Introduction to the Assuring Autonomy International Programme

Prof Tim Kelly

Agenda

- Robotics and Autonomous Systems (RAS)
- Realising the benefits of RAS
  - Lloyd's Register Foundation Review of RAS & Safety
  - The International Perspective
- Programme Status
- Programme Activities
  - Scope, Demonstrators, Core, Ecosystem, Collaboration, Community
- Conclusions

Robotics and Autonomy

Robotics & Autonomous Systems (RAS)

- RAS can undertake many tasks cost-effectively providing benefits to society, e.g.
  - Avoiding boring, repetitious and slow work in factories and warehouses
  - Supporting social care, enabling independent living

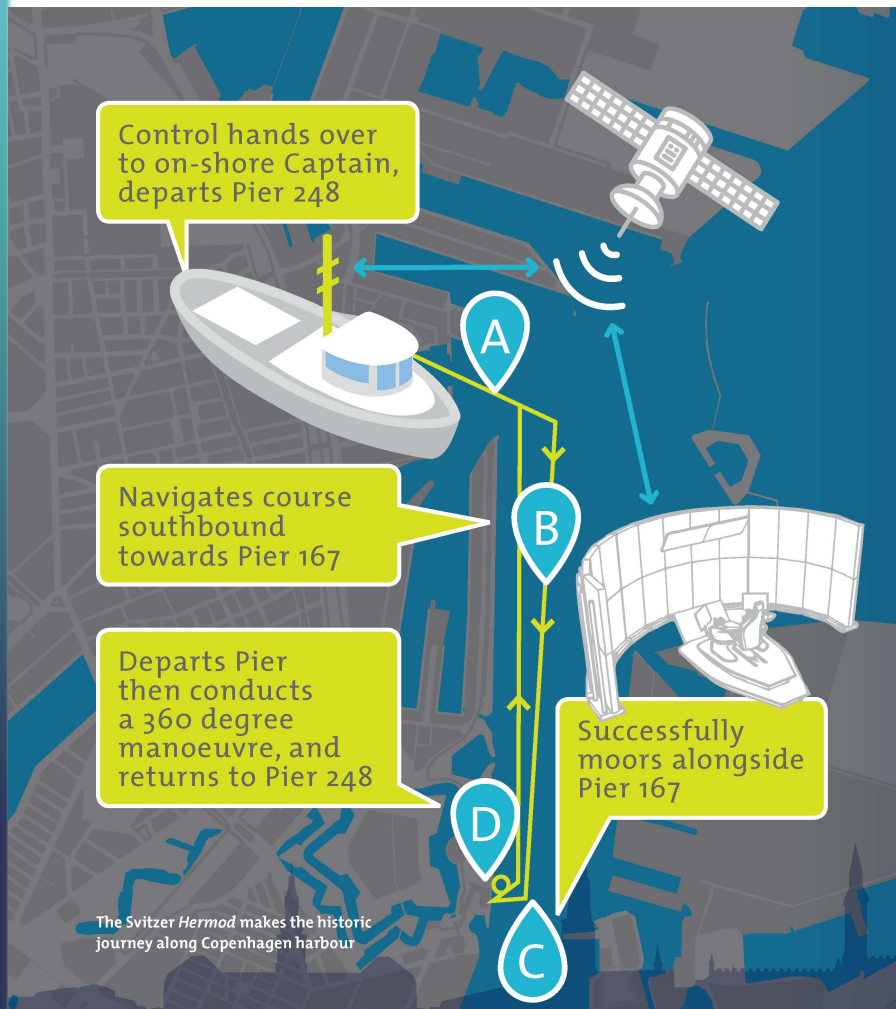
- In the near future there will be fully autonomous or remotely operated systems, e.g. in:
  - Driving, reducing accidents due to human error
  - Shipping, removing seafarers from harms way

Robotics and Autonomy

Remotely Operated Commercial Ship

Robotics and Autonomy

Demonstrations



The Svitzer *Hermod* makes the historic journey along Copenhagen harbour

The world's first remote control commercial vessel

Key facts

Rolls-Royce and Svitzer demonstrate the world's first remote controlled commercial vessel ● Test took place in Copenhagen harbour ● The 28 metre Svitzer *Hermod* was controlled by a Captain from shore ● It successfully demonstrated vessel navigation, situational awareness, remote control and communications systems ● Rolls-Royce Remote Operations Centre features state-of-the-art control ● Combination of Radar, Lidar and camera technology ensures Captain's awareness of surroundings

The tech

On board sensors to give Captain full awareness of surroundings

Sensors covering Radar, Lidar, camera and audio

State-of-the-art Remote Operations Centre on shore

Rolls-Rolls Dynamic Positioning systems control position of the vessel via satellite

The test

400+ individual validations met

42 individual safety requirements met

Passed 61 mandatory cyber security tests

Completed 16 hours of remote control operation and overseen by Lloyd's Register

The vessel

28 metre tug Svitzer *Hermod*

Built in 2016

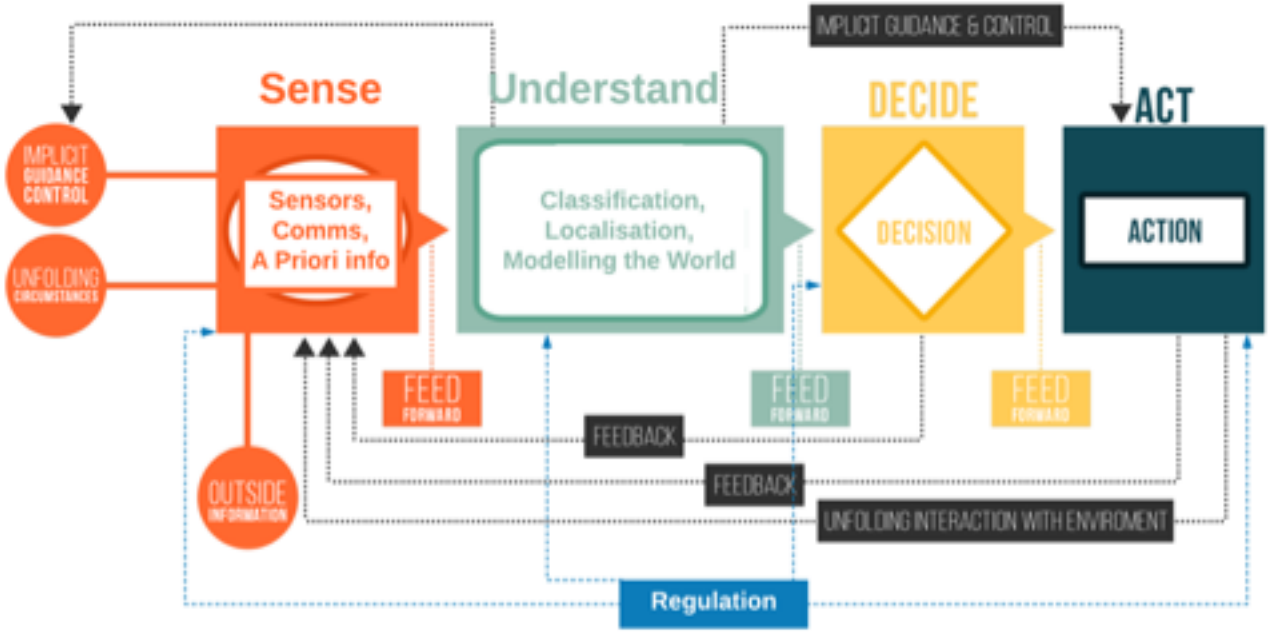
2 x MTU 16V4000 M63 diesel engines

Rolls-Royce

Robotics and Autonomy

A RAS model: the SUDA "loop"

- Sense, Understand, Decide, Act (SUDA)
  - Understanding and decision-making heavily dependent on Artificial Intelligence (AI) – key technical challenges include assuring AI and sensing capabilities

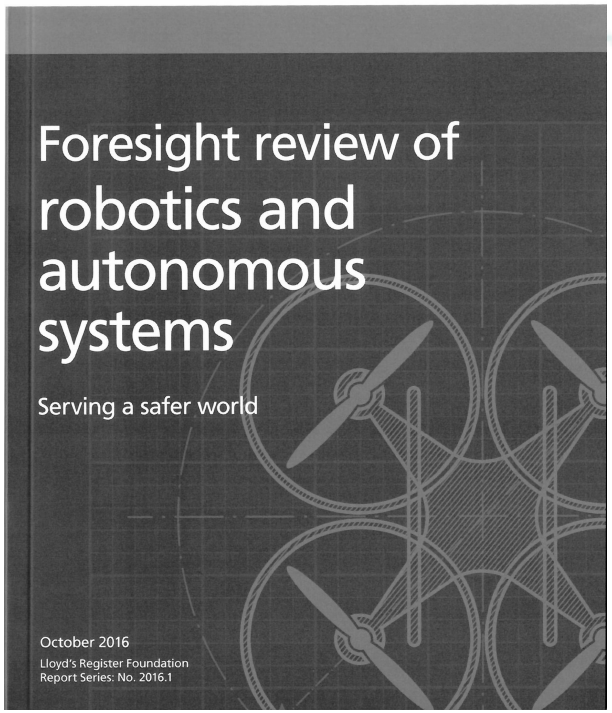


Realising RAS Benefits

The Foundation's Review of RAS

- Published in October 2016
  - Identified "white spaces" in assurance and regulation of RAS
  - Necessary to address these issues to realise benefits of RAS
- The York-led Programme is a response to the review
  - A strong focus on 'demonstrators' and working 'bottom up'

Lloyd's Register Foundation



Realising RAS Benefits

Safety of RAS Challenges

- How do we get sufficient visibility of what the RAS (AI) has learnt to assure safety?
- How do we reason about learning in operation?
  - Can reasoning be pre-operation, or must it be dynamic?
- How do we deal with interactions?
  - Other systems and people, including social cognition
- How do we assure normal functions?
  - As opposed to the traditional focus on failure
- What are appropriate criteria for acceptance?

Realising RAS Benefits

International Perspective

- Many problems are global
  - RAS need to operate internationally, hence need a global solution, not one for each country
  - Maritime environment a clear example
- Providing solutions is very challenging
  - The Programme cannot provide all the solutions itself
  - Must draw on work being undertaken globally
    - For access to solutions
    - For influence to get solutions disseminated and adopted

ASSURING AUTONOMY
INTERNATIONAL PROGRAMME

Addressing **global challenges** in **assuring the safety** of robotics and autonomous systems

Programme Status

Contracts

- Contract from January 2018 for five years
  - £10M from Lloyd's Register Foundation
  - Circa £2M from York for management and leadership
- Intent that significant parts of the Programme undertaken by other organisations
  - First five Demonstrator projects agreed and contracts being finalised
  - Second Demonstrator call just closed
- Expanding the scope of work through associated activities

Programme Team

Prof John McDermid | Prof Tim Kelly | Dr Radu Calinescu | Dr Mark Nicholson | Dr Ibrahim Habli | Dr Rob Alexander

Dr Ana MacIntosh | Sarah Heathwood | Chrysle Hudson | Dr Richard Hawkins | Dr Chiara Picardi | Dr Colin Paterson

Helen Monkhouse | Saud Yonbawi | Yan Jia | Sean White | John Bragg | Ioannis Stefanakos

Programme Activities

Scope

- Four main strands of work
  - Work on **assurance and regulation** in support of demonstrator projects (real-world prototypes or real deployments – use cases)
  - More **fundamental research**, e.g. on dynamic risk and assurance of AI including deep learning, dynamic safety cases
  - **Education and training**, for professionals in RAS/AI and safety (in the planning/recruitment stage)
  - Support to the international community

  All contributing to or using a **Body of Knowledge** (BoK)

Critical Barriers to Assurance

- Adaptation
- Bounding Behaviour
- Cross-Domain Usage
- Explanations
- Handover
- Human-Robot Interaction
- Incident and Accident Investigation
- Monitoring
- Risk Acceptance
- Role of Simulation
- Systems of Systems
- Training and Testing AI
- Validation
- Verification

Programme Activities

Initial Demonstrators

- Assistive Robotics in Healthcare
  - Led by Bristol Robotics
- Collaborating Construction Machinery
  - Industrial lead Volvo Construction Equipment, in Sweden
- Collaborative Robotics in Flexible Manufacturing
  - Led by Machining Centres Europe, in Italy
- Autonomous Medication Management Systems
  - Based in Derby Hospital Intensive Care Unit
- Autonomous Road Vehicles
  - Led by Adelard, involving vehicles in Japan

Programme Activities

Core Research & Education and Training

- The development of the Body of Knowledge (BoK) plus support for demonstrators, etc.
- Dynamic assurance, noting that classical safety processes cannot address operational learning
- Assurance of deep reinforcement learning, and generalisation to other technologies
- Work starting on education and training
  - Training needs analysis for Master's level training
  - Initial focus on awareness sessions for senior staff

Programme Activities

Ecosystem: European Training Network

- EU Project – Fraunhofer in Kaiserslautern, LAAS in Toulouse, KU Leuven, York
  - Collaboration on safety of autonomous systems, with all students having supervisors from two institutions

15 PhD positions in the EU Horizon 2020 Marie Skłodowska-Curie Project:

Programme Activities

Ecosystem: European Training Network

- Example Early Stage Researcher Positions:
  - Moving Safety Cases from Design Time to Run Time
  - Assurance Case Arguments for Machine Learning
  - Modelling functional insufficiencies in AS technologies
  - Achieving Situation Coverage in Simulation
  - …

Programme Activities

Ecosystem: Verification of RAS

Prestigious engineering award for Ana Cavalcanti

Posted on 13 April 2018

Computer Science Professor honoured by Royal Academy of Engineering

Professor Ana Cavalcanti has been named one of ten Royal Academy of Engineering Chairs in Emerging Technologies, securing funding for a ten-year programme that has been recognised as having the potential to bring significant economic and societal benefits to the UK. Ana's project, 'Software Engineering for Robotics: Modelling, Validation, Simulation, and Testing', will develop an approach for practicioners that allows them to solve problems using accessible domain-specific languages. She hopes to move the discipline of software engineering forward, using methods justified by mathematical principles that are routinely used in many engineering disciplines.

Programme Activities

Ecosystem: Autonomous Harvesting

- Feasibility study with Harper Adams
  - Programme will work on safety
    - Combine harvester and tractor
  - Hope to define a full-scale demonstrator

"We grew it, nursed it and now we've harvested it, completely autonomously. What an achievement."

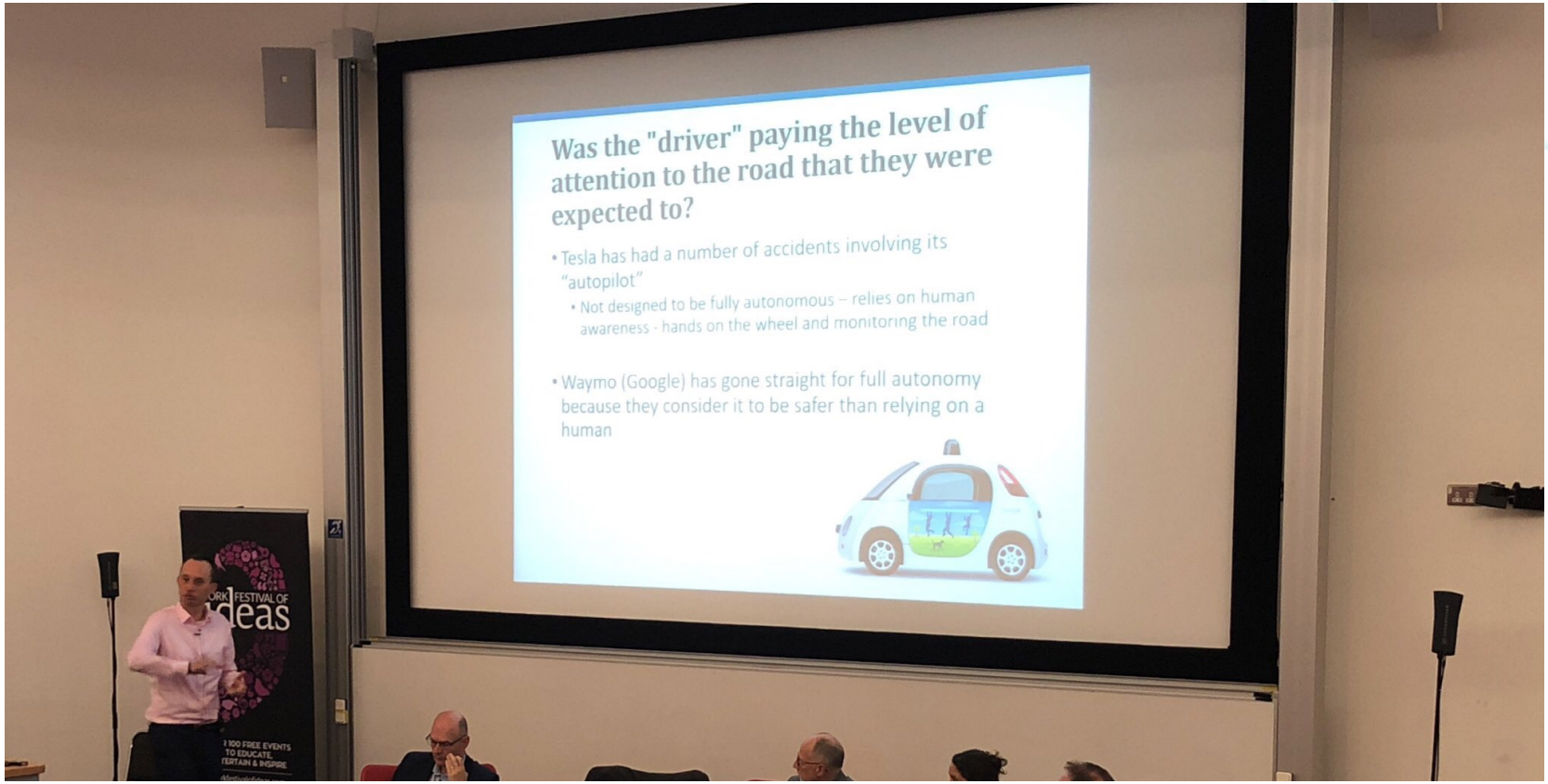
Programme Activities

Collaboration: EPSRC Hubs

- Participated in meeting with EPSRC funded Hubs on Robotics in challenging/extreme environments
  - RAIN (Nuclear), FAIR-SPAC (Space)E, NCNR (Nuclear) and ORCA (Maritime)
  - Related work, e.g. on responsible research innovation
  - Further information from Dr Lucy Martin
  - More links to current projects encouraged

Programme Activities

Community: Festival of Ideas



Conclusions

Challenges and Collaboration

- The Programme is extremely challenging
  - Hard technical problems – ill-structured, many with no known solutions
  - Social aspects of acceptability of risk
- The Programme cannot produce all the answers
  - The Programme neither has the resources nor the expertise to do it alone
  - Collaboration is essential, and some potential partners identified
- Initial steps promising, but much more to do …

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