Lloyd's Register Foundation

Call for Interested Parties in Robotics & Autonomous Systems

In October 2016 the Lloyd's Register Foundation published its foresight review in robotics and autonomous systems (RAS) www.lrfoundation.org.uk/publications/foresight-review-of-robotics-and-autonomous-systems-download.aspx .The priority areas identified in the review are summarised below:

Openness and sharing	Assurance and certification	Security and resilience	Public trust, understanding and skills
Open data standards	Asset self-certification	Cyber security of RAS	Ethical and trusted RAS frameworks
Open data sets	Assurance of RAS learning systems	Software system integrity	Assured skills for RAS
Shared curation of RAS knowledge			

An explanation of these priority areas is at the end of this document.

The Foundation intends to support a programme, programmes or network to increase understanding or practice. Of the above we anticipate the following areas will be of primary focus:

- Asset self-certification;
- Assurance of RAS learning systems;
- Software system integrity;
- Shared curation of RAS knowledge.

However, we are also interested in: Open data standards; Open data sets; Cyber security of RAS; Ethical and trusted RAS frameworks; Assured skills for RAS.

The Foundation's first step is to find out which companies and research organisations are active in these areas with a view to collaborating in a network or programme.

If you are interested in finding out more or are interested in participation then please send the following information to ras@lrfoundation.org.uk by 28th February 2017.

- Name of Organisation
- Website address of organisation (if available)
- Name of contact person
- Email address of contact person
- Short summary of your interest and activities in the focus areas outlined above. (Two A4 pages maximum)
- The Foundation is also interested in programmes, projects and interventions made by others relevant to the focus areas. It does not wish to duplicate work done elsewhere but aims to build upon and leverage other initiatives if relevant. Please indicate if you are engaged with or are aware of such opportunities for leveraging.

We will use this information that you submit to establish a mailing list for future meetings and calls.

Expressions of interest received after 28th February 2017 will still be considered but may miss early opportunities.

Enquiries can be sent to ras@lrfoundation.org.uk

Primary Focus	
Asset self-certification	Self-certification and assurance of an asset under operational conditions using RAS is a potentially disruptive development that could change the way the assurance industry does business. It therefore requires some activity to further study its feasibility and potential impacts. In particular, what levels of assurance and increased safety can this approach achieve? As part of this, dialog is required to study the effects of a possible self-certification capability on regulatory bodies and the perception and reality of risk and costs. In addition the core challenge of how to guarantee the integrity of the complete asset, including the RAS working on it and any condition monitoring systems, requires further development.
Assurance of RAS learning systems	Certification and assurance typically depend on a specification of system performance and state against which tests can be made for validation and verification. However, where a system contains components that learn during operation, there is the possibility it will learn things that undermine the key performance measures that verify its safety. It is not clear how to then offer certification and assurance on RAS with learning systems. One approach is to only learn off line: switch this off, carry out the verification and validation tests for certification and then leave the learning switched off. However, this loses some of the potential of the technical approach. The situation is further made challenging in highly unpredictable environments. How can a RAS be verified when it faces unknown situations?
Software system integrity	Ideally, RAS software will be developed to acceptable software integrity level standards, appropriate to the criticality of the application. This is not a cheap endeavour. Identifying and recommending cost-effective ways to do this will encourage adoption by developers and specification by customers. Allied to this is the embedding of fault detection and diagnosis as part of the RAS onboard health management, with acceptably low false alarm rates. Third party vendor software embedded as libraries should also be assured or at least firewalled and jacketed so that the RAS degrades gracefully, predictably and safely in the event of code and other errors.
Shared curation of RAS knowledge	An open and standard platform technology is required to make available knowledge services to RAS-of-opportunity so that they can access maintenance data, procedures and predicted areas requiring inspection or maintenance attention under operational conditions. This enables the RAS to perform inspection or intervention functions within its sensing and actuation capabilities. It also enables generic RAS hardware and software through 'apps' that use these knowledge services. Benefits include reduced RAS development time; increased flexibility of use in the field; representation, elicitation and curation of knowledge (as opposed to data) to enable the RAS to perform tasks; and real-time optimisation of what data to collect and how according to perceived events. Finally, links from these knowledge services to through-life asset design, including condition monitoring, should be explored to realise 'smart spaces'.

Secondary Focus	
Open data standards	The collection, curation, storage and analysis of asset data will require standards and a metrology that cut across sensors, assets, asset classes and organisations, and will need to consider the security and corruptibility of data at any point in the data lifecycle. Sharing data improves knowledge and integrity, saves lives and encourages competition. Open data standards make this technically feasible and are needed to facilitate data sharing for aggregation and re-use. A body could be set up to investigate the development of cross industry open standards for RAS based data to be collected and used. This should include development or monitoring of semantic ontology standards representing cognitive knowledge about asset conditions. It should also investigate how data privacy can be maintained and how asset class inspection can be enabled to enhance safety.
Open data sets	Researchers can make progress with and compare techniques for asset assurance and RAS operation given, common open data sets about infrastructure condition. Work is needed to pursue the collection, curation and any anonymising of large asset-integrity data sets with ground-truthed failures as a resource for 'public' researcher use, to identify an 'honest broker' for data ownership and to support them in a trial to make big data about a class of asset. This may require a club approach among data owners. Data and knowledge privacy and integrity guidelines are needed to create and enforce what is an acceptable use of RAS data and knowledge, recognising trade-offs between privacy and public good.
Cybersecurity of RAS	The cybersecurity and RAS research and development communities need to work closely. Some scoping activity could identify the opportunities and the needs in this area, to secure network connected RAS against a variety of classes of intrusion. This may include the need for encryption and the design of efficient approaches, including the role of digital ledger technology for guaranteed transaction records. Such RAS could be publically offered in a hack challenge to test their security.
Ethical and trusted RAS frameworks	Engineers alone should not be left to programme behaviours into robots that cross ethical boundaries. Nor can machines that learn be similarly empowered. Internationally agreed ethical standards for RAS are needed so that clear guidance and norms evolve, for example for 'no-win' decision making. A culture of ethical concern should be encouraged across the international R&D community.
Assured skills for RAS	We will need more RAS skills at all levels in the future, and more people who possess them and are passionate. Teachers need support to lay good foundations in schools, with examples such as Robokid offering good quality distance learning materials and access to maintained equipment. Undergraduate, postgraduate, continued professional development and fellowships all continue to be needed. Secondments for RAS students and researchers into the assurance industry would also provide useful mutual transfer of knowledge and skills.