Flinders University
Australian Industrial Transformation Institute

Submission to the House Standing Committee on Industry, Science and Resources

Developing Advanced Manufacturing in Australia Inquiry

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1 Advanced Manufacturing - How innovation will drive Australia's future

The Australian Industrial Transformation Institute (AITI) welcomes the opportunity to provide a submission to the House of Representatives Standing Committee on Industry, Science and Resources' inquiry into Developing Advanced Manufacturing in Australia.

AITI is situated within the College of Business, Government and Law at the Flinders University of South Australia. The Institute is a trans-disciplinary socio-economic and industry development research facility located at the university's Tonsley site - one of the nation's leading research and innovation districts. AITI brings together social scientists, economists, engineers and computer scientists to work collaboratively with government and communities. It was a foundation member of the Innovative Manufacturing Co-operative Research Centre which, between 2016 and 2022, was a national focal point for research in support of advanced manufacturing in Australia.

AITI currently hosts:

- The Line Zero Factory of the Future facility - a 4000 square metre fully reconfigurable advanced industrial test bed and education and training centre (supported by companies such as BAE Systems and its supply chain, local small and medium-sized enterprises, and advised by world-leading Sheffield University AMRC, which is part of the High Value Manufacturing Catapult).
- A Joint Advanced Manufacturing Research Lab with BAE Systems Maritime Australia to collaborate on testing and trialling of advanced manufacturing and digital technologies for potential application to future defence projects.
- The Digital Transformation Laboratory - a working space at Flinders University focussed on the latest digital technologies related to the full spectrum of manufacturing tasks. The lab is a working showcase of the application of the Digital Twin, enabling industry partners and university researchers to test innovative manufacturing designs prior to construction.
- The Tonsley Manufacturing Innovation Hub, showcasing certain Industry 4.0 technologies including a cyber-physical facility, and automation, sensor and robotic technologies.

1.1 Manufacturing in Australia

In the last decade, manufacturing in Australia underwent a profound transformation, losing about 20 per cent of its workforce, including as the result of the closure of major global car manufacturers' plants in this country: Ford closed in 2016, Toyota in 2017 and General Motors Holden also in 2017. The decline in manufacturing employment however had begun before those closures, affecting especially technical, sales, and administrative occupations and machinery operators (each decreasing by over 20%). In contrast, managerial and professional occupations contracted disproportionately less. This sharp differential in decline between manual and lower-level service occupations, on the one hand, and higher level and higher-skilled service occupations on the other, was very much unique to this sector. Moreover, research undertaken at the Australian Industrial Transformation Institute (by Associate Professor Dr. Andreas Cebulla) found that a disproportionate number of lower-skilled jobs in this sector must be considered automatable (using the National Skills Commission's Weighted Average Automatability Score). This again is a marked difference compared to other industry sectors in Australia, where growth occurred in higher-skilled occupations.[1] To the extent that automatability predictions can be relied upon, they raise the spectre of further and significant occupational restructuring affecting Australian manufacturing in the future. That said, automation also presents opportunities for creating better and safer jobs. A well thought out innovation strategy can play a key role in managing future transitions in manufacturing. Moreover, innovation has a significant contribution to make to achieving broader societal and economic objectives, notably sustainable de-carbonisation. As the COVID-19 pandemic further demonstrated, fundamental benefits accrue from developing a diverse, complex economy capable of producing and delivering quintessential goods and services.

AITI, in collaboration with industry partners, notably BAE Systems Australia - Maritime, has undertaken research in laboratory and workplace conditions, exploring the potential and appropriate application of advanced technology for safer, more efficient working environments. The research has sought to identify and support the needs of workers in a range of technical occupations; in supervisory and supervised, manual and non-manual positions, of diverse ages and varying levels of experience. Today, this research provides a repository of findings and substantive knowledge, which AITI will employ as it expands its pilot Factory of the Future into a fully operational institution linked to a new Technical College set up to train manufacturing's future workforce. In doing so, AITI works closely with the public sector as well as industry partners to ensure the systems and approaches put into place are appropriate, agreed and evaluated, and above all innovative so they meet current and future industry needs.

1.2 Innovation opportunities and principles

AITI has engaged with and helped to develop and improve a multitude of advanced manufacturing (AM) technologies, which can enhance efficiency of production and thus make workplaces safer and less strenuous as new technologies take on tasks previously left to humans. In the following, we present a brief summary of these technologies, but note that a key lesson from our laboratory and workplace research is that the safe and efficient use of advanced technologies requires adequate training and attention to the structure of whole jobs (Howard et al., 2022). Our research also showed that this can be best achieved in dialogue with the users of those technologies – thus overcoming barriers to adoption across skill levels, whilst concurrently promoting upskilling where appropriate.

1.3 Innovation technologies

Innovation and manufacturing transformation are critical factors to accelerate the growth of high-value industrial outcomes and jobs (AITI, 2021). AM can favour Australia as a large-scale trend that can be integrated into emerging Industry 4.0 technologies. Consequently, it can enable advances in national manufacturing and leverage workforce skills towards the digital transformation paradigm. Our summary here aims to highlight industrial AM trends integrated with emerging Industry 4.0 technologies and provide insights on leveraging innovation capabilities to absorb AM technologies towards industry transformation through a focus on human factors and ergonomics (HFE) to optimise worker acceptance of and successful interactions with technologies.

[1] Although many of higher-skilled occupations are also predicted to be at risk of automation, this is assumed more likely to affect job-related tasks, not displacing entire jobs, as is often considered the case for lower-skilled occupation.

1.4 Industrial trends and adoption of AM integrated with emerging Industry 4.0 technologies

Additive manufacturing – The effects of additive manufacturing capabilities, in particular with advances in 3D printing and new materials, enable mass customisation and weight reduction that, combined with the integration of data and IoT, provides higher efficiencies, greater utility and more ecologically friendly production (Khorasani et al., 2022). For example, AML3D, a leading company in freeform large-scale metal printing based in Edinburgh, SA, has undertaken trials and research projects with BAE Systems Australia - Maritime and Flinders University to further develop its large-scale metal additive manufacturing capability through added features such as in-process measurement, monitoring and adjustment that will improve printing quality (AML3D, 2021).

Cyber-physical systems, human-machine integration – In the context of Industry 4.0, cyber-physical systems (CPS) embrace several contemporary automation, data exchange, and manufacturing technologies, allowing a broad field of manufacturing technologies, with humans performing versatile operations with heterogeneous production infrastructure from different suppliers, and spatiotemporal relationships between objects in the system (Jeschke et al., 2017). CPS and human-machine integration will transform work toward technology-mediated interactions that are less physically demanding, abstract, loosely coupled and cognitively challenging. HFE will be essential for transitioning to Industry 4.0 and integrating solutions to address industrial impacts (O'Keeffe et al., 2020). In line with these interactions, Flinders University collaborates with the industry supply chain to examine the role that HFE plays in the uptake and diffusion of advanced manufacturing and digital technology capabilities.[2]

Biosensors and wearables – Combining numerous devices into wireless, easy-to-use garments based on IoT can capture real-time data from workers offering multi-parameter monitoring, including high-resolution ECG, respiration, and other vital signs. These new wearable technologies optimise industrial training, maintenance and production by supporting safety procedures and improving manufacturing efficiency (Canadian Space Science, 2021; Equivital, 2023). Currently, ASC Shipbuilding has invested heavily to support the vision of digital manufacturing and sustainment processes at the Osborne shipyard together with 'Line Zero – Pilot Factory of the Future', as a test site to test and validate the implementation of wearable devices and other technologies to leverage manufacturing and workforce capabilities (Flinders University, 2020).

Metaverse, digital twin and synchronous augmented bases on mixed reality systems – Metaverse enables the significant potential for industries integrated with powerful artificial intelligence and advanced virtual reality technologies to create realistic workspaces and scenarios (Siemens, n.d). Augmented reality (AR), virtual reality (VR), and mixed reality (MR) technologies are becoming more mature and opening new ways for remote collaboration, comprising environment, virtual objects, interaction, and avatars to designing and implementing synchronous remote collaboration systems (Schäfer et al., 2022). The digital twin is perhaps at the heart of the industrial metaverse and simulations in real-time (Siemens, n.d). A digital twin is a virtual representation of an object or system that spans its lifecycle, is updated from real-time data, and uses simulation, machine learning and reasoning to help decision-making (IBM, n.d). In manufacturing, very accurate simulations based on realistic environments can provide a safe workplace or suitable visualisations in real-time for training, maintenance, or development. Currently, the Digital Transformation Laboratory at Tonsley Innovation District in Adelaide, SA

[2] https://www.flinders.edu.au/australian-industrial-transformation-institute/human-factors-in-advanced manufacturing

tests virtual manufacturing scenarios designed for industrial applications that are changing the face of modern naval shipbuilding (BAE Systems, 2023).

Smart factories – One of the key constructs in Industry 4.0 is the smart factory, envisioned as a future state of a fully connected manufacturing system, mainly operating with edge technologies, transferring, receiving and processing necessary data to conduct all required tasks for production (Osterrieder et al., 2020). Line Zero - Pilot Factory of the Future at Flinders University brings innovation, Industry 4.0 technologies, research and training together to advance manufacturing and strengthen the nation’s economy (AITI, 2021). In addition, The Factory of the Future delivers reconfigurable advanced manufacturing tests, training and industry growth facility, benefiting from collaborations with research expertise and opportunities to integrate into domestic and international value chains (Factory of the Future, n.d).

1.5 How to leverage innovation capabilities to absorb AM technologies towards industry transformation?

Although promising innovations are emerging, there is still a need to leverage absorptive and dynamic capacities for innovation as critical factors for industrial transformation. Adoption and diffusion of AM across Australia is dependent on the presence of many factors, including strategic decision making, governance models, collaboration, resource allocation, workforce capability, and alignment between expectations and outcomes across diverse stakeholders. Essentially, to adopt this new industry paradigm, industries need to be prepared with appropriate skills and capacities – essential pre-requisites to attending to the new demands of industry and society’s needs.

In this context, technical capabilities and know-how play a fundamental role in enabling technological absorption and innovation outcomes, in which technological diversity and integration are essential in this process (de Macedo Soares et al., 2016; Bellini et al., 2019; Pereira et al., 2021). Innovation and industry transformation involve more than just the use of technology; AM adoption and diffusion incorporates motivations, incentives, governance, capacities, dissemination, investment and concrete financial and social benefits (Halpern et al., 2021).

Below, we suggest nine critical factors towards industry transformation that facilitate the adoption of AM into the innovation and industrial transformation paradigm:

1. Suitable innovation policies involving government-academia-industry-society, dissemination, and incentives.
2. Ecosystem maturity and market competitiveness to absorb and diffuse AM technologies.
3. National and global collaborations.
4. Human factors and ergonomics through optimising human and technology interaction.
5. Dynamic capabilities for innovation and knowledge management.
6. Adequate resources, including infrastructure, human capital, and investment.
7. AM assimilation and technology appropriation capabilities
8. Technological integration and diversification.
9. Capability to transform new knowledge and resources into innovation outcomes.

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