Aircraft Structural Repair

The conventional approach to through-life-support for aircraft structures can be divided into the following phases: (i) detection of defects, (ii) diagnosis of their nature and significance, (iii) forecasting future behaviour-prognosis, and (iv) pre scription and implementation of remedial measures including repairs. Considerable scientific effort has been devoted to developing the science and technology base for the first three phases. Of particular note is the development of fracture mechanics as a major analytical tool for metals, for predicting residual strength in the presence of cracks (damage tolerance) and rate of crack propagation under service loading. Intensive effort is currently being devoted to developing similar approaches for fibre composite structures, particularly to assess damage tolerance and durability in the presence of delamination damage. Until recently there has been no major attempt to develop a science and tech nology base for the last phase, particularly with respect to the development of repairs. Approaches are required which will allow assessment of the type and magnitude of defects amenable to repair and the influence of the repair on the stress intensity factor (or some related parameter). Approaches are also required for the development and design of optimum repairs and for assessment of their durability.

This occupational analysis is directed at the aircraft structural repair technician whose primary responsibilities include assessing damage and corrosion of aircraft structures; repairing, replacing and modifying sheet metal and/or composite structures; and repairing fabric surfaces and wood structures. This document provides a guide to the analysis, a list of occupations involved, descriptions of the basic knowledge and experience required, and specific knowledge required for sheet metal structures, composite structures, fabric and wood repair, and specialized work practices and processes.

Technical Order (TO) 1-1A-1 is one of a series of manuals prepared to assist personnel engaged in the general maintenance and repair of military aircraft. This manual covers general aircraft structural repair. This is a Joint-Service manual and some information may be directed at one branch of the service and not the other. Wherever the text of the manual refers to Air Force technical orders for supportive information, refer to the comparable Navy documents (see Table 1). The satisfactory performance of aircraft requires continuous attention to maintenance and repair to maintain aircraft structural integrity. Improper maintenance and repair techniques can pose an immediate and potential danger. The reliability of aircraft depends on the quality of the design, as well as the workmanship used in making the repairs. It is important that maintenance and repair operations be made according to the best available techniques to eliminate, or at least minimize, possible failures.

Aircraft Sustainment and Repair is a one-stop-shop for practitioners and researchers in the field of aircraft sustainment, adhesively bonded aircraft joints, bonded composites repairs, and the application of cold spray to military and civil aircraft. Outlining the state-of-the-art in aircraft sustainment, this book covers the use of quantitative fractography to determine the in-service crack length versus flight hours curve, the effect of intergranular cracking on structural integrity and the structural significance of corrosion. The book additionally illustrates the potential of composite repairs and SPD applications to metallic airframes. Covers corrosion damage assessment and management in aircraft structures Includes a key chapter on U.S. developments in the emerging field of supersonic particle deposition (SPD) Shows how to design and assess the potential benefits of both bonded composite repairs and SPD repairs to metallic aircraft structures to meet the damage tolerance requirements inherent in FAA ac 20-107b and the U.S. Joint Services

Beginning with a discussion of Aircraft Structural Elements, Basic Stresses, and the various properties of Aircraft Materials, this book continues with explanations of Blueprint Reading and Layout, the Uses of Aircraft Tootls and Equipment, Fabrication Procedures, Aircraft Riveting, Fasteners, Structural Repairs, Repairs of Tanks and Tubing, and the Repair and Maintenance of Rubberized Equipment, Plastics, and Fabric Coverings. It concludes with a section on Metalite

This document has been prepared to serve a growing need in the military to reduce aircraft structural maintenance costs to a more reasonable level commensurate with acceptable life-cycle costs. It is designed as an informative guide which will aid the aircarft designer in foreseeing maintenance problems and make proper trade-off evaluations to optimize the structural design for total life-cycle costs. The handbook points up several examples of high maintenance cost items on existing in-service aircraft and suggests changes to substantially reduce the life-cycle cost. In addition, many other costly maintenance items discovered during visits to military and industry maintenance and repair facilities are cited which could have been avoided or substantially reduced by more cost-effective considerations for serviceability during design. In this respect, the handbook includes, not only information on past problem areas in the form of 'lessons learned' but recommended considerations during initial design of every aspect of structural development. Since corrosion damage repair was found to be one of the most costly maintenance items, a part of the handbook provides design information usable in its prevention. Also, since the handbook is directed primarily toward the development of military aircraft, a section is devoted to battle damage and design considerations to increase survivability and permit repairs to minimize downtime on the aircraft.

The availability of efficient and cost-effective technologies to repair or extend the life of aging military airframes is becoming a critical requirement in most countries around the world, as new aircraft becoming prohibitively expensive and defence budgets shrink. To a lesser extent a similar situation is arising with civil aircraft, with falling revenues and the high cost of replacement aircraft. This book looks at repair/reinforcement technology, which is based on the use of adhesively bonded fibre composite patches or doublers and can provide cost-effective life extension in many situations. From the scientific and engineering viewpoint, whilst simple in concept, this technology can be quite challenging particularly when used to repair primary structure. This is due to it being based on interrelated inputs from the fields of aircraft design, solid mechanics, fibre composites, structural adhesive bonding, fracture mechanics and metal fatigue. The technologies of non-destructive inspection (NDI) and, more recently smart materials, are also included. Operational issues are equally critical, including airworthiness certification, application technology (including health and safety issues), and training. Including contributions from leading experts in Canada, UK, USA and Australia, this book discusses most of these issues and the latest developments. Most importantly, it contains real histories of application of this technology to both military and civil aircraft.

FAA regulations require commercial aircraft operators to repair damaged aircraft structures. These repairs must be performed in a timely manner to reduce aircraft downtime and loss of revenue. A guiding principal for such repairs is to restore the structure to the original (or better) static strength and stiffness. However, the repair can also be designed for adequate fatigue resistance, damage tolerance, and inspectability. Fatigue and damage tolerance (DT) analyses should be based on realistic stress histories which, in turn, should be derived from realist load spectra. Thus, an algorithm for the development of a stress history should be included in a comprehensive analysis of repairs. Since many damage repair stations and airlines do have at least basic computer facilities that can be used for fatigue and damage tolerance analysis, one goal has been the development of a relatively simple, yet accurate analytical tool to design aircraft repairs more effectively. Structural analysis and stress spectrum development procedures described in this report are approximate and, therefore, have certain limitations. These procedures might be used to qualitatively compare the quality of different repair options with the original structure. SKINFIX, Load spectra, static

strength, damage tolerance.
This series is specifically tailored to provide the information necessary to prepare an applicant for FAA mechanic certification with airframe and/or powerplant (A&P) ratings. These textbooks are designed for use by instructors and applicants preparing for the FAA Airframe Knowledge and Practical Exams, but also serve as an invaluable reference guide for certificated technicians who wish to improve their knowledge and practice. Chapter structure has been designed to ensure consistent and efficient internalization of the material presented. Photographs and detailed drawings illustrate concepts, improve understanding, and increase retention. a This volume of the series emphasizes theory and methods of practical application within the overall topic of the airframe of an aircraft: how it is built, maintained, and repaired. It covers subjects such as airframe construction features, assembly and rigging, fabric covering, structural repairs, and aircraft welding. The specific topics addressed include Aircraft Structures, Aerodynamics, Aircraft Assembly and Rigging, Aircraft Fabric Covering, Aircraft Metal Structural Repair, Aircraft Welding, Aircraft Wood and Structural Repair, Advanced Composite Materials, Aircraft Painting and Finishing, and Aircraft Electrical Systems."
This manual is a training guide and basic reference manual on airframe maintenance and report for airframe repairers. It contains general information on structural repair of Army fixed- and rotary-wing. It is not directed to specific aircraft. For information on structural repairs for a specific aircraft type, refer to the applicable aviation unit maintenance (AVUM) and aviation intermediate maintenance (AVIM) technical manuals for that type of aircraft.
This report documents the research and analysis conducted to (1) identify high-cost structural repair and maintenance items in existing U.S. military aircraft, (2) conduct a design study on

means to reduce life cycle costs for a number of selected structural problems on fighter, bomber, and cargo/tanker class aircraft, and (3) to develop a design handbook to provide guidance and information on methods to reduce aircraft structure cost of ownership. This program was limited to existing military aircraft metallic-type structures since separate programs for adhesively bonded and advanced composite structure design and repair are being developed by the Structures Division (FBS) of the Air Force Flight Dynamics Laboratory. The design handbook has been published as document No. AFFDL-TR-76-72, 'Aircraft Structural Design Handbook for Lower Cost Maintenance and Repair.' (Author).
This study evaluates existing structural integrity analysis methods for the repair of aircraft structures, primarily focusing on composite (patch) to metal surface structures. This research was necessitated by the growing need to keep current aircraft in service well beyond their normal design lives. When defects are discovered during inspections the components must be either repaired or replaced. In most instances, it is not economically feasible to replace entire components. Therefore, repairing the damaged area(s) is usually preferred and critical. Additionally, repairs must be made quickly so that the aircraft may be returned to service as soon as possible. The results generated in this study evaluate the status of various repair analysis codes, determine which tools are potentially the most useful to ALC engineers, and provide information to assist Wright Laboratory engineers in deciding whether these codes address current and future US Air Force requirements. However, this evaluation does not intend to 'recommend' or 'disapprove' the use of any one software or methodology to Air Force, government or contractor personnel. Also, this evaluation of the composite repair/analysis codes relates solely to the versions that were available during the evaluation period of July 95

to 28 Feb 96. This report program covers the determination of ALC requirements, a review of current repair/analysis codes, the determination of equivalent capability, and an evaluation of repair/analysis codes.

A typical aircraft can experience over 2,000 fatigue cycles (cabin pressurizations) and even greater flight hours in a single year. An unavoidable by-product of aircraft use is that crack, impact, and corrosion flaws develop throughout the aircraft's skin and substructure elements. Economic barriers to the purchase of new aircraft have placed even greater demands on efficient and safe repair methods. The use of bonded composite doublers offers the airframe manufacturers and aircraft maintenance facilities a cost effective method to safely extend the lives of their aircraft. Instead of riveting multiple steel or aluminum plates to facilitate an aircraft repair, it is now possible to bond a single Boron-Epoxy composite doubler to the damaged structure. The FAA's Airworthiness Assurance Center at Sandia National Labs (AANC), Boeing, and Federal Express completed a pilot program to validate and introduce composite doubler repair technology to the U.S. commercial aircraft industry. This project focused on repair of DC-10 fuselage structure and its primary goal was to demonstrate routine use of this repair technology using niche applications that streamline the design-to-installation process. As composite doubler repairs gradually appear in the commercial aircraft arena, successful flight operation data is being accumulated. These commercial aircraft repairs are not only demonstrating the engineering and economic advantages of composite doubler technology but they are also establishing the ability of commercial maintenance depots to safely adopt this repair technique. This report presents the array of engineering activities that were completed in order to make this technology available for widespread commercial aircraft use. Focused laboratory testing was conducted to compliment the field data and to address specific issues regarding damage tolerance and flaw growth in composite doubler repairs. Fatigue and strength tests were performed on a simulated wing repair using a substandard design and a flawed installation. In addition, the new Sol-Gel surface preparation technique was evaluated. Fatigue coupon tests produced Sol-Gel results that could be compared with a large performance database from conventional, riveted repairs. It was demonstrated that not only can composite doublers perform well in severe off-design conditions (low doubler stiffness and presence of defects in doubler installation) but that the Sol-Gel surface preparation technique is easier and quicker to carry out while still producing optimum bonding properties. Nondestructive inspection (NDI) methods were developed so that the potential for disbond and delamination growth could be monitored and crack growth mitigation could be quantified. The NDI methods were validated using full-scale test articles and the FedEx aircraft installations. It was demonstrated that specialized NDI techniques can detect flaws in composite doubler installations before they reach critical size. Probability of Detection studies were integrated into the FedEx training in order to quantify the ability of aircraft maintenance depots to properly monitor these repairs. In addition, Boeing Structural Repair and Nondestructive Testing Manuals were modified to include composite doubler repair and inspection procedures. This report presents the results from the FedEx Pilot Program that involved installation and surveillance of numerous repairs on operating aircraft. Results from critical NDI evaluations are reported in light of damage tolerance assessments for bonded composite doublers. This work has produced significant interest from airlines and aircraft manufacturers. The successful Pilot Program produced flight performance history to establish the durability of bonded composite patches as a permanent repair on commercial aircraft structures. This report discusses both the laboratory data and Pilot Program results from repair installations on operating aircraft to introduce composite doubler repairs into mainstream commercial aircraft use.

An up-to-date, revised version of the 2018 FAA-8083 AMT Handbook series, this volume is focused primarily on aircraft structures. This handbook has undergone a rigid review and edit process to sort out and correct errors. The result is Avotek's updated version of the FAA-H-8083-31A.Written for those preparing for AMT certification with the Airframe rating, the topics covered in this volume include aerodynamics, assembly and rigging; fabric covering; structural repairs; aircraft welding; wood and structural repair; advanced composite materials; painting and finishing; and the electrical system.Avotek's companion student workbook includes multiple choice, fill-in-the-blank and short answer questions to guide study and instruction of this FAA text.

Bonded repair is one of the structural repair technologies that the aircraft industry uses to restore the strength of fuselage structures and increase the life of an aircraft. Bonded repairs are superior to the conventional metallic fastened repairs in that the former yield a higher stiffness and lower stress concentrations and are more aerodynamically and structurally efficient. Bonded repair technology has been used to repair military aircraft for over three decades but has not been certified for repairing commercial aircraft due to the lack of sufficient performance data to support their airworthiness. Experimental work and analytical modeling of bonded repairs have also been limited to those of flat coupon specimen under ambient environmental conditions. In this study, experimental and analytical work on a full-scale curved fuselage panel with various bonded repairs is conducted to investigate their durability and integrity. The experimental work was carried out using the Federal Aviation Administration's Full-Scale Aircraft Structural Test Evaluation and Research fixture. The objectives are to characterize the durability and fatigue performance of boron/epoxy (B/Ep) and aluminum bonded repairs under a simulated service load condition over the design service life of the airplane and to investigate tools for evaluating and monitoring the repair integrity over the life of the part. During all test phases, damage formation and growth of cracks and disbonds were monitored and recorded using a structural health monitoring system and several nondestructive inspection methods. In addition, strains in the vicinity of the repair patches were continuously recording using strain gages and the digital image correlation method. Experimental results indicated that the bonded repairs are effective to reduce the fatigue crack growth rate. A linear elastic fracture mechanics based analytical model is developed to predict the growth rates of fatigue cracks in the curved panel repaired by bonded patches. The unique feature of this model is that, by using a fuselage-dependent geometric correction factor and incorporating the bonded repair theory, this model can be applied to predict the growth of a crack under any type of bonded repair in a given fuselage. The model has been validated by comparing the predicted crack growth rate results with that obtained experimentally.

Aircraft Structural Repair Technician

A complete course of study for the aircraft maintenance student in the subject of aircraft structures. Covers tools, materials, processes.