SYSTEMS ENGINEERING MSc

MSc SE Postgraduate module list 2014-15

CURRICULUM
Compulsory Modules

• Systems Thinking
• Systems Architecture
• Systems Design
• Soft Systems Engineering
• Individual Project

Optional Modules (choose four)

• Validation and Verification
• Holistic Engineering (industry-led module)
• Sensors and Actuators for Control
• Innovation and Entrepreneurship for Engineers
• Engineering and Management of Capability
• Understanding Complexity

Block taught, individual modules are also highly suitable as CPD for professional engineers working on systems engineering projects and challenges. The following descriptions of modules are intended as a guide to the curriculum. The content may be subject to change at the discretion of the University.
COMPULSORY MODULES

ELP060  Soft Systems Engineering
The aims of this module are: firstly to consolidate the students’ understanding of an enterprise as a system (made up of human, process and technical sub-systems) and provide them with knowledge, methods and tools to aid in the design and evaluation of such systems; and secondly to provide the students with an overview of Enterprise System Architectures and Architectural Frameworks.
It includes the following topics:
• application of systems thinking and methods to the design, modelling and evaluation of enterprise systems in a systems of systems context
• theory underpinning the study of enterprise systems
• rationale, relevance and limitations of alternative enterprise system modelling and enterprise system architecture approaches
• constraints and benefits of creating a ‘big picture’ enterprise systems model
• relevance of human factors/ergonomics theory and practice and socio-technical issues to the design, operation and use of enterprise system
• the relevance of the above to the design and use of the systems methods and approaches covered in the module
• application and integration of a range of systems tools and methods.

There will be a group case study running through the module culminating in a final day group presentation worth 60% of the module. An individual essay on Enterprise System Architectures completes the assessment for this module.

Professor Carys Siemieniuch

ELP062  Systems Thinking
The aims of this module are to provide a comprehensive introduction to the systems discipline from which participants will acquire the principles and concepts of systems thinking and will become aware of its broad application base.
It includes the following topics:
• Framework of systems science
• History and principles of the systems approach, introduction to systems concepts and theory.
• Information modelling: diagrammatic models, classification and type.
• Interactive methods for eliciting ideas from users; ideawriting; nominal group technique; interpretive structural modelling.
• Systems behaviour: cybernetics and information feedback, open loop and closed loop decision models.
• Systems methodologies: hard systems methodology, soft systems methodology and management cybernetics.
• Modelling methods: purpose, formulation, identification and evaluation.
• Systems dynamics modelling: use of spreadsheets and/or purpose built simulation packages.
• Applications of systems in a number of different engineering domains.

Professor Ron Summers

ELP065  Individual Project
The aim of this module is to provide an in depth opportunity for independent study that is related to one or more elements of a systems-based intervention. The research methods to be employed will be governed by the complexity of the system under study and may be hardware or software based or neither; largely theoretical or strictly practical or a mixture of both.
The project topic may be derived from a tutor list of research interests; from a specific interest of the student; or from an industrial need formulated by the student in collaboration with an industry partner and agreed with the Programme Director.

Professor Ron Summers

ELP066 Systems Design
The aims of this module are to give students: (i) practical knowledge of design and requirements engineering from a systems and model based viewpoint; (ii) an understanding of the relation between system design, system architecture, and verification and validation (V&V); (iii) an introduction to and practice with software and systems modelling languages, methods, and commercially available tools; and (iv) an introduction to system modelling and analysis in support of design. Students will learn a system design process aligned to ISO/IEC 15288 and to how model a system and use models for system design and analysis.

It includes the following topics:

- Logical and scientific basis for systems engineering
- System design process and engineering for the life cycle
- Structured analysis and design
- Relation between system design, architecture, and V&V
- Requirements engineering
- System concept definition and architecture specification
- System design specification
- System integration
- Introduction to the Unified and Systems Modeling Languages (UML and SysML) for software and systems
- Introduction to models and metamodels for system specification
- A model based approach to Quality Function Deployment and design trades
- Behavioural modelling and analysis
- Non-functional analysis
- Research and advanced methods in the international community.

Professor Charles Dickerson

ELP072 Systems Architecture
The aim of this module is to give students: (i) practical knowledge of systems from a model based and architectural viewpoint; (ii) an understanding of system and enterprise architecture frameworks; (iii) knowledge of and practice with software and systems modelling languages, methods, and commercially available tools; and (iv) an introduction to model driven architecture and analysis. The students will learn how to model the architecture of a system and use it to assess system functionality and performance.

It includes the following topics:

- Logical and scientific basis for systems architecture, models, and transformations;
- Relation between systems architecting and systems engineering, especially system design
- Using the Unified and Systems Modeling Languages (UML and SysML) for software and system development
- Metamodels, modelling system requirements, structure, and behaviour
- Structured analysis and design
- Model driven architecture and analysis
- System of system architecture, enterprise architecture and frameworks
- Defence architectures and frameworks
- Research and advanced methods in the international community.

Professor Charles Dickerson
Optional Modules

ELP067 Validation and Verification
The aims of this module are to give students: (i) practical knowledge of verification and validation (V&V) for testing and acceptance of systems from a systems and model based viewpoint; (ii) understanding of the relation between design and V&V with the objective of concurrent V&V and design of robust systems; (iii) an introduction to hardware and software in the loop testing; and (iv) an introduction to and practice with software and systems modelling languages and methods using commercially available tools. Students will learn V&V procedures and tests aligned to ISO/IEC 15288 and IEEE 1516 from a systems and model based viewpoint and how to use V&V to influence system design and analysis.
It includes the following topics:

- Logical and scientific basis for systems engineering
- V&V procedures and tests
- noise in test measurements
- reliability and other non-functional testing and evaluation
- hardware and software in the loop testing
- V&V design and analysis
- robustness metrics, design of experiments
- approaches to concurrent system design and V&V
- introduction to the Unified and Systems Modeling Languages (UML and SysML) for software and systems
- using models for system requirements, structure, and behaviour traceability
- realisation and capability assessment
- research and advanced methods in the international community.

Professor Charles Dickerson

ELP068 Sensors and Actuators for Control
The aims of this module are for the students to understand the options available and the issues related to selection of sensors and actuators for control systems.
It includes the following topics:

- Sensors: Sensed quantities; Sensor types and principles; Uses of Sensors; Dynamics of Sensors; Sensor systems; smart sensors; Sensor fault detection and redundancy.
- Actuation: Basic principles; Hydraulic systems; Pneumatic systems; Electrical systems; Advanced materials; Choice of actuation system; Open and closed loop actuator; Actuator Fault Tolerance and redundancy.
- System design of sensor/actuator systems and control systems.

Dr Roger Dixon

ELP069 Innovation and Entrepreneurship for Engineers
The aim of this module is for the students to understand the relationship between creative management, innovation and enterprise. By preparing a business plan the students will gain a competency that can make a direct contribution to UK plc.
It includes the following topics:

- Creative management: ideawriting, nominal group technique and interpretive structural modelling.
- Intellectual Property: an awareness of the breadth of methods available together with an appreciation of the issue of whether to protect or to license business ideas.
- Innovation: concepts, methods and models of idea generation and capture.

Professor Ron Summers
ELP071 Holistic Engineering
The aim of this module is for students to understand the range of challenges thrown up by complex engineering projects and the techniques that can be applied to overcome them. Whilst the nature of the role of engineering has evolved markedly over recent decades, it is the ability to take that role's holistic perspective that the module aims to develop in the student.
A range of case studies from the military aircraft domain provides the focus of the module, but the content, the systems approaches taken and the learning achieved are sufficiently transferable to other engineering domains and industrial sectors for any student to benefit from taking this module.
The module will push the boundaries of multi-disciplinary engineering through a mixture of practical experiences on hugely demanding programmes, and an exploration of the current state of theory as it applies to such programmes. The case studies from real programmes will be used to illuminate a range of critical topics including requirements definition, problem analysis, system architecture, the product lifecycle, engineering organisation design etc, which will then be subject to rigorous exploration in the theory and practical sessions.
It includes the following:
• Experience from five multi-national military aircraft programme case studies will be used to explore typical challenges posed by complexity in the problem domain, the solution domain, the commercial and business environment and the extended engineering enterprise within it.
• The systems perspective, holistic in its approach to solution lifecycle, the role of products, their missions and functions, the role of services, the contextual impact of solutions, their environmental impact and stakeholder interest management, will provide a framework for understanding the means to achieve multi-disciplinary engineering solutions to physical engineering problems.
• The learning from the five case studies will motivate, evidence and support the systems perspective and the engineering techniques within it. The students will practise the skill of developing an Engineering Management Plan to tackle a hypothetical case study outwith the military aircraft domain.

Professor Andrew Bradley

ELP460 Engineering and Management of Capability
The aims of this module are 1) To give students an understanding of capability provision and the Systems of Systems concepts that underpin it. 2) To give students an understanding of the challenges of capability management and the business transformation they imply and 3) Through case studies and group project work, to give students insight into the Systems of Systems Engineering through which suppliers and users provide and support capability.
It includes the following topics:
• The concept of Capability, provision of the systems that support it and the business and engineering challenges involved.
• Agility & Agile systems
• Interoperability within complex environments.
• Through Life Systems management, Life Cycles, Service Support, and Logistics
• Obsolescence Management and Through Life Costs.
• Risk and risk ownership.
• Network enabled capabilities.
• Knowledge management as a key component of organisational capability.

This module explores the complicated nature of sophisticated technology within the social, political, and commercial environment to consider the practical aspects of managing large-scale, complex systems. There will be a capability scenario running through the module and a group case study project culminating in an assessed final day project presentation.

Professor Mike Henshaw
ELP462 Understanding Complexity

The aims of this module are to introduce students to the problems of complexity as the size of systems grow and the methods used in addressing such problems. It includes the following topics:

- Reminder of Taylor’s theorem and its uses.
- Ordinary and Partial Differential Equations, Linear System theory.
- Non-linear dynamics and Chaos.
- Numerical Methods.
- Algorithmic Complexity.
- System Optimization: Design Space, Cost function, Search methods (Steepest Descent, Exhaustive Search, Evolutionary Computing e.g. GAs and NNs).
- Reliability theory, Structure function, FMECA, criticality analysis.
- Optimization under constraints and Lagrange Multipliers.

Dr Vince Dwyer

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For further information about the School of Electronic, Electrical and Systems Engineering, please see our website at www.lboro.ac.uk/ees