Systems-NET

EPSRC
Engineering and Physical Sciences Research Council

List of Top Research Grand Challenges

Challenge 1

Grand Challenge Statement: **Systems engineering methodology –How systems are defined, developed and tested is well established with different models existing. Can a scientific approach be used to determine if there is a better methodology that can be defined?**	**Score** 20 stars
Context: Improving the way we develop systems and coming up with an approach that is domain agnostic	
Potential Impact: Harmony in the way SE is applied and using a scientific approach to get there.	

Challenge 2

Grand Challenge Statement: **With the increase in autonomy in systems there is a need to ensure ethics can be embedded in a system rather than solely be applied at the operational phase by humans – legal issues**	**Score** 19 stars
Context: Increase of large complex interconnected cyber physical systems with demand for greater autonomy plus self-re-configuration.	
Potential Impact: Greater trust in systems Greater uptake of systems Gives potential to expand the autonomous functionality of systems	
Perceived Difficulty: Don't know how to do this	

Challenge 3

Grand Challenge Statement: **Importance of the knowledge base to support system development (knowledge management)**	**Score** 19 stars
Context: Different Domains /transferability between different domains, Decision making, Uncertainty and risk	
-Potential Impact -Extract required/needed knowledge -Interconnectivity/dependency -Consequences of failure/ prevention of fails -Multidisciplinary collaboration -Robotic systems, big data, maintainability of systems, expert support	

Challenge 4

Grand Challenge Statement: **Modelling the next generation Model Based Systems Engineering for the industry 4.0 (IoT) to allow scalability and add end-end value**	**Score** 18 stars
Context: At the moment there is no model to support the changing business environment. In order to support the	

industry 4.0 plus IoT (which goes across manufacturing, service, etc.) to add end- to -end value. The next generation MBSE tools should be able to address product/process interactions to make physical systems (e.g. factories) smart and flexible, as industry 4.0 doesn't exist without these two.	
Potential Impact: There is no MBSE tool for the Industry 4.0 or IoT. As whole industry is moving on a full autonomous approach. Having the next generation MBSE tool will allow studying the risk generated with system of systems and make them more resilient and flexible.	
Perceived Difficulty: • Organised data management (managing the real time information) • Self-learning (organising) based on real time information and unforeseen circumstances. • Human-machine interaction in order to address the issues due to a fully autonomous system	

Challenge 5

Grand Challenge Statement: **Reliability, robustness and recoverability of complex systems to support more flexible and autonomous negotiation between systems to enable/ease interoperability of different systems (including management of legacy and new systems) e.g. To develop systems for autonomous and connected transport systems.**	**Score** 16 stars
Context: Complex systems control critical operations like aircrafts, flying, nuclear power stations, railway system, etc. Failing of these systems might have catastrophic results that's why they should not in the first instance but if it happens they have to be recoverable – either autonomous or thanks to human intervention. Understanding these factors would be the goal of this challenge.	
Potential Impact: Increase of complex systems reliability; reduction of redundancy due to deeper understanding of these factors; reduction of losses due to systems failures.	
Perceived Difficulty: Medium – high; risk management goes into this direction but has to be combined with in depth system knowledge.	

Challenge 6

Grand Challenge Statement: **Semantic conflicts and uncertainty**	**Score** 12 stars
Context: Complexity science, cyber-physical systems. Sources of uncertainty Physical environments Heterogeneity Agent autonomy Hazards Natural disasters	
Potential Impact: A new generation of systems, A new science	
Perceived Difficulty: Extreme-domain specific	

Challenge 7

Grand Challenge Statement: **How do we achieve sustainability with Systems Engineering?**	**Score** 12 stars
Context: Systems engineering could play central role in preserving the environment and the human race.	
Potential Impact: The impact would be enormous in terms of improving quality of life.	
Perceived Difficulty: The technology is still not advanced enough to meet this challenge.	

Challenge 8

Grand Challenge Statement: **Renewable electricity generation to reach carbon neutral state**	**Score** 10 stars
Context: Preserving a liveable environment for future generations, maintaining species diversity.	
Potential Impact: Survival of human race (and other species), not needing to colonise mars	
Perceived Difficulty: International alignment, Social acceptance – changes to lifestyle, Economic stability	

Challenge 9

Grand Challenge Statement: **Decision making and big data era**	**Score** 7 stars
Context: System coupling is increasing and thus understand information around their interconnectivity becomes essential	
Potential Impact: Improve understanding in the consequences of system failure and how information around their use can reduce risk	
Perceived Difficulty: Challenging as data increases in size and in value, and thus involved parties are not prone in sharing	

Challenge 10

Grand Challenge Statement: **Achieving multi-disciplinary model integration across the system development lifecycle … to help deal with semantic conflicts and uncertainty**	**Score** 7 stars
Context: Understand systems interactions better	
Potential Impact: System quality improvement , Further development time	
Perceived Difficulty: Modelling tool self-integration and related standards	

Challenge 11

Grand Challenge Statement: **Understand emergent properties of complex systems using system identification of fractional order calculus; non-linearity needs to be accommodated.**	**Score** 5 stars
Context: Broad, addresses most of the existing grand challenges 1. Characterisation of materials	

2. Agriculture modelling of fresh water, conservation in plants 3. Energy/new superconducting technologies 4. Neuroscience understanding of neuronal form and function.	
Potential Impact: High, enables us to move from black box type input /output models to grey box and white box models understanding better the underlying systems	
Perceived Difficulty: High. Requires training of researchers to existing tools and mathematics control theory and systems identification.	

Challenge 12

Grand Challenge Statement: **Develop a framework for socio-technical interactions between stakeholders.**	**Score** 5 stars
Context: Being able to quantify and assess how stakeholders within a system affect each other and to what extent they affect each other.	
Potential Impact: The understanding of the implications of certain stakeholders working on projects/ programs and developing effective and efficient teams that deliver positive and beneficial outcomes allows greater resilience when forecasting issues between stakeholders.	
Perceived Difficulty: The quantifying impact of the interaction and understanding the extent to which an interaction may impact a system	

Challenge 13

Grand Challenge Statement: **Real time solution generation and update of integrated systems solution…** **And forecasting (what ifs) and predicting performance (e.g. for IoT)**	**Score** 5 stars
Context: Robotics systems require high expert knowledge to build. However, a design environment that can generate solutions based on operational lifecycle can help to highlight behaviour as well as highlight solution changes in real time.	
Potential Impact: Non-expert or semi-skilled people can use such capabilities to test their ideas plus innovate, as well as small companies can uptake manufacturing of highly technical systems.	
Perceived Difficulty: • Availability of knowledge databases from different domains • Technical challenges to developing intelligent solution • Modelling real time systems in uncertain environments	

Challenge 14

Grand Challenge Statement: **Systems of autonomous and connected transport systems**	**Score**
Context: Integration of autonomous vehicles into existing	5 stars

infrastructure meeting safety plus legal constraints building support infrastructure Driverless taxis => Google's/amazon automated delivery Handling unexpected events	
Potential Impact: Improved mobility, safety, efficiency, energy consumption, reduced emissions, allowing elderly people on the road safely.	
Perceived Difficulty: Varying => many technical, legal and public perception challenges	

Challenge 15

Grand Challenge Statement: **Proof and communicate the benefits of SE to increase its attractiveness to a wider audience**	**Score** 4 stars
Context: In order to increase levels of training, number of positions and funding for SE activities, political, economic and social entities have to inform and convince of its benefits	
Potential Impact: Increase of funding, use of SE methodology throughout, as well as public awareness of SE effects.	
Perceived Difficulty: Medium – high; biggest part is to actually start to do this and allocate money to it	

Challenge 16

Grand Challenge Statement: **Driven from context of a specific end solution ("go to Mars", solve power generation"...) develop and mature the set of techniques for defining and analysing verification and validation systems solutions with characteristics required.**	**Score** 3 stars
Context: Techniques need to cope with Complexity Multi-disciplinary aspects SoS Interactions (interfaces/negotiation Semantics/underpinning science / Optimisation New and or incremental level of Ethics/legislation Full lifecycle aspects Large scale/ scalability Autonomous aspects Integration of models Within coherent process framework Balancing Social technical aspects	

Challenge 17

Grand Challenge Statement: **Management of legacy plus integration of new**	**Score** 3 stars
Context: How does this apply to developing nations were legacy is not always so restrictive?	
Potential Impact: Legacy infrastructure is prevalent in many countries, and in many industrialised countries legacy	

infrastructure is reaching capacity constraints. Building resilience into connections between legacy and new systems	

Challenge 18

Grand Challenge Statement: **How do we actually engineer complex systems?**	**Score** 2 stars
Context: Complex systems exhibit emergent characteristics. How do we characterise these properties and provide systems engineering tools to support their construction (and verification and validation)?	
Potential Impact: Very significant – especially given internet of things/mobile technology	
Perceived Difficulty: Very difficult – the innate unpredictability of such systems makes them difficult to verify and validate.	

Challenge 19

Grand Challenge Statement: **Balancing V.S. optimising systems (and sub-optimal systems) and understanding roles of competition and collaboration, (negotiation of boundaries) including the constraints of networks of contracts**	**Score** 1 star
Context: Against architectural, legal requirements, organisational, people's expectations. Working towards good enough? May depend on the level of abstraction	

Challenge 20

Grand Challenge Statement: **The ability of humans to "interrogate" systems to understand, question, maintain or extract required data/ information /knowledge**	**Score** 1 star
Context: CPS (Cyber Physical Systems) etc., are all pervasive and geographically spread and in most cases are designed to be operated by a range of engineers, commercial/government organisations.	
Potential Impact: Improved use of systems, Improved transparency of systems, Improved maintainability of systems	

Challenge 21

Grand Challenge Statement: **Automated electricity demand management**	**Score**
Context: Balancing	1 star

Challenge 22

Grand Challenge Statement: **More flexible and automated negotiation between systems to enable/ease inter-operability of different systems**	**Score** 1 star
Context: Where multiple computer systems are used in "an environment" – e.g. organisation	
Potential Impact: Ability to address /solve problems not solvable by one system alone. "Modularity" of systems	

purchases. Extended lifetime of systems?	
Perceived Difficulty: Requirement for knowledge/ terminology/ agreed languages to enable negotiation - Artificial intelligence - Ontologies - Knowledge representation	