Unit T21: Aircraft Reliability Engineering

Unit code:	R/503/9999
QCF level:	6
Credit value:	15

Aim

The aim of this unit is to enable learners to statistically analyse failure, make reliability predictions on aircraft systems and assess the relationships between aircraft structural design and reliability.

Unit abstract

This unit focuses on applying reliability engineering principles and analysis to the reliability and availability prediction of aircraft on-board systems and structures.

The unit starts by introducing the objectives of general reliability engineering and the nature of reliability engineering programmes, including the need for a top-down management approach that ensures their successful implementation. The statistical tools and techniques necessary to analyse failure data are then introduced. There follows a learning outcome dedicated to the methods used to make reliability prediction estimates on aircraft systems. Finally, the relationships between aircraft structures and structural design methodology are considered.

Learning outcomes

On successful completion of this unit a learner will:

1 be able to analyse aircraft reliability engineering programmes

2 be able to statistically analyse life failure data

3 be able to determine aircraft systems reliability prediction estimates

4 be able to assess relationships between aircraft structural design and reliability.

Unit content

1 Be able to analyse aircraft reliability engineering programmes

Introduction: reliability engineering objectives (prevent or reduce the likelihood of failure, reduce the frequency of failures, identify causes of failure, correct causes of failure, determine ways of coping with undetected failures, determine reliability estimates); methods used to achieve reliability engineering objectives, eg probabilistic, statistical, practical testing, experience

Integrated reliability programmes: requirements, eg management, project, contracts, risks, costs, environment, test methods, processes, maintenance; tasks, eg specification, review of specification, design for reliability, design review, final design, development test plan, review, production plan, production control, in-service tasks; reliability methods to achieve tasks, eg reliability modelling, prediction methods (such as computer aided engineering (CAE), failure modes effects and criticality analysis (FMECA), failure reporting, analysis corrective action systems (FRACAS))

Reliability management: activities, responsibilities, decisions eg corporate policy, reliability programme development, human resources, physical resources, risk analysis, cost analysis, safety, quality assurance, quality systems, product liabilities, contracts, suppliers, reliability administration, plans, training

2 Be able to statistically analyse life failure data

Statistical probability: probability, eg terminology, concept of variation, events, rules of probability (joint, independent, conditional probabilities)

Statistical probability distributions: discrete distributions, eg use, limitations, parameter measures, binomial, Poisson; continuous distributions, eg use, limitations, reliability function, hazard function, probability density functions (pdf), probability distributions, parameter measures (central tendency, spread, skewness, peak), normal, lognormal, exponential, gamma, chi-square (x^2), Weibull, extreme value

Data sampling analysis: methods eg statistical confidence (limits), significance testing (z-test, x^2 significance test, differences in variance test, sign test, x^2 goodness-of-fit test), trend analysis

Life failure data analysis: data handling, eg data observation, data classification, data ranking, data probability plotting (normal, Weibull); data analysis eg choice of best fit statistical distribution model (such as normal, exponential, gamma, binomial, Weibull); computerised data analysis (rank regression, maximum likelihood method)

3 **Be able to determine aircraft systems reliability prediction estimates**

Prediction data sources: reliability safety standards (JAR/FAR/CS-23, 25, 27, 29, JAR/FAR 1309, MOD standards, MIL-HDBK-217, design codes, failure rate condition levels); field data (manufacturers' data, production data, fault rates, time to failure events, survival rates, alert level plotting)

Aircraft systems: categories, eg software, electrical, electronic, avionic, electro-mechanical, fluid, engine, warning; design for reliability, eg safety standards, codes of practice, duplicity, circuit design, redundancy, component selection, reliability testing

Reliability prediction methods: basic systems reliability, eg series model, active redundancy, standby redundancy, availability of repairable systems, block diagram analysis (cut set, tie set methods, common mode failures); additional methods, eg Markov analysis, Petri nets, fault tree analysis (FTA), failure modes and effects analysis (FMEA), failure modes, effects and criticality analysis (FMECA)

4 **Be able to assess relationships between aircraft structural design and reliability**

Prediction data sources: reliability safety standards (JAR/FAR/CS-23, 25, 27, 29, MOD standards, design codes, failure rate limits; field data (manufacturers' data, production data, fault rates, time to failure events, survival rates, alert level plotting)

Design for reliability: design standards, eg safety standards, codes of practice, structural categorisation (primary, secondary, tertiary, structurally significant items), failure rate limits; reliability design methods, eg failsafe, safe life, redundancy, component geometry, materials selection, environmental protection, corrosion protection

Reliability prediction methods testing, eg destructive materials tests, structural component tests, non-destructive tests; structural analysis, eg fracture mechanics, fatigue life estimation, creep rate estimates

Learning outcomes and assessment criteria

Learning outcomes On successful completion of this unit a learner will:	**Assessment criteria for pass** The learner can:
LO1 Be able to analyse aircraft reliability engineering programmes	1.1 Investigate the different methods used to achieve reliability engineering objectives, assessing their relative merits 1.2 Produce a reliability programme for a final design of a given aircraft component setting out all necessary requirements, tasks and reliability prediction methods 1.3 Produce a reliability programme for a given in-service aircraft, setting out the requirements and reliability methods needed to ensure its continued airworthiness 1.4 Analyse the impact of management activities, responsibilities and decisions on the effectiveness of reliability programmes
LO2 Be able to statistically analyse life failure data	2.1 Solve engineering problems involving, joint, independent and conditional probabilities 2.2 Assess the usefulness of normal, exponential, Weibull and binomial probability distributions, as reliability engineering mathematical tools 2.3 Select the most appropriate continuous and discrete probability distributions for given statistical data sets, determining required parameters 2.4 Analyse reliability sample data sets, determining required confidence limits, significance test results and trends 2.5 Analyse normal and Weibull probability plots determining required life failure data parameters 2.6 Analyse the range of available statistical distributions, determining the best fit for given failure data sets 2.7 Assess the merits of computerised data analysis and probability plotting

Learning outcomes On successful completion of this unit a learner will:	**Assessment criteria for pass** The learner can:
LO3 Be able to determine aircraft systems reliability prediction estimates	3.1 Investigate the sources used to obtain aircraft systems reliability prediction data, assessing their relative merits 3.2 Determine from block diagram models, estimates for the reliability of basic aircraft systems 3.3 Investigate the reliability design methods used for aircraft software, avionic and fluid systems, determining their effect on each system's operational reliability 3.4 Determine the circumstances under which each additional reliability prediction method may be applied 3.5 Carry out fault tree analyses on given aircraft systems determining failure prediction estimates
LO4 Be able to assess relationships between aircraft structural design and reliability	4.1 Assess the relative merits of the sources used to obtain structural prediction data 4.2 Determine the relationships between structural categorisation, the consequences of structural failure and imposed failure limits 4.3 Assess the impact of failsafe, safe life and redundancy design methodologies on the reliability of aircraft structures 4.4 Assess the use of aircraft structural and materials testing in making reliability predictions 4.5 Investigate the analytical methods used to determine aircraft fatigue life, assessing their relative merits

Guidance

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

The learning outcomes associated with this unit are closely linked with:

Level 4	Level 5	Level 6
Unit 1: Analytical Methods for Engineers	*Unit 36: Statistical Process Control*	*Unit T19: Aircraft Structural Analysis*
	Unit 89: Aircraft Structural Integrity	*Unit T20: Aircraft Conceptual Design*
		Unit T22: Avionic Systems Engineering

The content of this unit has been designed and mapped against the Engineering Council's current learning outcomes for IEng accreditation. The completion of the learning outcomes for this unit will contribute knowledge, understanding and skills towards the evidence requirements for IEng registration.

See *Annexe B* for a mapping of the Edexcel BTEC Level 6 Diploma units to IEng programmes.

Essential requirements

Learners need access to spreadsheet software and to *Practical Reliability Engineering* by P D T O'Connor and A Kleyner together with access to aircraft specialist airworthiness publications such as FAR/JAR/CS 23, 25, 27, 29 or their military equivalents.

Delivery

The learning outcomes should be delivered using a variety of teaching techniques and facilities appropriate to the unit content. Formal tutor input is likely to be through lectures, tutorials and structured visits to establishments where aircraft design and manufacture reliability imperatives are applied will prove particularly useful in enhancing learning.

Assessment

The unit may best be assessed through a combination of investigative assignments, together with formal written assessments, sufficient to meet external examiner requirements and centre quality standards.

Resources

Textbooks

CAA – *CAP562 Civil Airworthiness Information and Procedures* (The Stationery Office, 2011) ISBN 978-0117926165

CAA – *CAP747 Mandatory Requirements for Airworthiness* (The Stationery Office, 2011) ISBN 978-0117925663

Lawless J F – *Statistical Models and Methods for Lifetime Data*, Second Edition (Wiley, 2002) ISBN 978-0471372158

Narayan V – *Effective Maintenance Management Risk and Reliability Strategies for Optimizing Performance*, Second Edition (Industrial Press Inc, 2011) ISBN 978-0831134440

O'Connor P D T and Kleyner A – *Practical Reliability Engineering*, *Fifth Edition* (Wiley, 2012) ISBN 978-0470979815

Smith D J – *Reliability Maintainability and Risk Practical Methods for Engineers*, Eighth Edition (Butterworth Heinemann, 2011) ISBN 978-0080969022

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