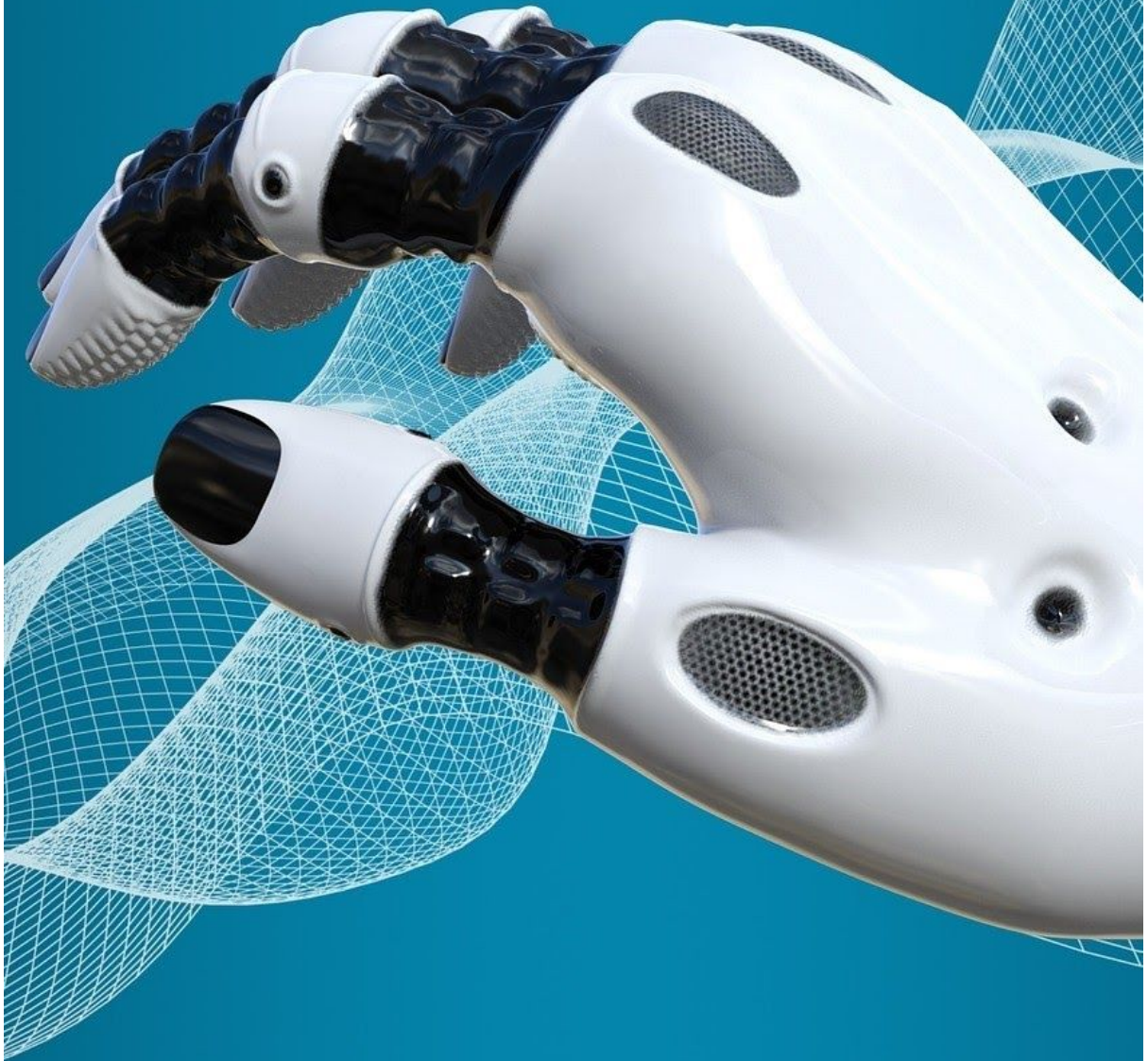


# NRN Roadmap



2020



## Introduction from the NRN Chair



Last year, the National Robotics Network (NRN) undertook a strategic mapping exercise of robotics and artificial intelligence (RAI) for the UK in a wide range of sector applications.

The primary aim of this exercise was to facilitate a desiloing of R&D efforts across these diverse sectors and promote the development of a cross sector supply chain for RAI technologies.

The analysis comprised detailed roadmapping of individual projects from a range of NRN members (representing different industry sectors) plus a workshop and conference calls to refine and

amalgamate the data received. The key findings were:

1. There was significant commonality in needs across many industries. In addition, the type of technologies being proposed to address those needs were also similar.
2. Primarily, the main differences across sectors exist in a difference of scale (large versus small), problem-specific needs and the regulatory environment.
3. There is clearly a substantial opportunity to focus research and development on a limited number of areas to yield particularly high benefits.

This roadmap explains those key themes and details the areas for further work. It also provides a framework for collaboration to support cross-sector development of technologies.

**Kevin Blacktop**

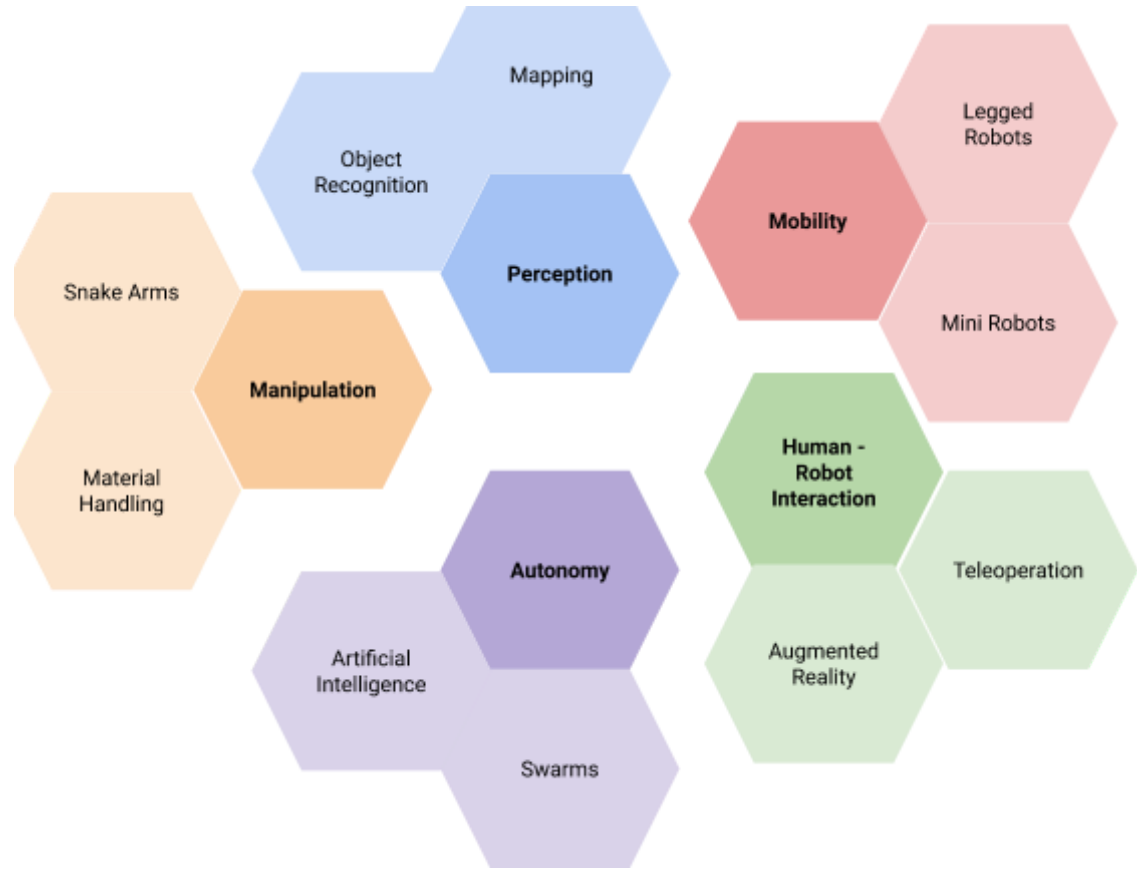
NRN Chair

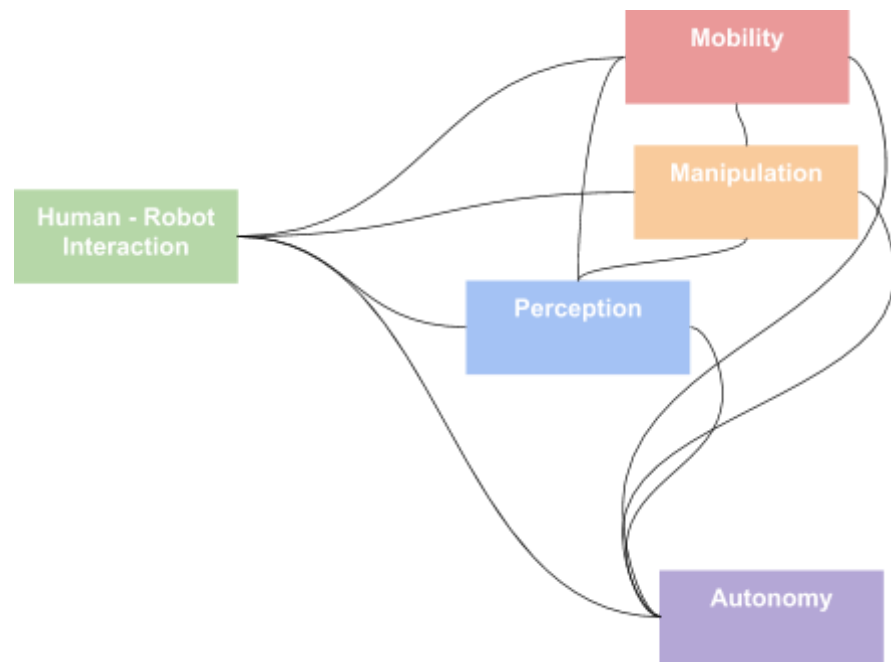


## Our Focus Areas

Focussed research and development in key themes offers a high rate of return since they will have applications across multiple industries.

We have identified **5 Key Themes** and **10 areas for collaboration** that have a significant opportunity for development across multiple industries.





The Themes are interrelated and development work will often require collaboration with other technical areas to provide a full-system capability.



## Our Matrix of Opportunities

The Themes, and associated development areas are applicable to many industries. The matrix below illustrates the main sectors appropriate to each development focus area.

Industry	Perception		Mobility		Manipulation		Autonomy		Human - Robot Interaction	
	Object Recognition	Mapping	Mini Robots	Legged Robots	Shake Arms	Material Handling	Artificial Intelligence	Swarms	Augmented Reality	Teleoperation
Aerospace										
Agriculture										
Archaeology										
Automotive										
Chemical / Pharmaceutical										
Computer/Software										
Consumer										
Conservation										
Defence/Homeland Security										
Education										
Entertainment / Sport / Recreation										
Ecology & Environmental										
First Responders / Emergency Response										
Financial / Insurance										
Food										
Foundry										
Healthcare										
Hospitality										
Humanitarian / Aid										
Information Technology										
Manufacturing										
Marine										
Media / Film & Creative										
Mining										
Municipal Waste / Recycling										
Nuclear										
Oil & Gas										
Rail										
Real Property / Infrastructure / Construction										
Retail										
Renewables										
Scientific Research										
Security										
Space										
Telecommunications										
Water & Sewerage										
Wholesale, distribution & logistics										
Service										



## Our Focus Area Outcomes

### Perception

Robots and robotic devices need to be able to know where they are and also to recognise what they are seeing or sensing.

#### Object Recognition

Goal: The ability for the robotic device to see and recognise its environment and see the things within it.

##### Desired Outcomes

Near Term (1-3 years):

- Real time video generic solutions
- Intelligent point clouds generic solutions
- Multisensor data integration generic solutions

Medium Term (3-5 years):

- Aerospace specific solutions
- Medical specific solutions
- Nuclear specific solutions

Long Term (5 years +):

- Extreme environments specific solutions

#### Mapping

Goal: The ability for the robotic device to know where it is within the surrounding environment.

##### Desired Outcomes

Near Term (1-3 years):

- Multi sensor fusion generic solutions
- SLAM back-end correction generic solutions
- Smaller / cheaper sensors generic solutions

Medium Term (3-5 years):

- Aerospace specific solutions
- Oil & Gas specific solutions
- Nuclear specific solutions

Long Term (5 years +):

- Extreme environments specific solutions



## Mobility

Robots and robotic devices need to be able to manoeuvre in small tight spaces and/or on uneven terrain.

### Mini Robots

Goal: The development of very small robotic devices that can move in small confined spaces.

#### Desired Outcomes

Near Term (1-3 years)

- Miniaturisation of platforms generic solutions
- Miniaturisation of sensors generic solutions
- Communications generic solutions

Medium Term (3-5 years):

- Power generic solutions
- Integration development generic solutions
- Aerospace specific solutions
- Medical specific solutions

Long Term (5 years +):

- Defence specific solutions
- Extreme environments specific solutions

### Legged Robots

Goal: The development of robotic devices (small and large) that can move over uneven terrain and climb stairs.

#### Desired Outcomes

Near Term (1-3 years)

- Locomotion development generic solutions
- Balance & coordination generic solutions
- Power & efficiency generic solutions

Medium Term (3-5 years):

- Reliability generic solutions
- Defence specific solutions

Long Term (5 years +):

- Industrial specific solutions
- Extreme environments specific solutions



## Manipulation

Robotic devices that can manoeuvre in complex spaces to move, handle, cut or otherwise manipulate the object of interest.

### Snake Arms

Goal: The development of a manipulator (small and large) that can move through confined, complex spaces.

#### Desired Outcomes

Near Term (1-3 years)

- Mini snake arm development generic solutions
- Mini end effector generic solutions
- Large end effector generic solutions

Medium Term (3-5 years):

- Aerospace specific solutions
- Medical specific solutions
- Nuclear specific solutions
- Defence specific solutions

Long Term (5 years +):

- Extreme environments specific solutions

### Material Handling

Goal: The development of robotic devices for handling or machining solid material.

#### Desired Outcomes

Near Term (1-3 years)

- Soft grippers generic solutions
- Haptic feedback generic solutions
- Laser cutting (large & small) generic solutions

Medium Term (3-5 years):

- Learning to Learn generic solutions
- Aerospace specific solutions
- Medical specific solutions
- Nuclear specific solutions
- Agriculture specific solutions

Long Term (5 years +):

- Extreme environments specific solutions





## Autonomy

Robots and robotic devices with the cognitive ability to operate by themselves either individually or collectively.

## Artificial Intelligence

Goal: The development of robotic devices with cognitive ability.

### Desired Outcomes

Near Term (1-3 years)

- Machine learning generic solutions
- Data management generic solutions
- Deep learning generic solutions

Medium Term (3-5 years):

- Plug & play algorithms generic solutions
- Medical specific solutions

Long Term (5 years +):

- Aerospace specific solutions
- Extreme environments specific solutions

## Swarm Robotics

Goal: The ability for many robotic devices to work as a single entity.

### Desired Outcomes

Near Term (1-3 years)

- Local sensing generic solutions
- Communications generic solutions

Medium Term (3-5 years):

- Centralised control generic solutions
- Defence specific solutions
- Aerospace specific solutions

Long Term (5 years +):

- Water specific solutions
- Urban specific solutions

## Human - Robot Interaction



Robots and robotic devices that can operate in an environment without a human physically located in the same environment.

## Augmented Reality

Goal: The ability for users to interact in a real world environment without being present.

### Desired Outcomes

Near Term (1-3 years)

- Headset, glasses & contact lens generic solutions
- 3D modelling generic solutions
- Computer vision generic solutions

Medium Term (3-5 years):

- Defense specific solutions
- Aerospace specific solutions
- Medical specific solutions
- Nuclear specific solutions

Long Term (5 years +):

- Space specific solutions

## Teleoperation

Goal: The ability for users to operate a robotic device from anywhere in the world.

### Desired Outcomes

Near Term (1-3 years)

- Haptic feedback generic solutions
- Tactile sensor generic solutions
- Communications generic solutions

Medium Term (3-5 years):

- Aerospace specific solutions
- Medical specific solutions
- Defence specific solutions

Long Term (5 years +):

- Nuclear specific solutions

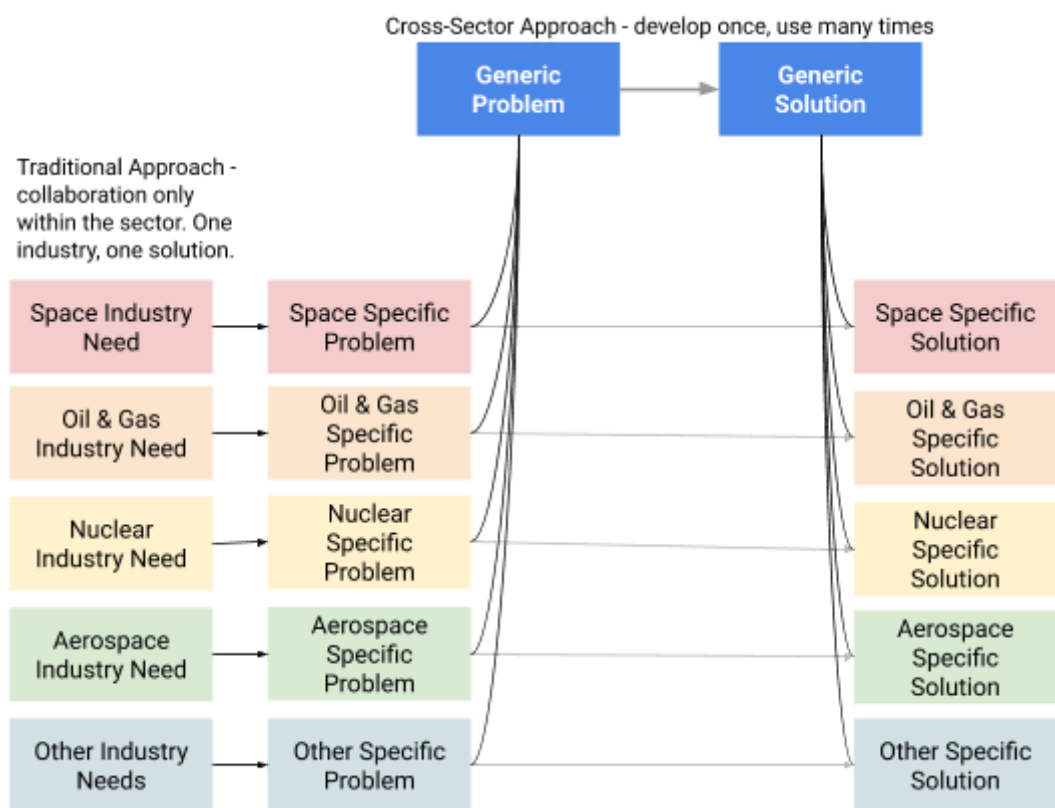
## Our Process for Collaboration

Across different industries the needs are often remarkably similar. Unfortunately it is often difficult or impossible to recognise this fact due to the specialised terminology used (Jargon). The needs (and subsequent research & development activities) are



explained in a particular communicative context and may not be well understood outside that context. This is what leads to silo working and limited collaboration.

This diagram illustrates how the NRN plans to overcome this barrier - it is called abstraction. Specific industry needs (and therefore their industry specific problems) are analysed to identify higher level functions. Solutions to these higher level problems are then developed collaboratively before specific industries are then developed further.



## Execution Strategy

Focussed research in the development areas identified in this roadmap offers a much higher rate of return on investment than normal since the work has multiple applications across more than one industry. To realise this benefit - to add value to the UK - it requires support from a number of groups.

## Government Policy Advisors



1. **Funding/Grants:** provide additional funding for innovation that provides for cross-industry innovation. Funding = Growth.
2. **Hubs/Catapults:** ensure there is a mechanism, intrinsic in the separate hubs, to facilitate cross-hub working, improve alignment and reduce duplication of effort. Less duplication means there is more money available for new innovation.
3. **Strategic Upscaling:** provide support to the supply chain in technology transfer / commercialisation to understand and develop cross industry pipelines.

## Industry Supply Chain

1. **Needs:** fully expect that your industry specific needs are, in fact, often quite similar to those in other industries. Understand what the needs are in other industries and what they are developing.
2. **Collaboration:** work with other industries to solve generic needs rather than solely considering your own industry specific need. This is much more efficient.

## NRN Board

1. **Industry Communication:** establish Working Groups for each priority are to improve communication and reduce duplication of effort.
2. **Policy Liaison:** identify potential funding programmes that will demonstrate the benefits of cross industry technology development.
3. **Barrier Mitigation:** resolve to mitigate barriers to collaboration.