Drury, K. L., Richards, A. G., & Ball, M. (2022). *T-B PHASE Annual Report 2021*.

Publisher's PDF, also known as Version of record

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T-B PHASE: Thales - Bristol
Partnership in Hybrid Autonomous Systems Engineering

Annual Report 2021

Business lead: Thales
University lead: University of Bristol

Summary

T-B PHASE is a £5M EPSRC prosperity partnership between Thales and the University of Bristol that aims to deliver design principles and processes for hybrid (human-machine) autonomous systems engineering. The research programme, which started in October 2017, is addressing the challenge of engineering confidence in hybrid autonomous systems, combining fundamental research studies with applications to live use cases within Thales. These include digital rail, maritime mission systems, intelligent surveillance and reconnaissance and unmanned traffic management.

Why T-B PHASE?

Hybrid autonomous systems (HAS) include groups of people and autonomous software or robots in direct, ongoing interaction. This might be, for example, a mixture of autonomous and human-operated trains and trams in an integrated transport system.

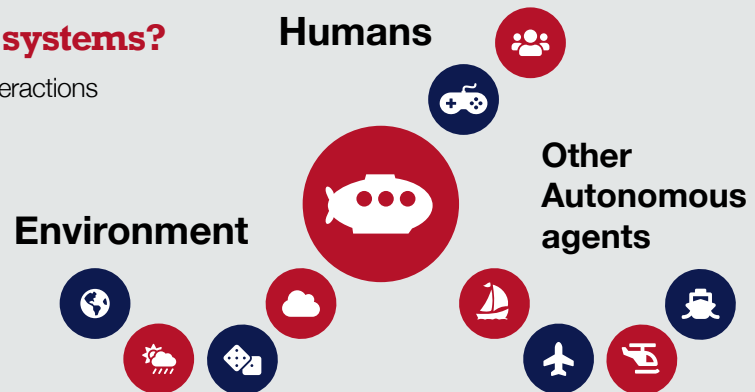### What are hybrid autonomous systems?

Autonomous implies behaviour shaped by interactions

- Not just following fixed instructions

Hybrid means three key interactions with:

- Humans
- Environment
- Other autonomous agents

System covers multiple agents

Emerging technologies in Robotics, Artificial Intelligence (AI) and Information and Communications Technology (ICT) mean that hybrid autonomous systems will become common in a wider set of situations, including a diverse set of Thales products in different application domains and business units. Smooth, reliable and safe interaction between machines and people teams will be key to their success. As Thales, its customers and its supply chain enter this new design space, a crucial challenge for engineers of hybrid autonomous systems

is to have confidence in the system behaviour, requiring fundamentally new, cross-domain approaches to the design and development of these systems.

Through T-B PHASE, University of Bristol and Thales have committed to share expertise and jointly pursue fundamental research questions in the context of highly practical design problems to significantly advance the capability to operate confidently in one of the most important emerging areas for modern engineering.

Delivering impact

In response to these challenges, T-B PHASE is working on:

- Innovative new design principles and processes
- New analysis and design tools
- Human factors studies
- Developing and growing a team of people

The partnership between academia and industry has enabled us to implement a programme of impact and integration activities that respond to the real stakeholder needs, in which the research team can engage with a set of use cases that span the future of HAS.
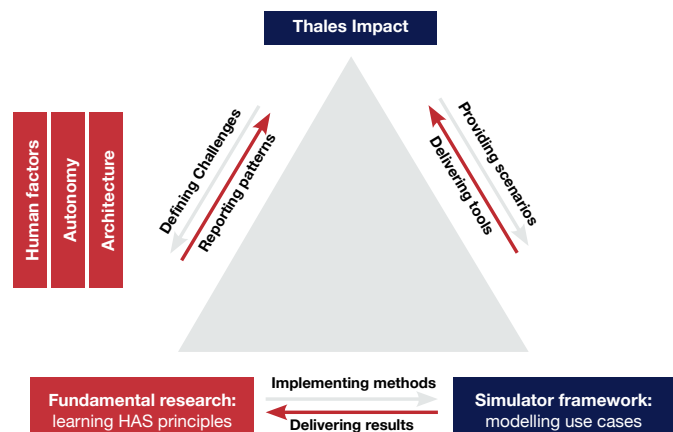
Our three key collaboration topics

1. Empowered Agency in Hybrid Autonomous Systems

The work aims to research the use of empowerment to improve performance (and integrity) in multi-agent hybrid autonomous systems. Empowerment is quantity which captures the level of control an agent has over the world it can perceive. It proposes to be a universal measure which is both agent and task agnostic. This makes it both intriguing and potentially exciting to T-B PHASE, leading to an understanding of when the (human) operator should intervene in the operation of a system in order to ensure effectiveness.

**Expected benefits to business use cases are:**

- It will allow the operator to determine when intervention is appropriate

- It will enhance likelihood of a hybrid autonomous system achieving its objectives

- It will potentially prevent the system from taking inappropriate actions which could lead to significant reduction in mission success or collateral damage

- It will lead to improved measures of effectiveness and hence improved mission outcomes with reduction in operator workload

- It will place improved trust in the hybrid autonomous system

## 2. Simulating and Communicating Agent Failure

This cross-project activity will integrate the T-B PHASE research to date into a common software framework. Focus on failures affecting performance of agents will be paramount to enable understanding of impacts in relation to real world use cases. The results expect to help inform the creation of more robust hybrid teams, particularly in the search and rescue use case, and in surveillance.

Expected benefits to business use cases are:

- Evaluate compatibility of algorithms, design patterns for common scenarios and distinct performance regimes

- Promote early adoption by showcasing the range of T-B PHASE work in an environment transferable to Thales
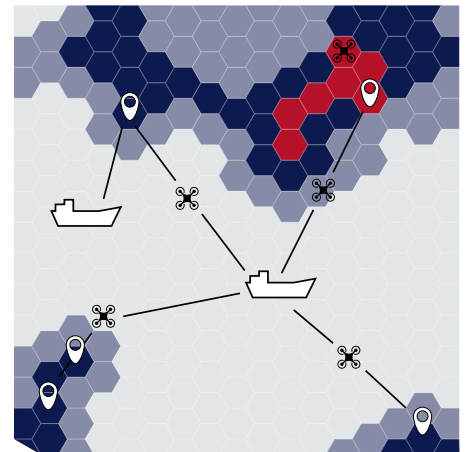
3. Human Swarm Control Training Strategies
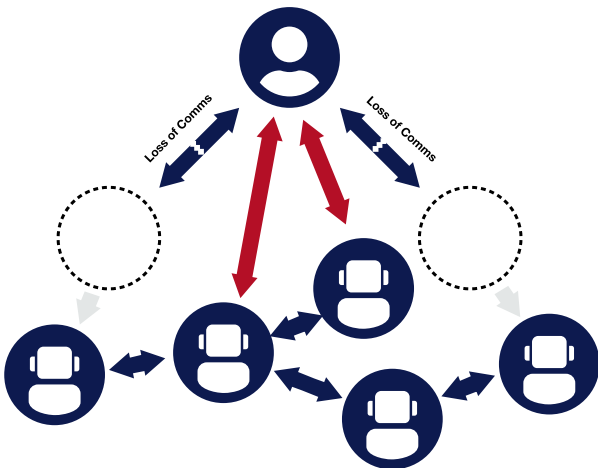
This multi-disciplinary project combines swarm robotics and psychology to design more intelligent swarms that are capable of dealing with real world tasks. It will attempt to improve the assessment of how the swarm changes strategies and how the human intervention can mitigate any potential failures.

Expected benefits to business use cases are:

- Development of design guidelines for a human-swarm interface – delivering understanding of what is needed for the human to understand or interact with the swarm without compromising the definitive self-organising nature of a swarm.

Project achievements 2021

Our major achievement of 2021 was to settle the workplan for the second half of the programme, via a structured co-creation exercise between the academic team and Thales stakeholders.

Focus was placed on joining together work from the first half of the programme and delivering impact to both Thales and the wider HAS ecosystem.

T-B PHASE Work Plan
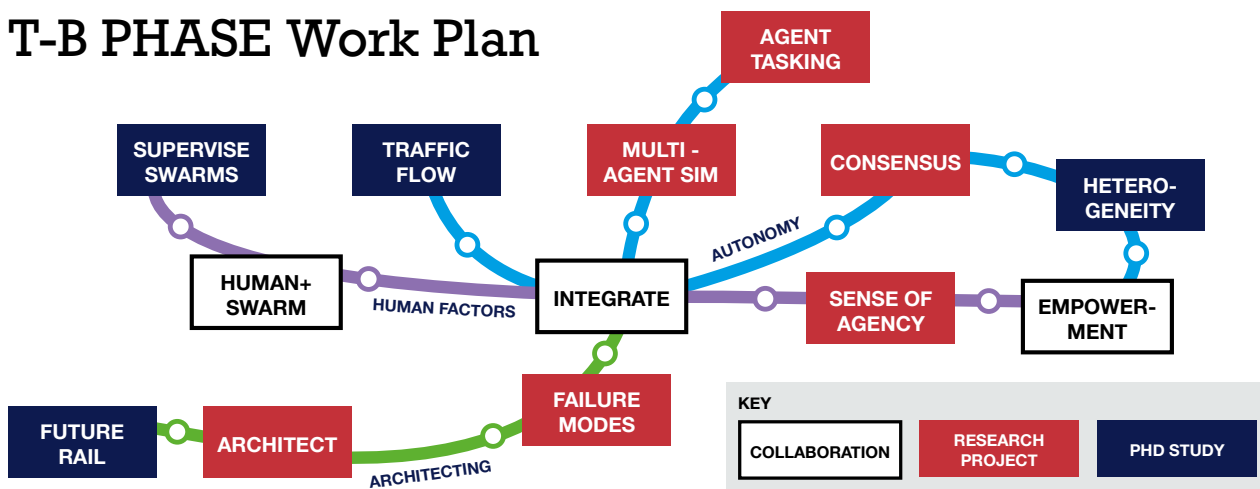
New collaborations

- This year T-B PHASE research has fed into Thales' new Autonomy Technology Centre activity, with team members participating in autonomy roadmapping exercises at Thales. The ATC is a federated innovation centre established in Thales that works collaboratively across industry, academia and government to bring together practical learning and experience across the land, maritime, air and space sectors. The Centre aims to multiply expertise in autonomous systems by focussing on a common approach and leveraging knowledge across the portfolio, ultimately aiming to help business users stay ahead of the curve and successfully bring their autonomous offerings to market. More widely the activity aspires to help UK industry set the standards for trusted, safe and ethical autonomous systems in the Digital Age – standards that will be trusted by users and used to advise Government departments on legislation. One of the key deliverables for the T-B PHASE programme is the transfer of knowledge from the research into the ATC, and we will continue to maximise the opportunities to engage and meet this goal. In addition we have started to build new relationships across the wider ATC network and seek onward collaborative research opportunities together.

- Our Technical Advisory Group was refreshed this year, with a new female chair appointed and new advisory group members taken on to support and steer the research programme as it moves into its final phase in 2022/23.

Staff Highlights

- We have new project leads following a mid-programme refresh: Prof. Arthur Richards (University of Bristol) and Dr Matt Ball (Thales), who will direct the research through the final phase and identify areas for onward development.

- The research team currently stands as 4 PDRAs, 4 PhD students, 7 Thales research engineers/technical specialists, 6 academic co-investigators and a Project Manager.

- This year the programme outputs included 7 peer reviewed papers, 6 talks at national or international level, and regular engagement with senior stakeholders from Thales Group, including use case development activity, cross-programme quarterly reviews and researcher presentations.

- Opportunities are currently being sought to offer placements for our PDRAs at Thales, aiming to both expand the skillset of the researchers to prepare them for future roles in industry and to facilitate existing partnership working.

- A new MSc by Research studentship commencing in January 2022 will support the human factors team and develop new research areas.

Dedication

This report is dedicated to the memory of Angus Johnson, who sadly passed away this year. Angus played a key role as T-B PHASE industry lead during the first half of the programme and managed the Bristol-Thales interface with characteristic humour, whilst steering the research towards Thales business needs. He will be missed by the T-B PHASE team and his long-standing colleagues in Thales RTI.