



Business and Engineering Asset Management Unit Outline

Reliability Engineering ASST8423

Credit: 6 points

Trimester 3
2009

Crawley campus

Dr. Kecheng Shen

<http://units.handbooks.uwa.edu.au/units/asst/asst8423>

PRELIMINARY OUTLINE 5/4/09

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UNIT DESCRIPTION

Introduction

Welcome to the Reliability Engineering (RE) unit. Reliability engineering is an interdisciplinary engineering field consisting of principles and practices based on which a wide variety of special management and engineering tasks are performed to ensure that reliability and other quality goals are achieved.

In this unit we will focus on building up a sound theoretical base regarding the fundamental reliability terms and concepts, basic mathematics of probability and statistics, graphical tools for data analysis, failure mechanisms and failure mode and effect analysis. This is supplemented by some tools and methods in reliability and availability modelling, maintenance strategies, life cycle cost, maintainability analysis and spare parts provision. A substantial amount of time will be spent working on examples and exercises to reinforce the topics. Delivery of material will include guided readings and Web supported lectures. The unit coordinator is Dr. Kecheng Shen from the Discipline Group for Engineering Asset Management at UWA.

Unit content

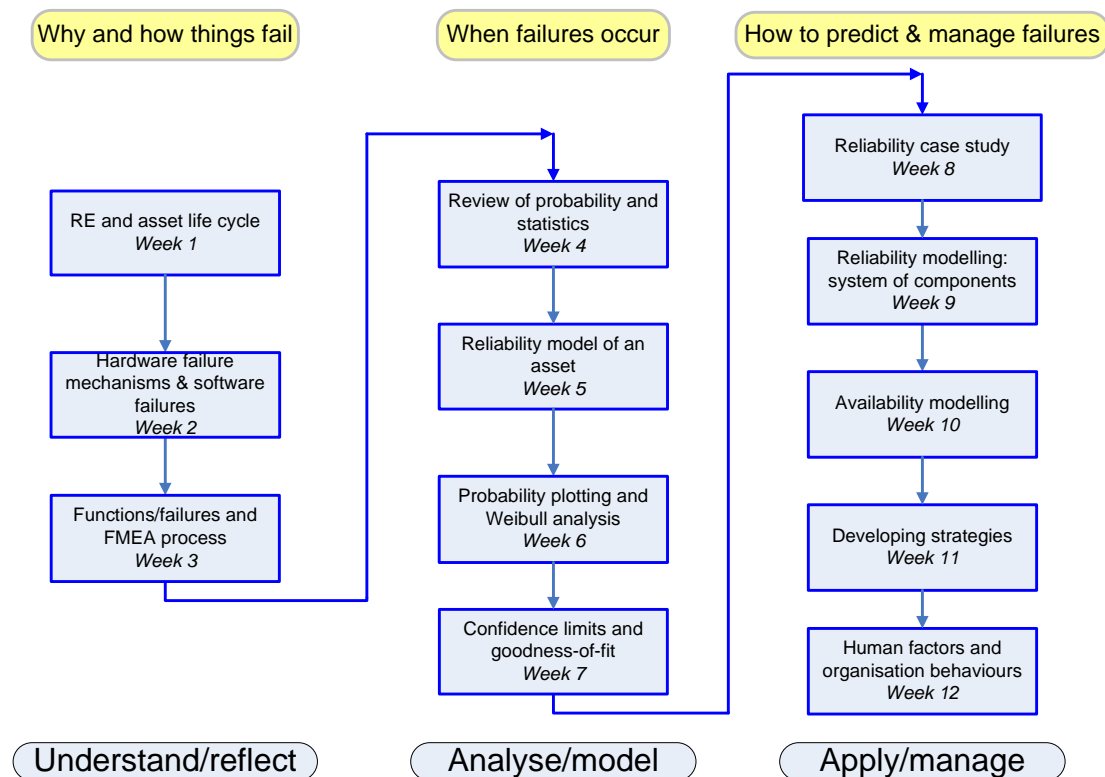


Figure 1: Topic Road Map

Learning outcomes

On completion of this unit, you should be able to

- Explain why and how things fail and the attributes of functions and failures of an asset,
- Develop the reliability model of an asset by applying statistical failure distributions and by analysing failure data,
- Deploy the processes and tools to predict the reliability performance of an asset and develop strategies to manage the failures.

Educational Principles

The unit integrates your background and work experience into the teaching programme and assignments to enhance the context and relevance of the material to your work situation. Delivery of material will be achieved using guided readings and Web supported lectures. Much of our on-campus time will be spent in workshops on case studies, discussing and applying concepts.

The material in the workshops is adapted from previous units of the same topic, in particular the reliability engineering unit for the EAM postgraduate program that was run last year. This unit concentrates on developing a clear understanding of the contents and structure of reliability engineering and the ability to analyse, predict and manage failures in order to improve asset reliability performance. Other engineering units in the EAM postgraduate program <http://www.mech.uwa.edu.au/meam/> concentrate on developing and implementing operational and maintenance strategies, disposal/renewal decision making and framework of engineering asset management. Risk management, stakeholder management, asset information location and data management themes are embedded through all of the engineering (ASST) units in the Masters program. Organisational, leadership, financial and management issues are covered in the MBA (MGMT) units.

CONTACT DETAILS

Unit coordinator	Dr. Kecheng Shen
Email	kecheng.shen@uwa.edu.au
Phone	08 6488 4748
Fax	08 6488 1024
Consultation Hours	By appointment
Lecture Times	6-9 pm Monday evenings
Lecture Venue	Room 1.05 1 st floor Mechanical Engineering building
Unit Web Site	Web CT: http://webct6.uwa.edu.au/

TEACHING AND LEARNING RESPONSIBILITIES

Teaching and learning strategies

Reliability Engineering is a broad field and the participants may have experiences from a variety of industries and within different phases of an asset's life cycle. We have tried to present the framework of reliability engineering as broad as possible. It is, however, our belief that it is crucial that the participants take with them home some of the most fundamental tools and methods, and be ready to apply them.

This Unit uses a variety of learning strategies including:

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- Case studies
- Class discussion & debate
- Lectures
- Pre-recorded lectures by Subject Matter Experts
- Independent study

Participation in debate is a vital part of the adult learning process. For this reason the reliability engineering unit is not offered in distance-learning mode. It is, therefore, important that you attend classes on campus. More formally, the University regulations state that 'to complete a course or unit, students shall attend prescribed classes, lectures, seminars and tutorials'. Students should not expect to obtain approval to miss more than two classes per unit, unless there are exceptional circumstances.

During the course you will also have the opportunity to hear from and discuss material with a small number of external subject matter experts (SMEs). Some of the activities they may be involved in are: pre-recorded lectures, delivering in-class case studies and lectures, feedback on presentations and group activities. These SMEs are carefully selected based on their experience in the field, educational background and their demonstrated commitment to the development of this and other postgraduate units at UWA. In general the SME's all hold adjunct or honorary positions in the UWA's Faculty of Engineering Computing and Mathematics and have formal postgraduate qualifications. SME's are not involved in the formal assessment processes which are conducted by the academic staff.

The principal academic staff member involved is the author of this outline, Dr. Kecheng Shen. I am supported by Dr. Melinda Hodkiewicz who coordinates the EAM & Risk units that complement this course. I have a BE (Machine design and manufacturing process automation), Beijing University of Science and Technology, China; Licentiate of Engineering (Reliability and safety in design), Lund University, Sweden; PhD (Reliability in engineering design), Lund and Linköping University, Sweden; Member of the Institute of Electric, Electronic Engineers (IEEE), USA.

My responsibilities are:

- To guide you through the course material by facilitating classroom discussions and activities.
- To coordinate external subject matter experts.
- To provide examples and anecdotes linking text material to real-world situations.
- To create a safe learning environment that encourages participation and interaction.

Your responsibilities are:

- To read the required readings and complete tutorial work before coming to class.
- To actively participate in class discussions.
- To complete all assignments on time.
- To respect all comments from others during class

Charter of student rights

This Charter of Student Rights and Responsibilities upholds the fundamental rights of students who undertake their education at the University of Western Australia.

It recognises that excellence in teaching and learning requires students to be active participants in their educational experience. It upholds the ethos that in addition to the University's role of awarding formal academic qualifications to students, the University

must strive to instil in all students independent scholarly learning, critical judgement, academic integrity and ethical sensitivity.

Please refer to the guild website the full charter of student rights, located at <http://www.secretariat.uwa.edu.au/home/policies/charter>

Student Guild contact details

The University of Western Australia Student Guild
35 Stirling Highway
Crawley WA 6009
Phone: (+61 8) 6488 2295
Facsimile: (+61 8) 6488 1041
E-mail: enquiries@guild.uwa.edu.au
Website: <http://www.guild.uwa.edu.au>

Use of student feedback

All units are routinely evaluated, through the SPOT and SURF surveys, and feedback from participants is taken into account when I reflect on and update the unit. I welcome your comments and feedback on the content, relevance, presentation and methods of assessment for the unit.

ASSESSMENT MECHANISM

Assessment mechanism summary

There are a number of reasons for having assessable tasks as part of an academic program. The assessable tasks are designed to encourage you to explore and understand the subject more fully. Each assignment has a set of specific learning objectives and a task description against which the work is assessed. Students are encouraged to read the University's policy on assessment:

http://www.teachingandlearning.uwa.edu.au/tl4/for_uwa_staff/policies/teaching,_learning_and_assessment.

Component	Weight	Due Date
Class participation	10%	Throughout trimester
Assignment 1 – Functions, failures and FMEA	15%	28 Sep (tbc)
Mid-term test	15%	12 Oct (tbc)
Assignment 2 – Analysis of failure data and uncertainty evaluation	15%	26 Oct (tbc)
Mini-assignments/tests	15%	Throughout trimester
Final Exam	30%	Exam week starts (tbc) Nov

Supplementary exams are not available in this unit.

Assessment details

Assignment 1 - Functions, failures and FMEA

The purpose of Assignment 1 is to assess your ability to:

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- Understand and explain what functions and failures of an asset are and how they are related to each other.
- Apply FMEA methodology on an asset.
- Manage the identified risks and recommend controls/actions.
- Document the work process and results, reflect on the learning outcomes and discuss advantages/limitations of the FMEA methodology.

This individual assignment assumes that you have been asked to perform an FMEA on an asset. Your work should be presented in a report style and you should refer to relevant, current literature and, wherever possible, use examples cited in course materials and from your reading. Ensure that your opinions and assertions are substantiated with evidence from readings, literature, models, and other forms of literature.

Assignment 2 – Analysis of failure data and uncertainty evaluation

The purpose of this individual assignment is to assess your ability to:

- Identify candidates for underlying distributions for time to failure and time to repair.
- Performs ranking of data and manage suspended data.
- Use graphic/numerical methods to determine distribution types and estimate distribution parameters.
- Establish confidence limits on the estimated parameters and evaluate the uncertainty.
- Perform goodness-of-fit to ensure conformity of the model to the data.

Assignment 2 involves not only statistical analysis of failure/repair data but also insights gained from the actual process of doing the analysis, in particular, insights into the challenge when applying acquired theoretical knowledge to solve a practical engineering problem. The results will be documented in a report, see also observations mentioned above about Assignment 1.

Mini-assignments/tests – The weekly topics may have associated questions (mini-assignments/tests) involving written work or numerical problems. The written work involves application of concepts and processes discussed in class or available from reading materials to your work situation. Some of these mini-assignments/tests will be for formative assessment. This gives you feedback on your work without involving formal grading. Other parts of the written or presentation mini-assignments will count as summative assessment; these will be assessed using the ‘Standard of Assessment’ criteria. Grading for numerical problems will involve assessment of appropriate process or calculation method, proficiency in use of the method and assessment of validity of result.

Mid-term test/Final exam - The purpose of these is to evaluate your understanding of the knowledge you have acquired during part of or the entire RE unit and your ability to apply that knowledge. Both will be in an open book format. The mid-term test is of 1.5 hours duration while the final exam is of 3 hours duration.

Submission of Assignments - Assignments should be submitted by e-mail or in class on the due date and time. You are expected to observe the due dates for assignments. Remember to keep an electronic copy of any work you submit. Extensions will only be given in extenuating circumstances. Please note that the

pressure of work commitments is not generally considered to be extenuating circumstances. Late assignments will attract a penalty of 5% per day. This penalty will be waived by the lecturer only in exceptional circumstances. No marks will be awarded to assignments submitted after other students in the class have had their assignments returned. Assignments will be returned by one of the following methods (1) in class (2) by e-mail. It is the intention that the marked assignments will be returned within two weeks of submission for major assignments and one week for the mini-assignments.

Guidelines for Assignments

Learning outcomes: Note the learning outcomes for the assignment. Take care to demonstrate achievement of these learning outcomes in your report/ article as this influences the overall assessment grade.

References: It is important to demonstrate evidence of wide reading and research in your assignments. An excellent paper/ report will be based on reference to relevant materials. It will draw on both the academic and practitioner literature to substantiate the discussion. The in-text references and list should be in accordance with the Harvard Style and include only those references referred to in the body of the essay. References that you have read during the course of your research but do not cite in your report/ presentation should not be included. Sources of diagrams and direct quotes should be page referenced and cited accordingly.

Writing Style: You are expected to adopt a writing style that is appropriate to technical academic writing and professional communication. Please note that the emphasis is on using your own words rather than the extensive use of quotes in written essays. Direct quotes should be used sparingly and only in certain circumstances such as when defining key constructs/terms, conveying a difficult concept that might be misinterpreted if the author's original words are not used, or for literary effect. Edit your work carefully for errors in grammar, spelling and punctuation and be precise in your choice of words and expression of ideas. All tables and figures should have a number and title

Assessment practices and procedures policy

Students are encouraged to read the University's policy on assessment:
http://www.teachingandlearning.uwa.edu.au/tl4/for_uwa_staff/policies/teaching,_learning_and_assessment.

Ethical Scholarship, Academic Literacy and Academic Misconduct

Refer to the Ethical Scholarship, Academic Literacy and Academic Misconduct and individual Faculty policies. For further information on the rules and procedures in respect of appropriate academic conduct you should visit:
http://www.teachingandlearning.uwa.edu.au/tl4/for_uwa_staff/policies/student_related_policies/academic_conduct

Appeals Against Academic Assessment

The University regulations relating to appeals and the form on which the appeal should be lodged can be found at

<http://www.secretariat.uwa.edu.au/home/policies/appeals>

THE UNIVERSITY POLICY ON SPECIAL CONSIDERATION

The university policy on special consideration has been altered so that from now on applications for consideration, deferral of tests or exams or extensions of time for assignments on medical, personal or other grounds must be lodged with the faculty office no later than three working days after the due date for the assessment in question. This rule will apply to all students, except in exceptional circumstances ('exceptional' does mean 'exceptional', not 'just didn't have time to get around to it').

Communicated by the Associate Dean (Students), Faculty of Engineering, Computing and Mathematics, on February 16, 2009.

TEXTBOOK(S) & RESOURCES

Unit Website

There is a unit web site on Web CT <http://webct6.uwa.edu.au/>
Course Material on-line: please visit UWA's library

Recommended/Required Text(s)

- O'Connor, P. D. T. 2004, '*Practical Reliability Engineering*', John Wiley & Sons, ISBN 0470 84463 9.
- Smith, D.J. 2005, '*Reliability, Maintainability and Risk – Practical methods for engineers*', Elsevier. ISBN 0 7506 6694 3 (an older version, 6th edition is available on-line through UWA library).
- Blanchard, B.S. & Fabrycky, W.J. 2006, '*Systems Engineering and Analysis*' Prentice Hall International Series in Industrial and Systems Engineering. ISBN 0-130186977-9.

The Australian Standards are available electronically through the UWA library.

Additional/Suggested/Alternate Text books/ Standards

- Jardine A. K. S. and Tsang A. H. C. 2005, '*Maintenance, Reliability and Replacement: Theory and Applications*', 2nd edition, CRC Press. (Chapters 1 and 2)
- Black et al. 2007, '*Australasian business statistics*', Wiley, ISBN 0-470-80944-2.
- Crespo Marquez, A. 2007, '*The Maintenance Management Framework – Models and Methods for Complex Systems Maintenance*', Springer. ISBN 978-1-84628-820-3.
- Rausand M. and Høyland A. 2004, '*System reliability theory, models, statistical methods and applications*', Wiley, New Jersey, ISBN 0-471-47133-X

- Ebeling C. E. 1997, 'An introduction to reliability and maintainability engineering', McGraw-Hill, Boston, ISBN 0-07-018852-1
- Goodwin P. and Wright G. 2004, 'Decision analysis for management judgment', John Wiley, ISBN 0-470-86108-8
- Standards Australia 2003 'Dependability management Part 3.1: Application guide – Analysis techniques for dependability – Guide on methodology', AS IEC 60300.3.1
- Standards Australia 2005 'Dependability management Part 3.14: Application guide – Maintenance and maintenance support, AS IEC 60300.3.14
- AS IEC 60300.3.11—2004, 'Dependability management Part 3.11: Application guide—Reliability centred maintenance'
- AS IEC 61708-2008, 'Analysis techniques for system reliability – reliability block diagram and Boolean methods'

Many relevant books and journal or conference papers are available on-line through the Library and the Super Search facility. Papers identified in the topic notes should be available through the Course Materials web page accessed at <http://cmo.library.uwa.edu.au/rfms/>

Technical requirements

The University only permits the use of calculators in examinations when the calculator has an approved sticker. If the student does not have an approved sticker on their calculator, they will not be permitted to use the calculator. Since this is a University wide policy it is not possible for unit coordinator to grant on the spot exemptions.

Software requirements

You will need access to a web-linked PC, be able to use word processing, PowerPoint and Excel software, know how to access recommended reading and other materials on the web and from the University Library system, access WebCT, and have an active email address. There are no specialist software requirements.

Additional resources & reading material

There are many journal and conference papers that are relevant to this course. The list is extensive so is not provided here. Please refer to the Course Materials Online web site.

UNIT STRUCTURE

Week	Date	Topic
0	(tbc) Aug	Orientation week for new students
1	31 Aug	Reliability engineering and asset life cycle concepts <u>Learning outcome:</u> <ul style="list-style-type: none"> ○ Define key reliability terms and definitions. ○ Identify RAMS tasks and considerations at each stage of the asset/system life cycle. ○ Identify significant developments that have influenced reliability practices. ○ Understand expectations for the course ○ Awareness of key material sources

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2	7 Sep	<p>Mechanical, electrical/electronic failure mechanisms and software failures <u>Learning outcomes:</u></p> <ul style="list-style-type: none"> ○ Articulate why things fail ○ Explain the load-strength model and its relationship to probabilistic reliability ○ Explain mechanical equipment failures ○ Explain electronic equipment failures ○ Explain software failures
3	14 Sep	<p>Functions and failures of an asset and FMEA <u>Learning outcomes:</u></p> <ul style="list-style-type: none"> ○ Articulate functions and failures of an asset ○ Explain the attributes of failures and their relationships ○ Explain the process and methodology of FMEA ○ Demonstrate ability to perform an FMEA
4	21 Sep	<p>Review of probability and statistics <u>Learning outcomes:</u></p> <ul style="list-style-type: none"> ○ Review and articulate concepts of probability ○ Demonstrate ability to apply laws of probability ○ Appreciate the concepts of random sample and effects of sample size ○ Identify distributions from data by means of e.g. histogram ○ Calculate sample mean, variance and standard deviation
5	28 Sep	<p>Reliability model <u>Learning outcomes:</u></p> <ul style="list-style-type: none"> ○ Define reliability function/unreliability function ○ Define/derive failure rate(hazard rate) function & cumulative hazard function ○ Interpret the bathtub curve: increasing/decreasing/constant hazard ○ Mean time to failure (MTTF).
6	5 Oct	<p>Probability plotting and Weibull analysis <u>Learning outcomes:</u></p> <ul style="list-style-type: none"> ○ Perform ranking of data ○ Consider suspensions ○ Construct and interpret Weibull probability plots ○ Analyse and scrutinize data when fitting into the Weibull distribution
7	12 Oct	<p>Confidence limits and goodness-of-fit <u>Learning outcomes:</u></p> <ul style="list-style-type: none"> ○ Select and apply the concepts of statistical confidence ○ Construct and use confidence intervals and limits ○ Do hypothesis testing using z-test, χ^2 test and F-test ○ Test goodness-of-fit using χ^2 test and Kolmogorov-Smirnov test ○ Use Laplace test of trend

8	19 Oct	<p>Reliability case study</p> <p><u>Learning outcomes:</u></p> <ul style="list-style-type: none"> ○ Apply the acquired knowledge to a practical reliability problem ○ Integrate the methods and tools to gain insights how the theoretical models can be used in practice ○ Review the learning outcomes and give feedback
9	26 Oct	<p>Reliability modelling: components and systems</p> <p><u>Learning outcomes:</u></p> <ul style="list-style-type: none"> ○ Perform basic reliability predictions ○ Select and apply basic system reliability models ○ Explain key concepts of system reliability modelling ○ Construct and analyze simple series and redundant (parallel, k out of n and standby) reliability block diagrams ○ Construct and analyze more complex reliability block diagrams ○ Articulate and apply the concept of redundancy
10	2 Nov	<p>Availability modelling</p> <p><u>Learning outcomes:</u></p> <ul style="list-style-type: none"> ○ Explain the framework of availability related to reliability, maintainability and maintenance ○ Interpret and analyze different times for availability and downtime ○ Understand mathematical basis for availability ○ Apply some most commonly applied availability measures ○ Articulate the system availability assessment methods ○ Predict availability of simple systems ○ Articulate Monte Carlo simulation ○ Articulate Markov model
11	9 Nov	<p>Developing strategies</p> <p><u>Learning outcomes:</u></p> <ul style="list-style-type: none"> ○ Define the operating profile of an asset and how this can affect reliability. ○ Use common processes to determine appropriate maintenance strategies (eg RCM) and challenge existing strategies. ○ Describe management theories that have been used to improve in-service ○ Articulate the role of the reliability group in the work management process
12	16 Nov	<p>Human factors and organisational behaviours</p> <p><u>Learning outcomes:</u></p> <ul style="list-style-type: none"> ○ Awareness of usability assessment methods to assess the effect of human factor on reliability ○ Identify characteristic features of a “high reliability organisation” (HRO)