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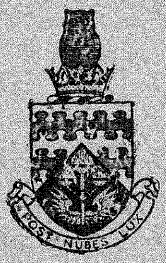

THE COLLEGE OF AERONAUTICS

CRANFIELD

AN ADVANCED COURSE IN AIR TRANSPORT ENGINEERING

by

D. Hyde

CoA Note Aero. No. 172

August, 1966

THE COLLEGE OF AERONAUTICS

DEPARTMENT OF FLIGHT

An Advanced Course in Air Transport Engineering

- by -

David Hyde, M.Sc.(Eng.)., D.I.C., A.C.G.I.

SUMMARY

In 1963 K.G. Wilkinson, then Assistant Chief Engineer of British European Airways, emphasised the lack of formal engineering education in the maintenance and operation of aircraft. This report describes the nine-month postgraduate-level course in Air Transport Engineering which was started in October, 1964 at The College of Aeronautics, Cranfield, in order to help in satisfying this requirement.

Contents

1. Introduction

The equipment operated by the air transport industry continues to become more complex. Together with the continuously growing size of the industry itself, the need for more professionally qualified engineers within the airlines is readily apparent. In a business where 'product differentiation' is limited and competition is consequently fierce, the overall economics have always been marginal. Maintenance costs alone usually account for between 15% and 20% of the total airline operating costs, so that the requirement for maintenance management to be of the highest quality is evident.

This situation led K.G. Wilkinson, now Chief Engineer of British European Airways, to specify in mid-1963 the requirements for formal training in airline engineering[1]. Wilkinson noted that fundamental divisions of activity could be made between (a) the design and manufacture of machines, and (b) their operation. Together with the division between technical and management functions within each of these activities, a quadrantal pattern could be formed in the following manner:

	Design and Manufacture	Operations
Technical	1	2
Management	3	4

Engineering education is concentrated in quadrant 1. Quadrants 2 and 3 generally receive very little attention, although effort in quadrant 3 has been increased during the last few years in the United Kingdom. Quadrant 4 is essentially untouched. Wilkinson's plea was that the possibility of developing a syllabus which would be appropriate to the operational/management and operational/technical areas, that is quadrants 2 and 4, should be investigated.

In his paper Wilkinson noted that '... I am running headlong into the objection that the management science that I have been talking about is more properly a postgraduate course and that the first degree can very well be one of the conventional engineering kind. My contention is that even the first degree in the last one or possibly two years should be modified for anybody making a career in an operational industry, in order to give the most useful basis for the early career and subsequent management training.'

In fact two courses have materialised from these suggestions. At the undergraduate level the Department of Aeronautics and Space Technology at the City University, London (previously the Northampton College of Advanced Technology), where Wilkinson first propounded his views on this subject in March 1963, have taken the initiative. The first intake for their new $4\frac{1}{2}$-year 'sandwich' course in Airline Engineering started in February, 1965[2]. With most of the required resources already available, Cranfield also responded independently by setting up a nine-month postgraduate course under the same name which began in October, 1964. The second such course started a year

later, although the actual name was changed to 'Air Transport Engineering' owing to the active participation of the manufacturing industry and the military services, in addition to the airlines. The elements of this syllabus are described in this report, based on the experience of the first two courses.

2. Cranfield and the Air Transport Engineering Course

The College of Aeronautics, Cranfield, is a Government sponsored institution which was founded in 1946 for the purpose of providing advanced courses in aeronautics and other branches of engineering science and technology and engaging in research. The original aeronautical courses have tended to become more specialised as technology has advanced, and the products of these are well known throughout the aircraft manufacturing industry. Normally such aeronautical students do two year courses and the final year is spent almost completely within one of the teaching departments of the College, i.e. Aerodynamics, Aircraft Design, Electrical and Control Engineering, Flight, Materials, Mathematics, Production and Industrial Administration, and Propulsion. However, some men are accepted directly into the specialist final year.

The Air Transport Engineering course uses a different approach compared with this classical pattern. Operational engineering problems are emphasised by a broad-based approach rather than a specialist treatment, but nevertheless a comprehensive understanding of the fundamental principles involved is given. Basically this is a nine month advanced course designed to give a comprehensive coverage of advanced techniques and disciplines in all aspects of air transport engineering and it is intended to be complementary to existing training programmes offered by airlines and technical colleges.

The first direct contributions in air transport education at Cranfield were made by the BEA experts, K.G. Wilkinson and S.F. Wheatcroft who, for several years, gave a short series of optional lectures on aircraft operations and economics to all students. A minor 'pilot' course on air transport was subsequently offered as an option to all final year aeronautical students. After mid-1963 the implications of Wilkinson's paper were realised and a concentrated effort was started in order to establish a syllabus for a nine-month full time course which would attract sufficient students to justify the work involved. Visits were made by members of the staff of the Department of Flight, who are responsible for organising the course, to various sectors of the manufacturing industry as well as to the airline Corporations and independent carriers. In fact periods of attachment were spent by staff with the two national Corporations so that Cranfield was in a position to fully understand their points of view. This co-operative effort and learning process must, of course, be continuous if the course is to be kept up-to-date: to this end, since the first intake was accepted at Cranfield in 1964, visits have been made to six European 'flag' airlines and four major North American operators in addition to the numerous day-to-day contacts within the U.K. industry.

Selected staff are also taking it in turn to attend the Royal Aeronautical Society's Annual Air Transport Course at Oxford.

The College has always recognised the importance of accepting students with Higher National Certificates or Diplomas, in addition to those with degrees and diplomas in technology. Consequently the standard of admission for the Air Transport Engineering course is that of a good honours degree or honours diploma in technology, usually in mechanical or aeronautical engineering, or alternatively an HNC or HND together with appropriate training and experience. Although such an arrangement obviously produces some minor problems arising from the disparity of the students' initial academic standards, it is felt that the mixing of those men with higher academic standards and those with wider industrial experience is invaluable in its own right. Candidates whose qualifications and experience do not meet these requirements may be offered the possibility of completing the first year of the College's two-year course in aeronautics as a preliminary year. Successful completion of the course leads to the award of a postgraduate Diploma. However the Committee on Higher Education (the 'Robbins Committee') recommended that higher degrees should be available for students of the College of Aeronautics and so it is expected that in the near future a Master's degree could be conferred on those who satisfy the prescribed academic requirements.

The course was originally designed for engineers who are employed in the airline industry. However it is also of interest to project, design, technical sales and service engineers in companies which manufacture transport aircraft and aero-engines, and to other engineers who are closely associated with the operation of transport aircraft. This wide interest is emphasised by an analysis of the sponsors of the students on the 1964/65 and 1965/66 courses: of the total of 27 in these two final years, 9 were sponsored by either BEA or BOAC, 5 by Hawker Siddeley Aviation and 1 each by British Aircraft Corporation, Bristol Siddeley Engines, the Air Registration Board and Transport Command of the Royal Air Force. The remaining 9 students left either BAC, HSA, East African Airways or the Indian Institute of Sciences in order to complete the course and they were maintained on grants and scholarships (The Science Research Council has approved the course for the tenure of its Advanced Course Studentships). Average age of the men has been 27-28 years and just over half of them have had an honours degree or honours diploma in technology before coming up to Cranfield.

It is difficult, if not impossible, to prove the immediate benefit to be gained by a potential sponsor of this course and an obvious problem is the difficulty of sparing men for a nine-month period. Often it is true to say that the very people who cannot be released are the ones who stand to benefit most by coming to Cranfield. Repositioning those who have completed the programme back into their organisation can also present problems. Despite these considerations, which should not be dismissed without careful thought, the initial support for the course has been excellent and interest in it appears to be increasing.

3. The Syllabus

The course covers the managerial and operational implications of air transport, in addition to the directly related aspects of design, materials and systems. Although it is somewhat arbitrary, a convenient division of the programme into the following five sections may be made:-

Management, Project, Systems Design and Development, Operations, and Maintenance and Overhaul. (see Appendix I for detailed syllabus).

Each lecture course is supported by appropriate practical demonstrations and exercises using the extensive laboratory resources of all Departments and the College aircraft. In the fundamental engineering aspects of the syllabus a thorough understanding of the advanced principles involved is taught, although the application of the techniques to airline industry practice is emphasised. Many of the non-engineering subjects are dealt with by an 'appreciation' approach. The object is to get a working knowledge of the many specialist jobs associated with the basic engineering function in air transport so that the engineer himself can get a better 'feel' for the specialist's function and can also talk to him in his own 'language'.

The first part, Management, deals with the principles and techniques of management and then applies these to the air transport situation. Accordingly the actual subjects covered are industrial management, management accounting and financial control, statistics, operational research and electronic data processing, together with airline organisation, airline economics and air law. Within each of these separate subjects there is, of course, a large amount of subject matter to be covered: for instance the operational research lectures alone include stock and spares control, critical path analysis, linear programming, queueing theory and Monte Carlo simulations. Previously a thorough grounding in statistics is given, highlighting the intelligent use of data, and this course is supported by a comprehensive series of experiments illustrating probability theory, distribution theory and sampling testing.

Every effort is made to keep the teaching topical. Two examples of this are, firstly, the use of the current BEA and BOAC Annual Reports and Accounts, together with the Air Corporations Act, as a basis for discussion in the accounting and control course and, secondly, the emphasis now being placed on the use of 'on-line' electronic data processing in airline organisation. Demonstrations using a Ferranti 'Pegasus' digital computer are used to illustrate data processing techniques. Airline economics deals with aircraft evaluation, involving tutorial sessions on the calculation of direct operating costs, and with airline indirect costs and the associated influences of price, regulation and competition. An example of a peripheral subject is seen in the air law lectures where the broad background of national and international law is covered, including the legal status of airline engineers.

Project work forms the basis of the second, relatively minor, section. Consideration is given to initial project design procedure and control, including flight paths and performance, optimisation of configuration, layout, weight prediction and basic loading actions. Specific problems associated with the design of conventional and VTOL civil transport aircraft, and their systems, are then discussed. Advanced transport projects, which have resulted from the detailed work carried out by previous study groups of College staff and students, form the basis for tutorial discussions.

An area of continually increasing complexity constitutes the third section, which deals with Systems Design and Development. The upsurge in material costs in recent years, which now usually predominate over the associated labour costs in practical airline maintenance situations, has focussed attention on the potential savings to be had by rapidly increasing the permissible operating times between overhauls of components and engines as experience is increased on a new aircraft type. However a thorough understanding of the aircraft systems is necessary in order to fully appreciate the 'lifing' problems of the systems components. The propulsion, electrical, radio and radar, flight control and hydraulic systems are all covered here. Some associated preliminary courses are also included in subjects such as fuels and combustion, electronics, and stability and control. Demonstrations and exercises for this section of the syllabus include testing and fault application in the electrical power systems laboratory, performance calibration and systems analysis on turbojet and turboprop test beds, airborne use of radio and radar aids and demonstrations of power controls.

Operations is the subject of the fourth segment of the course, and aircraft performance and flight operations form the main lecture coverage. Emphasis is placed on the derivation of Flight Manuals from certification procedures, noting the appropriate airworthiness requirements, and on the conversion and use of this information for flight planning. The opportunity is taken here to consider ergonomics and cockpit workload, and the use of computers in the analysis and synthesis of systems. Exercises range from the use of a flight simulator to demonstrations in the ergonomics laboratory. Full use is made of the two Hawker Siddeley 'Doves' and one twin-jet Morane Saulnier 'Paris' aircraft operated by the Department of Flight in order to demonstrate airworthiness requirements and air testing procedures. Cranfield airfield has paved runways and a wide range of navigational facilities including NDB, VOR, CRDF and ILS, together with surveillance radar which may be provided by RAE Bedford. In 1965 there were over 50,000 movements recorded, although the majority of these resulted from light aircraft training. Such a facility gives an invaluable and unique environment for an academic establishment offering an air transport engineering course. An operational flight research and development organisation, together with AID - and ARB - approved design and maintenance facilities, help to maintain this realistic atmosphere throughout the students' stay at Cranfield.

The final section is concerned with Maintenance and Overhaul. In

support of a better understanding of the degraduation of components in service and the future use of new materials, lectures are given in materials science and technology and the related aspects of fracture and fatigue, structural and mechanical testing and non-destructive testing. Corrosion, protection and the properties of metals in engineering environments together with possibilities such as the more extensive use of non-metals in components and wider application of non-destructive methods in the field are all discussed. Materials fabrication and testing are demonstrated, including the use of such techniques as X-radiography, ultrasonics, magnetic methods and metallography.

The knowledge of probability concepts given previously in the statistics course is used to develop the theory of reliability, including replacement, redundancy and life testing, with tutorial sessions to show sample calculations. In the general aircraft maintenance and overhaul lectures the practical implications of reliability and maintainability are discussed, consideration being given to component failure characteristics, life development, maintenance check systems and production planning and control. The subsidiary subjects of flight recording and the application of work study to maintenance are taught separately. Here again the laboratory demonstrations are geared as closely as possible to actual situations and, as an example, an aircraft transit at London (Heathrow) Airport is now being used to illustrate the principles of Memomotion photography and critical path analysis.

4. Individual Project Work and External Programmes

Each student is required to submit an essay near the end of the course which accounts for part of his final assessment. These essays give the opportunity to work on a specific problem and individual supervision is provided by the College staff. Organisations which sponsor students may co-operate in the choice of subjects in order that the students can work on problems of direct interest to their employers. This project work is finally examined orally and seminars are also held at which each student in turn presents his work before the rest of the course. The subjects chosen for these studies have ranged from investigations on management organisation and aircraft project work, through system economic studies and component reliability analyses, to critical reviews of current operational and maintenance problems (see Appendix II for details). Included in the operational area have been surveys on air-to-ground noise abatement, use of take-off monitors, minimisation of aircraft turnround times and the design of an integrated flight data recording system: in the maintenance field optimisation of aircraft utilisation, use of quality control, material procurement and defect investigation have been studied.

In addition to the formal course already outlined, an extensive programme of supplementary external lectures by experts in a wide spectrum of air transport subjects is arranged (see Appendix III for details). These sessions occur nearly every week in the three terms and are followed by informal discussion periods in which the course members are encouraged to

participate. A series of visits is also made. The national Corporations, being the largest sponsors of students on the course, are naturally included in this scheme. A technical presentation on a current transport aircraft is given by one of the airframe manufacturers and other days are spent at instrument or component firms (see Appendix IV for details).

Considerable importance is attached to the community life of the students and every encouragement is given to intellectual and social activities. The Air Transport Engineering course, like all others at Cranfield, is residential and this provides a valuable opportunity for the cross-fertilization of ideas with students reading other subjects. Opportunities for flying training and gliding are also available as extra-mural schemes which can assist the student in his appreciation of the course. The power flying is organised by the Department of Flight using a fleet of four Auster Aiglets. A deeper understanding of the pilot's point of view is felt to be very desirable for these engineers and so this type of activity is encouraged.

5. The End Product

The marriage of the management sciences to the selected technical aeronautical aspects at Cranfield will produce engineers with a wider knowledge of their task who are aware of the most recent techniques involved in the airline business. This should result in future engineering management being more flexible and appreciative of its inter-dependence with other departments of the organisation - a fact that has not always been true in the past. Consequently, it is believed that this unique new course will make a significant contribution towards the operation and economy of the air transport industry.

6. References

1. Wilkinson, K.G. — Education of the Airline Engineer. Journal of The Royal Aeronautical Society. July, 1963.

2. Buchanan, S. — An Undergraduate Course in Airline Engineering. Aircraft Engineering. February, 1965.

APPENDIX I

Syllabus

MANAGEMENT (95 lectures and 19 laboratory sessions)

Industrial Management (10 lectures) - The scope of industrial management problems in organisation, production, marketing, finance, personnel administration, business policy and industrial relations.

Management Accounting and Financial Control (10 lectures) - Definitions. Financial accounting. Cost accounting. Standard costs. Budgets. Breakeven analyses, marginal costing. Assessment of capital projects. Variances, accounts, audits. Interfirm comparisons. Management accounting.

Statistics (20 lectures) - Probability. Collection and summarisation of data. Distributions. Central limit theorem. Relationship between distributions. Fitting of distribution to data. Sampling theory.

Experiments to illustrate probability theory, distribution theory, sampling and significance testing (10 sessions).

Operational Research (15 lectures) - Stock and spares control: introduction, economic ordering quantity, fixed order quantity systems, fixed order cycle systems. Critical path analysis: network analysis, arrow diagram, calculation of event times, critical path. Queueing theory. Linear programming. Monte Carlo simulations. Computer applications.

Tutorials to complement lecture course (5 sessions).

Electronic Data Processing (10 lectures) - Basic elements. Computer systems. Input devices. Data collection and processing. Output devices. Flow diagrams. Computer languages. On-line systems.

Demonstrations using a Ferranti Pegasus digital computer (2 sessions).

Airline Organisation (10 lectures) - Organisation of activities in airline management. Organisation charts. Automatic data processing in airline industry. Schedules planning. Responsibilities in aircraft procurement.

Airline Economics (10 lectures) - Aircraft evaluation: route analysis, scheduling, direct costs. Airline indirect costs. Price policy. Regulation and competition.

Tutorials on aircraft evaluation (2 sessions).

Air Law (10 lectures) - International air law: I.C.A.O. and I.A.T.A. International conventions: Chicago and Warsaw conventions. Legal liabilities: Air Navigation Orders and Regulations. Legal status of airline engineers. Contracts. Aviation insurance.

PROJECT (30 lectures and 4 laboratory sessions)

Aircraft Design (10 lectures) - Specific problems associated with the design of civil transport aircraft. Structural design. Component design. Installation of engines, fuel systems, control systems. Engineering trends.

Wind tunnel demonstrations showing measuring techniques and flow visualisation (1 session).

Demonstration of detail and component design (1 session).

Initial Project Design (15 lectures) - Flight paths and performance. Choice of power plant and configuration. Aircraft layout. Weight prediction. Project design procedure. Loading actions.

Tutorials on advanced civil transport projects (2 sessions).

V.T.O.L. Aircraft (5 lectures) - Helicopters; other civil V.T.O.L. applications. Operational and economic problems. Future developments.

SYSTEMS DESIGN AND DEVELOPMENT (75 lectures and 11 laboratory sessions)

Propulsive Units and Gas Turbine Performance (10 lectures) - Criteria for assessing a propulsive unit and appropriate operating regimes. Variation of thrust or power and specific fuel consumption with altitude, airspeed and r.p.m. for turbojet, bypass, turbofan, and turboprop units. Engine layout. Design-point cases and analysis. Component characteristics. Performance of reheated turbojet, turbofan and bypass engines. Sypersonic intakes and convergent-divergent nozzles. Control systems.

Turbojet and turboprop performance calibration and systems analysis (2 sessions).

Gas Turbine Systems (10 lectures) - Requirements and methods of operation of the following systems: fuel, ignition, starting, fire protection, ice prevention and their interconnection and interaction.

Fuels, Oils and Combustion Systems (5 lectures) - Production, testing and properties of aviation fuels and oils. Fuel injection systems. Variables affecting combustion system performance and design.

Combustion chamber test (1 session).

Electronics (10 lectures) - Fundamentals of valves and semiconductors; application of valves and transistors. Other semiconductor devices, microelectronics, micrologic and integrated circuits; application to airborne systems, effect of environmental conditions. Magnetic amplifiers, power supplies, A.C./D.C. conversion, silicon controlled rectifiers, gas filled tubes.

Electrical Power Systems (10 lectures) - Aircraft electrical systems: D.C., rectified A.C., constant frequency A.C. and mixed systems. Utilisation equipment. Generators. Batteries. A.C. and D.C. motors. Non-rotating generators. Serviceability. Reliability.

Power systems laboratory: testing techniques and fault application on aircraft D.C. and A.C. systems (2 sessions).

Radio and Radar (10 lectures) - Wave propogation: choice of frequency. Principles of radar: primary and secondary radar, other applications. Radio navigation: radio altimeters, D/F principles, distance measuring equipment, hyperbolic systems. Landing aids: precision approach radar, beam systems. Doppler and inertial systems.

Demonstration of air traffic control ground facilities (1 session). Airborne demonstrations of navigation and landing aids (2 sessions).

Stability and Control (5 lectures) - Static and dynamic stability. Notation. Aerodynamic derivatives. Equations of motion. Stability modes and airworthiness requirements.

Airborne demonstrations of stability modes and handling qualities to meet airworthiness requirements (2 sessions).

Flight Control Systems (10 lectures) - Introduction. Feedback theory. Flight control systems: autopilots, auto-stabilisers.

Demonstration in flight control laboratory (1 session).

Fluid Power Systems (5 lectures) - Design and analysis of power sources, servo-valves, actuators and complete systems.

OPERATIONS (40 lectures and 11 laboratory sessions)

Aircraft Performance (25 lectures) - Drag. Performance of turboprops and turbojets. Performance equations. Take-off. Landing. Climb. Range. Airworthiness codes. Basis of airworthiness requirements. Manufacturers' flight trials for Flight Manual. Presentation of data for flight planning. Future airworthiness requirements.

Performance tutorials and flight demonstrations: calibration of aircraft systems, measurement of climb and range characteristics on a jet aircraft, air testing for A.R.B. certification (8 sessions).

Flight Operations (10 lectures) - Flight planning and operating techniques for short and long haul operations. Air traffic control: separation problems. Aircraft noise. Flight safety. Ergonomics. Cockpit display and pilot workload.

Demonstration in ergonomics laboratory (1 session).

Computers (5 lectures) - Digital and analogue techniques. Introduction to D.C. analogue computers. Electro-mechanical computing units. Use of simulators in analysis and synthesis of systems. Flight simulators.

Demonstration in flight simulator (1 session).
Demonstration in analogue computer laboratory (1 session).

MAINTENANCE AND OVERHAUL (85 lectures and 24 laboratory sessions)

Materials Science and Technology (25 lectures) - Introduction and structure of matter. Properties of metals in engineering environments. Non-metals. Welding and forming of metals and non-metals. Corrosion: primary mechanisms, influence of structure, stress corrosion, corrosion fatigue. Protection: metallic and non-metallic coatings, sacrificial protection. Non-destructive testing: basic principles, X- and γ-radiography, magnetic and eddy current methods, dye pentrants, ultrasonics, potentiality of new techniques.

Demonstrations illustrating fabrication of metals and polymers, welding processes, creep and fatigue in aircraft materials (4 sessions).

Demonstrations of non-destructive testing techniques including X-radiography, ultrasonics, magnetic methods and metallography (4 sessions).

Fracture and Fatigue (5 lectures) - Fractures: influences of materials, stresses and environment. Service fatigue loads; cumulative damage. Life evaluations; testing methods. Crack propagation. Preventive design.

Aircraft materials testing (1 session).

Structural and Mechanical Testing (5 lectures) - Experimental stress analysis, airworthiness test requirements, testing of large structures, testing at elevated temperatures.

Testing of components, undercarriage performance and ground resonance (3 sessions).

Instrumentation (10 lectures) - Aircraft instruments. Flight data recording: maintenance recorders, crash recorders.

Demonstrations of aircraft instrument calibration techniques, flight recording techniques and data handling facilities (3 sessions).

Reliability Theory (10 lectures) - Theory of reliability and replacement. Life tables. Reliability records. Design and testing for reliability; redundancy.

Tutorials to complement lecture course (5 sessions).

Aircraft Maintenance and Overhaul (20 lectures) - Technical publications. Reliability and maintainability: definitions, principles, requirements and programmes. Components: failure models and characteristics, lifting policies, life development. Engine life development and early failure detection. Maintenance check systems. Production planning and control: long and short term planning, material provisioning. Defect recording and analysis. Modifications. Aircraft turnround.

Tutorials to complement lecture course (2 sessions).

Work Study in Maintenance (10 lectures) - Study and review of methods. Introduction of new methods; labour relations. Techniques for setting time standards. Incentive schemes.

Demonstration of techniques (2 sessions).

APPENDIX II

List of Technical Essay Titles

Name	Title
1964/65 Course	
J.J.D. Brown	Maintenance requirements in aircraft design.
P.W. Dinnage	Optimum lifing policy for components with emphasis on the feasibility and economic aspects.
D.J. Goldsmith	The system costs of inter-city air travel.
M.T. Hards	Engines for supersonic airliners: choice of optimum types for Mach 2.2 and Mach 3.0 requirements.
H.J. Hay	Production planning and control of aircraft maintenance.
D.C. Johnson	Minimisation of aircraft transit and turn-round times.
A.W. Keywood	Optimisation of reliability development costs and reliability improvement in an existing aircraft system.
S.F.A. Kirmani	Ramwing craft on land: a preliminary design and economic study.
R.B. Page	A survey of take-off monitors and take-off directors.
R.M. Rumbelow	An organisation for the marketing of civil transport aircraft.
J.A. Sands	The development of air freight.
B.P. Sauer	The design of an integrated flight data recording system for modern aircraft.
N.H. Stewart	Air transport safety.
D.G. Yeomans	The optimisation of component rectification and overhaul lives.

Name	Title
1965/66 Course	
E.N. Allen	Take-off and landing noise measurement, analysis and optimum abatement procedure.
J.A. Anning	Some economic, design and performance considerations of the small cargo aircraft.
R.A. Ashby	Development of an alternative intermediate maintenance check pattern for long-haul operators.
B.A. Gosnold	A method of applying quality control to aircraft maintenance and overhaul.
J.M. Harvey	Preliminary design study of a commercial ramwing vehicle.
C.W.F. Hudson	Engine design for maintenance - a survey of current ideas leading to a recommended code of practice.
D.W. Mann	The operation of airliners in reduced visibility.
W.T. Phillips	Forecasting aircraft engine overhaul arising
G.A. Pickford	Economic comparison of the 1963 and 1965 College of Aeronautics Design Projects.
A.L. Rooks	Material procurement and control.
J.W. Saull	The analysis of aircraft systems' defects with particular reference to hydraulics.
J.C. Trevett	The economics of low-weather minima operations.
R. Yates	Take-off and landing noise - with special reference to economics and compressor noise.

APPENDIX III

List of Supplementary External Lectures

1964/65 Course

'Selling Air Cargo'
G. Batson (London Cargo Sales Manager, Pan American World Airways)

'Concord'
A. Symon (Sales Engineering Manager, British Aircraft Corporation (Operating) Ltd

'Use of Digital Computers in Civil Aircraft'
P.A. Hearne (Assistant General Manager, Elliott Flight Automation Ltd.)

'The Statistical Approach to Airworthiness Requirements'
W. Tye (Chief Technical Officer, Air Registration Board)

'An Aeromedical View of Safety Matters'
Dr. G. Bennett (Chief Medical Officer, Ministry of Aviation)

'The Systemworthiness Concept'
G. Prill (Assistant Administrator, Federal Aviation Agency)

'Inclusive Tour Operations'
J.E.D. Williams (Managing Director, Britannia Airways Ltd.)

'Flight Planning from an Airline Captain's Viewpoint'
Captain E.C. Miles (Boeing 707 Flight, BOAC)

'Flight Control Systems'
R. Bartop (Chief Engineer - Civil Autopilots, Elliott Brothers Ltd.)

'Recent Developments in Autopilots for Transport Aircraft'
D. W. Righton (Research Branch Manager, Smiths Aviation Division)

'Flight Recording'
A.S. Lucking (Senior Development Engineer, BOAC)

'Flight Safety'
M.H. Vivian (Deputy Director of Flight Safety, Ministry of Aviation)

'Non-Scheduled Air Traffic with Europe'
R. Peladan (Assistant to Director, Institut du Transport Aerien)

'Operating Problems of a Short Haul Airline'
A. Williams (Flight Services Superintendent, BEA).

'Some Aspects of Reliability'
N.H. Wood, A.E. Davies and J. Addington (Bristol Siddeley Engines Ltd., and British Aircraft Corporation (Operating) Ltd.)

'The Operator's Approach to Air Conditioning System Design'
C.B. Redgate (Senior Development Engineer, BOAC)

'Task and Technique of Airline Engineering' (2 lectures)
K.G. Wilkinson (Chief Engineer, BEA)

'Some Current Economic Problems in Airline Operations' (2 lectures)
S.F. Whatcroft (Consultant and Economics Adviser to BEA)

'Investigation of Aircraft Accidents'
F.H. Jones (Structures Department, RAE Farnborough)

1965/66 Course

'An Aeromedical View of Safety Matters'
Dr. G. Bennett (Chief Medical Officer, Ministry of Aviation)

'Film-Wire: A New Concept in Electrical Wiring for Airborne Systems'
Technical Presentation by M.B. Metals Ltd.

'The Economics of Load Factor'
J. Wayte (Deputy Chief Economics Adviser, BOAC)

'Marketing Air Cargo'
J.L. Guy (Cargo Sales Manager, BEA)

'The Statistical Approach to Airworthiness Requirements'
W. Tye (Chief Technical Officer, Air Registration Board)

'Flight Services Planning in a Short Haul Airline'
A. Williams (Flight Services Superintendent, BEA)

'An Airborne Integrated Maintenance System'
R.C. Rogers (Military Projects Group, Honeywell Controls Ltd.)

'Flight Planning from an Airline Captain's Viewpoint'
Captain E.C. Miles (Manager of Boeing 707 Flight, BOAC)

'Some Aspects of Reliability'
J. Addington, A.E. Davies and N.H. Wood (British Aircraft Corporation (Operating) Ltd. and Bristol Siddeley Engines Ltd.)

'Recent Developments in Autopilots for Transport Aircraft'
D.W. Righton (Research Branch Manager, Aviation Division of Smith Industries Ltd.)

'Flight Safety'
M.H. Vivian (Director of Flight Safety, Ministry of Aviation)

'Inclusive Tour Operations'
J.E.D. Williams (Managing Director, Britannia Airways Ltd.)

'The Use of a Computer for Improved Product Support'
P.W.L. Ward (Operational Cost Engineer, Rolls-Royce Ltd.)

'Airline Engineering'
K.G. Wilkinson (Chief Engineer, BEA)

'Market Research in the Aircraft Manufacturing Industry'
R.E.G. Davies (Market Research Economist, Hawker Siddeley Aviation Ltd.)

'Airports'
G.V. Hole (Chief Executive, British Airports Authority)

'Recent Developments in Non-Scheduled Air Traffic'
R. Peladan (Assistant to Director, Institut du Transport Aerien)

'Flight Deck Automation'
P.A. Hearne (Assistant General Manager, Elliott Flight Automation Ltd.)

'Investigation of Aircraft Accidents'
J. Forsyth (Structures Department, R.A.E. Farnborough)

'Current Problems in Airline Economics' (2 lectures)
S.F. Wheatcroft (Consultant and Economics Adviser to BEA)

APPENDIX IV

List of Visits

1964/65 Course

Royal Aeronautical Society, London.
Twentieth British Commonwealth Lecture - 'Tools of Airline Management' by J.T. Dyment, Chief Engineer, Air Canada.

BOAC - Airways Terminus, London and Cranebank, London Airport.
Passenger reservations system and flight simulator department.

Royal Aeronautical Society, London.
Symposium on Future Developments in the Air Transport System.

Hawker Siddeley Aviation Ltd., Hatfield.
Technical presentation on H.S.125 and H.S. Trident aircraft.

Smiths Aviation Division, Cheltenham.
Flight control systems, auto-checkout equipment and instrumentation presentations.

Royal Aircraft Establishment, Bedford.
Air traffic control and precision approach radar demonstrations.

BEA Engineering Base, London Airport.
Engine early failure detection, maintenance dock control and open discussion with senior staff.

1965/66 Course

Royal Aeronautical Society, London.
Twenty-first British Commonwealth Lecture - 'Private Enterprise in British Air Transport' by F.A. Laker.

BOAC - Airways Terminus, London and Cranebank, London Airport.
Passenger reservations system and flight simulator department.

British Aircraft Corporation (Operating) Ltd., Weybridge.
Technical presentation on BAC 1-11 aircraft.

Hawker Siddeley Dynamics Ltd., Hatfield.
TRACE (tape controlled automatic check-out equipment).

Royal Aircraft Establishment, Bedford.
Air traffic control and precision approach radar demonstrations.

BEA Engineering Base, London Airport.
Engine early failure detection, maintenance dock control and open discussion with senior staff.