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A Safety Readiness Tool to increase awareness and knowledge of collaborative robot safety.

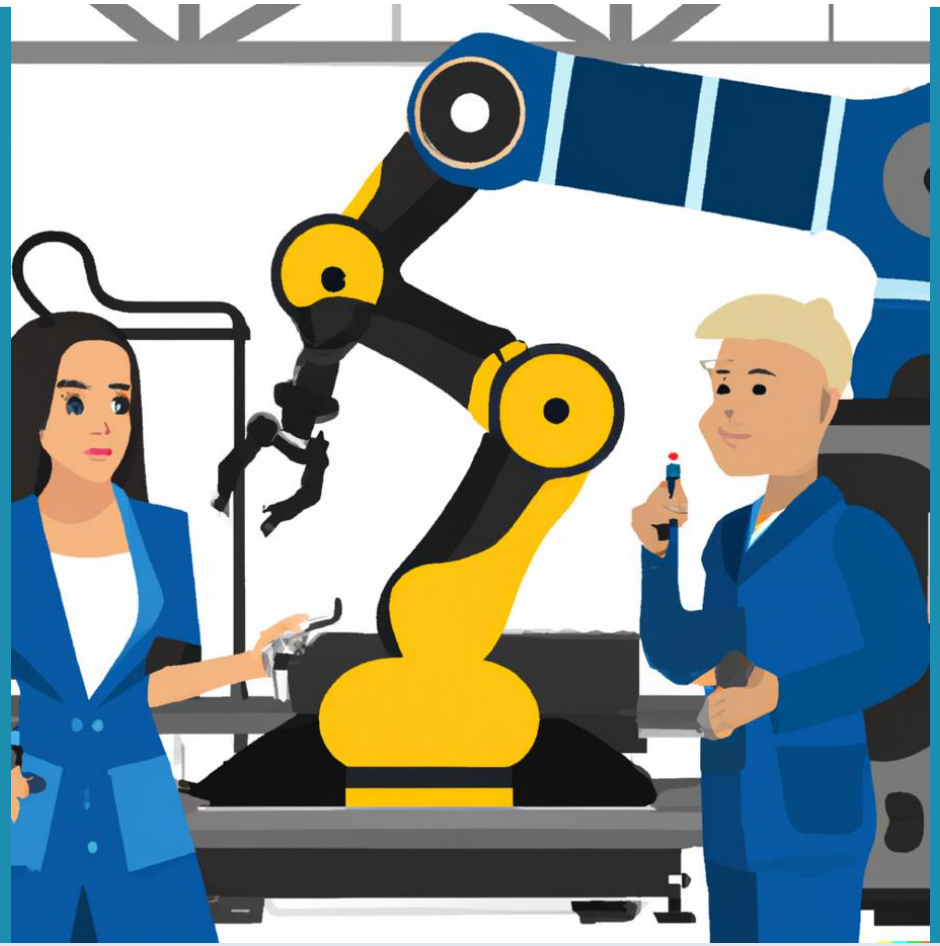

Photo credit DALL-E generated picture Aug22

Prepared for EFNMS

April, 2023

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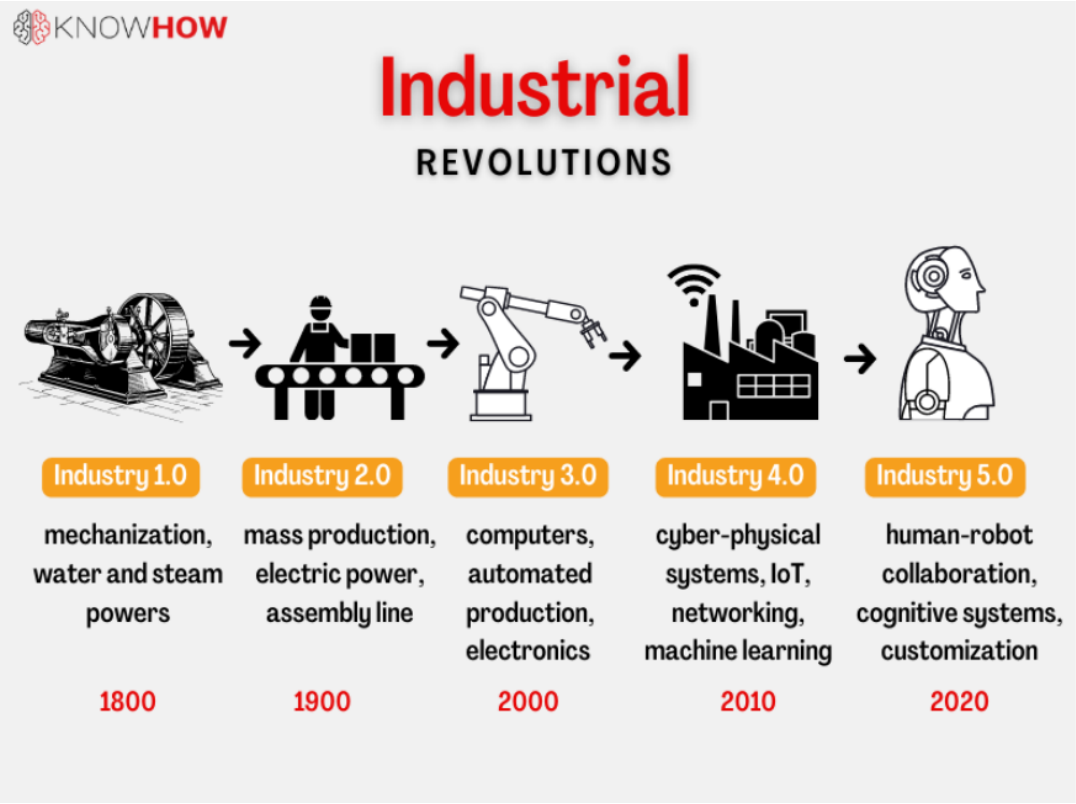
Human-centricity at the heart of Industry 5.0

Human-robot collaboration, a key technology of Industry 5.0



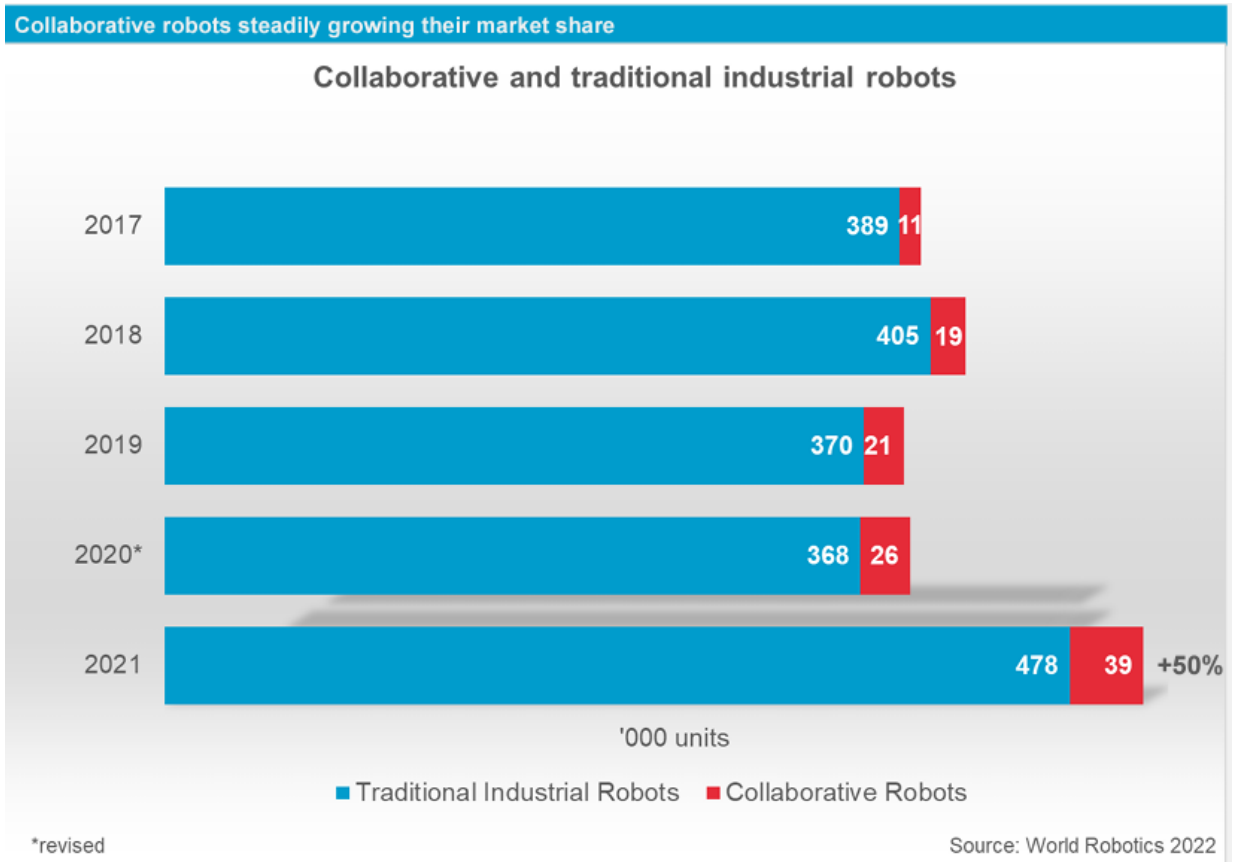
The EU vision of Industry 5.0*

"*Industry 5.0 provides a vision of industry that aims **beyond efficiency and productivity** as the sole goals, and reinforces the role and the contribution of industry to society.*"

"*It places the **wellbeing of the worker at the centre** of the production process and **uses new technologies to provide prosperity** beyond jobs and growth while respecting the production limits of the planet.*".

*https://op.europa.eu/en/publication-detail/-/publication/aed3280d-70fe-11eb-9ac9-01aa75ed71a1
https://www.forbes.com/sites/jeroenkraaijenbrink/2022/05/24/what-is-industry-50-and-how-it-will-radically-change-your-business-strategy/

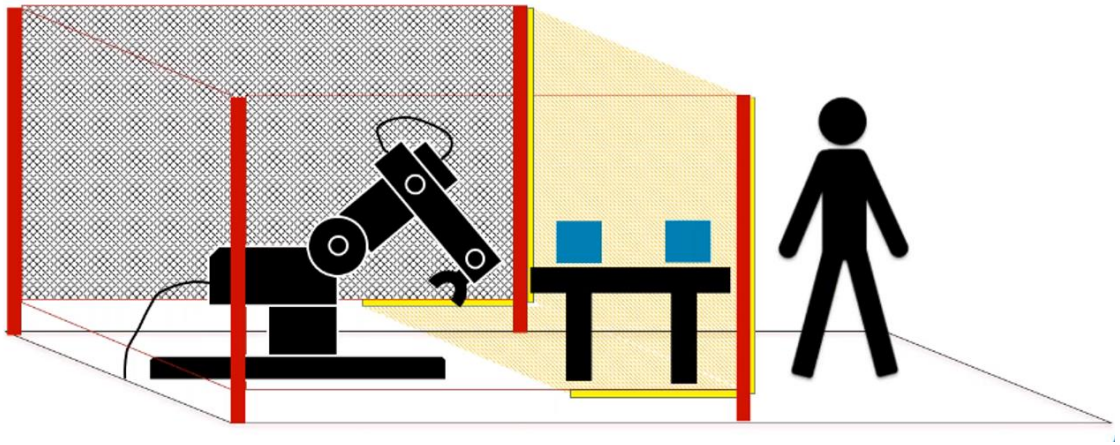
Despite their many advantages, cobots only represent 7,5 % of all robot installations.



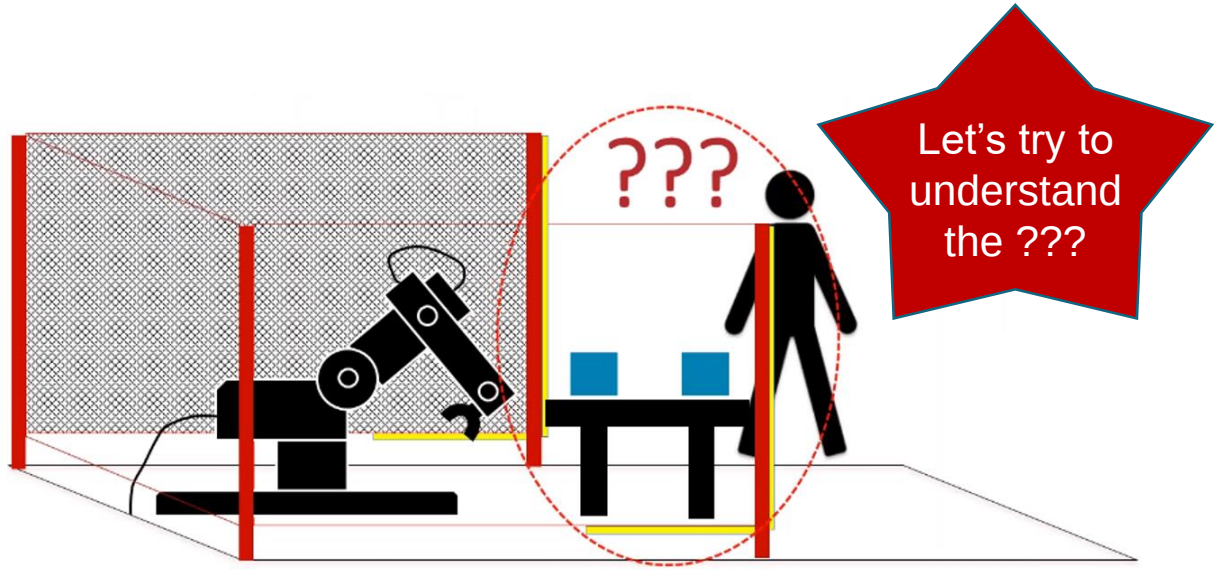
Cobots grow with 50% vs ly
Represent 7,5 % of total robot installations

Cobots are used differently than robots

Robot
Shielded from humans



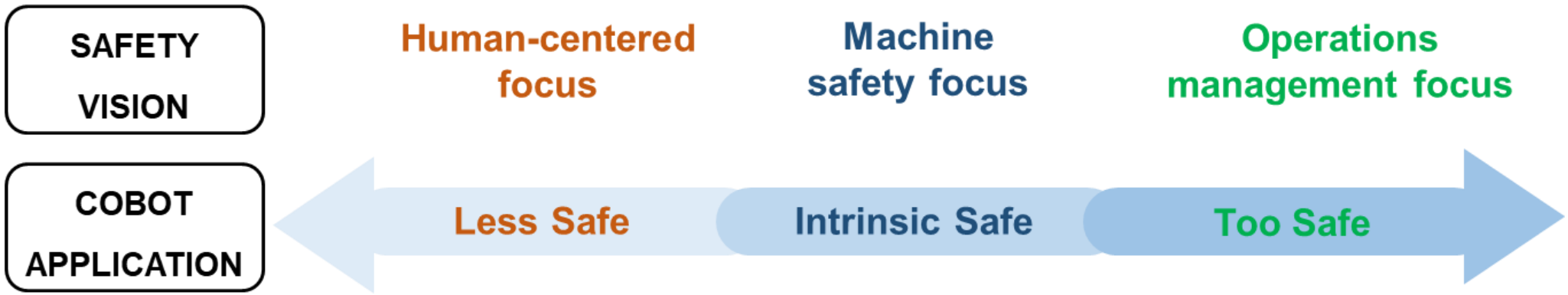
Cobot
Shares workspace, can move around



A safe cobot does not imply a safe application

1. C. Franklin, 2021. Cobot Safety. Presentation for The Association for Advancing Automation.
2. Toshiba Machine Industrial Robots, 2020. The Global Robotics Report. *tmrobotics.com.*

Confusing signals depending on safety vision



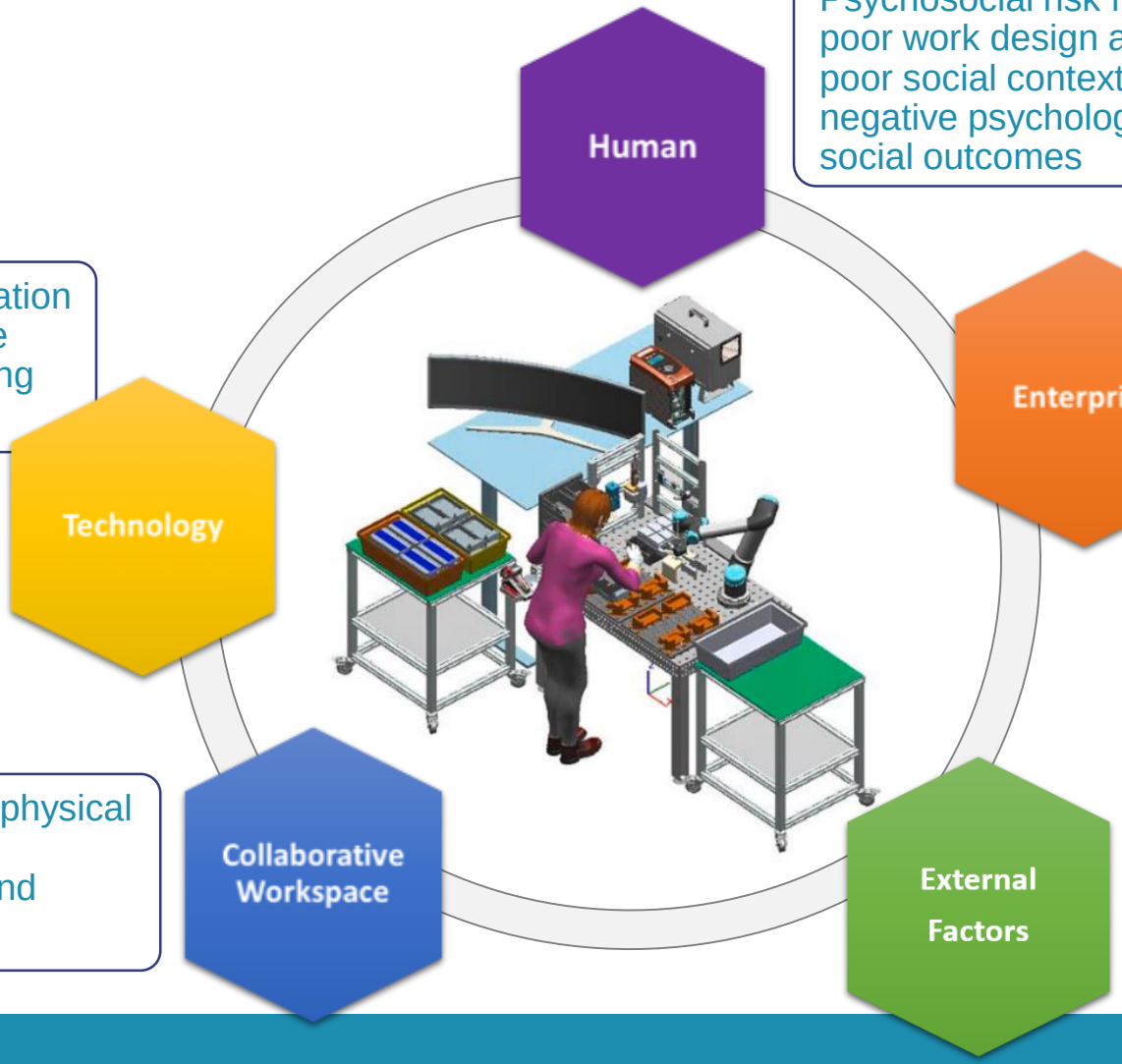
Adapted from The cobot safety tension scale *

* Examining the Role of Safety in the Low Adoption Rate of Collaborative Robots, 2022. Berx N., Decré W., Pintelon L.

New risks, beyond technological, emerge from a system-wide perspective

Psychosocial risk factors arising from poor work design and organization or poor social context of work, resulting in negative psychological, physical, and social outcomes

Risk factors related to information technology and the enterprise automation system overarching the cobot.



Risk factors related to organizational structures, policies, and processes of the enterprise..

Risk factors related to the physical and spatial design of the collaborative workspace and maintenance.

Risk factors outside of the organization and not directly influenceable by the organization or the human operator

N. Berx, et al., 2022. Identification and classification of risk factors for human-robot collaboration from a system-wide perspective. *Computers & Industrial Engineering*.

A system-wide perspective on cobot safety: 5 dimensions and 23 risk factors

7. Trust
8. Work stress
9. Physical workload
10. Cognitive workload

1. Operating System Security
2. Operating System Data management
3. Cobot Hardware
4. Tooling
5. Cobot Control Software
6. Application-specific hazards

15. Training
16. Work design
17. Social acceptance
18. Privacy
19. AI decision making
20. Safety strategy
21. Technology and digitization strategy

11. Access and clearance
12. Layout
13. Hazardous obstacles
14. Maintenance

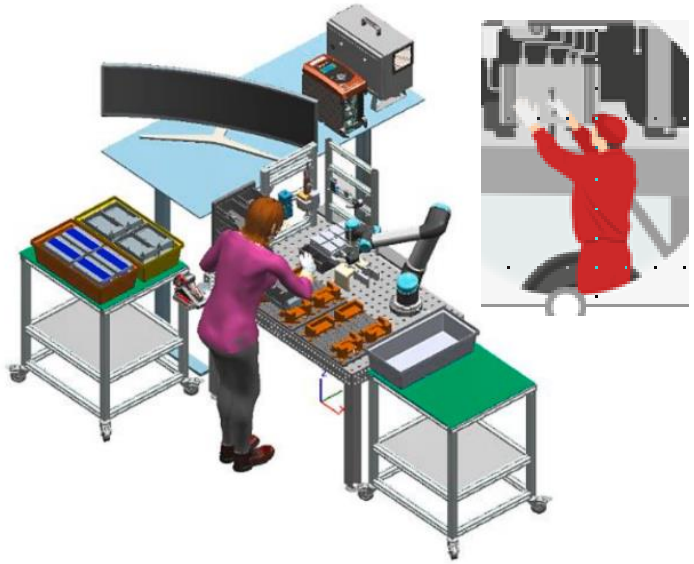
22. Regulatory
23. Environmental conditions

N. Berx, et al., 2022. Identification and classification of risk factors for human-robot collaboration from a system-wide perspective. *Computers & Industrial Engineering*.

Maintenance is an important cobot safety risk factors

Think about:

- Cobot maintenance: are the necessary safety measures known by the maintenance staff, and are they sufficiently trained?
- Are employees servicing other equipment in the collaborative workspace familiar with the safety precautions?
- Safety officers are not necessarily familiar with cobot (maintenance) safety.

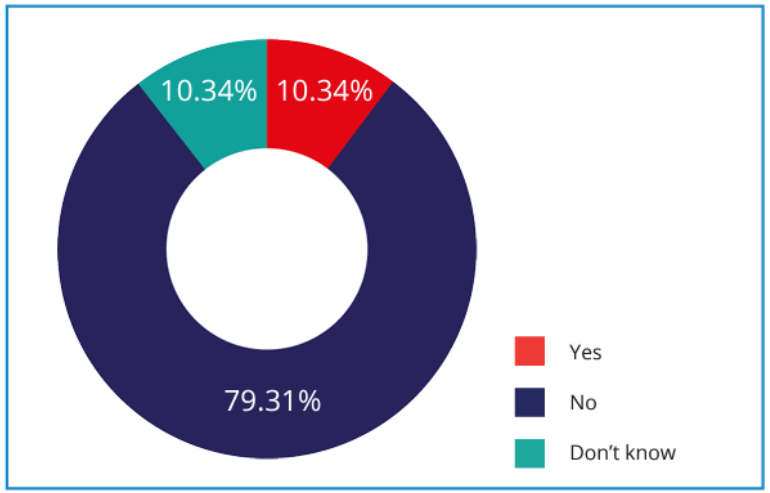


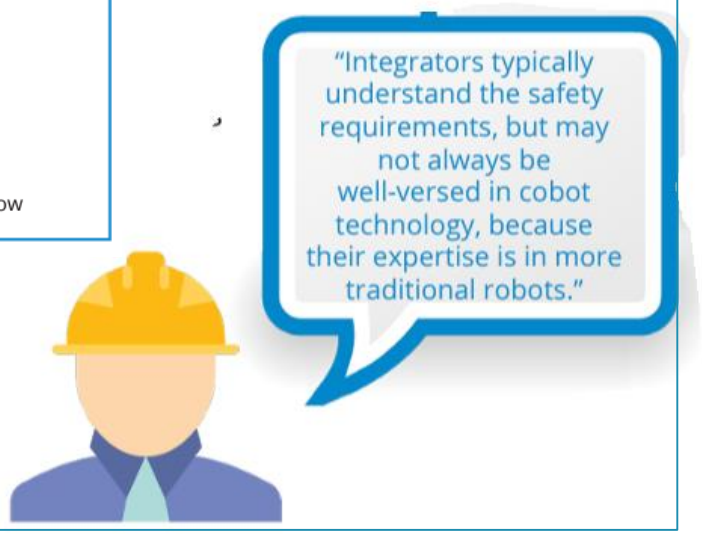
N. Berx, et al., 2022. Identification and classification of risk factors for human-robot collaboration from a system-wide perspective. *Computers & Industrial Engineering*.

Lack of (safety) knowledge is a hurdle

Toshiba Machine Industrial Robotics Distributor survey 2020

Do you feel that your customers fully understand the safety requirements of installing a CoBot?





Despite significant capital commitments, many companies are struggling to translate their intentions for robotics and automation into actions, with challenges related to knowledge and return on investment being particularly difficult hurdles.

McKinsey Global Industrial Robotics Survey,
(65 Senior executives, August 2022)

"*This study has identified **five main challenges**. Their prioritization are **related to the introduction of cobots in manufacturing SMEs**: **1. Safety** 2. Performance 3. Strategy 4. Involvement & training 5. Smart technology."*
(Schnell & Holm, 2022)

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CONCLUSION

There is a need for a Cobot Safety Readiness Tool

to increase the awareness and knowledge of cobot safety risk factors

Context

HRC is a driver for innovation and economic growth within I4.0 & I5.0

Industrial Collaborative Robots (Cobots) are used differently from conventional robots

The adoption rate of cobots is still below expectations

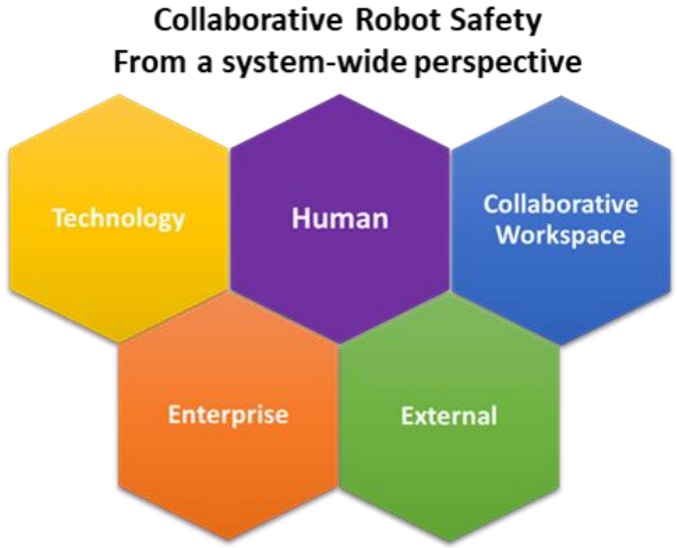
Challenges

The ‘inherently safe’ label for cobots can create a deceptive sense of safety:

- The application, not just the robot needs to be safe
- Safety is mainly approached from a technical perspective, while non-technical factors also influence safety in HRC

Lack of cobot (safety) knowledge and a different perception amongst stakeholders

How ‘Safety-Ready’ are you for collaborative robots?



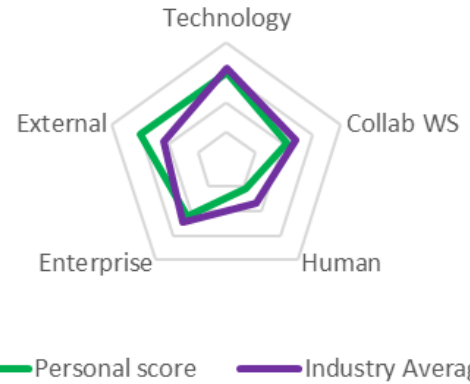
DO THE TEST!

https://kuleuven.eu.qualtrics.com/jfe/form/SV_54GdJUBIgol5NG

Take the test and receive a results report: readiness score

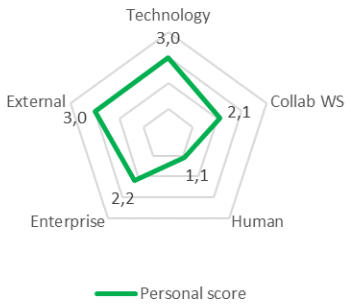
Your overall Cobot Safety Readiness score is
Elementary with a score of 2,28/4

Comparison personal and Industry score per dimension



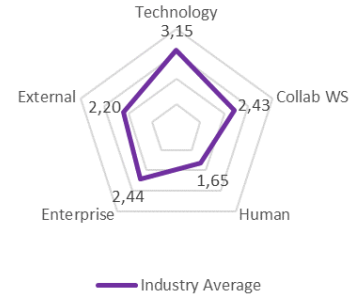
Illustration

Cobot Safety Readiness Score per Dimension
Personal Average



Level 1 Uninformed
Level 2 Elementary
Level 3 Basic
Level 4 Advanced

Cobot Safety Readiness Score per Dimension
Industry Overall Average (N=10)



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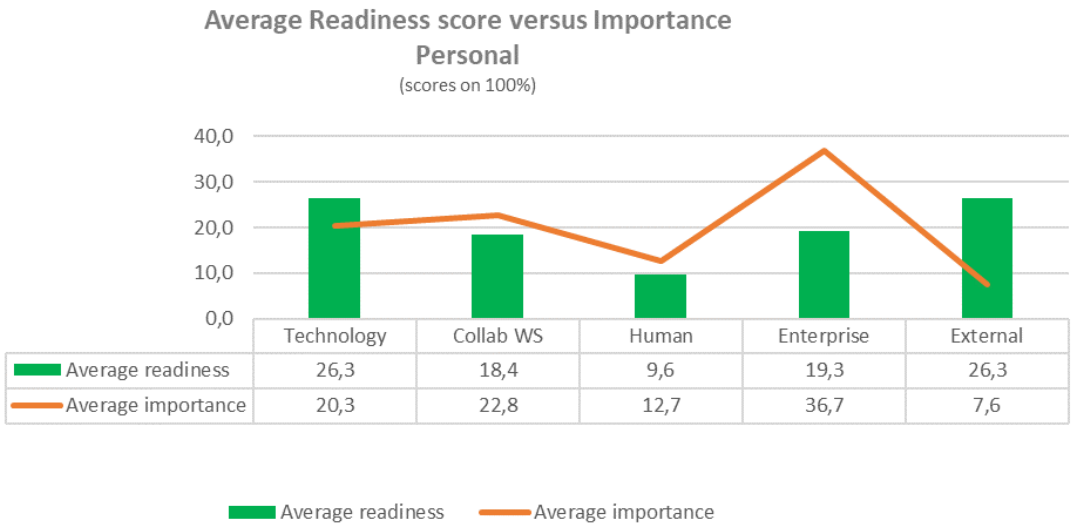
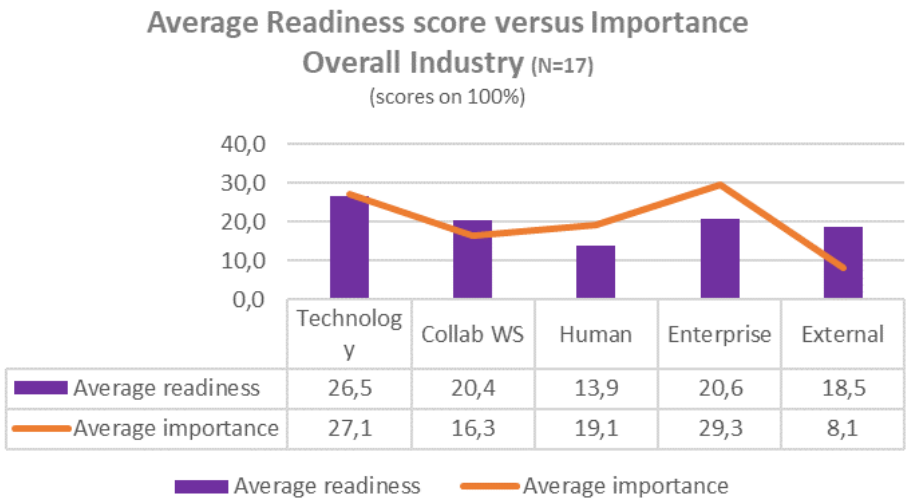
Take the test and receive a results report: Importance weighting

Illustration

You judge the **Enterprise and Human** dimension higher in importance than in readiness





Annex
Risk factors explained

The risk factors in the Technology dimension are related to information technology and the enterprise automation system overarching the cobot.

Operating System Security

Failing operating security can have safety repercussions.
Example: when hackers gain system control.

Data management

The risk associated with data input problems or insufficient (cloud) data storage.
Example: limited real-time data capturing and processing capability can impact the reaction speed of the cobot.

Cobot Hardware

The risk caused by a hardware failure.
Example: a hardware failure makes a cobot drop what it is carrying or a sensor failure causes the cobot to change its path unintentionally and hit the operator.

Tooling

The risk as a result of faults or hazardous contact with tools or devices that are connected to the end of a robot arm (gripper, welding head, paint spray gun, …)
Example: a tool the cobot is holding could hit the operator if the cobot and the operator are not well synchronized.

Cobot Control Software

The risk resulting from software faults and failures caused by software components.
Example: software bugs or an overlooked software reconfiguration necessary after a change in task execution can lead to a malfunctioning of the cobot causing safety risks for the operator.

Application-specific hazards

Mechanical hazards can arise from the specifics of each cobot application (and the related tools and workpieces mounted on the cobot arm). A safe cobot is not a guarantee for a safe collaborative application.
Example: an application where a safe cobot handles a sharp tool is unsafe, no matter how slow the cobot works.

The Human dimension includes psychosocial risk factors arising from poor work design and organization or poor social context of work, resulting in negative psychological, physical, and social outcomes. As a result, the perceived safety of the operator can be negatively influenced, potentially leading to an unwillingness to collaborate with robots.

Trust

The risk associated with the acceptance of the cobot. Trust is a key element for the successful collaboration between humans and robots and is known to influence the safety of the operator as it is closely associated with perceived safety.
Example: There can be too little trust (distrust) if many false alarms occur and too much trust (overreliance) when the operator believes that the cobot will take care of all problems.

Work stress

Work stress is recognized as a health risk. As result of working with a cobot, it can be caused by role ambiguity, job insecurity, or the physical appearance of the robot.
Example: The proximity of a cobot can generate stress because it looks big and strong, and makes unpredictable and fast movements. There might also be a fear of losing one's job to the cobot creating stress.

Physical workload

Unergonomic working posture can lead to musculoskeletal disorders
Example: The changed division of tasks due to working with a cobot requires different postures or force applications and repetitive movements affecting joints, muscles, or intervertebral discs (e.g., accepting a workpiece provided by the cobot is done in a non-ergonomic position).

Cognitive workload

Risk factors included are associated with mental strain due to the interaction with a robot.
Example: Cognitive underload due to monotony: the cobot takes over parts of the job resulting in boredom and reduced concentration increasing the safety risk. Or cognitive overload due to increased knowledge demands: the work now involves new aspects, such as operating a handheld device or monitoring multiple cobots.

The risk factors in the Collaborative Workspace dimension are related to the physical and spatial design of the collaborative workspace and maintenance.

Access and clearance

Risk caused by or for unauthorized persons in the collaborative workspace.
Example: safety problems may be caused by employees unfamiliar with the safeguards in place or their activation status.

Layout

The (unsafe) placement of equipment and machinery may lead to safety risks.
Example: an operator may stumble over equipment needed to operate the cobot.

Hazardous obstacles

Hazards from physical objects obstructing sensors or equipment can create safety risks.
Example: physical obstacles in front of a camera may prevent a sensor from working properly.

Maintenance

Safety risks can arise during the maintenance of the cobot or the collaborative workspace.
Example: the lack of safety measures (such as the ability to switch off and lock the cobot at all times) and training for maintenance employees (including third-party service providers).

The risk factors in the Enterprise dimension are related to organizational structures, policies, and processes of the enterprise..

Training

The introduction of a cobot creates knowledge needs for the operator. Lack of cobot training and regular updates can present a safety risk to the operator.
Example: unavailable training can lead to overwork and stress or involuntary errors.

Work design

The design of collaborative work can lead to performance pressure due to the mismatch between one's physical and/or cognitive abilities and work demands, or due to changing team composition.
Example: a worker's job satisfaction may be negatively influenced if there is a sense of increased monotony, or loss in autonomy, as a result of the cobot taking over parts of the work.

Social acceptance

Social acceptance refers to the perception and acceptance of a collaborative robot by the group of people working with the cobot.
Example: Safety risk can be caused by disregarding the consequences of introducing a cobot and leading to poor robot usage or frustration.

Privacy

Data capturing and sharing by the robot can invade the privacy of the operator.
Example: misuse of personal data can lead to both tangible (e.g., discriminatory treatment) and intangible harms (e.g., the fear that personal data could fall into the hands of those who exploit it unfairly).

AI decision making

The use of AI (Artificial Intelligence) in cobots will only increase. Algorithmic decision-making can lead to a lack of transparency and bias, a loss of data control, and performance pressure.
Example: operators may experience difficulties interacting correctly with AI-enhanced cobots and may suffer from stress and anxiety caused by the feeling of losing control, social connectivity, and the sense of increased surveillance and performance monitoring.

Safety strategy

Safety risk due to not integrating cobot safety into the company's overall safety assessment strategy.
Example: not integrating cobot safety into the overall safety strategy can lead to overlooking new safety risks and a lower chance of a successful, safe cobot installation.

Technology and digitization strategy

Occupational Safety and Health risks can emerge because of a lack of communication on the need and purpose of this new technology.
Example: as a result of a lack of communication and consultation, workers may not be able to comprehend the complexity of the new cobot technology and the need for training. This can also lead to a lack of acceptance and misunderstanding about the intended benefits (e.g., they might see the cobot as a threat, where in reality, it will relieve physical workload).

The External Factors dimension comprises risk factors outside of the organization and not directly influenceable by the organization or the human operator..

Regulatory

Even though many regulations and guidelines are available, clear translation into practical application is often unclear.
Example: It is difficult for regulators to keep up with the constant new evolutions, such as the increased use of AI or autonomous mobile robots, leaving the user unguided or dependent on outdated regulations.

Environmental conditions

Environmental conditions can affect the safe operation of the cobot.
Example: Direct sunlight can obstruct sensors or heat electronic cobot components.