FUTURE MANUFACTURING FLAGSHIP
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An initiative to enhance SME productivity through fit for purpose Information and Robotic technologies

The value of Lightweight Assistive Manufacturing Solutions

White Paper

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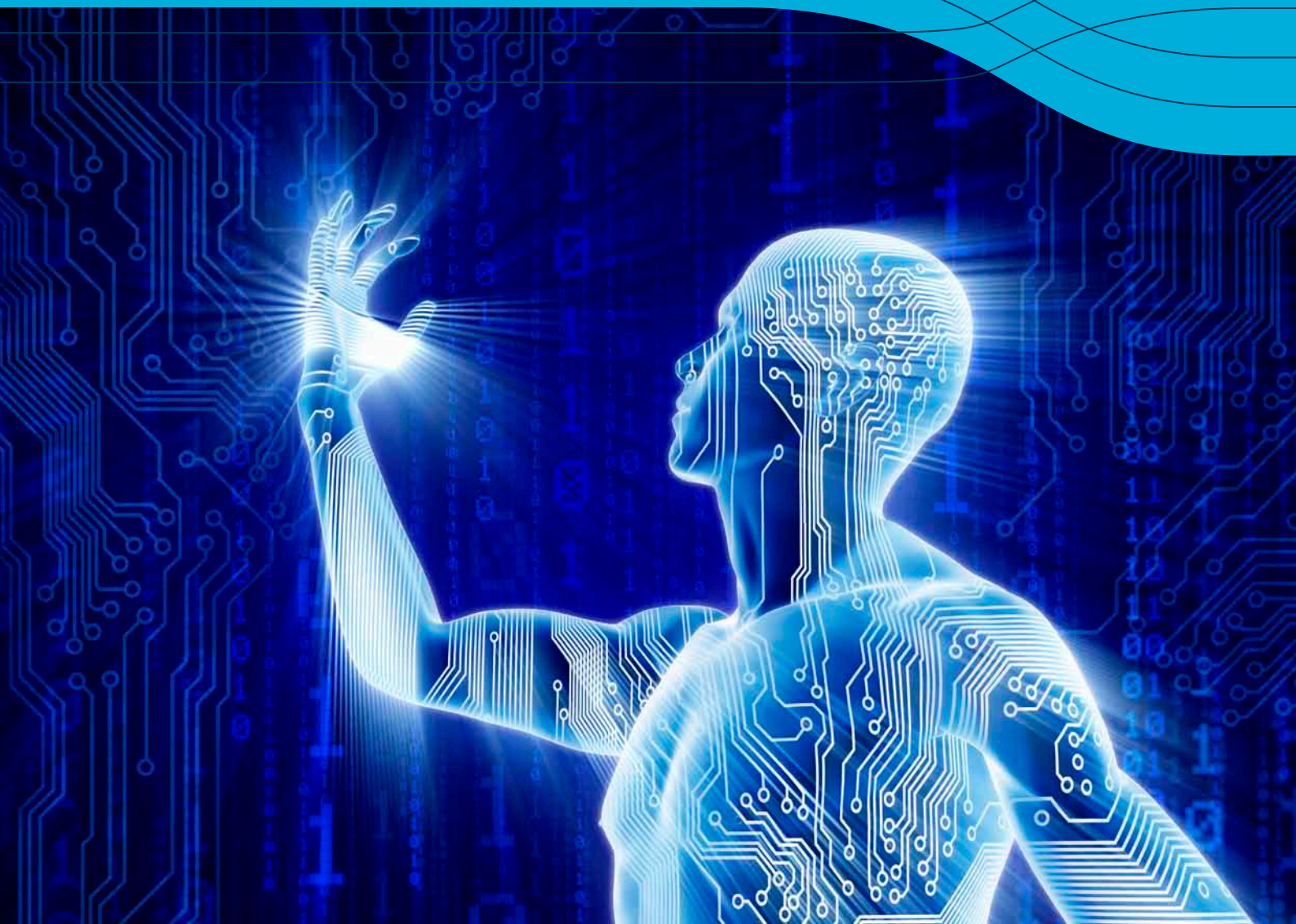

Future Manufacturing Flagship

Citation

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Important disclaimer

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1 Introduction and purpose

Facing increasing operational costs, skills shortages and comparatively low productivity growth, combined with external factors such as increasing competition from low-wage countries, manufacturers are in need of alternative solutions that give them the flexibility and agility to respond to a volatile demand, leading to an increase in productivity in the form of an affordable investment.

Industrial automation currently available is not flexible enough, designed for high volume, low variation processes and hence economically unviable for small and medium sized businesses (99% of industry). Moreover, current technology is designed to improve productivity by replacing the work force, a strategy that is not considered suitable to the Australian SME sector, as one of their key competitive advantages is the innovation that is generated on the manufacturing line.

Recent advances in robotics and information and communications technologies (ICT) are leading towards the convergence of close collaboration between worker and robot. Advances in sensor technology are also enabling the ability to perceive the dynamic manufacturing environment, with this digital information stream providing a safer work environment with improved quality and productivity outcomes. Through its research into the Australian SME sector, CSIRO foresees the enhancement (rather than replacement) of manufacturing workers with assistive information technologies and robotics-based technologies as a profound enabler for Australian SME's economic success.

This paper describes how current CSIRO advances in the field of ICT can be combined into Lightweight Assistive Manufacturing Solutions to lift workplace productivity and increase competitiveness - creating new business opportunities for Australia. It also explores the implications of these solutions in future manufacturing.

2 Australian manufacturing sector

From a global perspective, the manufacturing sector is the major driver for economic growth in developing countries. The industry has shifted from being predominantly localised with local supply chains and customers, to having globally integrated value chains (Future Manufacturing Industry Innovation Council, 2011). This has been driven by the advantages of lower labour costs as well as by pressures of strong global competition. This has boosted China's share of global manufacturing activity, as well as the share of other developing economies.

In Australia, the manufacturing industry has grown in absolute terms over the last 25 years, responsible for 1/3 of industry exports. It was also the second biggest contributor of business expenditure on research and development (R&D) in 2011 (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, 2012). However, its contribution to nation's gross domestic product has declined by 4% in the last 12 years, surpassed by the services, mining and construction sectors. Figure 1 illustrates this declining trend by comparing Industry Gross Value Added[1] of four of the most important sectors in Australia. A similar situation is seen in the manufacturing contribution to nation's employment.

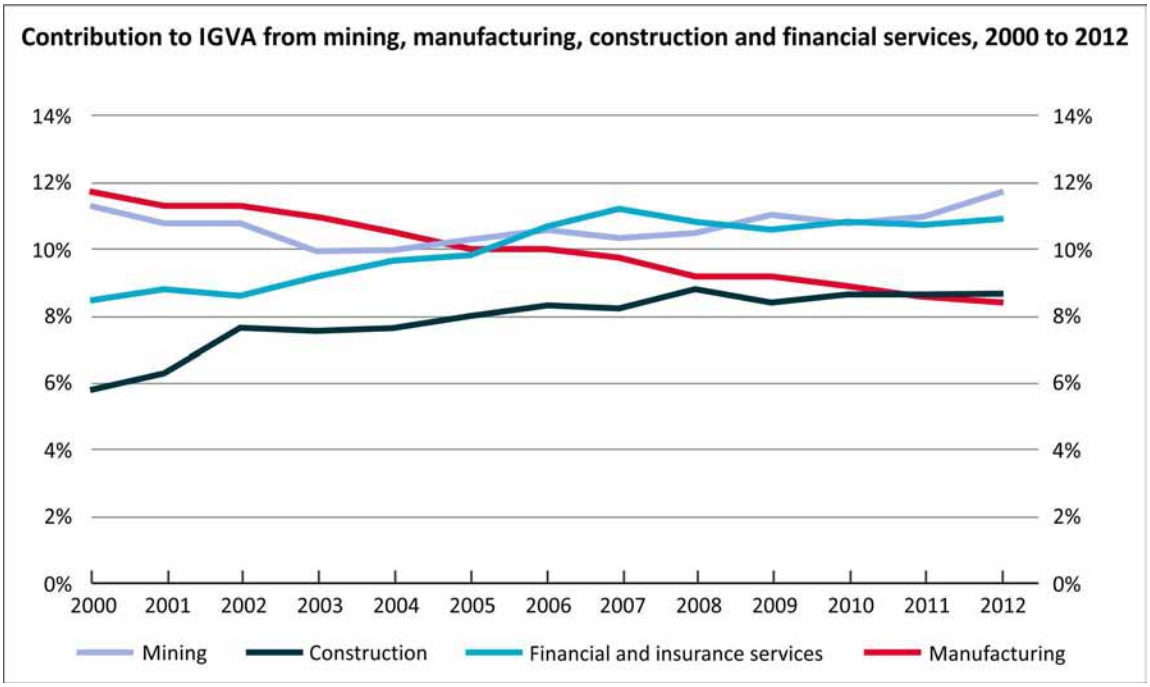

Figure 1 – Manufacturing contribution to Industry Gross Value Added (IGVA)[1], compared to other key industries (Australian Bureau of Statistics, 2012).

This decline in the industry's competitiveness has been attributed to internal factors such as increasing operational costs, as well as global changes, which requires a higher level of adaptability that is difficult for domestic manufacturers to reach, especially SMEs. Some of these factors are:

- **Uneven number of small firms**: Australia's manufacturing industry is made up of a disproportionate number of small firms (86%) many of which operate in small markets (Prime Minister's Manufacturing Taskforce, 2012).

[1] Industry Gross Value Added (IGVA) measures the value of industry production, and it is used to measure the contribution of individual industries to the gross product of a country.

- **Increasing unemployment**: The sector lost more than 100,000 jobs from 2008 to 2012, and is expected to lose another 85,000 in 5 years (Department of Education, Employment and Workplace Relations, 2012).
- **Skills shortage**: Especially in the heavy fabrication and engineering industry, being caused by: an ageing workforce, lack of specific skills in new workers, and skilled staff being attracted into the resources sector (Manufacturing Skills Australia, 2012).
- **High costs:** Rising living and energy costs, as well as a weak productivity growth have made Australia a 'high cost economy' by international standards, with the appreciation of the Australian Dollar exacerbating the issue.

Despite these challenges, the manufacturing industry is still an important employment source, a vital contributor to the Australian economy with a multiplier effect on other sectors such as mining and services, and the main source of technological innovation across the Australian business sector. This creates national need to increase the global competitiveness of Australian manufacturing firms to produce high-value offerings in a cost-effective way. This, in turn, requires a highly productive, well-skilled workforce equipped with the appropriate tools to revitalise productive performance.

Conventional industrial automation, the current tools available for manufacturers and widely used in the automotive industry, is driven by the need to automate specific mass-manufacturing tasks. However, new economic drivers are less focused on large-volume production, and more concentrated on the mass personalisation of products. Conventional automation has proved to be inflexible for manufacturers operating under a low volume, high-variety approach, economically inefficient for small businesses, and unsafe for humans. This situation dictates a national requirement for affordable assistive automation solutions, that support high variety – low volume production runs, that are easy to implement, highly flexible, and adaptable to operational processes, equipment and human resources already in place.

3 Lightweight assistive manufacturing solutions

In the quest for sources of sustainable competitive advantage, the information-technology domain, with a proven ability to increase productivity in manufacturing environments, is emerging as the next technological evolution which will improve the linkages between information technology capabilities, human workers and the physical working environment, to create smart and flexible factories in the future.

This will provide new levels of production quality, responsiveness, efficiency and labour productivity as well as broader opportunities for products/services that could not be realised with current manufacturing methods. For these reasons, CSIRO identifies lightweight robotics and advanced ICT-based systems as a viable next generation solutions to achieving these objectives, and the Lightweight Assistive Manufacturing Solutions (LAMS) initiative is the CSIRO proposal for the design, development and demonstration of real-life applicability of these solutions.

Recent advances in robotics and ICT are leading towards the convergence of robotic capabilities directly to human workers and facilitating team-working between man and robot, as well as augmenting worker's perception by putting digital information at their hands. Figure 2 shows the technological fields and trends that are shaping the structure of LAMS. These technologies will impose a whole new era of flexibility and agility to the industry, bringing enormous benefits to the sector and to the nation's economy.

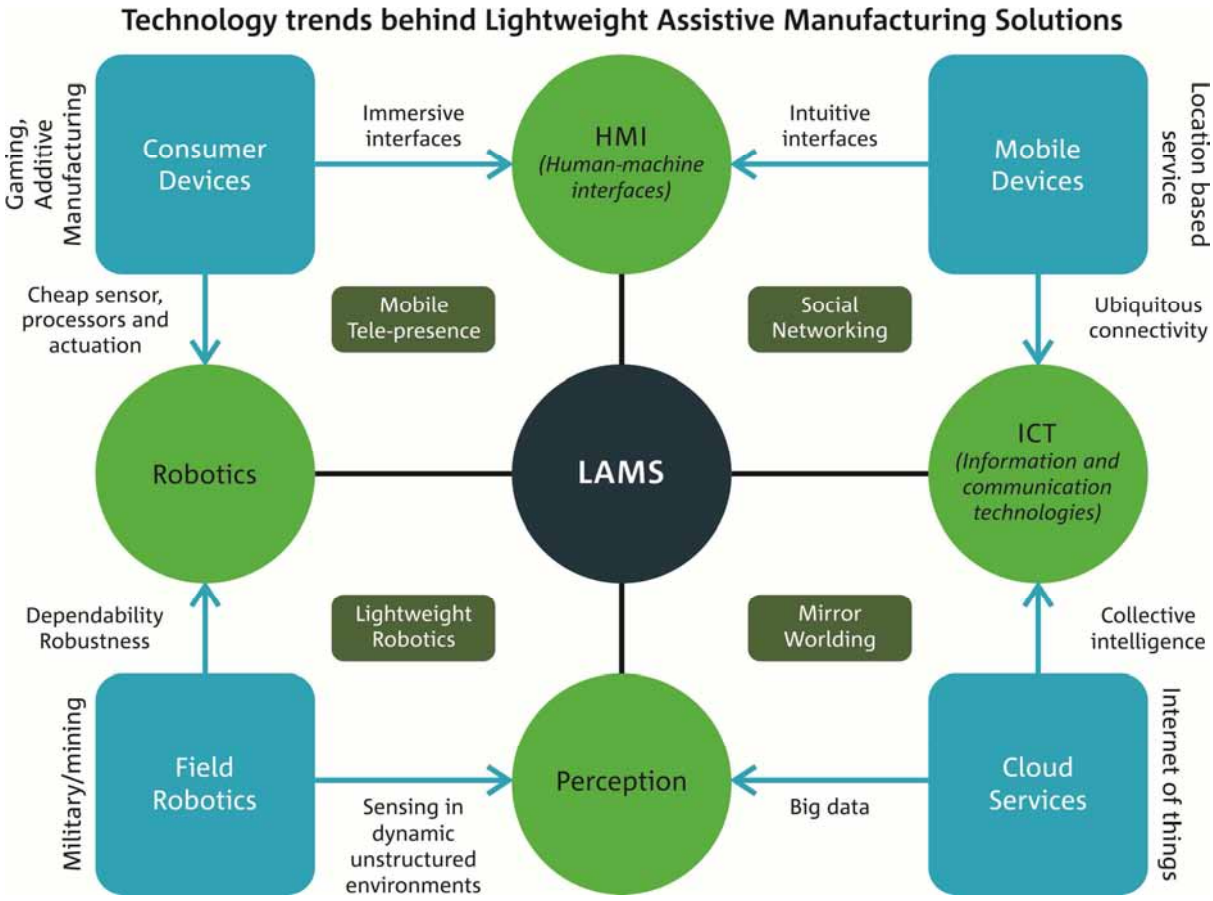

Figure 2 – Current and emerging technological trends underpinning the development of LAMS

Lightweight Assistive Manufacturing Solutions will deliver value to the manufacturing small and medium-sized enterprises (SME) in different ways, and will be strongly dependent on the nature of the solution and the form in which is utilised by users. Figure 3 articulates three solution scenarios in which LAMS will benefit a typical SME.

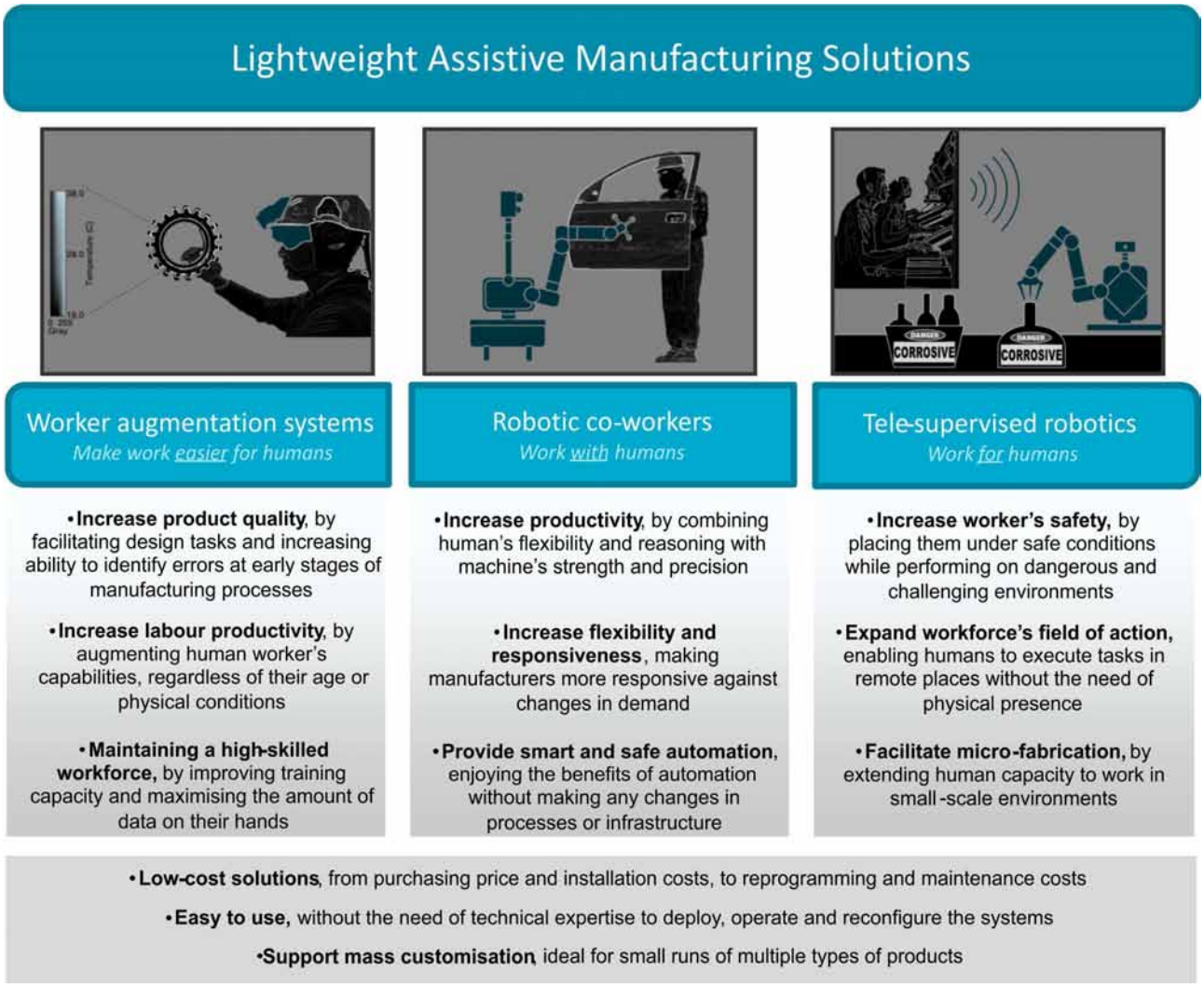

Figure 3 – Diagrammatic representation of the 3 types of solutions comprising *Lightweight Assistive Manufacturing Solutions* with corresponding value propositions to SMEs.

- Worker augmentation systems:

Provide virtual augmentation to the worker during a production, assembly or quality phase by enhancing their ability to do their job (e.g. Virtual/augmented reality systems, wearable machine vision). Ideal for firms who want to increase productivity by augmenting workforce capabilities, such as skills, perception, strength and data-processing capacity, to make them capable of fabricating high-quality products in a faster and more efficient manner, regardless of their age or physical conditions. This is also ideal solution to retain experienced elder workers as well as maintaining a skilled labour force capable of dealing with new product fabrication and incorporating changes rapidly and with fewer errors.

- Robotic co-workers:

Robots capable of collaborating with and assisting humans on manufacturing tasks in the form of mobile assistants, semi-autonomous manipulators and robot helpers, are intended to be used by firms seeking to introduce a degree of automation to their short-run manufacturing processes. The objective is to increase productivity, but by affording the appropriate degree of agility to responding to demand.

The solution is based on utilising collaborative robots that provide their human partner with machine capabilities but are directly controlled by the human worker itself, creating cooperative teams comprising the strength, speed and precision of robots and the flexibility, creativity and reasoning of humans.

- Tele-supervised robotics*:*

Automation that extends the reach of the workforce is ideally suited to firms that deal with challenging manufacturing or production conditions as a result of hazardous operational environments or distance/time constraints.

This solution exploits the benefits of the above technologies and by placing the worker safely away from the operational manufacturing function to now supervise the manufacturing process. This also provides scalability across a number of work cells and across a number of sites. Furthermore, this unique solution provides a new option to increase labour productivity and operational efficiency.

4 Industry consultations

To deliver the value proposed in this initiative, CSIRO recognises the importance of the industry input before, during and after the technology development process. Initial industry consultation in the form of interviews and workshops including manufacturing firms, peak bodies and governmental representatives has validated some of the initial requirements for Lightweight Assistive Manufacturing Solutions (LAMS) in the following categories:

a. Identify problems faced by Australian manufacturers: Issues associated with increasing product quality, timely response against volatile demand, skills shortage and a decreasing productivity where unanimously reported. Unavailability of cost-efficient automation systems for low-volume production and the lack of proper legislation to promote adoption of new technologies were also mentioned.
b. Learn from experience with conventional industrial automation: High barriers of entry, human unsafety and inefficiencies due to focus on small runs of multiple types of products (low-volume production) were the main negative factors reported during consultations.
c. Key requirements for LAMS: Safety for humans and affordable costs were among the most reported aspects that a lightweight assistive system must have (see Figure 4). During the workshop, the need for quality enhancement, downtime reduction and quick return-on-investment were also highlighted by participants.

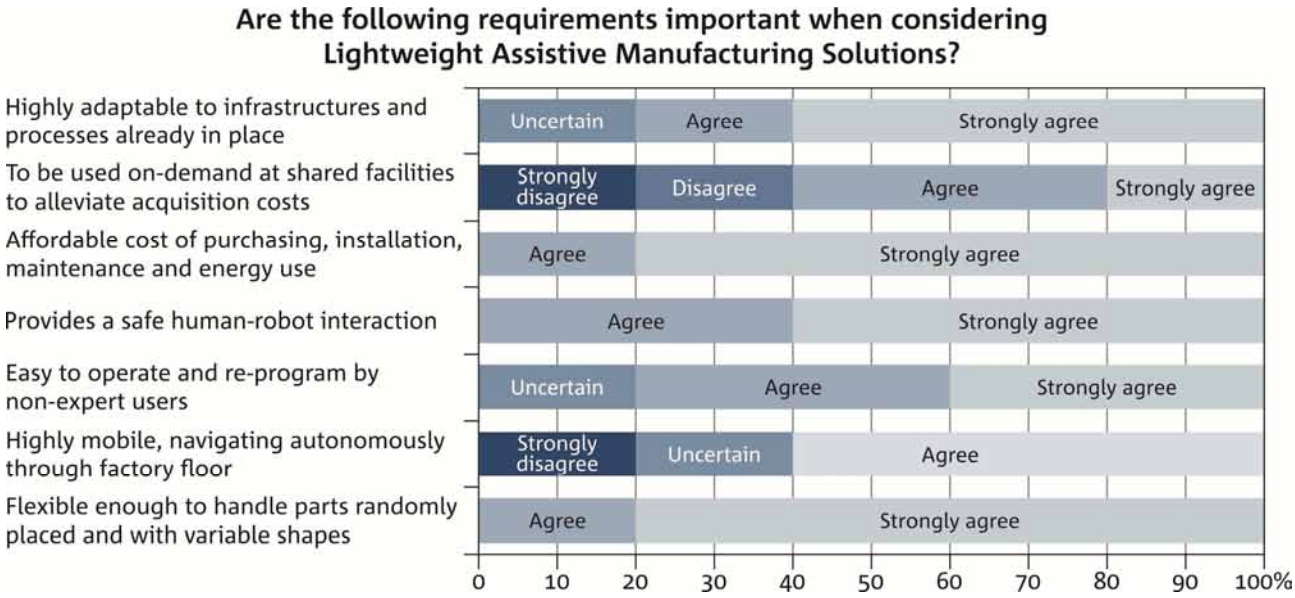

Figure 4 – Results from one-on-one interviews with five manufacturing SMEs from Queensland and Victoria, regarding key non-functional requirements when considering lightweight assistive manufacturing solutions.

Figure 5 derived from feedback obtained on industry's challenges, disadvantages of current automation and SME requirements on economic aspects of LAMS. As illustrated, equipping workforce with such systems should be economically more effective than conventional automation and pure manual labour in low-production environments. The "SME spectrum" (although not including SMEs solely) highlights the area in which LAMS will focus on.

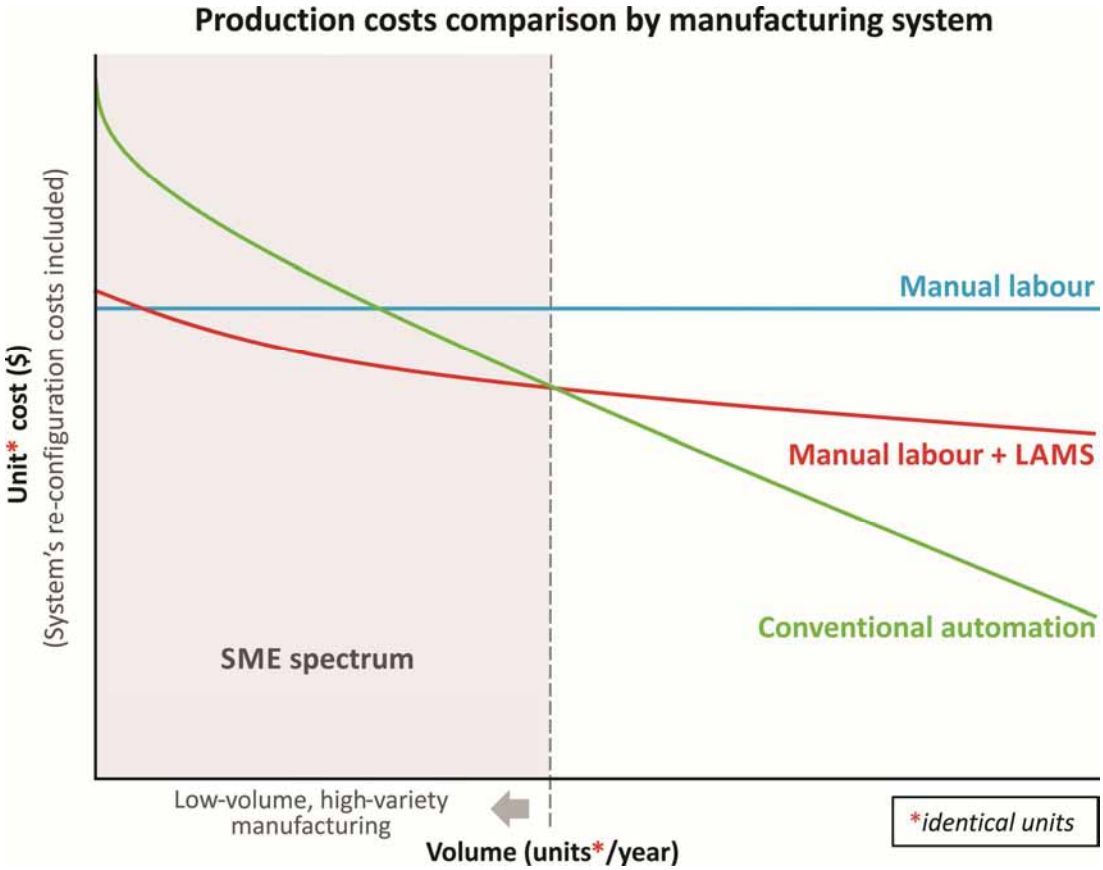

Figure 5 – Associated costs of fabricating a single product using conventional automation, pure manual labour and the proposed solutions.

The industry consultation process involved individual and/or group conversations with manufacturing professionals, managers, directors and representatives from 26 organisations. Representation spanned the Australian manufacturing ecosystem and comprised of 16 manufacturing firms from Victoria and Queensland, ranging from SME to MNE (Multinational enterprise); 6 industry peak bodies and 4 state and federal government department and agencies.

Each of the organisations involved in the consultation displayed a substantial level of interest in the proposal, and recognised it as an efficient way to connect with industry.

5 Relevance and impact

Lightweight Assistive Manufacturing Solutions (LAMS) will directly support Australian manufacturers in addressing international market opportunities and in growing revenues from domestic markets, but are also expected to have wider impact for Australia's workforce, economy and future manufacturing outlook.

Impact on Australian workforce:

- More and better jobs: Lightweight assistive systems will facilitate human's work in factories, resulting in jobs with more high-value tasks and less repetitive and physically demanding activities such as weight lifting and tool picking. Indirectly, an increase in the manufacturing industry's productivity and competitiveness will result in firm expansion, which will create more employment for Australians.
- Safer workplaces: LAMS has been designed to proactively address safety issues in factory floors by allowing operation in hazardous environments and safely execution of physically stressful activities.
- Workforce skilling: Remote training systems (a sub-category of LAMS) facilitate continuous on-the-job training for workers, and enable absorption of new apprentices into the industry. Additionally, an industrial environment that promotes training and up-skilling while makes use of the latest technologies available will have a motivational impact on skilled recruits to enter the manufacturing workforce.

Impact on Australian manufacturing firms:

- More profitable businesses: Based on the concept of using robotic co-workers so that the human spends more time adding real 'value' to the product in a shorter timeframe, will allow to capture more revenues by covering market needs faster and better than others.
- Access to international markets: Australian firms should indentify a suitable position within globalised supply chains where they can exploit and use their competitive advantages; LAMS intends to allow the creation of core competencies around quality control and assurance, innovative design and product personalisation.
- Maximise global competitiveness: To remain competitive, Australian manufacturers need to develop niche, high-value-added products/services that compete on value rather than on cost. Rapid re-configurability to support product variety, system scalability and solutions which capture market demands in a timely fashion are the key elements of the LAMS proposition.

Impact on Australian economy:

- Industry's sustainable growth: LAMS has the potential to equip SMEs with fit-for-purpose technology and prepare them for future challenges in a highly dynamic globalised industry; re-shoring manufacturing activities back to Australia as it will be cost-efficient to produce certain parts domestically; and bringing cohesion and interconnectedness to the industry through the use of ICT solutions on top of complementary infrastructure such as the National Broadband Network.
- Supporting other industries: Due to multiplier interrelations with the services and mining sectors, any economic benefit that lightweight assistive systems produce in manufacturing will be propagated in other sectors of the Australian economy.
- Competitive position in future robotics industry: The LAMS initiative will lay the foundations for Australia to capitalise and capture revenues from an emerging industry in the foreseeable future, through the formation of research and industrial capabilities around assistive and service robotics for industrial settings.

6 The future

The Lightweight Assistive Manufacturing Solutions (LAMS) initiative will contribute to building a national competitive advantage based on high-value-added product development and design in the SME space that will reiterate Australia's well-known competency for innovation. From this position, Australian firms will be able to face international competition head on and rapidly address demands from these emerging markets while maintaining a leadership in the domestic marketplace. They will maintain the leadership position without comprising worker safety, but will afford higher quality processes and maximise workforce productivity to form high-performance workplaces. The Australian SME sector now has an option to secure a beachhead for future growth by capitalising on the evolving global markets.

The emergence of the fibre based, broad band services across the manufacturing sector will complement LAMS and reduce the barrier to entry for the sector as it adapts the next manufacturing phase in which digital representation of physical settings will enable manipulation of every step across the manufacturing value chain, with digital information flowing purposely across the manufacturing supply chain. It will also support an era in which cloud services will be transferred to production activities, where simulation, modelling, design and fabrication of product and services will be offered on an on-demand basis.

Coupled with the access to new services and manufacturing options, the sector will also develop novel and appropriate business model innovations. The realisation of the full value of this initiative has the potential to redefine customer segments, markets and value propositions. Distribution channels will be re-engineered and disruptive new ways to create links with customers, and hence new revenue streams, will be defined not only on a national basis, but globally.

Given the underlying technologies and innovative concepts behind the initiative, LAMS represents a step forward in guiding Australia into the future world; a world in which organisations will need for smart solutions that are constantly measuring and calibrating themselves to maximise efficiency; a world that will demand for assistive solutions to enhance an ever-increasing ageing population; an era in which individuals will seek for solutions that makes them virtually accessible and reachable by anyone at anytime; and a society becoming more interested in customised solutions that meets their unique personal demands at low prices, which requires smart interconnected systems always aware of people's needs.

Australia's investment in information and communication technology has been exploited in a number of core economic sectors. It's time to leverage this investment and reinvigorate the innovation powerhouse of the economy, the manufacturing sector.

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