

# Military Airframe Costs

**The Effects of Advanced Materials  
and Manufacturing Processes**



**Obaid Younossi • Michael Kennedy • John C. Graser**

**Project AIR FORCE  
RAND**

# **Military Airframe Costs The Effects Of Advanced Materials And Manufacturing Processes**

**Obaid Younossi**



## **Military Airframe Costs The Effects Of Advanced Materials And Manufacturing Processes:**

*Military Airframe Costs* Obaid Younossi, Michael Kennedy, John C. Graser, 2001 In recent years a number of attempts have been made to estimate the cost of future weapon systems toward the goal of optimizing acquisition policy This report focuses specifically on the effects of material mix manufacturing techniques and geometric part complexity on the cost of military airframes It begins by offering background information on those materials that are most critical to airframe manufacture and on the relative advantages of both traditional and evolving part fabrication techniques It then proceeds to a quantitative analysis of the cost implications of various materials and manufacturing techniques on airframe production drawing both from an industry survey and from analysis of industry data The data thus derived are then integrated with those of a comprehensive historical database The report concludes that composites while offering a number of advantages over metals in airframe manufacture are generally associated with higher costs across a range of categories At the same time it concludes that while new manufacturing technologies hold the potential to diminish airframe manufacturing costs the increased airframe complexity of future fighter aircraft may well offset this advantage The report recommends that cost analysts remain abreast of changes in industry practice so that they may more accurately gauge the potential effects of such changes on future airframe costs

**Military Airframe Costs. The Effects of Advanced Materials and Manufacturing Processes**, 2001 Good cost estimates can make important contributions to effective acquisition policy RAND has a long history of producing cost estimating methodologies Two of its more recent studies are Hess and Romanoff 1987 and Resetar Rogers and Hess 1991 This report both updates and extends these earlier studies focusing on the effects of material mix manufacturing technique and part geometric complexity on cost We collected two types of information on these effects First we surveyed the military airframe industry for estimates of how aircraft production costs vary with airframe structure material mix Second we analyzed a large set of actual part data from recent aircraft manufacturing efforts that we collected from industry We also estimated a set of airframe relationships CERs for labor hours based on MACDAR a historical airframe database We then integrated the effects of material mix into these estimates

**The Effects of Advanced Materials on Airframe Operating and Support Costs** Raj Raman, John C. Graser, Obaid Younossi, 2003 Presents a methodology for forecasting operating and support costs for airframe parts made from advanced materials versus parts made from aluminum

*Historical Cost Growth of Completed Weapon System Programs* Mark V. Arena, 2006 This report is one of a series from a RAND Project AIR FORCE project The Cost of Future Military Aircraft Historical Cost Estimating Relationships and Cost Reduction Initiatives The purpose of the project is to improve the tools used to estimate the costs of future weapon systems It focuses on how recent technical management and government policy changes affect cost This report focuses on the accuracy of cost estimates For our analysis we used a very specific sample of Selected Acquisition Report SAR data namely only programs that are complete or are nearly so The analysis indicates a systematic bias toward underestimating the costs and

substantial uncertainty in estimating the final cost of a weapon system In contrast to the previous literature the cost growth was higher than previously observed We also found few correlations with cost growth but observed that programs with longer duration had greater cost growth and electronics programs tended to have lower cost growth Although there were some differences in the mean cost growth factors among the military departments the differences were not statistically significant While newer programs appear to have lower cost growth this trend appears to be due to factors other than acquisition policies

**Sources of Weapon System Cost Growth** Joseph G. Bolten, Robert S. Leonard, Mark V. Arena, Obaid Younossi, Jerry M. Sollinger, 2008-06-19 This analysis uses data from Selected Acquisition Reports to determine the causes of cost growth in 35 mature major defense acquisition programs Four major sources of growth are identified 1 errors in estimation and scheduling 2 decisions by the government 3 financial matters and 4 miscellaneous The analysis shows that more than two thirds of cost growth measured as simple averages is caused by decisions most of which involve quantity changes requirements growth and schedule changes

**Software Cost Estimation and Sizing Methods** Shari Lawrence Pfleeger, Felicia Wu, Rosalind Lewis, 2005 Recommends an approach to improving the utility and accuracy of software cost estimates by exposing uncertainty in understanding the project and reducing the risks associated with developing the estimates The approach focuses on characteristics of the estimation process such as which methods and models are most appropriate for a given situation and the nature of the data used such as software size describing symptoms and warning signs of risk in each factor and risk mitigation strategies

*Impossible Certainty*, 2006 This report is one of a series from a RAND Project AIR FORCE project The Cost of Future Military Aircraft Historical Cost Estimating Relationships and Cost Reduction Initiatives

*Evolutionary Acquisition* Mark A. Lorell, Julia Lowell, Obaid Younossi, 2006 So far EA implementation of military space programs has produced mixed results The capabilities and requirements definition and management processes are major challenges in all EA programs EA programs require an evolutionary costing approach most cost analysts interviewed expressed generally positive views about EA

BOOK JACKET [Is Weapon System Cost Growth Increasing?](#) Obaid Younossi, 2007 In recent decades there have been numerous attempts to rein in the cost growth of U S Department of Defense DoD acquisition programs Cost growth is the ratio of the cost estimate reported in a program s final Selected Acquisition Report SAR and the cost estimate baseline reported in a prior SAR issued at a particular milestone Drawing on prior RAND research new analyses of completed and ongoing weapon system programs and data drawn from SARs this study addresses the following questions What is the cost growth of DoD weapon systems What has been the trend of cost growth over the past three decades To address the magnitude of cost growth it examines cost growth in completed programs to evaluate the cost growth trend over time it provides additional analysis of a selection of ongoing programs This sample of ongoing programs permits a look at growth trends in the more recent past Changes in the mix of system types over time and dollar weighted analysis were also considered because earlier studies have suggested that cost growth varies by program

type and the cost of the program The findings suggest that development cost growth over the past three decades has remained high and without any significant improvement      *Systems Engineering and Program Management* David E. Stem, Michael Boito, Obaid Younossi, 2006 Systems engineering and program management SE PM constitute a large portion of the acquisition cost of military aircraft and guided weapons systems The goal of this study was the development of a set of cost estimating relationships that can be used to estimate the SE PM cost element for development and production of aircraft and weapons programs The authors investigate trends in SE PM costs over time to generate methods that cost analysts can use early in the life cycle of a program when little cost information is available      **Fiber Reinforced Composites** Kuruvilla Joseph, Kristiina Oksman, George Gejo, Runcy Wilson, Saritha Appukuttan, 2021-03-20 Polymer based fibre reinforced composites FRC s have now come out as a major class of structural materials being used or regarded as substituent s for metals in several critical components in space automotive and other industries marine and sports goods owing to their low density strength weight ratio and fatigue strength FRC s have several commercial as well as industrial applications ranging from aircraft space automotive sporting goods marine and infrastructure The above mentioned applications of FRC s clearly reveal that FRC s have the potential to be used in a broad range of different engineering fields with the added advantages of low density and resistance to corrosion compared to conventional metallic and ceramic composites However for scientists researchers R D s to fabricate FRC s with such potential there should be careful and precise design followed by suitable process development based on properties like mechanical physical and thermal that are unique to each application Hence the last few decades have witnessed considerable research on fibre reinforced composites **Fibre Reinforced Composites Constituents Compatibility Perspectives and Applications** presents a widespread all inclusive review on fibre reinforced composites ranging from the different types of processing techniques to chemical modification of the fibre surface to enhance the interfacial adhesion between the matrix and fibre and the structure property relationship It illustrates how high value composites can be produced by efficient and sustainable processing methods by selecting different constituents fibres and resins Researchers in academia working in composites and accompanying areas materials characterisation and industrial manufacturers who need information on composite constituents and how they relate to each other for a certain application will find the book extremely useful when they need to make decisions about materials selection for their products Focuses on the different types of FRC s that are currently available e g from polymeric matrices to metallic and ceramic matrices from carbon fibre to different types of natural fibres and from short to long fibre reinforced their processing techniques characterization of different properties and how to improve the interfacial adhesion between an incompatible fibre and matrix and their applications Looks at crisis areas such as how to incorporate incompatible fibres and matrices together e g Non polar polypropylene matrix is not compatible with that of polar natural fibres and hence suitable surface modifications are required to make them compatible with each other along with low cost processing methods low density and high strength

Uncovers clarifications to both elementary and practical problems related to the fabrication of FRCs Schematic representations depicting the interaction between different fibre types and matrices will be provided in some chapters

**Titanium** So-mi Söng, Somi Seong, Obaid Younossi, Benjamin W. Goldsmith, 2009 Between 2003 and 2006 the price of titanium more than doubled The authors attempt to answer four primary questions What triggered this price surge What are titanium's future market prospects and emerging technologies What are the implications for the production cost of future military airframes How might the Department of Defense mitigate the economic risks involved in the titanium market

*Budget Estimating Relationships for Depot-level Reparables in the Air Force Flying Hour Program* Gregory G. Hildebrandt, 2007 Budget estimating relationships BERs for flying depot level reparable DLRs explain the direct effect of specified variables on obligated funds associated with spare parts that directly support the U S Air Force USAF Flying Hour Program In FY02 net sales of DLRs to Air Force commands hit historic highs To provide the Air Force Cost Analysis Improvement Group with a tool to better understand the commands budgetary submissions we develop several explanatory BERs to understand why flying DLRs are at their particular levels Using longitudinal regression statistical methods we explain the historical net sales of flying DLRs using estimating models that relate net sales to the contemporaneous values of aircraft characteristics operational tempo and time related variables This is but one part of a larger project to develop better estimating methods for use by the acquisition community and to examine the impact of Air Force and DoD policies on weapon system costs The findings will also be of interest to those in the national security community who are involved in analyzing alternative military postures and to members of the aircraft industry's analytical community

**Defence Inflation** Keith Hartley, Binyam Solomon, 2018-10-18 Defence inflation is a recurring factor in determining defence spending It is widely reported in official government publications and in the trade press but remains relatively neglected by defence and peace economists In this book international contributors from Finland Norway Sweden the UK and the USA distinguish between defence inflation and cost escalation and identify the causes of both They use specific case studies to address a wide variety of theoretical and empirical issues and key questions including the following Does defence inflation affect all countries What are its effects Why does it occur How if at all can defence inflation be controlled While most industry and trade press devote considerable ink and space to the discussion of defence inflation cost escalation and their consequential impact on the purchasing dollars of the armed forces economists have been relatively silent This book aims to rectify this oversight through a multinational survey and analysis of the topic while also identifying the opportunities for further theoretical and empirical research in the field This book was originally published as a special issue of the journal Defence and Peace Economics

*Production at the Leading Edge of Technology* Thomas Bauernhansl, Alexander Verl, Mathias Liewald, Hans-Christian Möhring, 2023-11-17 The German Academic Association for Production Technology WGP annually invites researchers coming from its institutes and from industry to contribute peer reviewed papers in the field of production technology This congress

proceedings provides recent research results and findings on leading edge manufacturing processes Main aim of this scientific congress is to push forward existing borders in production and to provide novel solutions of Production at the Leading Edge of Manufacturing Technology The subtitle Technology Based Sustainable Production for Circular Economy of this year s congress emphasizes challenges for global productions in the light of climate change and resource scarcity Different sessions were held on the topics Environmentally neutral production e g energy and material efficiency Resilient Value Creation Systems Biointelligence Digitization as an Enabler for Sustainable Production Production Technologies for a Circular Economy

**Machining of Light Alloys** Diego Carou,J. Paulo Davim,2018-08-06 Aluminium magnesium and titanium are alloys of special interest for engineering applications in a wide range of sectors such as aeronautics automotive and medical Their low density along with sufficient mechanical properties makes them especially adequate for sectors such as transportation allowing diminishing weight less fuel consumption and emissions to the atmosphere Nowadays machining is still one the most important manufacturing processes not only for metal parts but also for specially designed hybrid parts for more demanding new applications A wide range of valuable research has been done on the machining of conventional engineering materials However when dealing with light alloys and hybrid materials containing them they need to face new challenges Particularly it is important to analyse the suitability of the machining of these alloys in the current context of Industry 4 0 focusing on the development of cost effective and sustainable processes This book is a comprehensive source on the machining of light alloys presenting a collection of both experimental and review studies The work is arranged in eight chapters presented by a group of international scholars which analyse the main problems related to the machining of these alloys from different perspectives Key Features A comprehensive state of the art reference source on machining of light alloys Provides research on conventional and non conventional machining process Offers current research topics on sustainable machining Presents research on the machining of hybrid materials using light alloys Includes applications for Industry 4 0 environments Machining of Light Alloys Aluminum Titanium and Magnesium The aim of the book is to serve as a tool for helping researchers and practitioners to face machining challenges and facilitating the development of new industrial applications for light alloys

*Proceedings of the 13th World Conference on Titanium* Vasisht Venkatesh,Adam L. Pilchak,John E. Allison,Sreeramamurthy Ankem,Rodney R. Boyer,Julie Christodoulou,Hamish L. Fraser,M. Ashraf Imam,Yoji Kosaka,Henry J. Rack,Amit Chatterjee,Andy Woodfield,2016-04-26 This book contains the Proceedings of the 13th World Conference on Titanium

F-22A Multiyear Procurement Program Obaid Younossi,2007 Congress asked RAND for an independent review of whether the estimated savings from proposed multi year contracts for 60 F 22A aircraft over three years would yield the promised savings Researchers found that a multi year procurement of three lots of F 22A fighters would save an estimated 411 million about 4 5 percent of the total contract value and that savings attributed to the multi year contract by the contractors appear to be reasonable

**Freightliner Progress?.** ,196? **Thermal and Structural**

**Performance of Tow-placed, Variable Stiffness Panels** Kingsley Chauncey Wu, 2006 In this study a combination of experiments and analyses are performed to characterize the structural response of two variable stiffness composite panels to a series of thermal and mechanical loads This characterization covers all phases of the structure's lifetime from design through global failure These panels are advanced composite structures in which the fiber orientation angle varies continuously as tows are laid down along predefined curvilinear paths within each ply The panels are manufactured from AS4 977 3 graphite epoxy prepreg using an advanced tow placement system Both variable stiffness panels have the same nominal layup but one panel the panel with overlaps has overlapping tow bands of varying thickness and the other panel the panel without overlaps has a theoretically uniform thickness laminate A conventional uniform thickness panel with a straight fiber 45° layup the baseline panel is also evaluated



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