FROM CO-EXISTENCE TO COLLABORATION:

Human factors shaping the uptake of collaborative robots in manufacturing

Summary Report

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BAE SYSTEMS Maritime Australia

Flinders UNIVERSITY

SUMMARY

Cobots – robots that interact with humans to perform tasks – are emerging in the manufacturing industry. Cobots have value for repetitive tasks across applications such as pick-and-place, palletising, machine tending and tool-pathing.

Ensuring that cobots are a good fit for the workplace and supporting employees to achieve work outcomes is critical to successful deployment and uptake. This requires consideration of human factors and ergonomics (HFE) including culture and attitudes, job design and work environment layout.

1 Cobots can create direct and indirect benefits for industry

Direct commercial benefits

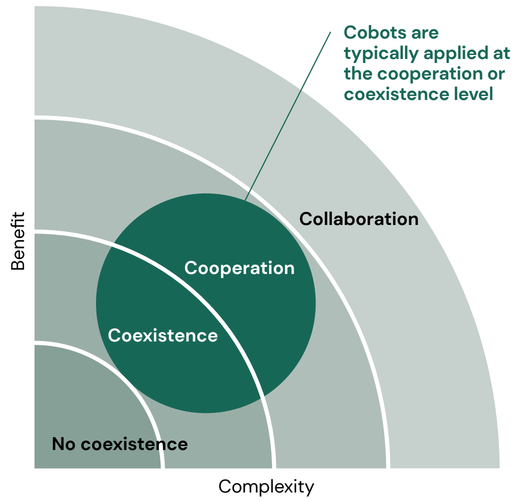
- Improved productivity
- Improved operational efficiency
- Improved product quality

Indirect economic benefits

- Improved health and safety for employees
- Improved employee task variety

2 The way cobots are used is changing and will help manufacturers move up the value chain

Cobots are typically being applied in industry at fairly low levels of collaboration. This is forecast to change as we seek to move up the value chain and deploy cobots in more Australian workplaces.



3 Australian industry can take steps to accelerate adoption of cobots

1. Assess the full impact / advantages of applying cobots in the work environment
2. Pay close attention to both technical and human considerations including cobotic requirements and workplace design
3. Rethink workers' jobs to capture the benefits of cobots
4. Treat the introduction of cobots as a change management process

ADVANCED MANUFACTURING IS INCREASINGLY COMPETITIVE AND TECH-INTENSIVE, INCLUDING EXTENSIVE USE OF AUTOMATION AND ROBOTICS

Australia has a track record of innovation in advanced manufacturing. The ultrasound scanner, black box flight recorder and bionic ear were all developed in Australia. Advanced manufacturing now makes up around half of Australia's A$100 billion-plus annual manufacturing output and is one of the fastest-growing export sectors.[1] Australia needs to prepare for the next wave of advanced manufacturing innovation.

Australian manufacturers face growing global competition driven by:

NEW TECHNOLOGY

Digitisation is occurring across all stages of the manufacturing process – from design to production, supply chain management and customer experience – with a gulf emerging between manufacturers that do and don't embrace new technology.

SCARCE TALENT

Talent attraction is becoming more competitive with manufacturers increasingly paying a premium to attract scarce trades and technical talent.

COST PRESSURES

Global supply chains are increasing price transparency and requiring manufacturers to pursue cost reduction strategies and seek greater efficiencies.

Robotics and automation are helping manufacturers respond to these pressures and anchor the move towards digital manufacturing.

THE FULL VALUE OF COBOTS (ROBOTS THAT INTERACT WITH HUMANS TO PERFORM FUNCTIONS) IS EMERGING

Historically, the use of robotics and automation in manufacturing has been challenging. Robots have lacked flexibility because they are designed for high-volume, low-variation processes and are not economically viable for many SMEs.

A new generation of robots, known as cobots, are providing one possible solution to this challenge. Cobots are designed to work collaboratively with humans and each other to perform different parts of a task. Cobots have greater flexibility and applicability to tasks with higher variability than traditional robotic and automation techniques.

Cobots are widely used to partially automate manufacturing processes that are ergonomically challenging, repetitive or difficult to fully automate. Internationally, automotive manufacturers such as BMW Group, Audi, Volkswagen, Nissan and Skoda use cobots in their work cells collaboratively alongside human workers for tasks such as assembly, dispensing, finishing, machine tending, material handling, welding and more[2].

Common applications for cobots include:

1 PICK-AND-PLACE including assembling products

Electrolux — Label placement on products

CLIPSAL by Schneider Electric — Switchboard assembly

2 MACHINE TENDING including loading and unloading machines with parts or materials

REDARC — Hopper feeding

kennewell CNC MACHINING — CNC machine tending

3 PALLETISING including preparing packaging for distribution and shipment

Penfolds — Palletising wines for distribution

4 TOOL-PATHING including completing process tasks such as welding, gluing and dispensing

BMW, Audi, VW, NISSAN, ŠKODA — Welding automotive parts

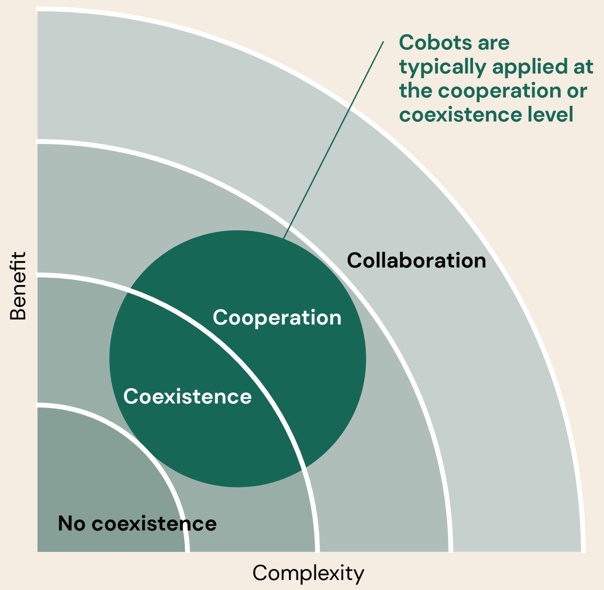
The primary investment case for cobots is commercial; compared with humans they are faster, have lower running costs, are more available and enable predictable quality. This can create substantial benefits for manufacturers including:

- **Improved productivity:** Cobots can reduce assembly time and enable significant increases in production capacity. For example, REDARC in Australia increased production capacity 250% by using cobots for machine tending and pallet handling tasks.[3]
- **Improved operational efficiency:** Cobots can reduce unit costs and enable a greater variety of products to be produced at smaller batch sizes. For example, Multi-Wing in the Czech Republic reduced the production cost of ventilation fans 10-20% by using cobots for machine tending.[4]
- **Improved product quality:** Cobots can reduce human errors and inconsistencies in production. Combining the cognitive capacity of a human and the accuracy and repeatability of a cobot can objectively improve product quality and increase task consistency.[5] For example, Craft and Technik Industries in India increased production 15-20% with no defects or customer rejections by using cobots for automotive parts inspections.[6]

Less documented, but potentially just as important, are the indirect economic advantages related to improved employee wellbeing and safety. Cobots can reduce employees' exposure to health and safety risks in a number of ways such as reducing the need for humans to work in harsh and dangerous work environments, decreasing repetitive movements that cause strain and injury, and reducing exposure to monotonous activity that can lead to reduced morale / employee engagement. The flow-on benefits are improved career longevity, staff retention and lower costs associated with injury to the employee and organisation.

THE WAY MANUFACTURERS USE COBOTS WILL CHANGE FROM CO-EXISTENCE TO COLLABORATION WITH HUMANS

The degree of collaboration between employees and cobots varies. Despite being termed collaborative robots, cobots are typically being applied in industry at fairly low levels of collaboration, such as coexistence or cooperation.



No coexistence

- Physical separation, i.e. traditional industrial robots

Coexistence

- Human works in partially or completely shared space with the robot
- No shared goals
- Human and robot activities are unrelated

Cooperation

- Human and robot work towards a shared goal in partially or completely shared space

Collaboration

- Human and robot work simultaneously on a shared object in a shared space

The level of collaboration is forecast to change as we seek to move up the value chain and deploy cobots in more Australian workplaces. To facilitate this change, we need to better understand the relationship between humans and cobots (including physical and mental impacts on employees using cobots) to produce optimum outcomes for business performance and employee wellbeing. Without this understanding, there is a risk that industry and employees may delay or under-utilise cobots.

HUMAN FACTORS ARE CRITICAL TO THE UPTAKE AND SUCCESS OF COBOTS

When deploying technology, organisations often put more emphasis on system functionality than how humans interact with these systems. Human Factors and Ergonomics (HFE) seeks to change this. HFE is a combination of many disciplines such as social sciences (psychology, sociology), health sciences (medicine, physiology, biomechanics) and design sciences (engineering, industrial design, architecture, user interface design). More specifically, HFE is the science of designing a job to fit the worker, rather than expecting the worker to fit the job.

HFE is more than implementing the latest stretching program (although that may play a role in decreasing injuries) or supplying ergonomic chairs; it takes a holistic look at the tasks that are being performed and matches them with the capabilities of the worker to minimise injury risk and stress, and maximise quality and efficiency.

Key elements considered as part of HFE include:

Critical HFE considerations for cobots are:

Culture and attitudes:
How will workers respond to cobots performing and assisting with tasks that they have traditionally been responsible for?

Job design:
How will workers' jobs need to change in light of the introduction of cobots?

Work environment layout:
Where do cobots need to be located to ensure accessibility and to support better human and robot collaboration?

Usability:
What design features do cobots need to ensure workers have a positive experience when interacting with them?

Flinders University researchers simulated tasks that cobots might perform in a manufacturing facility and sought to understand how they can be embedded in the work environment

To better understand the relationship between humans and cobots, Flinders University assembled a cross-disciplinary team to trial a low complexity glue dispensing task. Glue dispensing on component parts is a common sub-task in automotive and furniture assembly. Industrial glues frequently contain hazardous chemicals to which human exposure should be minimised. When this sub-task is completed manually, employees are required to accurately dispense an adhesive bead along, at times, complex paths. The physical demands made on a human engaging in this process often include repetitive movements, fine-motor skills, and awkward postures and hand-force application.[8]

Flinders' research trial involved simulating a shipbuilding task, comparing manual dispensing efforts with cobot-assisted dispensing. Trial participants taught the cobot the glue path via hand-guiding to rapidly generate a real space toolpath for dispensing glue.

The manual method

The cobot method

The cobot-assisted method:

- Was faster than manual methods, dispensing glue in almost half the time required by a human
- Placed significantly less physical burden on trial participants than manual methods, and resulted in less stress and frustration
- Consumed significantly more glue than the manual method due to the design of the dispenser. This can be refined prior to deployment in industry.

Source: AITI Photo Stock 2021

ADOPTION PRINCIPLES FOR INDUSTRY

Every manufacturer has a different context and needs to assess whether cobots are right for them. For example, cobot technology tends to be better suited to repetitive tasks and is less likely to be appropriate in machining shops and contract manufacturers where products are built to order and there is unstable demand. Questions that manufacturers are potentially asking include:

- Do our employees perform repetitive or hazardous tasks that could benefit from the application of cobots?
- Are our competitors and industry peers using cobots?
- Are we prepared to make changes to the work environment and rethink employees' jobs when introducing cobots?
- How will our employees respond to the introduction of cobots?
- What's the return on investment from cobots when you consider the full costs including investments in HFE?

To accelerate the adoption and diffusion of cobots in work environments, manufacturers and industry more broadly should:

1 Assess the full impact / advantages of applying cobots in the work environment

Manufacturers should develop business cases when considering the implementation of cobot technology. These business cases can detail the impact / cost of inaction (i.e. what are the costs to the business when employees are engaging in 'dull, dirty and dangerous' work?) and should consider savings related to the prevention or minimisation of injury, absenteeism and disengagement in addition to any quality and productivity gains. Where appropriate, technology trials can be used to help determine the value and type of investment appropriate for the business.

2 Pay close attention to both technical and human considerations

Poor usability, cobot design constraints and work environment set-up (e.g. poor accessibility to work surfaces) can impair employees' experience and performance when using cobots. Cobots should be deployed with user-centred design principles and workplace controls should be introduced in industrial environments to facilitate seamless interaction between employees and cobots. Understanding how users interact with cobots in the intended location is essential so technology and tools can be tailored to the environment to meet user needs.

3 Rethink workers' jobs to capture the benefits of cobots

Completing a low complexity dispensing task for extended periods, whether manually or with the assistance of a cobot, does not constitute good job design and will not lower employees' physical and mental stress. The shift to cobots necessitates that manufacturers rethink workers' jobs and ensure they entail skill variety, task identity, task significance, autonomy and job feedback.

4 Treat the introduction as a change management process

Adoption of change management models can help to accelerate the successful uptake and diffusion of new technologies. Manufacturers should clearly articulate to employees the reasons for adopting cobots, listen carefully and respond sensitively to employees' feelings and concerns, and provide both technical (e.g. cobot programming) and personal development (e.g. growth mindset) training to employees to support successful use of cobots.

[1] https://www.austrade.gov.au/international/buy/australian-industry-capabilities/manufacturing

[2] BMW Group (2013); KUKA (2016); Robotics and Automation News (2017); Universal Robots (2018); Winkelmann (2017)

[3] Kittel (2019)

[4] Von Hollen (2019)

[5] Vysocky & Novak (2016); Zanchettin, Croft, Ding, & Li (2018)

[6] Von Hollen (2019)

[7] Aaltonen & Salmi (2019)

[8] Colim et al. (2020)

TAKING THE WORK FORWARD

and how Flinders University can help

Contact us to discuss how
we can help your organisation.

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