Sources	University of Bristol, UKRI	Date	November 2020

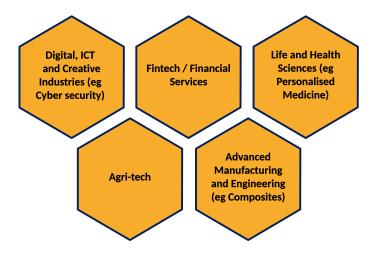| Potential scale of impact	Certainty of outcome	Impact horizon		
★★★★	★★☆☆	H1	H2	**H3**

Swarming is a collective behaviour exhibited by insects and birds when they aggregate together to accomplish tasks such as migration. One field of robotics that is maturing fast is dedicated to building swarm intelligence - multi-robot systems that can interact with each other for problem-solving. Swarm robots can investigate and analyse complex systems and determine appropriate courses of action. Research at Bristol University is aimed at using artificial evolution to develop robots with the capacity to learn swarm behaviours. Robotics could replace humans in work too dangerous to do such as toxic waste clean up. A swarm could, for example, investigate a toxic waste site autonomously and instruct and execute clean up efficiently and without any human intervention.

The potential is enormous. Researchers in Germany have developed micro and nano-sized robots that can autonomously move in the opposite direction to the way a fluid flows. This makes them particularly promising for intervening inside the human body. Among other things, these robots could be used to carry drugs, genes or other substances to specific sites inside the body, opening up new possibilities for treating different medical conditions.

Future robotics may allow machines to learn from problems they confront, write their own instructions and then respond to sudden external changes. This means that autonomous systems can change their behaviour from what was initially programmed, thus becoming independent from human controllers. They would not be limited to what is written in their system; they would become smarter, artificially intelligent and perhaps even more 'aware'.

This raises important issues around ethics and the design of trustworthy machine systems. UK Research and Innovation's (UKRI) Trustworthy Autonomous Systems (TAS) programme has granted each of six university research nodes £3 million in funding, in order to look at the processes used to design fully autonomous systems and the associated legal, ethical and social contexts for the possible applications of independently acting machines.

Digital, ICT and Creative Industries (eg Cyber security)

Fintech / Financial Services

Life and Health Sciences (eg Personalised Medicine)

Agri-tech

Advanced Manufacturing and Engineering (eg Composites)

TRUSTWORTHY AUTONOMY

Machines that act independently need to be ethical and trustworthy