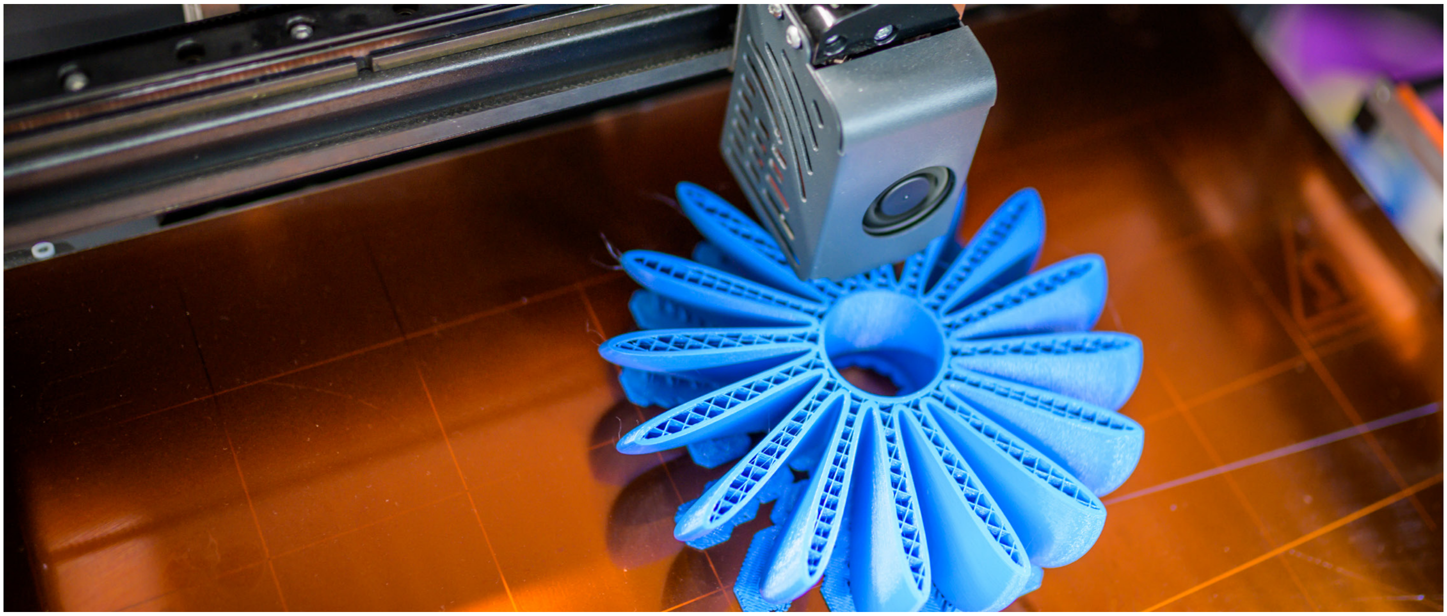


Remote operations? Aging equipment? No problem

Additive manufacturing enables a more resilient, secure, and efficient supply chain

The military base in Alert, Nunavut. Troop deployments to conflict zones around the world. Unexpected **increases in operational needs** depleting stock levels of aging equipment that's no longer supported by its manufacturer.

Leaders in such military operations shouldn't have to be worrying about getting parts if an armoured personnel carrier breaks down or when they're far from a supply depot.

Additive manufacturing (AM) is a promising solution to these decades-old problems. Also known as 3D printing, it enables complex parts to be produced at volume—and because it uses deployable technology and common raw materials to produce any number of specialized parts, it's portable and versatile.

This type of manufacturing is particularly well-suited to organizations—such as the Government of Canada—that operate large, complex equipment fleets because it can help extend the service life of those assets, simplify inventory planning, and improve support to assets operating in remote locations.

The future of manufacturing will be characterized by the **commoditization of part production**, with more of the value residing in the content or technical data than in how many parts need to be kept on the shelf. This means AM will gain a more prominent role in the supply chain and in risk mitigation.

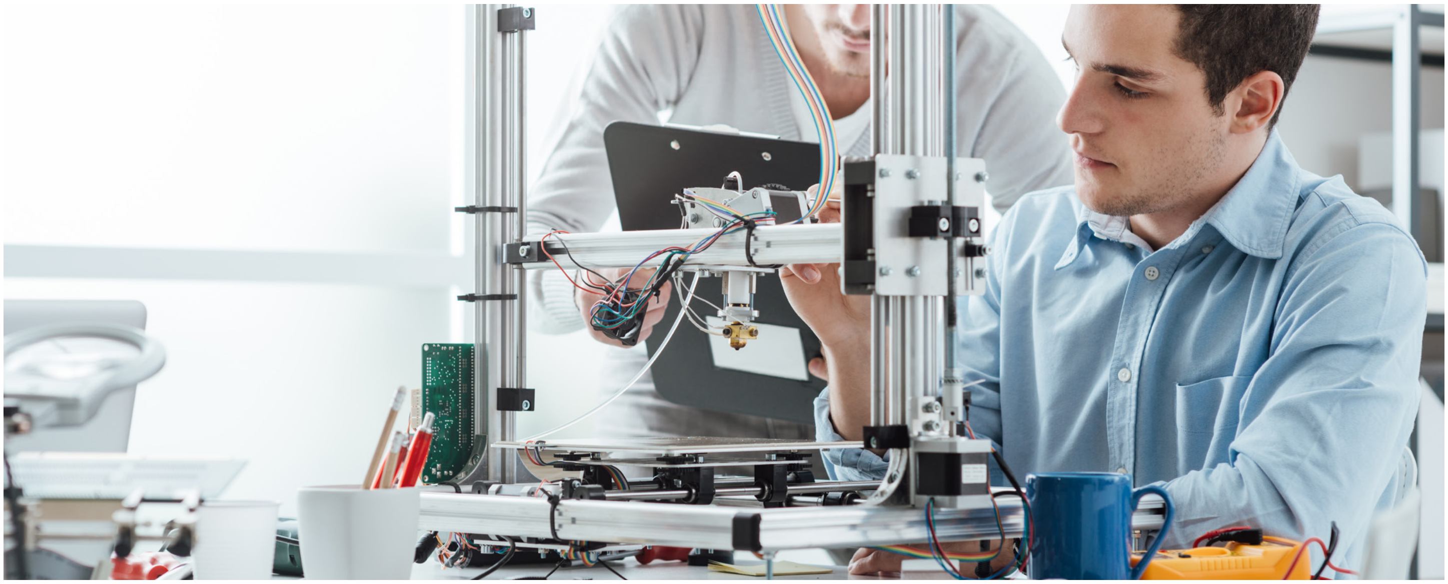
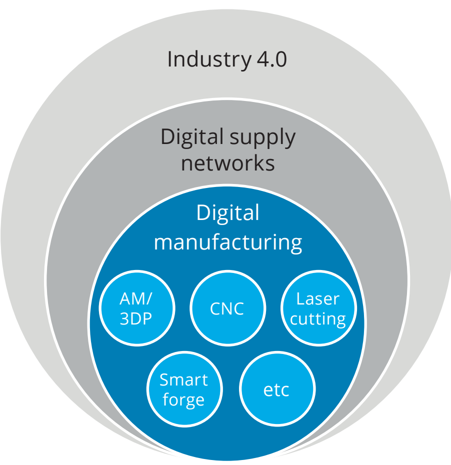


Figure 1. Additive manufacturing and the latest industrial revolution



Industry 4.0, which is driven by advances in IT, data availability, and analytics, is characterized by smart automation and broad impact across the supply and manufacturing value chains.

Digital technologies can collapse traditional supply chains into a **digital supply network** that establishes a "digital thread" through physical and digital channels, connecting information, goods, and services in powerful ways. These networks are dynamic, integrated, and characterized by a high-velocity, continuous flow of information and analytics.

Digital manufacturing includes laser cutting, smart forging, and more as well as AM.

Additive manufacturing (also known as 3D printing):

A category of manufacturing processes that share the same iterative, layer-based approach. An object or part is first conceived as a computer-aided design (CAD) model and then brought into physical form by adding material layer by layer.[1]

The word additive serves to contrast this category of manufacturing processes from traditional subtractive (machining, milling) and formative (casting, stamping, injection-moulding) manufacturing.[2] It's becoming increasingly accessible as the price of 3D printers drops, printing techniques improve, and different types of materials (e.g., plastics, metals)—even combinations of different materials in one object—become printable.[3]

1. International Organization for Standardization, "ISO/ASTM 52900:2015–Additive Manufacturing–General Principles–Terminology," 2015.
2. Herron, C.; Ivus, M.; Kotak, A., Just Press 'Print': Canada's Additive Manufacturing Ecosystem, Information and Communications Technology Council (ICTC), 2021
3. Deloitte Netherlands, Additive manufacturing for spare parts

Serious supply challenges

In meeting domestic and international obligations, Government of Canada departments own, operate, and sustain a wide range of such complex capital fleet assets. These are often operated to and beyond their designed operational life, which poses a variety of challenges that can create significant risks:

- Mission-readiness is impeded when ships and other units must operate in remote locations for prolonged periods with limited ability to deploy with the necessary inventory on hand
- Logistical challenges complicate the delivery of spare parts to assets deployed in remote locations and operating in harsh conditions
- Inventory holding costs are high for stockpiling replacement parts for prolonged periods, during which the parts' reliability can be expected to diminish
- Trade-offs must be managed between ensuring the availability of replacement parts and the risk of obsolescence, write-offs, and disposal costs as certain stockpiles outlast the operating life of the assets must be managed
- In-service support contracts for assets that are operated beyond their forecasted useful life must be managed, which includes: retaining access to the intellectual property necessary to produce and manage the replacement parts; securing continued sources of supply for replacement parts as well as the supporting infrastructure (e.g., tools, dies) to manufacture them; and agreeing on service and performance standards with suppliers to deliver replacement parts in a timely manner.

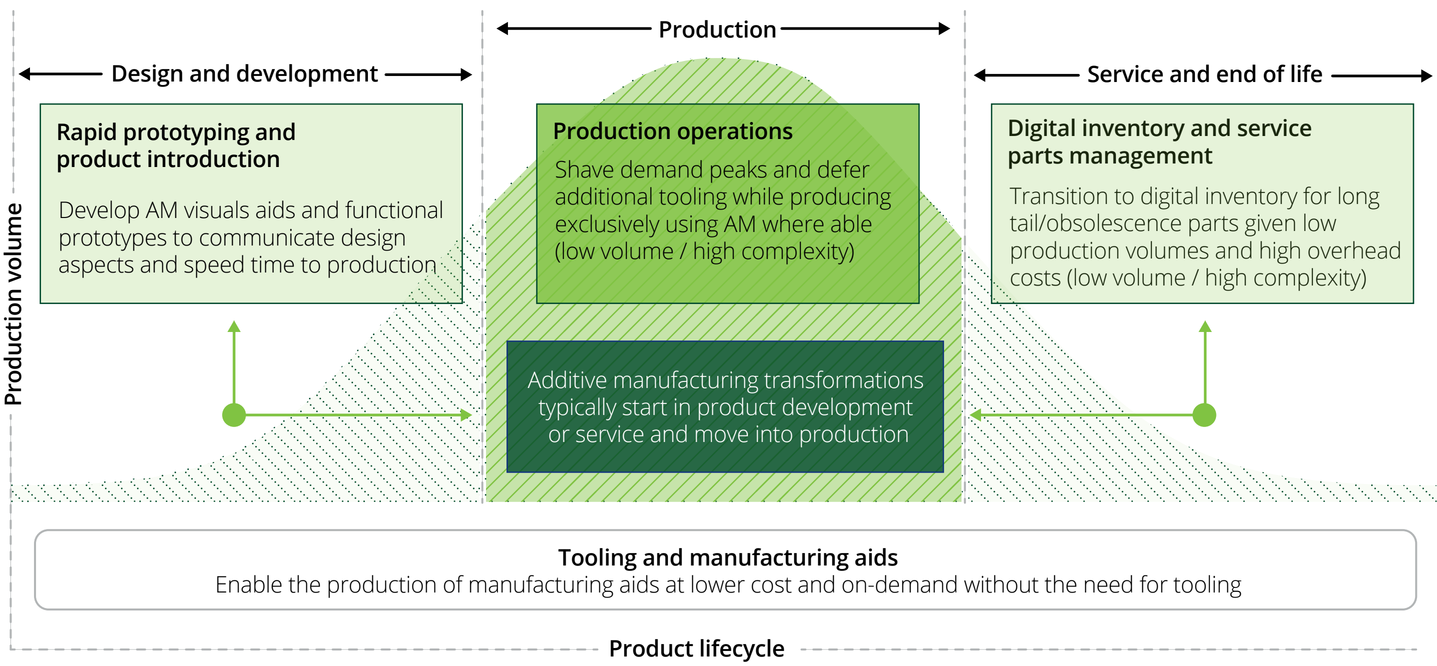
Potential application

Some National Shipbuilding Strategy decisions on the recapitalization of the Royal Canadian Navy and the Canadian Coast Guard mean that most ships currently in service will be expected to operate well into their fourth decade. This makes support from the original equipment manufacturer increasingly difficult because many will have long since stopped production runs or even operations altogether.

AM could be considered as the solution for manufacturing ship parts as necessary. The printers could be housed at naval bases or even on-board.

Logistical challenges complicate the delivery of spare parts to assets deployed in remote locations and operating in harsh conditions.

Figure 2. The benefits of AM over an asset's life cycle



In the resilient, responsive supply chain

Many assets with a broad commercial base, such as car fleets and personal computers, have well-established and varied networks of suppliers and supply chains that can support them over their expected life cycles.

Other assets, such as specialized equipment platforms, military aircraft, RCN warships, and CCG ships—the kinds of capital assets the Government of Canada operates—are more complex, with a much narrower supplier base and lower volumes of production. In addition, their life cycle management will include a period of obsolescence toward the end that can at times be measured in years.

Additive manufacturing is well-suited to these circumstances. It will substantively mitigate the risks by creating an alternative source of supply (see Figure 2) that can be physically located much closer to where the need is. It can also produce exactly the quantity of parts needed, negating the need for inventory stockpiling—like parts manufacturing on demand.

In capital asset management

Incorporating provisions for the use of AM into asset procurement and in-service-support strategy decisions and design is sound public fiscal policy. Enabled by modest investments in AM capabilities and secure access to the intellectual property of the parts to be manufactured, it creates the best conditions for efficient, effective operations and complex long-run supply chain management.

Leaders should also consider cultivating internal expertise in areas such as intellectual property and contracting mechanisms, which will grow the government's ability to make informed decisions in the long term on where and how to integrate AM into the government supply chain framework.

Vision

To improve the cost-effectiveness of in-service support and the supply chain, thereby improving the availability and effectiveness of fleet, vehicle, and other assets while managing the risks of their obsolescence.

Ambition

- To improve the ability to operate assets for longer in remote locations.
- To facilitate the delivery of replacement parts to assets deployed in remote locations and under challenging conditions.
- To reduce inventory levels and warehousing costs.
- To increase the availability of the fleet, vehicle, and other assets with a more responsive and reliable supply chain.
- To mitigate the risks of obsolescence.

Figure 3. The key benefits of additive manufacturing

Increase functionality	Reduce costs	Increase service level	Reduce risk
• New design possibilities at no additional costs • Lightweight • Organic forms • Internal structures	• Lower inventory costs • Lower transportation costs • Reduced cost of customization • Material saving • Reduced downtime	• Increased speed of delivery of spare parts • Obsolete spare parts become available again	• OEM-certified parts • Reduced downtime • Reduced supply chain complexity

When determining how to nurture internal expertise, the following principles are helpful to keep in mind:

- Assess the potential for AM where appropriate in in-service support and supply-chain sourcing decisions and strategies
- Develop and implement complementary competencies (e.g., intellectual property management, 3D scanning)
- Assess the potential for AM to contribute to effectiveness and efficiency; think of it as a means, not an end
- Understand when developing internal AM capabilities is necessary and cost-effective, and when it's better to source them from the market
- Understand when to centralize production and when to distribute it, and how the approach should evolve over the operating life of the asset
- Track advances in the development of AM to identify opportunities to increase its value and potential for use over time

Continued improvements in the processes and capabilities of additive manufacturing will create new opportunities to increase the responsiveness of supply chains, while integrating it with in-service support and sustainment operations may substantively improve overall through-life performance.

Given its advantages in mitigating the myriad challenges of operating capital assets in far-flung locations, we expect additive manufacturing to become an important component of the sustainment strategy for the Government of Canada long into the future. And, with the advantages of AM incorporated into the supply chain, leaders can be more confident the military base in Alert, the troops in the field halfway around the world, and the unexpected increase in operations can be resupplied quickly and efficiently.

Contact us:

Jonathan Hopkins
Government and Public Services Leader, Supply Chain and Network Operations
Email: jphopkins@deloitte.ca

Acknowledgements

Jim Kilpatrick
Global Leader,
Supply Chain & Network Operations

Allan Benson
Director, Consulting
Defence, Security & Justice Sector