A COMPILATION OF COMPUTER PROGRAMS IN FLIGHT VEHICLE TECHNOLOGY 1964-1967

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FOREWORD

The Air Force Flight Dynamics Laboratory at Wright-Patterson Air Force Base, Ohio is one of the eight Laboratories under the Director of Laboratories, Air Force Systems Command. This Laboratory is the Air Force focal point for exploratory and advanced development (including simulation techniques) for the entire technology required (except for avionics and propulsion) to develop any type of flight vehicle.

It is the policy of the Director of Laboratories that Air Force Laboratories shall be responsible for informing the scientific community at large of significant accomplishments within the Laboratories' areas of cognizance.

One of the objectives of the Air Force Dynamics Laboratory's program is to develop techniques for simplifying and reducing the cost of design, development and test of future Air Force flight vehicles.

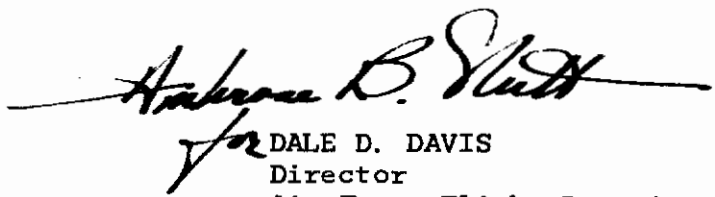
It is with the above policy and objective in mind that this compilation of computer programs, useful in the design of flight vehicles, is published.

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

All of the programs described herein were developed by engineers and scientists of the Air Force Flight Dynamics Laboratory, either in-house, or as directed by them on contract. The report was compiled by the Technical Staff of the Laboratory.

PUBLICATION REVIEW

This technical documentary report has been reviewed and is approved.



for DALE D. DAVIS
Director
Air Force Flight Dynamics Laboratory

ABSTRACT

A compilation of computer programs useful in the design of flight vehicles. Technical domains covered include the following:

Structures
Aerodynamics
Vehicle Dynamics
Flight Control
Environmental Control
Crew Escape and Retardation
Landing Gear Subsystems

All programs were devised in-house in the Air Force Flight Dynamics Laboratory or were prepared for them under R&D contracts.

CONTENTS

INTRODUCTION

The compatibility of the computer programs described herein with any given Electronic Data Processing (EDP) equipment depends upon the programming lanugage, the operating system used, as well as the type of computer available to the prospective user. Sufficient information is provided on each program to allow its usefulness to be assessed.

More detailed information on any given program may be obtained from the Air Force Flight Dynamics Laboratory (AFFDL) contact indicated for each program in this document by writing the Air Force Flight Dynamics Laboratory; Wright-Patterson Air Force Base, Ohio, 45433; Attention: (Name and office symbol of AFFDL contact).

Telephone contact may be made by calling Area Code 513-25- and the five digit extension indicated for the program AFFDL contact in this document.

Any program described herein is available to any of the Department of Defense Agencies or their contractors.

COMPUTER PROGRAMS IN

VEHICLE DYNAMICS TECHNOLOGY

Summary of Vehicle Dynamics Technical Effort in AFFDL

Exploratory and advanced development on methods to insure prevention of adverse effects of noise, sonic fatigue and pseudo noise in aerospace vehicles; also accamplishing of research to predict and prevent aerothermoelastic and vehicle dynamic problems such as flutter and vibration.

Title: Dynamic Loads in Variable Geometry Aircraft

Usage: Used to determine loads and moments associated with variable geometry aircraft.

Math Technique Used: Normal structural analysis techniques

Computer Used: Direct analogy Electric Analog Computer

FDL Contact: A. G. Gerardi, FDDS, 55584

Contractor: General Dynamics Corporation, Fort Worth Division

Date of Availability: 1 January 1967

Brief Description of Program: The analog models used were the F-111A and one early AMSA configuration. These models were used to determine response loads and moments at various wing and fuselage stations during various maneuvers including towing, landing, gusts, gun firing, and store ejections One important part of the program was the simulation of free play in the wing pivot bearing and resulting dynamic loads caused by the free play.

Title: FREIGN (Beam mode shapes and frequencies determination)

Usage: Determine the natural mode shapes and frequencies of a beam. The program can handle cantilever or free-free straight or swept wings of the high aspect ratio type.

Math Technique Used: Influence coefficient methods with a modified matrix iteration technique with convergence acceleration. The eigenvalue routine was adopted from an SEFD program.

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: A. L. Sharp, FDDS, 55584

Availability: Present

Program Description: Calculates natural frequencies and nodal shapes for a wing beam of high aspect ratio using influence coefficient methods. The matrix iteration routine is very fast and can shred out close roots. Requires flexibility and mass matrices from other sources.

Title: Vibration of Rotationally Symmetric Shells

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: S. J. Pollock, FDDS, Ext 53297

Contractor: Lehigh University

Date Available: Present

Math Technique & Brief of Program Usage: The program calculates natural frequencies and mode shapes for rotationally symmetric elastic shells with or without axisymmetric prestress. The method used is Kalnin's multisegment, direct numerical integration approach. The program is applicable to axially symmetric shells to which any number of axisymmetric branches are attached. The geometry and elastic parameters may vary in an arbitrary manner along the meridian of the shell. The program automatically finds either all natural frequencies within a prescribed frequency interval or a specified number of consecutive frequencies above a given frequency. The mode shapes of all displacements and stresses (or stress-resultants) are calculated within a specified accuracy and printed out at any desired number of points. (Ref Kalnin's, A., Free Vibration of of Rotationally Symmetric Shells, Journal of the Acoustical Society of America, Vol 36, No 7 1355-1365, July 1964)

Title: Antisymmetric Wing-Tail-Fuselage Aircraft Vibration

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: L. J. Huttsell, FDDS, Ext 53297

Contractor: In-House

Date Available: April 1968

Math Technique & Brief of Program Usage: The program calculates the natural frequencies and mode shapes for a wing-tail-fuselage representation with the following degrees of freedom: rigid body roll, fuselage torsion, wing bending-torsion, and tail bending-torsion. The model is freed in the desired rigid-body degrees of freedom by the use of the rigid-body modifying matrix (Ref John Dugundji, On the Calculation of Natural Modes of Free-Free Structures, Journal of the Aerospace Sciences, Feb 1961). The fuselage torsion degree of freedom is included by appropriately modifying the influence coefficients of the wing or tail. Wing sweep angle can also be included.

Title: Prediction of Unsteady Aerodynamic Forces for General Wing/ Control Surface Configurations in Subsonic Flow

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: S. J. Pollock, FDDS, Ext 53297

Contractor: Grumman Aircraft Engineering Corporation

Date Available: February 1968

Math Technique & Brief of Program Usage: The program calculates subsonic oscillatory pressure distributions and generalized forces for finite-aspect-ratio wings with full or partial-span control surfaces. The procedure employs either a conventional planar kernel function or, on an optional basis, a nonplanar kernel function which considers the effect of an initially deflected control surface. The basic wing pressure-series functions used in previous kernel function applications have been augmented to include the logarithmic singularity at the control surface leading edge, and to account for gap effects at the control surface side edges. The solution for the unknown coefficients of the pressure-series functions is performed in a least-squares sense based on downwash values at locations chosen by the program user. (Ref AFFDL-TR-67-117)

Title: Unsteady Aerodynamics - A Transonic Box Program for Planar Lifting Surfaces

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: S. J. Pollock, FDDS, Ext 53297

Contractor: North American Rockwell Corporation

Date Available: Present

Math Technique & Brief of Program Usage: The transonic box method is based on the representation of the velocity potential by a doublet distribution. The method applies to an oscillating wing at M = 1 and is analogous to the supersonic Mach box method. The program, based on the transonic box method, applies to a planar wing of polygonal planform with a straight trailing edge and as many as three sweep angles along the leading edge. For a maximum of ten models of oscillation, the program computes the oscillatory potentials and pressures and a generalized force matrix. (Ref FDL-TDR-64-152, Part II and AFFDL-TR-66-121)

Title: Supersonic Mach Box Program for Intersecting Planar Lifting Surfaces

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: S. J. Pollock, FDDS, Ext 53297

Contractor: North American Rockwell Corporation

Date Available: Present

Math Technique & Brief of Program Usage: The computer program calculates a matrix of generalized forces for a wing with symmetrically folded tips. The Mach box method used follows the aerodynamic influence coefficient procedure of Zartarian and Hsu. Each surface and diaphragm are overlaid with a grid of rectangular Mach boxes, the diagonals of which are parallel to the Mach lines. The generalized forces computed are those due to motion of the surface which may consist of a linear combination of as many as ten modes of motion. By proper specification of the modes and frequencies, the user may obtain lift coefficients, longitudinal stability derivatives, loads due to symmetric sinusoidal gusts, drag due to surface warpage, or an array of generalized forces which may be used to calculate flutter speeds. If the surface is free from flutter, the same arrays may be used in a Fourier series approach to calculate the responses to random or discrete gusts. (Ref FDL-TDR-64-152, Part IV and AFFDL-TR-67-104)

Title: GIP (Beam Structural Analysis)

Usage: Calculate bending, torsion, bending-torsion and torsion bending influence coefficients of a swept high aspect ratio beam.

Math Technique Used: Standard strain energy equations Simpson's integration technique for determining area under bending and torsional modulus curves.

Language: Fortran IV

Computer Used: IBM 7094

FDL Contact: A. L. Sharp, FDDS, 55584

Date Available: Present

Program Description: Program determines influence coefficients and punches the data on cards. The program can be used for swept high aspect ratio wing beams. The coefficients are determined by integrating under curves generated from given bending and torsional modulus curves.

Title: PANDORA (Dynamic analysis of launch vehicles)

Usage: Dynamic analysis of clustered launch vehicles

Math Technique Used: Standard dynamic technique, details shown in FDL-TDR-64-105

Computer Used: IBM 7040/7094 DCS

Language: Fortran II, Fortran IV

FDL Contact: Robert Cook, FDDS, 55584

Contractor: Ling Temco Vought

Date of Availability: Immediate

Program Description: The program determines the motion and configuration for a general elastic body executing a large "rigid-body" displacement. Specifically the program describes a clustered launch vehicle from launch throughout its trajectory and ending outside the atmosphere. Forcing functions such as a simplified gust, impulsive spin-up, initial displacements in the first mode of vibration as well as fuel slosh and mass efflux are incorporated. The equations of motion are solved by a 4 step Runge-Kutta technique.

Title: Runway Power Spectral Densities (PSD)

Usage: Computation of Power Spectral Densities using a profilograph or a rod and level to gather runway profile data.

Math Technique Used: Fourier transform

Computer Used: IBM 7094/7044 DCS

Language: Fortran II

FDL Contact: B. H. Groomes, FDDS, 55584

Date of Availability: 1960

Program Description: Computes runway PSD from runway measured dat

Title: TAKEOFF (Vehicle T.O. distance calculation)

Usage: Calculate takeoff distance of a vehicle operating on clay or sandy soil

Math Technique Used: Empirical data - Runge-Kutta integration

Language: Fortran IV

Computer Used: IBM 7094

FDL Contact: A. L. Sharp, FDDS, 55584

Date of Availability: February 1967

Program Description: Program gives time history of velocity, acceleration distance, soil sinkage, gear drag and drag ratio for a jet aircraft operating on clay or sandy soils.

Title: Space Package Alightment Dynamic Loads

Program Usage: This program is a three-dimensional digital simulation for a space capsule having either telescoping or articulated landing legs using crushable honeycomb for energy absorption.

Math Technique Used: Runge-Kutta-Merson Integration

Computer Used: IBM 7044/7094

FDL Contact: R. J. Ashenbrenner, FDDS, 55584

Program Language: Fortran IV

Contractor: General Dynamics/Pomona Division

Date of Availability: October 1966

Program Description: Separate simulations were developed for the telescoping and articulated leg configurations. The simulations are three-dimensional and utilize inputs of vertical and horizontal velocities, capsule inclination, roll rates, and terrain slopes. This program is used to define stability boundaries since it tells when the capsule either tumbles or bottoms out.

Title: MAC PSD (Power Spectral Density)

Usage: Computer power spectra of stationary random time history data - much faster than conventional techniques.

Math Technique Used: Cooley-Tukey algorithm

Computer Used: IBM 7044/7094

Language: Fortran IV

FDL Contact: Phyllis Bolds, FDDS, Ext 54127, 52392, 52543

Contractor: Measurement Analysis Corporation

Date of Availability: 1 Dec 1967

Program Description: Input format is constant with Systran. The number of points processed at any one time must be same integer power of two, all on the computer core, or the time advantage is lost.

Title: Multiple Rank Test

Usage: The Multiple Rank Test is used to simultaneously test more than two sets of data for homogeneity

Math Technique Used: Rank order statistics

Computer Used: IBM 7044/7094

Language: Fortran IV

FDL Contact: Phyllis Bolds, FDDS, Ext 54127, 52392, 52543

Contractor: Measurement Analysis Corporation/University of Dayton

Date of Availability: 1 Dec 1967

Program Description: The result of the test is a simple "yes" or "no". For the case of a "no" answer (rejection of the homogeneity hypothesis) there is no information provided as to which set or sets of data are nonhomogeneous.

COMPUTER PROGRAMS IN

VEHICLE EQUIPMENT TECHNOLOGY

Summary of Vehicle Equipment Technical Effort in AFFDL

Experimental and advanced development in vehicle equipment for future Air Force systems; advanced technology in areas of crew escape, retardation and recovery, internal environmental control and mechanical elements such as bearings, and alighting gear.

Title: Tractor Rocket Six-Degree of Freedom (Crew Escape System)

Usage: The program is used to determine the feasibility and limitations of the Tractor Rocket Crew Escape technique.

Math Technique: The program uses the Runge-Kutta Fourth Order Integration Method

Computer Used: IBM 7090/7094 and CDC 3600

Lanugage: Fortran IV

FDL Contact: Mr. M. C. Whitney, FDFR, 53305

Contractor: Weber Aircraft Company

Date of Availability: 1 January 1968

Description: The program is a six-degree of freedom computer program designed for the tractor rocket ejection crew escape system. It includes both the spin stabilized rocket and the aerodynamically stabilized rocket. This program traces the kinematic and dynamic response of pertinent items from the time of initiation of the escape sequence up to terminal recovery of the ejected occupant. The program outputs initial conditions just prior to initiation and the following parameters with respect to time from initiation; the aircraft trajectory, the occupant (ejectee) trajectory, the towline position with respect to the ejectee, the towline position with respect to the rocket, the rocket displacement coordinates with respect to the ejectee, towline stretch and tension force, the relative velocity with respect to the ejectee, rocket thrust, rocket spin and the human tolerance coefficient. The program features comments on various phases of the escape trajectory as well as inherent diagnostics of pertinent maladies associated with an abnormal or undesirable occurrence.

Title: Performance Analysis of Crew Escape Techniques

Usage: The program is used for trajectory analysis for open and encapsulated ejection seats and separable crew compartment escape systems, with or with or without DART (Directional Automatic Realignment of Trajectory) or STAPAC (Gyro Controlled Vernier Rockets) Stability Subsystems.

Math Technique: The program uses the Fourth Order Runge-Kutta Integration Method

Computer Used: IBM 7090/7094

Language: Fortran IV

FDL Contact: J. M. Peters, FDFR, 53305

Contractor: North American-Rockwell Company
Los Angeles Division

Date of Availability: 15 January 1968

Description: The program is a six-degree of freedom computer program that calculates the attitude and position-time history of a rigid body moving through three-dimensional space in accordance with the physical laws of motion. The program considers the forces produced by propulsive thrust, friction, aerodynamic characteristics, gravity and retardation devices. The program accomodates four different escape concepts and related aerodynamic tables impulse curves, and parachute data. The program can be flagged for either six-degree of freedom (DOF) or three degree of freedom. Two unique escape system stabilization systems (DART and STAPAC) are available as subroutines. DART (Directional Automatic Realignment of Trajectory) and STAPAC (Gyro-Controlled Vernier Rocket Stabilization) are utilized to stabilize an ejection seat against conditions of c.g.-man rocket thrust misalignment and aerodynamically induced pitching moments. The program provides for three methods of producing output: (1) Numerical Printout (2) SC-4020 (Cathode-Ray Tube) and (3) Benson-Lehner Graphical. There are 42 output parameters for 6 DOF and 24 for 3 DOF.

Title: Computerized Data Catalog and Data Retrieval System for Deployable Aerodynamic Decelerators

Usage: This program will be utilized to store all pertinent deployable aerodynamic decelerator performance and design information and to provide rapid retrieval of selective data when required.

Math Technique: N/A

Computer Used: IBM 7090/7094

Language: Fortran IV

FDL Contact: Mr. L. L. Watson, FDFR, 52490

Contractor: Technology Incorporated - USAF Contract No. F33615-67-C-1232

Date of Availability: 1 January 1968

Description: In the development of a computerized data catalog and data retrieval system for deployable aerodynamic decelerators, the results were twofold: (1) a list of parameters which completely define the information pertinent to these decelerators; and (2) a data base (the structure to arrange the data elements making up a unit of information) and the computer programs to manipulate the data base. The combination of these results constitutes a system to store and retrieve by computer techniques all data related to deployable aerodynamic decelerators.

Title: Sabatier Reactor Design Program

Usage: The program facilitates the design of an optimized carbon dioxide reduction reactor as an atmosphere regeneration subsystem.

Math Technique Used: Solution of simultaneous equation related to enthalpy and gas concentration

Computer Used: IBM 7090

Language: Fortran

FDL Contact: E. B. Thompson, Jr., FDFE, 55352

Contractor: Dynamics Sciences Corp.

Date of Availability: Immediate

Brief Description of Program: The computer program handles simultaneous chemical reactions. Included in the input data is a provision to study heat loss as it increases with temperature. That is, the input data includes a base cooling temperature for the reactor, in addition to the inlet temperature of the reaction gases. The program solves simultaneous, equations related to: concentration, concentration change, and enthalpy.

Title: CONFAC II, A General Computer Program for the Determination of Radiant Interchange Configuration and Form Factors

Usage: To calculate geometric configuration and form factors for radiant heat transfer.

Math Technique Used: Numerical integration of Nusselt formulation of the radiation problem.

Computer Used: IBM 7094

Language: Fortran II

FDL Contact: W. L. Haskin, FDFE, 54063

Contractor: North American Aviation, Inc.

Date of Availability: April 1964

Program Description: A numerical method is used to determine radiant interchange factors. The source of flux may be any general plane polygon and the receiver may be any general plane or nonplanar polygon, the surface of an arbitrary polyhedron, or an arbitrary combination of such surfaces. It is therefore possible to accurately determine factors from a plane surface to another surface occluded by intervening surfaces. Polygons or polyhedra may be generated internally, and coordinates may be transformed automatically.

Title: Computer Program for Determining Steady-State Space Radiator Thermal Performance

Usage: To determine extended surface (tube-fin) space radiator steady-state thermal performance including temperature distribution along the fin.

Math Technique Used: Solution of differential and algebraic equations.

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: C. J. Feldmanis, FDFE, 53021

Contractor:

Date of Availability: January 1966

Program Description: The program calculates heat rejection rates from two radiator configurations: (a) both radiator sides are active (flat radiator), and (b) only one side of the radiator is active (cylinderical radiator). The program also calculates fluid outlet temperature, tube wall temperature and temperature distribution along the fin.

Title: Computer Program for Determining Directional "SCRIPT F" (Radiation Heat Transfer Analysis)

Usage: To determine "SCRIPT F" for radiant heat exchange calculations when radiating surfaces have directional properties and components of reflection which are diffuse and specular.

Math Technique Used: Matrix Algebra

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: C. J. Feldmanis, FDFE, 53021

Contractor: TRW Systems Group

Date of Availability: October 1965

Program Description: A method of radiation heat transfer analysis has been programmed which uses directional thermal radiation properties and accounts for the specularity and/or diffuseness of these properties. The results of this program can be incorporated into most existing thermal analysis programs. The user has a choice of the specular, the diffuse, or the specular-diffuse assumption.

Title: Environmental Control Systems Process Optimization and Decision

Usage: To determine the pair of heat exchanger cores which will result in the lowest weight system for transferring heat between two fluids when pump power and volume penalties are considered.

Math Technique Used: Solution of algebraic equations and comparison of results.

Computer Used: IBM 7094

Language: Fortran II

FDL Contact: W. L. Haskin, FDFE, 54063

Contractor: North American Aviation, Inc.

Date of Availability: September 1964

Program Description: Given the heat exchange process, the property data for a pair of fluids, a range of vehicle densities, power penalties, and an array of heat exchanger cores, the program will characterize and optimize each core in combination with a standard core or a complete array of cores for the opposite side. The program will select the pair of cores that, in combination, will yield a minimum weight parameter. The selection may be evaluated for off-optimum design variations. the program contains numerous subroutines for ranking, interpolation, extrapolation, and CRT plotting.

Title: Thermal Analyzer Program for Semiactive Thermal Control System

Usage: To calculate steady state or transient temperatures, fluid flow rates, and valve postions for heat transfer systems.

Math Technique Used: Algebraic equations and finite difference solution of differential equations.

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: W. L. Haskin, FDFE, 54063

Contractor: Lockheed California Company

Date of Availability: June 1967

Program Description: Electrical type networks are used to mathematically describe the heat transfer system. The equations specifying heat flow to each node point are then solved. Fluid flow rates, automatic control valve positions and temperature distribution are calculated for specified constant or changing heat inputs. The temperature distribution may also be calculated with specified fluid flow rates and heat inputs. Variable fluid and materials properties can be included in the calculations.

Title: Solid Cryogen Cooler Design

Usage: To calculate the weight and volume of solid cryogen and insulation used in spherical and cylindrical solid cryogen coolers which do not contain guard coolants.

Math Technique Used: Solution of algebraic equations and comparison of results to find a minimum.

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: W. L. Haskin, FDFE, 54063

Contractor: Aerojet-General Corporation

Date of Availability: March 1968

Program Description: The weight of cryogen required to absorb the heat leak through the container insulation is compared with the weight of the insulation until an insulation thickness which results in a minimum total weight is obtained. Applied heat loads and structural heat leaks are added to the heat leak through the insulation.

Title: Regenerator Analysis with End to End Conduction and Wall Effect

Usage: To numerically solve for the inefficiency and losses of compact, cryogenic, thermal regenerators.

Math Technique Used: Step-by-step numerical procedure requiring iteration for solution of differential equations.

Computer Used: IBM 1620

Lanugage: Fortran II

FDL Contact: J. E. Chenoweth, FDFE, 53021

Contractor: Syracuse University Research Institute

Date of Availability: June 1967

Program Description: The digital computer program is used to numerically solve for the inefficiency, thermal loss, and the screen and wall conduction loss for compact cryogenic thermal regenerators. The program is written for packed, fine mesh screen regenerators but can be modified for other types of thermal regenerators. The program consists of differential and empirical equations governing the heat transfer processes and takes into account the material properties of the regenerator. A solution is obtained by dividing the regenerator into segments and using an iteration process until the allowable error limit is reached.

COMPUTER PROGRAMS IN

FLIGHT CONTROL TECHNOLOGY

Summary of Flight Control Technical Efforts in AFFDL

Exploratory and advanced development programs in the field of flight path control and motional behavior of aerospace vehicles; areas being investigated include: control display, aerodynamic stability, handling qualities, control equipment and instrumentations, portable ILS equipment, and use of pilot as control element.

Title: Step I Validation of the Allocation of Control Tasks

Usage: To define the problems inherent to having the pilot and co-pilot share active control of the aircraft on final approach and demonstrate conceptual solutions which show that allocation of control is a feasible technique.

Math Technique Used:
1. Time-History Study
2. Analysis of Variance, Means & Standard Deviations

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: Mr. Terry Emerson, FDCS, Ext 55496

Contractor: Bunker-Ramo Corporation

Date of Availability: Current

Description: The program computes an analysis of variance, means and standard deviations, on time history data and on error scores.

Title: Interim Remote Area Terminal Equipment (IRATE) Program: Evaluation of the TALAR Guidance System

Usage: IRATE is intended to provide an interim letdown capability under low visibility conditions based upon accelerated development and evaluation of essentially off-the-shelf terminal guidance systems, TALAR and STATE.

Math Technique Used: Analysis of Variance of Polar and Non-Polar data (1) for Time History and specific data points, and (2) over integrated error scores.

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: Mr. Terry Emerson, FDCS, Ext 55496

Contractor: Bunker-Ramo Corporation

Date of Availability: Current

Description: The program uses a "within and between subjects" design to compute Polar and Non-Polar Means and Standard Deviations and Analysis of Variance.

Title: Analysis of Mission Success Probability

Usage: Systems Integration

Math Technique Used: Trial-and-error comparison

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: R. O. Anderson, FDCC, 52148

Contractor: Bell Aerosystems Co.

Date of Availability: Immediate

Description: The AMSP digital computer program integrates systems design, reliability analysis, and human factors information into an overall mission success probability and provides a listing in ranked order of probability of those failure mode combinations making the greatest contribution to the probability of mission failure.

Title: A Digital Computer Program for the Determination of Safe Take-Off Paths

Usage: Optimal Control

Math Technique Used: Calculus of Variations

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: D. K. Bowser or A. J. Connors, FDCC, 52148

Contractor: N/A (In-house)

Date of Availability: Immediate

Description: The program computes optimum take-off-and-climb trajectories which minimize some function which is related to the probability of crash due to system failure. The program is limited to longitudinal force equations.

Title: Non-Linear Random Process Analysis

Usage: Subroutine

Math Technique Used: Runge-Kutta numerical integration, and a random number generator based upon a modified table look-up routine.

Computer Used: IBM 7094

Language: Fortran IV and Map

FDL Contact: D. K. Bowser, FDCC, 52148

Contractor: N/A (In-house)

Date of Availability: Immediate

Description: This program inputs a gaussian random process with an exponentially decaying autocorrelation function to a set of non-linear flight control systems. The output is in terms of means, variances, and density functions of the parameter of interest.

Title: Random Function Generator

Usage: Subroutine

Math Technique Used: Modified table look-up

Computer Used: IBM 7094

Language: Map

FDL Contact: D. K. Bowser, FDCC, 52148

Contractor: N/A (In-house)

Date of Availability: Immediate

Description: This program generates a pseudo white noise random process with a gaussian density function based upon a modified table look-up method.

Title: Mean Square Integral Routine

Usage: Subroutine

Math Technique Used: Determinate Evaluation Routine

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: D. K. Bowser, FDCC, 52148

Contractor: N/A (In-house)

Date of Availability: Immediate

Description: This program computes variances from power spectral density and transfer function, i.e.,

$$I = \frac{1}{2\pi j} \int_{-j\infty}^{+j\infty} \left| \frac{N(S)}{D(S)} \right|^2 ds$$

Title: Jet Interaction Effectiveness Program

Usage: High Speed Dynamics

Math Technique Used: Interaction for the separation point

Computer Used: UNIVAC 1108

Language: Fortran IV

FDL Contact: Eugene Fleeman, FDCC, 54331

Contractor: McDonnell Douglas Missiles & Space Division

Date of Availability: Immediate

Description: This program predicts the control effectiveness of transverse jets interacting with a high-speed free stream. The point of separation is then determined.

Title: Program for Calculating Laminar Flow Separation over Supersonic Controls and Inlets with Heat Transfer

Usage: High Speed Dynamics

Math Technique Used: Dorodnicyn's Method of Integral Relations for the Numerical Solution of Partial Differential Equations.

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: Eugene Fleeman, FDCC, 54331

Contractor: Nielsen Engineering and Research Corp.

Date of Availability: 1 July 1968

Description: This program calculates laminar separated flows at supersonic speeds for two-dimensional or axisymmetric configurations. The axisymmetric configuration is reduced to an equivalent two-dimensional one by a Mangler transformation. The computation is performed in the equivalent plane then transformed back into the axisymmetric one.

Title: Hypersonic Unsteady Flow Field

Usage: High Speed Dynamics

Math Technique Used: Small perturbation theory; from the steady state solution of gravalos for blunt bodies, modified Taylor-Maccoll for pointed bodies.

Computer Used: IBM 7094

Language: Fortran II

FDL Contact: Jerry E. Jenkins, FDCC, 54331

Contractor: General Electric, MSD

Date of Availability: Immediate

Description: This program computes the inviscid static and dynamic stability derivatives for a pointed or spherically blunted body of revolution (or the analogous two-dimensional shape) in supersonic or hypersonic flight. Solutions are valid for small motions from zero angle of attack; perturbations in the flow field due to angle of attack, rate of change of angle of attack, and pitch velocity are computed. A complete description is given in FDL-TDR-64-149, Part III.

Title: Laitone-Chou Phugoid Comparison

Usage: Stability and Control

Math Technique Used: Elementary

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: R. J. Woodcock, FDCC, 55960

Contractor: N/A (In-house)

Date of Availability: Immediate

Description: This program compares three simple methods of calculating phugoid period and damping when derivatives are invariant with Mach number.

Title: Extraction of Stability Derivatives from Flight Test Data

Usage: Stability and Control

Math Technique Used: The method of Least Squares

Computer Used: IBM 7044

Language: Fortran IV

FDL Contact: Capt. James Pruner, FDCC, 54315

Contractor: Cornell Aeronautical Laboratories, Inc.

Date of Availability: Immediate

Description: Input data consisting of time histories as well as the trim condition at the start of each time history for various maneuvers are fed into the computer. The coefficients of the equations of motion are then calculated in a least squares sense.

COMPUTER PROGRAMS IN

FLIGHT MECHANICS TECHNOLOGY

Summary of Technical Effort in AFFDL

Exploratory and advanced development (including simulation) in aerodynamics, aerothermodynamics, gasdynamics and flight performance to establish configuration and mission profiles for aerospace vehicles.

Title: Combined Free Piston Cycle Program

Usage: Piston motion and gas properties for a free piston adiabatic compressor apparatus are determined.

Math Technique Used: Finite Differences

Computer Used: IBM 7090/7094 Direct coupled system

Language: Fortran IV

FDL Contact: Lawrence A. Walchli/FDMT/53376

Contractor: Fairchild Hiller, Republic Aviation Division

Date of Availability: Operational

Description: This program provides a description using the method of characteristics for the piston motion and gas properties for a free piston adiabatic compressor apparatus, covering both piston acceleration and deceleration phases. The effects of chambrage and multiple shock reflection ahead of the piston are treated. Ideal gas relations are assumed throughout.

Title: Valve Reservoir Flow

Usage: Gas flow properties are determined throughout a check valve system in a free piston shock tube.

Math Technique Used: Finite Differences

Computer Used: IBM 7090/7094 Direct coupled system

Language: Fortran IV

FDL Contact: Lawrence A. Walchli, FDMT, 53376

Contractor: Fairchild Hiller, Republic Aviation Division

Date of Availability: Operational

Description: This program describes an analytic study of the flow of gas through a valve system in a free piston shock tube. It calculates, at various locations of the valve section and downstream reservoir, the Mach number, temperature, pressure, weight, rate of flow, enthalpy and entropy of the gas. Ideal gas relations are assumed throughout this frictional flow process.

Title: Reservoir Decay History for an Impulse Facility Using Real Air For the Effluent

Usage: Real air properties are determined as a function of time for a reservoir exhausting through a choked orifice.

Math Technique Used: Finite Differences

Computer Used: IBM 7090/7094 direct coupled system

Language: Fortran IV

FDL Contact: Lawrence A. Walchli, FDMT, 53376

Contractor: N/A

Date of Availability: Operational

Description: The thermodynamic properties of real air are determined as a function of time for a reservoir exhausting through a choked orifice. In addition, all properties of the air at the sonic point are determined. Heat transfer is neglected throughout.

Title: HYPNZ (Hypersonic Nozzle Flow)

Usage: Hypersonic Nozzle Program

Math Technique Used: Analytical and Method of Characteristics

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: Mr. J. Van Kuren, FDME, 55043

Contractor: Convair

Date of Availability: Current

Description: The hypersonic nozzle program utilizes an analytical approach developed by Foelsch, and modified to incorporate equilibrium gas properties as suggested by Burgess and Lewis. This approach analyzes the nozzle flow field in several regions utilizing techniques appropriate to each region. The final results provided by this program are a complete tabulation of the coordinates and the flow properties along the isentropic core boundary.

Title: TBL (Turbulent Boundary Layer)

Usage: Turbulent Boundary Layer Program

Math Technique Used: Numerical Integration

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: Mr. J. Van Kuren, FDME, 55043

Contractor: Convair

Date of Availability: Current

Description: The boundary layer program calculates the growth of the turbulent boundary layer along the isentropic core boundary by a numerical integration of the Von Karman momentum integral equation for axisymmetric flow. Equilibrium real gas properties are accounted for in evaluating the local skin friction coefficient and in determining integral properties of the boundary layer. The program adds a local displacement thickness to a local coordinate height to determine the final nozzle contour.

Title: HANK (Hypersonic Nozzle Flow)

Usage: Nonequilibrium Gas Flow Area Matching

Math Technique Used: Treanor's Numerical Integration

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: Mr. J. C. Boison, FDME, 55043

Contractor: North American Aviation

Date of Availability: Current

Description: This program was developed for one-dimensional nonequilibrium reacting gas flow. In addition to nonequilibrium chemistry, the program includes nonequilibrium vibrational and electronic energy relaxation and coupling effects between these energy modes and the chemistry. The formulation is based on a one-dimensional flow matching either a prescribed pressure or area variation along a streamtube. Thermodynamic properties are computed by assuming an ideal gas mixture and the equilibration of translational and rotational temperatures. The internal energy modes, rotation, vibration, and electronic excitation, are considered uncoupled; and a rigid rotor, cut off simple harmonic oscillator, independent of the electronic state, is assumed. Excitation of vibrational and electronic energies are treated similarly with terms which account for relaxation and chemical reactions. The effects of nonequilibrium vibrational and electronic states on chemical rates are included in the coupling analysis. The vibrational relaxation time constants were obtained from the Millikan and White data while the electronic relaxation time constants were determined for nitrogen from an analysis of existing shock tube radiation measurements. The computer program was used to solve for the nonequilibrium flow in a hypersonic nozzle and for eight streamlines in the inviscid flow field over a spherically blunted nine-degree semiapex angle cone at zero angle of attack.

Title: SEMLOG (Semilog Curve Plotting)

Usage: Automatic Plotting of Semilogarithmic Curves

Math Technique Used: None

Computer: IBM 7094 and Benson-Lehner Plotter

Language: Fortran IV

Contact: Mr. D. E. Holsapple, FDME, 55043

Contractor: None

Date of Availability: Current

Description: The program is designed to use the Benson-Lehner automatic plotter and the library subroutine Plot 1 available at Wright-Patterson AFB. The program will take an X-array and Y-array of coordinates and automatically scale the X-array to some convenient scale. The Y-array will be plotted on the correct semilog paper that matches its order of magnitude. Up to ten cycles may be plotted for a single curve. Up to eight curves may be plotted on a single sheet of paper. Much of the handwork is eliminated from plots with many points.

Title: ISEQEX (Isentropic Equilibrium Expansion)

Usage: Isentropic Equilibrium Expansion Program

Math Technique Used: Trial and error solutions of algebraic equations.

Computer Used: IBM 7094

Language: Fortran IV

Contact: Lt. T. E. Miller, FDME, 55043

Contractor: None

Date of Availability: Current

Description: To calculate the isentropic equilibrium expansion of a converging-diverging nozzle when the input data is:

$$P_t,\ H_t,\ \text{and } d^* \quad \text{or} \quad \infty_t,\ T_t,\ \text{and } \dot{w}$$

Reference: "Empirical Equations for the Thermodynamic Properties of Air and Nitrogen to 15,000°K" by C. H. Lewis and E. G. Burgess, III (AEDC-TDR-63-138)

Title: Stagnation Point Heat Transfer

Usage: For outputs of heat transfer and skin friction

Math Technique Used: Simultaneous solution of ordinary differential equations

Computer Used: IBM 7094

Language: MIMIC

FDL Contact: Lt. T. M. Weeks, FDME, 55043

Contractor: None

Date of Availability: Current

Description: Computes stagnation point heat transfer to a two dimensional flat plate (Heimentz flow) when a spatial pattern of vorticity exists in the free stream. The program computes vorticity amplification and viscous dissipation and accounts for the appearance of higher frequencies.

Title: Fay & Riddell Plus Vorticity Interaction

Usage: Computes the change in heat transfer due to finite vorticity

Math Technique Used: Modified boundary conditions

Computer Used: IBM 7094

Language: MIMIC

FDL Contact: Lt. T. M. Weeks, FDME, 55043

Contractor: None

Date of Availability: Current

Description: Consists of two programs which include the modified boundary conditions obtained from vorticity interaction considerations. The first is applied to the Fay & Riddell "Method 1", the other to "Method 2".

Title: Shock Wave-Boundary Layer Interaction (Supersonic Aerodynamics)

Usage:

Math Technique Used: Standard digital techniques

Computer Used: IBM 7090/7094

Language: Fortran IV

FDL Contact: D. Sedlock, FDMM, 53528

Contractor:

Date of Availability: August 1966

Description: The method determines the laminar boundary growth in the region of a laminar boundary layer-shock wave interaction on a two-dimensional body in a perfect gas. Analysis currently limited to T_w/T_T = 1.0 and .2, but can easily be extended to other ratios.

Title: External Method of Characteristics (Supersonic Aerodynamics)

Usage:

Math Technique Used: Standard Digital Techniques

Computer Used: IBM 7090/7094

Language: Fortran II

FDL Contact: D. J. Stava, FDMM, 53528

Contractor:

Date of Availability:

Description: This program will compute the inviscid perfect gas flow field about 2-dimensional bodies (planar or axisymmetric) of arbitrary shape. Provision is made for sharp or blunt leading edge options, and can be coupled with a boundary layer program to provide an iterative viscous/inviscid analysis. Modifications currently under way are for real gas and exhaust nozzle application.

Title: Exhaust Nozzle Installed Performance

Usage:

Math Technique Used:

Computer: IBM 7090/7094

Language: Fortran IV

FDL Contact: J. A. Laughrey, FDMM, 53528

Contractor:

Date of Availability: September 1967

Description: The analytical techniques will calculate the effects of non-uniform external flow on the performance of convergent-divergent ejector, blow-in-door ejector and plug nozzles. The data required to perform the calculations include the conditions of the primary and secondary flow and the variation around the nozzle of the external pressure, Mach number and boundary layer thickness.

Title: Engine Face Distortion Parameter

Usage:

Math Technique Used: Standard Digital Techniques

Computer Used: IBM 7090/7094

Language:

FDL Contact: J. A. Laughrey, FDMM, 53528

Contractor:

Date of Availability: May 1967

Description: The program will calculate a distortion parameter at the entrance to a turbojet engine. The data required is the radial and circumferential distribution of the total pressure at the engine face.

Title: Theoretical Ejector Pumping Characteristics

Usage:

Math Technique Used: Normal Numerical Analysis Techniques

Computer Used: IBM 7090/7094

Language: Fortran IV

FDL Contact: J. A. Laughrey, FDMM, 53528

Contractor:

Date of Availability: September 1967

Description: The program will calculate the pumping characteristics of an ejector nozzle for either a viscous or an inviscid interaction between the primary and secondary flows: The primary flow field is determined by the method of characteristics and the secondary flow is assumed to be one-dimensional and isentropic.

Title: Smith and Clutter Nonsimilar Solution of the General Equations for Steady, Compressible Laminar Boundary Layer Flow

Usage:

Math Technique Used: Standard Digital Techniques

Computer Used: IBM 7090/7094

Language: Fortran IV

FDL Contact: D. Sedlock, FDMM, 53528

Contractor:

Date of Availability: October 1965

Description: The program will calculate the laminar boundary layer growth on two-dimensional or axisymmetric bodies for a perfect gas or equilibrium dissociative flow. The method allows arbitrary conditions of pressure gradient, heat transfer, mass transfer, surface temperature and fluid properties. Program has been modified to ignore transverse curvature terms.

Title: Modified Reshotko-Tucker Turbulent Boundary Layer Analysis

Usage:

Math Technique Used: Standard Digital Techniques

Computer Used: IBM 7090/7094

Language: Fortran II

FDL Contact: D. Sedlock, FDMM, 53528

Contractor:

Date of Availability: January 1965

Description: The program will calculate the turbulent boundary layer growth on two-dimensional or axisymmetric bodies for a perfect gas solution. The method allows arbitrary conditions of pressure gradient and heat transfer for a constant wall temperature. Program has been modified by altering shear stress distribution term. Modifications continue to improve analysis for severe adverse pressure gradients and real gas flow.

Title: Air and Nitrogen Mollier Diagrams up to 15,000° K

Usage:

Math Technique Used: Standard Digital

Computer Used: IBM 7090/7094

Language: Fortran IV

FDL Contact: G. K. Richey, FDMM, 53528

Contractor:

Date of Availability: January 1965

Description: This computer program calculates the equilibrium thermodynamic properties of air and nitrogen according to equations found in AEDC TDR 63-138. Suitable for use as a subroutine in computer programs where equilibrium properties are desired.

Title: Inlet Compression Surface Interative Chair Program

Usage:

Math Technique Used: Standard Digital

Computer Used: IBM 7090/7094

Language: Fortran II

FDL Contact: G. K. Richey, FDMM, 53528

Contractor:

Date of Availability: July 1966

Description: The method of characteristics and Prandt/Mayer inviscid analysis are coupled with the linearized Cohen-Reshotko laminar flow analysis to compute the entire flow field on wedges, cones, and inlet compression surfaces of arbitrary pressure gradient. The program automatically iterates between the inviscid flow field and the boundary layer solution until convergence is obtained. The original surface is modified according to the displacement thickness variation of the boundary layer to describe the effective contour.

Title: Linearized Cohen-Reshotko Laminar Boundary Layer Analysis

Usage:

Math Technique Used: Standard Digital

Computer Used: IBM 7090/7094

Language: Fortran II

FDL Contact: G. K. Richey, FDMM, 53528

Contractor:

Date of Availability: July 1965

Description: Method calculates laminar boundary layer integral properties, skin friction and heat transfer for arbitrary pressure gradient. Method has been modified for improved accuracy of separation prediction in strong adverse pressure gradients. Application is to supersonic/hypersonic inlet compression surfaces and control surface deflections.

Title: Generalized Prediction Method for Subsonic Base Pressure

Usage:

Math Technique Used: Algebra, Trigonometry

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: L. W. Rogers, FDMM, 55564

Contractor: GD/Convair

Date of Availability: September 1965

Description: Program can be used for the prediction of base pressures in three-dimensional flow at subsonic speeds. The method accounts for the independent effects of boundary layer thickness at separation, base flow angularity and base planform effects. This program evolved from a mathematical description of the fluid mechanics of two-dimensional base flow with the addition of empirical relations which extended the technique to three-dimensional flow.

Title: REALMS (Re-Entry Aerodynamics at Low & Mid Speed)

Usage: Prediction of Aerodynamic Characteristics of High L/D Type Re-Entry Vehicles at Subsonic and Supersonic Speeds

Math Technique Used: Algebra, Trigonometry, Numerical Interpolation and Iteration

Computer Used: IBM 7094

Language: Fortran IV and MAP

FDL Contact: Lt. Keel/FDMM/55564

Contractor: None

Date of Availability: 1 April 1968

Description: The program predicts C_L, C_D, & L/D vs. angle of attack for high L/D type Re-Entry Vehicles for Subsonic and Supersonic (Math 1.25 to 4.5) Flight. The program is a major modification of TREND (Trade-offs for Lifting Re-Entry Vehicle Evaluation and Nominal Design) which was developed by Fort Worth Division of General Dynamics. The input required is a geometric description of the vehicle and the flight condition (Mach and altitude).

Title: Data Reduction Program for Six Component Force Test

Usage:

Math Technique Used: Algebra, Trigonometry

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: N. H. Allen, FDMM, 55564

Contractor: N/A

Date of Availability: 1 March 1967

Description: The program will reduce the data generated by a six component force test to coefficient form. The coefficients can be referenced to the body, wind and stability axis. The program will compute Mach number, dynamic pressure, Reynolds number and the base pressure coefficient. The program can utilize the pitch-roll model capability and compute combined angles of model pitch and yaw.

Title: One-Dimensional Potential Flow in Hypersonic Nozzles

Usage: Calculates aerothermodynamic flow parameters at the exit of a conical hypersonic nozzle, based upon given stagnation conditions and nozzle geometry.

Math Technique Used: Iterative method

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: Capt Thomas L. Larsen, FDME, 52742

Contractor:

Date of Availability: Current

Description: This program was developed to predict hypersonic wind tunnel operating parameters based upon arc heater operating conditions and nozzle geometry. Stagnation pressure and enthalpy in the arc heater are the primary inputs along with nozzle geometry data. The program calculates a one-dimensional potential flow expansion through the nozzle, using the real gas properties given in the AEDC Mollier Deck. The boundary layer displacement thickness is calculated and applied to the nozzle geometry. The free stream flow may be divided into a hot core and cool shroud characteristic of high pressure arc heater operation. Chemical freezing may be applied to the expanding flow. The program then uses an iterative method to reach the final solution.

Title: Finite Difference Hypersonic Blunt Body Solution

Usage: Calculates aerothermodynamic flow conditions around a blunted cone in hypersonic flow

Math Technique Used: Finite difference method to achieve the complete solution of the Navier-Stokes equations.

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: Capt Thomas L. Larsen, FDME, 52742

Contractor: General Dynamics/Convair

Date of Availability: Current

Description: This program was developed to calculate the aerothermodynamic conditions surrounding a blunted cone in hypersonic flow, so that the results could be compared with wind tunnel data. The model may have either a hemispheric or elliptically blunted nose. The nozzle exit conditions or free stream conditions ahead of the model, along with model geometry data, are the primary inputs to the program. The finite difference method is used to develop the complete solution to the Navier-Stokes equations as applied to the flow over the model.

Title: Investigation of Techniques to Evaluate Design Trade-Offs in Lifting Re-entry Vehicles

Usage:

Math Technique Used:
1. USAF DATCOM Handbook
2. Hankey and Alexander Hypersonic Theory (ASD-TR-63-668 - Confidential)

Computer Used: IBM 7094 Digital Computer

Language: Fortran IV

FDL Contact: Duane R. Burnett, FDMS, 55006

Contractor:

Date of Availability: Operational

Description: During preliminary design evaluation studies, rapid methods are required in order to evaluate trade-offs between various configuration geometry design parameters. The prediction techniques consist of relationships between vehicle geometric design parameters and performance parameters in the technical areas of lift and drag, stability and control and aerothermodynamics. These relationships were established in the subsonic, supersonic and hypersonic flight regimes. Wherever possible, sensitivity factor equations (i.e., partial derivatives) were developed from the prediction techniques for use in the computer program. In cases where the analytical differentiation of relationships was not possible, a finite difference technique was employed in the computer program for obtaining sensitivity factors.

Title: Newtonian Arbitrary Body Program

Usage: Computes the inviscid hypersonic aerodynamic characteristics for vehicles of arbitrary shape

Math Technique Used: Algebra; Numerical Integration

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: Val Dahlem, FDMG, 52630/52149

Contractor: In-house

Date of Availability: Current

Description: Newtonian impact theory is applied whereby the hypersonic aerodynamic characteristics are computed using inputs determined from geometrical constructions. The pressure coefficients are integrated over the surface of the body using numerical techniques.

Title: Modified Super Newtonian Arbitrary Body Program

Usage: Aerodynamic characteristics of lifting body shapes can be calculated down to Mach 1.5

Math Technique Used: Algebra, iteration, double integration using Simpson's rule

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: Val Dahlem, FDMG, 52630/52149

Contractor: In-House

Date of Availability: Current

Description: Inputs are the geometry of the vehicle. Pressure coefficients are calculated as function of Mach No. and local deflection angle, then integrated over the body surface to find forces and moments. Pressure coefficients follow a curve fit of the cone tables.

Title: Gentry Arbitrary Body

Usage: To determine the aerodynamic characteristics of complex hypersonic vehicle shapes

Math Technique Used: Algebra, Numerical Integration

Computer Used: IBM 7090/94

Language: Fortran IV

FDL Contact: D. Shereda, FDMG, 52630

Contractor: Douglas

Date of Availability: Current

Description: This analysis system consists of four basic program components under the control of an executive main program. The outstanding feature of this system is its flexibility in covering a wide range of problems. The geometric description techniques provide the capability of handling completely arbitrary 3-dimensional shapes (Ref. DAC Report 56080 Vol I & II)

Title: Laminar Boundary Layer Displacement Thickness

Usage: Computes boundary layer properties in continuum flow and iterates along surface streamwise contour

Math Technique Used: Algebra

Computer Used: CDC 160A

Language: Fortran II

FDL Contact: Val Dahlem, FDMG, 52630/52149

Contractor: In-house

Date of Availability: Current

Description: Two dimensional flow of a Blasius laminar boundary layer is calculated using the Reference Temperature method to account for compressibility. A simultaneous match of displacement thickness and thickness slope is used to keep pressure distributions continuous over changes in local surface angles.

Title: Boundary Layer Program

Usage: To calculate flow properties within laminar compressible boundary layers

Math Technique Used: Implicit finite-difference method

Computer Used: IBM 7090/7094

Language: Fortran IV

FDL Contact: D. Shereda, FDMG, 52630

Contractor: General Applied Science Lab.

Date of Availability: Current

Description: This program calculates flow properties within boundary layers, for an "ideal" compressible gas. The governing differential equations are approximated by an implicit-differencing scheme which is posed directly in physical coordinates. The program is designed for two-dimensional or axisymmetric bodies and the initial data through the boundary layer must be prescribed. (Ref. GASL TR 629)

Title: Real Gas Oblique Shock

Usage: Computes the two-dimensional oblique shock properties of air in chemical equilibrium

Math Technique Used: Algebra with multiple iterations

Computer Used: IBM 7094 and CDC 160A

Language: Fortran II and IV

FDL Contact: Val Dahlem, FDMG, 52630/52149

Contractor: In-House

Date of Availability: Current

Description: Two dimensional oblique shock properties are computed for air. The real gas effects of NACA TN 4259 (Hansen & Heims) is used. The solution follows the method suggested in WADC TR 59-610. A Tech Memo is available describing the IBM 7094 version of the program, ASRMDF TM 61-9. Since then it has been re-programmed for the CDC 160A and the iteration schemes modified to speed computations and eliminate regions of no solution.

Title: Coordinate Generator

Usage: To generate X-Y coordinates from drawings of vehicle cross-section data used as inputs to other programs

Math Technique Used: Algebra

Computer Used: CDC 160A

Language: Fortran II

FDL Contact: P. Gord, FDMG, 52630

Contractor: In-House

Date of Availability: Presently available

Description: Electrical impulses, proportional to physical dimensions, are generated by a converted X-Y plotter. The electrical impulses are fed through an analog-digital unit to the CDC 160A computer, where they are recorded on Mag-tape in millivolts. The coordinate generator program reduces the data from millivolts to physical dimensions according to any arbitrary scale.

Title: Low Speed Aerodynamics of Hypersonic Vehicles

Usage: To predict the low speed performance of slender bodies

Math Technique Used: Algebra and Numerical Integration

Computer Used: CDC 160A

Language: Fortran II

FDL Contact: P. Gord, FDMG, 52630

Contractor: In-House

Date of Availability: Prototype form available now.

Description: Program uses as inputs the physical characteristics of any slender lifting body. Based on these inputs, the program calculates the lift, drag, normal force, axial force, and pitching moment coefficients as a function of angle of attack and control surface deflections. Program at present can calculate only a linear normal force coefficient, but with future modifications, it is hoped to have the capability to calculate a non-linear normal force.

Title: Modified Creager

Usage: To determine aerodynamic characteristics and pressure distributions over flat plate or delta wing

Math Technique Used: Algebra

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: E. McElderry, FDMG, 52630

Contractor: In-House

Date of Availability: Current

Description: The procedure calculates aerodynamic characteristics utilizing Newtonian, tangent wedge, blast wave, and viscous interaction theories. Applicable in high Mach number range, moderate to high angle of attack, sweep angles to about 70 degrees.

Title: Delta Wing Pressure Integration

Usage: To determine aerodynamic forces on a delta wing by integrating a measured pressure distribution

Math Technique Used: Double interpolation; summation

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: E. McElderry, FDMG, 52630

Contractor: In-House

Date of Availability: Current

Description: Any number of pressures (theoretical or experimental) may be input with their corresponding (X,Y) locations on the model surface. The program divides the surface into a number of chordwise stations and radial lines. A double interpolation scheme determines a pressure at the intersection of each station with each radial line. The pressures are then averaged over the elemental area and summed.

Title: Interference Analysis of Parallel Staged Blunt Delta Wings

Usage: Predicts the centerline shock shape about a blunt delta wing at moderate angles of attack.

Math Technique Used: Multiple iterations, algebra, integration

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: Val Dahlem, FDMG, 52630/52149

Contractor: In-House

Date of Availability: Current

Description: The program predicts the shock shape along the centerline of a blunt delta wing in the following manner: (1) the local shock angles along the centerline of a blunt delta wing at zero angle of attack are first computed (2) the local shock angles at the desired angle of attack are then computed by correcting the zero angle of attack results for effects of attack (3) the resulting local shock angles are then used to compute the shock shape for the desired angle of attack.

Once the initial (non-interference) shock shape about both the upper and lower delta wing is computed, shock-shock interaction and shock-expansion interaction effects on the shock shapes are determined.

Title: Douglas 2-Dimensional Characteristics for Interfering Flow Fields

Usage: Predicts the aerodynamic interference associated with two parallel bodies in hypersonic flow.

Math Technique Used: Method of Characteristics

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: Val Dahlem, FDMG, 52149/42630

Contractor: Douglas

Date of Availability: Current

Description: The program predicts the shock-shock intersection point and shock-body intersection point for adjacent cone-cylinder bodies and delta wings for variable gap and stagger distances. The flow field and shock-shape upstream of the shock-shock intersection point is listed as output.

Title: Skin Friction (Described in TM 65-27)

Usage: To compute real gas skin friction coefficients for use in computing aerodynamics of hypersonic re-entry vehicles.

Math Technique Used: Iteration on several cubic equations

Computer Used: IBM 7090/94

Language: Fortran IV

FDL Contact: D. Shereda, FDMG, 52630

Contractor: In-House

Date of Availability: Current

Description: Solves a cubic equation for the velocity ratio across an oblique shock while computing the dissociation and ionization factors. The program computes the skin friction by using the reference-enthalpy method.

Title: HTF Tunnel Condition and Calibration

Usage: Determination of high temperature facility test conditions and/or facility test section calibration data.

Math Technique Used: Algebra

Computer Used: CDC 160A

Language: Fortran II

FDL Contact: E. Marshall, FDMG, 52630

Contractor: In-House

Date of Availability: Current

Description: Reduces pressure and temperature data from the high temperature facility. Calculates free stream Mach number from measured impact pressure and then calculates all free stream conditions. Included all heater, nozzle, test cabin, diffuser, heat exchanger and vacuum system data.

Title: 3-Component Force and Moment Data Reduction Program

Usage: Determination of normal force, axial force and pitching moment coefficients during force tests in the high temperature facility.

Math Technique Used: Algebra

Computer Used: CDC 160A

Language: Fortran II

FDL Contact: R. Smith, FDMG, 53061

Contractor: In-House

Date of Availability: Current

Description: Program uses measured normal force; axial force and pitching moment, automatically correcting for tare values, to determine the appropriate coefficients. No correction for loads due to water cooling jackets are taken into account.

Title: Nozzle Boundary Layer Analysis

Usage: Calculates displacement boundary layer thickness for axially symmetric wind tunnel nozzles (hypersonic) also curve fits potential flow boundary.

Math Technique Used: Integration, Algebra Transformations

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: C. Schnable, FDMG, 52630

Contractor: In-House

Date of Availability: June 1967

Description: Used with method of characteristics program (also available) to determine flow properties in axisymmetric hypersonic wind tunnel nozzles.

Title: Axially Symmetric Method of Characteristics For Hypersonic Wind Tunnel Nozzles

Usage: To calculate flow properties at any point in axisymmetric hypersonic wind tunnel nozzles.

Math Technique Used: Axisymmetric method of characteristics finite differences method.

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: C. Schnable, FDMG, 52630

Contractor: In-House

Date of Availability: June 1967

Description: If potential flow boundary is known, flow properties are calculated directly. If potential flow boundary is not known, can be used with boundary layer program (also available) to determine potential flow boundary and then to calculate flow properties. Also generates data to plot:

(1) Characteristic mesh points showing flow direction at each point
(2) Lines of constant Mach Number
(3) Mach number distribution at any station in the nozzle
(4) Mach number along potential flow boundary

Title: Nozzle Boundary Layer Analysis

Usage: Calculates displacement boundary layer thickness for axisymmetric hypersonic wind tunnel nozzles.

Math Technique Used: Modified Stewartson transformation momentum equation - Crocco's quadratic

Computer Used: CDC 160A

Language: Fortran II

FDL Contact: C. Schnable, FDMG, 52630

Contractor: In-House

Date of Availability: June 1967

Description: Step-by-step integration of momentum equation allows calculation of momentum and displacement thickness in hypersonic wind tunnel nozzles.

Title: A Method to Compute Test Section Flow

Usage: To calculate the test section flow characteristics of an arc-type facility.

Math Technique Used: Algebra, Integration iteration

Computer Used: CDC 160A

Language: Fortran II

FDL Contact: William Rockwell, FDMG, 66610

Contractor: In-House

Date of Availability: Present

Description: A method of estimating the test section flow properties of a hypersonic wind tunnel is presented. The test medium, air, is considered to expand isentropical from a reservoir through a converging-diverging nozzle and to be either in chemical equilibrium or chemically and vibrationally frozen. The flow is assumed to freeze at a plane in the throat. An effective flow cross section is determined by subtracting the flow area due to boundary layer displacement thickness. Stagnation point heat transfer rates are computed using Fay and Riddell's correlation formulas for a catalytic wall.

Title: Unified Flow Field Program

Usage: Calculates nonuniform, nonequilibrium flow fields about blunt axisymmetric and two dimensional bodies.

Math Technique Used: Integration, Algebra, Methods of Characteristics

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: A. Lewis, FDMG, 55510

Contractor: Cornell Aero. Lab.

Date of Availability: Present

Description: A modification of the inverse technique of Van Dyke is used to solve the system of equations in the bow region. A characteristic solution based on Hartree characteristics is used in the supersonic region.

This program was designed primarily for use with nonequilibrium, nonuniform free stream conditions found in hypersonic wind tunnels. It will handle up to 15 species and 35 chemical reactions with two nonequilibrium vibrators. In addition the effect of up to 16 radiating systems body oriented magnetic and a field can be included. Boundary layer displacement thicknesses are obtained by a local similarity technique. Output includes all physical parameters plus specie concentrations at each point calculated.

Title: Subsonic Blunt Body Program

Usage: To compute the subsonic flow field about a blunt body.

Math Technique Used: Integration, Interpolation, Algebra

Computer Used: IBM 7090/94

Language: Fortran IV

FDL Contact: D. Shereda, FDMG, 52630

Contractor: General Applied Science Laboratory

Date of Availability: Present

Description: This program uses a time dependent technique in which the shock is a discrete discontinuity. The body (2-dimensional or axisymmetric) and an initial shock must be prescribed (Ref. GASL TR 583).

Title: Reacting Gas Boundary Layer Program

Usage: To calculate the nonequilibrium boundary layer about axisymmetric and two dimensional bodies.

Math Technique Used: Finite difference scheme of Crank-Nicolson

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: A. Lewis, FDMG, 55510

Contractor: Cornell Aero Laboratory

Date of Availability: Present

Description: The Reacting Gas Boundary Layer Program is used as a compliment to the Unified Flow Field Program. It calculates the boundary layer parameters based on edge conditions obtained from the Unified Program. The chemistry is limited to 7 species and a set of chemical reactions built into the program. It does allow for the injection of one inert specie into the boundary layer and also allows for variable catalyticity at the wall. Output includes viscous and wall edge conditions plus profile data including specie concentrations.

Title: Inverse Method of Characteristics

Usage: To compute the supersonic flow field about an unknown two dimensional or axisymmetrical body.

Math Technique Used: Method of Characteristics

Computer Used: IBM 7090/94

Language: Fortran IV

FDL Contact: D. Shereda, FDMG, 52630

Contractor: General Applied Science Laboratory

Date of Availability: Present

Description: This program has been developed to compute the steady supersonic flow field of an inviscid, non-homo-energetic, non-homentropic, compressible, calorically and thermally perfect gas which may or may not have imbedded shocks. This inverse program requires as initial data an uprunning characteristic and the prescribed pressure. The resulting bottom streamline corresponds to the edge of the boundary layer. (Ref. GASL TM 156)

Title: Three-Dimensional Flow Field Program

Usage: To compute the viscid-inviscid flow field about three-dimensional bodies.

Math Technique Used: Method of Characteristics, Finite Difference

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: A. Lewis, FDMG, 55510

Contractor: Norair

Date of Availability: March 1968

Description: The computer program will determine the flow, for Mach number greater than approximately 5, about a class of bodies at arbitrary angles of attack, but zero yaw. The class of bodies treated consists of blunt, leading-edge delta wings with variable width of flats, variable thickness, and variable leading-edge eccentricity, but with continuous slopes everywhere. The initial portion of the body must, however, be spherical. The computer program can calculate the flow fields using either an ideal gas (with a constant but arbitrary specific heat ratio), or a real equilibrium gas (for temperatures up to 15,000 K and pressures less than 10 atmospheres). The program has several limitations:

1. The angle of attack is limited to those values for which the body sonic point remains on the spherical nose. (Roughly = 45 degrees).

2. The boundary layer is treated as though it is always attached.

3. No imbedded or secondary shocks are calculated.

4. The boundary layer is assumed to be entirely laminar.

Title: Laminar-Turbulent Momentum Integral Program

Usage: To calculate aerodynamic heating to bodies with a turbulent boundary layer.

Math Technique Used: Integration, Algebra

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: G. Burke, FDMG, 52701

Contractor: Boeing

Date of Availability: Present

Description: The program calculates heating distributions on a simple shapes as spheres, cylinders, two-dimensional and axisymmetric bodies and sharp delta wings with minimal input. More complicated shapes can be handled if the body, pressure and temperature distributions, and streamline divergence factors are described. The program, which uses the Boeing reference rho-mu method, is discussed in AFFDL 67-144, Volume III, written under contract AF 33(615)-2372.

Title: Swept Leading Edge Flow Field Program

Usage: To calculate the flow about swept leading edge in hypersonic flow.

Math Technique Used: Integration, Algebra

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: G. Burke, FDMG, 52701

Contractor: North American

Date of Availability: Present

Description: Program consists of two decks. The first deck is used for swept infinite cylinders without spanwise gradients. It is also used to punch data cards for the second deck, which, with additional input, calculates the flow about a leading edge with spanwise gradients induced by tip or end effects.

Title: Swept Wind Stagnation Line Heating

Usage: To determine center line heating on delta planform for performance analysis constraint.

Math Technique Used: Algebra, Integration

Computer Used: CDC 160A

Language: Fortran II

FDL Contact: S. Rinn, FDMG, 55488

Contractor: In-House

Date of Availability: Present

Description: This program employs flat plate strip theory to compute the equilibrium wall temperature on the stagnation line or centerline of a swept wing and applies outflow theory to include sweep effects. Real gas effects are included and an empirical technique is utilized to compute the transition between laminar and turbulent flow. Low Reynolds No. effects are also considered.

Title: Stagnation Point Heating

Usage: To compute stagnation heating for flight performance constraint.

Math Technique Used: Algebra, Iteration

Computer Used: CDC 160A

Language: Fortran II

FDL Contact: S. Rinn, FDMG, 55488

Contractor: In-House

Date of Availability: Present

Description: This program utilizes the Fay and Riddell heat transfer equation to compute the equilibrium wall temperature of a hemispherical nose. Real gas, low Reynolds number, and shock layer radiation effects are also included.

Title: Six-Degree-of-Freedom Computer Program

Usage: To compute the performance of flight vehicles throughout the altitude and velocity spectrum.

Math Technique Used: Algebra, Integration

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: R. Nash, FDMG, 55488

Contractor: McDonnell

Date of Availability: Present

Description: In its basic form the program is set up to determine vehicle performance throughout the entire flight regime of speed and altitude in the atmosphere and gravity field of a non-spherical rotating planet. The program is formulated for seven options of varying refinement from the six-degree-of-freedom problem to the two-degree-of-freedom point mass problem. A reverse option for the aerodynamic analysis of flight test data is included in the program.

Title: Three-Dimensional Optimization Program

Usage: To compute optimum maneuvers of boosters re-entry vehicles or aircraft.

Math Technique Used: Steepest Descent

Computer Used: IBM 7094 (Basic), CDC 6600(Mod)

Language: Fortran IV (Basic), Fortran IV (Mod)

FDL Contact: R. Nash, FDMG, 55488

Contractor: McDonnell

Date of Availability: Present (Basic), Jan 68 (Mod)

Description: In its basic form the program is set up to handle the three-dimensional, point mass, vehicle flight path trajectory optimization problem. The program is capable of simultaneously handling up to fifteen state variable, six control variables and ten constraints. Most of the usual functions required in flight path studies are available within the program; others may be added as desired by simple program additions.

Title: Flight Path Error and Dispersion Analysis

Usage: To compute the error and dispersion of vehicle flight paths based upon random errors.

Math Technique Used: Root sum squares

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: R. Nash, FDMG, 55488

Contractor: McDonnell

Date of Availability: August 1968

Description: The program was formulated to perform error and dispersion analyses of flight vehicle trajectories. Three alternate methods for performing the statistical analysis are included. These methods range from the root-sum-squares combinations of deviations to the more complex random sampling of the trajectory population by computing trajectories with randomly generated multi-error sources.

Title: Specific Energy Program

Usage: To calculate contours of specific energy.

Math Technique Used: Algebra, Integration

Computer Used: CDC 160A

Language: Fortran II

FDL Contact: B. Benson, FDMG, 52134

Contractor: In-House

Date of Availability: January 1968

Description: The program was originally formulated to compute the excess specific power (P_s) maps for any prescribed power level over a prescribed load factor spectrum. To provide more information modifications have been incorporated to give range factor and radius of turn maps as well as Ps.

Title: 3D Preliminary Trajectory Program

Usage: Preliminary performance estimates of vehicle concepts.

Math Technique Used: Euler integration

Computer Used: CDC 160A

Language: Fortran II

FDL Contact: B. Benson, FDMG, 52134

Contractor: In-House

Date of Availability: Present

Description: The program solves the three dimensional equations of motion in a system of cylindrical coordinates. The vehicle forces are balanced in the wind axes system using the ARDC 1959 Atmosphere. Lateral trajectory control is through bank angle of zero, i.e. all coordinated maneuvers. Aerodynamic characteristics are input as an altitude varying set of coefficients as a series solution for C_L and C_D as a function of angle-of-attack.

COMPUTER PROGRAMS IN

STRUCTURES TECHNOLOGY

Summary of Technical Effort in AFFDL

Exploratory and advanced development in flight loads, atmospheric turbulence, analysis methods, statistical procedures, simulation techniques, flight load sensors, structural design concepts and materials utilization; work in these areas encompasses the entire flight regime of aerospace vehicles.

Title: Automated Minimum Weight Structural Design

Usage: Computer program to determine the least weight design for a given structural configuration under the action of a multiplicity of external loading (mechanical and thermal) conditions, and subject to pre-assigned limitations on the stresses and deflections of the structure. The range of structures which may be optimized is only limited by the extent to which a given structure may be satisfactorily idealized using the discrete elements available (axial force, shear panel/web, triangular and quadrilateral membrane, axial-flexural-twist element).

Math Technique Used: Matrix algebra, calculus, linear programming

Computer Used: IBM 7090, 7094; 7094 II; 7040/7094 DCS; 7044/7094 II DCS

Language: Fortran IV

FDL Contact: J. R. Johnson, FDTR, 55689

Contractor: Bell Aerosystems Co., Buffalo, N.Y.

Date of Availability: January 1967 (AFFDL-TR-66-180)

Description: Two programs are available, an intermediate capacity linear merit function program (104B), and a large scale nonlinear program (3548). The linear program can be used for the optimization of major structural components of up to 170-200 degrees of freedom, and the nonlinear program can handle structures with up to 450 degrees of freedom and includes geometric variables. The matrix displacement method is used for the analysis. (Ref: AFFDL-TR-66-180; AFFDL-TR-64-141).

Title: Second Version of Fortran Matrix Abstraction Technique - FORMAT II

Usage: A digital computer program for matrix analysis. Two special subroutines are provided for the automatic generation of matrices required for analysis of indeterminate structures by the Redundant Force Method and the Direct Stiffness Method. The range of problems which may be solved is only limited by the extent to which a given formulation may be expressed in matrix algebra. For structural problems, the force method matrix generator provides for general bars and shear panels, and the displacement method matrix generator provides for general bars and triangular and rectangular panels that carry in-plane forces.

Math Technique Used: Matrix algebra, Linear equations

Computer Used: IBM 360/50-/65 -75; GE 635; UNIVAC 1108; CDC 6600; IBM 7090, 7094, 7094 II, 7040/7094 DCS, 7044/7094 II DCS

Language: Fortran IV

FDL Contact: J. R. Johnson, FDTR, 55689

Contractor: Douglas Aircraft Company, Long Beach, Calif.

Date of Availability: 1967

Description: The basic program provides for abstraction of matrix and pseudo matrix operations on matrices up to 2,000 order. Available operations include all standard operations of matrix algebra and various nonstandard operations useful in structural analysis, e.g., the "structure-cutter" for automatic selection of optimum redundants in the matrix force method. If desired, the analyst can program his problem directly in matrix notation using simple Fortran-like statements without concern for bookkeeping required for storage of data on external devices (e.g., tapes). Up to nine user-coded subroutines can be added to function as integral parts of the program. (Ref: AFFDL-TR-66-207, Vol I-IV).

Title: Lockheed Thermal Analyzer

Usage: The program solves heat transfer problems by means of a network analogy. The problem is defined in terms of thermal capacitances and thermal resistances.

Math Technique Used: Finite Difference

Computer Used: IBM 7094 - IBM 7099 II
IBM DCS 7040/7098
IBM DCS 7044/7094 II

Language: Fortran IV

FDL Contact: R. M. Engle, Jr., FDTR, 55651

Contractor: Lockheed-California Company

Date of Availability: 13 March 1967

Description: The program consists of three basic sections. Section one compiles the input data. Section two performs the calculations and prints the desired results. Section three provides for on-line plots of temperature versus time for a maximum of twenty-five nodes. The input data limitations are very flexible. A maximum of 15,000 cells is available for data. Other restrictions include: 4000 nodes, 4000 resistors, 4000 capacitors, 2000 tables.

Title: Thermal Response in Sandwich Panels

Usage: Used to determine heat flow and temperature in either single or stacked panels considering connection, conduction, and radiation.

Math Technique Used: A forward finite difference form of the heat balance equation is solved to give temperature versus time results.

Computer Used: 7090, 7094, 7094 II, 7040/7094 DCS, 7044/7094 DCS

Language: Fortran II

FDL Contact: G. E. Maddux, FDTR, 55689

Contractor: Martin Marietta, Orlando Division

Date of Availability: 1964

Description: An analytical model is presented for predicting thermal response in honeycomb sandwich panels. The model considers a variety of configurations involving single or stacked panels. Consideration is given to all three modes of heat transfer and to temperature dependent thermophysical properties of the materials of fabrication. The heat balance equations are ofthe finite difference technique for solution. A stability criterion is presented for the heat balance equations. Validity of a portion of the analytical model is established by comparing predicted results to existing experimental data for single honeycomb panels. (Ref: FDL-TDR-64-135).

Title: Point Matching Solutions of Boundary Value Problems

Usage: Used to solve any Harmonic or Biharmonic boundary value problem with specific application to plate bending problems.

Math Technique Used: The method of undetermined parameters is employed.

Computer Used: 7090, 7094, 7094 II, 7040/7094 DCS, 7044/7094 II DCS

Language: Fortran II

FDL Contact: G. E. Maddux, FDTR, 55689

Contractor: Ohio State University

Date of Availability: 1964

Description: The equations of linear, thin, elastic plate theory, including thermal effects, are presented. Solutions to the governing differential equation require complementary and particular parts. Various forms of complementary and particular solutions suitable for handling arbitrary boundary shape and loading are presented, along with the resulting form of the slope, moment, and shear equations. Two forms of complementary solution are presented: the Michell solution, in polar coordinates, and the Levy solution, in rectangular coordinates. Three forms of particular solution are described: trigonometric and power series in rectangular coordinates, and concentrated load functions. The application of these solutions by the point matching method to the problems of thermally and transversely loaded plates are demonstrated by several examples. Application of the point matching method to other boundary value problems solvable in terms of harmonic and biharmonic functions is described; e.g., torsion, conductive heat transfer, plane elasticity, slow motion of a viscous fluid, membrame deflection, and electromagnetics. (Ref: AFFDL-TR-64-159).

Title: Discrete Element Thermal Stress

Usage: Used to design and analyze structural elements and assemblies.

Math Technique Used: Matrix abstraction and manipulation is used to minimize the potential energy in a structural system.

Computer Used: 7090, 7094 DCS, 7094 II, 7040/7094 DCS, 7044/7094 II DCS

Language: Fortran IV

FDL Contact: G. E. Maddux, FDTR, 55689

Contractor: Bell Textron

Date of Availability: 1 March 1968

Description: Using established matrix techniques, a general purpose large order discrete element Structural Analysis Program was written to furnish the means for accurate and efficient predictions of stresses and deformations in heated structures, including both orthotropic and isotropic behavior.

Title: SUNFIRE-I (Nuclear weapons effects)

Usage: Prediction of nuclear weapons fireball effects.

Math Technique Used: Numerical integration

Computer Used: IBM 7094/7044

Language: Fortran IV

FDL Contact: F. Janik/FDTR/52294

Contractor: Lockheed Missiles and Space Co.

Date of Availability: Current

Description: SUNFIRE-I predicts fireball ablation on a supersonic blunt body in a region near the stagnation point.

Title: SUNFIRE-II

Usage: Prediction of nuclear weapons fireball.

Math Technique Used: Numerical integration

Computer Used: IBM 7094/7044

Language: Fortran IV

FDL Contact: F. Janik, 52294, FDTR

Contractor: Lockheed Missiles and Space Co.

Date of Availability: Current

Description: SUNFIRE-II predicts fireball ablation on a subsonic blunt body in a region near the stagnation point.

Title: HIMACH (Nuclear weapons effects)

Usage: Prediction of nuclear weapons fireball effects.

Math Technique Used: Numerical integration

Computer Used: IBM 7094/7044

Language: Fortran IV

FDL Contact: F. Janik, FDTR, 52294

Contractor: Lockheed Missiles and Space Co.

Date of Availability: Current

Description: HIMACH predicts fireball ablation on a hypersonic blunt body both at the stagnation point and around the vehicle for surface axis angles greater than 30 degrees.

Title: LATA-II (Low Altitude Thermal Ablation-II)

Usage: Prediction of nuclear weapons fireball effects.

Math Technique Used: Numerical integration

Computer Used: IBM 7094/7044

Language: Fortran IV

FDL Contact: F. Janik, FDTR, 52294

Contractor: Lockheed Missiles and Space Co. and In-House (AFFDL)

)ate of Availability: Current

escription: LATA-II predicts the response to thermal radiation of structures immersed in, or very near, a fireball.

Title: HATA-II (High Altitude Thermal Ablation-II)

Usage: Prediction of nuclear weapons fireball effects.

Math Technique Used: Numerical Integration

Computer Used: IBM 7094/7044

Language: Fortran IV

FDL Contact: F. Janik, FDTR, 52294

Contractor: Lockheed Missiles and Space Co.

Date of Availability: Current

Description: HATA-II predicts the response to thermal radiation of structures immersed in, or very near, a fireball.

Title: VIBRA (Vibratory Inelastic Bending Response Analysis)

Usage: Prediction of nuclear weapons blast and thermal effects

Math Technique Used: Numerical Integration

Computer Used: IBM 7094/7044

Language: Digital

FDL Contact: F. Janik, FDTR, 52294

Contractor: Kaman AviDyne Inc.

Date of Availability: Current

Description: VIBRA predicts the survivability and vulnerability of A/C to nuclear weapons blast and thermal effects.

Title: PFR (Post-Failure Response)

Usage: Prediction of nuclear weapons blast and thermal effects

Math Technique Used: Numerical Integration

Computer Used: IBM 7094/7044

Language: Digital

FDL Contact: F. Janik, FDTR, 52294

Contractor: Kaman AviDyne Inc.

Date of Availability: Current

Description: PFR predicts the post-failure response of aircraft to nuclear weapons blast and thermal effects.

Title: Fatigue Life Prediction

Usage: Calculation of structure fatigue damage

Math Technique Used: Algebra

Computer Used: 7094

Language: Fortran IV

FDL Contact: D. Simpkins, FDTR, 55319

Contractor:

Date of Availability: On Request

Description: The program is based on the linear cumulative damage theory, and basic input data to the program is fatigue strength allowables and repeated load spectra for a structure for which damage is to be computed.

Title: Random Frequency Response

Usage: The frequency response function is computed from given random input and output time histories.

Math Technique Used: The spectra of the input and of the output and the cross-spectrum are utilized.

Computer: 7094

Language: Fortran IV

FDL Contact: Lynn Rogers, FDTR, 55573

Contractor: N/A

Description: Standard techniques are used to find spectra and cross-spectra. The method is documented in NASA TR R-70.

Title: Aerodynamic Loads Calculations

Usage: Calculation of Subsonic, Transonic and Supersonic Load Distributions and Interference Effects.

Math Technique Used: Matrix

Computer Used: IBM 7090/7094

Language: Fortran II

FDL Contact: C. J. Schmid, FDTR, 55319

Contractor:

Date of Availability: Currently available

Description: The executive program receives the Mach number and geometrical parameters (sweep angle, aspect ratio, taper ratio, angle of attack, and spanwise twist distribution) as input data; controls the calculation of spanwise loading; and prints out the total lift coefficient, lift curve slope, root bending moment curve slope, spanwise and chordwise location of the center of pressure, section lift coefficient, section center of pressure, spanwise loading parameter, spanwise angle of attack distribution, and complete pressure distribution as output data. The interference program additionally considers the geometrical parameters of the body and prints out the interference calculations with and without the effect of the body included.

Title: Aerodynamic Heating Analysis of Wing Structures

Usage: Program is oriented to identification of critical loading conditions for associated mission flight trajectories.

Math Technique Used: Algebraic operations

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: D. Simpkins, FDTR, 55319

Contractor:

Date of Availability: On request

Description: The program is designed such that flight trajectories can be flown and output interpreted in terms of critical loading conditions.

General input data consist of wing planform geometry, material properties, element geometry, weight, trajectory data, aerodynamic and heat transfer data. General output data consist of element temperatures, deflections and stresses.

Title: Wind Sounding Data Reduction

Usage: Reduce raw wind data for engineering application

Math Technique Used: Numerical Analysis

Computer Used: IBM 7040/7094

Language: Fortran II

FDL Contact: George Muller, FDTR, 55573

Contractor: AviDyne Research Inc.

Date of Availability: Currently available

Description: This program is used to assist in the detection of the more blatant errors in raw wind data as taken directly from WBAN Form 20, calculate statistical quantities of wind and wind shear, and format the data for direct use in engineering problems. Wind velocity and direction are given for each one-minute interval of balloon ascent.

Title: Trajectory Loads for Ballistic Vehicles

Usage: Compute external bending loads

Math Technique Used: Numerical Analysis

Computer Used: IBM 7040/7094

Language: Fortran II

FDL Contact: George Muller, FDTR, 55573

Contractor: AviDyne Research Inc.

Date of Availability: Currently available

Description: This program is used to determine the rigid body wind shear response of ballistic vehicles. Dependent vehicle characteristics are provided by a subroutine. Bending moments are computed along the length of the vehicle in two planes. Engine deflection angles are computed in two planes. Equivalent bending due to axial acceleration can be accounted for, if desired. Displacements along the trajectory are provided in three planes at specified time increments.

Title: Wind Loads for Preliminary Design of Ballistic Vehicles

Usage: Rapid computation of preliminary design loads that are caused by wind shear for Ballistic vehicles.

Math Technique Used: Numerical Analysis

Computer Used: IBM 7040/7094

Language: Fortran IV

FDL Contact: George Muller, FDTR, 55573

Contractor: Kaman AviDyne

Date of Availability: Currently available

Description: This program provides speed with excellent accuracy for establishing wind design loads using quantities of measured wind data. A 30 to 1 time saving with a 4.7% loss in accuracy in the 1% design loads is provided for preliminary design. The ground work provided by the preliminary analysis allows a similar time saving in final design without the accuracy loss.

Title: Application of Multiparameter Flight Loads Data to Structural Design Criteria

Usage: To develop exceedance curves, flight envelopes and calculate loads on wing and tail.

Math Technique Used: Statistical

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: Gene Durkee/FDTR/52788

Contractor: North American Rockwell Corporation Space Division

Date of Availability: 1 February 1968

Description: The program utilizes 8 channels of flight recorded digital data consisting of three translational accelerations (n_z, n_x, n_y), three rotational velocities ($\dot{p}$,$\dot{q}$,$\dot{r}$) equivalent velocity and pressure altitude. Eight parameters (p, q, n_{zc}, H_c, $\emptyset$, M and weight) are computed. The program performs the functions of counting and recording peaks and other parameters corresponding to the peaks and of recording time distribution. The program will automatically plot exceedance curves, envelopes and bar charts on the CRT SC-4020 plotter.

Title: Digital Computer Program for the Analysis of Crack Propagation in Cyclic Loaded Structures

Usage: The program is useful in solving numerous problems occurring in aircraft type structures, such as fatigue crack propagation and crack growth emanating from projectile impact damage.

Math Technique Used: Digital Analog Simulation Program (MIMIC)

Computer Used: 7094, 7094 II, 7040/7094 DCS, 7044/7094 II DCS

Language: MIMIC

FDL Contact: Howard A. Wood, FDTR, 55651

Contractor: In-House

Date of Availability: 1967

Description: The program calculates the crack propagation behavior of cyclic loaded structures by means of the theory and equation developed by Forman. The program was specifically written to take into account complex crack geometries and cyclic loads of nonuniform character. Crack description and loading is input in terms of the stress intensity factor range ΔK. In addition to providing crack length after a prescribed number of cycles, the solution determines the number of cycles required for crack instability or rapid growth to failure. (Ref: AFFDL-TR-67-5)

Title: Thermal Analyzer

Usage:

Math Technique Used: Finite difference

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: W. H. Goesch, FDTS, 52938

Contractor: Lockheed California Company

Date of Availability: Current

Description: The thermal analyzer program solves transient and steady state heat flow problems by providing a digital solution of an analogous R-C electrical network. The program analyzes in three dimensions a block that is heated by conduction, convection and radiation.

Title: One Dimension Charring Ablator Analysis

Usage:

Math Technique Used: Finite difference

Computer Used: IBM 7094

Language: MIMIC

FDL Contact: W. H. Goesch, FDTS, 52938

Contractor: In-House

Date of Availability: Current

Description: This program computes the initial material thickness needed to prevent exceeding some maximum stated temperature at the mounting surface throughout the heating period. The program uses a one dimensional analysis with a line for the pyrolysis zone.

Title: A Beam Analysis Including Time-Independent Plasticity for Determining the Air Load and Thermal Stress of a Hypervelocity Re-entry Vehicle

Usage:

Math Technique Used: Finite Difference

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: W. H. Goesch, FDTS, 52938

Contractor: Bell Aerosystems

Date of Availability: Current

Description: This program computes the longitudinal stresses at any station plan cross-section of a re-entry vehicle. The shape of the vehicle is restricted to a body which has a wedge plan view, an elliptical upper cross-section and a flat lower surface. The structural configuration and temperature distribution must be symmetric about the vertical centerline of the section. The analysis takes into consideration the time independent plastic strain of the structural material.

Title: Aerodynamic Heating and Aerodynamic Loads on a Hypervelocity Re-entry Vehicle

Usage:

Math Technique Used: Finite Difference

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: W. H. Goesch, FDTS, 52938

Contractor: Bell Aerosystems

Date of Availability: Current

Description: This program computes the cold wall heating rates, radiation equilibrium wall temperature and structural loads on a specific three-dimensional body during a hypersonic glide re-entry. The body is a flat bottom ellipse with a non-constant ratio of semi-axes.

Title: Cooling System Transient Analysis Program

Usage:

Math Technique Used: Finite Difference

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: W. H. Goesch, FDTS, 52938

Contractor: Bell Aerospace

Date of Availability: Current

Description: This is one of two programs used to design and analyze the structural cooling systems of hypervelicity vehicle airframes. This program determines the performance of a given cooling system design throughout a specified flight path.

Title: Cooling System Design and Weight Program

Usage:

Math Technique Used: Finite Difference

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: W. H. Goesch, FDTS, 52938

Contractor: Bell Aerospace

Date of Availability: Current

Description: This is one of two programs used to design and analyze the structural cooling systems of hypervelocity vehicle airframes. This program determines the sizes of certain items of the cooling system; the diameter and spacing of the cooling tubes, size of coolant storage tank, size of heat exchanger, etc. Pertinent information, like the coolant flow and pressure drop through the cooling tubes are also calculated. Also the weights of the various components and total weight of the cooling system are computed.

Title: Heat Transfer and Vehicle Weight Analysis

Usage:

Math Technique Used: Finite Difference

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: W. H. Goesch, FDTS, 52938

Contractor: Bell Aerosystems

Date of Availability: Current

Description: This program is one of three used for the analysis of thermal protection systems. It uses the steady state and transient heat transfer programs as subroutines in order to determine the weight of the complete vehicle.

Title: Transient Heat Transfer and Unit Weight Analysis

Usage:

Math Technique Used: Finite Difference

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: W. H. Goesch, FDTS, 52938

Contractor: Bell Aerosystems

Date of Availability: Current

Description: This program is one of three used for the analysis of thermal protection systems. It solves the same problem as the steady state problem except that the heat input is a function of time.

Title: Steady State Heat Transfer and Unit Weight Analysis

Usage:

Math Technique Used: Finite Difference

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: W. H. Goesch, FDTS, 52938

Contractor: Bell Aerosystems

Date of Availability: Current

Description: This program is one of three used for the analysis of thermal protection systems. It determines the thickness of insulation and weight of the thermal protection system required to maintain a given backface temperature for a given constant heat input for a given length of time.

Title: Automated Method for the Large Deflection and Instability Analysis of Three-Dimensional Truss and Frame Assemblies

Usage: Applicable for large deflection and stability studies of structural models with moderate number of bar and frame elements.

Math Technique Used: Function Minimization

Computers Used: IBM 7094, 7094 II, 7040/7094 DCS, 7044/7094 II DCS

Language: Fortran IV

FDL Contact: L. Berke, FDTR, 55689

Contractor: Case Institute of Technology

Date of Availability: 1967

Description: The Total Potential Energy of the bar and frame structural model is generated as the scalar sum of the contributions of each element and load for the current vector of generalized displacement variables. A direct minimization is used to select the displacements vector for which the Total Potential is stationary. The method predicts the behavior of structures that exhibit nonlinearity due to large deflections (geometric nonlinearity). For three-dimensional bar assemblies, truly large deflections and rotations can be studied for frame assemblies, moderate rotations are the limitations. (Ref: AFFDL-TR-66-102).

Title: Digital Computer Program for the Analysis of Aerospace Structures by the Matrix Displacement Method

Usage: Applicable to structures that can be idealized as an assembly of axial force members (bars), triangular and rectangular membrane plate elements.

Math Technique Used: Matrix Algebra

Computer Used: IBM 7094, 7094 II, 7040/7094 DCS, 7044/7094 II DCS

Language: Fortran IV

FDL Contact: L. Berke, FDTR, 55689

Contractor: In-House

Date of Availability: 1964

Description: The Matrix Displacement Method is programmed to solve idealized structures consisting of axial force members, triangular and rectangular in-plane elements with linear edge displacement and a rectangular element with linear stress distribution. Three dimensional assemblies of the above elements with a maximum of sixty (60) joints may be analyzed. Joint displacements, joint forces and member stresses are printed out. Five independent thermal-mechanical loading conditions may be analyzed simultaneously. (Ref: AFFDL-TR-64-18).

Title: Window System Computer Program

Usage: Essential criteria in the design and development of window systems for future aerospace vehicles.

Math Technique Used: The solution is obtained by numerically solving a system of partial differential equations each representing a heat balance of a finite element within the glaze. These equations, which are written in the finite difference form, are solved by applying the techniques of matrix Algebra.

Computer Used: IBM 7094

Language: Fortran IV under Ibsys

FDL Contact: Lt. David B. Reuber, FDTS, 55021

Contractor: Midwest Research Institute

Date of Availability: March 1969

Description: The Computer Program predicts temperature distributions and heat fluxes through coated and uncoated, single and multiple glaze semitransparent materials subjected to individual and combined convective and radiative heating. The mathematical model accounts for emission, transmission, absorption, and attenuation of radiant energy within glaze, including the multiple reflections of radiant energy due to the surface reflectance of the glaze.

Title: Arbitrary Shell of Revolution - Eigenvalue Program

Usage: Calculates the linearized buckling load in thin-walled elastic shells subjected to static edge surface and/or temperature loads (symmetrically distributed).

Math Technique Used: Numerical Integration - Iteration

Computer Used: IBM 7094, 7094 II, 7040/7094 DCS, 7044/7094 II DCS

Language: Fortran IV

FDL Contact: T. Bernstein, FDTR, 55689

Contractor: Lehigh University

Date of Availability: 1967

Description: Program is applicable to rotationally symmetric shells to which any number of axisymmetric branches are attached. The restrictions on the shell are that the geometric boundaries, material properties and loading are symmetric about one axis, however, the geometry, elastic properties and loading may vary in an arbitrary manner along the shell meridian.

TITLE: Arbitrary Shells of Revolution - Static Stress Analysis Program

Usage: Calculates stresses and displacements in thin-walled elastic shells subjected to static edges surface and/or temperature loads.

Math Technique Used: Numerical Integration

Computer Used: IBM 7094

Language: Fortran IV

FDL Contact: T. Bernstein, FDTR, 55689

Contractor: Lehigh University

Date of Availability: 1967

Description: Program is applicable to rotationally symmetric shells to which any number of axisymmetric branches are attached. The only restriction on the shell is that its geometry, boundaries and material properties are symmetric about one axis, however, the goemetry and elastic properties may vary in an arbitrary manner along the meridian of the shell. The surface loads and temperature loads may vary arbitrarily over the surface of the shell.

COMPUTER PROGRAM IN

V/STOL TECHNOLOGY

Summary of Technical Effort in AFFDL

Guidance of exploratory and advanced development programs in the area of vertical/short take-off and landing technology; establishment of requirements for parametric studies; planning, initiating managing and integrating of advanced technology development programs.

Title: V/STOL Propulsion and Power

Usage: Lift & Lift/Cruise Engine Performance Computation

Math Technique Used: Customer Deck

Computer Used: IBM 7094

Language: Version 5

FDL Contact: R. Hirt, D. Fraga, FDV, 52893/53565

Contractor: General Electric

Date of Availability:

Description: Parameters of turbo jet engine are input, program computes performance (thrust, SFC, η) and power available including SHP removed, bleed flows and bleed pressure available for control powers.

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13. ABSTRACT

A compilation of computer programs useful in the design of flight vehicles. Technical domains covered include the following:

Structures
Aerodynamics
Vehicle Dynamics
Flight Control
Environmental Control
Crew Escape and Retardation
Landing Gear Subsystems

All programs were devised in-house in the Air Force Flight Dynamics Laboratory or were prepared for them under R&D contracts.

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