Autonomous and Intelligent Systems

Closing date: 4th August 2011

Summary

The Engineering and Physical Sciences Research Council (EPSRC) and a number of industrial partners have formed a strategic partnership to fund novel research in autonomous and intelligent systems. It is expected that many academic disciplines will have research ideas to contribute to this call. Funds of up to £6 million from EPSRC and partners, including a range of in kind contributions from partners is available for this call. Proposals will be for up to five years in length and we will be looking for a suite of research to address a number of key challenges. A lead university may be selected for management purposes from the successful grant holders. Successful projects must start by 31st March 2012.

Background

Autonomous and intelligent systems which are capable of independent action in dynamic, unpredictable environments are a challenge in a number of scenarios. Research including:

- software architectures
- sensor exploitation
- situational awareness
- decision making and planning
- information management
- Verification of autonomous systems
- Model building and learning

are areas which proposals must target at least one of.

In order to contribute to the future research interests of the EPSRC partner companies, we are inviting novel research leading to future exploitable technologies for autonomous and intelligent system following successful research programmes.

EPSRC and it partners in this call, BAE Systems, NNL, Sellafield Ltd, Cisco, Scisys and Network Rail are funding the research on an approximately 50:50 basis including funds and access to industrial facilities and advice, and will oversee the research projects as they progress.

Funding available

Funds of up to £6 million from EPSRC and partners, including a range of in kind contributions from partners is available for this call.

The areas in which autonomous and intelligent systems research is required are shown in Table 1. From these areas, a number of scenarios have been identified and these are listed in the appendix to this call. The scope of the call is not for full systems but technologies which will show potential exploitation as parts of a wider autonomous intelligent system.

Table 1: Research Interests in Autonomous and Intelligent Systems

1.0 Software Architectures	This area of research addresses software architectures for housing intelligent autonomous systems software. Software architectures are essential for organising the component software functions that form an autonomous system. A good architectural approach offers modularity, traceability, certifiability and robustness.
2.0 Sensor Exploitation	Autonomous systems are data driven and rely on stored and/or sensed data to create plans and make decisions. Effective exploitation of sensor and stored data improves the performance of an autonomous system through inferring useful information from potentially large volumes of sensor data.
3.0 Situational Awareness and Information Abstraction	Autonomous systems have to create an internal model (world model) of the external environment if they are to simulate a degree of human awareness. Autonomous systems also need awareness of their own current internal state and predicted future state, so that their own capabilities and limitations are understood. This should help to make systems more robust to failures and capable of self-sustainment A combination of information inferred from real-time sensor data feeds together with stored or communicated reference information provides means, through reasoning, to raise the abstraction level to provide inferred contextualisation and beliefs to inform planning and decision making processes.
4.0 Planning	Processes, algorithms and tools for creating, maintaining and metricating plans. Plan formats in this sense are generic, and could be seen as a set of simple instructions or steps for a machine to follow. Plans may be expressed at varying levels, including at the level of high-level goals which inform detailed planning within the autonomous system.

5.0 Trusted Decision Making and Human Machine Interaction	Methods techniques and algorithms for machine decision making, and human interaction with the decision making system. Solutions should consider varying degrees of software integrity levels in the chosen solution.
6.0 Information Management	Intelligent methods of managing information transfer from an autonomous system, including managing bandwidth, prioritising communications and observing operating constraints. Optimising transfer of information.
7.0 Verification and Validation of Autonomous Systems	Autonomous systems can be non-deterministic and existing methods of testing systems software may not provide sufficient evidence to support certification. New techniques for the verification and validation of complex decision making and planning software are needed.
8.0 Model Building and Learning	Autonomous systems will carry out their activities by reference to governing reference models of various types, which will place hard and soft constraints on the operation of the system, as well as more general guidance. O ver time, such reference models need to be developed and adapt to new external influences and to learning about effective operation

Applicants who are unsure about the suitability of their research project are strongly advised to contact EPSRC (see contacts section) before submission.

Eligibility

For information on the eligibility of organisations and individuals to receive EPSRC funding, see the EPSRC Funding Guide:
http://www.epsrc.ac.uk/funding/apprev/basics/Pages/fundingguide.aspx

As this call is a targeted funding opportunity provided by EPSRC, higher education institutions, Research Council Institutes and Independent Research Organisations are eligible to apply. A list of eligible organisations to apply to EPSRC is provided at:
http://www.rcuk.ac.uk/research/Pages/Eligibilityforrcs.aspx

How to apply

Submitting proposals

You should prepare and submit your proposal using the Research Councils' Joint electronic Submission (Je-S) System (https://je-s.rcuk.ac.uk/).

When adding a new proposal, you should select:

Council 'EPSRC'

Document type 'Standard Proposal'

Scheme 'Standard Grants'

On the Project Details page you should select the 'Autonomous and Intelligent Systems' call.

Details of which research organisations have registered to use Je-S are available from http://www.so.stfc.ac.uk/jes/jes1/RODetails(Web).pdf.

Note that clicking 'submit document' on your proposal form in Je-S initially submits the proposal to your host organisation's administration, not to EPSRC. Please allow sufficient time for your organisation's submission process between submitting your proposal to them and the call closing date. EPSRC must receive your application by 16:00 on 4th August 2011.

Guidance on the types of support that may be sought and advice on the completion of the research proposal forms are given on the EPSRC website (http://www.epsrc.ac.uk/funding/apprev/Pages/default.aspx) which should be consulted when preparing all proposals.

Guidance on writing proposals

Proposals may be submitted by individual research groups or by a number of groups either within a single university or across a number of universities. The proposal should cover the proposed scientific research programme, including management considerations and milestones.

No more than 8 sides of A4 text for the case for support (11pt minimum font size) will be accepted. Margins should be at least 2 cm.

You should also include a gant chart, 2 page justification of resources and 2 page impact statement.

If your proposal exceeds the page limit, or does not conform to this format, your proposal will not be considered.

Please note the RCUK policy for equipment procurement and funding of new research equipment will apply to this call.

For advice on writing proposals see:

http://www.epsrc.ac.uk/funding/apprev/preparing/Pages/default.aspx

Please note you do not need letters of support from the sponsoring organisations.

Assessment process

All proposals will undergo independent postal peer review, the results of review assessment will be passed to a decision panel.

This panel, including independent assessors, and speakers from both the industrial partners and observers from EPSRC will consider the proposals. The panel will be asked to make recommendations to the funding bodies.

Assessment criteria

The assessment of proposals and the decisions will take account of the priorities and interests of both the EPSRC and it's partners, and will be based on the following criteria:

- Scientific quality - scientific quality and merit.
- A high quality vision to contribute in at least one of the research scenarios outlined in the call.
- Adventurous and novel approaches, applying new technologies to the area.
- Relevance to the partner interests and adherence to the requirements in Table 1.

Guidance for reviewers

Information about the EPSRC peer review process and guidance for reviewers can be found at:
http://www.epsrc.ac.uk/funding/apprev/review/Pages/default.aspx

Additional grant conditions

In addition to the standard terms and conditions for grants, successful applicants and their Research Organisations, must be prepared to work on an intellectual Property (IP) agreement with the industrial partners. You should note that we cannot allow a grant to start without a signed Agreement in place.

Key dates

4th August 2011: Closing date for Submission of Proposals

Mid December 2011: Panel Review of Proposals

31st March 2012: Latest start dates of Proposals

Call partners

The partners in this call are BAE Systems, NNL, Sellafield ltd, Cisco, Scisys and Network Rail. They are funding the research on an approximately 50:50 basis including funds and access to industrial facilities and advice, and will oversee the research projects as they progress.

Contacts

Further details about the process, resources and application procedures can be obtained from:

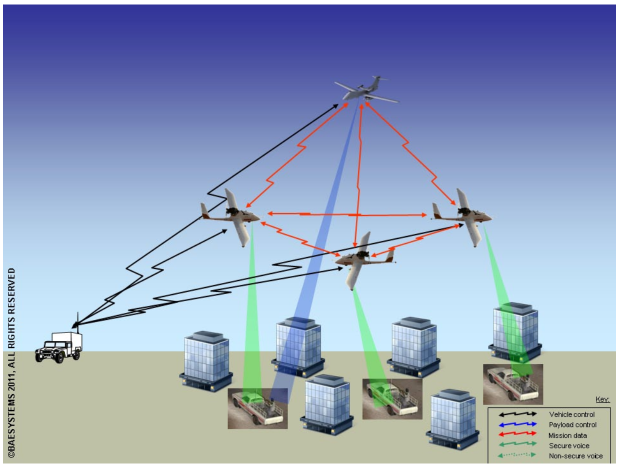
Dr Simon Crook
Aerospace & Defence
EPSRC
Polaris House
North Star Avenue
Swindon
SN2 1ET
Phone: 01793 444425
Email: simon.crook@epsrc.ac.uk

For clarification or queries on the technical scope of the call queries will be passed by EPSRC to the relevant technical partner.

Appendix – Research Scenarios

Please note that the scenarios are simply to give examples of the kinds of conditions your proposed research area could be expected to operate in and an example of the interests of the industrial partners. They are not a prescribed research agenda which must be applied against.

Multi-Vehicle Cooperative Autonomy



Scenario Description

The scenario focuses on the coordinated use of multiple, different, autonomous platforms to gather intelligence (e.g. Images) of the location of potentially hostile forces. The area of operations is large and consists of urban and rural areas.

The vehicles must operate in a safe manner and the overall system must be robust to a relatively rapid change in the number of points of interest, available assets and environmental conditions. It is anticipated that the human controller will delegate some authority to the vehicles and that differing parts of the multi-vehicle system will be operating at different PACT levels.

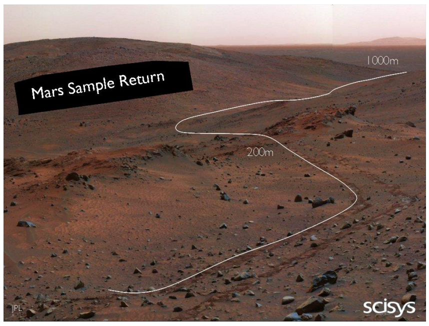
The autonomous vehicles are controlled from a single ground station and the overall work load should be compatible with there being a single human controller.

The problem is how to coordinate sensing tasks, route planning and collision avoidance activities such that the right capability is in the right place at the right time.

Theme	**Research Challenges**
1.0 Software Architectures	On platform and cross platform software architectures to host the autonomy software
2.0 Sensor Exploitation	How to best control and exploit the sensors, particularly across multiple vehicles.
3.0 Situational Awareness	How to extract useful information from the

and Information Abstraction	vehicles' sensors to understand the outside world situation and recognising objects in the scene. Inferring information from the gathered data.
4.0 Planning	Creating real-time planning software to coordinate the platforms and schedule the sensor use.
5.0 Trusted Decision Making and Human Machine Interaction	Minimising the control infrastructure required to operate the vehicles, providing the human in the loop with timely and informative information, and efficient methods of interacting with the autonomous systems.
6.0 Information Management	Managing the information gathered by the sensors and transferring it off the platform making best use of available communication services.
7.0 Verification and Validation of Autonomous Systems	The vehicles must operate in a safe manner and the overall system must be robust. How to V&V the algorithms contributing to the above topics.
8.0 Model Building and Learning	How to design, implement and dynamically update models which constrain the performance of the system, ensure it operates within limits, safely and legally.

A Long Range Mars Rover



Scenario Description

The focus of current Mars exploration activities in the US and Europe is to be able to get samples of scientifically interesting material from the surface of Mars and return it to earth.

The current approach is to divide the mission into two elements, the first is a scientific Rover to scour the surface of Mars for the most interesting samples, which will then be cached somewhere. The second phase is to send a second mission to fetch the cached samples and take them to an ascent vehicle which will return them to earth. The cached samples should be found and recovered rapidly.

The environment is very hostile and communications are limited to short periods typically 15 minutes every 12 hours. In addition the delays to radio signals mean that teleoperation is impossible. The missions must therefore be autonomous and robust yet be operated using systems that require minimal mass, power and processing resources. Getting the mission managers to accept that autonomy is dependable and useful is essential to getting it embarked on the vehicle.

The problem consists of navigating in a GPS free environment, avoiding hazards such as rocks but also less obvious ones like sand traps. The vehicle must ensure it does not simply drive past interesting science but must also repair its operations plan when circumstances change to ensure resources are not exhausted or communications sessions missed.

As part of its Contribution in Kind, SciSys can provide access to a representative platform (including sensors) and domain knowledge of current and future space exploration missions.

Theme	**Research Challenges**
1.0 Software Architectures	Generally single platform to host the autonomy software, but needs to be flexible and allow remote updates.
2.0 Sensor Exploitation	Fusing of Data from different sensors is critical due to low mass/power constraints. Some sensors such as LIDAR are typically too power and processor hungry for use in space.
3.0 Situational Awareness and Information Abstraction	Need to be able to examine surroundings in order to ensure important science is not missed and also trying to avoid hazards like sand traps which cannot be detected on a DEM.
4.0 Planning	Need to be able to modify/repair a plan for up to 24 hours operation in response to changing events. Needs to cover near real-time planning of experiments, sensors and resources such as power, data storage and time.
5.0 Trusted Decision Making and Human Machine Interaction	Interactions are typically possible every 12 hours and are too short to allow teleoperation. Interactions must be robust.
6.0 Information Management	Communications sessions with the orbiter are typically only 15 mins and data rates are low. It is therefore essential to identify valuable information and mange that.
7.0 Verification and Validation of Autonomous Systems	Vehicles operate in an environment where any mistake can result in the loss of the mission. The cost of these missions and publicity surrounding them is such that validation is a huge issue. Validation has to be intuitive, comprehensive and convincing to get it signed off.
8.0 Model Building and Learning	Models must be easily updated but easily revalidated. Models must also be able to be used on very constrained processing resources.

Investigate and Repair Defective Infrastructure

Scenario Description

This scenario focuses on the detection of degraded infrastructure from multiple sources such as track recording data and image analysis from on board systems with measuring trains and in-service trains and fixed location asset monitoring sensors. The objective is to analyse, assess and investigate the full extent of the problem from the data and, identify location, recommend maintenance/repair and apply corrective action by AIS with minimum disturbance to the operations/timetable. The autonomous maintenance group will communicate plan and present situation with a route controller. The infrastructure repair/maintenance vehicle is brought to location. The operation will be completed to AIS plan unless the route controller intervenes.

Relationship to AISP Technical Themes

Theme	Research Challenges
1.0 Software Architectures	On platform and cross platform software architectures to host the autonomy software
2.0 Sensor Exploitation	How to best control and exploit the sensors, particularly across multiple vehicles.
3.0 Situational Awareness and Information Abstraction	How to extract useful information from the vehicles' and static sensors to understand the outside world situation and recognising objects in the scene. Inferring correct information from the gathered data.
4.0 Planning	Creating real-time planning software to coordinate the platforms and schedule the sensor use.
5.0 Trusted Decision Making and Human Machine Interaction	Minimising the control infrastructure required to operate the vehicles, providing the human in the loop with timely and informative information, and efficient methods of interacting with the autonomous systems.
6.0 Information Management	Managing the information gathered by the sensors and transferring it off the platform making best use of available communication services.
7.0 Verification and Validation of Autonomous Systems	The vehicles must operate in a safe manner and the overall system must be robust. How to V&V the algorithms contributing to the above topics.
8.0 Model Building and Learning	How to design, implement and dynamically update models which constrain the performance of the system, ensure it operates within limits, safely and legally.

Support will include access to Network Rail facilities and advice & discussions with engineering and te chnical staff, and w ill oversee the research projects as they progress.

To develop the technology to progress from: Tele-operation… To Teleautonomy

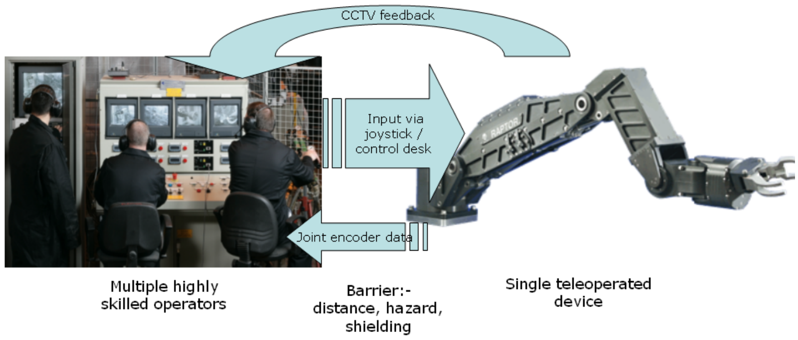


Figure 1 (multiple in the loop operators : single device)

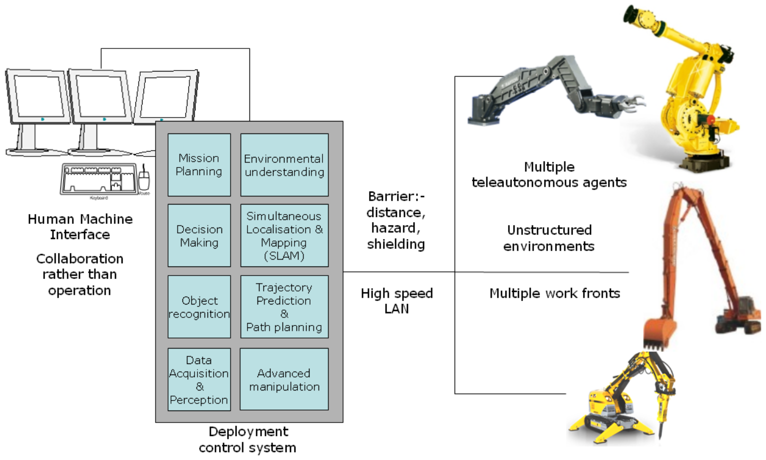


Figure 2 (Single supervisor : multiple agents)

Description of Scenarios:-

- Develop the transition from teleoperation to teleautonomous agents for execution of **complex decommissioning tasks.**
- **ISI – In Service Inspection, NDE, in-situ sampling and characterisation.**
- **Reverse engineering and real time 3D environmental modelling.**
- **Teleautonomous decontamination systems, for the removal of surface layers of concrete and for penetrating** deep in to section of concrete where contamination may have spread via micro cracks.
- Teleautonomous multi agent remote dismantling and size reduction of contaminated plant and equipment.
- Teleautonomous remote sentencing and segregation of waste materials.
- Optimised waste packing.
- Remote teleautonomous demolition of large heavily reinforced contaminated concrete structures, including: Site surveillance and monitoring, prediction and modelling of spread of contamination.

ISI / NDE inspections on highly active pipe work and vessels. Zero man access. Also possible repairs on such systems in event of failures. (see figures below taken during plant commissioning).

Relationship to AISP Technical Themes

Theme	Research Challenges
1.0 Software Architectures	To develop common software architectures that can be used across a variety of hardware. Need to develop modularity, traceability and certifiability in order to demonstrate compliance with Nuclear Site Licence conditions.
2.0 Sensor Exploitation	How to best control and exploit the sensors, particularly across multiple agents.
3.0 Situational Awareness and Information Abstraction	Develop the ability to understand the work environment which will be unstructured and constantly changing. Collision avoidance, object recognition, hazard perception and recognition. Radiation mapping/modelling.
4.0 Planning	Develop mission planning systems that can be used to dictate / suggest sequence of activities. Must provide operator supervisors with easy access and ability to track progress and make changes and interact with the system. Need to develop user interface to be intuitive and present large volumes of data in user friendly format.
5.0 Trusted Decision Making and Human Machine Interaction	Minimising the control infrastructure required to operate the manipulator systems, providing the human on the loop with timely and informative information, and efficient methods of interacting with the autonomous systems.
6.0 Information Management	Managing the information gathered by the sensors and transferring it off the platform making best use of available communication services.
7.0 Verification and Validation of Autonomous	The manipulator systems must operate in a safe manner and the overall system must be

Systems	robust. The system must be prevented from any action that may cause a loss of containment and or loss of shielding Provision of self diagnostic systems, self maintenance, system redundancy, recovery scenarios,