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**A COMPILATION OF COMPUTER
SOFTWARE PROGRAMS
AVAILABLE IN THE FLIGHT
DYNAMICS LABORATORY, 1979**

JAMES L. TERRY

TECHNICAL REPORT AFFDL-TR-79-3155

DECEMBER 1979



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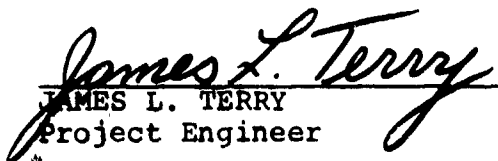
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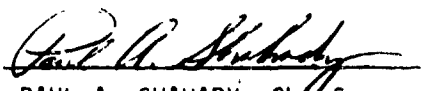
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This technical report has been reviewed and is approved for publication.


JAMES L. TERRY
Project Engineer

FOR THE COMMANDER


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INTRODUCTION

The Air Force Flight Dynamics Laboratory (AFFDL) is part of the Air Force Wright Aeronautical Laboratories (AFWAL), a four laboratory organization located at Wright-Patterson AFB, Ohio. The Laboratory develops flight dynamics technologies needed by all Air Force Systems Command Product Divisions and provides the in-house technical audit capability for the Air Force. In maintaining the superior technical base required to perform this function, the Laboratory has over the years compiled a significant number of computer programs in the technical areas of flight vehicle structures, aerodynamics, flight performance analysis, vehicle dynamics, flight control, environmental control, vehicle equipment, vehicle integration and design.

Recent visits to industry and other government agencies during the AFFDL Military Application Activity indicated the need for this technical document to collect and publish current information on available computer programs within AFFDL. Additionally, the document is useful internally to the Laboratory personnel by providing information of existing capabilities thus reducing duplication of effort in the computer programming activity.

Although some of the programs are similar to those available elsewhere, this collection should be useful to organizations with limited system libraries and particularly to those organizations involved in flight dynamics research and development leading to acquisition of future flight vehicles.

A loose leaf format was chosen to facilitate the addition of new programs. AFWAL/ACD will periodically provide additional or updated inserts to maintain a current and useful document. The criteria for AFFDL applicable program inclusion into this report are:

- (1) The program should be a production program (debugged and requiring no substantive changes).

(2) It should be of potential use to other than the present users.

(3) It should be directed toward real needs.

(4) It should be sufficiently documented so that the potential users can determine program logic and assumptions.

Instructions for submitting a program to be included in this document are found in the Appendix.

SECTION I
AERODYNAMICS

PROGRAM TITLE: Navier-Stokes Inlet Analysis Program

DESCRIPTION: MacCormack's algorithm is employed to solve the Navier-Stokes equations. These are used to solve the supersonic inlet flow fields.

APPLICATION: Two dimensional, supersonic inlet flow analyses.

KEY WORDS: High Speed Inlets, Navier-Stokes Equations, Computation Fluid Dynamics

ABSTRACT: A set of computer programs has been developed to calculate the flowfield in two-dimensional mixed-compression high speed inlets. The full mean compressible Navier-Stokes equations are utilized, with turbulence represented by an algebraic eddy viscosity model which incorporates a relaxation correction. A curvilinear body-oriented coordinate system is employed to allow handling of arbitrary inlet contours. Boundary layer bleed is incorporated.

The numerical algorithm of MacCormack is employed to solve the Navier-Stokes equations. A variety of techniques are incorporated to improve code efficiency, including time-splitting of the finite-difference operators, automatic mesh-splitting, and a separate algorithm for the treatment of the viscous sublayer portion of the turbulent boundary layers.

The numerical codes have been successfully applied to the calculation of a variety of flows including shock-boundary layer interaction of a flat plate (including both unseparated and separated cases), and three different simulated high speed inlet configurations. In all cases, good agreement was obtained with the experimental data.

The numerical codes represent a substantial improvement in computational efficiency. For a Mach 3.5 inlet at a Reynolds number of 13 million, the typical computer time on the CYBER 175 is two to four hours, depending on the amount of internal compression. This represents a decrease of approximately an order of magnitude compared to the author's previous work.

PROGRAM OUTPUT OPTIONS: General flow parameters.

PROGRAM INPUTS: Geometry, flow conditions.

LIMITATIONS/RESTRICTIONS: Supersonic, two dimensional flow.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
CYBER 74

LANGUAGES: Fortran

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL-TR-79-3138, Vol I and Vol II.

RESPONSIBLE ENGINEER: D. J. Stava
AFWAL/FIMM
Phone: (513) 255-6207
Autovon: 785-6207

PROGRAM TITLE: Missile Aerodynamic Characteristics

DESCRIPTION: This program is a method for predicting the static aerodynamic characteristics of typical missile configurations for angles of attack to 180 degrees.

APPLICATION: To determine the static longitudinal aerodynamic characteristics of typical missile configurations throughout the subsonic, transonic and supersonic speed regimes at angles of attack to 180 degrees.

KEY WORDS: Aerodynamics, Missiles, High Angle of Attack

ABSTRACT: The program was written by Bernard Saffell, Jr., Milland L. Howard and Eugene Brooks, Jr. of the Naval Ship Research and Development Center (NSRDC) in the early 1970's.

This is a method for predicting the static, longitudinal aerodynamic characteristics of typical missile configurations at zero roll angle. It can be applied throughout the subsonic, transonic and supersonic speed regimes to slender bodies of revolution or to nose-cylinder body combinations with low aspect-ratio lifting surfaces. The aerodynamic characteristics can be computed for missile configurations operating at angles of attack up to 180 degrees. The effect of control surface deflections for all modes of aerodynamic control are taken into account by this method. The method is based on well known linear, nonlinear, crossflow and slender body theories with empirical modifications to provide the high angle of attack capability.

PROGRAM OUTPUT OPTIONS: Printout of aero coefficients.

PROGRAM INPUTS: Simple geometry input information and flight conditions.

LIMITATIONS/RESTRICTIONS: Low aspect-ratio configurations, zero roll angle, β . $AR \cong 10.0$.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 74

LANGUAGES: Fortran II

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
NSRDC Report 3645

RESPONSIBLE ENGINEER: Donald E. Shereda
AFWAL/FIMG
Phone: (513) 255-4410
Autovon: 785-4410

PROGRAM TITLE: Vortex-Lattice Fortran Program for Estimating Subsonic Aerodynamic Characteristics of Complex Planforms.

DESCRIPTION: The program uses the configuration planform definition as inputs, representing the lifting planform with an equivalent vortex lattice, and calculates the linear aerodynamic characteristics at subsonic Mach numbers.

APPLICATION: The program has application to complex planforms that may include variable geometry, camber, twist, and dihedral.

KEY WORDS: Subsonic Aerodynamics, Linear Aerodynamics, Vortex-Lattice, Potential Flow Aerodynamics, Non-Linear Aerodynamics

ABSTRACT: The computer program, developed at NASA-Langley Research Center is used for estimating the subsonic, linear aerodynamic characteristics of complex planforms, which are represented by an equivalent vortex lattice. The complex planforms include wings with variable geometry, changes in twist, camber and/or dihedral, and wing-tail-canard combinations.

The program has been updated to include a non-linear aero analysis developed at NASA LRC by Polhamus.

PROGRAM OUTPUT OPTIONS: Output parameters include lift, pitching moment, drag-due-to-lift (induced drag), leading edge thrust/suction, and loading distribution. Damping in pitch, roll and change in lift due to pitch rate are also available if required.

PROGRAM INPUTS: The inputs must include a description of the planform shape as well as any camber, twist or dihedral.

LIMITATIONS/RESTRICTIONS: The program functions at subsonic Mach numbers only. Limits are set for the number of straight line segments used to represent the lifting surface and a maximum of two lifting surfaces may be included. Limitations are also imposed on the maximum number of horseshoe vortices in the vortex lattice (i.e., grid density).

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 74

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

NASA TN D-6142,
NASA TN D-7921,
NASA TN D-8090,
NASA TR R-428.

RESPONSIBLE ENGINEER: P. R. Gord
AFWAL/FIMG
Phone: (513) 255-5404
Autovon: 785-5404

PROGRAM TITLE: Supersonic - Hypersonic Arbitrary Body Program (HABP)

DESCRIPTION: A program to calculate the supersonic/hypersonic aerodynamic characteristics of complex arbitrary three dimensional shapes.

APPLICATION: Used for computing the aerodynamic coefficients of completely arbitrary three dimensional configurations at supersonic/hypersonic Mach numbers.

KEY WORDS: Aerodynamics, supersonic, hypersonic, arbitrary body.

ABSTRACT: This is a digital computer program system that is capable of calculating the supersonic and hypersonic aerodynamic characteristics of complex arbitrary three-dimensional shapes. This program is identified as the Mark IV Supersonic-Hypersonic Arbitrary-Body Computer Program. This program is a complete reorganization and expansion of the Mark III Hypersonic Arbitrary-Body Program. The Mark IV program has a number of new capabilities that extend its applicability down into the supersonic speed range.

Features of this program include its flexibility in covering a very wide variety of problems and the multitude of program options available. The program is a combination of techniques and capabilities necessary in performing a complete aerodynamic analysis of supersonic and hypersonic shapes. These include: vehicle geometry preparation; computer graphics to check out the geometry; analysis techniques for defining vehicle component flow field effects; surface streamline computations; the shielding of one part of a vehicle by another; calculation of surface pressures using a great variety of pressure calculation methods including embedded flow field effects; and computation of skin friction forces and wall temperatures.

Although the program primarily uses local-slope pressure calculation methods that are most accurate at hypersonic speeds, its capabilities have been extended down into the supersonic speed range by the use of embedded flow field concepts. This permits the first order effects of component interference to be accounted for.

PROGRAM OUTPUT OPTIONS: Basic aerodynamic coefficients; detailed results; checkout data; intermediate results

PROGRAM INPUTS: Depending of program options selected.
Normal mode: X,Y,Z coordinates of configuration external geometry and conditions to run (i.e., α , B, M, ALT, etc.).

LIMITATIONS/RESTRICTIONS: Mach Number must be greater than 1.0

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 74

LANGUAGES: CDC FORTRAN Extended

SPECIAL REQUIREMENTS: Not required but useful: Tektronix Terminal/Calcomp plotter for drawing input geometry to check for correctness.

AVAILABLE DOCUMENTATION: From DDC: AFFDL TR 73-159 Volumes I, II and III; AD 778 443, AD 778 444 and AD 778 445

RESPONSIBLE ENGINEER: Donald E. Shereda
AFWAL/FIMG
Phone: (513) 255-4410
Autovon: 785-4410

PROGRAM TITLE: Two Dimensional, Transonic Airfoil Analysis
Code (Program H)

DESCRIPTION: This program calculates the pressure distributions on a two dimension airfoil in subsonic and transonic flow. It has a viscous boundary layer calculation and integrates the pressures to obtain C_l , C_d , C_m .

APPLICATION: The program is used for predicting chordwise pressure distributions and drag rise characteristics for 2-D airfoil sections.

KEY WORDS: Two dimensional, transonic, airfoil, lift coefficient, drag coefficient, moment coefficient, pressure distribution, supercritical flow

ABSTRACT: This program was written by F. Buaer, P. Garabedian, D. Korn, A. Jameson of New York University in work supported by NASA Grants. The program solves the full potential equation about a lifting single element airfoil using a finite difference approximation in a mapped computational plane. Viscous effects are approximated with a turbulent boundary layer model which is iteratively imposed on the airfoil using the potential flow solution for edge conditions. The boundary layer transition estimated by the program may be overridden by user specification. The number of iterations required to meet convergence criteria rises as the strength of the shock(s) increases (e.g., due to increasing lift, thickness, and/or free stream mach number).

PROGRAM OUTPUT OPTIONS: Airfoil shape, lift, drag, and moment coefficients; and tabulated pressure distribution. Plots of these values are optional.

PROGRAM INPUTS: Airfoil coordinates (pairs x, y's), Mach number, lift coefficient, angle of attack, and Reynolds number.

LIMITATIONS/RESTRICTIONS: Limited to subsonic free stream Mach numbers. Requires an accurate description of the airfoil.

COMPUTER SYSTEM ENVIRONMENT: CDC/Cyber 175

LANGUAGES: Fortran

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: Supercritical Wing Sections I, II, and III in Lecture Notes in Economics and Mathematical System by Springer-Verlag publishers.

RESPONSIBLE ENGINEER: David Hammond
AFWAL/FIMB
PHONE: (513) 255-5288
AUTOVON: 785-5288

PROGRAM TITLE: Two Dimensional (2-D) Navier-Stokes Solutions

DESCRIPTION: An Implicit-Explicit finite differencing procedure for solving compressible Navier-Stokes equations (time dependent).

APPLICATION: Flow fields containing strong inviscous-viscous interactions including flow separation.

KEY WORDS: 2-D Navier-Stokes equations; Eddy viscosity model.

ABSTRACT: An implicit-explicit numerical method has been developed for obtaining asymptotic steady-state solutions of the Navier-Stokes equations. The numerical solution of practical engineering problems requires fine spatial mesh distributions to resolve viscous layers near wall boundaries. The fine mesh, coupled with the stability limitations of fully explicit methods, yields large computing times. The implicit-explicit algorithm has been developed for obtaining solutions to the Navier-Stokes equations to reduce the computational time required. The implicit method is used in regions where the fine mesh is required, while the explicit method is retained in the remainder of the flowfield. Numerical solutions are obtained for two- and three-dimensional strong inviscid-viscous interactions. This method exhibits an order of magnitude reduction in computing time over the fully explicit method with comparable accuracy.

PROGRAM OUTPUT OPTIONS: Velocity components and thermodynamic variables

PROGRAM INPUTS: Mach number, Reynolds number, free stream temperature, surface temperature, number of grid points

LIMITATIONS/RESTRICTONS: (1) two dimensional flow; (2) relatively simple body geometric configuration; (3) core size limitation; (4) algebraic turbulence model.

COMPUTER SYSTEM ENVIRONMENT: CDC, IBM, etc.

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AIAA Journal Vol. 16, No. 5, May 1978
AIAA Journal Vol. 13, No.10, Oct 1975
AIAA Journal Vol. 17, No. 7, Jul 1979

RESPONSIBLE ENGINEER: J. Shang
AFWAL/FIMM
PHONE: (513) 255-3178
AUTOVON: 785-3138

PROGRAM TITLE: Three Dimensional (3-D) Navier-Stokes Solutions

DESCRIPTION: Explicit finite differencing procedure for solving 3-D compressible Navier-Stokes equations (time dependent).

APPLICATION: 3-D flow fields containing strong inviscous-viscous interactions including flow separation.

KEY WORDS: 3-D time dependent Navier-Stokes equations, eddy viscosity model

ABSTRACT: This program is a three-dimensional, time dependent Navier-Stokes code using MacCormack's explicit scheme that has been vectorized for the CRAY-1 computer. Computations were performed for a turbulent, transonic, normal shock wave boundary layer interaction in a wind tunnel diffuser. The vectorized three-dimensional Navier-Stokes code on the CRAY-1 computer achieved a speed of 128 times that of the original scalar code processed by a CYBER 74 computer. The vectorized version of the code outperforms the scalar code on the CRAY computer by a factor of 8.13.

PROGRAM OUTPUT OPTIONS: Velocity components, thermodynamic variables

PROGRAM INPUTS: Mach number, Reynolds number, free stream temperature, surface temperature, number of grid points, coordinates of the configuration

LIMITATIONS/RESTRICTIONS: (1) Vectorized version can only be used on CDC Star (CYBER 200), or CRAY-1 computer; (2) Core size limitation

COMPUTER SYSTEM ENVIRONMENT: CDC 7600, CDC STAR 100, CRAY 1

LANGUAGES: FORTRAN, SL1

SPECIAL REQUIREMENTS: (1) Vector data processor, (2) Restart file or data manager

AVAILABLE DOCUMENTATION: AIAA preprint 79-1448
AIAA preprint 80-0062

RESPONSIBLE ENGINEER: J. Shang
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PHONE: (513) 255-3178
AUTOVON: 285-3138

PROGRAM TITLE: Compressible Turbulent Boundary-Layer Algorithm

DESCRIPTION: This program is based on a finite difference algorithm to solve the two-dimensional compressible, turbulent boundary-layer equations with the Cebeci-Smith eddy viscosity model.

APPLICATION: Any two-dimensional boundary layers with Mach number greater than zero. Laminar solutions may be generated by placing transition downstream of the area of interest.

KEY WORDS: Turbulent boundary layers, compressible boundary layers, numerical solution, eddy viscosity models

ABSTRACT: A finite difference algorithm for solving the equations for laminar, transitional, and turbulent compressible boundary layers for either planar or axisymmetric flows is presented. The Reynolds stress terms in the fully developed turbulent region are calculated using the Cebeci-Smith algebraic eddy viscosity model. The properties of the transitioned boundary layer are calculated by multiplying the eddy viscosity by the Dhawan and Narasimha intermittency function. A specifiable turbulent Prandtl number relates the turbulent flux of heat to the eddy viscosity model. The Levy-Lees transformation is used to reduce boundary-layer growth, as was Cebeci's geometric normal coordinate stretching to cluster points near the model. The implicit finite difference scheme permits doubling of the streamwise step size at user specified stations to speed up the computations. The momentum and energy equations are solved simultaneously and the velocity and temperature profiles are allowed to relax to a specified tolerance.

Numerous comparisons with experimental data have shown the program to be robust and accurate. Improvements for flows with strong adverse pressure gradients, nearing separation, are under development.

PROGRAM OUTPUT OPTIONS: Program prints a summary of boundary-layer properties at each station. Detailed printouts of entire profiles may be obtained at user specified stations.

PROGRAM INPUTS: Free stream Mach and Reynolds numbers and static temperature, surface temperature and pressure along surface, surface distance to transition location. Other parameters may be specified if desired.

LIMITATIONS/RESTRICTIONS: Boundary layers, two dimensional with Mach number greater than zero.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: CDC FORTRAN Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: ARL Reports 73-0041 and 74-0044, AIAA Paper 73-164 and 80-0136.

RESPONSIBLE ENGINEER: C. E. Jobe
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PROGRAM TITLE: Subsonic Doublet-Lattice Unsteady Aerodynamics

DESCRIPTION: Subsonic lifting surface theory for calculating unsteady aerodynamic forces on surfaces and bodies.

APPLICATION: Used for calculating unsteady aerodynamic forces in dynamic response and flutter calculations for general wing/body combinations in subsonic flow.

KEY WORDS: Unsteady Aerodynamics, Subsonic Flow, Aerodynamic Interference

ABSTRACT: Two methods of accounting for body-lifting surface interference in subsonic unsteady flow have been programmed. Both methods use the application of nonplanar lifting surface elements (doublet-lattice) to the lifting surfaces. In the first method, the body is treated as an annular wing with an axial doublet introduced to account for body incidence effects. The second approach uses an image system and an axial singularity system to account for the effects of the bodies.

The doublet-lattice method can be used to predict unsteady aerodynamic loads on wing/body combinations in subsonic flow. Loads predicted by this method are required for flutter, gust, frequency response and static aeroelastic analyses.

PROGRAM OUTPUT OPTIONS: Printed output consists of pressures, if desired, and generalized aerodynamic forces.

PROGRAM INPUTS: Input consists of geometry, Mach number, reduced frequency, and polynomial expressions for modal data.

RESTRICTIONS/LIMITATIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC

LANGUAGES: Fortran

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

AFFDL-TR-71-5, Subsonic Unsteady Aerodynamics for General Configurations.

RESPONSIBLE ENGINEER: Mr. Samuel J. Pollock
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PROGRAM TITLE: Aerodynamics of Guided and Unguided Weapons

DESCRIPTION: Aerodynamic characteristics prediction for projectiles and missiles. Subsonic, transonic, and supersonic Mach regions.

APPLICATION: Computes the static and dynamic aerodynamics on configurations such as guided and unguided tactical weapons for Mach numbers, from 0 to 3 and angles of attack from 0° to 15° (includes circular body ballistic shapes).

KEY WORDS: Tactical Weapons, Aerodynamic Prediction, Stability Characteristics

ABSTRACT: The program is capable of handling wing alone, body alone, wing-body, or canard-body-tail configurations. Bodies may be pointed or blunted (spherical or truncated noses) ogival or cone shapes. Nose lengths up to 1.5 diameters can be handled and a discontinuity is acceptable. The afterbody (if used) may not be longer than 10 diameters and will be assumed to be cylindrical if present. Boattails may or may not be included. If included, they may be conical, ogive, or flared in shape. The wings can be one of two airfoil sections; biconvex or modified double wedge with shaped or blunted leading and trailing edges (see specific inputs for variations accepted). "Wings" include wings, canards, and tails.

PROGRAM OUTPUT OPTIONS: The reference conditions (speed of sound, air density, etc.) and input data are listed. The component forces and moments are given in tabular form as well as summary table for the total static and dynamic aerodynamics.

PROGRAM INPUTS: Complete body/wing/tail description including Mach number range to be considered (lengths, weight, diameter, etc.).

LIMITATIONS/RESTRICTIONS: Requires large amount of machine core (night job size). Documentation of all methodologies used are contained in NSWC/DL TR's; TR-3018 and TR-3584. This documentation lists all limitations or restrictions of the theories used to develop the program.

COMPUTER SYSTEM ENVIRONMENT: CDC 6600 series compatible, including CYBER 74 and CYBER 175

LANGUAGES: Fortran

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

Documentation is available on current and revised versions of program (NSWC/DL TR-3036 and NSWC/DL TR-3600).

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PROGRAM TITLE: Grumman Ames AFFDL Transonic Viscous Wing Body Analysis Program (GAC AMES)

DESCRIPTION: This is an automated procedure for computing the three dimensional transonic flow over wing-body combinations. It utilizes the Bailey-Ballhaus modified small disturbance equations for inviscid flow and a 2-D strip boundary layer formulation for viscous effects.

APPLICATION: GAC AMES can analyze wings alone or wing-body combinations at transonic Mach numbers less than one.

KEY WORDS: Aircraft Aerodynamics, Subsonic Flow, Transonic Flow, Viscid-Inviscid Flow Interactions, Small Disturbance Equation, Boundary Layer

ABSTRACT: GAC AMES is a numerical method used to predict the detailed pressure distribution and force and moment results for wing-body combinations at transonic Mach numbers less than one. The basic inviscid prediction method is the modified transonic small disturbance theory program developed by Ballhaus, Bailey and Frick at NASA Ames. In order to provide accurate surface pressure predictions on the wing, several additional features of the transonic flow field have been incorporated. These consist of the viscous displacement effect, local strong viscous interaction at the shock wave foot and at the trailing edge (including an approximate treatment of local shallow separations), and finally, the interaction effect of the fuselage.

The program should not be expected to produce results if there are significant regions of separated flow, and this fact can be used to determine the limits of program applicability for any particular case. Body effects are incorporated into the program by providing an infinite rectangular cross-section upon which the fuselage slopes are applied. Suitable modifications of these slopes are made via slender body theory to take into account the transfer of the boundary condition from the fuselage surface to the rectangular cross-section boundary condition support surface.

Viscous effects are accounted for through two different approaches. The full viscous-inviscid iteration is carried out assuming a boundary layer of the infinite swept wing type at each span station, augmented by local treatments of the strong interaction regions at the shock foot and trailing edge, and regions with shallow separations. The above method is fully coupled with the inviscid calculation. The second approach uses the 3-D boundary layer code of Nash and Scruggs which computes the fully 3-D laminar and/or turbulent boundary layer on finite wings. The Nash-Scruggs program is not fully coupled with the inviscid calculation; however, the inviscid/strip viscous program will automatically produce the input data set for the 3-D BL program.

PROGRAM OUTPUT OPTIONS: Printouts of C_p and local Mach number at each of 28 semi-span stations and along the fuselage are produced. A summary sheet of section C_n , C_a , C_p , C_d , C_m is printed. Tabular boundary layer data can be produced. Calcomp plots are not yet available.

PROGRAM INPUTS: Program options are selected by using a name-list input which also contains flight conditions. Detailed data on the wing platform, airfoil coordinates, and body coordinates must be input. The program has a restart capability which can use a previously saved solution to generate the solution at a new flight condition.

LIMITATIONS/RESTRICTIONS: This program requires approximately 300 minutes for a converged inviscid solution and 500 minutes for a converged viscid/inviscid solution on the ITEL system. A version of the program is available on the AMES CDC 7600 computer and requires 10 minutes for inviscid and 17 minutes for viscid/inviscid.

COMPUTER SYSTEM ENVIRONMENT: AFFDL: ITEL AS/5
AMES: CDC 7600, Update format

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

AFFDL-TR-77-122, An Automated Procedure for Computing the Three Dimensional Transonic Flow over Wing-Body Combinations, Including Viscous Effects

Volume I: Description of Analysis Methods and Applications

Volume II: Program User's Manual and Code Description

Volume II, App A: Computer Code Listing and Flow Chart

Volume III: An Implicit Method for the Calculation of Three Dimensional Boundary Layers on Finite, Thick Wings

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PROGRAM TITLE: Panel Aerodynamics (PANAIR) Pilot Code

DESCRIPTION: A subsonic/supersonic higher order aerodynamic paneling method.

APPLICATION: Computes linearized, compressible potential flow about arbitrary three dimensional configurations (single or multi-body) in subsonic or supersonic flow.

KEY WORDS: Aerodynamics, Panel Methods, Subsonic Flow, Supersonic Flow, Higher Order Singularities, Three Dimensional Geometry

ABSTRACT: PANAIR uses a higher order panel method to solve boundary value problems involving the Prandtl-Glauert equation for subsonic and supersonic potential flows. These higher order panels eliminate many of the modeling problems and restrictions that lower order panels typically have. Two important aspects of the present higher order panel method formulation are that (1) the doublet strength is continuous across all panel edges, and (2) all adjacent panels can have contiguous edges. This eliminates the generation of spurious line vortex behavior which can produce disastrous numerical effects in supersonic flow.

Of particular note is the capability for exact surface modeling (as opposed to linearized boundary condition formulations) of complex features such as the true wing surface geometry, complex fuselage contours, canopies, engine inlets, external stores, and so forth, whose influence can have a dominant role in a vehicle's aerodynamics. These are capabilities that are not offered by any other current panel method program for supersonic flow analysis. In most cases the same paneling can be used in both subsonic and supersonic analysis. Exact surface modeling is not new in subsonic analysis, but here too, the advanced higher order panel technology of the PANAIR system yields significant gains over existing methods. More accurate velocity distributions (necessary for interfacing with three dimensional boundary layer codes) are produced by this method than by lower order codes. The relative insensitivity of the solutions to paneling arrangements for a given geometry makes the results more reliable and less user dependent. Also, much fewer numbers of panels, as compared with a lower order method, are generally required to provide comparable accuracy. Each panel which represents a physical surface contains singularities which can be comprised of source and/or doublet distributions. (Panels comprised of both sources and doublets are called "composite" panels.) The source strength varies linearly over each panel and the doublet strength varies quadratically. The term "higher order" refers to these higher order strength distributions, as opposed to "lower order" panels having constant strengths.

ABSTRACT (Cont.):

In PANAIR, generality is provided not only in the geometry sense but also in the boundary value modeling sense. The key feature in this latter sense is the generality of boundary condition formulation. The user can: (a) choose from several different types of boundary condition terms which specify normal mass flux, normal velocity, tangential velocity and velocity potential; (2) control the flow on both sides of a singularity sheet since the composite-panel formulation allows for two different types of boundary conditions at each control point; and (3) construct a linear combination of the different boundary condition types.

PROGRAM OUTPUT OPTIONS: System output consists of detailed surface singularity distributions, detailed surface pressures and velocities, and forces and moments on both the configuration as a whole or on selected components.

PROGRAM INPUTS: Program inputs consist largely of a detailed panel corner point description of the geometry of the configuration being analyzed (the points are grouped together into networks which represent portions of the configuration), parameters which describe the flow conditions to which the configuration is subjected, and other parameters which determine the boundary conditions to be used in the problem solution.

LIMITATIONS/RESTRICTIONS: Geometry input data must be less than 2000 panel corner points distributed on less than 100 networks. The program required fifteen disk files.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: Fortran IV
Compass (CDC assembly language)

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
Available from NTIS: NASA CR 3062, A Higher Order Panel
Method for Linearized Supersonic Flow
NASA CR 152047, Users Manual, Subsonic/
Supersonic Advanced Panel Pilot Code.

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PROGRAM TITLE: Unified Subsonic Supersonic Aerodynamics (USSAERO)
Version B

DESCRIPTION: USSAERO uses the method of surface singularity distributions to compute pressure distributions and aerodynamic characteristics for linearized, compressible potential flow over three dimensional wing-body-tail aircraft configurations in subsonic and supersonic flow.

APPLICATION: The program computes pressures, forces, and moments on general three dimensional aircraft configurations in both subsonic and supersonic flow.

KEY WORDS: Linearized Potential Flow, Panel Methods, Surface Singularity Distributions, Subsonic Flow, Supersonic Flow, Surface Vorticity Distribution

ABSTRACT: USSAERO calculates the pressure distribution and aerodynamic characteristics of wing-body-tail combinations in subsonic and supersonic potential flow. The configuration surface is subdivided into a large number of panels, each of which contains an aerodynamic singularity distribution. Constant source distributions are used on fuselage panels. Wing, canard, and tail panels are modeled differently than fuselage panels depending on which of two boundary condition options is chosen. Using the planar boundary condition option, the panels are located in the mean plane of the wing surface. Linearly varying source distributions are used to simulate the airfoil thickness, and linearly varying vortex distributions are used to simulate the effects of camber, twist, and thickness. This option can be used in both subsonic and supersonic flow. Using the non-linear boundary condition option, panels are located on the actual wing surface while the singularity distribution consists solely of linear vorticity. This option can only be used in subsonic flow.

The normal components of velocity induced at specified control points by each singularity distribution are calculated and make up the coefficients of a system of linear equations relating the strengths of the singularities to the magnitude of the normal velocities. The singularity strengths which satisfy the boundary condition of tangential flow at the control points for a given Mach number and angle of attack are determined by solving this system of equations using an interactive procedure. Once the singularity strengths are known, the pressure coefficients are calculated, and the forces and moments acting on the configuration determined by numerical integration.

PROGRAM OUTPUT OPTIONS: Program outputs include computed pressures, forces, moments, and surface singularity distributions on a configuration, as well as optional plots of the input geometry, the panel model, and the computed pressure distributions.

PROGRAM INPUTS: Program input consists of 1. a detailed panel corner point description of the geometry of the configuration being analyzed, with options for a simplified input if the fuselage cross section is circular; 2. a similar input set to describe the desired paneling, with options for a simplified input if the paneling is the same as the geometry input; and 3. a set of parameters describing the desired flow conditions (Mach number and angle of attack) and output options.

LIMITATIONS/RESTRICTIONS: The program requires 135000 octal words of core and uses 15 disk files. A configuration can be paneled with up to 500 fuselage panels, 30 fuselage cross section stations, and 600 wing, canard, and/or fin panels. The program has the following modeling limitations. The configuration must be symmetric about the X-Z plane (the fuselage centerline is assumed to be on the X-axis). The arbitrary cross section capability is limited to those shapes for which the radius, in a polar coordinate system centered on the cross section, is a single valued function of the polar angle.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 75/175
NOS/BE Operating System

LANGUAGES: Fortran IV

SPECIAL REQUIREMENTS: The program requires that the Calcomp subroutine library CCAUX be attached as a library file.

AVAILABLE DOCUMENTATION:

NASA CR 2228, An Improved Method for the Aerodynamic
Analysis of Wing-Body-Tail Configurations in
Subsonic and Supersonic Flow,

Part I: Theory and Application,

Part II: Computer Program Description.

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PROGRAM TITLE: Aerodynamic Preliminary Analysis System (APAS)

DESCRIPTION: This program computes linearized aerodynamic solutions at subsonic and supersonic speeds for arbitrary configurations.

APPLICATION: The APAS is a preliminary analysis tool which permits the study of complex three-dimensional aircraft configurations.

KEY WORDS: Aerodynamics, Linearized Theory, Arbitrary Configurations.

ABSTRACT: Many aerodynamic analysis methods for computing subsonic and supersonic solutions are limited to thin wing approximations to the linearized potential and vortex equations. This limits applications to thin-wing airplanes. The APAS program can generate solutions to many diverse configurations including conventional airplanes, fighters, the Space Shuttle, and lifting bodies.

Configurations are simulated by distributions of source and vortex singularities which satisfy the linearized small perturbation potential equation of motion. Singularity strengths are determined by satisfying boundary conditions at the local surface. Configurations are composed of slender bodies, interference shells, aerodynamic surfaces (wings, tails, canards, etc.), and offset bodies such as nacelles and stores.

Perturbation velocities and integrated pressures are reduced into force and moment coefficients. Skin friction, wave drag, and induced drag are included in the total drag coefficient calculations. Static stability, control, and selected rotary derivatives are calculated. The aerodynamic coefficients calculated by the program represent the potential solution. Increments due to leading edge vortices must be added to the potential solution.

The APAS is composed of three programs. The Geometry and Analysis Program contains the digitize, editing, curve fitting, display, slender body, aerodynamic analysis, plotting and other operational routines. The Isolated Body Program computes the pressures and perturbation velocities on the slender body. The Unified Distributed Panel Program calculates the pressures and velocities on the lifting surfaces and then integrates the data from all components into reduced aerodynamic coefficients.

PROGRAM OUTPUT OPTIONS: Output from Geometry and Analysis Program comprise geometry data and plotting instructions written on permanent files. Forces and velocities generated by the Isolated Body and UDP Programs are written on permanent files. The UDP Program prints force and velocity matrices, force and moment coefficients, and derivatives. Aerodynamic data plots and geometry plots are generated by the Geometry and Analysis Program on the computer terminal.

PROGRAM INPUTS: Configuration data and a computer display terminal are input via the computer terminal. Geometry data are files to be used by the Isolated Body and Unified Distributed Panel (UDP) Programs.

LIMITATIONS/RESTRICTIONS: The Geometry and Analysis Program must be operated from a computer display terminal such as the Tektronix 7014 terminal.

COMPUTER SYSTEM: CDC 175 and 7600; NOS/BE operating system, IBM 370.

LANGUAGES: FORTRAN EXTENDED

SPECIAL REQUIREMENTS: Tektronix 4014 Computer Display Terminal, Tektronix 4953/4954 Graphics Tablet; hard copy unit.

AVAILABLE DOCUMENTATION: NASA CR 145284
NASA CR 145300

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PROGRAM TITLE: Nonplanar Lifting Systems Method

DESCRIPTION: This program calculates the induced drag reduction capability of winglets.

APPLICATION: This program determines the effect of adding winglets to a wing at the wingtip.

KEY WORDS: Winglets, Induced Drag Reduction

ABSTRACT: Since the advent of the high speed digital computer, numerous potential flow numerical methods for the analysis of lifting wings have been developed. The more sophisticated of these methods have generally fallen into two classes. The most rigorous methods, often referred to as Neumann methods, solve the three-dimensional potential flow problem without making any limiting assumptions concerning the geometry of the wing. The second class of methods are usually referred to as lifting surface theories. These methods neglect the thickness of the wing and generally impose small perturbation assumptions to linearize the problem. While these flow assumptions are generally reasonable for "conventional" wing configurations, there are many cases where the linearization assumptions are not valid. Among the problems that cannot be adequately solved using linearized methods are nonplanar wings, such as wings with "winglets," wings with highly deflected flaps, and wings in ground proximity.

This program presents a new method which can still be classified as a lifting surface theory in that thickness effects are neglected but the method makes none of the small perturbations and linearization assumptions of other lifting surface theories. In addition, the new method represents the lifting surfaces by distributed vorticity which realistically models the loading distribution, rather than the unrealistic loading representations of earlier methods.

PROGRAM OUTPUT OPTIONS: Wing element geometric data, chordwise distribution of the pressure jump coefficient, spanwise and total loading of all wing elements.

PROGRAM INPUTS: Geometrical data required to define a wing and/or winglet.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC 6600/CYBER 175

LANGUAGES: FORTRAN IV

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: McDonnell/Douglas Report No. MDCJ6985

RESPONSIBLE ENGINEER: Duane R. Burnett
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PROGRAM TITLE: Aircraft Stores Interference Prediction Program

DESCRIPTION: A program that calculates the aerodynamic coefficient increments due to external store loadings.

APPLICATION: This program will allow the engineer to estimate the effects of stores on aircraft aerodynamics. The usefulness of this program can be realized in the design of new conventional aircraft where external stores are expected to be incorporated.

KEY WORDS: External Stores, Stores Interference, Aerodynamic Increments, Aerodynamics

ABSTRACT: External stores aerodynamic compatibility and effects on current and future military aircraft is and will continue to be a pressing problem due primarily to the many options available in choosing configuration details. Due to the variety of mission requirements, airborne weapons come in many sizes and shapes as do fuel tanks and instrumentation pods. Additional variables are introduced by the options of where and how to carry these external stores. This situation creates a real need for effective methods to perform comparative evaluations of these options during configuration studies. Information concerning candidate configurations is more often than not obtained from wind tunnel tests, the data of which may become available too late to influence the selection.

Data needed for this purpose include incremental effects of external stores on the airplane aerodynamics. Drag information is needed because of the effects on speed, range and altitude capabilities. Stability and control data are important to analyze store effects on aircraft flying qualities. Therefore, an early prediction of these parameters is crucial to the proper evaluation of configuration options.

The program identified provides the engineer with a technique for predicting the aerodynamic effects of carrying external stores on aircraft. The methods and equations used were developed from detailed correlations and analyses of experimental data for many combinations of aircraft with external store configurations. The program is applicable to stores carried at subsonic to supersonic speeds on single and multiple carriage racks mounted on aircraft wing and fuselage armament stations. Additionally, the program is applicable to conventional aircraft having wings mounted on the upper, middle or lower fuselage. Output from the program provides data concerning incremental drag, lift, side force, pitching moment, and yawing moment due to stores and should provide sufficient accuracy for preliminary analysis.

PROGRAM OUTPUT OPTIONS: Printout of aircraft and stores identification parameters and resulting increments to which clean aircraft coefficients can be added.

PROGRAM INPUTS: Data for the program consists of a sequential input of aircraft and store configuration parameters as well as clean aircraft aerodynamic data if desired.

LIMITATIONS/RESTRICTIONS: The program is empirically based using data from representative high and low wing aircraft wind tunnel tests. Verification of the program's computational procedures included running test cases of high, low, and mid-wing aircraft incorporating various store loadings. In general, the following comments can be made about the prediction accuracy. Predicted drag at subsonic speeds is generally high whereas supersonically predicted drag is somewhat low. Transonically, inaccuracies in predicted drag and side force may result. Inaccuracies in calculated lift increment usually centered around centerline carriage of stores. In addition, the more complicated a store structure, i.e. MER or TER, the greater the possibility for inaccuracies in lift and yaw calculations. Lastly, since the program is not based on any representative mid-wing aircraft, some inaccuracy resulted in neutral point and yaw calculations for this type of aircraft.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

AFFDL-TR-75-95, Technique for Predicting Aircraft Aerodynamic Effects Due to External Stores Carriage,
Vol I: Technical Summary Report,
Vol II: Technique User's Manual,
Program User's Manual will be written in FY80.

RESPONSIBLE ENGINEER: Capt. Randall Mainquist
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SECTION II
STRUCTURES AND DYNAMICS

PROGRAM TITLE: CRACKS-PD: A Computer Program for Crack Growth Analysis Using the Tektronix 4051 Graphics System

DESCRIPTION: CRACKS-PD is a desk-top computer program for predicting the response of cracked structures to aircraft spectrum loading.

APPLICATION: CRACKS-PD provides the capability of predicting crack growth lives for aircraft structure. The program is intended for material trade-off studies and other preliminary design level problems such as design limit stress determination.

KEY WORDS: Crack Propagation, Load Generation, Life Prediction

ABSTRACT: CRACKS-PD is a BASIC language computer program for determining critical crack lengths and crack growth lives for structures subjected to variable amplitude loading. A simplified stress history is generated internally from input exceedance curves. The program accounts for load interaction effects on an average basis using a modified version of the Wheeler model. This enables the analyst to perform rapid, realistic material trade-off studies at the preliminary design level. Graphical output is provided on both the Tektronix 4051 screen and a digital incremental plotter.

PROGRAM OUTPUT OPTIONS: Tabular output consists of crack length and crack growth rate versus flight hours as well as critical crack size. Plot output in addition to the above, gives the input exceedance curve and material properties.

PROGRAM INPUTS: The necessary inputs are: (1) material properties; (2) selection of stress intensity factor formulation; and (3) exceedance curve.

LIMITATIONS/RESTRICTIONS: Current restrictions are: (1) constant shape surface flaw analysis; (2) exceedance curve should define small block of usage (e.g. 200 flight hours) to prevent stress intensity factor gradients from becoming large; and (3) array sizes (limits are printed during input phase).

COMPUTER SYSTEM ENVIRONMENT: Tektronix 4051 Desk Top Graphics System

LANGUAGES: Tektronix Extended BASIC

SPECIAL REQUIREMENTS: Tektronix 4662 Digital Plotter for report quality plots.

AVAILABLE DOCUMENTATION:

AFFDL-TM-79-63-FBE, CRACKS-PD, A Computer Program for Crack Growth Analysis Using the Tektronix 4051 Graphics System

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PROGRAM TITLE: CRACKS - A FORTRAN IV Digital Computer Program
for Crack Propagation Analysis

DESCRIPTION: CRACKS is a batch program for predicting the response of a cracked structure to aircraft flight-by-flight stress histories.

APPLICATION: CRACKS provides the capability of predicting lives of structures containing flaws subjected to aircraft load histories. This analysis enables the engineer to select or determine inspection intervals, aircraft modifications, and maintenance schedules for service aircraft.

KEY WORDS: Crack Propagation, Variable Amplitude Loading, Life Prediction

ABSTRACT: CRACKS is essentially a specialized integration routine. The program integrates a crack growth rate relationship of the form $da/dN=f(a,\sigma)$ through the stress history defined by a given aircraft mission profile. Using this relationship, CRACKS determines the incremental crack growth for each of the series of discrete loads levels, given a stress intensity factor formulation. CRACKS provides the capability of modeling load interaction effects (crack growth retardation).

For each load level in the stress history, CRACKS determines the stress intensity factor, K , corresponding to the current crack length. These values then are modified by the load interaction model to account for retardation effects. The resulting "effective" K is used in conjunction with the crack growth relationship to determine the incremental crack growth. The crack growth increments are then summed to give crack growth as a function of time (e.g. flight hours, flights, etc.)

PROGRAM OUTPUT OPTIONS: Output consists of crack length, K, and retardation parameters in tabular format. Frequency of output is a user option.

PROGRAM INPUTS: The necessary inputs are: (1) material properties, (2) crack growth rate relationship, (3) definition of K (as a combination of 10 available correction factors), (4) applied stresses for each mission and (5) the mission profile to be analyzed.

LIMITATIONS/RESTRICTIONS: Current restrictions on the analysis are: (1) aspect ratio ($a/2c$) for surface flaw analysis must be less than 0.5, (2) surface flaw analysis assumes constant shape, (3) compressive load truncated to zero except when using closure model.

COMPUTER SYSTEM ENVIRONMENT: CDC 6600
CDC CYBER 74
IBM 360/65
IBM 370/145
UNIVAC 1108

LANGUAGES: Fortran IV

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL-TR-70-107, CRACKS, A Fortran IV Digital Computer
Program for Crack Propagation Analysis
AFFDL-TM-74-173-FBE, CRACKS II User's Manual

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PROGRAM TITLE: Sequence Accountable Fatigue Analysis (SAFA)

DESCRIPTION: SAFA is a batch program to calculate cumulative damage of notched structural members subjected to arbitrary spectra.

APPLICATION: SAFA provides the capability to predict crack initiation times for notched members under typical aircraft loadings.

KEY WORDS: Aircraft Structures, Fatigue Life Prediction, Spectrum Loading, Residual Stress

ABSTRACT: The Sequence Accountable Fatigue Analysis (SAFA) computer program was developed to calculate cumulative damage in notched structural members subjected to arbitrary spectra. SAFA develops sequence sensitivity by tracking residual stresses local to the notch throughout the stress history. Residual stress relaxation analysis is included to increase the generality of the results.

PROGRAM OUTPUT OPTIONS: Output options include (1) local stress history at the notch, (2) plastic strain and associated damage, (3) Range-Pair counted elastic stress history and associated damage and (4) total damage for each block in spectrum.

PROGRAM INPUTS: Input data requirements are: (1) stress-strain behavior, (2) specimen geometry, (3) S-N data and (4) stress history.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 74
CDC 6600

LANGUAGES: Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

AFFDL-TR-74-23, A User's Manual for the Sequence Accountable
Fatigue Analysis Computer Program

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PROGRAM TITLE: Aeroservoelastic Analysis Procedure (ASEP)

DESCRIPTION: ASEP is a program which predicts adverse interactions between the aircraft structure and active control systems, and defines potential flight instabilities.

APPLICATION: ASEP has application to all aircraft with high gain flight control systems and the study of active flutter suppression.

KEY WORDS: Aeroservoelasticity, Active Flutter Suppression, Flutter, Nyquist Theory, Active Control Systems

ABSTRACT: The unforced, or flutter, equations of motion for a general aeroelastic system as traditionally used are expressed as a function of a nondimensional parameter called reduced frequency, $k = b\omega/V$. This parameter has been used in the development of nearly every aerodynamic theory available to the flutter analyst. The flutter instability can be determined from eigenvalue solutions for the aeroelastic system equations of motion for chosen values of the reduced frequency.

The usual practice in this "V-g" method of flutter analysis is to determine both the frequency and damping for each of the system eigenvalues. The flutter instability is indicated at the particular value of k which produces a root of the equations with a positive value of damping indicating a divergent harmonic oscillation. Both the flutter frequency, ω_F , and the flutter velocity V_F , are determined from the eigenvalue for this unstable root and the particular reduced frequency, k_F , at which it occurs.

When feedback control systems are included in the analysis, the stability assessment is significantly more difficult. A basic and fundamental problem exists because the control system equations are usually expressed in the frequency domain in terms of the Laplace variable, $S = i\omega$. A compatible solution for the combined equations of motion for the coupled control system aeroelastic airframe (Servo-aeroelastic system) is possible only when the dimensional frequency parameter for the control system (ω) is the same as the frequency imbedded in the nondimensional parameter for the aeroelastic airframe, $\omega = Vk/h$.

Two separate computer programs for servo-aeroelastic stability analyses are provided. The first program is designed to be used with the traditional aeroelastic formulation referred to above. It maintains, at every step in the analysis, a perfect match for the two essentially different frequency parameters.

The second program is designed to be used with an aerodynamic theory in which the reduced frequency has been factored out of the aerodynamic expressions. This approach is referred to

ABSTRACT (cont.): as an indicial lift formulation. The indicial formulation is generally restricted to two-dimensional Theodorsen strip theory type aerodynamics subject to any modifications of coefficients to account for effects such as aspect ratio and compressibility. Frequency response, as opposed to eigenvalue techniques, is used in both programs.

PROGRAM OUTPUT OPTIONS: Mikhailov criterion plots, open and closed loop bode plots, open loop modified Nyquist plots, and tables of frequency dependent data which form the basis for the plots.

PROGRAM INPUTS: Input data consists of generalized mass, stiffness, damping and unsteady aerodynamics. The program also requires control surface data, transfer functions and flight condition information.

LIMITATIONS/RESTRICTIONS: An aerodynamic interpolation program is required to preprocess the unsteady aerodynamic force matrices and to form a data tape or permanent file. Approximately 600 sets of aerodynamics (aerodynamics for 600 different reduced frequencies) are necessary to obtain good resolution for the output plots.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

MDC Report A288,	Computer Programs for the Frequency Response Stability Evaluations of Servoelastic Systems,
AFFDL-TR-72-116,	Active Flutter Suppression Systems for Military Aircraft, A Feasibility Study,
AFFDL-TM-77-7-FBR,	Control System/Airframe Interaction Analyses for the YF-16 Missile-on Configuration.

RESPONSIBLE ENGINEER: Mr. Thomas E. Noll
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PROGRAM TITLE: Indicial Lift Flutter Analysis

DESCRIPTION: This computer program is used to obtain a transient flutter solution using subsonic aerodynamic derivatives for a swept tapered primary surface with trailing edge control surfaces and tabs.

APPLICATION: This program may be used for primary surfaces (wing or tail) with or without control surfaces and tabs.

KEY WORDS: Indicial Lift, Flutter Analysis, Ship Theory, Transient Flutter Solution

ABSTRACT: A flutter solution procedure is presented for subsonic flow using an indicial lift function. It is based primarily on the unsteady two-dimensional incompressible potential flow theory given by Theodorsen and Garrick. This nondimensional time domain approach to flutter analysis has several unique features, namely:

(1) The method permits assessment of dynamic characteristics at specific airspeeds.

(2) The method allows for the specification of structural damping in each individual mode at an arbitrary level as well as allowing for the evaluation of the effects of external damping mechanisms such as control surface flutter dampers.

(3) The aerodynamics are formulated to allow the use of either theoretical or experimental values for the aerodynamic coefficients.

(4) In a general sense, the indicial lift method retains much of the insight available from the conceptual flutter viewpoint, while retaining all the aerodynamic terms considered in the classical solution.

PROGRAM OUTPUT OPTIONS: Tabular data for various airspeeds, and V-g and V- ω plots of the data.

PROGRAM INPUTS: Geometry, flight conditions generalized mass, and damping, natural frequencies modal information per strip, and various aerodynamic coefficients (optional).

LIMITATIONS/RESTRICTIONS: Number of control surfaces/tabs cannot exceed the number of assumed wing sections.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

MDC A2716, Computer Program for Flutter Analysis Using an
Indicial Lift Function

RESPONSIBLE ENGINEER: Mr. Thomas E. Noll
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PROGRAM TITLE: Flutter and Strength Optimization Procedure
(FASTOP-3)

DESCRIPTION: FASTOP-3 is intended to optimize lifting surface structure with strength, flutter, and deflection constraints.

APPLICATION: Minimum weight design of metal and composite lifting surfaces.

KEY WORDS: Structural Analysis, Flutter Analysis, Structural Optimization, Flutter Optimization, Minimum-Weight Design

ABSTRACT: High performance requirements of modern aircraft make it essential that lifting surface designs be as light as possible and yet stiff and strong enough to avoid structural failure. Conventional design methods result in a lifting surface initially sized to withstand the static load conditions encountered, then corrected to avoid flutter through the addition of structural stiffness and mass balance. Such a design procedure can easily lead to excessive weight penalties for flutter prevention.

Under the belief that both weight and time savings could be achieved through the application of strength and flutter constraints in the same preliminary design step, Grumman Aerospace Corporation in December 1975, under contract to the Air Force Flight Dynamics Laboratory, completed the development of FASTOP (Flutter and Strength Optimization Procedure). This set of programs was capable of obtaining near-minimum weight designs of lifting surface preliminary designs subject to both strength and flutter requirements.

The FASTOP system provides capability for the analysis and near-minimum-weight structural sizing of a lifting surface to meet strength and flutter-speed requirements. The package is comprised of two major programs, each one designed to perform successive analysis and resizing functions in a single computer submission. The Strength Optimization Program (SOP) focuses on basic aspects of static structural analysis and minimum-weight design for strength requirements. It provides for automated calculation of applied loads, performance of conventional strength and flexibility (or stiffness) analysis, and automated resizing of a structural idealization to achieve a fully stressed design. It also prepares data required for direct input to the second major program. The Flutter Optimization Program (FOP) addresses dynamic analysis requirements and provides the redesign capability for achieving a desired value of flutter speed with minimum cost in weight. Using output data from the first program, FOP establishes a mass matrix input for vibration mode analysis, computes normal mode shapes and frequencies, determines the surface's critical flutter speed, and performs resizing if desired to increase flutter speed. Finally, the second program saves data required for re-entering SOP.

PROGRAM OUTPUT OPTIONS: Strength-flutter efficient finite element model geometry.

PROGRAM INPUTS: Finite element model geometry, static loads, flutter speed goal, aerodynamic grid.

LIMITATIONS/RESTRICTIONS: Single lifting surface, 3000 elements, 1000 grid points, 6000 DOF's, no static load correction for aeroelastic effects.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: Fortran (some subroutines in assembler)

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

AFFDL-TR-78-50, Vol. I: FASTOP-3, A Strength, Deflection,
and Flutter Optimization Program
for Metallic and Composite
Structures, Theory and Application,
Vol. II: FASTOP-3, A Strength, Deflection,
and Flutter Optimization Program
for Metallic and Composite
Structures, Program User's Manual

RESPONSIBLE ENGINEER: Terry Harris
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PROGRAM TITLE: Structural Analysis of General Shells (STAGSC-1)

DESCRIPTION: STAGSC-1 is a comprehensive computer code intended for the static and transient analysis of arbitrary shells consisting of up to 30 branches.

APPLICATION: The code can be used for linear stress analysis, geometrically nonlinear elastic stress analysis, geometrically linear or nonlinear inelastic stress analysis, bifurcation buckling analysis (small vibration analysis) with linear or geometrically nonlinear elastic stress and transient response analysis, linear or geometrically nonlinear, elastic or inelastic.

KEY WORDS: Nonlinear Structural Analysis, Finite Difference Methods, Shell Analysis, Computer Code for Shell Analysis, Collapse of Shell, Bifurcation Buckling of Shells, Energy Methods, Thermal Stresses, Plasticity

ABSTRACT: STAGSC-1 is intended for the static analysis of arbitrary shells including the effects of nonlinearities caused by material behavior and finite deformations. Collapse loads based on nonlinear analysis can be computed as well as buckling loads based on classical bifurcation buckling theory with linear prestress. Arbitrary thermal and mechanical loadings can be specified. The manual provides instructions for use of the code and presents sample problems and solutions. The theoretical basis for the program also is presented. Any combination of point forces, line loads and distributed surface tractions can be applied. Loading by specification of displacements or thermal gradients (through the shell wall and over the shell surface) is also permitted. Any configuration of linear boundary conditions or other displacement constraints can be included in the analysis. In the nonlinear static and in the transient analysis a restart capability is available. Intermediate data can be saved on tape or file so that the analysis may be continued later. The input data are automatically checked for certain errors or inconsistency. If so desired, the user can suppress execution of the program and only obtain a check on the input. The output from such a preliminary run may include a graphic presentation of the shell geometry with a display of the grid lines. The results of a STAGSC-1 run can be transferred to tape or disk file and subsequently used as input for a post-processor. Graphic displays of results are obtained from the post-processor. These include contour- or cross-plots of displacements, stress resultants and stresses. Displacement histories can be obtained in the case of transient or nonlinear static analysis.

PROGRAM OUTPUT OPTIONS: Displacements, stress resultants, strains, stresses, point forces can be printed at each load or time step. Plots of displacements and stresses must be obtained from a post-processor.

PROGRAM INPUTS: Program inputs consist of data for load factors, inertial loads, non-linear prestress, cluster definitions, material properties, shell geometry and construction (including imperfections), and mesh description (including cutouts). User coded functions can be input to describe complex surface geometry, load, and temperature characteristics.

LIMITATIONS/RESTRICTIONS: STAGSC-1 is presently being made operational on CDC 6600 type operating systems. Available through COSMIC (NASA computer library).

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 74
NOS/BE Operating System

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
Report No. LMSC-D633873, July 1979

RESPONSIBLE ENGINEER: Dr. N. S. Khot
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PROGRAM TITLE: Analysis of Aerospace Structures with Membrane Elements (ANALYZE)

DESCRIPTION: A computer program which uses the displacement method of finite element analysis to analyze a metallic structure.

APPLICATION: ANALYZE is a program capable of analyzing metallic structures which can be approximated and described by finite elements.

KEY WORDS: Structural Analysis, Finite Element Analysis, Membrane Elements, Aerospace Structures

ABSTRACT: ANALYZE can be used to examine metallic structures represented by sets of finite elements. The four finite elements incorporated in the program are: a bar, a membrane triangle, a membrane quadrilateral and a shear panel. The displacement method of finite element analysis is used to analyze the structure.

ANALYZE is an in-house program and can be used on INTERCOM for problems up to 150 to 200 degrees of freedom and a comparable number of elements. This program is extremely useful in training engineers in the use of finite element programs, in the development of finite element models of large aerospace structures, and in structural analysis and optimization.

PROGRAM OUTPUT OPTIONS: Output includes: input echo, element information such as, type, number, thickness, planform area, stresses, strain energy and margin of safety, and nodal information such as number, coordinates, applied forces and resulting displacements.

PROGRAM INPUTS: Finite element idealization input data, material properties, applied loads and constraints.

LIMITATIONS/RESTRICTIONS: None. Core requirements are determined by problem size.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL-TR-78-170

RESPONSIBLE ENGINEER: Dr. V. B. Venkayya/Ms. V. Tischler
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PROGRAM TITLE: GCSNAST

DESCRIPTION: This is an interactive graphics program designed to help the structural analyst prepare a finite element model and to view the deflection and stress results of an analysis.

APPLICATION: GCSNAST can be used to reduce the time required to perform a finite element analysis. It simplifies the model generation and the analysis of the results by converting the numerical data to a visual display.

KEY WORDS: Finite Element Analysis, NASTRAN, Interactive Graphics, Structural Analysis, Mesh Generation

ABSTRACT: GCSNAST is an interactive graphics program designed to help the structural analyst prepare a finite element model and to view the deflection and stress results of an analysis. NASTRAN, SAP4, or SDB (Structural Data Base) data can be displayed, however, model creation or editing is done using the NASTRAN data form of input. This program, in conjunction with a digitizer, concept, and/or quickcon, can greatly reduce the time required to perform a structural analysis.

GCSNAST allows the user to:

- (1) View the model in any orientation. (REDRAW, VIEW)
- (2) Label grid points, elements, and properties and mark grid point locations. (LABEL)
- (3) Display constraints, loads, and bar element offsets. (DISPLAY)
- (4) Blow-up selected portions of the display. (CLIP)
- (5) Create scaled CALCOMP (or HOLOQUE) plots of the display. (CALCOMP)
- (6) Retrieve point data from the common data base. (CDB)
- (7) Digitize grid point data or cross section data. (DIGIT)
- (8) Add grid points and elements via keyboard or cursor input. (ADD)
- (9) Generate grid points. (G1GEN, G2GEN, TRANSLATE, ROTATE, PERMUTE, GSCALE, LINE, MESH)
- (10) Generate elements. (GENEL2, LINE, MESH)
- (11) Delete grid points and elements. (DELETE)
- (12) Display static deformations or normal modes. (DEFORMATION)
- (13) Display stresses from a static analysis. (STRESS)
- (14) Calculate bar/beam element cross-section properties. (XSEC)

PROGRAM OUTPUT OPTIONS: Output includes: input echo, NASTPAN input file, Calcomp plot data, display of stresses, display of static deformations or normal modes.

PROGRAM INPUTS: NASTRAN, SAP4 or SDB data, grid point locations, element definitions.

LIMITATIONS/RESTRICTIONS: The display is limited to about 1200 grid points. If the model contains more than this number, coordinate (X, Y, Z) limits must be specified so that no more than 1200 grid points fall within the limits. The number of elements that may be displayed is usually not critical. All SAP4 elements are displayed except for the PIPE elements. All continuation cards must immediately follow the parent card.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175 with execution from:
Tektronix 4014,
Tektronix 4010 or
Imlac Graphics terminals under TIS

LANGUAGES: CDC Fortran and Assembler

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
Users Manual

RESPONSIBLE ENGINEER: J. R. Johnson/2Lt. S. K. Bryan
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Autovon: 785-4893/5651

PROGRAM TITLE: Structural Analysis Via Generalized Interactive Graphics (STAGING)

DESCRIPTION: A computer based system for supporting structural analysis through interactive graphics.

APPLICATION: STAGING can be used to display or edit the input model, display the deformed structure or generate a finite element model interactively.

KEY WORDS: Interactive Graphics, Finite Element Model, Structural Analysis, Mesh Generation, Computer Aided Design, Computer Aided Analysis, Data Base

ABSTRACT: STAGING is intended to place structural analysis as much as possible at an engineer's fingertips. It helps an engineer generate and validate finite element models and evaluate the results of each finite element analysis. A key feature is the ease with which the experienced user may interface STAGING to any given finite element analysis program. This feature makes STAGING widely applicable since any model input and resultant analysis output may be displayed. STAGING also includes a large number of utility programs that make the handling of pre- and post processed information from analysis of a wide variety of finite element problems as easy and straightforward as possible.

STAGING is a modular system controlled by its own "executive monitor". The different modules, designed to help the engineer with different tasks in his finite element analysis, are:

- (1) Preprocessor module--helps the engineer generate the finite element model,
- (2) Display and Edit module--helps the engineer evaluate his model, locate errors, and make needed corrections,
- (3) Analysis interfacing provides for user implementation for interfacing any analysis program to STAGING. Includes a data conversion routine to convert the model from the STAGING Data Base format to the input data format of the selected finite element program. A data conversion routine also converts the analysis program output results to the STAGING Data Base format for interactive display and study once the analysis is finished,
- (4) Postprocessor--helps the engineer study his analysis results.

PROGRAM OUTPUT OPTIONS: Output includes: a display of any portion of the input model and its associated finite element data, nodal displacements, element stresses, deformed shapes, mode shapes, stress contour plots and x-y plots of the analysis results.

PROGRAM INPUTS: A STAGING data base must be created via a conversion routine from finite element idealization data. This data can be generated using the preprocessor module within STAGING, any other mesh generating program, a digitizer, or card input.

LIMITATIONS/RESTRICTIONS: For a given analysis program conversion routines must exist or be written in order to transfer the input data into the STAGING data base, to transfer the corrected STAGING data base into the input format of the given analysis program, and to transfer the output results into the STAGING data base.

COMPUTER SYSTEM ENVIRONMENT: CDC 6000
Cyber Computer Configurations using
Tektronix graphics terminals

LANGUAGES: CDC Fortran Extended, CDC assembler machine language

SPECIAL REQUIREMENTS: Tektronix Graphic Terminals

AVAILABLE DOCUMENTATION:

AFFDL-TR-79-3074, Vol I: Final Summary Report,
Vol II: User's Manual,
Vol III: System Manual,
Vol IV: Appendices to the "Systems Manual".

RESPONSIBLE ENGINEER: Bernard H. Groomes/Sherry Mummert
AFWAL/FIBR
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PROGRAM TITLE: MARC-STRESS

DESCRIPTION: A general purpose finite element program designed for the linear and non-linear analysis of structures in the static and dynamic regime.

APPLICATION: MARC can be used to perform a linear elastic, elastic-plastic, creep, large displacement, buckling, heat transfer and dynamic analysis.

KEY WORDS: Finite Element, Elastic, Elastic-Plastic, Creep, Buckling, Stress Analysis, Heat Transfer, Large Displacement, Non-Linear

ABSTRACT: MARC-STRESS provides elastic, elastic-plastic, creep, large displacement, buckling and heat transfer analysis capabilities. It also performs dynamic analysis by the modal of direct integration procedures. Geometry plotting is available for the elements available in the program.

MARC-STRESS can be used to perform a linear elastic analysis of two-and-three dimensional solids, shells, and beams; and applications where non-linear material and geometric effects are needed for geometric modeling. Both the linear and non-linear analysis can be carried out in both the static and dynamic regimes for stress analysis and also for heat transfer (diffusion) analysis. Mesh generators, graphics, and post-processing aid the user in the preparation of input and the interpretation of results.

The program allows the user to select from three comprehensive libraries for elements, materials and structural procedures, respectively. The element library contains over 50 elements which allow the user to describe any geometry that may be encountered. The material library contains over 35 different material models which together cover the material behavior of most engineering materials in the linear and non-linear regimes. Each structural procedure steers the program through its various modules in order to simulate a particular physical phenomena, such as temperature cycling, buckling, dynamic transient, and etc. The structural procedures library contains about 15 structural procedures. Thus MARC allows the user to combine any number of components from each of the three libraries, and in so doing puts the tools to solve almost any structural mechanics problem at the disposal of the user.

PROGRAM OUTPUT OPTIONS: Display of the mesh being used for analysis. Plane, two-dimensional or perspective, three-dimensional plots are available. The mesh may be sectioned to allow detailed views of the selected parts. Post-plotting capability provides for displaced position plots and contour plots. Echo of the user's input data, followed by the interpretation of his data with default values displayed. Distributed load per degree of freedom. Element and nodal data for each increment. Element data is provided at the centroidal point or at each integration point of each element and depends on the element type. Invariants as applicable, such as Tresca, Mises and Mean Normal intensity and principal values. State variables are given at any point where they are non-zero. Reaction forces are calculated based on integration of element stresses.

PROGRAM INPUTS: Input is made up of three distinct sections: the problem type and size description defines the elements to be used, the type of analysis, core allocation, input and other tape operations, and the type of equation solution. The detailed problem description defines the model such as geometry, material constants, boundary conditions, etc., and the initial loading. The load history definition specifies the type of analysis for the next series of load increments. Boundary conditions and tying data can be changed and new thermal and traction data can be input.

LIMITATIONS/RESTRICTIONS: The MARC STRESS program is on lease from the MARC Analysis Research Corporation. The MARC Corporation will correct all coding errors in the program and will provide all updates and improvements. MARC can only be exercised on the CDC computer at WPAFB.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

Vol I: Non Linear Finite Element Analysis Program
Vol II: Program Input.

RESPONSIBLE ENGINEER: V. Tischler
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PROGRAM TITLE: NASTRAN

DESCRIPTION: NASTRAN is a finite element computer program for structural analysis that is intended for general use.

APPLICATION: The intended range of applications of the program extends to almost every kind of structure and to almost every type of construction.

KEY WORDS: Structural Analysis, Finite Element, Static Response, Dynamic Response, Vibration, Stability, Matrix, Heat Transfer, Aeroelasticity

ABSTRACT: NASTRAN can be used for the analysis of almost every kind of structure of almost every type of construction. Structural elements are provided for the specific representation of the more common types of construction including rods, beams, shear panels, plates, and shells of revolution. More general types of construction are treated by combinations of these elements and by the use of "general" elements. Control systems, aerodynamic transfer functions, and other nonstructural features can be incorporated into the structural problem.

The range of analysis types in the program includes: static response to concentrated and distributed loads, to thermal expansion and to enforced deformation; dynamic response to transient loads, to steady-state sinusoidal loads and to random excitation; determination of real and complex eigenvalues for use in vibration analysis, dynamic stability analysis, and elastic stability analysis. The program includes a limited capability for the solution of nonlinear problems, including piecewise linear analysis of nonlinear static response and transient analysis of nonlinear dynamic response.

NASTRAN has been specifically designed to treat large problems with many degrees of freedom. The only limitations on problem size are those imposed by practical considerations of running time and by the ultimate capacity of auxiliary storage devices. The program is decidedly not a core program. Computational procedures have been selected to provide the maximum obtainable efficiency for large problems.

PROGRAM OUTPUT OPTIONS: Titling and bulk data echo; calculated response of components in the solution set for dynamics problems such as accelerations, displacements, velocities and nonlinear loads; stresses and forces as well as the calculated response of degrees of freedom used in the model such as single-point forces of constraint, applied loads, accelerations, displacements, velocities, the number of harmonics, strain energies, temperatures, pressures, multipoint forces of constraint and frequency dependent aerodynamic loads; plot output such as undeformed and deformed plots, mode shapes, x-y graphs of transient response, frequency response or static response, V-f and V-g graphs of flutter analysis, topological displays of matrices and contour plots of stress and displacement.

PROGRAM INPUTS: Input consists of the Executive Control, Substructure Control, Case Control and Bulk Data decks. The executive control deck includes cards which describe the nature and type of the solution to be performed. The substructure control deck defines the general attributes of the Automated Multi-Stage Substructuring capability. The Case Control deck includes cards that indicate selection of specific sets of data from the bulk data deck, selection of printed or punched output, definition of subcases and the definition of plots to be made. The bulk data deck contains all the details of the structural model and the conditions for the solution.

LIMITATIONS/RESTRICTIONS: NASTRAN was developed by NASA and purchased from COSMIC for use at WPAFB.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175

LANGUAGES: CDC Fortran Extended and Compass

SPECIAL REQUIREMENTS: Ncne

AVAILABLE DOCUMENTATION:

NASTRAN Theoretical Manual,
NASTRAN User's Manual,
NASTRAN Programmers Manual,
NASTRAN Demonstration Problem Manual

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PROGRAM TITLE: BANDIT - Version 8B

DESCRIPTION: BANDIT is a NASTRAN preprocessor which reads a Nastran deck and resequences the grid points to reduce the matrix bandwidth, profile or wavefront.

APPLICATION: The NASTRAN computer runs most efficiently for minimum bandwidth matrices. Matrix bandwidth is minimized by the BANDIT program. Thus BANDIT should be used as a preprocessor for all medium and large scale NASTRAN data decks.

KEY WORDS: NASTRAN Preprocessor, matrix bandwidth, matrix profile, resequencing algorithms, SEQGP cards

ABSTRACT: BANDIT is a matrix bandwidth reduction preprocessor for use with the NASA structural analysis computer program, NASTRAN. BANDIT is written in Fortran and uses either the Cuthill-McKee or Gibbs-Poole-Stodckmeyer strategy for resequencing grid points.

The NASTRAN program allows the user to include in his input data deck a set of cards referred to as SEQGP cards. These cards define a look-up table giving the correspondence between the original grid numbers used in defining the problem and a new set of numbers to be used internally for all calculations.

PROGRAM OUTPUT OPTIONS: There are two levels of BANDIT printed output: minimum printing or maximum printing. If resequencing is elected, the basic minimum output consists of a listing of the SEQGP cards generated and a user summary which contains the original and new matrix semi-bandwidth and profile, the number of grid points, elements, components and points of zero degree. Maximum output includes in addition a sorted echo of the complete NASTRAN data deck, an internal/external grid point correspondence table, three connection tables, and a set of informational messages concerning the renumbering strategy. Punched output includes the SEQGP cards or the entire Nastran data deck. Disk file (TAPE8) contains the complete Nastran deck plus the SEQGP cards.

PROGRAM INPUTS: There are two levels of BANDIT input. Maximum input consists of a standard Nastran data deck (ID card through ENDDATA card, inclusive) plus one or more BANDIT option cards. Minimum input includes BANDIT option cards, BEGIN BULK, element connection cards and the ENDDATA card.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175, IBM, UNIVAC, HONEYWELL

LANGUAGES: Fortran IV, Assembly language

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: 1) "The BANDIT Computer Program for the Reduction of Matrix Bandwidth for NASTRAN," Gordon C. Everstine, DTNSRDC REPORT 3827, AD743056, March 1972. 2) "BANDIT User's Guide," Gordon C. Everstine, DTNSRDC TM-184-77-03.

RESPONSIBLE ENGINEER: J. R. Johnson/V. A. Tischler
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PROGRAM TITLE: PLSTRM

DESCRIPTION: This program performs stress analysis computations using finite elements.

APPLICATION: Stress analysis of planar structures of isotropic and anisotropic (including laminated) materials.

KEY WORDS: Stress-strain Analysis, Finite Element

ABSTRACT: This program breaks down planar structures into elements and determines stresses and strains in the elements. The elements available are bars, triangular and quadrilateral. The development of elements is based upon the linear displacement field within the elements.

PROGRAM OUTPUT OPTIONS: Printed output of values for laminate stresses and strains.

PROGRAM INPUTS: Structure geometry and material data. (See program NEWPLOT)

LIMITATIONS/RESTRICTIONS: Limited to two dimensional planar structures.

COMPUTER SYSTEM ENVIRONMENT: CDC 6600

LANGUAGES: Fortran IV

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: None

RESPONSIBLE ENGINEER: R. S. Sandhu
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PROGRAM TITLE: NEWPLOT

DESCRIPTION: This is a program to plot finite element data and check inputs for PLSTRM.

APPLICATION: The program is used to verify inputs before submitting an expensive PLSTRM run.

KEY WORDS: Plotting, Finite Element

ABSTRACT: This program will read an input deck for PLSTRM. During the input phase data will be checked for consistency and against program requirements. The program also has the capability to read displacements produced by PLSTRM and to produce a plot of the deformed model. The plot produced will fill the screen with or without Y axis distortion (user option). The plot generated can be nodal points or elements with or without numbering. The user can select, with cross-hairs, an area to be magnified.

PROGRAM OUTPUT OPTIONS: Plots of deformed or undeformed model.

PROGRAM INPUTS: Input deck for PLSTRM.

LIMITATIONS/RESTRICTIONS: Maximum nodes = 400
Maximum elements = 1050

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175

LANGUAGES: Fortran IV

SPECIAL REQUIREMENTS: Textronix 4014 Graphics Terminal.

AVAILABLE DOCUMENTATION: None

RESPONSIBLE ENGINEER: Dale E. Nelson
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PROGRAM TITLE: SQ-5

DESCRIPTION: This is a program to perform point stress analysis of composites.

APPLICATION: Laminate design.

KEY WORDS: Design, Stress, Composites, Laminate Design

ABSTRACT: This program computes the laminate constituent properties. The stresses, strains, and margins of safety are computed from the applied loading. Versions are available for CDC Fortran IV and Hewlett-Packard 9830 basic.

PROGRAM OUTPUT OPTIONS: Laminate data, stresses, margins of safety, thermal analysis, strains.

PROGRAM INPUTS: Material properties, stacking sequence, loads.

LIMITATIONS/RESTRICTIONS: Only applies to inplane loads.

COMPUTER SYSTEM ENVIRONMENT: CDC 6600 or HP 9830

LANGUAGES: Fortran IV Version
Basic Version

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: Users Manual

RESPONSIBLE ENGINEER: Dale E. Nelson
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PROGRAM TITLE: Vibration Control for Airborne Optical Systems

DESCRIPTION: This is a series of computer programs to analyze and control the structural dynamics of airborne optical systems.

APPLICATION: The programs apply to various kinds of airborne electro-optical systems, from high-power lasers and large optical benches to pod-mounted cameras and target designators. The programs will analyze the structural dynamics of the optical system and define an active feedback control system for vibration isolation.

KEY WORDS: Vibration, Active Isolation, Control Systems, Laser, Gimbal, Optical Systems, Isolators.

ABSTRACT: Current developments in airborne optical systems have produced pointing and tracking systems with very stringent requirements for pointing accuracy. This implies that these systems must be effectively isolated from the aircraft vibration. In the past, passive isolators consisting of damped springs have been used; now, however, there is a need for active feedback control systems to control low-frequency, high-amplitude vibration. These programs resulted from a contracted effort to analyze the dynamics of airborne optical systems, to develop guidelines for the selection of vibration control systems, and to design the optimum parameters for such control systems using linear-quadratic-gaussian control analysis. The computer programs apply to hard-mounted systems as well as passive and active isolation. Control loops having the correct gain, compensation networks and bandwidth can be developed for each configuration.

PROGRAM OUTPUT OPTIONS: Line printer outputs of system parameters and plots of frequency response of controlled systems.

PROGRAM INPUTS: The inputs are the physical parameters of the system to be controlled.

LIMITATIONS/RESTRICTIONS: The system matrix is limited to 68 x 68. The system can handle up to 30 modes of vibration and 20 actuator inputs.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: CDC FORTRAN Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

AFFDL-TR-76-145 Vol I: Vibration Control for Airborne
Optical Systems
Vol II: User's Manual for Vibration Control
Computer Programs

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PROGRAM TITLE: Materially and Geometrically Nonlinear Analysis
(MAGNA)

DESCRIPTION: A finite element computer program for the nonlinear, static and dynamic analysis of complex, three-dimensional structures.

APPLICATIONS: MAGNA is especially well-suited for the transient dynamic analysis of aircraft windshield and canopy structural systems subjected to bird impact loads. It may, of course, be used for the nonlinear analysis of any structure subjected to static or transient loads.

KEY WORDS: Finite Element, Computer Program, Large Displacements, Finite Strains, Finite Rotations, Elastic-Plastic, Static, Dynamic, Bird Impact, Aircraft, Windshields, Canopy, Transparencies

ABSTRACT: MAGNA is a large-scale computer program for the static and dynamic analysis of complex, three-dimensional engineering structures. The program is based on the finite element method of analysis to permit the simulation of practical structures composed of many different types of elements. MAGNA combines effective isoparametric modelling techniques with state-of-the-art numerical analysis and programming methods to provide accurate and efficient solutions for large problems involving highly nonlinear response.

In contrast to most existing nonlinear finite element systems, MAGNA is oriented primarily toward the nonlinear analysis of three-dimensional structures including solids, shells, and laminated constructions. The program operates largely out of core to remove most restrictions on the number of elements, number of degrees of freedom, and model topology. Problems involving bars, membranes, thin plates, shells and solids experiencing large displacements, finite strains, finite rotations, and elastic-plastic deformations may be solved using MAGNA.

PROGRAM OUTPUT OPTIONS: Plotting utilities for postprocessing are available with MAGNA. Scaled and exploded views or close-up plots of the deformed structural model can be generated with the undeformed geometry optionally superimposed. Stress and strain contour plots and stress relief plots are also available.

PROGRAM INPUTS: A powerful preprocessor is available with MAGNA. It permits the generation of element nodal coordinate data and element connectivity data for finite element models of structures. The preprocessor can be executed from any one of a variety of initial geometrical descriptions of the structure including: mathematical equations, lofting data, parametric bicubic patch data, numerical data, or previous finite element models.

LIMITATIONS/RESTRICTIONS: MAGNA is restricted to use only by Federal Government personnel and Federal Government contractors for conducting work only in performance of Federal Government contracts. Use of MAGNA is permitted only on the ASD CYBER 74 and 175 computers at Wright-Patterson Air Force Base.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: Calcomp Plotter or Tektronix Hard Copy Unit, Tektronix Terminal

AVAILABLE DOCUMENTATION:
UDR-TR-79-45, MAGNA: A Finite Element Program for the
Materially and Geometrically Nonlinear
Analysis of Three-Dimensional Structures
Subjected to Static and Transient Loads

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PROGRAM TITLE: IMPACT

DESCRIPTION: Linear, finite element, computer program for calculation of transient dynamic response of aircraft structures subjected to impact loading.

APPLICATION: IMPACT has been especially designed for the purpose of calculating the transient dynamic response of aircraft windshield and canopy systems, composed of laminated transparencies and support structures, to bird impact.

KEY WORDS: Aircraft, Bird Impact, Canopy, Dynamic, Linear, Finite Element, Laminate, Modal Analysis, Transient, Transparency, Windshield

ABSTRACT: In the past, design verification of an aircraft windshield or canopy system subjected to bird impact has been accomplished primarily by test. A reliable analytical tool was needed to support the design process, and to reduce the amount of testing required for substantiation. In particular, a math model was required to simulate the response of a windshield or canopy structural system to bird impact, including displacements, internal stresses, and strains. A finite element computer program was judged to be a satisfactory solution.

IMPACT was developed to fill this requirement; it was designed as a complete package for aircraft transparency bird-strike analysis. IMPACT can fully accommodate three-dimensional problems, calculate the transient dynamic response of the structure involved, and accept any temporal and spatial distribution of forces and pressures applied to the structure of interest.

PROGRAM OUTPUT OPTIONS: Printed Listings only.

PROGRAM INPUTS: A preprocessor is available for use with IMPACT. It requires as input the coordinates of finite element nodes on the outer surface of the structure being analyzed. The preprocessor uses this data and some additional input parameters to generate the coordinates of interior nodes and the connectivity of elements. This feature is especially helpful in modelling laminated transparency structures.

LIMITATIONS/RESTRICTIONS: No limitations exist on the use of IMPACT. The primary obstacle to its use is the requirement to develop nodal coordinate data for the outer surface of the structure of interest by means other than IMPACT itself.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: CDC Fortran Extended.

SPECIAL REQUIREMENTS: Scratch tapes for temporary storage of voluminous data between execution of various modules of IMPACT.

AVAILABLE DOCUMENTATION:

AFFDL-TR-77-99, Aircraft Windshield Bird Impact Math
Model, Part 1: Theory and Application
AFFDL-TR-77-99, Aircraft Windshield Bird Impact Math
Model, Part 2: User's Manual
AFFDL-TR-77-99, Aircraft Windshield Bird Impact Math
Model, Part 3: Programming Model
AFFDL-TR-79-3103, Evaluation of the IMPACT Computer
Program as a Linear Design Tool for Bird-
Resistant Aircraft Transparencies

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PROGRAM TITLE: Flutter of Aircraft Carrying External Stores (FACES)

DESCRIPTION: This program provides a rapid analytical approach for flutter clearance of aircraft carrying a variety of external stores.

APPLICATION: The program can be used to obtain vibration and flutter characteristics for aircraft carrying a variety of external stores.

KEY WORDS: Flutter, Wing/Store, Pylon, Aeroelasticity, Vibration

ABSTRACT: The FACES program uses a finite section vibration model for a complete aircraft with external stores carried on from one to five pylons per side, with either single or multiple stores on each pylon. The wing can have up to fourteen sections with one or two control surfaces per semispan. Up to 24 fuselage sections can be included. Four types of empennage, conventional, T-Tail, H-Tail and twin verticals, are available. Each vertical and each horizontal tail can include up to 14 sections and each surface may contain up to two control surfaces.

Modified strip theory, doublet-lattice and piston theory aerodynamic modules are available. Externally obtained aerodynamics can also be used or added.

An interface program has been developed which allows the use of the NASTRAN finite element program to calculate vibration characteristics. The output from NASTRAN is fully coupled to all FACES aerodynamics and flutter solutions.

PROGRAM OUTPUT OPTIONS: Printed output consisting of vibration, aerodynamic and flutter characteristics.

PROGRAM INPUTS: Basic data such as geometry, mass, and stiffness. Optional inputs are calculated vibration data and/or aerodynamic data.

LIMITATIONS/RESTRICTIONS: The maximum number of degrees of freedom for the flexible wing with rigid aircraft free body motion is 88.

COMPUTER SYSTEM ENVIRONMENT: CDC

LANGUAGES: Fortran

AVAILABLE DOCUMENTATION:

AFFDL-TR-78-199, Vol I: Improved Aircraft External Store Flutter, Theory and Application,
Vol II: Improved Aircraft External Store Flutter, User's Manual for FACES Computer Program,
Vol III: Improved Aircraft External Store Flutter, Programmer's Manual for FACES Computer Program, May 1979

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PROGRAM TITLE: Fortran Matrix Abstraction Technique (FORMAT)

DESCRIPTION: This is a three phase system of computer programs consisting of a matrix generator that forms the matrices required to model complex structures, the basic matrix algebra capability for structural analysis by the force or displacement method, and a special output program that provides printed and graphical results.

APPLICATION: The program will analyze general aircraft structures by the matrix force, displacement, or combined method. FORMAT provides for the solution of internal stresses and deflections of a structure due to thermomechanical loading, the investigation of the elastic stability characteristics of a structure, and the investigation of the undamped vibration characteristics of the structure.

KEY WORDS: Matrices, matrix algebra, structural analysis, force and displacement method, finite element method, stresses, deflections

ABSTRACT: FORMAT is a digital computer program system consisting of three distinct programs written entirely in Fortran IV. The system provides for generation, manipulating, printing, and plotting of large order (i.e., 2000) matrices commonly used in state-of-the-art structural analyses. Phase I of the system automatically generates matrices required in the thermomechanical analyses. Modules for converting continuous-to-discrete loads, and analytic-to-discrete loads, and analytic-to-discrete geometry and for maintenance of a master case data file are also provided to minimize input data requirements. Phase II provides an abstraction capability to effect basic matrix algebra via the standard matrix operations (e.g., add, multiply, etc.), several pseudo-matrix operations (e.g., adjoin, diagonalize, etc.), and several control operations (e.g., save and print matrices, etc.). The sequence of operations is user designated. Phase III provides for self-explanatory report form printing of matrix data resulting from Force or Displacement Method analyses, and a nominal graphical display capability for matrix and geometry data.

PROGRAM OUTPUT OPTIONS: Stresses, deflections and reactions are output in printed format. Graphical displays or loads and deflections can be obtained via a Stromberg-Carlson 4020 graphical display device.

PROGRAM INPUTS: Input can be on cards or input tape or created by a user-coded subroutine.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: The program is written in Fortran IV for universality. It has been used on IBM 7094, IBM 7094/7044 DCS, GE635, and CDC 6600 with minimal implementation.

LANGUAGES: Fortran IV

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

AFFDL-TR-66-207, Volume V:	Engineering User and Technical Report
VI:	Programming Documentation for Phase I - Matrix
VII:	Programming Documentation for Phase II - Generation
VIII:	Programming Documentation for Phase III - Special Output

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SECTION III
VEHICLE EQUIPMENT

PROGRAM TITLE: Environmental Control Analysis System (EASY)

DESCRIPTION: This program consists of two main program segments, a number of subroutines, and a file maintenance program. The first segment generates a model of a user defined environmental control system (ECS), and the second performs analyses on the system model.

APPLICATION: The EASY computer program provides the engineer with a flexible tool for simulating and analyzing the dynamics of arbitrarily complex environmental control systems. The program, which produces both printed and (optionally) graphic results from its analyses, assists the engineer in developing optimum environmental control systems.

KEY WORDS: Model Generation Program, Analysis Program, Steady State Analysis, Dynamic Analysis, Linear Analysis, Nonlinear Analysis

ABSTRACT: The Environmental Control Analysis System computer program is a real time simulation which generates and analyzes the performance of user defined environmental control systems. The program constructs its models from a library of standard component models with the user option of supplying his own component subroutines where desired. Model generation is a precompiler program that converts user description instructions into FORTRAN subroutines which represent the model.

After generating the system model, EASY provides the user with a line printer schematic of the system and a listing of the inputs required for the analysis program. Once these inputs are supplied, the EASY program performs the system analyses.

The system analyses include: nonlinear simulation, steady state analysis, linear model generation from the original nonlinear model, eigenvalue calculation, root locus analysis, transfer function calculation, and several other dynamic analysis techniques. In addition, the program can design and analyze the performance of optimal regulation type controllers for environmental control systems.

PROGRAM OUTPUT OPTIONS: Calcomp plots of analyses results.

PROGRAM INPUTS: Data for the EASY program consists of descriptions of the environmental control system desired and the analysis data requirements produced by the model generation program. The types and format of input data for this program are listed in the user's guide.

LIMITATIONS/RESTRICTIONS: The user employ at least one of the standard library components in his model description.

COMPUTER SYSTEM ENVIRONMENT: CDC Cyber 74
NOS/BE OP SYS

LANGUAGES: FORTRAN IV

SPECIAL REQUIREMENTS: Calcomp Plotter

AVAILABLE DOCUMENTATION:

AFFDL-TR-77-102, Vol I: Component Mathematical Models
Vol II: Component Transient Computer Program
Vol III/Part 1: User's Guide
Vol III/Part 2: Program Listing
Vol IV: Optimal Control and Design Synthesis

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PROGRAM TITLE: Program ROVAK2 (ROVAK 2)

DESCRIPTION: Program ROVAK2 is a digital computer program which provides design point sizing and performance analyses of rotary vane air cycle machines (ACMs).

APPLICATION: This program operates in a batch environment to provide the user with simultaneous solution of air cycle thermodynamics, ACM kinematics, leakage, friction, and heat transfer equations. ROVAK2 is primarily designed to allow the engineer to investigate and optimize the design and performance of ROVAC rotary vane ACMs for use in environmental control systems (ECS).

KEY WORDS: ROVAC Corporation, Program ROVAK, Program ROVAK2, Design Point Sizing, Performance Analysis, Air Cycle Machine (ACM), Rotary Vane, Environmental Control System (ECS)

ABSTRACT: The ROVAK2 program is a modified and updated version of Program ROVAK, which was designed to provide analysis for an investigation of the use of rotary vane air cycle coolers for small remotely located aircraft heat loads. Further studies of the possible uses of positive displacement ACMs indicated that a moderate sized machine might provide more effective thermal management of fighter aircraft while using less engine bleed air than currently available heating and cooling machinery.

As a result of the studies, ROVAK2 was developed to perform the extensive optimization studies necessary to determine a candidate ROVAC ACM design to fabricate and test for eventual employment in fighter aircraft ECS.

Program ROVAK2 provides the engineer with dynamic analyses of ROVAC ACMs. It produces detailed and accurate computations on air cycle thermodynamics, sizing of the ACM to satisfy the airflow requirements, kinematic analysis of vanes and associated rollers, porting flow losses, heat transfer effects, leakage losses, and moisture effects.

PROGRAM OUTPUT OPTIONS: ACM size and performance data as specified.

PROGRAM INPUTS: ROVAK2 requires the input values for a specified set of variables. The format for input data is found in the technical report.

LIMITATIONS/RESTRICTIONS: A numerical value must be given for each input parameter even if the parameter is not required in the computations to be carried out.

COMPUTER SYSTEM ENVIRONMENT: CDC Cyber 74
NOS/BE OP SYS

LANGUAGES: FORTRAN IV Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

AFFDL-TR-77-6, Advanced Rotary-Vaned Air Cycle Machine for
Military Aircraft ECS.

RESPONSIBLE ENGINEER: Stephen Flores
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PROGRAM TITLE: Generalized Refrigerant Properties (GRP)

DESCRIPTION: GRP is an integrated system of computer subprograms designed to provide the user with thermodynamic and transport property data for refrigerants.

APPLICATION: The program was designed as an augmentation tool for engineering analysis programs, GRP operates in a batch environment to provide refrigerant properties data for further computations in a calling program.

KEY WORDS: Refrigerants, Subprograms, Thermodynamic Properties, Transport Properties, Integrated System

ABSTRACT: The Generalized Refrigerant Properties system of subprograms allows the user to compute properties such as: pressure, temperature, specific volume, enthalpy, entropy, heat capacity, compressibility, acoustic velocity, dynamic viscosity, and thermal conductivity for most refrigerants. For engineering analysis programs requiring refrigerant properties as input for computations, the GRP subprograms eliminate the need for user input of table or table interpolated values of the required properties.

The system allows equation of state computations for densities up to several times the critical density, vapor pressure and saturated liquid density computations over the range between freezing and the critical point, and heat capacity computations from freezing to thermal breakdown temperature. The solution of equations is by the Newton-Raphson iteration method or an adaptation of it for properties which have no existing directly solvable equations.

Because of the generalized nature of this system of subprograms, the properties for any refrigerant, existing or future, can be computed without changing the user program.

PROGRAM OUTPUT OPTIONS: Any or all refrigerant properties discussed in the abstract may be specified.

PROGRAM INPUTS: GRP is a "called" system of subprograms in which each individual subprogram requires a specified set of calling arguments to be passed from the main program.

LIMITATIONS/RESTRICTIONS: This system of subprograms currently functions only in a supporting role for calling engineering analysis programs. The arguments passed by the calling program must be of the type and within the domain required for computation in the called subprogram.

COMPUTER SYSTEM ENVIRONMENT: CDC Cyber 74
NOS/BE Operating System

LANGUAGES: CDC FORTRAN Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

York Division, Borg-Warner Corporation, Generalized
Refrigerant Property Subsystem, March 1968, Revision #6,
April 1978, York, Pennsylvania 17405.

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PROGRAM TITLE: Thermal Analyzer for General Heat Transfer Problems

DESCRIPTION: This program provides analyses of thermal systems with ability to run consecutively with previously computed results.

APPLICATION: Thermal Analyzer operates in a batch environment and permits "the direct solution of complex transient problems involving conduction, convection, radiation, and heat storage." Also, by specifying a quantity as an arbitrary function of another, it is possible to solve problems involving change of state, variable thermodynamic properties, arbitrary variable boundary conditions, and other nonlinear effects.

KEY WORDS: Thermal Analyzer, Thermal Resistance-Capacitance Analogy, Time-Temperature Plots, Network Design

ABSTRACT: The Thermal Analyzer for General Heat Transfer Problems computer program was developed in response to a need for accurate transient heat transfer analyses of complex thermal systems employed by conventional and high speed aircraft. Engineers require analyses of these systems in order to predict transient structural temperature distributions and component and environmental temperatures. Thermal Analyzer provides rapid, accurate, and detailed analyses of arbitrarily complex thermal systems beyond the scope of ordinary hand calculations.

The approach taken to providing analyses of thermal systems involves converting the system to an analogous electrical resistance-capacitance network. Once this is accomplished, the thermal system, now described in terms of lumped thermal capacities connected by thermal resistors, can be solved for temperature history using the lumped parameters, or finite differences, approach.

Incorporated in the design of this program is the "ability to accept various subroutines, or functions, as required by the particular problem." Because of this, the user may add his own subroutines without altering the basic program in order to meet problem requirements.

PROGRAM OUTPUT OPTIONS: This program allows the user to prescribe his own format for printing results. In addition, the program can produce a plot tape for machine plotting of the time-temperature history.

PROGRAM INPUTS: Thermal Analyzer requires that the thermal system be input in terms of time, temperature, and a thermal network analogous to an electrical network. Input is on the medium of punched cards.

LIMITATIONS/RESTRICTIONS: The problem description for each case is divided into five distinct blocks and two subroutines. The user's manual provides sequence and format information for input cards.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 74

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: Plotting Library, Plot Tape, and Calcomp Plotter if plot option is exercised.

AVAILABLE DOCUMENTATION:

National Aeronautics and Space Administration Documentation
Manual #LR16902

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PROGRAM TITLE: Advanced Environmental Control System (AECS)

DESCRIPTION: A computer program consisting of two main segments. The first analyzes ECS performance and the second provides sizing data for the individual ECS components.

APPLICATION: This program operates in a batch environment and provides steady state performance analysis and sequential component sizing of a user defined ECS. In addition, the user has the option of receiving relative aircraft penalties output from the sizing segment.

KEY WORDS: Environmental Control System (ECS), Performance Analysis, Steady State, Component Sizing, Aircraft Penalties

ABSTRACT: With the employment of increasing quantities of avionics equipment in Air Force weapons systems, new and greater demands are being made on the system ECS. The need for environmental control systems which can support sensitive avionics equipment, in addition to regular system support, and which impose the least possible weight and performance penalties, has lead to the development of the Advanced Environmental Control System computer program.

The AECS program provides performance analysis on all or a portion of weapons system ECS, the components of which are defined by the user. The flow system analysis is accomplished by the simultaneous solution of a set of nonlinear equations, using a generalized Newton-Raphson iteration method. While the program has no optimization capability, it provides the engineer with the steady state performance, component sizing, and penalty data needed to determine an optimum from existing and proposed ECS configurations.

PROGRAM OUTPUT OPTIONS: Component sizing and relative aircraft penalties.

PROGRAM INPUTS: The user must supply the program with the configuration of the system or portion of the system to be analyzed. Also, the user must input values, either rough or refined, for a set of key variables called "state variables".

LIMITATIONS/RESTRICTIONS: Only components defined within the source program can be analyzed. In addition, each fixed output parameter must be paired with a floating input parameter.

COMPUTER SYSTEM ENVIRONMENT: CDC Cyber 74
NOS/BE OP SYS

LANGUAGES: FORTRAN IV

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

AFFDL-TR-72-9, Vol I: ECS Design,
Vol II: ECS Computer Program,
Vol III: ECS User's Manual,
AFFDL-TR-76-77, AECS Computer Program User's Manual

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PROGRAM TITLE: Advanced Brake Control System Dynamic Analysis Program

DESCRIPTION: The ABC/EASY Program consists of two subprograms, model generation and model analysis, which allow a wide variety of dynamic ground handling systems to be modeled for the F-4E aircraft and analyzed in steady state or dynamic conditions.

APPLICATION: ABC/EASY is an analytical tool to evaluate the dynamic performance of advanced brake control system concepts. These concepts attempt to integrate the control functions of rudder, nose wheel steering and differential braking to reduce pilot load and increase ground control without affecting braking performance during adverse weather landing rollouts.

KEY WORDS: Adverse weather ground control systems, advanced brake control system, stability and control analysis, mathematical models, aircraft dynamics modeling, dynamic analysis, EASY, transfer function analysis, equations of motion solutions.

ABSTRACT: An essential tool for the development of a successful Advanced Brake Control (ABC) system is a general purpose computer program for dynamic simulation and analysis. To provide this capability, an ABC component library for the EASY Model Generation and analysis computer program was created. The ABC library contains components for F-4E aircraft modeling, rigid body six degree of freedom dynamics, tire and strut kinematics, engine thrust, lateral aerodynamic model, longitudinal aero model, rudder control, single stage oleo, dual stage oleo, strut dynamics, nose gear steering, tire/wheel dynamics-ground forces, anti-skid control system, brake characteristics, hydraulic system dynamics, wind model, terrain model and an automated control system.

The modeling of most systems can be accomplished by describing the system in terms of standard components. The models of these standard components have been constructed in a general fashion so that with the proper choice of input parameters and tables, a wide range of specific components can be modeled by each standard component. If a particular system cannot be described using the standard components, Fortran statements can be included in the model description to describe it. Given a description of the system model, the EASY model generation program generates Fortran subroutines which represent that model in program form.

This computerized model can then be analyzed by any of the non-linear, linear, dynamic or steady state techniques available in the EASY analysis program. The analyses include: non-linear simulation steady state analysis, linear model generation from the original

nonlinear model, eigenvalue calculation, root locus analysis, transfer function calculation, and several other dynamic analysis techniques. In addition to these analyses, optimal controllers of the optimal linear regulator type can also be designed by the analysis program.

PROGRAM OUTPUT OPTIONS: Calcomp plots on-line; printouts of time history data and analysis; and on line printer plots

PROGRAM INPUTS: Input data for model generation and/or analysis must include the operating points for each component. Data is entered through tape, disk or cards. The main program files are available in either source or binary from tape or disk.

LIMITATIONS/RESTRICTIONS: The ABC/EASY program will be available at WPAFB during September 1980 upon completion of the current contract.

COMPUTER SYSTEM ENVIRONMENT: C C CYBER 175
NOS/BE Operating System

LANGUAGES: CDC FORTRAN Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: ABC/EASY documentation will be available in September 1980; AFFDL-TR-77-102, Environmental Control System Transient Analysis, Dynamic Analysis Program to Aircraft Environmental Control Systems - Reference Guide, October 1977.

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PROGRAM TITLE: Two Dimensional Transient Disc Brake Temperature Prediction (I1D)

DESCRIPTION: This program solves the transient two-dimensional finite difference equations resulting from applying the first law of thermodynamics to disc brakes.

APPLICATION: The program will predict temperatures with respect to time within each rotor and stator and within hardware adjacent to the rotors and stators. The tire, rim, housing, torque tube and tire contained air temperatures are available.

KEY WORDS: Brakes, Landing Gear, Finite Difference, Thermal Analysis

ABSTRACT: The program predicts the temperatures in disc brakes. The number of rotors in the brake is a variable. The non-linear equations resulting from the application of the first law of thermodynamics are solved using the finite difference numerical technique. The Euler Time Matching technique is employed.

The program has the capability of analyzing materials of variable thermal conductivity as a function of direction as well as of temperature. Heat capacity is also variable with temperature. The work input at the rotor-stator interface is a function of both radius and time. The boundary conditions include the use of an experimentally determined (or approximated) radiative-convective heat transfer coefficient.

Brakes that contain wear pads at the rotor-stator interface can also be analyzed. The capability exists within the program to include a mass representing the wear pads and to allow a contact resistance between the pads and the remaining portion of the rotor or stator.

The program has been correlated with experimental results. The program development and experimental correlation are contained in AFFDL-TR-79-3112.

PROGRAM OUTPUT OPTIONS: Output is digital and can be user changed simply by changing the appropriate print card.

PROGRAM INPUTS: Program inputs are controlled through individual cards within the program. Inputs include: initial temperatures, thermal properties, brake torque, stop time, brake geometry, material properties, ambient temperature and heat transfer coefficients.

LIMITATIONS/RESTRICTIONS: The program is currently configured without read cards for data input. Data is input by changing specific cards or statements within the program itself. No plotting subroutine is employed.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL-TR-79-3112, Transient Thermal Effects in Disc Brakes

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PROGRAM TITLE: Air Cushion Landing Systems Dynamic Analysis Program (ACLS/EASY)

DESCRIPTION: The ACLS/EASY Program consists of two subprograms, a model generation subprogram and a model analysis subprogram, which allow a wide variety of dynamic systems to be modeled and analyzed for steady state or dynamic behavior.

APPLICATION: ACLS/EASY is an analytical tool to evaluate the dynamic performance of air cushion systems for application to launch and recovery of aircraft. The program can be used to determine the parameter values of an ACLS application so that the system requirements and stability can be evaluated.

KEY WORDS: Air Cushion Landing System, Stability and Control Analysis, Mathematical Models, Dynamic Analysis, Air Flow Systems, Arresting Systems, EASY, Transfer Function Analysis, Aircraft Dynamics Modeling, Equations of Motion Solutions

ABSTRACT: To provide the dynamic simulation and analysis capability essential to successful ACLS development, an ACLS component library for the EASY Model Generation and Analysis computer program was created. The ACLS library contains components for aircraft modeling, air flow systems, elastic or inelastic ACLS trunks, air bags, and arresting systems.

The modeling of most systems can be accomplished by describing the system in terms of standard components. The models of these standard components have been constructed in a general fashion so that with the proper choice of input parameters and tables, a wide range of specific components can be modeled by each standard component. If a portion of a particular system cannot be described using the standard components, FORTRAN statements can be included in the model description to describe these portions of the system. Given a description of the system model, the EASY Model Generation program generates FORTRAN subroutines which represent that model in program form.

This computerized model can then be analyzed by any of the nonlinear, linear, dynamic, or steady state techniques available in the EASY analysis program. These analyses include: nonlinear simulation, steady state analysis, linear model generation from the original nonlinear model, eigenvalue calculation, root locus analysis, transfer function calculation, and several other dynamic analysis techniques. In addition to these analyses, optimal controllers of the optimal linear regulator type can also be designed by the analysis program.

PROGRAM OUTPUT OPTIONS: Calcomp plots on-line, printouts of time history data and analysis, and on-line printer plots.

PROGRAM INPUTS: Input data for model generation and/or analysis is required to specify the operating points for each component. Data is entered through tape, disk or cards. The main program files are available in either source or binary from tape or disk.

LIMITATIONS/RESTRICTIONS: Use of the ACLS/EASY program must be by the batch mode due to large storage requirements and large core requirements (120,000 octal for typical run).

COMPUTER SYSTEM ENVIRONMENT: CDC Cyber 175
NOS/BE Operating System

LANGUAGES: CDC FORTRAN Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

- AFFDL-TR-79-3106, EASY-ACLS Dynamic Analysis, Vol I, Component Math Models, Vol II, Component Computer Programs (two parts), Vol III, Descriptions of Simulations, Sept., 1979.
- AFFDL-TR-77-102, Environmental Control Systems Transient Analysis, Vol I, Component Math Models, Vol II, Component Programs, Vol III, Part 2, Program Listings, Vol IV, Optimal Control and Design Synthesis, Oct., 1977.
- AFFDL-TR-77-103, Application of the EASY Dynamic Analysis Program to Aircraft Environmental Control Systems: Reference Guide, Oct., 1977.

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PROGRAM TITLE: Simulation of the Dynamic Tensile Characteristics of Nylon Parachute Materials.

DESCRIPTION: Various subroutines which model the uniaxial cyclic behavior of common nylon parachute materials.

APPLICATION: The subroutine models which have been developed are intended for a variety of parachute analysis applications. They have been used as part of larger analysis packages for stress, opening dynamics, and stability analysis of parachute systems.

KEY WORDS: Computer Models, Impact, Nylon, Material Properties, Subroutines.

ABSTRACT: Computer programs have contributed much to the design and analysis of deployable aerodynamic deceleration systems. Most of the major parachute analysis computer programs developed in the 1970's include in some form a mathematical model for the properties of the materials comprising the system. While difficult to accomplish, modelling the dynamic behavior of parachute materials is considered essential to a satisfactory analysis of aerodynamic deceleration systems. It is essential because the dynamics of parachute systems prove to be very sensitive to material properties, and at the same time it becomes an obstacle primarily because the behavior of parachute materials is so complex.

These subroutine models account for material plasticity, creep, and hysteresis. They predict forces and strains accurately (+ 5 percent) and are valid over broad ranges of strain rate and tensile load. Previous models are simplistic by comparison and have been, in general, unsatisfactory.

PROGRAM OUTPUT OPTIONS: This software is not intended for separate use but as part of other dynamic analysis packages. The output is tensile load data for structural members of a nylon parachute and is carried through a labelled common block.

PROGRAM INPUTS: Primary inputs to the subroutines are time, length of the structural member, axial rate of deformation of the structural member, and creep strain of the structural member. Values for these inputs are passed to the subroutines via dummy arguments in the calling statement.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175, NOS/BE Operating System.

LANGUAGES: CDC FORTRAN Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TR-78-169, Simulation of the Dynamic Tensile Characteristics of Nylon Parachute Materials.

RESPONSIBLE ENGINEER: Mr. Robert E. McCarty
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PROGRAM TITLE: Trunk Flutter Analysis (DYSYS)

DESCRIPTION: The program is a simulation of the behavior of a two-dimensional air cushion trunk in presence of air flow from the cushion.

APPLICATION: The program allows study of particular trunk shapes, geometries, materials and flows to ascertain how these parameters effect trunk flutter.

KEY WORDS: Air Cushion Landing System, Flutter, Trunks, Air Cushion Vehicles

ABSTRACT: The program is a simulation of the behavior of a two-dimensional air cushion system. The program simulates the dynamic behavior of the trunk including the air within the trunk, the air flow from the trunk, and the air within the cushion area.

The program has a modular structure such that the main program coordinates the operations of a number of subroutines, each of which perform a specific function. Four steps are: (a) data input and initialization; (b) initial condition acquisition and estimation; (c) dynamic part execution; and (d) plotting of results.

The program integration subroutine uses a fourth order Runge-Kutta scheme. Seven subroutines are used. One is the Runge-Kutta scheme code. One is for trunk shape geometry. Another is to compute state derivatives and pressure-flow-geometry. The remaining four are for plotting the results.

PROGRAM OUTPUT OPTIONS: Output includes input parameters, dynamic simulation data and time response plots. Plots are symbols without connecting lines.

PROGRAM INPUTS: Trunk shape, geometry, fan characteristics, trunk elasticity, flow areas. Three types of inputs are employed: (a) data cards for variables frequently changed; (b) statements within program such as physical constants; (c) subroutine TRUNK which can be used for a trunk shape.

LIMITATIONS/RESTRICTIONS: The program is two-dimensional and thus does not take into account end trunk sections or the hoop stress generated by addition of the third dimension.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

AFFDL-TR-79-3121, Trunk Flutter Program User's Manual
AFFDL-TR-79-3102, Analysis of Trunk Flutter in an Air
Cushion Landing System

RESPONSIBLE ENGINEER: B. J. Brookman
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PROGRAM TITLE: Optimization of Three Stage Cryogenic Refrigerators

DESCRIPTION: A computer program which permits optimization of certain classes of refrigerators by an iteration procedure. Given desired cooling loads and temperatures, size and power required can be predicted.

APPLICATION: Optimization of three stage Vuilleumier (V-M) cycle cryogenic refrigerators as used in spacecraft to cool up to three devices at three different temperatures.

KEY WORDS: Vuilleumier (V-M) Cycle, Cryogenic Refrigerators, Spacecraft, Cooling

ABSTRACT: This computer program is based on a dry lubricated cooler which was developed under contract by Hughes Aircraft Company. It can be used to optimize similar coolers. These refrigerators provide cooling for three devices at three different temperatures simultaneously while using heat as the primary input power. Since boiling liquids are not involved, a change in temperature or heat load at any point in the refrigerator will cause changes throughout the refrigerator. These changes are especially complex in three stage refrigerators.

Spacecraft systems designers need accurate, detailed information on refrigerator alternatives for their tradeoff studies because cryogenic refrigerators are a major consumer of power aboard a spacecraft. Designers need to know the effect on refrigerator size and power consumption of their solution of the cooling loads and temperatures of the three cold end stages and the effect of their selection of heat rejection fluid flow rate and temperature.

The computer program consists of a main program and four subroutines. The main program reads the desired parameters, calculates inputs for the subroutines and calls the subroutines. The subroutines calculate component temperatures, volumes and flows and check for system compatibility. The calculations are repeated until the system is within tolerance or the iteration limit is reached.

PROGRAM OUTPUT OPTIONS: Print output of summaries of calculated losses and net refrigeration available at each cold stage and refrigerator design parameters.

PROGRAM INPUTS: Cold stage temperatures for each of the three stages (DEG K), cold stage heat loads for each (WATTS), coolant flow rate (Gallons/Minute) and coolant inlet temperatures (DEG K).

LIMITATIONS/RESTRICTIONS: Inputs are limited to specified ranges and the program is intended to optimize intermediate size coolers corresponding to high capacity spacecraft coolers. Very large or very small refrigerators should be checked by a refrigerator designer. Estimates of controller power and motor power must be added to the heater power to obtain the total power consumed by the refrigerator system.

COMPUTER SYSTEM ENVIRONMENT: CDC 6600

LANGUAGES: Fortran 4

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

AFFDL-TR-76-27, "Computer Program for Optimizing Three Stage Vuilleumier Cycle Cryogenic Refrigerators", February 1976.

RESPONSIBLE ENGINEER: Ronald White
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SECTION IV
INTEGRATION AND DESIGN

PROGRAM TITLE: Optimal Design Integration of Military Flight Vehicles (ODIN/MFV)

DESCRIPTION: The system consists of an executive program which operates on a library of independent computer programs supplied by the user

APPLICATION: The system can be used for synthesis or optimization of preliminary designs or other applications where linking of more than one program is desired. The system is not currently operational at WPAFB

KEY WORDS: Design, Vehicle Design, Design Integration, Executive Program

ABSTRACT: The ODIN/MFV program provides the designer with a "building block" approach to vehicle design. The design simulation parallels that now employed in industry, however, all interdisciplinary data interchange may be performed within the computer rather than by hand outside the computer. Program operation in this mode required the use of a conventional design team approach.

The executive program is the heart of the system and controls the design synthesis and optimization by operating on the technology module library under control of a user-specified data input stream. Synthesis procedures in any simulation are established by the input data, hence any set of matching and sizing loops can be defined.

PROGRAM OUTPUT OPTIONS: Dependent on technology programs chosen

PROGRAM INPUTS: Dependent on technology programs chosen

LIMITATIONS/RESTRICTIONS: The program is very system dependent. Overhead is charged by the system every time a new program is set up for execution which runs up I/O time. The program is not currently maintained on Cyber 175.

COMPUTER SYSTEM ENVIRONMENT: Cyber 175

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TR-72-132 Optional Design Integration of Military Flight Vehicles

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PROGRAM TITLE: Vehicle Synthesis for Advanced Concepts (VSAC)

DESCRIPTION: The VSAC program is a tool in preliminary sizing studies of manned high speed interceptor aircraft and technology demonstration vehicles. Single-stage aircraft with either conventional takeoff and landing capability or airborne start, and two-stage vehicles can be sized.

APPLICATION: VSAC is intended for analysis of high speed aircraft, with emphasis on Mach 4 manned aircraft. Its program structure was designed to allow ready modification to vehicles outside this class. Replacement or modification of performance, propulsion, aerodynamics, weight, or geometry routines can tailor the program to a wide range of flight vehicles.

KEY WORDS: Synthesis, Aerodynamics, Performance, Sizing, Propulsion, Weights Analysis

ABSTRACT: VSAC has the capability for preliminary sizing of manned high speed flight vehicles for atmospheric flight missions. It is applicable to Mach 4 advanced interceptors and other similar hypersonic flight vehicles and missions. One or two stage vehicles can be sized. The sizing is accomplished primarily by the use of geometric scaling in a photographic (similarity) sense; weight scaling according to empirical equations for subsystems weights that are statistically derived; and propellant requirements obtained by the iterative use of flight performance routines.

PROGRAM OUTPUT OPTIONS: Printout consists of: (1) input data, (2) geometric data, (3) weights breakdown, (4) mission description, and (5) vehicle weights and propulsion summary.

PROGRAM INPUTS: Numerous geometric, propulsive and weight data.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC 6600/CYBER 175

LANGUAGES: Fortran IV

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL-TR-71-40

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PROGRAM TITLE: Tradeoffs for Lifting Reentry Vehicle Evaluation and Nominal Design (TREND)

DESCRIPTION: The primary objective of this program is to rapidly evaluate the influence of design perturbations of lifting reentry vehicles on pertinent performance parameters. The primary analysis and output of the program are in the form of sensitivity parameters, i.e., partial derivatives.

APPLICATION: TREND provides a method for the rapid and efficient analysis of aerodynamic tradeoffs incurred by the geometric variation of lifting reentry vehicle designs.

KEY WORDS: Aerodynamics, Reentry Vehicles, Performance Tradeoffs, Design Perturbations

ABSTRACT: The purpose of TREND is to evaluate the influence of vehicle design perturbations on vehicle performance. The influence of design perturbations may be analyzed in the form of sensitivity factors or in the form of increments.

Sensitivity factors are computed in the program from the basic equations that relate geometric variables and performance variables. In the subsonic and supersonic speed regimes, the sensitivity factor is determined by computing the basic equation in finite-difference form with respect to the specific geometric variable being considered. The finite-difference method is used because of the many plotted curves required for the subsonic and supersonic techniques which were selected. However, at hypersonic speeds the direct partial differentials of the analytical expressions for the basic quantities are available.

Sensitivity factors may be calculated and given in the output of the program in several dimensional forms: (1) unit/unit, (2) percent/unit, and (3) percent/percent. These forms may be optionally specified. The specific uses of the sensitivity factors should be considered when the dimensional-form option is selected for a given problem. The unit/unit form is directly applicable to the external determination of performance increments for given values of geometric increments. The percent/percent form is useful in assessing the relative importance of independent geometric variables. The percent/unit form is included for completeness, and may be useful in certain cases. Sensitivity factors are computed for the applicable dependent variables with respect to almost all of the independent geometric variables.

PROGRAM OUTPUT OPTIONS: Printout consists of: (1) input data, (2) sensitivity factors, (3) increments of performance parameters, and (4) absolute values.

PROGRAM INPUTS: Numerous geometrical data necessary to define a reentry vehicle.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC 6600/CYBER 175

LANGUAGES: Fortran IV

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL-TR-66-77

RESPONSIBLE ENGINEER: Duane R. Burnett
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PROGRAM TITLE: Supersonic Aircraft Design & Analysis Program

DESCRIPTION: This program includes routines for calculating skin friction, wave drag and drag due-to-lift in the supersonic flight regime.

APPLICATION: To aid in the design (advance preliminary design) and analysis of aircraft capable of supersonic flight.

KEY WORDS: Supersonic, Aircraft, Design, Analysis, Drag, Lift, Wave Drag

ABSTRACT: An integrated system of computer programs has been developed for the design and analysis of supersonic configurations. The system uses linearized theory methods for the calculation of surface pressures and supersonic area rule concepts in combination with linearized theory for calculation of aerodynamic force coefficients. The description of the design and analysis system is broken into three parts, covered in three separate documents.

- Part 1 - General Description & Theoretical Development
- Part 2 - User's Manual
- Part 3 - Computer Program Description

PROGRAM OUTPUT OPTIONS:

PROGRAM INPUTS: Fuselage description (circular or digitized), wing description, and tail descriptions.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC/CYBER

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: Large core requirements, large file approx 350 record blocks, can involve long run times depending on options.

AVAILABLE DOCUMENTATION: A Computational System for Aerodynamic Design and Analysis of Supersonic Aircraft Part 1, 2, 3, W.D. Middleton, J.L. Lundry; NASA CR-2715, 2716, & 2717.

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PROGRAM TITLE: Computer-aided Synthesis Program (CASP)

DESCRIPTION: This is a conceptual design program for sizing military and commercial aircraft.

APPLICATION: This program allows the user to rapidly determine the size and weight of an aircraft for a given mission.

KEY WORDS: Aircraft, Design, Ccnceptual

ABSTRACT: CASP is an aircraft sizing program by which a user may either determine the gross weight of a particular configuration for a given mission or determine the configuration for a given gross weight and mission. In addition, for a given configuration and gross weight, either the mission radius or time may be maximized. An additional option allows CASP to be run as a straight mission performance program with tabular aerodynamic and propulsion input.

PROGRAM OUTPUT OPTIONS: Output consists of printed values for mission, geometric, weight, center of gravity, aerodynamic and propulsion characteristics. Time histories are also available for all mission segments.

PROGRAM INPUTS: Inputs consist of aircraft geometry, weights, mission description, and propulsion data.

LIMITATIONS/RESTRICTIONS: Fighters and transports only. Accuracy is at a conceptual level.

COMPUTER SYSTEM ENVIRONMENT: CDC Cyber 175 NOS/BE operating system

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TR-74-35 Vol III User's Manual
Also unpublished updated User's Guide

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PROGRAM TITLE: Aeroelastic Tailoring and Structural Optimization (TSO)

DESCRIPTION: TSO is an interdisciplinary design program combining aerodynamic, static aeroelastic, flutter, and structural calculations to provide aeroelastic information of aeroelastically tailored lifting surfaces.

APPLICATION: TSO is used by the designer to facilitate configuration selection and the design and evaluation of alternate concepts during early stages of the design of an aircraft.

KEY WORDS: Aeroelastic Tailoring, Composites, Computer Generated Design

ABSTRACT: The potential for increasing structural efficiency through use of high-strength, high-modulus composites has been well established by technical programs sponsored through the Air Force development laboratories. The most effective use of composite materials can be achieved only if a total design is developed to couple the advantages of composite materials with aerodynamic planform and airfoil requirements to achieve the maximum benefit from both technologies. Significant performance increases can be obtained when the aerodynamic configurations include lifting surface planforms and thickness ratios beyond the practical limits of metal designs. Wing flexibility is a crucial parameter because of the impact of stiffness requirements for flutter, divergence, static deflection control and control surface effectiveness in this type design.

The directional properties of advanced composites permit the wing or tail flexibility to be tailored to yield improved static and dynamic aeroelastic characteristics. Efficient and accurate preliminary analysis and design procedures are needed to take advantage of this capability.

The Aeroelastic Tailoring and Structural Optimization Procedure (TSO), also known as the Wing Aeroelastic Synthesis Procedure, uses the direct Rayleigh-Ritz energy formulation to design and/or analyze low to moderate aspect ratio wings. By using this formulation, wings can be rapidly designed to satisfy a number of conditions. For composite or metal wing skins, TSO has nonlinear programming techniques to calculate optimum skin thickness and composite ply orientations that satisfy any of the following constraints or design objectives: deflected shape, strain margins, control effectiveness, divergence, mass, natural frequencies, or flutter.

ABSTRACT (cont'd): Procedure TSO is a computer program combining many computer programs developed early in a program to study the use of advanced composite materials. In follow-on programs, improved aerodynamic capabilities and an improved optimization routine were added to the basic program. TSO has become a computer tool useful in sorting out feasible designs early in the design stage.

PROGRAM OUTPUT OPTIONS: Tabular output of input data, ply distribution, ply thickness, stress and strain, stiffness polynomials, wing deflection, aeroelastic data, frequency and mode shape. Plotted output of ply distribution, V-g, and V- ω . Isometric plots of wing mode shapes and wing deflection due to loading.

PROGRAM INPUTS: 1. Three tape files are required: one steady aero tape, one unsteady aero tape, and one Legendre Polynomial tape; 2. a program deck containing analysis, design, output and plot specifications.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: CDC Fortran Extended - overlaid (adaptable to IBM)

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

- AFFDL-TR-73-111, Dynamic Characteristics of Advanced Filamentary Composite Structures, Volume II-Aeroelastic Synthesis Procedure Development
- AFFDL-TR-76-100, Aeroelastic Tailoring of Advanced Composite Structures for Military Aircraft, Volume III-Modifications and User's Guide for Procedure TSO

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PROGRAM TITLE: Transport/Bomber Spectrum Simulation

DESCRIPTION: Transport/Bomber Spectrum, Simulation is a batch program to create flight-by-flight Transport/Bomber Aircraft Load Histories.

APPLICATION: Transport/Bomber Spectrum Simulation is used to develop structural load histories for design and analytical purposes. The documentation is complete to exactly duplicate 116 load histories created in AFFDL-TR-78-134. A study of load history variation effects on Fatigue Crack growth under Transport/Bomber Aircraft usage.

KEY WORDS: Aircraft, Transport Aircraft, Bomber Aircraft, Power Spectral Density (PSD), Spectrum Generation, Load Spectrum Generation, Crack Growth Interaction, Over Loads, Mission Mix, Load Truncation, Stress History

ABSTRACT: The report contains, in the form of a user's manual, the listing and complete description of a computer program to generate fatigue spectrum loading sequences. The program is specifically tailored for the development of random cycle-by-cycle, flight-by-flight loading sequences typical of aircraft structures. However, its general features allow the development of any type spectrum. The random sequence of cycles and flights is produced by a random number generator. Alternate non-random flight sequences can also be generated.

PROGRAM OUTPUT OPTIONS: The output of this program is a load level sequence describing the Transport/Bomber Aircraft usage through typical maneuvers. The load-exceedances are also output.

PROGRAM INPUTS: Input data requirements, PSD "P"s and "B"s, Load Truncation Level, Mission Mix, Mission Exceedance Curves, Usage Variation Parameters.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC
CYBER 74
CDC 6600

LANGUAGES: Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL-TR-78-136, A User's Manual for a Computer Program to
Generate Fatigue Spectrum Loading Sequences.

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PROGRAM TITLE: Stress History Simulation (SPECGEN (1) and SPECGEN (2))

DESCRIPTION: Stress History Simulation is a batch program to create flight-by-flight fighter aircraft load histories.

APPLICATION: Stress History Simulation is used to develop structural load histories for design and analytical purposes. The documentation is complete to exactly duplicate 104 load histories created in AFFDL-TR-76-112, a study of load history variation effects on fatigue crack growth under fighter aircraft usage.

KEY WORDS: Aircraft, Fighter Aircraft, Power Spectral Density (PSD), Spectrum Generation, Load Spectrum Generation, Crack Growth Interaction, Over Loads, Mission Mix, Load Truncation, Stress History

ABSTRACT: Stress history simulation is a batch program to create stress histories for fighter aircraft using random Noise Theory in SPECGEN (1). A digital PSD approach is used to create a time history for a structural component with a given load exceedance curve. The Gaussian random time history is generated and searched to detect peaks and valleys. The Gaussian peak and valley history is transformed to simulate a real time history. The resulting list of peaks and valleys is filtered in order to eliminate stress excursions below an input truncation level.

SPECGEN (2) combines the output histories of SPECGEN (1) to develop mission mix, peak stress level, load or design, and other typical fighter aircraft stress history variations.

PROGRAM OUTPUT OPTIONS: The output of this program is a load level sequence describing the fighter aircraft usage through typical maneuvers. The load exceedances are also output.

PROGRAM INPUTS: Input data requirements are: PSD as a function of frequency, random seed, truncation filter level, mission mix, mission exceedance curves.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEMS ENVIRONMENT: CDC CYBER 74
CDC 6600
IBM 370

LANGUAGES: Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

AFFDL-TR-76-113, Vol I: Stress History Simulation - A User's Manual for a Computer Program to Generate Stress History Simulations
Vol II: Stress History Simulation - A User's Manual for a Computer Program to Modify Stress History Simulations

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PROGRAM TITLE: Hypersonic Aerospace Structures Program (HASP)

DESCRIPTION: This is an aircraft weights prediction program

APPLICATION: Applicable to the preliminary design weight estimation of advanced aircraft.

KEY WORDS: Aircraft weights estimation, mass properties

ABSTRACT: HASP is a generalized mass properties analysis program which is capable of estimating the weight, longitudinal balance, moments of inertia and size adequacy for longitudinally propelled aircraft as well as winged and nonwinged, lifting and nonlifting reentry vehicles. A data base including advanced vehicles such as X-15, B-70, and APOLLO is provided.

PROGRAM OUTPUT OPTIONS: The program output includes values such as component weight, center of gravity, moments of inertia, etc.

PROGRAM INPUTS: General aircraft design information and geometry. Wing area, wing span, length of body, number of engines, thrust, subsystem data, etc.

LIMITATIONS/RESTRICTIONS: The program has not been updated to include more recent aircraft such as F-15, F-16, F-18.

COMPUTER SYSTEM ENVIRONMENT: CDC 6600 NOS/BE operating system

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TR-68-129

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PROGRAM TITLE: A Computational System for Aerodynamic Design and Analysis of Supersonic Aircraft.

DESCRIPTION: A computational system based on lifting surface theory.

APPLICATION: The aerodynamic analysis and design of supersonic aircraft.

KEY WORDS: Wing design, aerodynamic analysis, wave drag, pressure distribution.

ABSTRACT: An integrated system of computer programs has been developed for the design and analysis of supersonic configurations. The system uses lifting surface theory methods for the calculation of surface pressures and supersonic area rule concepts in combination with linearized theory for calculation of aerodynamic force coefficients. Interactive graphics for plotting are available. The description of the design and analysis is broken into three parts covered in three separate documents.

PROGRAM OUTPUT OPTIONS: Printed output of wing design parameters, analysis of configuration drag-due-to-lift, skin friction drag, far-field and near-field wave drag analysis, etc. can be obtained. Plots of body configuration and numerous X-Y plots can be obtained via CRT or calcomp plotter.

PROGRAM INPUTS: Complete descriptions of fuselage, wing, and other components of airplane in (x,y,z) coordinates.

LIMITATIONS/RESTRICTIONS: The program is not capable of handling non planar components such as vertical tails when calculating drag-due-to-lift.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175, NOS/BE Operating System.

LANGUAGES: CDC FORTRAN Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: NASA CR-2715-16,-17,
Part I - General Description and
Theoretical Development
Part II - User's Manual
Part III - Computer Program Description

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PROGRAM TITLE: APAS III (Automated Predesign of Aerospace Structures)

DESCRIPTION: This program combines geometric and loading information for the automated sizing of transport type aircraft structures.

APPLICATION: The program may be used for preliminary weight optimization design and analysis of aircraft structures.

KEY WORDS: Structural design, optimization, analysis

ABSTRACT: This program will optimize and/or analyze a transport aircraft from geometrical and loading information. Fatigue and fracture criteria, as well as weight minimization, can be specified for the optimization. Sizing uses box beam theory.

PROGRAM OUTPUT OPTIONS: Optimized structural design based on input loads, structure thickness, stringer spacing, stringer height, stringer dimensions, residual strength, and structure lifespan.

PROGRAM INPUTS: A/C loads, geometrical data, construction type

LIMITATIONS/RESTRICTIONS: Can only use preprogrammed construction types.

COMPUTER SYSTEM ENVIRONMENT: CDC 6600

LANGUAGES: Fortran IV

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: Users manual AFFDL-TR-77-110 Vol. III

RESPONSIBLE ENGINEER: Dale E. Nelson
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PROGRAM TITLE: STEP-Composites (Structural Technology Evaluation Program)

DESCRIPTION: This is a program to assist in the preliminary design of composite aircraft structure.

APPLICATION: The program is used to determine the effect of design on the cost of the aircraft.

KEYWORDS: Aircraft Design, Composites, Composite Assembly Cost, Computer Aided Design

ABSTRACT: This program is used by structural preliminary design engineers to develop low cost structural layouts for detail design. The program uses pseudo isotropic composite box beam analysis. A detailed cost study utilizing the output of this analysis can be performed.

PROGRAM OUTPUT OPTIONS: Tabular data representing the optimized structural design and cost.

PROGRAM INPUTS: Aircraft geometric data, material and labor costs.

LIMITATIONS/RESTRICTIONS: Limited to composite materials. Will not work on operating systems superseding NOS/BE 1.0 PSR 434.

COMPUTER SYSTEM ENVIRONMENT: CDC 6600 with NOS/BE 1.0 PSR 434 operating system.

LANGUAGES: Fortran IV & Compass

SPECIAL REQUIREMENTS: CDC equipment with NOS/BE 1.0 PSR 434 operating system.

AVAILABLE DOCUMENTATION: Technical Manual AFFDL-TR-79-3082 Vol I, Users Manual AFFDL-TR-79-3082 Vol II (available second half CY 1980)

RESPONSIBLE ENGINEER: Dale E. Nelson
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PROGRAM TITLE: Interactive Computer Inverse Airfoil Design Procedure

DESCRIPTION: A computer program which relates the aerodynamic characteristics and geometry of a class of airfoils.

APPLICATION: This program can be used to design subcritical airfoils from given pressure distribution.

KEY WORDS: Airfoil Design, Inverse Airfoil Design, Sub-critical Airfoils, Interactive Graphics

ABSTRACT: This program is an interactive implementation of the basic Eppler inverse airfoil design program. It utilizes a Tektronix graphics terminal as the input, output, and graphic display device. The user has the option of using default input values or changing some or all of these. From the ensuing airfoil profile versus velocity distribution plots, the user can change the input parameters to alter the design or proceed to generate a boundary layer energy form factor versus running Reynold's number plot. At this point, the user can save the output generated by this design iteration and restart with new input parameters.

The user should be familiar with the basic Eppler design program, however, no previous knowledge of the operation of the computer or interactive terminal is required.

PROGRAM OUTPUT OPTIONS: Plots of airfoil profile and velocity distribution, boundary layer energy form factor versus running Reynold's number, printed output of input data, airfoil coordinates, velocity distribution, boundary layer results and lift and drag characteristics.

PROGRAM INPUTS: Data for circle plane segments, angles of attack, airfoil pressure recovery and closure parameters, Reynold's numbers, boundary layer transition criteria.

LIMITATIONS/RESTRICTIONS: Incompressible flow

COMPUTER SYSTEM ENVIRONMENT: CDC 6600
CYBER 74

LANGUAGES: Fortran

SPECIAL REQUIREMENTS: Tektronix 4014 display terminal

AVAILABLE DOCUMENTATION:
AFFDL-TM-77-14-FXM

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PROGRAM TITLE: Dynamic Data Editing and Computing (DYNADEC)

DESCRIPTION: Using engine compressor face dynamic total pressures, DYNADEC computes pressure distortion indices and determines the maximum distortion index and the compressor face total pressure pattern.

APPLICATION: The program can be used to determine maximum distortion compressor face indices for engine stability audits. It can also evaluate inlet/engine compatibility.

KEY WORDS: Aerodynamic distortion, compressor face pressure patterns

ABSTRACT: Many military aircraft have experienced an inlet-engine compatibility problems during their development or operational phase. In several instances, this has resulted in a reduction of Mach number, maneuver, or engine transient capability. The concern is one of inlet-engine compatibility as affected by total pressure distortion at the engine face.

The inlet flow has been recognized to be dynamic and becomes increasingly so at critical conditions. In general, the engine is capable of responding to pressure distortion patterns that persist on the order of 3-10 milliseconds or 1 rotor revolution. It can become a time consuming and expensive process to identify inlet distortion patterns that represent a potential problem by the conventional approach of digitizing the pressure data.

In recognition of these problems, the following requirements were established; (1) provide a full assessment of compatibility, (2) identify problem areas in the inlet data, (3) provide rapid distortion data screening, (4) have the flexibility to easily change distortion indices, and finally, (5) develop an approach which would reduce the cost and time by three orders of magnitude.

The end result has been the development of an analysis system called DYNADEC, which allows the rapid screening of large quantities of pressure distortion data to identify potential compatibility problems. Engine distortion parameters are used as the screening criteria to relate inlet flow to engine response. DYNADEC uses the unique capabilities of the hybrid computer to accomplish this task.

PROGRAM OUTPUT OPTIONS: (1) General Electric, Pratt & Whitney, Williams, R. C. distortion indices. (2) Compressor face total pressure pattern.

PROGRAM INPUTS: Analog tape with FM multiplexed dynamic total pressures.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: ASD Hydrid

LANGUAGES: None

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL TM-74-32-FXM

RESPONSIBLE ENGINEER: Mr. Dennis Sedlock
AFWAL/FIMM
Phone: (513) 255-6207
Autovon: 785-6207

PROGRAM TITLE: Computer Program for Design and/or Analysis of Two-Dimensional and Axisymmetric Inlets

DESCRIPTION: This is a program to design or analyze various inlet configurations, including 2-D, axisymmetric, or isentropic.

APPLICATION: The program predicts capture area, recovery, and drag characteristics of inlet systems.

KEY WORDS: Inlets, Inlet Design, Inlet Analysis, Inlet Performance

ABSTRACT: Advanced methods for the design and/or analysis of two-dimensional and axisymmetric inlets intended for operation in the supersonic flight regime up to about $M=5$ are presented in this report. The procedures are applicable for the design and/or analysis of the inlet external compression surface. The analysis also includes computation of inlet flow, total pressure recovery, drag, and other characteristics of the supersonic flow field.

PROGRAM OUTPUT OPTIONS: Printed values for inlet design parameters, drag coefficient, recovery, mass flow, etc. can be obtained.

PROGRAM INPUTS: Geometry, flow conditions.

LIMITATIONS/RESTRICTIONS: Supersonic flow

COMPUTER SYSTEM ENVIRONMENT: CDC 6600

LANGUAGES: Fortran

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL-TR-79-3094

RESPONSIBLE ENGINEER: D. J. Stava
AFWAL/FIMM
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Autovon: 785-6207

PROGRAM TITLE: STEP-Metallics (Structural Technology Evaluation Program)

DESCRIPTION: This is a program to assist in the preliminary design of metallic aircraft structures.

APPLICATION: The program is used to determine the effect of design on the cost of the aircraft.

KEY WORDS: Aircraft Design, Structural Analysis, Cost, Fatigue, Fracture, Computer Aided Design

ABSTRACT: This program is used by structural preliminary design engineer to develop low cost structural layouts for detail design. The program performs optimized box beam structural analysis with fatigue and fracture considerations. A detailed cost analysis can be performed to determine the effects of design changes on cost.

PROGRAM OUTPUT OPTIONS: Tabular data representing the optimized structure design and cost.

PROGRAM INPUTS: Aircraft geometric data, material and labor costs.

LIMITATIONS/RESTRICTIONS: Generally limited to transport aircraft limited to metallic structure. Does not run on operating systems superseding NOS/BEL.0 PSR 434.

COMPUTER SYSTEM ENVIRONMENT: Memory $\leq$ 60K

LANGUAGES: Fortran IV & Compass

SPECIAL REQUIREMENTS: CDC equipment with NOS/BEL.0 PSR 434 operating system.

AVAILABLE DOCUMENTATION: Technical Manual AFFDL-TR-77-110 Vol I, Users Manual AFFDL-TR-77-110 Vol II-Vol XVI

RESPONSIBLE ENGINEER: Dale E. Nelson
AFWAL/FIBS
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Autovon: 785-5864

PROGRAM TITLE: Minimum-Weight Design of Structures Subjected to Strength and Deflection Constraints (ASOP-3)

DESCRIPTION: A computer program to design a minimum weight composite and metallic structure with stress and/or deflection constraints.

APPLICATION: ASOP-3 can be used to design a minimum weight structure which is idealized with triangular and quadrilateral membrane elements, beam, shear and bar elements. The membrane elements can be metal or laminated composites.

KEY WORDS: Structural Optimization, Filamentary Composites, Stress Constraints, Finite Element Analysis, Minimum Weight Design, Deflection Constraints, Fully Stressed Design, Stability.

ABSTRACT: ASOP-3, which operates on a finite-element model of the structure, applies the approach known as fully-stressed design for the satisfaction of strength requirements. In this approach, the structural members are sized so that every member is stressed to a permissible limit, in at least one loading condition, or is at a specified minimum gage. In the case of statically determinate structures, an optimum (minimum-weight) design can be arrived at directly. However, in the case more common in aerospace structures, that of highly redundant structures, an iterative procedure is necessary, with successive resizing of the members of the structure until a fully-stressed design is achieved.

ASOP-3 uses element average stresses for resizing purposes. In the case of bars and triangular membrane elements, which are uniform-strain elements, the average stress is simply the uniform stress associated with the strain. In the case of quadrilateral membrane elements and shear panels, a heuristic procedure based on equilibrium is used to determine average stress. In beam elements, only that portion of the stress associated with axial load is an average stress; the bending stress is permitted to vary along the element and its maximum value is readily determined.

The program can accommodate laminates consisting of up to six layers, where a layer is defined as the aggregate of all laminae of a given material and fiber direction, and the fiber directions can be arbitrary. It is still necessary, however, that the strength of the laminate be "fiber-controlled". An option in the program permits the balancing of the numbers of laminae in specified pairs of layers.

In the analysis of composite structures to determine nodal deflections and internal loads, the full stiffness properties of the composite laminae, including the contribution of the matrix material, are taken into account. The internal loads are determined in this way for the whole laminate, which is then treated as a unit in the strength resizing process.

ABSTRACT (CONT.):

In ASOP-3, a deflection-constraint resizing procedure, based on an optimality criterion involving gradients to a deflection-constraint surface, is used. The program can treat laminated composites, sizing each layer independently to satisfy the deflection constraint, unless layers are to be balanced, in which case the combined effect of such layers is taken into account. The interaction between stress and deflection constraints is taken into account in a manner which permits smooth and rapid convergence to a design that satisfies both constraints with near-minimum structural weight. Furthermore, the deflection constraint can be represented as a linear combination of translational displacements, in specified degrees of freedom, at a number of given nodes. This permits the introduction of constraints on angular displacements, or on deformation shapes such as lifting-surface camber.

PROGRAM OUTPUT OPTIONS: Output includes: input echo, data subject to revision in each iteration cycle in the stress and deflection constraint modes, and data associated with the final design, including nodal deflections, member gages, weights, stresses, strains, internal loads, critical stress ratios and critical load conditions.

PROGRAM INPUTS: Finite element idealization input data, material properties, optimization data, applied loads and constraints.

LIMITATIONS/RESTRICTIONS: Program is overlaid. Program size is problem dependent.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175,
IBM 370/168

LANGUAGES: CDC Fortran Extended, Assembler for CDC Version

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL-TR-76-157

RESPONSIBLE ENGINEER: Dr. V. B. Venkayya/Ms. V. Tischler
AFWAL/FIBR
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Autovon: 785/4893/5651

PROGRAM TITLE: OPTSTAT - A Computer Program for the Optimal Design of Structures Subjected to Static Loads

DESCRIPTION: A computer program to design a minimum weight composite and metal structure with stress and/or displacement constraints.

APPLICATION: OPTSTAT can be used to design a minimum weight structure which is idealized with triangular and quadrilateral membrane elements, shear and bar elements. The membrane elements can be metal or laminated composites.

KEY WORDS: Finite Element Analysis, Optimality Criteria, Stress Constraints, Displacement Constraints, Composites, Optimization.

ABSTRACT: OPTSTAT is used for the optimization of aerospace structures modeled with membrane elements and subjected to static loads. The weight of the structure is the merit function in optimization. The constraints are on stresses, displacements and sizes of the elements. The program library consists of a bar, a membrane triangle, a membrane quadrilateral and a shear panel. The bar and shear panel can only be used with materials having isotropic or equivalent isotropic properties. The triangle and quadrilateral can be used with isotropic, orthotropic or layered composite materials.

PROGRAM OUTPUT OPTIONS: Output includes: input echo, design data, element and nodal information after the optimization is complete such as, sizes, stresses, fiber distribution for layered composite elements, strain energy and displacements at the node points.

PROGRAM INPUTS: Finite element idealization input data, optimization data, material properties, applied loads and constraints.

LIMITATIONS/RESTRICTIONS: None. Core requirements are determined by problem size.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL-TM-79-67

RESPONSIBLE ENGINEER: Dr. V. B. Venkayya/Ms. V. Tischler
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PROGRAM TITLE: A 'Magic' Compatible Large Scale Automated Minimum Weight Design Program (OPTIM II)

DESCRIPTION: A computer program based on the fully stressed-design concept to design a stress constrained problem and an optimality criterion to design a displacement constrained problem.

APPLICATION: The program can be used to design a minimum weight metal structure which is idealized for finite element analysis.

KEY WORDS: Finite Element, Metals, Optimization, Minimum Weight Design, Stress Constraints, Displacement Constraints

ABSTRACT: OPTIM II can be used to design a minimum weight metallic structure idealized with finite elements. The eight finite elements incorporated in the program are: axial bar, shear web, triangular plate, quadrilateral plate, tubular beam, axial bar with mid-point node, and triangular and quadrilateral plates with mid-point nodes. The displacement method of finite element analysis with MAGIC compatible input data is used to analyze the structure. The stress constraints are handled using the fully stressed-design method. The displacement constraints are satisfied by using a recurrence relation based on an optimality criterion for a stiffness constraint. The Von Mises reference stress criterion is used in the plate elements. For the elements subjected to predominately compressive loads, panel buckling stresses are evaluated. The elements can be linked to have the same design variable value.

PROGRAM OUTPUT OPTIONS: The design variables, stresses, and displacements corresponding to the minimum weight design are printed out. The intermediate design weights are also printed.

PROGRAM INPUTS: The finite element idealization input data in the MAGIC format is used.

LIMITATIONS/RESTRICTIONS: OPTIM II requires up to 7 scratch files for input, output and intermediate calculations. Due to dynamic storage allocation techniques, problem size is controlled by two arrays (WORK and NWORK) in the MAIN routine. Current size is 20,000 words. If there is insufficient storage space defined for a problem, the program will print a message indicating the amount of storage required for the problem and the amount of storage reserved by arrays WORK and NWORK.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

AFFDL-TR-74-97, Vol I: Engineers and Users Manual
Vol II: Programmer's Manual

RESPONSIBLE ENGINEER: Dr. Narendra S. Khot
AFWAL/FIBR
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Autovon: 785-4893/5651

PROJECT TITLE: TOTAL

DESCRIPTION: An interactive computer-aided design program for digital and continuous control system analysis and synthesis.

APPLICATION: Used for design and analysis of digital and continuous linear control systems.

KEY WORDS: Control Systems, Digital Control, Root Locus, Time Response, Frequency Response, Polynomial Factoring, Matrix Operations, Control Analysis, State Space

ABSTRACT: TOTAL is designed as a tool to be used with as much speed, agility, and confidence as one would use a familiar hand calculator. The following is an overview.

TOTAL is built around twelve general-purpose polynomials of maximum degree 50, and seven general-purpose 10×10 matrices. Eight of the polynomials may be paired to form the numerators and denominators of four general-purpose transfer functions. With just these polynomials, matrices, and transfer functions, the user is able to use the entire spectrum of TOTAL's capabilities, which include: (a) add, subtract, multiply, divide, factor, expand, and copy polynomials; (b) add, subtract, multiply, invert, transpose, obtain eigenvalues, preset, and copy matrices; (c) obtain root locus, frequency response, and time response in both continuous and digital domain of open and closed-loop transfer functions; (d) perform block diagram reduction; (e) computer transfer functions from state-space; (f) transfer between continuous and digital domains using a variety of methods. A built-in 20-memory scientific calculator with a 4-register stack is available to the user at all times. The user may quickly list, transfer, or modify any variable, at any time, anywhere in the program. Complete error detection, diagnostics, and abnormal termination protection are provided. Specific help is available at any time by simply typing a question mark.

PROGRAM OUTPUT OPTIONS: TOTAL will calculate transfer functions (if not directly provided) and will output tabular data or plots for time response, frequency response or root loci. Also printed are roots of polynomials. Listings and plots can be made on terminal, line printer, Calcomp or Tektronix hardware.

PROGRAM INPUTS: Transfer functions can be inputted as equivalent state-space equations in matrix form.

LIMITATIONS/RESTRICTIONS: Program is written in overlay form.

COMPUTER SYSTEM ENVIRONMENT: CDC 6600
CYBER 175

LANGUAGES: Fortran

SPECIAL REQUIREMENTS: Calcomp Plotter or Tektronix Graphics Terminal

AVAILABLE DOCUMENTATION:

AFIT Thesis: "An Interactive Computer-Aided Design Program for Digital and Continuous Control System Analysis and Synthesis," NTIS AD/A-055 418.
User's Manual is available from AFWAL/FIGC.

RESPONSIBLE ENGINEER: Stanley J. Larimer
AFWAL/FIGC
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Autcvon: 785-3734

PROGRAM TITLE: Optimization of Composite Structures (OPTCOMP)

DESCRIPTION: This is a two phase computer program utilized to design a minimum weight composite and metal structure with stress and local buckling constraints.

APPLICATION: The program can be used to design a minimum weight structure which is idealized with triangular and quadrilateral membrane elements, shear and bar elements. The membrane elements can be metal or laminated composites.

KEY WORDS: Finite Element Analysis, Advanced Composites, Metals, Optimization, Minimum Weight Design, Stress Constraints, Local Buckling Constraints

ABSTRACT: The computer program OPTCOMP can be used to optimize or analyze a composite or metal structure. The program uses an iterative procedure based on an optimality criterion to design a minimum weight structure. The response of the structure to the applied loads is obtained by finite element analysis. The design variables are modified during each iteration by using a recurrence relation. The four strength criteria included in the program are: maximum stress, maximum strain, Hills' criterion modified by Tsai and Norris' criterion. The membrane plate elements can be designed to prevent local buckling. The elements can be linked to have the same sizes if desired. A mixture of composite and metal structure can be designed by a suitable definition of the elastic properties. The idealized structure can also be analyzed and elements which do not satisfy a specified criterion can be determined.

PROGRAM OUTPUT OPTIONS: Print out of design and analysis data. The output gives the stresses in the elements, displacements at the node points and the minimum weight design.

PROGRAM INPUTS: OPTCOMP uses standard information required for any finite element analysis program.

LIMITATIONS/RESTRICTIONS: The program is currently dimensioned to optimize a structure defined by 120 members, 50 nodes, 2 loading conditions, and 4 layers in the composite elements. This needs 114K [octal] core. However, instruction in the comment cards gives information on necessary changes required to solve a large problem.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175 or
any system which accepts standard
Fortran language.

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL-TR-76-149

RESPONSIBLE ENGINEER: Dr. Narendra S. Khot
AFWAL/FIBR
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PROGRAM TITLE: JOINT - Interactive Composite Joint Design

DESCRIPTION: This is a collection of composite joint analysis/optimization routines that have been connected with graphics input/output routines having interactive capability.

APPLICATION: JOINT offers a computer-aided analysis capability for the non-specialist to design, analyze, and optimize different types of bolted and bonded composite structural joints.

KEY WORDS: Graphics, Composites, Tektronix, Bolted Joints, Bonded Joints, Computer Program

ABSTRACT: A computing technique was developed to determine the feasibility of combining several batch computer programs, for the numerical analysis of composite joints, into one interactive computer program. JOINT utilizes the software package provided by TEKTRONIX for the graphics display. The combining approach produced a design tool for the analysis of several classes of bolted or bonded composite joints.

Solutions of the joint problem are formulated in terms of differential equations for classical continuum mechanics. The analysis is based on numerical methods and numerical input and output. The classes of joints which can be analyzed or optimized include:

- (1) Bolted Standard Double-Lap
- (2) Bolted Unsupported Single-Lap
- (3) Bolted Supported Single-Lap
- (4) Bolted Stepped-Lap
- (5) Bonded Standard Double-Lap
- (6) Bonded Unsupported Single-Lap
- (7) Bonded Supported Single-Lap
- (8) Bonded Stepped-Lap
- (9) Bonded Scarfed

The possible modes of failure considered in the program include:

- (1) Failure in tension at bolt hole
- (2) Failure in bolt bearing
- (3) Failure in bolt shear
- (4) Failure in bolt shear tear-out
- (5) Failure of bonding adhesive due to in-place stress
- (6) Failure of bonding adhesive layer in shear
- (7) Failure of bonding adhesive due to peel stress
- (8) Failure of bonded adhered matrix due to peel stress

ABSTRACT (cont.): JOINT provides the user with menus for selecting analysis options as well as data file manipulation. Therefore, the program is easily mastered and is extremely useful to the non-specialized engineer in designing and optimizing composite joints.

PROGRAM OUTPUT OPTIONS: Output includes: input echo, design information such as joint weight, joint strength, stresses, and strains.

PROGRAM INPUTS: Design parameters such as joint load, safety factor, temperature, material, overlap, strength moduli, etc. may be input or changed from the terminal or disc files using the screen crosshairs or the graphics tablet pen.

LIMITATIONS/REQUIREMENTS: The SAVE file can store no more than 100 solutions.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175

LANGUAGE: Standard Fortran

SPECIAL REQUIREMENTS: Tektronix Terminal

AVAILABLE DOCUMENTATION:

AFFDL-TR-78-38: Part 1, Final Technical Report,
Part 2, User's Manual,
Part 3, Programming Manual.

RESPONSIBLE ENGINEER: 2Lt Philip J. Conrad/Mr. James R. Johnson
AFWAL/FIBR
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Autovon: 785-4893/5651

PROGRAM TITLE: Parachute Design and Performance Data Bank

DESCRIPTION: This is a system for storing and retrieving design and performance data for deployable aerodynamic deceleration systems.

APPLICATION: The program answers inquiries concerning parachute design and performance; provides advisory, reference and literature-searching services; analyzes data; distributes data compilations; permits on-site use. Services are provided free to Government agencies and their contractors.

KEY WORDS: Parachutes, Data Banks, Data Storage, Information Retrieval.

ABSTRACT: The program is intended to be used for the design and performance analysis of parachute systems. It is not just a bibliographic reference system but includes a wealth of design and performance data extracted from technical documents for storage. A computer program providing highly flexible and very selective retrieval of data is used to operate on the accumulated information base.

The Parachute Performance and Design Data Bank does much to relieve problems confronting the designer/analyst who needs data. It greatly reduces the necessity for laborious, haphazard data searches. The most unique aspect of the system lies in the fact that every item of information stored, whether it is of a narrative, numerical, logical, or tabular nature can be called during data recovery. Furthermore, the actual values of most of these items can be examined. While requiring considerable initial effort to establish such a comprehensive base of information, the system pays off by providing a variable depth of interrogation as well as immediately useful output in the form of quantitative performance data along with essential design and test information.

PROGRAM OUTPUT OPTIONS: Printed listings only.

PROGRAM INPUTS: Input data to the Data Bank is prepared only by AFWAL/FIER personnel following established procedures and formats. No active data storage has occurred since 1977 or is planned in the future.

LIMITATIONS/RESTRICTIONS: Although originally intended as an AFWAL/FIER function alone, data search and retrieval is possible by the individual user. Procedures for accomplishing data retrieval are discussed in detail in the reference document. Current job control language may be obtained from the responsible engineer.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175, NOS/BE Operating Systems.

LANGUAGES: CDC FORTRAN Extended.

SPECIAL REQUIREMENTS: Alphanumeric INTERCOM Terminal or punched cards for job submission.

AVAILABLE DOCUMENTATION: AFFDL-TR-74-45, Parachute Design and Performance Data Bank.

RESPONSIBLE ENGINEER: Mr. Robert E. McCarty
AFWAL/FIER
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Autovon: 785-5060

SECTION V
PERFORMANCE

PROGRAM TITLE: Take-Off and Landing Analysis Program (TOLA)

DESCRIPTION: This program provides complete simulation of aircraft horizontal take-off and landing.

APPLICATION: Aircraft dynamic motion analysis during take-off and landing (six degrees of freedom) as well as landing gear dynamic analysis.

KEY WORDS: Aircraft Take-Off, Aircraft Landing, Landing Gear Design, Loads, Dynamic Motion Analysis

ABSTRACT: The program provides a complete simulation of the aircraft takeoff and landing operation. Effects simulated in the program include: (1) aircraft control and performance during glide slope, flare, landing roll, and takeoff roll, all under conditions of changing winds, engine failures, brake failures, control system failures, strut failures, runway length and control variable limits, and time lags; (2) landing gear loads and dynamics for aircraft with up to five years; (3) multiple engine aircraft; (4) engine reversing; (5) drag chute and spoiler effects; (6) braking; (7) aerodynamic ground effect; (8) takeoff from aircraft carriers; and (9) inclined runways and runway perturbations. The program is modular so that glide slope, flare, landing, and takeoff can be studied separately or in combination.

PROGRAM OUTPUT OPTIONS: Plots and/or printed values are output for all aircraft translational and rotational motion, aircraft position in 3 dimensions, velocity, sink rate, altitude, distance, and landing gear dynamics such as gear loads, position, strut pressures, etc.

PROGRAM INPUTS: Complete aircraft 6 degrees of freedom requirements of weight, inertias, aerodynamics, thrust, etc., complete landing gear and oleo strut description.

LIMITATIONS/RESTRICTIONS: The program is complex.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175

LANGUAGES: Fortran

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

AFFDL-TR-71-155, Parts I, II, III and IV.

RESPONSIBLE ENGINEER: Charles Bursey

AFWAL/FIMG

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Autovon: 785-6578

PROGRAM TITLE: Derivative Program (DERIVP)

DESCRIPTION: This program makes corrections to PIPSI input maps to more closely represent the design being analyzed.

APPLICATION: Data editing for Propulsion System Installation Program (PIPSI) input.

KEY WORDS: Propulsion Installation, Inlet Drag, Inlet Recovery, Nozzle Drag, Afterbody Drag

ABSTRACT: This computer program allows the user to select inlet and nozzle data from a library of configurations and then to perturb these maps in a first order level of accuracy to more closely represent the design configuration being analyzed. The program then produces a new set of maps for use as input data to the PIPSI program.

PROGRAM OUTPUT OPTIONS: Provides edited data sets for use with PIPSI.

PROGRAM INPUTS: Inlet and nozzle descriptions on library files.

LIMITATIONS/RESTRICTIONS: Requires Library Files of inlet and nozzle performance maps. Used only to produce input maps for the PIPSI program.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175

LANGUAGES: Fortran

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL-TR-78-01

RESPONSIBLE ENGINEER: Gordon Tamplin
AFWAL/FIMB
Phone: (513) 255-5288

PROGRAM TITLE: Propulsion System Installation Program (PIPSI)

DESCRIPTION: This program allows rapid calculations of installed engine performance using input maps of inlet and nozzle/afterbody characteristics.

APPLICATION: Preliminary and conceptual aircraft design for analysis of propulsion system installation losses.

KEY WORDS: Propulsion Installation, Inlet Drag, Inlet Recovery, Nozzle Drag, Afterbody Drag

ABSTRACT: This program is a computerized preliminary design analysis procedure for calculating propulsion system installation losses. These losses include inlet and nozzle internal losses and external drag losses for a wide variety of subsonic and supersonic aircraft configurations up to Mach 3.5. The calculation procedures used in this program are developed from existing engineering procedures and experimental data and are suitable for preliminary studies of advanced aircraft configurations.

PROGRAM OUTPUT OPTIONS: Provides installed engine performance, inlet and nozzle drag and recovery information.

PROGRAM INPUTS: Uses library files of inlet and nozzle descriptions or modifies configurations calculated by DERIVP.

LIMITATIONS/RESTRICTIONS: Requires library files of inlet and nozzle performance maps.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175

LANGUAGES: Fortran

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL-TR-78-91

RESPONSIBLE ENGINEER: Gordon Tamplin
AFWAL/FIMB
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Autovon: 785-5288

PROGRAM TITLE: Flight Propulsion Control Coupling Simulation
(FPCCSIM)

DESCRIPTION: FPCCSIM is a digital simulation of a future fighter aircraft, represented by the full set of non-linear equations with non-linear engine models, in which maneuverability is enhanced through aero-propulsion coupling

APPLICATION: The study of the flight control implications of changing aero-propulsion coupled coefficients of the aircraft model. Non-linear control blending can be accomplished.

KEY WORDS: Flight/Propulsion Coupling, Jet Flap Controls, Vectored Thrust Control, Flight Control, Control Coupling Methodology.

ABSTRACT: This program takes the FPCC aerodynamic data and trims and linearizes the equations of motion. The output is in state equation format for the six degree-of-freedom equations of motion. The eigenvalues of the linearized equations are provided for the six degree-of-freedom case, as well as for the longitudinal axis and the lateral axis.

Two trim options are provided; the first uses the trim variables thrust, horizontal canard deflection, and angle-of-attack. This option is reached by specifying flight conditions 7 through 10. By use of this option, the aircraft can be trimmed at any specified load factor, 1 g being level flight. The second trim option is reached by specifying flight conditions 1 through 6, and uses the trim variables load factor, horizontal canard deflection, and angle-of-attack. In this option, the load factor is determined consistent with the specified thrust.

PROGRAM OUTPUT OPTIONS: (See Documentation)

PROGRAM INPUTS: (See Documentation)

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC 6600 CYBER 74

LANGUAGES: FORTRAN IV

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: Contact Lt. Steve Dron or Elisha Rachovitsky

RESPONSIBLE ENGINEER: Elisha Rachovitsky
AFWAL/FIGL
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AUTOVON: 785-3686

PROGRAM TITLE: Segmented Mission Analysis Program (NSEG)

DESCRIPTION: NSEG is used to calculate aircraft flight performance and includes 19 performance maps, such as energy maneuverability. It also includes a rapid mission analysis code.

APPLICATION: NSEG is used to evaluate the total flight performance capability of an aircraft and is also used to compare the performance of two different aircraft.

KEY WORDS: Aircraft Performance, Aircraft Missions, Performance Comparisons

ABSTRACT: NSEG was originally developed by ASD and contains some modifications by AFFDL/FING. Automatic Calcomp plots can be obtained for 19 different performance parameters. Overlay plotting for two aircraft, or the difference in performance for two different aircraft, can be obtained on one plot. A rapid and flexible mission analysis code is included. Provisions are available for 3 different fourier settings and several options are available for aerodynamics. A take-off routine is also included.

NSEG is an advanced mission analysis program for evaluating aircraft flight performance. The program models a time history of the mission for one or two aircraft. Two methods of analysis are provided: Mission Analysis and Point Performance mapping.

PROGRAM OUTPUT OPTIONS: NSEG provides information in two forms: Mission Analysis and Point Performance mapping. A time history of the mission using the end points of the flight segments is printed. 14 different maps can be generated. Also an altitude-Mach number or Mach number-load factor grid are provided. Calcomp plots are available.

PROGRAM INPUTS: Input requirements include aerodynamic, propulsion, and vehicle physical characteristics and option definitions.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: Fortran

SPECIAL REQUIREMENTS: Calcomp plotter, subroutine library

AVAILABLE DOCUMENTATION:
AFFDL-TM-FXG-79-38. NSEG-Segmented Mission Analysis Program.
AFFDL Users Manual, April 1979.

RESPONSIBLE ENGINEER: David T. Johnson
AFWAL/FIMG
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Autovon: 785-6578

PROGRAM TITLE: Combat Optimization and Analysis Program (COAP)

DESCRIPTION: Given two vehicles, the program will develop two simultaneously coupled three-dimensional point mass trajectories about a rotating oblate planet having a multilayered atmosphere.

APPLICATION: The program is applicable to the analysis of a wide range of combative or cooperative two vehicle flight paths.

KEY WORDS: Air combat analysis, two vehicle flight paths, point mass trajectories, parameter optimization, nonlinear programming.

ABSTRACT: Point mass equations of motion for a two vehicle system are defined. Motion takes place about a rotating oblate planet having up to five harmonics in its gravitational field. A non-uniform atmosphere may be simulated. The vehicles may have arbitrary and independent aerodynamic and propulsive characteristics. Combat logic is defined in terms of relative vehicle states with feedback control. Parameter optimization is available for use in the feedback control or other vehicle parameters.

The program has been improved to permit optional data input from an update file, addition of three-dimensional position time history plotting, addition of viscous parameters and the control logic to be used when an opponent goes out of sight. The fire control functions have also been expanded. These changes have been documented in AFFDL-TM-78-76-FXG.

PROGRAM OUTPUT OPTIONS: COAP provides trajectory histories for the two aircraft being modeled. Flight conditions, angles between aircraft and fire functions are given in various forms. Print tables, printer plots, Calcomp plots, Tektronix plots or three-dimensional plots of vehicle trajectories can be provided.

PROGRAM INPUTS: Vehicle characteristics, strategy information, and central options for the two aircraft (e.g., attack strategies, load factors, minimum flight altitudes, etc.).

LIMITATIONS/RESTRICTIONS: Limited to two vehicle analyses. The core requirement is large.

COMPUTER SYSTEM ENVIRONMENT: CYBER 175 NOS/BE Operating System.

LANGUAGES: CDC FORTRAN Extended

SPECIAL REQUIREMENTS: Requires tape or disc storage capability. For 3-D plots, Calcomp or Tektronix capabilities are required.

AVAILABLE DOCUMENTATION: AFFDL-TR-71-52, Vol. I, Trajectory and Combat Formulations, Vol. II, Program User's Manual, Vol. III, Programmer's Manual, Vol. IV, Parameter Optimization Subprogram Manual. AFFDL-TM-78-76-FXG (updates).

RESPONSIBLE ENGINEER: David T. Johnson
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PROGRAM TITLE: Six Degree of Freedom(6-D) Trajectory Program

DESCRIPTION: This program computes the motion of a flight vehicle in six degrees of freedom. Additional options are available for reduced degrees of freedom, including three degree of freedom (3-D) point mass.

APPLICATION: The primary use is in dynamic motion analysis using the 6-D option and in point mass trajectory analysis using the 3-D option. The program is applicable to any type of flight vehicle.

KEY WORDS: Flight Analysis, Dynamic Motion, Trajectories, Re-entry, Ascent.

ABSTRACT: The program can be used to determine vehicle performance throughout the flight regime defined by speed and altitude in the atmosphere and gravity field of a planet. The planet may be rotating or non-rotating and either spherical or oblate. The formulation includes seven options of varying degrees of refinement from 6-D problems to Two Degree of Freedom (2-D) point mass problems. Provisions are available for an autopilot, but normally a program modification is required to incorporate the specific data required for 6-D dynamic motion analysis. Several options are available for both aerodynamic and propulsion data inputs. The 3-D option has a number of provisions for angle of attack and bank angle control. Flight plan programmers (guidance) allow a specified altitude or path angle to be followed. Also, steering is provided to fly to a target specified by its geodetic location.

PROGRAM OUTPUT OPTIONS: Off-line print and optional off-line calcomp plots by means of a generated plot tape.

PROGRAM INPUTS: Required inputs are the vehicle aerodynamic, propulsion, and physical characteristics, initial conditions, control options, and output options.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175, NOS/BE operating system.

LANGUAGES: FORTRAN EXTENDED, VERSION IV

SPECIAL REQUIREMENTS: Calcomp Plotter, Subroutine Library.

AVAILABLE DOCUMENTATION:

AFFDL-TR-75-1 Six Degree of Freedom Flight Path Study
Generalized Computer Program. Users
Manual, July 1975.

RESPONSIBLE ENGINEER: Richard Nash
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PROGRAM TITLE: Extension of the Method for Predicting Six-Degree-of-Freedom Store Separation Trajectories

DESCRIPTION: A batch fortran computer program which simulates the release of external stores at speeds up to the critical speed. The program has the ability to include a fuselage with non-circular cross section.

APPLICATION: The modeling of realistic fighter/bomber configurations with external stores.

KEY WORDS: Store Separation, Flow Fields

ABSTRACT: The primary objective of this report is to describe improvements and extensions which have been made to the method of predicting six-degree-of-freedom trajectories of stores released from fighter-bomber aircraft previously published by the authors in AFFDL-TR-72-83. In the present work, the circular fuselage restriction has been removed. Methods are presented for flow modeling fuselages with non-circular cross sections including canopies and engine air inlets. The inlet to free-stream velocity ratio can be varied between zero and unity. To more accurately account for wing-fuselage interference, the wing-pylon vortex-lattice method used in the earlier work has been modified. A secondary objective is to present experimental results from a wind-tunnel test program designed to provide data to aid in developing and testing the theory. Comparisons between theory and experiment are presented for flow fields, store loading distributions, store forces and moments, and store trajectories.

PROGRAM OUTPUT OPTIONS: Tabulated six-degree-of-freedom store trajectories

PROGRAM INPUTS: Geometric information

LIMITATIONS/RESTRICTIONS: External stores must be studied at speeds less than the critical speed of the configuration in question.

COMPUTER SYSTEM ENVIRONMENT: CDC or equivalent

LANGUAGES: ANSI Standard

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TR-74-130 Volumes I and II

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SECTION VI
MISSION, VULNERABILITY, ENVIRONMENT AND COST ANALYSES

PROGRAM TITLE: Generalized Airlift Deployment Simulation (GADS)

DESCRIPTION: GADS simulates the deployment of up to 250 loadsets located in at most 1,000 different bases to one Aerial Port of Debarkation (APOD).

APPLICATION: GADS produces information such as closure time, sorties flown, average loads, for use in a deployment analysis.

KEY WORDS: Airlift, Deployment, Mobility

ABSTRACT: The RAND Corporation developed GADS as a method of deployment analysis. Input flexibility allows for complex deployment problems to be handled at various levels of detail.

GADS analyzes the movement of load sets from APOEs to APODs. An aircraft loading model (such as ALP) should be used in conjunction with GADS to provide loading information. Descriptions of the load sets and aircraft are required as input.

GADS can be used to determine the length of time required to move various combinations of military loads over different routes. Aircraft characteristics can be changed. GADS also models the use of outsized aircraft and the loading of outsized equipment.

PROGRAM OUTPUT OPTIONS: GADS provides information on closure time, average aircraft loads, time when the loadset leaves and when it arrives.

PROGRAM INPUTS: GADS requires several input files containing average aircraft loads, aircraft characteristics, distances loadsets will be flown over, ground times, and loadset tonnages.

LIMITATIONS/RESTRICTIONS: GADS is restricted to deploying up to 250 loadsets located in at most 1,000 different bases. There are at most 10 types of loads which are all sent to one unique destination. Although the model is built to simulate five aircraft types, the equations used are crude when more than a single aircraft type is involved.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
Technical Memo in press.

RESPONSIBLE ENGINEER: Lt. James Hickin
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PROGRAM TITLE: Aircraft Loading Program (ALP)

DESCRIPTION: ALP simulates the loading of military equipment into transport aircraft, giving number of sorties required as an output.

APPLICATION: ALP provides aircraft loading information for use with deployment analysis or logistics studies in determining fleet requirements.

KEY WORDS: Airlift, Mobility, Deployment Analysis

ABSTRACT: ALP was developed by Lockheed-Georgia Company as the "Two Aircraft Mix Loading Program".

The dimensions of the cargo boxes for a maximum of two aircraft serve as input into the model. Load sets, representing various military equipment types, are then fitted on board the aircraft. The model makes five attempts to optimize the loading arrangement. The model will play out-sized equipment and aircraft.

Three levels of output are provided. A detailed output provides equipment locations within the cargo box of each aircraft.

PROGRAM OUTPUT OPTIONS: Three options are available: short, intermediate, and long. Each lists equipment and troops loaded, sorties required, and average payloads. The intermediate and long contain more detailed information such as equipment loaded on each sortie.

PROGRAM INPUTS: Inputs which guide the loading logic and those that describe the equipment (dimensions, weights) and the aircraft. Run control cards are also required.

LIMITATIONS/RESTRICTIONS: 25 aircraft types and 500 unit types can be stored as input. The program will load at most 2 aircraft types with only those units specified on the run control cards. The long output requires more lines of output than the default value.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
In press.

RESPONSIBLE ENGINEER: Lt. James Hickin
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PROGRAM TITLE: Modular Life Cycle Cost Model (MLCCM)

DESCRIPTION: A methodology to predict life cycle costs for advanced aircraft during the design phase of the development program.

APPLICATION: Aircraft design studies for which cost or comparative cost predictions are required.

KEY WORDS: Life Cycle Costs, Advanced Aircraft, Design Phase

ABSTRACT: The MLCCM is a design-oriented computerized methodology for calculating life cycle costs of advanced aircraft during the conceptual and preliminary design phases of a system development program. The program uses aircraft design parameters normally available during the preliminary design process. The modular feature permits costs to be predicted for one or all phases of the life cycle (RDT&E, Production, Support) and for one or all subsystems (structure, propulsion, avionics, etc.). The program operates in either batch or interactive mode.

PROGRAM OUTPUT OPTIONS: Outputs LCC costs for desired phase/
subsystem combinations in detailed or summary form.

PROGRAM INPUTS: Aircraft design parameters in form of an external
or local file.

LIMITATIONS/RESTRICTIONS: Limited to U.S. Government agencies
only; other requests must be referred to AFFDL/FIMB, Wright-Patterson
Air Force Base, Ohio 45433.

COMPUTER SYSTEM ENVIRONMENT: CDC 6600
CYBER 175
NOS/BE Operating System

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: Seqload Loader

AVAILABLE DOCUMENTATION:
AFFDL-TR-78-40, Volume I, II and III.

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PROGRAM TITLE: Piloted Air Combat and Maneuvers (PACAM V)

DESCRIPTION: This program simulates air combats up to 2 versus 2 for fighter vs fighter, fighter versus bomber, and fighter and/or SAMs versus bomber.

APPLICATION: The program is used to determine air combat capabilities of advanced aircraft/missiles/guns/lasers.

KEY WORDS: AirCombat Simulation, PACAM V, Dog Fight, Tactics, Model, Simulation, Duel, Multi-aircraft Combat, Aircraft, SAM, AAM, Laser, Endgame Model, Air-to-Air Missiles, Air-to-Air Guns, Air-to-Air Lasers, Surface-to-Air Missiles

ABSTRACT: PACAM V is a digital air combat simulation program that can model air combats of up to 2 versus 2. It includes provisions for modeling bomber versus fighter and/or surface to air missiles and fighter versus fighter air combats. This program is used for comparative survivability analyses of advanced aircraft and considers the impact of advanced technologies, aircraft, weapons, tactics, and force ratio.

At each time pulse, the PACAM V program calculates the aero state of each active air vehicle (aircraft and missiles), relative geometries, and information states (sensor contact) between vehicles. Weapons firing opportunities are checked for each aircraft. If firing opportunities are possible and the aircraft tactics call for firing then (firings may be held until conditions will worsen), gun time is accumulated or missiles are launched and placed in the inventory of active air vehicles as appropriate. When weapons simulations are in progress, the integration step size is reduced.

Using the tactics data, each aircraft selects the vehicle to which it will respond and the appropriate maneuver. The maneuver is expressed as desired changes in heading angle dive/climb angle and velocity and is adjusted to match attainable limits. If selected, "dead" aircraft are removed from the combat after weapons scoring. Current aircraft values are output and all air vehicles "fly" their maneuver.

The process is repeated until a maximum time for the combat is reached or until one side is destroyed if kill removal is used. The combat is displayed "post run" to visualize the tactical maneuver selection. Probabilities of survival or number of aircraft killed/survived are obtained from the standard output file.

PROGRAM OUTPUT OPTIONS: Aircraft trajectories for AIRAEP display, aircraft/missile trajectories for color movie, time history output, weapons screen time histories, and events file.

PROGRAM INPUTS: Aircraft: aeroperformance, propulsion, sensors, signatures, gun. Missiles: aeroperformance, propulsion, signature, lethality, and guidance. Firing: ranges and angles and their rates and times, etc. required for lock on/launch. Control, Tactics, Laser, initial conditions also required.

LIMITATIONS/RESTRICTIONS: Uses AIRAEP program from Avionics Lab to display aircraft trajectories "postrun". Requires Tektronix terminal to run graphics (AIRAEP).

Interaction required to determine appropriate tactical inputs.

COMPUTER SYSTEM ENVIRONMENT: CDC Cyber 175 NOS/BE operating system

LANGUAGES: Fortran extended

SPECIAL REQUIREMENTS: AIRAEP (Avionics Lab) used to display trajectories. Preprocessing program (PACVDATAPREP) helpful.

AVAILABLE DOCUMENTATION: PACAM V Users Manual Oct 78

RESPONSIBLE ENGINEER: Capt. Robert A. Mercier
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PROGRAM TITLE: Advanced Composites Cost Estimation Model (ACCEM)

DESCRIPTION: The program estimates manufacturing costs of individual composite parts.

APPLICATION: Preliminary design estimates of manufacturing costs of composite parts. The program can be used in trade studies with metallic parts. Will handle discrete aircraft parts such as a rib, a spar, a cover panel.

KEY WORDS: Cost Analysis, Composites Cost Estimation

ABSTRACT: This program estimates the recurring costs associated with the fabrication of advanced composite detail parts and components. The system employs Industrial Engineering Standard equations developed in the program to calculate standard hours for the detail composite fabrication operations of layup, core preparation, part consolidation and finishing. With these standards as base, recurring costs are derived through the application of variance factors, improvement curve slopes and labor rates.

PROGRAM OUTPUT OPTIONS: The program outputs include manufacturing manhours, labor cost, and material cost by component.

PROGRAM INPUTS: Detailed design information of the part under consideration; type of material, number or plies, ply orientation, etc.

LIMITATIONS/RESTRICTIONS: The program estimates only the manufacturing costs of individual parts. It will not handle the assembly costs to make a complete component such as a wing.

COMPUTER SYSTEM ENVIRONMENT: CDC 6600
NOS/BE operating System

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TR-76-87

RESPONSIBLE ENGINEER: R. Mueller
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PROGRAM TITLE: Techniques for Estimating Aircraft Structural Expense (TEASE)

DESCRIPTION: This is an airframe structural cost estimation model.

APPLICATION: Preliminary design cost analysis and trade studies for advanced aircraft.

KEY WORDS: Cost Analysis, Aircraft Cost Estimation, Cost Trade Studies.

ABSTRACT: A capability has been developed for estimating a range of alternative structure and material combinations. A technique for independently assessing complexity factors has been developed and demonstrated. Manufacturing costs are separately estimated for the primary elements of substructure: ribs, spars, covers, leading edges, trailing edges, etc.

PROGRAM OUTPUT OPTIONS: The model outputs include airframe structural cost in terms of material and labor cost, and manufacturing manhours.

PROGRAM INPUTS: General aircraft design data, type of material, type of construction.

LIMITATIONS/RESTRICTIONS: Limited to metallic aircraft type construction and fixed wing aircraft.

COMPUTER SYSTEM ENVIRONMENT: CDC 6600
NOS/BE Operating System

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TR-71-74
AFFDL-TR-75-44
AFFDL-TR-77-24

RESPONSIBLE ENGINEER: R. Mueller
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PROGRAM TITLE: Fast Shot-Line Generator (FASTGEN)

DESCRIPTION: This program develops shot-line descriptions of target components and air spaces which are encountered by uniformly distributed parallel rays emanating from specified directions (or attack aspects).

APPLICATION: The FASTGEN output data is primarily used as input in other computer programs, such as COVART I and II and versions of VAREA, to determine the vulnerability of aerial and surface targets to impacts by fragments and projectiles.

KEY WORDS: Shot-line generator, target description, vulnerability, vulnerable areas, vulnerability assessment

ABSTRACT: The program accepts as input the location and configuration of all masking and critical (or potentially vulnerable) components of the target and produces line-of-sight (LOS) descriptions of the components and air spaces or compartments encountered by uniformly distributed parallel rays (or shotlines) emanating from specified attack aspects. The principal output from the FASTGEN program contains records of eight words each which define the X', Y', and Z' coordinates of the point at which the shotline enters the component, the normal thickness or radius of the component, the space code for the air space or compartment immediately adjacent to the component, the component code number, the LOS distance through the component, and the secants of the obliquity angles between the shotline and the normals to the entry and exit surfaces of the component. The X', Y' and Z' coordinates of the shotline/component intercepts are with respect to the attack aspect coordinate system.

The FASTGEN program has options for:

- Developing shotline data only for selected portions of the target or for the entire target,
- Producing output data for all shotlines which encounter the target or for only shotlines which encounter critical components of the target,
- Restarting the program to add additional shotline data to an existing output tape.

PROGRAM OUTPUT OPTIONS: Primary output is a file containing descriptions of the components and airspaces encountered by each of the shotlines that pass through the target or encounter critical components.

PROGRAM INPUTS: Run specification data and target description data such as component geometry and material.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC 6600

LANGUAGES: CDC FORTRAN IV Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: FASTGEN (Program 7052) User Manual

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PROGRAM TITLE: Simulation Program for Computation of Vulnerable Areas and Repair Times (COVART)

DESCRIPTION: COVART incorporates in one program the determination of vulnerable areas and repair times for specific levels of damage caused by a single fragment or projectile when penetrating various types of targets.

APPLICATION: The primary emphasis of this model is on the determination of vulnerable areas and repair times for aircraft such as tactical and strategic combat types. The program can also be used to determine vulnerable areas of ground targets whose damage definitions are consistent with the model.

ABSTRACT: For years aircraft vulnerability and survivability analyses have been concerned almost exclusively with attrition and mission prevention damage categories. In recent years, studies were made on aircraft hit by ground fire in Vietnam. Damage nomenclature ranged from "continued to fly" to "shot down and lost." The studies reveal that damaged and recovered aircraft can impose a burden upon the maintenance system when a large volume of minor or major repairs is required. These repairs could be a significant factor in logistic, tactical and strategic planning. Further consideration of this repair problem demonstrated the need for a new kill category in aircraft vulnerability, sometimes referred to as a "soft" or "mission available" kill. The damage criterion developed for this type of kill is based on repair time. An objective of the COVART program is to provide a method for associating meaningful repair times with the specific projectile types which are likely to hit aircraft. The program combines the fixed wing vulnerable area routines from the VAREA02 computer program and the battle damage repair time and helicopter vulnerable area routines from the HART computer program.

PROGRAM OUTPUT OPTIONS: Defeat definitions, type of component vulnerable areas, repair times, vulnerable area by kill category, vulnerable area by threat and incremental vulnerable area for each component.

PROGRAM INPUTS: The program requires information generated by tracing shot lines through a geometric description of the target. The COVART program can accept shot line information generated by programs such as SHOTGEN, MAGIC, FASTGEN or their equivalent. Other inputs include P_k given a hit as a function of fragment or projectile velocity and mass, weapon type and end game geometry.

LIMITATIONS/RESTRICTIONS: COVART has been designed to run on small computer systems such as the GA SPC-16, thus imposing a penalty on running time for the larger computers. The run time can be diminished by increasing the indexing of the various arrays within the programs.

COMPUTER SYSTEM ENVIRONMENT: COVART has been run on the following systems: Ballistic Research Laboratories Electronic Scientific Computer, CDC 6600, UNIVAC 1108, GA SPC-16.

LANGUAGES: FORTRAN IV

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: Joint Technical Coordinating Group for Munitions Effectiveness, Aerial Target Vulnerability Subgroup, Computer Programs Modification and Standardization Panel; "COVART, A Simulation Program for Computation of Vulnerable Areas and Repair Times."

RESPONSIBLE ENGINEER: Gary Streets
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PROGRAM TITLE: Aircraft Fuel Tank/System Data Analysis Programs

DESCRIPTION: The programs provide means of rapidly retrieving and manipulating data, including test data, used in survivability vulnerability analyses.

APPLICATION: Storage, retrieval and statistical analysis of data pertinent to fuel tank and fuel systems vulnerability studies.

KEY WORDS: Aircraft fuel tank system, passive protection, vulnerability, fire, explosion, fuel

ABSTRACT: A major cause of aircraft combat losses has been the high vulnerability of the fuel tank/system to nonnuclear threats. Projectile or fragment penetrations that lead to fuel fires and explosions and the failure of the tanks and supporting structure due to dynamic loading may mean critical structural damage or massive fuel loss. In many cases, however, experimental data have not been sufficient for completely reliable survivability assessments. Because of limitations in the quantity of tests conducted, the large number of independent variables, and the problems involved in obtaining realistic data, the quality of statistical analyses has been restricted, the reliability of intuitive analyses has been inhibited, and widely accepted analytical survivability models have, therefore, not been developed. The limitations of individual experiments may be overcome by the judicious combination and analysis of similar test data. Once the available data are organized, as by this Fuel Tank/System Data Storage and Retrieval Program, improved relationships predicting critical fire, explosion, and structural damage conditions may be generated within stronger confidence intervals. These improved capabilities will greatly enhance survivability assessment tasks. This program has developed for the Air Force the beginning of the needed technology for conceptual systems applications as well as for the evaluation of existing systems. The output from this program can be used as updated input for a design tool such as described in the Aircraft Fuel Tank/System Survivability/Vulnerability Analysis Report (AFFDL-TR-74-132).

The Fuel Tank/System Data Storage and Retrieval Program is divided into three operational computer programs. The first, FUEL1, is designed to create the data bank (stored on magnetic tape). This program can be used to create a new tape, update an existing tape, or modify the storage tape. The second program (FUEL2) is used to search the data bank and retrieve all cases which are between specified limits. As many as 56 parameters may be examined in one pass through the data bank. The third program (FUEL3) is used to retrieve any data package, given that the file number is known.

PROGRAM OUTPUT OPTIONS: A report of the selected tests is generated containing data such as target description, test fluid type, passive protection, threat detonation area, threat description, striking velocity regime, etc.

PROGRAM INPUTS: The data bank file is provided with the programs. The user enters various selection parameters to be used to select tests from the data bank. Some of these selection parameters are: target description, test fluid, tests reaction, threat description, passive protection, etc.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC 6600

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TR-76-39, Vols. I, II, III, IV

RESPONSIBLE ENGINEER: Lt. M. H. Cox
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PROGRAM TITLE: Aircraft Fuel Tank/System Survivability/Vulnerability Analysis Programs

DESCRIPTION: This is a program intended for the analyses and evaluation of the impact of fuel tanks and fuel systems on aircraft survivability by comparing unprotected systems with systems protected to various levels.

APPLICATION: The program can be used by aircraft designers and analysts to assess fuel tank and fuel system vulnerability to non-nuclear threats.

KEY WORDS: Aircraft fuel tank/system, survivability/vulnerability analysis, survivability merit rating, defended and undefended aircraft.

ABSTRACT: The programs model threat effects, threat-fuel tank/system interactions, damages, and failure modes. Failure mode probabilities of occurrence are calculated and summarized for each tank/component and for the entire system. Failure mode probabilities are categorized according to mode, (i.e., system degradation, fire, explosion, and fuel depletion).

These failure modes probabilities for the system can be combined outside the programs into a single probability of kill which can then be converted into the protective performance level (PPL). The PPL represents a conditional survivability, that is, the probability of survival given a hit by the specified threat.

A computer run based on the PPL for the defended design is then made to calculate the Merit Rating number (MR), which is the total life cycle cost of a force of defended aircraft having the same combat mission effectiveness as the baseline.

If the defended design is more cost effective, the MR defended will be less than the MR baseline. Because of the higher PPL for the defended cases, the number of aircraft in the defended force will be so much smaller, for an effectiveness equal to the baseline aircraft force, that the MR defended system life cycle cost will be lower (better).

The final output, the survivability design merit rating number, MR, for the baseline aircraft is the total life cycle cost of a force of baseline aircraft with a combat mission effectiveness based on the baseline PPL.

PROGRAM OUPUT OPTIONS:

PROGRAM INPUTS: The computer program's inputs are the aircraft fuel tank/ system design configuration, aircraft operating conditions, and threat definition. Failure modes and probabilities, and Merit Rating numbers.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: IBM 370, CDC 6600

LANGUAGES: FORTRAN IV

SPECIAL RLQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL TR-74-132, Vols I, II, III
(Vol. II is confidential)

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PROGRAM TITLE: Automated Financial Analysis Program (AFA)

DESCRIPTION: Analyzes and evaluates data obtained from contractor submitted cost performance reports and cost/schedule status reports.

APPLICATION: The program can be used to analyze and evaluate cost reports (CPR) submitted IAW DI-F-6000 or DI-F-6000A and cost/schedule status reports (C/SSR) submitted IAW DI-F-6010.

KEY WORDS: Financial Analysis, Cost Performance Report Analysis, Cost/Schedule Status Report Analyses, Cost/Schedule Control Systems Criteria

ABSTRACT: The AFA program was developed by the Cost Analysis Division, Comptroller, Electronic Systems Division, Air Force Systems Command. The program is capable of analyzing and evaluating CPR's and C/SSR's.

PROGRAM OUTPUT OPTIONS: The program provides the following outputs: Reprint of current and cumulative input data, error checks, cumulative schedule performance, cumulative cost performance, completion status, performance indices, work remaining, BAC/LRE changes and status, G&A/overhead analysis, projected costs at completion (5 methods), fee/profit computation, and executive summary.

PROGRAM INPUTS: Program inputs are provided by the contractor through the CPR or C/SSR, i.e., monthly and/or cumulative budgeted cost for work scheduled (BCWS), budgeted cost for work performed (BCWP), actual cost for work performed (ACWP), schedule variance (SV), and cost variance (CV), budget at completion, latest revised estimate, undistributed budget, and management reserve.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC 6600

LANGUAGES: Fortran

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:

"Automated Financial Analysis Program - A User's Guide."
Available from Cost Analysis Division, Comptroller,
Electronic Systems Division, AFSC, USAF, Hanscom AFB,
Bedford, Mass.

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PROGRAM TITLE: AEROICE

DESCRIPTION: This is a computer program to evaluate the aerodynamic penalties due to icing.

APPLICATION: The specifiable options of AEROICE allow the user to output ice accretion parameters, drag increments or changes in coefficient of lift.

KEY WORDS: Icing, icing penalties, aerodynamics, airfoil

ABSTRACT: Investigations into icing requested by ASD resulted in the identification of several reference works completed by the National Advisory Committee for Aeronautics (later NASA) from 1940 through 1964. One of those reports, NASA TN D-2166, "Prediction of Aerodynamic Penalties Caused by Ice Formations on Various Airfoils," formed the basis for this program.

Additional requests for support in the summer of 1978 prompted the laboratories to adapt the contents of NASA TN-2166 to an analysis of aircraft icing penalties. By September 78, a basic form of AEROICE was operational. Since then, adaptations have been made to the computer program to allow more ease in its use until it became available in its current form. AEROICE has been used in the analysis of the Air Launched Cruise Missile, the Harassment Drone and the A-10.

PROGRAM OUTPUT OPTIONS: Ice accretion parameters, changes in lift and drag coefficients.

PROGRAM INPUTS: Inputs required are aerodynamic parameters specifying the airfoils (i.e., thickness, chord, surface area, angle of attack, projected height, leading edge radius and span). Meteorological parameters to be identified are altitude, speed, temperature, density, viscosity, and drop size.

LIMITATIONS/RESTRICTIONS: The program can handle airfoils of 4-16% thickness only. Airspeeds should not exceed 500 knots.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: CDC FORTRAN Extended

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TM-79-91-WE: AEROICE: A Computer Program to Evaluate the Aerodynamic Penalties Due to Icing, October 1979.

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SECTION VII
FLIGHT CONTROL & SIMULATION

PROGRAM TITLE: Advanced Terminal Aerial Weapon Delivery Simulation (ATAWDS)

DESCRIPTION: A set of three digital simulations that allow the assessment of accuracy and survivability of advanced flight and fire control systems. The three simulations include: (a) Statistical Time Domain Program, (b) Frequency Domain Analysis Program, and (c) P001 Aircraft Survivability Program.

APPLICATION: The ATAWDS computer simulations enable the user to simulate advanced fighter aircraft configurations performing the terminal phase of the weapon delivery. These simulations are useful in the design of flight control systems and integrated flight and fire control system couplers. These new designs can then be implemented in the simulations to provide accuracy, survivability and flying quality analyses.

KEY WORDS: Air-to-Air Gunnery, Air-to-Ground Gunnery, Bombing, Pilot Modeling, Deterministic Simulation, Fire Control, Flight Control, Gunnery, Flying Qualities, Simulation, Stochastic Simulation, Weapon Delivery, Weapon Delivery Sensitivity, Survivability, Antiaircraft Artillery

ABSTRACT: The principal analytical capabilities of the Advanced Terminal Aerial Weapon Delivery Simulation (ATAWDS) programs are to (a) relate the dynamics of closed loop integrated aircraft weapon systems to weapon delivery impact errors for aerial gunnery, and air-to-surface gunnery or bombing tasks, (b) conduct survivability analyses for aircraft performing air-to-surface weapon delivery, and (c) perform frequency domain stability analyses and design syntheses.

The modeling capability of the ATAWDS programs enable the user to simulate weapon delivery tasks for F-15, F-16, AFTI-15 (Variant IV) and YF-CCV-16 aircraft, all configured with various advanced integrated flight and fire control configurations. Advanced flight control modes include (a) FIREFLY II control laws for the F-15 and F-16 aircraft, and (b) automatically and manually coupled fire/flight control closures for the AFTI-15 and YF-CCV-16 aircraft. Advanced fire control system models include (a) Advanced Directors such as the FIREFLY II Director and AFTI-DEFT Director for aerial gunnery and air-to-surface gunnery and (b) Future Impact Point and Continuously Computed Impact Point Bomb sights. For the gunnery mode, options are provided for modeling large excursion and small excursion movable guns. The computer programs should be used as design and evaluation tools in conjunction with the development of integrated flight and fire control systems.

PROGRAM OUTPUT OPTIONS: All output is via permanent disc files or printer listing. The statistical time domain program output printouts include time history responses of the weapon delivery performance ensemble statistics and time history plots of a maximum of 15 variables. When selected, two permanent files are created for interfacing with the frequency domain analyses and P001 programs.

The analytic outputs from the frequency domain analyses program includes open loop and closed loop systems. All plots are produced by the printer. The P001 program includes a time history of the aircraft's inertial trajectory and the aircraft's survivability against anti-aircraft artillery.

PROGRAM INPUTS: Required information includes four categories: Aircraft Physical Data, Encounter Control Data, Aircraft Dynamics Data, and Fire Control Systems data. When utilizing the frequency domain program, in addition to the data from the time domain program, a file containing modeling instructions is required.

LIMITATIONS/RESTRICTIONS: The program requires 157K of central memory. Because it utilizes a multileveled overlay structure, as much as 1,500 seconds of Input/Output time is required.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: CDC FORTRAN Extended

SPECIAL REQUIREMENTS: Software Packages: Time and Frequency Domain Loader Directive Files, BMD02R Stepwise Regression Program (used for curve fitting aerodynamic data that is in look up table format).

AVAILABLE DOCUMENTATION:

AFFDL-TR-79-3033, ATAWDS Final Report,
AFFDL-TR-79-3034, Vol I: Time Domain User's Manual, Vol II:
Frequency Domain User's Manual, Vol III:
P001 User's Manual
AFFDL-TR-79-3035, Vol I: Time Domain Software Manual, Vol II:
Frequency Domain Software Manual, Vol III:
P001 Software Manual, Vol IV: Time Domain
Listing, Vol V: Frequency Domain Listing

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PROGRAM TITLE: FLEXSTAB 3.02 Computer Program System (CPS)

DESCRIPTION: FLEXSTAB consists of 13 technical computer programs and one high level language precompiler program. Three of the technical programs are aerodynamic modeling programs, five are structural modeling programs, and five are airplane analysis programs.

APPLICATION: The FLEXSTAB system of digital computer programs uses linear theories to evaluate static and dynamic stability, trim state, inertial and aerodynamic loading, and elastic deformations of aircraft configurations at supersonic and subsonic speeds.

KEY WORDS: Stability and Control, Elastic Airplane, Linear Aerodynamic Theory, Structural Influence Theory, Flexible Aircraft.

ABSTRACT: FLEXSTAB is a system of computer programs designed to predict stability and control characteristics of elastic airplanes in the subsonic and supersonic flight regimes from geometry, mass distribution, and flexibility information. The numerical process is based on linear aerodynamic and structural influence coefficient theory, which provides a framework for incorporating linear and/or nonlinear empirical corrections.

The level 3.02.00 version of FLEXSTAB contains several significant improvements over the 3.01.00 version. New capabilities include: aeroelastic analysis of cantilevered flexible models, dynamic stability analyses at the higher frequency elastic modes, a linear time response for a time history dynamic stability analysis. In addition, Level 3.02.00 is significantly more efficient at storing and retrieving data and in operating upon matrices.

The User's Manual includes sufficient detail to enable the user to prepare input data decks, execute programs, and interpret results. It is assumed that the user is knowledgeable in the dynamics of aircraft and has been introduced to computer programming applications.

PROGRAM OUTPUT OPTIONS: [PSD, BODE, NYQUIST, MODAL PLOTS]
GEOMETRY and STRUCTURAL (Finite Element Elastic Axis) PLOTS

PROGRAM INPUTS: Pertinent information for aircraft stability and control analysis is required for each program in the form of card decks. Data produced by a previous program is stored on magnetic tape for use in a subsequent program. The programs are accessed from permanent file.

LIMITATIONS/RESTRICTIONS: To run the entire sequence of programs requires a core of at least 175K with run times anywhere from 10 to 5000 seconds of CP time depending on the complexity of the model.

COMPUTER SYSTEM ENVIRONMENT: CYBER 175, NOS/BE Operating System.

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: The host computer system must supply the CALCOMP Basis Software routines; Requires CALCOMP plotter and a tape transport; Requires a disk system with at least a 2.5-million-word capacity for small problem solution (100 aerodynamic singularities) and a 12-million-word capacity for general problem solving (200 to 500 aerodynamic singularities); Programs compile using the FORTRAN Extended Version 3.0 or 4.2 compiler; Assembly language routines are processed using the COMPASS Version 3.0 assembly language processor.

AVAILABLE DOCUMENTATION: FLEXSTAB 3.02.00, Vol I - Theoretical Description, Vol II - User's Manual, Vol III - Program Description

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PROGRAM TITLE: Dynamic Modeling and Analysis Program (EASY)

DESCRIPTION: EASY consists of two programs which independently model and analyze six degrees of freedom aircraft dynamics and flight control systems.

APPLICATION: The EASY Modeling program generates a Fortran model of aircraft dynamics and associated control systems using a variety of standard components (subroutines) which can model any general system configuration. The EASY Analysis program allows several different dynamic, static, linear, or nonlinear analysis techniques to be applied to the nonlinear dynamic system model generated by the modeling program.

KEY WORDS: Dynamic System Modeling, Nonlinear Simulation, Steady-State Analysis, Root Locus, Eigenvalues, Transfer Function, Sensitivity Analysis, Optimal Controllers

ABSTRACT: The EASY program consists of two programs, which allow a wide variety of dynamic systems to be modeled and analyzed for steady-state or dynamic behavior. The EASY Model Generation program is a precompiler program which accepts model description instructions and from these instructions generates a Fortran model of a system. The modeling of most systems can be accomplished by describing the system in terms of standard components. The models of these standard components have been constructed in a general fashion so, with the proper choice of input parameters and tables, a wide range of specific components can be modeled by each standard component. If a portion of a particular system cannot be described using the standard components, Fortran statements can be included in the model description to describe these portions of the system.

Given a description of the system model, the EASY Model Generation program generates Fortran subroutines which represent that model in program form. This computerized model can then be analyzed by any of the nonlinear, linear, dynamic, or steady-state techniques available in the EASY Analysis program. These analyses include: nonlinear simulation, steady-state analysis, linear model generation from the original nonlinear model, eigenvalue calculation, root locus analysis, transfer function calculation, and several other dynamic analysis techniques. In addition to these analyses, optimal controllers of the optimal linear regulator type can also be designed by the analysis program.

PROGRAM OUTPUT OPTIONS: The EASY Model Generation program prints a schematic of the system model, a list of required input parameter values and tabular data for the model, a lineprinter and/or punched source listing of the model, and warning messages concerning errors in the user supplied statements describing the system model. The EASY Analysis program prints listings, tables, and graphs (including an option for Calcomp plots) associated with the particular analysis option selected.

PROGRAM INPUTS: Input data consists of: (1) command statements which define the dynamic model, (2) numerical scalar parameters and tabular data which describe the specific dynamics of the system, and (3) command statements which execute the analysis options.

LIMITATIONS/RESTRICTIONS: Due to core requirements, EASY must be run in a batch mode.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: CDC Fortran Extended and CDC Assembly Language

SPECIAL REQUIREMENTS: Calcomp Plotter and DISPLA library to obtain Calcomp plots.

AVAILABLE DOCUMENTATION:

User's Manual, November 1976,
Application of the EASY Dynamic Analysis Program to Aircraft
Modeling, Final Report, Contract F33615-75-C-3165,
AFFDL-TR-77-102, Volumes I-IV, Environmental Control System
(ECS) Transient Analysis, October 1977.

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PROGRAM TITLE: Tanker Avionics/Aircrew Complement Evaluation/
Boom Station Simulator (TAACE/BOSS)

DESCRIPTION: This program is a dedicated software package used to drive displays for a KC-135 boom station simulator.

APPLICATION: Specific application is for the KC-135 boom station simulator. Parts of the software could be incorporated in other systems requiring a video tracking task and/or digital scaling routines.

KEY WORDS: Analog/Digital Conversion, AID Conversion, Digital Scaling, Digital Multiplication, Digital Video Control, Video, Graphics, Tracking Tasks, KC-135 Boom Station Simulator, Boom Station Simulator

ABSTRACT: A need for a minimum tracking task for the KC-135 station became apparent during earlier phases of the Tanker Avionics/Aircrew Complement Evaluation (TAACE). Without some minimal amount of task realism, the boom station operator was unable to provide a valid workload assessment during data collection portions of the mock-up study.

A part-task boom station simulator has been designed and is under fabrication. The simulation program contains digital scaling routines for driving fuel gauges and a video tracking task to simulate the refueling operation. Two updated versions of the boom station are available, in addition to the baseline configuration. The simulator is not a training aid. It is an engineering design evaluation tool.

PROGRAM OUTPUT OPTIONS: Video (TV) display which simulates the view from the boom station viewing window; baseline KC-135 configuration plus two updated versions.

PROGRAM INPUTS: Analog fuel gauge signals and control stick signals. Configuration select and condition discretes.

LIMITATIONS/RESTRICTIONS: In order to be used with no modifications, the same hardware must be used as was used for the simulator.

COMPUTER SYSTEM ENVIRONMENT: Z-80 microprocessor based kit. All hardware modifications well documented.

LANGUAGES: Assembly language

SPECIAL REQUIREMENTS: 4K EPROM in addition to monitor routines, 6K RAM, Video Interface.

AVAILABLE DOCUMENTATION:

Manual for Basic Z80 System (SDS Z80 Starter),
Z80 Programming Manual,
Video Interface Manual.

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SECTION VIIJ
APPLIED MATHEMATICS AND COMPUTATIONAL AIDS

PROGRAM TITLE: Plotting Language Utilizing Graphical Optics (PLUGO)

DESCRIPTION: A two phase system of computer programs which allows for interactive plotting and analysis of engineering data.

APPLICATION: PLUGO combines batch processing with interactive graphics to provide the engineer with an analysis tool capable of handling large quantities of data such as wind tunnel data, free flight data, engine test data, structural test data, or any general engineering type data.

KEY WORDS: Data Analysis, Plotting, Interactive Graphics, Data Reduction, Aerodynamics, Wind Tunnel Tests.

ABSTRACT: Current testing techniques and data accumulation methods have resulted in large amounts of data acquisition describing aerodynamic models, structural models, engine simulations and even chemical reactions. The development of a practical method for searching, analyzing and disseminating this information in a timely and efficient manner is of prime importance. A search of available computer programs yielded either simplistic programs that simply plotted data or very complex systems such as NASA/SADSAC which were specifically designed and not general in nature. Specific programs tend to be inefficient when utilized or adapted for other purposes.

Plotting Language Utilizing Graphical Optics (PLUGO) was conceived as a tool for the engineer to manipulate large amounts of data and arrive at engineering conclusions suitable for documentation purposes. The system is general in nature and was approached from a mathematical viewpoint and computational consistency.

Historically, PLUGO was a single batch computer program capable of searching large amounts of data and creating plots of data points determined by preset conditions imposed. This Phase I portion of PLUGO was a versatile data handling tool. However, the end results were simply plotted data points. Engineers still were faced with the ultimate task of analysis which quite frankly is overpowering when significant amounts of data are involved. Also, repeatability or duplication of analysis done manually is literally impossible. With the advances in computer hardware and the wealth of software available, a mathematical approach was taken to curve fit (mathematically define) and perform analysis on this plotted data. The approach was to employ an interactive graphics program that allowed the engineer to communicate with the computer to inject sound engineering judgement for a synergistic system (man in the loop). The PLUGO system provides the user with a powerful data analysis tool.

PROGRAM OUTPUT OPTIONS: Calcomp plots on-line or off-line; print-outs of plot data or analysis; and/or permanent disc file.

PROGRAM INPUTS: Input data to PLUGO consists of a single sequential file (tapes or disc) and a program deck which consists of initialization and plot specifications to generate specific plots (Phase I). Disc file plotted data from Phase I is input to the interactive graphics portion (Phase II).

LIMITATIONS/RESTRICTIONS: The PLUGO input data file must be a single sequential file containing not more than 100 variables in a fixed formatted record. Each plot may contain 248 data points with up to 20 curves per plot. The plot specification cards must be less than or equal to 17 in order to be displayed on the graphics terminal (Phase I). Most program errors occur during the curve fit option. The probable cause is bad data, which the curve fit routine cannot handle. When this happens, abort and control returns to intercom (Phase II).

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE Operating System

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: Calcomp Plotter or Tektronix Hard Copy Unit, CDC Cybergraphics Terminal or Tektronix Terminal, Input Tape, Disc or Cards, 2 Plotting Libraries.

AVAILABLE DOCUMENTATION:

AFFDL TR-78-55 Vol I: User's Guide, May 1978
Vol II: PLUGO System Description

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PROGRAM TITLE: Automated Engineering and Scientific Optimization Program - (AESOP)

DESCRIPTION: This is a digital computer program designed for solution of a wide range of multivariable parameter optimization problems.

APPLICATION: Constrained or unconstrained parameter optimization problems. The Program was originally developed for NASA-AMES. It has been used for trajectory optimization and antenna design at WPAFB.

KEY WORDS: Parameter Optimization

ABSTRACT: The program has available eleven search techniques for problem solution: they are sectioning, adaptive creeping, steepest descent, quadratic search, Davidson's method, random point search, random ray search, ray search. The searches may be employed separately or in any sequential combination at the user's option.

The program has the ability to solve constrained optimization problems involving up to one hundred parameters. The program may be coupled to a wide class of parameter optimization problems.

PROGRAM OUTPUT OPTIONS: Printout can be obtained for function parameters, control parameters, and individual search parameters.

PROGRAM INPUTS: Data defining the search selection, control and optimization functions.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CYBER 175

LANGUAGES: FORTRAN IV

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TR-71-52 Vol. IV - Combat Optimization and Analysis Program - COAP

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PROGRAM TITLE: Generalized Computer Digitizing Program (CR3D)

DESCRIPTION: A program which allows the reading of 2D information from the Tektronix tablet to storage in the host computer.

APPLICATION: Geometry preparation for the supersonic/hypersonic arbitrary body computer program and reading of plotted graph information.

KEY WORDS: Digitizing, Geometry, Graphs, Interactive

ABSTRACT: The original CR3D program was written by ASD/XR for use in their computer aided design system. The program was obtained from ASD/XR by FIMG to provide a tool for automating the reading of the x, y, z coordinates used for describing the external geometry for input into the Supersonic-Hypersonic Arbitrary Computer Program (HABP). A number of minor modifications and additions were made to better accomplish the necessary format and to make it a more generalized program. The present version will allow the reading of any 2-D information and is particularly useful for reading graphs, especially ones having odd scales.

The program is interactive and prompts the user to supply the necessary information to perform the digitizing (such as tablet calibration factors, etc.). An unspecified number of points may be read in or the user may specify (up to 50) a set number of points and the program will curve fit and generate the specified number of points.

The user may display resulting points from either option on the Tektronix scope and choose to accept points for saving or discarding.

PROGRAM OUTPUT OPTIONS: (1) X, y, z coordinates on disk file,
(2) geometry cards for HARP code.

PROGRAM INPUTS: Reads in calibration information from keyboard
and tablet. Reads in y, z coordinates from graphics tablet.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: Tektronix terminal with graphics tablet.

AVAILABLE DOCUMENTATION: None

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PROGRAM TITLE: Graphic Input Digitizing Program

DESCRIPTION: An interactive graphics program to allow digitizing of points from Tektronix terminal screen, digitizing tablet or plotter.

APPLICATION: To digitize and redisplay/store any graphical input form such as drawings, symbols, pictures, logos, designs, etc.

KEY WORDS: Digitize, Input, Graphic

ABSTRACT: This program was written in-house to allow better utilization of Tektronix equipment in FIMG. Graphical input is read from TAPE1, terminal screen, digitizing tablet or 4662 plotter. The program will redisplay, either the same size, maximum for device or using input scale factors, on either the screen or plotter. A tabular listing of x, y coordinates is stored on a disk file (TAPE1) for further use (addition of more points later or redisplay).

The interactive program prompts the user with questions as to options desired such as device for input, redisplay of figure, scale factors and restart.

PROGRAM OUTPUT OPTIONS: Tektronix 4662 plots, Tektronix hardcopy pictures, x, y coordinates.

PROGRAM INPUTS: Answering of program prompts.

LIMITATIONS/RESTRICTIONS: 1000 points per picture.

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175

LANGUAGES: CDC Fortran Extended

SPECIAL REQUIREMENTS: Tektronix 4014 terminal with either digitizing tablet or 4662 plotter.

AVAILABLE DOCUMENTATION: None

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PROGRAM TITLE: Aircraft Plot

DESCRIPTION: This program generates plots on a graphics capable terminal (i.e., 4014 Tektronix) or on calcomp plotter, a digitized aircraft model.

APPLICATION: To review accuracy of input for various programs that require a digitized description of the aircraft as input (i.e., wave-drag routine, etc.). It is also used to graphically record input for documents, etc.

KEY WORDS: Digitized, Aircraft, Geometry, Graphics, Plot.

ABSTRACT: This program was generated to aid in reviewing the large number of data points required to digitize an aircraft's geometry. The data must be in the proper format (i.e., far field wave drag format). It can be used either on line (graphic terminal) or off-line (Calcomp Plotter).

PROGRAM OUTPUT OPTIONS: Plots of aircraft from various vantage points with hidden lines optionally removed.

PROGRAM INPUTS: Data file of digitized airplane points.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: Calcomp plotter or graphics terminal.

AVAILABLE DOCUMENTATION: NASA Memo, "Description of a Digital Computer Program for Airplane Configuration Plots," by Charlotte Craidon.

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PROGRAM TITLE: LINPACK

DESCRIPTION: A set of subroutines which analyze and solve various classes of systems of simultaneous linear algebraic equations.

APPLICATION: General purpose numerical analysis.

KEY WORDS: Numerical Analysis, Numerical Methods, Linear Algebra, Systems of Linear Algebraic Equations.

ABSTRACT: LINPACK is a collection of Fortran subroutines which analyze and solve various classes of systems of simultaneous linear algebraic equations. The collection deals with general, banded, symmetric indefinite, symmetric positive definite, triangular, and tridiagonal square matrices, as well as with least squares problems and the QR and singular value decompositions of rectangular matrices.

A subroutine-naming convention is employed in which each subroutine name consists of five letters which represent a coded specification (TXXYY) of the computation done by that subroutine. The first letter, T, indicates the matrix data type. Standard Fortran allows the use of three such types: S real, D double precision, and C complex. In addition, some Fortran systems allow a double-precision complex type: Z complex*16. The second and third letters of the subroutine name, XX, indicate the form of the matrix or its decomposition. The final two letters, YY, indicate the computation done by the particular subroutine.

The LINPACK package also includes a set of routines to perform basic vector operations called Basic Linear Algebra Subprograms (BLAS).

Gaussian elimination, Cholesky decomposition, QR, and singular value decomposition solution methods are used.

PROGRAM OUTPUT OPTIONS: Dependent on subroutine.

PROGRAM INPUTS: Dependent on subroutine.

LIMITATIONS/RESTRICTIONS: There are no routines for general sparse matrices or for iterative methods for very large matrices.

COMPUTER SYSTEM ENVIRONMENT: CDC 6600
CYBER 175

LANGUAGES: Fortran

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION:
AFFDL-TM-79-89-FBR

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PROGRAM TITLE: SIMITZ

DESCRIPTION: This a program to solve the real generalized symmetric eigen problem by simultaneous iteration.

APPLICATION: Structural analysis of aerospace and naval vehicles involving the partial solution of the generalized algebraic eigenvalue problem.

KEY WORDS: Eigenvalues, eigenvectors, diagonalizable matrices, simultaneous iteration, sparse matrices, numerical linear algebra, computer software.

ABSTRACT: This program (actually a subroutine) is an implementation of the simultaneous iteration algorithm for calculating the eigenvalues largest in magnitude and corresponding eigenvectors of a real matrix symmetric relative to a prescribed inner product.

Let $ip(n, w, z)$ denote an inner product in the space of real column n -tuples and let the real n -square matrix C satisfy $ip(n, Cw, z) = ip(n, w, Cz)$. Then C is symmetric relative to ip , and if the p -square positive definite matrix B satisfies $ip(n, w, z) = w^T Bz$ then C is B -symmetric. The equation $BC = C^T B$ characterizes the B -symmetry of C . Given an optional set of p initial approximate eigenvectors of a real n -square B -symmetric matrix C corresponding to p eigenvalues and em corresponding eigenvectors, $0 \leq em < p \leq n$, to a precision dependent on the structure of C and on a prescribed tolerance, eps . The matrix B is presented to the program as an independently prepared real function subprogram which calculates $ip(n, w, z) = w^T Bz$, given column n -vectors w and z . The matrix C is presented as an independently prepared subroutine subprogram $op(n, w, z)$ which, when given an n -vector z , computes its image $w = Cz$. The program is an outgrowth of a literal FORTRAN translation of the ALGOL procedure *ritzit*, to which it is substantially equivalent when $ip(n, w, z) = w^T z$, the standard inner product. But depending on the choice of B and C , the present program enables the direct treatment of a wide variety of symmetric eigenproblems.

PROGRAM OUTPUT OPTIONS: Computed eigenvalues and eigenvectors

PROGRAM INPUTS: Optional initial approximate eigenvectors, execution control parameters, user defined functions that indirectly define the B and C matrices.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC 6600-CYBER 175

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TR-76-118

RESPONSIBLE ENGINEER: Paul J. Nikolai
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PROGRAM TITLE: EISPACK

DESCRIPTION: A collection of programs to solve the algebraic eigenvalue problem, to perform the singular value decomposition and to solve the associated least squares problem.

APPLICATION: General purpose numerical solution of the matrix eigenvalue problem.

KEY WORDS: Eigenvalue, eigenvector, matrices, matrix systems, numerical calculations, singular value

ABSTRACT: Eispack is a collection of FORTRAN subroutines to solve the standard eigenproblem for any one of the following classes of matrices--real general, certain real tridiagonal, real symmetric, real symmetric band, real symmetric tridiagonal, complex general and complex Hermitian; to solve the generalized eigenproblem for real symmetric positive-definite and real general matrix systems; and to perform the singular value decomposition of a real rectangular matrix and solve an associated least squares problem. The individual subroutines total 71.

PROGRAM OUTPUT OPTIONS: Dependent on the specific subroutine.

PROGRAM INPUTS: Dependent on the specific subroutine.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC 6600/CYBER 175

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TM-76-131-FBR

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PROGRAM TITLE: ODE

DESCRIPTION: A subroutine for solving the initial value problem for ordinary differential equations by Adams Pece method.

APPLICATION: Mathematical analysis

KEY WORDS: Differential equations, ordinary differential equations.

ABSTRACT: Subroutine ODE integrates a system of NEQN first order ordinary differential equations of the form

$$BY(I)/DT = F(T, Y(1), Y(2), \dots, Y(NEQN))$$

Y(I) given at T.

The subroutine integrates from T to TOUT. On return, the parameters in the call list are set for continuing the integration. The user has only to define a new value TOUT and call ODE again.

The differential equations are actually solved by a suite of codes DE, STEPl, and INTRF. ODE allocates virtual storage in the arrays Wbrk and Iwork and call DE. DE is a supervisor which directs the solution. It calls on the routines STEPl and INTRP to advance the integration and to interpolate at output points. STEPl uses a modified divided difference form of the Adams Pece formulas and local extrapolation. It adjusts the order and step size to control the local error per unit step in a generalized sense. Normally each call to STEPl advances the solution one step in the direction of TOUT. For reasons of efficiency DE integrates beyond TOUT internally, though never beyond $T+10^8(TOUT-T)$, and calls INTRP to interpolate the solution at TOUT. An option is provided to stop the integration at TOUT but it should be used only if it is impossible to continue the integration beyond TOUT.

PROGRAM OUTPUT OPTIONS: Solution at T -- Y(T)

PROGRAM INPUTS: Number of equations, initial conditions, integration limits. The user must supply a subroutine to evaluate $DY(I) / DT = YP(I) = F(T, Y(1), Y(2), \dots, Y(NEQN))$

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC 6600/CYBER 175

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TM-78-97-FBR

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PROGRAM TITLE: RKF45

DESCRIPTION: This is subroutine for solving the initial value problem for ordinary differential equations by Runge-Kutta methods.

APPLICATION: Mathematical analysis.

KEY WORDS: Runge-Kutta, differential equation, initial value differential equations.

ABSTRACT: Subroutine RKF45 integrates a system of NEQN first order ordinary differential equations of the form, $OY(I)/OT = F(I, Y(I), Y(2), \dots, Y(NEQN))$, where the $Y(I)$ are given at T . Typically the subroutine is used to integrate from T to $TOUT$ but it can be used as a one-step integrator to advance the solution a single step in the direction of $TOUT$. On return the parameters in the call list are set for continuing the integration. The user has only to call RKF45 again (and perhaps define a new value for $TOUT$). RKF45 uses the Runge-Kutta-Fehlberg method.

PROGRAM OUTPUT OPTIONS: Solution at $T - - Y(T)$

PROGRAM INPUTS: The number of equations to be integrated, initial conditions, and integration limits. The user must supply a subroutine to evaluate $DY(I)/DT = YP(I) = F(T, Y(1), Y(2), \dots, Y(NEQN))$

LIMITATIONS/RESTRICTIONS: None

RKF45 is primarily designed to solve non-stiff and mildly stiff differential equations when derivative evaluations are inexpensive. RKF45 should generally not be used when the user is demanding high accuracy.

COMPUTER SYSTEM ENVIRONMENT: CDC 6600/CYBER 175

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TM-78-97-FBR

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PROGRAM TITLE: FUNPACK

DESCRIPTION: This is a set of subroutines covering several mathematical functions.

APPLICATION: The numerical evaluation of certain special functions encountered in mathematical analyses of physical problems.

KEY WORDS: Bessel functions, elliptic integrals, exponential integrals, Dunson's integral, psi function, Digamma function, numerical methods, special functions.

ABSTRACT: Currently there are 13 "packets" available in FUNPACK. These are NATSJO, NATSJ1, NATSBESY, NATSIO, NATS11, NATSKO, NATSK1, all of which are Bessel functions; EI, exponential integrals; ELIPK, complete elliptic integral of the first kind; ELIPE, complete elliptic integral of the second kind; DAW, Dawson's integral; NATSPSI, Psi (or Digamma) function; and MONERR, which provides error monitoring facilities.

PROGRAM OUTPUT OPTIONS: Dependent on subroutine used.

PROGRAM INPUTS: Dependent on subroutine used.

LIMITATIONS/RESTRICTIONS: None

COMPUTER SYSTEM ENVIRONMENT: CDC 6600/CYBER 175

LANGUAGES: FORTRAN

SPECIAL REQUIREMENTS: None

AVAILABLE DOCUMENTATION: AFFDL-TM-77-87-FBR

RESPONSIBLE ENGINEER: Paul J. Nikolai
AFWAL/FIBR
PHONE: (513) 255-5350
AUTOVON: 785-5350

PROGRAM TITLE: Finite Intersection Test (FIT)

DESCRIPTION: An interactive computer program that performs simultaneous tests of hypotheses concerning k populations of p-variate data.

APPLICATION: FIT performs either one or two sided tests on data that satisfies the requirements: a) the k populations are distributed as a p-variate normal, and b) the covariance matrices of the k populations are equal.

KEY WORDS: Simultaneous test, null hypothesis, covariance matrix, p-variate normal, chi-square, F, and t distributions.

ABSTRACT: Program FIT was developed under direction of Dr. P.R. Krishariah of the University of Pittsburgh and was sponsored by a grant from the Air Force Flight Dynamics Laboratory. Theoretical analysis of the required distributions was performed and as a result FIT computes (as an intermediate step) approximations of the required percentage points of these distributions.

Assume that for $t = 1, \dots, k$, random vector $\tilde{x}_t^1 = (x_{t1}, \dots, x_{tp})$ satisfies the requirements above with mean vector $\tilde{\mu}_t = (\mu_{t1}, \dots, \mu_{tp})$ and covariance matrix Σ . The null hypothesis to be tested is $H : \mu_1 = \mu_2 = \dots = \mu_k$.

If this hypothesis is rejected, we can gain insight by considering the quantities

$$\lambda_g = \sum_{t=1}^k c_{gt} \tilde{\mu} \quad (g=1, \dots, q).$$

The null hypothesis H is decomposed into q subhypotheses H_g such that

$$H = \bigcap_{g=1}^q H_g \text{ where } H_g : \lambda_g = \underline{\mu}.$$

H is accepted as true if and only if each of the H_g are accepted, and rejected otherwise. Each of the H_g are tested simultaneously against a suitable alternative. The resulting output indicates which (if any) of the subhypotheses should be rejected and the component of the mean vectors contributing to the discrepancy. The robustness of the test is currently being evaluated.

PROGRAM OUTPUT OPTIONS: Outputs include: sample mean matrix, comparison of populations, acceptance or rejection of null hypothesis.

PROGRAM INPUTS: Unit 1 (LFN TAPE 1) must contain the raw data having the following structure: one floating point value per record, X_{rst} ($r=1, \dots, p$), ($s=1, \dots, N_t$), ($t=1, \dots, k$) where p =No. of dependent variables, k =No. of populations, N_t =No. of observations of population t . Standard Fortran ordering is assumed with first subscript varying fastest, etc. Options and parameters are entered on unit 5 (LFN TAPE 5)

LIMITATIONS/RESTRICTIONS:

$$k \leq 10$$

$$p \leq 10$$

$$\sum_{t=1}^k N_t \leq 300 \text{ not necessarily equal for all } t$$

$$\sum_{t=1}^k c_{gt} = 0 \text{ for } g = 1, \dots, q$$

$$q \leq 21$$

COMPUTER SYSTEM ENVIRONMENT: CDC CYBER 175
NOS/BE operating system INTERCOM

LANGUAGES: CDC FORTRAN Extended

SPECIAL REQUIREMENTS: International Mathematics Subroutine Library

AVAILABLE DOCUMENTATION: Cos and Fang, "Computer Program for Krishnaiah's Finite Interaction Tests for Multiple Comparisons of Mean Vectors," University of Pittsburgh, Department of Mathematics and Statistics, in press.

RESPONSIBLE ENGINEER: Dr. John Reising/Matthew Miller
AFWAL/FIGR
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APPENDIX

ORGANIZATIONS SUBMITTING PROGRAM DESCRIPTIONS

<u>Organization Symbol</u>	<u>Programs Submitted</u>
AFWAL/FIBE	5
FIBG	1
FIBR	26
FIBS	9
FIEE	6
FIEM	4
FIER	4
FIES	4
FIGC	4
FIGL	2
FIGR	2
FIMB	11
FIMG	12
FIMM	10
FIMS	5
FII	1
WE	1
TOTAL	107

AFWAL/FT COMPUTER SOFTWARE PROGRAM SUBMITTAL INSTRUCTIONS

PROGRAM TITLE:

Give the descriptive title of the program and any associated abbreviation or acronym.

DESCRIPTION:

Use one or two sentences to briefly describe the function or subject of the program. If the program is multi-faceted, give some indication as to its general purpose and record the functions as part of the ABSTRACT below.

APPLICATION:

Give a prospective user a short descriptive statement of the program's current and potential applications.

KEY WORDS:

List key words or phases which could be used to cross-reference this program by application, reduction method, specific or general topic, field of study, etc.

ABSTRACT:

This should be a two or three paragraph discussion of the program's functions and capabilities, similar to an abstract for a paper.

PROGRAM OUTPUT OPTIONS:

Discuss the types of results that will be generated by the program. Also include any physical outputs such as graphs, plots, data files, etc.

PROGRAM INPUTS:

The user will require some information about the data inputs to the program. Describe the basic types of data (angles, lengths, masses, etc.), the medium from which the data will enter the program (tape, disk, cards, terminal, internal, etc.) and the source of the inputs (previous program, test results, lab equipment). If no data is required, then discuss any options or leave blank.

LIMITATIONS/RESTRICTIONS:

Discuss the programs limitations; unique data sets, special conditions, special run requirements, data smoothing. Specify if the program is atypical in its execution (large core requirements, long runtime, bulk outputs, excess storage, intense human interaction, etc.).

COMPUTER SYSTEM ENVIRONMENT:

Describe the current computer and operating system the program is executing on. Only the mainframe needs to be specified (i.e., CDC Cyber 175, IBM 370/145, DEC PDP 11/70).

LANGUAGES:

List all languages used in writing the source code of the program.

SPECIAL REQUIREMENTS:

List any special software packages required by the program (plotting routines, statistical packages, etc.). Note if the program requires any library routines that may be unique to the installation.

List any special hardware requirements (i.e., plotters, digital tablets, light pens, joysticks, etc.).

List any peripherals, such as tape drives, floppy disks or drums, required for input, scratch, or output files. Card readers, printers and terminals are assumed available.

AVAILABLE DOCUMENTATION:

List any publications or in-house documents which can be made available to the user upon request.

RESPONSIBLE ENGINEER:

Give the name, office symbol, and the phone number(s) (Bell system and/or Autovon) of the individual currently responsible for the program.

NOTE: Submit write-up to AFWAL/ACD (Paul A. Shahady)

TO: AFWAL/ACD (Paul A. Shahady)

SUBJECT: AFWAL/FI Computer Software Program Questionnaire

PROGRAM TITLE:

DESCRIPTION:

APPLICATION:

KEY WORDS:

ABSTRACT:

ABSTRACT (Cont'd.):

PROGRAM OUTPUT OPTIONS:

PROGRAM INPUTS:

LIMITATIONS/RESTRICTIONS:

COMPUTER SYSTEM ENVIRONMENT:

LANGUAGES:

SPECIAL REQUIREMENTS:

AVAILABLE DOCUMENTATION:

<u>RESPONSIBLE ENGINEER:</u>	NAME
	OFFICE SYMBOL
	PHONE
	AUTOVON

DISTRIBUTION LIST

1. ORGANIZATIONS

AFWAL/FI

FIB, FIBE
FIBG
FIBR
FIBS

FIE, FIEE
FIEM
FIER
FIES

FIG, FIGC
FIGL
FIGR

FIM, FIMB
FIMG
FIMM
FIMS

FII

AFWAL/TST

AFWAL/WE

DDC (12)

2. INDIVIDUALS

<u>Name</u>	<u>Organization</u>
Brookman, Ben J., Jr.	FIEM
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De Jong, Jay E., Capt.	FIMM
Dexter, Peter	FIEF
Didaleusky, Dennis, Capt.	FIGC
Dyer, Calvin L.	FIGC
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Kahot, Narenda S.	FIBR
Large, Robert A., Capt.	FIMM
Larimer, Stanley J.	FIGC
Mainquist, Randall, Capt.	FIMM
Mayer, Arnold H.	FIEE
McCarty, Robert E.	FIER
Mercier, Robert, Capt.	FIMB
Miller, Matthew	FIGR
Mueller, R.	FIBS
Mummert, Sherry	FIBR
Nash, Richard	FIMG
Nelson, Dale E.	FIBS
Nicolai, Paul	FIBR
Noll, Thomas E.	FIBR
Norris, Richard B.	FIMS
Osborn, Russell	FIMM
Pearson, Jerome	FIBG
Pinney, Mark A.	FIMB
Pollock, Samuel J.	FIBR
Potter, J. M.	FIBE
Rachovitsky, Elisha	FIGL
Reising, John	FIGR
Sandhu, R. S.	FIBS
Sedlock, Dennis	FIMM
Seyler, Donald P., Lt.	FIGR
Shang, Joseph	FIMM
Sherada, Donald E.	FIMG
Smith, Richard	FIMG
Sotomayer, W.	FIBR
Southern, Jerrell, Lt.	FIGC
Stava, D. J.	FIMM
Sternberger, Nathan	FIMB
Streets, Gary	FIES
Tamplin, Gordon	FIMB
Terry, James L.	FIMS
Tischler, Vicki A.	FIBR
Turelli, Robert, Capt.	FII
Ulrich, Paul C.	FIEM
Venkayya, V. B.	FIBR
Watts, Ronald	FIEE
White, Ronald	FIEE
Yeakel, Scott, Lt.	FIGL