. (1983). Human factors: Understanding people-system relationships. Wiley, New York.
- Wickens, C.D., Hollands, J.G., Banbury, S., Parasuraman, R. (2013). Engineering Psychology and Human Performance. Pearson, Upper Saddle River.



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# Cyber Physical Systems Issues – Adaptable Dynamics

## ■ Definition

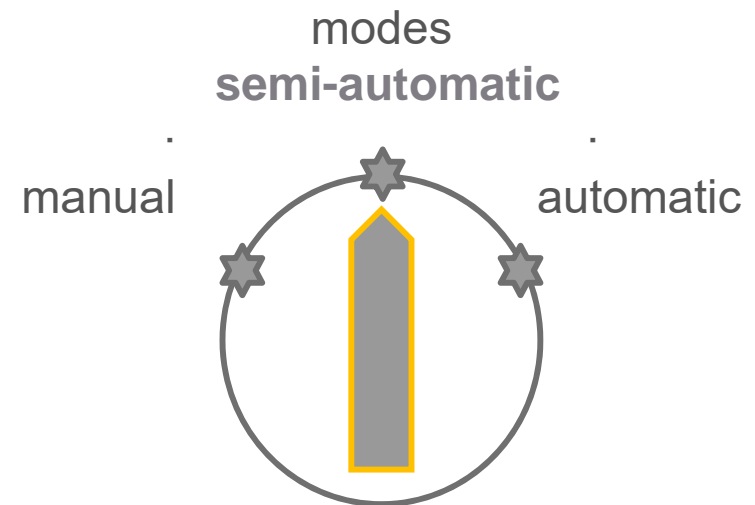
- Function allocation is dynamic when (various) functions (to different degrees) can flexibly be allocated to humans and to machines.
- Adaptable and adaptive automation provide solutions for interaction challenges.

## ■ Explanation

- Technology-centred design leads to unintended uses.
- changes and errors in automation are difficult to identify and impossible to compensate for by operators, due to high automation and insufficient information.

## ■ Example

- Adaptable automation mode switching keeps human operator in the loop.



## ■ References

- EN 614-2 Safety of Machinery – Ergonomic design principles – Part 2: Interactions between the design of machinery and work tasks – Task design. Brussels: CEN.
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## Conclusions

### ■ Internet platform available

- [www.safe-machines-at-work.org](http://www.safe-machines-at-work.org)

### ■ Organisational issues

- add information
- design, structure and layout
- editorial office

### ■ Invitation to participate

- by reading
- by comments
- as a member of the ISSA MSS

### ■ Contact and information

- [scholl@ivss.org](mailto:scholl@ivss.org)



The screenshot shows the ISSA website interface. The header includes the ISSA logo and navigation links: Contact, Sitemap, Search. The main banner features an illustration of a worker in a blue uniform and orange hard hat operating a machine, with the text 'HUMAN FACTOR, ERGONOMICS AND SAFE MACHINES'. Below the banner is a navigation menu with items: Home, About us, Control Devices, Digital Manufacturing, Explosion Protection, Human Factors (highlighted), Stop Defeating, Membership, Useful Links. The main content area displays a breadcrumb trail: Home | Human Factors | Design of Work Systems under Digital Transformation | Work Equipment Issues. A sidebar on the left lists sub-topics under 'Design of Work Systems under Digital Transformation': Work System Concept Issues, Work Behavioural Issues, Work Equipment Issues, Task Interface Design, Interaction Interface Design, and Information Interface Design. The main content area is titled 'Work Equipment and Software Issues' and contains introductory text and sub-sections for 'Task interface design' and 'Interaction interface design'. A large yellow banner at the bottom of the screenshot reads 'www.safe-machines-at-work.org'.