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ORGANIZATION, PROGRAMS, AND ACTIVITIES OF THE TECHNICAL SECTIONS NORTRONICS-HUNTSVILLE

1 MAY 1968

NORTRONICS – HUNTSVILLE
NORTHROP CORPORATION
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from the desk of

J. A. BARCLAY

26 September 1968

Mr. David L. Christensen:

The information on technical publications issued by Nortronics-Huntsville is contained in Section IV of this publication.

J. A. Barclay

J. A. Barclay

ORGANIZATION, PROGRAMS, AND ACTIVITIES
OF THE
TECHNICAL SECTIONS
NORTRONICS-HUNTSVILLE

1 May 1968

Dr. Steve S. Hu
Technical Director

NORTRONICS - HUNTSVILLE
HUNTSVILLE, ALABAMA

FOREWORD

This brochure is intended to depict the present status of the technical activities of Nortronics-Huntsville as of the date indicated. It is based on all currently available information. It is subject to periodic revision as additional pertinent information becomes available.

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SECTION I

INTRODUCTION & BACKGROUND

1.1 NORTHROP CORPORATION

1.2 NORTRONICS-HUNTSVILLE

SECTION I

INTRODUCTION & BACKGROUND

1.1 NORTHROP CORPORATION

Northrop Corporation was founded in 1939 and, during the 28 years of its existence, has experienced a steady growth. At the present time, the Corporation employs over 20,000 personnel with over 5,000,000 square feet of engineering and research facilities. The company is organized as a line-managed corporation, designed to provide an advantageous combination of strength and flexibility along with sharp delineation of authority and responsibility. The top management of the Corporation is the Office of the President, which consists of Mr. Thomas V. Jones, President and Chief Executive Officer. The Office of the President, two Senior Vice-Presidents, and their corporate staff officers comprise the Corporate Headquarters. The operations of the company are executed by the line divisions as shown in Figure 1-1 under the direction of their respective General Managers. The General Managers, as Corporate Vice-Presidents, participate in the formulation of policies and plans of the Corporation and in the exploitation of its resources, wherever located, for the most effective discharge of its contractual commitments.

1.2 NORTRONICS-HUNTSVILLE

Nortronics-Huntsville, under the direction of John A. Barclay, was established in November 1962 as an advanced space research and technology department of Northrop Corporation. A chart depicting the current Nortronics-Huntsville organization is presented in Figure 1-2. Prior to his retirement, Major General John A. Barclay was Deputy Commanding General of the U. S. Army Ordnance Missile Command at Redstone Arsenal, Alabama. He was Commanding General of the Army Ballistic Missile Agency during the development of the Jupiter and Pershing Missiles and the initiation of the Saturn booster program.

The Nortronics-Huntsville management, research, and engineering facilities are housed in a 40,000 square foot, two-story building at 6025 Technology Drive in the Huntsville Research Park. Nortronics-Huntsville has access to the

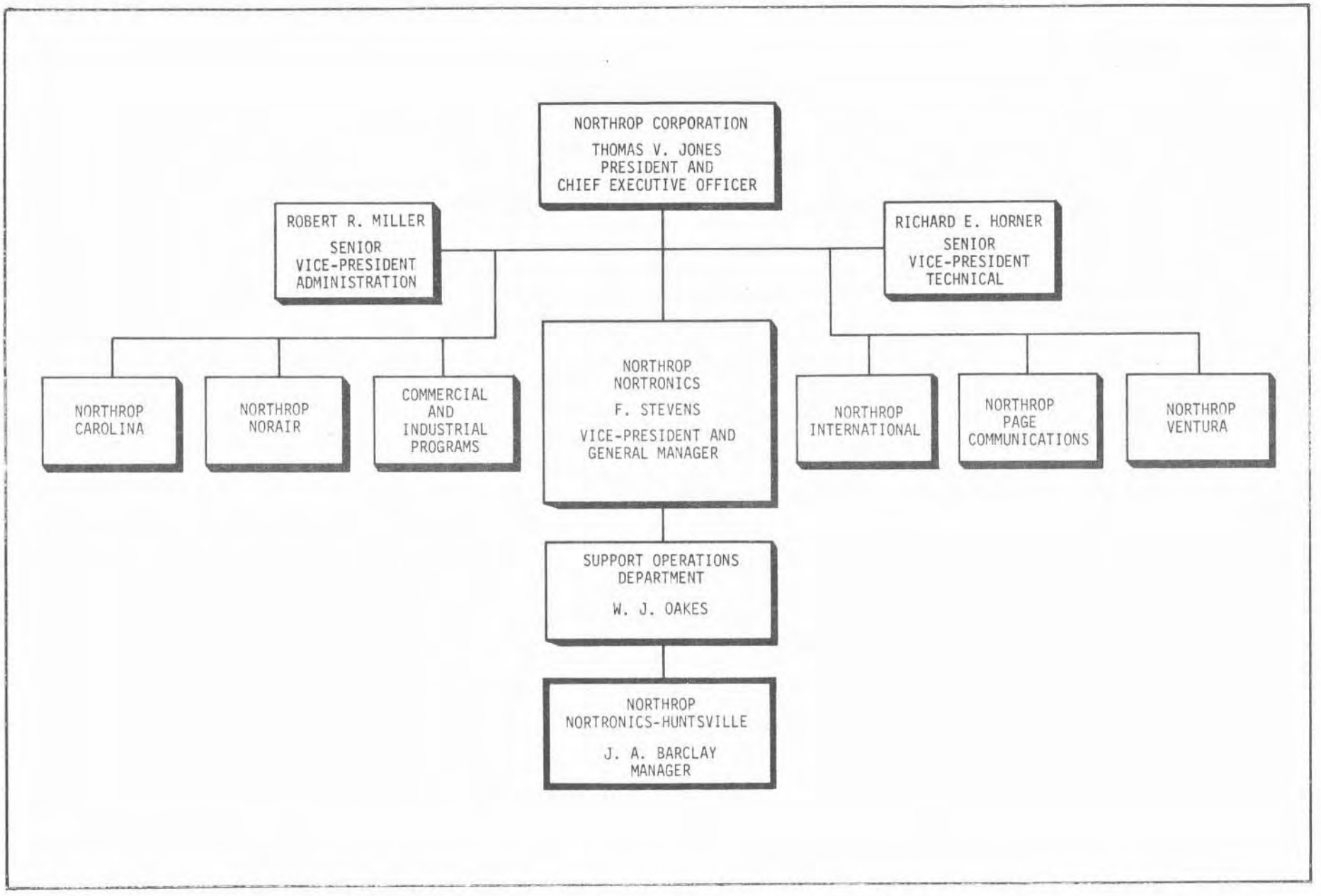

Figure 1-1. NORTHROP CORPORATION ORGANIZATION CHART

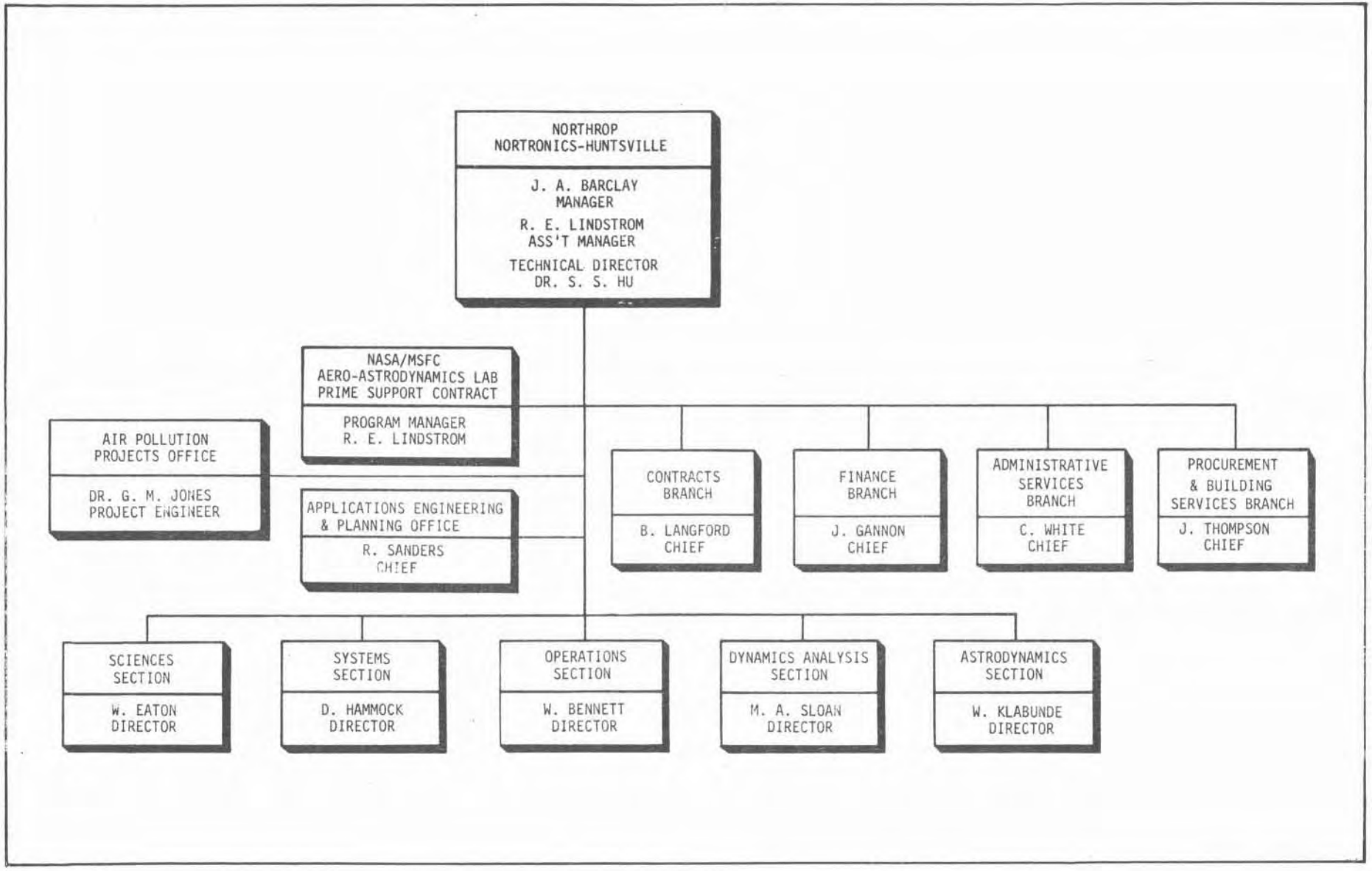

Figure 1-2. NORTRONICS-HUNTSVILLE ORGANIZATIONAL CHART

resources of the parent corporation as needed. These resources include a manpower pool of over 20,000 employees; aerospace engineering facilities of over 5,000,000 square feet; and a corporate history of 28 years experience in design, development, and production of aerospace vehicles, subsystems, components, and support equipment, including many important research, analysis, and systems projects.

SECTION II

TECHNICAL ORGANIZATION

2.1 GENERAL DESCRIPTION

2.2 SUPERVISORY AND STAFF PERSONNEL

2.3 SECTION DESCRIPTIONS

SECTION II

TECHNICAL ORGANIZATION

2.1 GENERAL DESCRIPTION

The overall technical activities of Nortronics-Huntsville are coordinated through Dr. Steve S. Hu, Technical Director. These technical activities or operations are conducted through five technical sections. Each section is composed of Groups and/or Branches which encompass the diversified disciplines comprising the technical capabilities of Nortronics-Huntsville. These overall technical activities or operations are carried out by more than 250 engineers, scientists, mathematicians, and supporting personnel. The technical interests of these personnel cover the spectrum of scientific endeavor and are represented by degrees in mathematics, physics, chemistry, physiology, geology, and most branches of engineering. The majority of the senior staff hold Ph.D. and M.S. degrees in science and engineering. The remaining personnel are technical supporting staff, most of whom hold B.S. degrees. The senior staff has an average of over ten years experience in research and development work.

2.2 SUPERVISORY AND STAFF PERSONNEL

TECHNICAL DIRECTOR

Dr. S. S. Hu

SECTION DIRECTORS:

Sciences Section	W. G. Eaton
Systems Section	D. M. Hammock
Operations Section	W. G. Bennett
Dynamics Analysis Section	M. A. Sloan
Astrodynamics Section	W. A. Klabunde

GROUP CHIEF:

Integrated Life Support Group (As a part of Operations Section)	T. W. Holt

BRANCH CHIEFS:

Sciences Section

Aero-Thermodynamics Branch	F. B. Tatom
Space Environment Branch	J. T. Stanley
Mathematics-Physics Branch	J. F. Andrus

Systems Section

Systems Engineering Branch	O. O. Ohlsson
Mission Analysis Branch	P. R. Odom
Design and Development Branch	D. M. Hammock (Acting)
Space Systems Branch	D. R. Spence
Weapons Systems Branch	D. M. Hammock (Acting)

Operations Section

Facilities Operations Branch	H. S. Ryan
Propellant Test Branch	M. L. Essick (Supervisor)

Dynamics Analysis Section

Control Dynamics Branch	F. L. Echols
Structural Dynamics Branch	C. M. Pearson
Guidance and Flight Performance Branch	I. E. Smith

Astrodynamics Section

Flight Mechanics Branch	D. R. Raney
Flight Evaluation Branch	W. A. Klabunde (Acting)
Trajectory and Orbital Analysis Branch	W. A. Klabunde (Acting)

RESEARCH PLANNING COMMITTEE: (Ph.D. & Ph.D. Candidates)

Dr. S. S. Hu	Dr. G. M. Jones
Dr. W. R. Garrett	Dr. M. Y. Su
Dr. W. J. Gray	Dr. J. D. Alexander
Dr. D. W. Lyons	Dr. S. C. Zien
Dr. J. F. Andrus	Dr. J. C. Williams
Dr. K. Seo	Dr. C. P. Bhalla
Dr. G. E. Baird	Dr. R. S. Kavipurapu
Dr. A. F. D'Souza	Dr. G. A. Petitt

RESEARCH PLANNING COMMITTEE: (Ph.D. & Ph.D. Candidates) (Concluded)

Dr. W. H. Purcell	Dr. B. L. Cline
Dr. J. C. Yu	Dr. T. F. Hung
Dr. J. G. Goree	Dr. W. F. Powers
Dr. J. D. Mahlmann	Dr. R. L. King
Mr. H. R. Rosner	Mr. R. Silber
Mr. S. V. Paranjape	Mr. C. K. Chou
Mr. D. O. Barnett	Mr. R. V. S. Yalamanchili

2.3 SECTION DESCRIPTIONS

2.3.1 Sciences Section

The Sciences Section, under the direction of Mr. W. G. Eaton, is organized into three scientific and engineering branches.

1. Aero/Thermodynamics
2. Mathematics-Physics
3. Space Environments.

Perform research, analysis, and engineering in: Aerodynamics, fluid mechanics, thermodynamics, heat transfer, gas dynamics, astrophysics, space radiation, planetary atmospheres, geophysics, mathematical analysis, scientific programming methods, and applied physics.

2.3.2 Systems Section

The Systems Section, under the direction of Mr. D. M. Hammock, is organized into five branches:

1. Systems Engineering
2. Mission Analysis
3. Design and Development
4. Space Systems
5. Weapons Systems

Perform systems engineering, development, and program management in areas of space systems, subsystem design and development, experiment development, weapon systems, conduct operations analyses pertinent to system and program definition.

2.3.3 Operations Section

The Operations Section is divided into three branches and one group:

1. MSFC Facilities Operations
2. MSFC Technical Documentation
3. Propellant Test Support
4. Integrated Life Support.

Provide Engineering Support to:

- Aero-Astrodynamics Laboratory Systems Office
- Aero-Astrodynamics Laboratory Crossed-Beam Project

Operating and Maintain:

- MSFC Wind Tunnel Facilities
- LRC Integrated Life Support and Propellant Test Facilities.

2.3.4 Dynamics Analysis Section

The section is divided into three branches:

1. Control Dynamics
2. Structural Dynamics
3. Guidance and Flight Performance.

Conduct research, analysis, and performance studies of dynamical systems in the areas of control dynamics, guidance and flight performance, and structural dynamics.

2.3.5 Astrodynamics Section

The Astrodynamics Section consists of three branches:

1. Flight Mechanics
2. Flight Evaluation
3. Trajectory and Orbital Analysis

Conduct research and analysis in flight trajectory optimization, shaping techniques, planetary entry dynamics and low thrust trajectory mechanics, as well as perform investigations of preflight and post flight trajectories, of Saturn type vehicles and conduct studies involving tracking networks, orbit determination and lifetime characteristics.

SECTION III

PROGRAMS & PROJECTS

SECTION III

PROGRAMS AND PROJECTS

The Technical Sections of Nortronics-Huntsville are currently engaged in or have completed numerous technical support and research contracts. These efforts, for the National Aeronautics and Space Administration and the Army Missile Command, are briefly described in the following paragraphs.

- NAS8-5233 - Studies in Dynamics, Flight Mechanics, and Astrophysics (2/5/63 to 12/31/63)

  This contract, for the Aero-Astrodynamics Laboratory, Marshall Space Flight Center, involved studies to determine parameters required for design criteria to be used in the development of large Saturn-type vehicles. Analytical investigations were conducted in Astrodynamics and Celestial Mechanics, Dynamics and Vehicle Performance, and Astrophysics.

- NAS8-9203 - Oscillograph Bay Group (12/21/63 to 5/4/64)

  Under this contract, Northrop designed and fabricated a data recording system consisting of two 50-channel recording oscillographs and associated signal conditioning, power supplies, and controls. The system includes calibration and monitoring equipment and is capable of recording up to 100 instrumentation data channels simultaneously.

- NAS8-11096 - MOLAB Evaluation Method (8/1/63 to 6/30/65)

  This study established a model for use in evaluating MOLAB design concepts. The technique used has wide applicability for various design concepts. Parameters considered were: development risk, reliability, maintainability, crew safety, cost, design simplicity, lunar terrain negotiability, performance efficiency, and weight. The parameters were considered for the storage, deployment, dormant, and operational phases of the mission. Analyses were also performed for lunar shelters, scientific instrument investigations, and small manned lunar surface vehicles in the form of a Lunar Surface Scientific Module (LSSM).

- NAS8-11111 - Mission Support Services (9/9/63 to 4/30/65)

  This contract, which represented an extension and enlargement of NAS8-5233, involved supporting research to the Aero-Astrodynamics Laboratory. In addition to the areas described in the above contract, research efforts in support of the Aerodynamics Division, the Systems Concepts Planning Office, and the Aero-Astrophysics Office were provided.

- NAS8-11552 - Portable Acoustic Monitoring System (PAMS) (10/2/63 to 5/30/65)

  Under this contract, Northrop designed, developed, and fabricated an acoustic data gathering system. The system is used to measure sound pressure levels generated by Saturn first-stage vehicles. Up to 50 remote measuring stations, at radii up to 25 miles from the test vehicle, controlled by a central station through two-way command and telemeter radio links, constitute the system.

- NAS8-11573 - FM for Field Acoustic Monitoring Station (LAMS) (12/9/63 to 7/9/64)

  This engineering and manufacturing contract required the design and fabrication of remote, pole-mounted acoustic data units. This system, also designed to gather sound pressure data, used wire lines rather than R.F. for transmission of telemetry and command. Test sets to facilitate maintenance of the pole-mounted stations were also designed.

- NAS8-11171 - Aerodynamic Facilities Operation, Marshall Space Flight Center (2/19/64 to 3/13/65)

  Under this contract, Northrop personnel operated and maintained aero/thermodynamic test facilities. The effort included test engineering, development of instrumentation and control systems, technical photography, the acquisition and automatic reduction of test data, and redesign and modification of components and systems associated with wind tunnels, jet simulation facilities, a shock tunnel, and a base heating facility.

- NAS8-11197 - Structural Analysis Criteria (3/28/64 to 5/23/65)

  Under this contract, Northrop/Huntsville provided technically trained personnel to the Chairman of the Strength Analysis Panel, NASA Structures Criteria Subcommittee to aid in the development, preparation, writing, and editing of structural analysis criteria documents. The end results of this effort were the establishment of a uniform set of strength analysis methods and procedures to adequately guide stress analysts and structural designers. These documents provide tools for maintenance of overall structural efficiency and integrity when independently designed stages and spacecraft are integrated into complete vehicle structural systems.

- NAS8-11221 - Analytical Study and Mathematical Research for Development and Implementation of the Path-Adaptive Guidance Mode (5/20/64 to 6/19/66)

  This contract, for the Aero-Astrodynamics Laboratory, MSFC, originally consisted of two assignments. The first assignment involved providing analytical research aimed at increasing the efficiency of the path-adaptive guidance concept. Emphasis was placed on solving analytical problems arising from efforts to enlarge the class of missions to which adaptive guidance might be applied.

  As a second assignment, which represented an extension and expansion, Northrop/Huntsville investigated the flight phase from orbit to a target point in the vicinity of the lunar sphere of influence using the iterative guidance scheme and the associated analytic cutoff surface. Points considered included error analysis to prove or disprove the adequacy of the scheme. Scheme behavior in response to thrust and center of gravity misalignments, sensitivity to noise, scheme stability, and time lags between data acquisition and command generation were also investigated.

- NAS8-11255 - Longitudinal Vibrations of Large Booster Rockets (5/25/64 to 11/20/65)

  Northrop/Huntsville, in accordance with this contract for the Aero-Astrodynamics Laboratory, conducted an investigation of longitudinal

vibration of large booster rockets as a general parametric study in order to provide a solid foundation for the understanding of the fundamental concepts involved. A classical vibration analysis of long-uniform cylindrical shells which are subject to periodic time-varying thrust was conducted. Paralleling the cylindrical shell analysis, a uniform beam analysis was completed. Various composite cylindrical structures and stepped-beam analyses were undertaken upon completion of the cylindrical shell and uniform beam analyses.

- NAS8-11385 - Study Effects of Engine Ignition on Air Flow Over Vehicle (6/29/64 to 1/28/65)

  Northrop/Huntsville efforts under this contract with the Structures Division of the Propulsion and Vehicle Engineering Laboratory resulted in the development of a computer program which predicts the surface air flow around the Saturn IB vehicle during the ignition and engine-burning hold-down sequence. By means of the developed technique, the change in speed and direction of the horizontal surface wind profile is calculated at heights of 100, 200, and 300 feet above ground level.

- NAS8-11431 - Guidance System Error Study (6/25/64 to 5/23/65)

  The objectives of the research efforts conducted under this contract for the Astrionics Laboratory were to determine a scheme which would yield the effect of guidance and control hardware errors on space vehicle performance, and to define explicitly the physical significance of the error model and the results yielded for comparison with the results obtained from other error models.

- DA-01-021-AMC-11481(Z) - Inertial Guidance Research (10/7/64 to 9/5/65)

  This contract, for the Guidance and Control Laboratory, U. S. Army Missile Command, involved the evaluation of several typical vehicle guidance schemes to determine the feasibility of their application over a broad range spectrum. The study utilized modified and new computer programs to analyze trajectory and impact error data.

- NAS8-11499 - SULINAC (1/4/65 to 6/30/65)

  This contract, for the Astrionics Laboratory, MSFC, involved a feasibility study and analysis directed toward definition of a control

system for use with a vertical Super Linear Accelerator (SULINAC) currently under development. The device has been designed with the capability of providing any discrete acceleration level from 10- to 100-g's.

- DA-01-021-AMC-11953(Z) - Advanced Systems Laboratory Support (3/17/65 to 2/25/66)

  Northrop/Huntsville provided technical support services to the Systems Evaluation and Aerodynamic Branches of the Advanced Systems Laboratory, U. S. Army Missile Command, under this contract. Specific tasks included analysis of drag and ballistic coefficient data of various missile configurations, and the presentation of wind tunnel test data in a form applicable for input to an analog or digital computer. Detail design of wind tunnel models also was accomplished.

- NASW-1165 - Analytical Research in Guidance Theory (4/20/65 to 7/10/66)

  Northrop/Huntsville continued the efforts to develop more reliable guidance functions and methods under this contract with the National Aeronautics and Space Administration, Washington, D.C. Included in these efforts were studies to develop analytical methods for direct solution of two-point-boundary-value problems. In particular, solutions for space-flight guidance functions for immediate and future missions were investigated. As an additional part of this contract, the development was continued of application procedures for the List Processing Computer Languages for symbolic calculations.

- NAS8-11440 - Development and Improvement of the AMTRAN Programming System (6/29/65 to 1/19/68)

  This contract with the Research Projects Laboratory was for development of the AMTRAN programming system. AMTRAN is intended for use by nominally trained scientists or engineers; its language is quite simple and closely resembles that of ordinary mathematics. An unusual feature is its orientation toward functional mathematical operations, accomplished by automatic array arithmetic. The AMTRAN language is to be implemented in a time-sharing environment with remote terminals located where desired. Programming from these consoles is

accomplished with a typewriter and array of pushbuttons to call major subroutines. Answers can be obtained graphically on a plotter, a cathode-ray scope, or a printer.

- NAS8-20082 - Aero-Astrodynamics Laboratory Mission Support, Marshall Space Flight Center (3/16/65 to date)

Nortronics-Huntsville, is presently the prime technical contractor for the Aero-Astrodynamics Laboratory of the Marshall Space Flight Center. Northrop personnel are carrying out analyses and studies in aerodynamics, fluid mechanics, trajectory optimization, orbital mechanics, vehicle failure mode determination, structural dynamics, flight performance, system and mission analysis, aerospace environments, and operations analysis in addition to providing facility operation and technical documentation support.

- NAS8-20183 - Simultaneous Solution of Sets of Nonlinear Algebraic Equations (6/28/65 to 9/24/66)

This study, for the Aero-Astrodynamics Laboratory, Marshall Space Flight Center, was concerned with the simultaneous solution of sets of nonlinear algebraic equations. The particular equations under consideration were characteristic of filter circuit analysis problems. The unknowns in the equations represented elements in an electrical circuit (resistors, inductors, and capacitors). Because of the physical nature of such elements, only real positive roots to the equations were desired. The problem was further restricted by considering only those roots whose magnitude fell within a prescribed range corresponding to the available range of values for the appropriate circuit element.

- NAS8-20200 - Flow Coefficients for Flat Plate Outlets (6/29/65 to date)

This contract, with the Aero-Astrodynamics Laboratory, Marshall Space Flight Center, involves the planning and conducting of a wind tunnel test program to evaluate the flat plate outlet flow coefficient having very narrow, exhaust slots, low jet-to-external mass flow ratio, and various boundary layer thicknesses. The work requires determination of the optimum combination of facilities and instrumentation

necessary to accomplish the test program as well as definition of a detailed test plan and test model.

- NAS8-20211 - Study of Resultant Thrust Vector Characteristics for Engine Clusters Including All Tolerances (6/29/65 to 9/28/66)

This study, for the Astrionics Laboratory, Marshall Space Flight Center, required definition of a general solution for determining the magnitude and location of the resultant thrust vector and a moment about this vector. The resultant thrust vector was defined with respect to a fixed coordinate system located in the thrust frame and containing its center line. All tolerances affecting the thrust vector location were considered as well as other pertinent factors, such as number and location of engines, etc.

- NAS8-20537 - Lunar Drill (7/16/65 to 9/30/66)

The Lunar Drill Program consists of: (a) the design of a flight weight deep subsurface lunar drill capable of taking cores to depths of 100 feet; (b) the design and fabrication of an engineering model of this drill; and (c) test of the engineering model drill in simulated lunar environmental conditions and at a selected earth site. In addition, the program encompasses the preparation of a resources plan which defines how the drill system is to be developed to the flight weight configuration, and the time, manpower, facilities, materials, and other costs associated with the development.

The flight weight lunar drill system is to weigh 200 pounds or less, and drill to depths of 100 feet or greater in dry, solid rock materials such as basalt, granite, or sandstone. The drill is to take continuous cores at five-foot intervals or less. Additionally, the drill is to be compatible with astronaut operation on the lunar surface and is to be mounted on Apollo Applications Program payloads such as the MOLAB or the LEM/Shelter. The drill system is to require no more than 5 kw of electrical power from the Apollo Applications Program payload to which it is mounted. The environmental constraints

on the lunar drill are those imposed by operation in the lunar environment at ambient temperatures of from -250° to + 250°F and a pressure estimated at 10^{-14} torr.

- NAS8-20116 - Lunar Dust Removal/Prevention Techniques (3/8/66 to 6/7/67)

  This study, for the Propulsion and Vehicle Engineering Laboratory, Marshall Space Flight Center, was concerned with the removal and prevention of dust accumulations on radiators located on the lunar surface. A layer of dust, caused by the movement of men and vehicles in the vicinity of a radiator, may severely degrade radiator performance. The degree of such degradation was investigated, and methods of removing or preventing accumulations of dust were established.

- NAS8-20409 - Study of Numerical Solution of Special Flow Problems Related to Saturn-Type Vehicles (6/20/66 to 9/20/67)

  Northrop developed numerical techniques and computer programs for solving the entire flow field about Saturn-type bodies at zero angle of attack. The solution is for an ideal, inviscid, supersonic free stream. Shock waves are treated as discrete discontinuities. The program includes capabilities for solving both blunt- and sharp-nosed body flow. In addition, capability for solution of flow about a frustum with a slope too great to support supersonic flow is included. A separate program for the blunt-body solution was prepared.

- NAS12-500 - Analytical Research in Guidance Theory (9/15/66 to date)

  The objective of this study contract was to explore methods for determining analytical expressions for optimal space flight guidance functions. The guidance problems were formulated in terms of the calculus of variations and direct approaches to their solutions were sought. The resulting guidance functions are of the Path-Adaptive type and are considerably more accurate and flexible than the currently employed approximation.

  The main guidance problems studied were: (1) Optimal Ascent to Circular Orbit, (2) Optimal Transformation from Circular Orbit to

Ellipse, and (3) Interception of a Vehicle in Circular Orbit in Minimum Time.

An important phase of these studies was the application of symbol manipulating computer languages for the automation of routine mathematical manipulations.

- NAS8-21027 - Path-Adaptive Guidance Mode (9/30/66 to date)
  After NASA's acceptance of the path-adaptive guidance concept for all Saturn and Saturn-Apollo missions, the initial contract was extended. Under the extended contract Nortronics-Huntsville is investigating the application of this guidance concept to various missions. Among these are earth-orbital rendezvous, lunar deboost, and direct ascent rendezvous missions. Also, extensive hardware error analyses are being performed.

- NAS8-20820 - Lunar Drill (2/12/67 to date)
  The Lunar Drill Program consists of: (a) the design of a flight weight deep subsurface lunar drill capable of taking cores to depths of 100 feet; (b) the design and fabrication of an engineering model of this drill; and (c) test of the engineering model drill in simulated lunar environmental conditions and at a selected earth site. In addition, the program encompasses the preparation of a resources plan which defines how the drill system is to be developed to the flight weight configuration, and the time, manpower, facilities, materials, and other costs associated with the development.

- NAS1-6888 - Propellant Testing, Langley Research Center, (12/17/66 to date)
  This contract involves the production of solid propellant fuels and the obtaining of test data in support of numerous current and anticipated research programs in the field of solid propellant rocketry. Additional efforts include the production of hardware components for NASA flight research vehicles and the conducting of preflight qualification test programs.

- NAS1-7399 - Integrated Life Support System, Langley Research Center, (6/15/67 to date)

  Under this contract Northrop personnel are providing support of various engineering, biological, and chemical programs associated with the overall operation of the Integrated Life Support System (ILSS) at Langley Research Center. Additional efforts are required in support of programs involving investigations with respect to pressure suits, lunar gravity simulators, vacuum chambers, materials investigations, and related space-oriented projects.

- NAS1-7703 - 55-Foot Vacuum Cylinder, Langley Research Center, (8/16/67 to 1/14/68)

  Under this contract with Langley Research Center, Northrop personnel performed studies to provide detailed definition of preferential modes of operation and equipment requirements for projected human factors research programs in the Langley 55-foot Vacuum Cylinder. The efforts included definition of proposed usage of facility components and identification of needs and functions of additional components and/or equipment which might be required to configure the facility for intended research programs.

SECTION IV

LISTING OF NORTRONICS-HUNTSVILLE TECHNICAL PUBLICATIONS:1963-1968

4.1 TECHNICAL REPORTS

4.2 MEMORANDUMS

4.3 INTERNAL NOTES

4.1 TECHNICAL REPORTS

No.	Title	Author	Date
1	Basic Governing Equations in Trajectory Optimization & Space Guidance by Variational Calculus	Dr. S. S. Hu	7/1/63
2	Saturn V Guidance Equations for Boost To Transit	Dr. S. Hu	7/17/63
3	An Analytical Approach to Polynomial Guidance Functions for Optimal Space Flight	Dr. S. Hu	8/9/63
4	Progress on Lunar Flight Analysis	Lunar Flight Analysis Study Team-Astrodynamics & Space Group	8/10/63
5	Progress Report on Mathematical Research in Optimal Satellite Insertion	M. L. Thompson	8/10/63
6	Progress Report on Plane Change Studies by COV Techniques	Trajectory Analysis Study Team-Astrodynamics Group	9/6/63
7	Progress Report on Mathematical Research on Optimal Satellite Insertion	M. L. Thompson & Astrodynamics Space Guidance Group	12/20/63
9	Torsional Pendulum Analogy for Quarter - & Eighth-Sectored Cylindrical Tanks Subject to Roll Oscillation	J. Ryan, J. Walls, J. Mooney	2/21/64
10	Slosh Handbook - Progress Report	J. Ryan, J. Walls, J. Mooney	2/21/64
11	The LISP 1.5 - A System for Symbolic Computation with Digital Computer	M. L. Thompson, P. L. Clem	1/20/64
12	A Tentative Draft of a Preliminary Progress Report on Application of Iterative Guidance Mode to Lunar Orbit and Rendezvous Missions	Dr. S. Hu, D. L. Cooper, V. A. Dauro, E. J. Holmbeck, R. R. Keith, J. F. Martin, Dr. R. L. Plunkett, D. Raney	2/19/64

No.	Title	Author	Date
13	Propellant Expenditures During Optimized Boost to Injection for Various Earth to Mars Trajectories	E. J. Holmbeck	2/64
14	Liquid Natural Frequencies of a Tank with Partially Submerged Sector Walls	J. Mooney, J. Walls, J. Ryan	4/6/64
15	Progress Report No. 2 on Application of Iterative Guidance Mode to Lunar Orbit and Rendezvous Missions	Dr. S. Hu, Dr. R. L. Plunkett, C. E. Beeson, D. Cooper, V. Dauro, E. J. Holmbeck, D. Raney, R. R. Keith, J. Martin,	5/15/64
16	Network Synthesis and a Method to Define a Transfer Function from Prescribed Phase-Magnitude Characteristics	J. Wilcox, S. Tung, K. White	5/19/64
17	Command Functions for Hypothetical Surface-to-Air-Missile Beam-Riding Guidance System	V. A. Dauro, Dr. R. L. Plunkett, K. B. White, H. J. Wilcox	5/19/64
18	Slosh Handbook - Progress Report #2	J. Mooney, E. Basurto, J. Kincaid, J. Ryan, J. Walls	6/19/64
19	A Beam - Shell Theory	J. Mooney	6/17/64
20	Thrust Structures Analysis Monograph	J. Ryan, J. Walls, J. Mooney, R. Craver	7/29/64
21	Computer Solution of the Vlasov Equations	H. Rosner	8/1/64
22	Lecture Notes on Quantum Mechanics	H. Rosner	8/11/64
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24	The Results of a Comprehensive Literature Survey of Inertial Guidance Error Analysis Techniques	D. Raney, B. Seagren, J. Thornton, S. Tung	9/1/64

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220A	Mission Command and Control	Meagher, Ryland	7/64
221A	Scientific Instrument Plan for the MOLAB	Berlot, Azmon, Stanley	6/64
222A	Test Requirements for Integrated MOLAB and Related Systems	King, McCoy	6/64

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224A	Groundwave Propagation on the Lunar Surface for a Lunar Mobile Laboratory	Hughlett	6/64
225A	Power Systems Studies for a Lunar Mobile Laboratory	DeLong, Ule	6/64
226A	Mobility Development Test Requirements MOLAB Locomotion Subsystem	King, Sloan, Sponsler	7/64
227A	MOLAB Equipment Support	Ligocki, Youngblood	7/64
228A	Rock Identification in the MOLAB	Berlot, Azmon, Stanley	7/64
229A	Electric Power Systems Conceptual Design	DeLong, Breazeale	9/64
230A	Command and Control Systems Conceptual Design	Meagher, Bonham	9/64
231A	Navigation/Guidance Systems Conceptual Design	Thomas	9/64
232A	Communications Systems Components Analysis	Hughlett	9/64
233A	MOLAB Concept Evaluation Method	Ross	9/64
234A	Mobility Analysis and Vehicle Definition for Extreme Lunar Surface Conditions	Miles, Andrisan	9/64
235A	Preliminary Estimate of Development Costs and Schedule for MOLAB	Waltz	10/64
236A	Operations Analysis of Saturn V/MOLAB Flight Profile	Myers	10/64
237A	MOLAB Duty Cycle Description	Myers	11/64
238A	Design and Analysis of ALSS Payloads Tie-down. Deployment and Leveling Systems	Ligocki, Youngblood, Dreier, Coughlan	11/64
239A	Environmental Control Systems Study	Kosfeld	12/64
240A	AES Alternate Payloads	Myers	1/65

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241A	Interim Report on Mission Command and Control	Meagher, Bonham	1/65
242A	Analysis of Lunar Flying Vehicle Guidance and Navigation	HHR Systems Section	1/65
243A	Scientific Instrument Investigation	Stanley, Lucas	3/65
244A	Mobility Test Article (MTA) Program Preliminary Definition Stuey	Ross, Miles, Andrisan, Sponsler/McCoy	12/64
245A	Local Scientific Survey Module (LSSM)	Systems Section	3/65
246A	LEM Application to Lunar Shelters and Mobile Labs	Systems Section	3/65
247A	Radioisotope Power System for MOLAB	Breazeale	3/65
248A	Heat Rejection System for a Lunar Surface Vehicle	Sabet	3/65
249A	Power System Analog Simulation for a Mobile Lab	DeLong	3/65
250A	Navigation System Studies for a Lunar Mobile Lab	Thomas	3/65
251A	Preliminary Resources Analysis for Local Scientific Survey Module	Systems Section	4/65
252A	Ground Wave Propagation on the Lunar Surface	Hughlett	3/65
253A	Analysis of ETV Test Equipments	McCoy, Miles, Ross	4/65
254A	Simplified Guidance and Navigation System for Lunar Flying Vehicle	Systems Section	4/65
255A	Power System Analog Simulator for a Mobile Lab	Systems Section	4/65
256A	Mission Command and Control for a Lunar Mobile Lab	Meagher, Bonham	4/65
257A	AES Scientific Program Investigation	Systems Section	4/65

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258A	Mockup Fabrication Sketches and Operational Procedures for Certain MOLAB Experiments	Lucas, Stanley	4/65
259A	Report on State-of-the-Art of Radioisotope Power Systems for Lunar Roving Vehicles	Breazeale	5/65
260A	Supplemental Payload Envelop Definition for all Payloads Used with the LEM Shelter	Ligocki, Youngblood	5/65
261A	Preliminary Resources Analysis for Lunar Scientific Survey Module	Systems Section	4/65
262A	Lunar Flying Vehicle Guidance and Navigation System Study	Systems Section	4/65
263A	Lunar Flying Vehicle Guidance and Navigation Systems Study (Combination of Task Order N-54 and N-63, Contract NAS8-11096)	Systems Section	4/65
264A	Manned Flying Systems - (MFS) Kinesthetic Effects	Systems Section	4/65
265A	Statistical Analysis of Lunar Features	J. E. Hilliard	5/7/65
266A	Radioisotope Power Systems Fuels Survey	L. Breazeale	6/65
267A	Jacob's Staff Investigation	Stanley	6/23/65
268A	Manned Flying System (MFS) Kinesthetic Control	Thomas	6/28/65
269A	AES Manned Flying System Major System Test Program	Bonham, Ligocki, Miles, Ross	7/65
270A	Preliminary Report - Manpower Requirements for MTA Block I Test Program	Ligocki	7/16/65
271A	Preliminary Outline of a General Test Specification for the AES Scientific Instruments and Related Subsystems	Bonham	7/30/65
272A	AES Report on Lunar Gravity Simulation Studies for the Mobility Test Article (MTA) Program	Ligocki, Bonham, Miles, Ross	8/65
273A	Pitch Stability Investigation of Saturn V LOR with Quarter-Sectored S-IC Propellant Tasks	Meagher	9/65

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274A	AES Payload Relationships and LEM/S Interface Requirements	Schloredt, DeLong, Bonner, Brower	10/65
275A	Preliminary Test Program for the Combined Systems LEM Shelter Payload	Ligocki	10/65
276A	Resource Analysis	McCly, Lambert	8/6/65
277A	Memorandum Report - Applicability of MTA Test Results to other LSV Systems - Block I	Miles	8/9/65
278A	Memorandum Report - Applicability of MTA Test Results to other LSV Systems - Block II	Miles	8/13/65
279A	Memorandum Report - Applicability of MTA Test Results to other LSV Systems - Block III	Miles	8/13/65
280A	Resource Analysis	Lambert	9/2/65
281A	Preliminary Test Program for Manned Flying System	Ligocki, Miles, Bonham	9/13/65
282A	State-of-the-Art - A Survey of Lunar Atmosphere Models	Lucas	9/22/65
283A	Norshield I & II Space Systems Radiation Shielding Evaluation	DeBaryshe	9/30/65
284A	Lunar Analog Study	Hannum, Lucas, Stanley, Svestka	10/65
285A	Dependency of Proposed Lunar Experiments	Hannum	11/2/65
286A	Apollo Extension System Studies Activities/ Time Analysis for ESS Deployment	Schloredt	11/10/65
287A	Requirements for Monitoring of Manned Surface Excursions During AES Lunar Missions	Schloredt	11/24/65
288A	Apollo Extension Systems Report on MFS/LSSM Joint Usage Study	Ligocki, Stanley, Byrn	2/21/66
289A	Prefeasibility Study of Space Environment Monitoring System	Hill	3/8/66
290A	Final Draft-MTA Block I Preliminary Steady State Test Program	Ligocki, et al.	3/15/66

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291A	Final Report - Lunar Gravity Simulation for Mobility Test Article (MTA) Program	Ligocki	3/15/66
292A	A Survey of Gravity Simulator Concepts of Lunar Surface Vehicles	MacKenzie	3/15/66
293A	Interim Report - Lunar Environmental Analysis - A Survey of Lunar Surface Models	Stanley, Lucas, Breazeale	3/15/66
294A	Prefeasibility Study of a Space Environment Monitoring System (SEMOS) Phase I - Summary and Analysis of Liaison Efforts	Chou, Kang, DeBaryshe, Hill, Thadani	3/15/66
295A	Prefeasibility Study of a Space Enrivonment Monitoring System (SEMOS) Phase I - Summary and Analysis of Liaison Efforts Annex A	Chou, Kang, Hill, Thadani	3/15/66
296	Fortran IV Computer Programs for the Evaluation of Parameters Appearing in Corrected Mechanical Impedance Equations	Merville, Pearson, Couchois, Morrow	11/66
297	Generalized Hypersurface Subroutine	McCraney, Frey	11/66
298	Control Parameter Analyses for AS-204 Manual-Abort Sensors (EDS)	Thornton, Hix, Wells	10/66
299	Feasibility Studies in Heliocentric Transfer and Planetocentric Orbit-Keeping Related to a Mars Photographic Mission Using Solar Electric Ion Propulsion	Way, Morris	12/66
300	Guidance Switchover Guidelines Study	Bray, Bentley	12/66
301	Monte Carlo Simulation of the Resultant Thrust of Rocket Engine Clusters	Bradford, Echols, Hilliard, Hinds, Murdock	9/66
302	Advanced Launch Vehicle Computer Programs for Vertical Takeoff Trajectories, Horizontal Takeoff Trajectories, and Horizontal Takeoff Trajectories with Sonic Boom Calculation	Butler, Perkins	12/66
303	Statistical Analysis of Thrust Vector Characteristics for Rocket Engine Clusters	Bradford, Echols, Hilliard, Hinds, Murdock	9/66

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304	The Saturn S-IB SA-204 Launch Vehicle Emergency Detection System Signal Flow from the Navigation, Guidance, and Control System	H. B. Smith	10/66
305	The Generation of Launch Vehicle Dispersion Data for the AS-208 Spacecraft Error Analysis (U) (CONFIDENTIAL)	Keith, Wang, Smith, Sprouse	12/66
306	Variation of Atmospheric Density of Mars with Solar Activity Levels	Blair	12/13/66
307	Study of Impedance Prediction Techniques - Final Report	Pearson, Couchois, Kavipurapu, Merville, Roberts, Morrow	12/66
308	The Generation of Launch Vehicle Dispersion Data for the AS-207 Spacecraft Error Analysis (U) (CONFIDENTIAL)	Keith, Smith, Sprouse, Wang, Wyatt	1/10/67
309	Numerical Techniques and Their Application to Low-Thrust Guidance Problems	Dauro	12/66
310	Influence Coefficients and Equivalent Rigidities of Cantilevered, Stiffened, Thin-Walled,Conical Frustums Subjected to End Loading	Pearson, Lee	10/66
311	Lunar Environment Analysis A Survey of Lunar Surface Models	Stanley, Lucas, Breazeale	11/11/66
311	Analytical Model of Martian Surface	Blair, Lucas, Stanley, Tatom	3/15/67
312	An Experimental Study of Numerical Integration Methods for Low-Thrust Near-Planet Trajectory Simulation	Way	1/67
312	Study of a Mars Surface Sample & Return Probe Launched from a Manned Mars Flyby - Vol. I and II. Summary Results and Conclusions	Odom, Hill	2/67
313	Thrust Filtering Analysis	Shady	2/67
314	Static Aerodynamic Characteristics of the Aborted Apollo-Saturn V Vehicle	Glasgow	2/67
315	Bolza Problems with End Orbits: Studies on the Application of the Theory of Bolza's Problem to Space Missions	Silber	3/67

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316	Pre-Test Report for Experimentally Determining Generalized Venting Characteristics	Rader	4/67
317	Data Report of the Characteristics of Cold Flow Free Jet Experimental Investigation	Delaney, Tidmore	5/2/67
318	Performance Characteristics of the Voyager Spacecraft In Powered Flight with Attitude Control	Sutherlin	6/1/67
319	A Study of Transient Erosion & Temperature Program Resulting from Jet Impingement in a Vacuum - Final Report	Rauser, Yalamanchile	6/67
320	RC Transfer-Function Synthesis and Digital Computer Application	Fontenot	6/67
321	Lunar Dust Degradation Effects and Removal/Prevention Concepts	Tatom, Johnson,Cline Srepel, Contaxes,	6/7/67
322	S-IVB Attitude Control Failures During Orbital Coast	Setchfield	7/67
323	Lunar Dust Degradation Effects and Removal/Prevention Concepts	Tatom, Srepel Johnson, Contaxes, Adams, Seaman, Cline	7/7/67
324	Preliminary Mission and Systems Analyses of Saturn V/Voyager Applications to Advanced Missions, Volume I	Odom	7/67
325	Preliminary Mission and Systems Analyses of Saturn V/Voyager Applications to Advanced Missions, Volume II	Odom	7/67
326	Mathematical Models for Aerodynamic, Gravity Gradient, Electromagnetic, and Solar Radiation Torques Acting on Earth Satellites	Clark, Morris, Roberts, Stockwell, Wright	7/67
327	ODYSSEY I Program - Final Report Volume I - Tech.		7/67
328	ODYSSEY I Program - Final Report Volume II - Program Plan		7/67
329	ODYSSEY I - Experiment Implementation Plan	Youngblood, Ligocki, Walters	7/67

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330	An Analog Study of the AS-501/S-IVB Vehicle	Brothers, Odum, Roberts	7/67
331	Pre-Test Report for Determination of Flow Coefficients for Flat Plate Outlets Discharging Transverse to an External Stream in the MSFC 14-Inch Trisonic Wind Tunnel	Delaney Rader	7/67
332	Conversion of Boundary-Value Problems into Problems of Numerical Integration	Andrus	9/67
333	High Inclination Orbit Study	Tatom	9/67
334	Users Guide & Deck Description for Northrop Planetary Entry Trajectory Program	Raney, Hurst	9/28/67
335	Documentation of the Northrop Steepest-Descent Reentry Program	Hurst, Raney	9/67
336	Determination of the Subsolar Point of Mars and Prediction of Martian Seasons in Terms of Earth Dates	Deshpande	9/67
337	An Analog Simulation Study of a Nonlinear Slosh Model	Brothers	9/67
338	Prediction of Saturn V Normal Aerodynamic Loads During Lift-Off	Tatom, Yalamanchili, Thomas	7/67
339	Introduction to the Method of Krylov, Bogoliubov, and Mitropolsky	Yu	9/67
340	MULPO - Symbolic Manipulation of Polynomials Interim Report	Armstrong	10/67
341	Preliminary Study of the Scientific Experiments and Systems Requirements for Exploration of the Jovian Satellites	Gamblin, Lucas	10/67
342	Deck Description and User's Guide for Northrop "Orbit Operations Computer Program"	Kessmann	9/67
343	Survey of Learning Control Systems	D'Souza	8/67
344	Slosh Control for the S-IVB Stage of Saturn AS-501 in a Zero-G Environment	Meagher	9/67
345	Analytical Research in Guidance Theory "Automated Analytic Procedures for Obtaining Optimal Guidance Functions"	Thompson, Armstrong	10/31/67

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346	A Theoretical Study of Attitude Motion	Yu	9/67
347	Analyses of Jupiter Orbiter/Solar Probe Mission With Solar Probe Flight Over the Sun's Polar Regions	Odom, Hill	9/67
348	Investigation of Saturn V Induced Flow Field	Tatom, Yalamanchili, Graham	10/27/67
349	Laboratory Simulation of Mars Atmosphere, A Feasibility Study	Chang, Lucas, Youngblood	9/67
350	Apollo Applications Cluster I Mission Decision Logic	Mitzner, Moorhead	1/68
351	Analytical Research in Guidance Theory	Thompson	11/67
352	Power Series Approximations to Lagrange's Multipliers for Optimal Ascent Trajectories	Kilpatrick, Newkirk, Thompson	12/67
353	Study of an Analytic Filter Design Technique	Sutherlin, Mayeaux	2/68
354	Human Factors Program for the Langley Research Center 55-Foot Vacuum Chamber	Beeson	1/68
355	The AMTRAN Interpretive Programming System	Koehler, Eaton	2/68
356	Comparative Reliability Estimates for Advanced Solar System Missions of the 1970-1985 Launch Era	Couchois	2/68
357	Document of Computer Simulation of the Orbital Launch Window Problem	Leung	2/68
358	Saturn IB High Inclination Orbit and Launch Window Study	Cottle	12/67
359	Advanced Launch Vehicle Computer Program for Horizontal Takeoff 3-D Trajectories	Perkins	3/68
360	Performance Characteristics of the Voyager Spacecraft in Powered Flight	Sutherlin	3/68

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361	Supplement to Advanced Launch Vehicle Computer Programs for Vertical Takeoff Trajectory, Horizontal Takeoff Trajectory, with Sonic Boom Calculation	Perkins	3/68
362	Modification and Redesign of Moderate Depth Lunar Drill Assembly and Parts	Hullings, Hughlett	3/68
363	Explicit Solutions to Problems of Optimal Guidance	Andrus	1/68
364	A Method for the Prediction of the Martian Temperature and Some Applications of Meteorological Analysis	Lou, Hung	3/68
365	The Natural Space Environment 150 KM to 800 KM above the Earth	Blair, Comfort, Contaxes	3/68
366	Solar Flare Probability Model	Blair, Svestka	3/68
367	Advanced Launch Vehicle Computer Program for Flyback and Recovery Trajectories	Perkins	3/68
368	An Approximate Method for Calculating the Viscous and Pressure Forces Resulting from Jet Impingement on a Flat Plate in a Vacuum	Lanning	1/68
369	Calculation of Optimal Trajectories by Techniques Involving the Equations of Variations	Armstrong, Burns	1/68
370	Users Guide, Deck Description, and Critical Evaluation of the "Gordon II" Low-Thrust Heliocentric Trajectory Optimization Program	Way	3/68
371	Mixing and Combustion in Exhaust Plumes	Graham, Yalamanchili	3/68
372	Static and Transonic Aerodynamic Characteristics of a 4-Percent Model of the Apollo-Saturn V Vehicle	Waldrop, Glasgow	4/68
373	On-Board Astro-Inertial Guidance Technique for Minimum Time Insertion, Rendezvous, and Interception of Missiles and/or Aerospace Vehicles	Hu, S. S.	4/68

4.2 MEMORANDUMS

No.	Title	Author	Date
01	Verification of TM No. 297	McCraney, Sport	3/67
02	Steepest Ascent Optimum Reentry Analysis	Hurst, Raney	4/67
03	An Investigation of Type II Earth-to-Mars Trajectories	Dauro, Keith, Mantler	4/67
04	Addendum to "Formulation and Development of Necessary Conditions on the Solutions of Several Optimum Orbit Transfer Problems"	Way	3/67
05	Addendum to "An Analysis and Method of Numerical Solution of an Advanced Problem in Trajectory Optimization"	Way	4/6/67
06	A Presentation of Studies Related to Reentry and Low-Thrust Trajectory Optimization	Raney, Way	3/67
07	Preliminary Analysis of a Mars Voyager Planetary Vehicle Concept for Adaption to a Venus Orbiter-Lander Mission	Odom, Hill, Lucas	4/14/67
08	Environment Design Criteria from 90 Km Above Earth's Surface to Mars	Stanley	4/28/67
09	Generation of Operational Trajectory Guidance Presettings	Williams	4/25/67
10	A Stress Analysis of a Flat Plate Model for Determining Discharge Coefficients of an Air Jet Discharging Transverse to a Free Stream	Hilliard	4/67
11	Tracking Capability Summary	Henderson	4/67
12	Temperature History of a Semi-Infinite Fin	Thomas	5/4/67
13	Summary Report of Saturn IB/V Venting Analysis	Walters, Rader	4/67
14	Study of S-IVB/Voyager Vehicle and Shroud Separation Trajectories	Echols, Mayeaux	5/25/67
15	Users Guide and Deck Description for Northrop "Variable Mixture Ratio" Trajectory Optimization Computer Program	Kessmann	6/9/67

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16	Inflight Venting Analyses for the S-II and S-IVB Interstage of the Apollo-Saturn V Vehicle Trajectories 503 and 504	Walters, Glasgow, Rader	6/22/67
17	Special Test Section (14-Inch TWT) Test Duration Studies	Paranjape	6/67
18	Pre-Test Report for Q-Ball Calibration Test in the MSFC 14-Inch Trisonic Wind Tunnel	Waldrop, Lanning	7/67
19	Preliminary Evaluation of the Piecewise Correlation Program for Non-Stationary Data	Bradford, Hinds	7/67
20	User's Guide and Deck Description for Northrop Multistage Trajectory Optimization Computer Program	Kessmann	8/67
21	Data Reduction Procedures for Pressure Data from a 4-Percent Saturn V Model in the AEDC 16-Foot Transonic Wind Tunnel	Waldrop	9/67
22	Mid-Course Velocity Correction for Injection Bias for a Mars Mission	Sprouse, Keith	9/67
23	Revised Static Aerodynamic Characteristics of the Aborted Apollo-Saturn V Vehicle	Glasgow	9/67
24	Pre-Test Report for November 1967 Wind Tunnel Test in AEDC 16-Foot Transonic Wind Tunnel	Waldrop, Glasgow	9/67
25	Gravity Simulation Workbench Interim Status Report	Ross	10/67
26	Status Report of Automatic Filter Design Study	Thorbjornsen	12/67
27	Application of Tunnel Detection Methods to Installation Defense	Lucas, Comfort, Bonham	1/68
28	Supplement to Preliminary Saturn S-IB/S-IVB Performance Analysis	Keith	11/15/67
29	Analysis of Saturn V Actuator Malfunctions at Lift-Off	Bradford, Hettinger, Stewart	11/67
30	A Technique for Compressing Data from Long-Duration Missions of the Apollo Applications Program Type	Purcell, Jones	2/68

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31	Prediction of Martian Surface Temperature	Tatom, Deshpande, Hung	10/67
32	Revised Static Aerodynamic Characteristics of the Aborted Apollo-Saturn IB Vehicle	Glasgow	3/15/68
33	Digital Simulation Program for S-IVB Stage Response	Odum	3/68
34	ODYSSEY I - Aeronomy and Aerodynamic Measurements in the Thermosphere	Youngblood,	4/68

4.3 INTERNAL NOTES

No.	Title	Author	Date
1	Patched Conic Solution of Earth-Moon Transit Trip Times for Various Earth Centered Conic Injection Energy Levels	E. A. Smith	10/15/64
2	November Progress Report on Automatic Controls	F. L. Echols, H. J. Mayeaux, Jr., J. E. Rasch, D. W. Sutherlin, M. A. Sloan, Jr.	12/18/64
3	Inertial Guidance Study Progress Report #1	E. Clark, L. Morrow, D. Raney, P. Rhodes, P. Roberts, B. Seagren, M. Sloan	1/19/65
4	Prediction of the Thermal Environment of the Moon	F. B. Tatom	1/19/65
5	December Progress Report for Automatic Controls Unit	F. L. Echols, H. J. Mayeaux, Jr., J. E. Rasch, D. W. Sutherlin, M. A. Sloan, Jr.	1/20/65
6	January Progress Report for Automatic Controls Unit	F. L. Echols, H. J. Mayeaux, Jr., J. E. Rasch, M. A. Sloan, Jr., D. W. Sutherlin	2/22/65
7	Bending Moment Calculations	F. L. Echols, H. J. Mayeaux, Jr., J. E. Rasch, M. A. Sloan, Jr., D. W. Sutherlin	2/25/65
8	Computer Program Explanation of the Matrix Input Data Program (ACP03A)	F. L. Echols, H. J. Mayeaux, Jr., J. E. Rasch, M. A. Sloan, Jr., D. W. Sutherlin	3/9/65

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9	Computer Program Explanation of the Aerodynamic Coefficient Program - Automatic Controls Unit	F. L. Echols, H. J. Mayeaux, Jr., J. E. Rasch, M. A. Sloan, Jr., D. W. Sutherlin	3/18/65
10	Preliminary Data from Inertial Guidance Research Contract DA-01-021-AMC-11481(Z)	E. Clark, L. Morrow, D. Raney, P. Rhodes, P. Roberts, B. Seagren, M. Sloan	3/19/65
11	February Progress Report - Automatic Controls Unit	F. L. Echols, H. J. Mayeaux, Jr., J. E. Rasch, M. A. Sloan, Jr., D. W. Sutherlin	3/23/65
12	Computer Program Explanation of the Matrix Expansion Program (ACP05A)	F. L. Echols, H. J. Mayeaux, Jr., J. E. Rasch, M. A. Sloan, Jr., D. W. Sutherlin	4/5/65
13	Computer Program Explanation of the Sensor Transfer Program (ACP06A)	F. L. Echols, H. J. Mayeaux, Jr., J. E. Rasch, M. A. Sloan, Jr., D. W. Sutherlin	4/14/65
14	Proposed Experimental Physics Program	G. A. Petitt, G. Sharp	4/19/65
15	March Progress Report-Automatic Controls Unit	F. L. Echols, H. J. Mayeaux, Jr., J. E. Rasch, M. A. Sloan, Jr., D. W. Sutherlin	4/23/65
16	Proposal for Company Sponsored Experimental Research in Thermo-Engineering	F. B. Tatom	5/15/65
17	Proposed Physics Laboratory for NSL/ Huntsville	Dr. G. A. Petitt, G. Sharp	5/20/65

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18	Proposal for the Study of the Effect of a Vibratory Environment on Heat Transfer and Fluid Dynamics	B. L. Cline	5/20/65
20	Computer Program Explanation of the Frequency Response Program (ACPO7A) - Automatic Controls Unit	F. L. Echols, H. J. Mayeaux, Jr., J. E. Rasch, M. A. Sloan, Jr., D. W. Sutherlin	6/15/65
21	Computer Program Explanation of the Root-Locus Program (ACPO8A)	F. L. Echols, H. J. Mayeaux, Jr., J. E. Rasch, M. A. Sloan, Jr., D. W. Sutherlin	6/15/65
22	Introduction to Statistics and Correlation Techniques	Dr. S. R. Kavipurapu	6/17/65
23	An Approximate Evaluation of Strain Nonlinearity Due to Rotation Effects on a Long, Simply Supported, Uniformly Loaded Beam	P. R. Odom	6/65
24	Computer Program Explanation of the Rigid Body Gain Calculation Program (ACP13A)	F. L. Echols, H. J. Mayeaux, Jr., J. E. Rasch, M. A. Sloan, Jr., D. W. Sutherlin	6/65
25	Visibility Analysis of Saturn IB/Apollo in Low Polar Orbits	F. M. Loveless, G. L. Maddox	6/65
26	Survey of the Thermoelastic Analysis of Plates	P. R. Odom	7/65
27	SA-201 Data Processing and Display Study	C. O. DeLong	7/65
28	Conformal Mapping: Theory and Some of Its Applications	E. R. Basurto	7/65
29	Results of Aerodynamic Analysis of the Saturn V LOR Vehicle for Vehicle Emergency Detection System Studies	R. K. Ellison	8/23/65
30	Results of the Determination of Abort Apollo-Saturn IB Load Distributions	R. K. Ellison	8/20/65

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31	Results of the Determination of Aerodynamic Characteristics of the Saturn V LOR Vehicle for Range Safety	W. Zeitfuss	8/23/65
32	Cislunar Pegasus Visibility and Accuracy Study for ½ and ¼ Lunar Periodic Orbits	F. M. Loveless, G. L. Maddox	9/65
33	Description and Analysis of Computer Program to Calculate Forces and Moments on An Isolated Missile Fin in a Non-Uniform Flow Field	W. R. Waldrop, W. Zeitfuss	10/25/65
34	Time-Keeping Systems	L. C. Allen	11/65
35	Computation Scheme for the Response of Vibration of a Circular Cylindrical Elastic Tank, Partially Filled with An Incompressible Fluid, Undergoing An Axial Acceleration Composed of a Uniform and a Periodic Component	T. N. Lee, G. C. Kao, J. G. Goree, C. M. Pearson	11/19/65
36	Earth-Moon Line of Site Communication Time	B. G. Brown, J. V. Butler	12/65
37	Literature Survey on Low-Thrust Earth-Moon Flight Mechanics	R. H. Hansen	12/65
38	Analysis and Correlation of Saturn V/LOR Vehicle Body Alone Tail-Barrel Data from Wind Tunnel Test P-58	R. K. Ellison	1/66
39	Addendum to In Flight Venting Analysis for the Saturn II and Saturn IVB Interstage of the Saturn V Vehicle	W. P. Walters	2/25/66
40	A Matrix Solution for Vibration of a Series of Shell Structures Subjected to Random Excitation	C. S. Kang, T. N. Lee, G. C. Kao, C. M. Pearson	3/66
41	An Approximate Reentry Corridor Analysis	D. Raney, C. P. Liu	6/15/66
42	Derivation of the Transversality Condition for Optimal Transfer Between Orbits	M. L. Thompson	7/66
43	The Generation of Preliminary Launch Vehicle Dispersion Data for the AS-208 Spacecraft Error Analysis	R. R. Keith, Jr. E. A. Smith, R. W. Sprouse, L. H. Wang	9/9/66

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44	A Presentation of Major Studies Conducted Under the Iterative Guidance Mode Contract	Hu, Cooper, Hall, Keith, Kessmann, Kopp, Metzger, Smith, Sprouse, Wang	9/66
45	Quarterly Report on Filter Transfer Function Synthesis Study	J. A. Bishop, F. L. Echols	9/66
46	A Summary Manual for Users of the IBM 1130 Computer	T. J. Thomas	10/66
47	A Derivation of a Relationship Between Two Point Product Mean Values of K and Covariance of Two Fluctuations in Steady Isotropic Turbulence	Howard Yen	10/66
48	Summary of Presentation of Impedance Prediction Techniques	Pearson, Lee, Couchois, Merville	1/4/67
49	A Study of the Mu-Mesic Atom	C. K. Chou	11/66
50	A Study of the IGM Gravity Prediction Method	Smith, Sprouse, Wang, Keith	1/24/67
51	Properties of a Martian Atmosphere	Hsu, Deshpande	2/67
52	Literature Survey on the Propagation of Laser Beams in the Atmosphere	Hayes	3/15/67
53	Thermodynamic and Meteorological Considerations in the Establishment of a Martian Surface and Atmospheric Model	Mahlman, Deshpande	3/67
54	Aerodynamic Forces on Orbital Vehicles	Waldrop	3/67
55	Investigation of the Maximum Expected Error in Discharge Coefficient as a Result of a Two-Percent Error in Pressure and Temperature Readings	Rader	6/1/67
56	Single-Impulse ΔV Requirements for Planetary Capture	Stewart	6/67
57	Capture Coefficient Determinations of Directed (Molecular Beam) and Random Fluxes of Gaseous Carbon Dioxide and Water Vapor on a Cryogenically Cooled Crystal	Youngblood	6/27/67
58	On the Determination of Minimum Impulses Velocity Increments for Mars Orbital Launch Window Problem	Leung, Kot	7/67

No.	Title	Author	Date
59	A Mathematical Technique for Correcting Experimental Data Influenced by Other Data Near the Measurement Point	Schroeder	9/67
60	Pod Concept for Rear Hemisphere Protection	Tatom	10/17/67
61	A Summary Manual for Users of the IBM 1130 Computer	Thomas	10/67
62	An Analytical Approach to the Orbital Launch Window Problem	Leung	10/67
63	Aerodynamic Considerations for a Gravity Simulation Workbench	Barnett, Rader	12/67
64	Preliminary Elastic Response Analysis of the Apollo Telescope Mount	Aramayo, Bloom, Pearson, Akers, Gaissert, Hereford	1/68
65	Wall Cooling Effects in the Marshall Space Flight Center Low Density Wind Tunnel	Williams	1/68
66	Prediction of the Martian Subsolar Point in Terms of Earth Time	Tatom, Hooie, Deshpande	1/68
67	Aerodynamic Drag Balances and Comments on the Feasibility of a Support Free Drag Balance	Youngblood, Williams	3/68

SECTION V

STAFF & QUALIFICATIONS

5.1 DEGREE & CAPABILITY DISTRIBUTION

5.2 ADVANCED DEGREE TECHNICAL PERSONNEL (Ph.D's and Ph.D. Candidates)

5.1 DEGREE & CAPABILITY DISTRIBUTION

TECHNICAL SECTIONS NORTHROP/HUNTSVILLE

Degree	Physics	A.E.	M.E.	E.E.	Math.	C.E.	E.M.	N.E.	Geol.	I.E.	I.A.	Physi-ology	Pol. Sci.	Total
Ph.D.*	7	6	7	2	5	1	1	1	-	-	-	-	-	30
M. S.	5	3	15	7	5	-	1	2	1	1	-	-	-	39
B. S.	14	32	12	10	26	9	1	-	1	-	1	1	1	108
TOTAL	26	41	34	19	36	10	3	3	2	1	1	1	1	177

AREAS OF EXPERIENCE AND RESEARCH

Degree	Astro-dynamics & Orbital Mechanics	Aero-dynamics & MHD	Dynamics & Applied Physics	Guidance & Control	Thermo-dynamics & Propulsion	Astro-Physics	Nuclear & Plasma Physics	Life Sciences & Geology	Instru-mentation & Electronics	Applied Math	Systems Design
Ph.D.*	12	12	19	9	9	6	11	-	4	30	-
M. S.	16	12	32	19	18	5	3	1	6	33	4
B. S.	31	29	48	35	30	9	3	2	24	65	10

* 6 Ph.D. Candidates

5.2 ADVANCED DEGREE TECHNICAL PERSONNEL

(Ph.D.'s and Ph.D. Candidates)

Dr. S. S. Hu, Technical Director, Nortronics/Huntsville, is supervising all research and analysis projects as well as personally participating in several space programs including space flight mechanics, space optimization guidance theory, non-equilibrium hypersonic flow field analysis, and space recovery heating analysis.

Prior to joining Northrop in 1960, Dr. Hu had been active in aerospace research and engineering for over fifteen years. He was associated with JPL of the California Institute of Technology, Rocketdyne of North America, Aerojet-General, Lockheed Propulsion Company, RCA, United Aircraft, and General Electric. With these firms, he worked on problems of propulsion gas dynamics including non-equilibrium multi-phase flow optimization, reentry and aerodynamic heating, thrust vector control, space recovery, meteorological phenomena, space environment, rocket nozzle design and aerospace design concepts and stress analysis.

Dr. Hu is presently a full professor of Aerospace Engineering on a part-time basis at the University of Alabama. He is in charge of post-graduate research in the area of space flight mechanics, as well as teaches a four-course series on the post-graduate level in Astrodynamics:

> Astrodynamics I: Fundamentals of basic dynamics, aerodynamics, propulsion dynamics, space environments, space physics, and space dynamics; Astrodynamics II: Orbital mechanics, n-body problems, and space perturbations; Astrodynamics III: Atmospheric flights, low thrust flights, reentry dynamics, and thermodynamics; Astrodynamics IV: Theories of navigation, guidance, control, optimization, and error analysis.

Prior to December 1963, Dr. Hu taught as professor in the graduate schools of many universities, including the University of Arizona, the University of Southern California, and Auburn University in Alabama. Subjects taught included subsonic, supersonic, and hypersonic aerodynamics; rocket and nuclear propulsion; nuclear engineering; mechanical vibration; heat transfer; and helicopter engineering. Dr. Hu organized and managed a 500-employee aircraft

piston engine, and air compressor plant during 1944-1949, and successfully produced and delivered 1000 units of A-26 attack bomber aft-fuselages and 40,000 units of portable 4-cylinder compressors.

Dr. Hu holds a degree of Sc.D. with top honor from Massachusetts Institute of Technology. He was a recipient of "Salisbury Prize" and was elected a "General Motors Research Fellow" for his straight "A" rating and outstanding scholastic achievement at M.I.T.

In August 1965, Dr. Hu received a Certificate of Merit from top Northrop Management for his dynamic leadership in developing the technical capability at Northrop Space Laboratories/Huntsville. In September 1965, Dr. Hu was elected Chairman of the American Astronautical Society, Southeastern Section, directing the Society's professional activities in eight southeastern states. He was elected National Vice-President of the American Astronautical Society in May 1967.

Dr. Hu has published numerous papers and reports in the field of aerospace research and engineering. His recent papers include "Rapid Generation of On-Board Guidance Command Signals through Analytical Solution of Two-Point Boundary Value Problems" presented at AIAA Annual Symposium, 1966; "On Cross-Beam Monitoring of Atmospheric Winds and Turbulence with Two Orbiting Telescopes", NASA Technical Memo. X-53538, 1966; "On-Board Optimal and Homing Guidance Signals to Distant Celestial Bodies", Proceedings of AAS Symposium, 1967. Dr. He is the editor of "American Astronautical Science and Technology Series 1967" and is the author of "Flight Mechanics and Guidance/Control Theory," 1967.

Dr. Shih-Cheng Zien, a Senior Engineer in the Sciences Section, is currently involved in the analysis of aerodynamic force of the Saturn V, and flow coefficient for flat plate outlets discharging transverse to an external stream. He is primarily concerned with the aerodynamic problems, such as the calculating formulas for the normal force coefficients of Saturn V at very large angles of attack, the interaction of incident shock with boundary layers, and the relations of vent-jet with the free-stream. Dr. Zien's experience also includes research activities and teaching in the University of Alabama Aerospace Engineering Department, and consulting work with Hayes Aircraft Corporation of Birmingham, Alabama. While he was a research fellow, Dr. Zien was able to attend advanced aerodynamic, structural, and mathematical courses at California Institute of Technology in Pasadena, California.

Dr. J. F. Andrus, Branch Chief of Mathematics-Physics Branch, is currently participating in research programs in applied mathematics, numerical analysis, computer techniques, and their applications to space flight guidance and simulation.

Dr. J. C. Williams, a Member of the Technical Staff of the Sciences Section, is currently participating in complex research and analytical problems in aerothermodynamics. Dr. Williams is also a Professor in the Department of Mechanical Engineering at North Carolina State University. He has over 15 years of theoretical and applied experience in aerothermodynamics, boundary layer theory, heat transfer, orbital mechanics, plasma heating and propulsion, experimental aerodynamics, and fluid mechanics.

Dr. C. P. Bhalla, a Member of the Senior Technical Staff of the Sciences Section, has thirteen years of experience as a physicist. He is currently involved in the new calculational methods applicable to nuclear reactor design. His responsibilities also include the research of μ-meson interactions with the space vehicle and the related radiation effects on electronic components. He also is an Associate Professor of Physics at the University of Alabama Research Institute, Huntsville, Alabama. Prior to his association with Northrop and the University of Alabama, he was a senior scientist with the Atomic Power Division of Westinghouse Corporation. While employed by Westinghouse, Dr. Bhalla also served as a consultant for Union Carbide at the Oak Ridge National Laboratories, and for the National Bureau of Standards.

Dr. K. Seo, a Member of the Technical Staff of Nortronics-Huntsville is presently assigned to the Astrodynamics Section. Dr. Seo is Associate Professor of Mathematics at Clemson University and is teaching courses in elementary and advanced probability theory. Prior to his association with Clemson, Dr. Seo was Associate Professor of mathematical statistics at Colorado State University for four years. He taught courses in mathematical programming, dynamic programming, linear algebra, and statistical decision theory.

Dr. G. E. Baird, a Member of the Technical Staff of the Sciences Section, has five years of experience as a physicist. He is currently involved in a study of the mathematical optimization theory employing the calculus of variations with special emphasis on applications to two-stage rocket trajectories, and in research in mathematical physics and communication theory. He has done research in theoretical physics at Rice and Duke Universities, and has taught at both of these institutions.

Dr. S. R. Kavipurapu, a Member of the Technical Staff of the Sciences Section, has seven years of experience in nuclear engineering and physics. He is currently engaged in the dynamic stability analysis of large flexible boosters and in the analysis and conceptual design of control systems for space boosters. He is also engaged in the problems of neutron transport theory. Dr. Kavipurapu taught physics at Pennsylvania State University. He also taught analog computer technique courses as applicable to nuclear control theory at the University of Florida. His experience has included work with the Atomic Energy Establishment, Trombay, India, and in the IGY Radio Astronomy Program at Hyderabad, India. He also participated in a study of Random Noise Techniques at the University of Florida.

Dr. G. A. Petitt, a Member of the Technical Staff of the Sciences Section, is directing a group conducting an experimental program in which the Mossbauer effect is used to study the magnetic and electrical properties of materials and the dynamics of crystal lattices. In addition, he is studying techniques for solving mixed boundary value problems of the type which occurs when optimization theory is applied to trajectory calculation, and he is involved in a study of the nonlinear phenomena governing the dynamics of charged particles in a plasma. He was a Research Assistant during his graduate career, and performed experiments in Neutron Scattering with the Duke University 4MeV Van de Graaff accelerator and its associated "time-of-flight" system. He assisted in the design and construction of electronic equipment for the time-of-flight system and shielding equipment. He is an Assistant Professor of Physics at Georgia State College.

Dr. W. H. Purcell is presently using the calculus of variations technique in orbit optimization in the Physical Research and Mathematics Branch of the Sciences Section. He is also Assistant Professor of Mathematics at Georgia Institute of Technology and is writing a paper on a dynamic program which uses Lagrange multiplier techniques. Prior to his teaching, Dr. Purcell was associated with General Dynamics where he was engaged in dynamic computer programming.

Dr. W. R. Garrett, a Member of the Technical Staff of the Sciences Section, is presently engaged in the formulation of a μ-meson research study to be conducted at NSL/Huntsville. He is an Assistant Professor of Physics at the Univesity of Alabama, Huntsville Center. Dr. Garrett is currently conducting research in low energy atomic electron scattering; negative ion formulation and photo-detachment cross sections; atomic polarizabilities in ground and excited states; and dielectric properties of high-temperature gases at the University of Alabama. He previously taught Physics at the main campus of the University of Alabama.

Dr. W. J. Gray, a Member of the Technical Staff of the Sciences Section, is presently studying the applications of the LISP technique to computer programming. Dr. Gray teaches graduate and senior level courses in advanced mathematics, topology, and computer techniques at the University of Alabama. Prior to teaching, Dr. Gray was associated with the Army Ballistic Missile Agency where he conducted experimental aerodynamic tests and evaluated the resulting test data.

Dr. D. W. Lyons, a Member of the Technical Staff of the Dynamics Analysis Section, is presently engaged in the dynamic stability analysis of large flexible and rigid-body boosters. Dr. Lyons is also Assistant Professor of Mechanical Engineering at Clemson University. He has served as a consultant to the Langan Corporation and has been associated with the Boeing Company as a controls engineer in the Guidance, Navigation, and Control Section, Aerospace Division. He taught senior and graduate level courses at Georgia Institute of Technology.

Dr. G. M. Jones, a Member of the Technical Staff of the Astrodynamics Section, is presently involved in a study to determine methods of entering atmospheres of the major planets with a scientific probe. Prior to joining Northrop, Dr. Jones did contractural work for Space Craft, Inc., involving analyses of various power systems and studies of lubrication in a space environment, in-space sterilization, and cryogenic contamination sensors involving nuclear radiation measurement techniques. At the University of Alabama, Dr. Jones was a graduate assistant, responsible for the mathematical simulation of a Knudsen Cell to study the effect of pertinent variables on the error between actual and measured vapor pressures of substances tested. He also taught senior engineering students a special problems course in chemical engineering relative to the design and manufacture of an instrumented liquid-level-control facility.

Dr. B. L. Cline, a Member of the Technical Staff of the Sciences Section, is presently responsible for an investigation to establish the effects of dust on a radiator surface in a lunar environment. He is also associated with the University of Chattanooga as Coordinator of the new Graduate School of Engineering, and Associate Professor of Mechanical Engineering. He has been associated with Combustion Engineering, Inc., Kreisinger Development Laboratory, and the Lawrence Radiation Laboratory. His work involved experimental studies in the fields of heat transfer, fluid dynamics, and thermodynamics. He taught thermodynamics at Georgia Institute of Technology. Dr. Cline was an NDEA Fellow and a Ford Foundation Fellow.

Dr. J. G. Goree, is an Engineer of structural dynamics for the Dynamics Analysis Section. He is also an Assistant Professor of Engineering Mechanics at Clemson University. He has conducted studies on the interaction of fuel oscillations with elastic fuel research on Army Contract No. DA-01-021-ORD-11878, and with Rohm & Haas, where he obtained approximate solutions for the stresses in thick-walled elastic cylinders using numerical methods, and was involved in experimental work in photoelasticity.

Dr. R. L. King is a Member of the Technical Staff in the Sciences Section. He is currently involved in the application of numerical techniques, using high-speed computers, to the prediction of atmospheric sciences projects to develop numerical weather prediction and general wind circulation techniques.

Dr. W. F. Powers, is a Member of the Technical Staff in the Sciences Section of Nortronics-Huntsville. Dr. Powers specializes in applied mathematics and optimization theory for space flight dynamics and guidance. Dr. Powers received his Ph.D. from the University of Texas and worked with the Aero-Astrodynamics Laboratory of Marshall Space Flight Center, NASA, for the period from 1963 to 1966.

Dr. J.C.M. Yu, a Member of the Technical Staff in the Astrodynamics Section, is engaged in a theoretical analysis of the attitude motion of a rigid body due to various disturbing moments. He is also associated with the Department of Mechanical Engineering at Auburn University. Dr. Yu's varied experience includes material strength, statics, stress analysis, particle dynamics, and research in nonlinear mechanics.

Dr. A. F. D'Souza, a Member of the Technical Staff in the Dynamics Analysis Section, has been most recently involved in a study of learning control systems for potential application to booster control. Dr. D'Souza is also an Assistant Professor of Mechanical and Aerospace Engineering at the Illinois Institute of Technology. His experience includes work in linear and nonlinear control systems, statistical design, and optimal and adaptive control systems.

Dr. M. Y. Su is a Member of the Technical Staff in the Operations Section. He is currently concerned with statistical analysis of the crossed-beam remote sensing technique. Dr. Su's major field of interest is in application of statistical theory to prediction of turbulence in the atmosphere. He has also worked on the application of statistical techniques to the analysis of subsonic, supersonic, and hypersonic flows past paraboloids of revolution.

Dr. F. T. Hung, a Member of the Technical Staff in the Sciences Section, is engaged in a study using radiation analysis for prediction of the temperature of landing vehicles resting on the lunar surface. He recently completed an analysis of techniques applicable to the prediction of Martian surface temperatures which considered both radiation and convection effects.

Dr. J. D. Alexander is a Member of the Technical Staff in the Astrodynamics Section. He is currently involved in studies of vehicle flight dynamics, trajectory optimization, and advanced missile systems. He has made major contributions to company-funded studies of methods of controlling exhaust emissions related to the national air pollution problems. Dr. Alexander has made significant contributions to the study of soil erosion by landing rockets, developed optimization equations for aerodynamically controlled interception missiles, and conducted investigations of matter under conditions of high temperature and pressure induced by various nuclear weapon configurations.

Dr. J. D. Mahlmann, a Member of the Technical Staff in the Sciences Section, has most recently been involved in the development of application techniques for the crossed-beam atmospheric sensing technique. His experience includes work on the dynamics of the polar night vortex breakdown and its possible relationship to the observed seasonal oscillations in vertical debris transport out of the stratosphere.

Mr. S. V. Paranjape, a Ph.D. candidate in Mechanical and Aerospace Engineering, is an Engineer of fluid dynamics for the Operations Section. His associations with Argonne National Laboratory and Union Carbide Corporation gave him experience in the measurement of characteristics of plasmas and the thermal characteristics of plastic materials. He has taught at Illinois Institute of Technology, Penn State, and Madras Institute of Technology. He is presently engaged in the theoretical analysis of nonlinear lift due to cross-flow components in axisymmetric bodies moving at high angles of attack. Specifically, he is developing methods for pressure distribution about such bodies and the analysis of the field of velocity in cross-flows.

Mr. H. R. Rosner, a Ph.D. candidate in Physics, is a Member of the Technical Staff of the Sciences Section. He is currently active in the completion of his doctoral program at Kansas State University. He has nine years of experience as a physicist and engineer, and has been associated with the Republic Aviation Corporation at Mineola, New York, and under contract to the Air Force Special

Weapons Center, Albuquerque, New Mexico. His work included analytical studies of Argus layer formation and radiation, of various types of plasma radiation effects connected with the expansion of nuclear bomb debris, surveys of the orbital and rigid-body dynamics of dumbbell and Nimbus satellites, and research in quantum mechanics and field theory.

Mr. D. O. Barnett, a Ph.D. candidate in Mechanical Engineering, is currently participating in the design of a plug nozzle for use in the experimental phase of the Crossed-Beam Atmospheric Measurement project. He is also participating in the fluid dynamics phase of a preliminary design study of a "zero-g" workbench for the Apollo program. Mr. Barnett has over seven years experience in the fields of aerothermodynamics, fluid mechanics, heat transfer, propulsion, and experimental aerodynamics.

Mr. R. Silber, a Ph.D. candidate in Mathematics, is a Member of the Technical Staff of the Sciences Section. He is currently working on calculus of variations applications and the development of adaptive guidance schemes. He is conducting an in-house course in theory and the application of the calculus of variations and is engaged in the study of the application of the iterative guidance mode to space vehicle trajectories. He is also an Associate Professor of Mathematics at Clemson University. Prior to joining Northrop, Mr. Silber taught mathematics at Southern Illinois University while engaged in his doctoral studies. Previously, he was employed by NASA at Marshall Space Flight Center where he was involved in trajectory optimization and guidance theory studies.

Mr. C. K. Chou, a Ph.D. candidate in Physics, is an Engineer of plasma physics in the Sciences Section. He is currently engaged in doctoral studies at Columbia University. He was previously involved in a study of nonlinear equations governing the dynamics of collisionless plasmas. Mr. Chou has taught courses in physics, chemistry, applied mechanics, and advanced mathematics at Columbia University. He also worked in Columbia's Nevis Cyclotron Laboratory, conducting research in slow neutron, resonance reaction, and nucleon nucleus scattering.

Mr. R.V.S. Yalamanchili, a Senior Engineer in the Sciences Section, is a doctoral candidate in mechanical engineering at the University of Alabama. His most recent work has been an analysis of mixing and combustion in exhaust plumes. The analysis included approaches such as finite rate chemistry, equilibrium chemistry, and frozen flow cases. His previous work at Northrop has included analysis of the induced flow field and normal aerodynamic loading on an Apollo/Saturn V vehicle during lift-off, and an analysis of the effect of the interaction of rocket exhaust flow impinging on the lunar surface.

SECTION VI

PLANNED EXPERIMENTAL & COMPUTER FACILITIES IN HUNTSVILLE AND SUPPLEMENTAL CORPORATE CAPABILITY

6.1 PLANNED EXPERIMENTAL & COMPUTER FACILITIES/HUNTSVILLE

6.2 MAP SHOWING NORTHROP FACILITIES/HUNTSVILLE

6.3 AERIAL VIEW OF NORTHROP COMPLEX/HAWTHORNE

6.4 OTHER NORTHROP FACILITIES

6.1 PLANNED EXPERIMENTAL AND COMPUTER FACILITIES/HUNTSVILLE

Present plans are for Northrop/Huntsville to establish the necessary experimental and computer facilities to assist and verify present and future theoretical and analytical studies. These facilities will include:

Engineering Group:	Aerodynamics Laboratory (including hypersonic aerodynamics and real gas effects)
	Electronics Laboratory
	Thermodynamics Laboratory
	Gasdynamics Laboratory (including Magneto-hydrodynamics)
	Thermochemical Kinetics Laboratory
	Material Laboratory
Science Group:	Nuclear and Solid State Physics (Partially operational)
	Plasma Physics
	Space Physics
	Aerophysics
	Planetary Physics
	Laser Physics
Computer Group:	Analog Computers
	Digital Computers (IBM 1130 currently in use)

The experimental facilities will be on a limited scale and are not intended for conducting extensive experimental work as such. Large-scale experimental and computational assignments will be carried out through the regular research facilities of Northrop Corporation in California.

6.2 MAP SHOWING NORTHROP FACILITIES/HUNTSVILLE

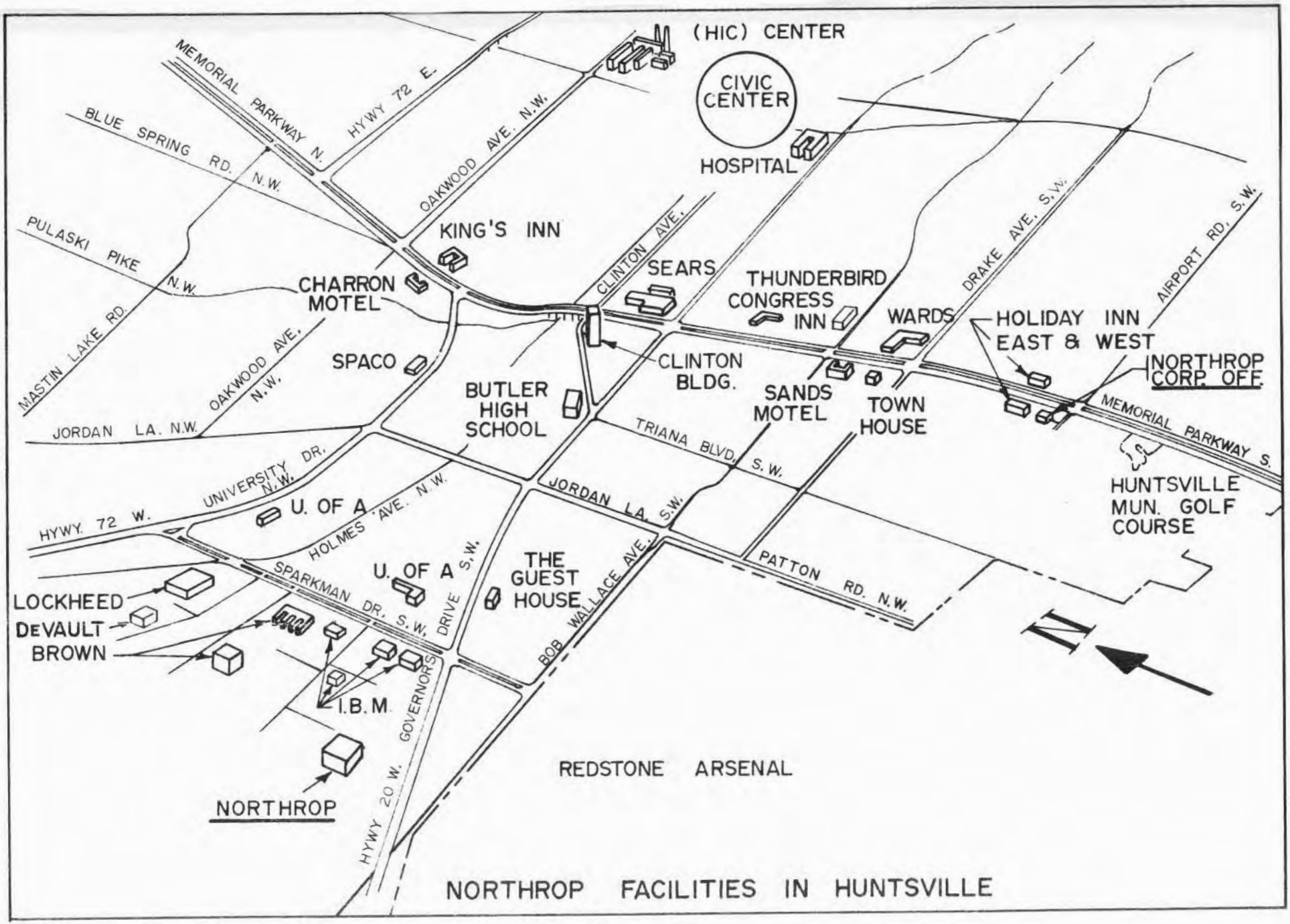
(HIC) CENTER
CIVIC CENTER
HOSPITAL
MEMORIAL PARKWAY N.
HWY 72 E.
BLUE SPRING RD. N.W.
OAKWOOD AVE. N.W.
KING'S INN
PULASKI PIKE N.W.
CHARRON MOTEL
CLINTON AVE.
SEARS
THUNDERBIRD
CONGRESS INN
WARDS
DRAKE AVE. S.W.
AIRPORT RD. S.W.
HOLIDAY INN EAST & WEST
NORTHROP CORP. OFF.
MASTIN LAKE RD.
OAKWOOD AVE. N.W.
SPACO
CLINTON BLDG.
BUTLER HIGH SCHOOL
SANDS MOTEL
TOWN HOUSE
MEMORIAL PARKWAY S.
JORDAN LA. N.W.
TRIANA BLVD. S.W.
UNIVERSITY DR. N.W.
HUNTSVILLE MUN. GOLF COURSE
HYWY. 72 W.
U. OF A
HOLMES AVE. N.W.
JORDAN LA. S.W.
SPARKMAN DR. S.W.
U. OF A
S.W. DRIVE
THE GUEST HOUSE
PATTON RD. N.W.
BOB WALLACE AVE.
LOCKHEED
DEVAULT
BROWN
I.B.M.
GOVERNORS
HYWY 20 W.
REDSTONE ARSENAL
NORTHROP
N
NORTHROP FACILITIES IN HUNTSVILLE

Figure 7-3

6.3 AERIAL VIEW OF NORTHROP COMPLEX/HAWTHORNE

AERIAL VIEW OF NORTHROP COMPLEX/HAWTHORNE

6.4 OTHER NORTHROP FACILITIES

The Northrop facilities in Hawthorne, California perform a broad spectrum of experimental research and development testing in support of company product areas. These facilities are operated, maintained, and supported by personnel under one central organization, providing coordinated and expeditious conduct of test programs from their inception through the numerous design, construction, and test phases, to the completion of the final data report. This organization originates and executes experimental research projects and maintains a high degree of operational efficiency of the test facilities. The Northrop/Hawthorne complex includes the following facilities:

- Nuclear Measurements Facility - Operational since 1957, this facility is supplied with the finest available equipment to conduct investigations in radiation detection, spectral analysis, activation analysis, and radiotracer techniques.

- Reactor Radiation Laboratory - Housing the Northrop Reactor, which employs a TRIGA advanced Mark F stainless steel core, this facility is unique among privately-owned reactor facilities in that the reactor is capable of both pulsing and steady-state operation.

- Space Simulation Equipment - As a result of extensive work in the areas of space environment simulation, sealant investigations, material properties, and thermal radiation characteristics, Northrop/Hawthorne has acquired or developed the equipment required to conduct comprehensive studies in these areas. Included in this equipment are two 18-inch diameter bell jar vacuum systems; a metal vacuum chamber with internal dimensions of 2.5-feet diameter by 5-feet high; a metal vacuum chamber with internal dimensions of 5-feet diameter by 7-feet long; and a small versatile vacuum system employing a clay absorption roughing pump and an ion pump.

- Materials Preparation and Evaluation Equipment - A partial listing of the more significant equipment available for studies in these areas includes: Rubber mill and calendar; Aging ovens and annealing

furnaces; Leak detection devices; Hydraulic presses; Low temperature test chamber; Surface preparation equipment; Perkin-Elmer spectrophotometer; Dynamic modulus apparatus; and a Gier-Kunkle integrating sphere spectrophotometer.

There are other extensive facilities available for use in analytical determinations, testing, specimen preparation and fabrication, and supporting services within the Corporation. These facilities include:

- Norelco X-ray Diffractometer
- Jarrell-Ash Emission Spectrograph
- Gas Chromatograph
- Leitz Dilatometer
- Instron Tensile Tester
- Light Gas Gun Hypervelocity Facility
- Planetary Physics and Chemistry Laboratory - Equipment includes: Transis-tronics Kiloton Hydropress (Model 3); Brown Dual-Scale Recorder and Temperature Control System; Moseley X-Y Recorder; Leeds and Northrop Two-Pen Strip Chart Recorder; Hewlett-Packard Test Oscillator; Hewlett-Packard Single-Beam Oscilloscope; Tecktronic Dual-Beam Oscilloscope; Lindberg 3000°F Muffle Furnace; Rock Crusher and Pulverizer; Abbe Refractometer; Diamond Lapping and Sawing Equipment; Kinney KC-46 Vacuum Pump; Petrographic Microscope; and a Nuclear Magnetic Resonance spectrometer.
- Plasma Physics Laboratory - This facility is fully equipped to perform extensive experiments on plasma flow research. Major items of equipment available are: Three fully instrumented vacuum tanks, an arc chamber which can be operated above or below atmospheric pressure, two vacuum pumps with a combined capacity of 17,000 cubic feet per minute, thrust stands capable of measuring forces from 0 to 20 pounds in either direction, and six plasma generators consisting of four water-cooled jets and two radio frequency plasma generators.
- Computation Laboratory - This facility provides support to all Northrop activities through the operation of complete computer facilities including an IBM 7094 digital computer.

Palos Verdes Electronic Facilities: These facilities provide support to all Northrop activities in the areas of electronics, guidance systems, control systems, guidance subsystems, and on-board computers, as well as related theoretical research and analysis in "guidance & control" applicable to marine, aero-, and astro-systems and operations.

Boston Area Precision Product and Navigational-Guidance Analysis Facilities: These facilities are equipped to perform extremely high precision production of navigational equipment such as inertial gyro sensors as well as the production and assembly of all types of navigation and guidance subsystems for all types of modern transportation and communication systems.