

## Education at the Birmingham Centre for Railway Research and Education

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## Overview of Presentation

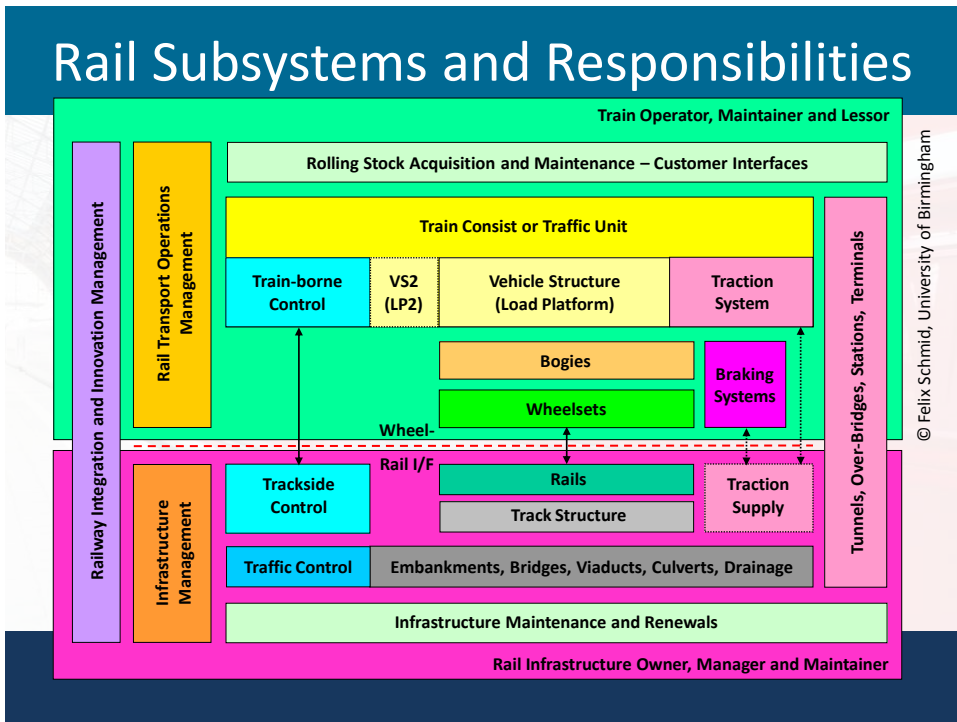
- Characteristic properties of railways;
- Railway subsystems and responsibilities;
- Structure of postgraduate education in BCRRE;
- Programmes offered at Birmingham;
- New 3-week primer course;
- MSc in Railways Systems Engineering and Integration;
- MSc in Railway Risk and Safety Management;
- MRes in Railway Systems Integration;
- Programmes under development.

## Characteristic Properties of Railways

- Railways' natural characteristics result in substantial demands on technical and managerial competence:
  - The railway as a system is highly diverse;
  - Railways have many tightly coupled internal and external interfaces;
  - Railways are long and thin: staff and assets are very dispersed;
  - Railways operate in highly variable environments;
  - Railway asset lives are diverse but all elements must work together:
    - Some railway assets have very short lives (<1 year);
    - Many railway assets have lives of about 30 years;
    - Others have very long lives (>150 years).
  - Railways work only when they operate according to robust timetables;
  - Railways operate in an excessively regulated environment;
  - The shelf-life of the products of the railway is exceedingly short.
- Railways are complex and complicated systems.

## Railways are Tightly Coupled Systems

- Physical characteristics require careful management:
  - Single degree of freedom of movement of rolling stock requires infrastructure with variable geometry;
  - Limited adhesion requires railway control and signalling;
  - Stiffness of wheel / rail interface requires high quality trains and infrastructure and high quality maintenance;
  - Linear nature of the railway asset propagates failures and is open to environmental influences;
- Requirement for reliable timetabled operation;
- Need for good resource management;
- Distributed staff must be managed and supervised.



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# Education and Continuous Professional Development

21<sup>st</sup> Anniversary Railway Systems Engineering

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## Overview of Education Activities

- Undergraduate Programmes (20 Students):
  - BEng and MEng in Civil and Railway Engineering;
  - BEng and MEng in Electrical and Railway Engineering.
- Masters programmes (230+ full and part time Masters students):
  - MSc in Railway Systems Engineering and Integration (from 1995);
  - MSc in Railway Risk and Safety Management (2013-14);
  - MSc in Electrical Transportation Systems and Infrastructure (2014-15);
  - MSc in Railway Network Asset Management (from 2016-17);
  - MSc in Railway Signalling and Control (from 2016-17)
- Masters by Research in Railway Systems Integration.
- Specialist CPD programmes:
  - Bespoke courses for London Underground and Network Rail;
  - Summer courses for school children for the Smallpeice Trust.

## Taught Postgraduate Programmes

- MSc in Railway Systems Engineering and Integration:
  - 120 taught credits and 60 dissertation project credits.
- MSc in Railway Risk and Safety Management:
  - 120 taught credits and 60 dissertation project credits;
  - Joint programme with The University of York since 2013.
- Postgraduate Diploma and Certificate:
  - 120 or 60 taught credits from MSc programmes.
- MRes in Railway Systems Integration:
  - 60 taught credits, of which 30 are research training;
  - 120 credits from a major thesis project.
- 10 credit Continuous Professional Development blocks.
- New programmes to be launched in academic year 2016-17:
  - MSc in Railway Network Asset Management;
  - MSc in Railway Signalling and Control;
  - PG Cert in Railway Education and Training.

## Focal Areas of the Programmes

- Focal systems engineering areas of the programmes:
  - Fundamental science for railways and its application;
  - Development of engineering know-how (and skills);
  - Project organisation and management;
  - Interface engineering and process management;
  - Cross-disciplinary work and projects;
  - Understanding trade-off issues;
  - Risk and safety management.
- Personal development objectives of the programmes:
  - Development of communication skills;
  - Development of management skills;
  - Development of railway systems engineering feel;
  - Learning to co-operate between disciplines and in hierarchy.

## Target Audience for BCRRE Programmes

- Programmes aimed at new and mature candidates:
  - Working or planning to work for mainline railways;
  - Working or planning to work for metro railways;
  - Working or planning to work for tram systems;
  - Working or planning to work for government bodies tasked with ensuring railway safety;
  - Working or planning to work on people movers;
- Programmes are partnering with existing and new railway businesses and organisations;
- Robust relationships with local / national bodies.

## Generic MSc Programme Structure

- Programmes based on 8 to 10 short modules (1 week each):
  - Allows different patterns of full-time, part-time and distance study, including deferral of modules between years when studying part-time or from a distance;
  - Allows attendance by students from Britain and world-wide, on part-time and DL basis and tailored to students' circumstances;
  - Total time spent in Birmingham by PT and DL students in each of years one and two is ca. 6 weeks for UK based students;
  - Total time spent in Birmingham by European PT students from the Continent is ca. 5 weeks in each of years one and two;
  - Total time spent in Birmingham by overseas DL students (from 3 time zones) is ca. 6 weeks in each of years one and two.
- Exams can be taken near home in many cases;
- Programme duration for most people is 1-1.5 years (FT), 2-3 years (PT / DL) ... or longer.

## Why BCRRE and Birmingham?

- Programmes designed and developed in conjunction with Industry
  - Global reach and
  - Global relevance
  - Immediate and future relevance
- Industrial Advisory Group
  - School of Engineering
  - Birmingham Centre for Railway Research & Education
- Dedicated administrative staff
  - Care throughout study
  - Post-study community

## Background of MSc Students

- Professional backgrounds of MSc students:
  - Civil, electrical, materials and mechanical engineering;
  - Economics, finance, law and history;
  - Railway engineering and operations backgrounds;
  - Prior qualifications from nothing to PhD;
  - Age range: 23 to 58 years.
- Origins of MSc students past, present and future:
  - Czech Republic, France, Germany, Great Britain, Greece, Hungary, Ireland, Italy, Norway, Poland, Portugal, Spain and Switzerland;
  - Australia, Brazil, China, Ghana, Hong Kong, India, Indonesia, Iran, Israel, Japan, Korea, Malaysia, Mexico, Nigeria, Pakistan, Rwanda, Singapore, South Africa, Taiwan, Thailand, USA, Venezuela and Zimbabwe.

## Sponsors of MSc Programmes

- Private businesses:
  - AECOM, Alstom, Amey, Angel Trains, Atkins, Bechtel, Balfour Beatty Rail, Birse, Bombardier, British Rail (as was), Carillion, DeltaRail, Eurostar, Eurotunnel, Eversholt Leasing, Freightliner, Halcrow (as was), HMRI, HSBC Rail, Invensys (as was), Lloyd's Register Rail, Mott McDonald, Owen Williams, Scott Wilson Railways (as was), Siemens, Skanska, URS (as was), Westinghouse (as was).
- State railways and franchisees:
  - Irish Rail, Israel Railways; Korean Railway Infrastructure Manager, London Midland Railway, London Underground, Metronet (as was), Network Rail, Northern Rail, Northern Ireland Railways, Queensland Rail, Railtrack (as was), RSSB, SERCO Docklands, SNCF, Southern Railway, Tubelines.
- National governments:
  - Brazilian Government, French Government, Hong Kong Dept. of Transport, Indonesian Dept. of Transport, Malaysian Dept. of Transport, Government of Mexico, Government of Rwanda, Singapore Land Transport Authority, Government of Thailand, UK Government, World Bank.

## Primer Course: New for 2015-2016

- Changes in society mean that students are no longer well prepared for postgraduate study;
- Areas of difficulty:
  - Literature research, English language and academic writing;
  - Developing intellectual arguments, e.g., using hypotheses;
  - Understanding plagiarism and fraud.



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## MSc in Railway Systems Engineering and Integration (RSEI)

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## Programme Origin and Development

- 1<sup>st</sup> programme launched at The University of Sheffield in 1995:
  - Support from British Rail and the UK's engineering institutions.
- Programme characteristics:
  - Broad based content – no specialisations;
  - Very intensive programme – with MBA connotations;
  - Systems integration and systems operations focused;
  - All railway disciplines covered from a high level perspective;
- Only course of its nature in the world (we believe);
- At the University of Sheffield from 1995 to 2005 (and 2008):
  - 209 University of Sheffield graduates – until 2008.
- Moved to University of Birmingham on 25 September 2005:
  - Integration into a research intensive environment;
  - About 280 University of Birmingham graduates to date.

## Rail Experience Weekend at Wirksworth



## Taught Module Progression RSEI

|              |  |
|--------------|--|
| <b>RSPC</b>  | Railway Systems Primer Course              |
| <b>LMR30</b> | Induction Weekend and Railway History      |
| <b>LMR31</b> | Strategic Management of Railway Operations |
| <b>LMR32</b> | Rolling Stock Systems Design               |
| <b>LMR33</b> | Railway Traction Systems Design            |
| <b>LMR34</b> | Systems Engineering for Dependability      |
| <b>LMR35</b> | Railway Infrastructure and Track Systems   |
| <b>LMR36</b> | Railway Control Systems Design             |
| <b>LMR37</b> | Railway Technology Strategy and Economics  |
| <b>LMR38</b> | Ergonomics in Railway Systems Design       |
| <b>LMR21</b> | European Study Tour                        |

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## Induction for all Taught Students

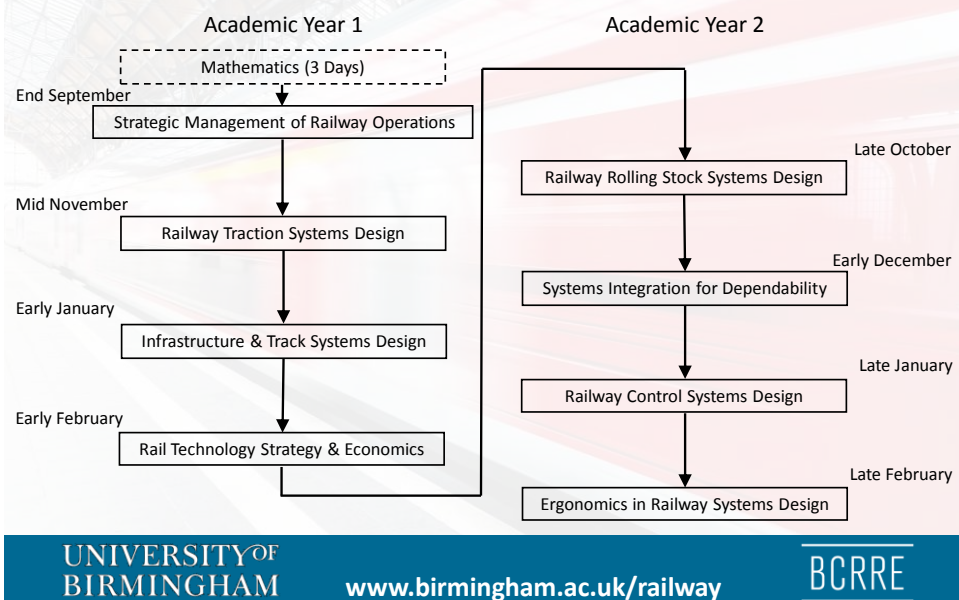


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## RSEI Programme Structure Part-Time



## Example Module Content: LMR31

- Philosophy and design of railway operations;
- Fundamental issues in creating a safe and effective railway system:
  - Main line passenger and freight, light rail, tram and automated rapid transit.
- Key issues involved in the management of railway operations:
  - Legal and regulatory framework for railways in Britain and Europe;
  - Financing the railway;
  - Making money with a railway;
  - Demand based and operationally based planning for main line railways;
  - Operationally based planning for light rail and metro systems;
  - Operational reliability and safety.
- Railway safety and incident case studies;
- Human factors, human behaviour and health and safety;
- Marketing the railway internally and externally;
- Stakeholders, competition and co-operation with other modes.

## Example Module Content: LMR32

- Performance requirements of passenger and freight rolling stock:
  - Managing processes occurring at wheel-rail interface / contact patch;
  - Managing processes involved in steering and supporting vehicles on rails;
  - Kinematics of rail vehicles and dynamic stability;
  - Railway vehicle Aerodynamics.
- Choice of suspension systems for passenger and freight vehicles;
  - Methods of operation of standard suspension systems;
  - Advantages of different types of suspension systems.
- Choice of vehicle structures for particular applications:
  - Material selection and fatigue and fracture issues;
  - Crashworthiness of vehicle structures
- Computer assisted development of rolling stock:
  - Design, simulation and modelling techniques;
  - Assessment of whole train performance.
- Technical specifications for interoperability and acceptance processes.

## European Study Tour 2015 in Warsaw



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## MSc in Railway Risk and Safety Management

Sustainable Management of Railway  
RAMS: Reliability, Availability,  
Maintainability and Safety

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## Railway Risk and Safety Management

- MSc in Railway Risk and Safety Management:
  - 1800 h taught programme for qualified engineers;
  - 4 modules on railway technologies (400 h);
  - 1 module on railway leadership and strategy (100 h);
  - 5 modules on risk and safety management (500 h);
  - 2 modules on research and product and process development skills (200 h);
  - Dissertation module (600 h).
- Collaboration between the Universities of York and Birmingham, funded by Lloyd's Register Foundation.

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## Taught Module Progression RRSM

|             |  |
|-------------|--|
| <b>RSPC</b> | Railway Systems Primer Course                    |
| <b>IWRH</b> | Induction Weekend and Railway History            |
| <b>ROCS</b> | Railway Operations and Control Systems Design    |
| <b>SARM</b> | Safety and Risk Management                       |
| <b>RTES</b> | Railway Traction and Traction Supply Systems     |
| <b>CASA</b> | Computers and Safety in Critical Systems         |
| <b>RSIS</b> | Railway Rolling Stock and Infrastructure Systems |
| <b>SMSR</b> | Safety Management Systems for Railways           |
| <b>SBMR</b> | Strategic Business Management for Railways       |
| <b>TLSA</b> | Through Life Safety Assessment and Management    |
| <b>PERS</b> | Practical Ergonomics for Railway Systems         |

## Introductory Generic Modules

- **FSST Foundations of System Safety Thinking:**
  - Distance learning module focussing on the fundamentals of risk and system safety;
  - Introduction of basic risk and safety terminology.
- **IWRH Induction and Study Skills Module:**
  - Study skills, writing and research skills;
  - Site visit and introduction to the research module.
- **SARM Safety and Risk Management:**
  - Identification and analysis of hazards and the tracking and management of system safety risks;
  - Classical system safety analysis techniques, such as fault tree analysis (FTA) and Failure Modes and Effects Analysis (FMEA).

## RRSM Programme Structure

- A broad, interdisciplinary approach:
  - Railway systems engineering from UoB;
  - Safety-critical systems engineering from UoY;
  - Risk and human resource management from UoB and UoY.
- Characteristics of taught modules:
  - Pre-study module on risk theories by distance learning;
  - Study at University of York and University of Birmingham;
  - 10 one-week class room based modules with team work;
  - About 27 hours of teaching per week;
  - About 7 hours of tutorials per week;
  - Excursions, independent study and weekly tests;
  - One-week study tour to sites on Continent of Europe.
- Industry based projects during 2nd or 3rd year.

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## Master of Research in Railway Systems Integration

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## Master of Research Programme

- Purpose: development of researchers;
- 30 credits of research training:
  - Literature research and review;
  - Communication skills;
  - Data acquisition and data handling skills.
- 30 credits of technical studies (MSc modules);
- Practical thesis project, either university based or working with industry;
- 120 credits for thesis.
- Study Full-Time or combine work and research via Part-Time mode

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## Programmes under Development

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## Railway Network Asset Management

- MSc in Railway Network Asset Management:
  - Will be offered from 2016-2017;
  - 1800 h taught programme for qualified engineers;
  - 3 modules on network asset management (600h)
  - 2 modules on applied asset management in railway (400h)
  - 2 modules on railway technologies and business (400 h):
    - Rolling stock interactions
    - Operations and control systems
    - Strategic business management
  - Dissertation module (600 h).
  - Full-time, Part-time, Distance Learning mode and CPD opportunities

## Railway Signalling and Control

- MSc programme development in collaboration with IRSE:
  - Formerly at the University of Central Queensland;
  - To be offered at Birmingham from 2016-2017;
  - 1800 h taught programme for qualified engineers;
  - Successful completion of taught part provides exemption from IRSE examination;
  - Train services, railway capacity and their management (200 h);
  - Railway control principles (200 h);
  - Railway control applications (200 h);
  - Advanced railway control technologies (200 h);
  - Assessed industry based design projects (300 h);
  - Industry based dissertation project (600 h).

## Railway Education and Training

- PG Certificate in Railway Education for teachers;
- 600 h taught programme for qualified engineers:
  - 2 modules on railway technologies (200 h);
  - 1 module on railway control and operations (100 h);
  - 1 module on railway leadership and strategy (100 h);
  - 1 module on theory of railway education (100 h);
  - 1 module on practice of railway education (100 h).
- Pilot programme in Birmingham;
- Plan to create both a PG Diploma and an MSc programme in Railway Education and Training.

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## December 2013 Graduation Ceremony



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## The 'Railway Minor' Undergraduate Programmes

BEng/MEng

Civil and Railway Engineering  
Electrical and Railway Engineering

## Purpose of the Programmes

- To produce civil and electrical engineering graduates, with the educational and technical background and knowhow to become professional chartered engineers;
- To equip students to work effectively in a professional and managerial capacity, for example in design, construction or research and development, with specific application to the railway sector;
- To give students experience of working in a multi-disciplinary context on railway based projects;
- To meet the growing demand of the railway industry for graduate engineers with both engineering skills and a knowledge of the railway industry.

## Programme Structure, Common Core

- Year 1, MEng and BEng:
  - General engineering content, identical to the existing MEng programmes: 100 credits;
  - Introduction to Railway Engineering: 20 credits.
- Year 2, MEng and BEng:
  - Civil or electrical engineering content: 80 credits;
  - Railway Infrastructure Systems: 20 credits;
  - Railway Traction Systems: 20 credits.

## Programme Structure, Industrial Placement

- Dedicated Industrial Liaison Officer arranges events for industry and students to meet, to apply and arrange placements:
  - Summer jobs
  - Industrial year placements
- Specific railway industry events
- Industrial placement year is recommended after BEng Y2 or MEng Y3
- Placement can be taken anywhere in the world
- Student sponsorship is encouraged

## Programme Structure – BEng

- Year 3:
- Civil or electrical engineering material: 40 credits;
- Individual project: 40 credits;
- Communications and Railway Control: 20 credits;
- Railway Management and Operations: 20 credits.

## Programme Structure – MEng

- Year 3
- Core civil or electrical engineering content: 40 credits;
- Multi-disciplinary design project: 40 credits;
- Communications and Train Control: 20 credits;
- Railway Management and Operations: 20 credits.
- Year 4
- Individual project – 60 credits:
- Civil or Electrical Engineering material: 20 credits;
- Advanced Topics in Railway Engineering: 40 credits.

## Durations of Programmes

| Degree Title     | Duration Full-Time | Duration Part-Time | Taught Credits | Research Credits   |
|------------------|--------------------|--------------------|----------------|--------------------|
| BEng / MEng      | 3 / 4 Years        | n.a.               | 320            | 40 Dissertation    |
| BEng / MEng + IP | 4 / 5 Years        | n.a.               | 420            | 40 Dissertation    |
| PG Certificate   | 4 Months           | 1 Year             | 60             | n.a.               |
| PG Diploma       | 8 Months           | 2 Years            | 120            | n.a.               |
| MSc in RSEI      | 12 Months          | 2-3 Years          | 120            | 60 Dissertation    |
| MSc with IP      | 18 Months          | n.a.               | 100            | 20+60 Dissertation |
| MSc in RRSM      | 12 Months          | 2-3 Years          | 120            | 60 Dissertation    |
| MRes in RSI      | 12 Months          | 2-3 Years          | 30+30          | 120 Thesis         |
| MRes with IP     | 18 Months          | n.a.               | 30+30          | 120 Thesis         |
| Mphil            | 24 Months          | 4-5 Years          | 20             | Thesis             |
| PhD              | 36-48 Months       | 6-8 Years          | 20             | Thesis             |

## Industrial Placement Detail

- Undergraduate programmes:
  - Tasks that are appropriate for both the discipline and the level of study and that can be very practical;
  - BEng two 10-14 week placements during summer;
  - MEng three 10-14 week placements during summer.
- MSc and MRes programmes:
  - Tasks that require independent investigation and ‘proper research’, as well as some ‘sparkle’;
  - MSc: equivalent of 600 hours of full-time work;
  - MRes: equivalent of 1200 hours of full-time work.

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## Questions and Discussion

Jenny Illingsworth,  
Clive Roberts, Felix Schmid

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