OPPORTUNITIES FOR POSTDOCTORAL RESEARCH

IN

AEROSPACE-RELATED SCIENCES

at

NASA LANGLEY RESEARCH CENTER
Langley Station
Hampton, Virginia 23365

1967-1968

POSTDOCTORAL RESIDENT RESEARCH ASSOCIATESHIPS
in association with the
NATIONAL RESEARCH COUNCIL
National Academy of Sciences
National Academy of Engineering
Washington, D. C. 20418
Described here are some of the areas of research in which a Postdoctoral Resident Research Associateship may be awarded for 1967-1968 at the NASA Langley Research Center in association with the National Research Council. The stipend for the Regular Postdoctoral Resident Research Associate will normally be at the rate of $11,500 per annum. The stipend for investigators with suitable research experience beyond the doctorate will be set by a National Research Council board; the stipend for a Senior Postdoctoral Resident Research Associate will be adjusted in terms of the individual's present salary together with a proper dislocation allowance. For a foreign award, the basis would be a level of stipend which would match the salary of the individual's American counterpart. An appropriate travel grant will be determined by the board for each Associate. All stipends will be subject to income tax. Requests for application forms should be addressed to the Office of Scientific Personnel, Room 318, National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. Completed applications are to be received in this office.

A completed application for an Associateship must include evidence that the specific problem suggested by the applicant for postdoctoral research lies within an area of investigation acceptable to the scientific adviser under whom he would work. Names of such advisers and possible research problems are listed herein.

The Langley Research Center is engaged in basic and applied research to provide scientific and technical background necessary for accomplishment of manned and unmanned exploration and use of space, the improvement in the performance, safety and utility of airborne flight, and the generation of new and advanced
concepts for future NASA programs. Langley Research Center programs thus offer research opportunities in many areas of the physical sciences, in mathematics, in engineering, and in bioscience and biotechnology. The advanced research and development problems described herein do not represent the complete research program, thus are indicative only; inquiry is invited in any related research area. Correspondence requesting information concerning an applicant's plan of research may be addressed to the appropriate adviser and Mail Stop number at the NASA Langley Research Center, Langley Station, Hampton, Virginia 23365. Potential applicants are reminded that any contact or correspondence with NASA Langley Research Center research scientists in no way obligates either the National Research Council or NASA-Langley Research Center in the appointment of a Research Associate; any action with regard to an appointment is the responsibility of the National Research Council.

It will be noted that the broad research mission of Langley is carried out in 10 research divisions. Whereas the research carried out in each division is generally oriented toward a fairly specific area, it is not necessarily restricted and many interfaces and overlaps naturally occur among these divisions; each research item is thus identified with the appropriate organizational division and the code is given below:

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Available to Research Associates are the extensive and varied experimental facilities at Langley Research Center; plant value of this laboratory, celebrating its 50th Anniversary in 1967, is about $250,000,000. Certain major Langley facilities available for common usage by the research staff deserve special mention, for example, the large and complete library. Also available are the facilities of the extensive analysis and computation center which provides a variety of analog and simulation equipment coupled to a large central digital computer complex. The latter is, of course, available for uncoupled use by the research staff on its various research problems which require use of the most modern high-speed electronic digital computers. Also, the instrumentation divisions provide services to the other research divisions in addition to their own research activities. There are, of course, extensive shop and other supporting laboratory central-service facilities.
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Boundary-Layer Separation in Hypersonic Flow (APD) J.R. Sterrett, MS 164

Improved theories for predicting conditions in separated and reattachment flow are being sought. The goal of this study is to improve our theoretical and experimental understanding of separated two- and three-dimensional flow, and to apply this knowledge wherever possible to practical aerodynamic problems.

Interactions Between Ablative Surfaces and Hypersonic Boundary Layers (AMPD) G.D. Walberg, MS 214

Studies are being carried out to define the response of ablative surfaces to high enthalpy gas flows. Particular emphasis is placed on defining the nature of the char layers produced by these materials, the processes responsible for the removal of the char and the gaseous species which are introduced into the boundary layer. Studies of the effects of the gaseous ablation products on the boundary-layer flows are also being carried out. Present approaches emphasize the coupled chemical and aerodynamic aspects of the problem; both analytical and experimental investigations are underway. A complex of high enthalpy wind tunnels, which produce a wide range of hyperthermal test conditions, are available in the experimental program.

Mass Transfer into Turbulent Boundary Layers (SRD) R.T. Swann, MS 206

The heat-transfer reduction which results from mass injection into a turbulent boundary layer must be defined. Of particular interest is the downstream cooling obtained from injection at discrete points. Parameters include mass injection rate and details of the injection process. Theoretical or experimental techniques, or a combination of the two, can be applied as required.
Boundary-layer transition from laminar to turbulent flow and turbulent heat transfer are being investigated for local Mach numbers up to 15 and local Reynolds numbers up to 400 x 10^6. Data will be obtained from conical bodies during high-speed ballistic reentry. This research involves investigation into areas affecting transition such as pressure and entropy gradients, roughness, Mach number, Reynolds number, and body motions and asymmetries, and into areas affecting turbulent heating such as real gas physics, chemistry of boundary layers, equilibrium and nonequilibrium flows, convective heating, transport properties, and space and time correlation of turbulent heating.

Boundary-layer research oriented toward aircraft from subsonic to hypersonic speeds is in progress including studies of laminar boundary layers, transition and turbulent boundary layers, all with and without heat transfer. Improved theories for three-dimensional flows are sought and studies of practical aspects such as effects of surface roughness, angle of attack, control boundary layer deflection and inlet/bye-pass design need increased attention. Results of these Researches find primary application to the design of supersonic and hypersonic aircraft.
AERODYNAMIC HEATING

Heat-Transfer Analysis (DLD)  
P.J. Bobbitt, MS 245
Continued basic analytical research is required in heat-transfer problems where real gas effects and various surface phenomena (such as mass injection, vaporization, etc.) are factors. In addition, increased research effort on fluid flows in body wakes involving viscous effects and heat transfer is desired.

Radiant Heating During Atmospheric Entry (SRD)  
R.T. Swann, MS 206
Development of practical methods for calculating radiant heating rates and heating distributions to an entry vehicle is required. Emphasis will be on simplified but realistic flow field calculations and integration over the flow field to yield surface radiant heating. The effects of injected species on radiant heating are also of prime importance. Conditions encountered during earth entry at 50,000 ft/sec are of primary interest.

Ablation Materials Flight Experiments (AMPD)  
B.J. O'Hare, MS 215
Advanced thermal protection materials are being studied by means of rocket flight experiments to determine the adequacy of existing theories and empirical correlations. Some of the primary areas of interest are: the effect of model size on material behavior; the effect of turbulent flow on material performance; the effect of the ablator upon transition Reynolds number; the effects of high aerodynamic shear levels on char retention and the effect of dynamic pressure on material loss rates.
Physics of Reentry Flows (APD) R.L.Trimpi, MS 161

Basic research on the flow phenomena associated with very high-speed reentry including such problems as convective and radiative heating is in progress. Emphasis is on basic theoretical studies and experiments pertaining to both boundary-layer and potential flow over a wide range in Mach number, Reynolds number and total enthalpy. The program also includes fundamental research on new techniques and apparatus for heat-transfer and radiation measurements and for complete simulation of re-entry and real-gas effects.

A Study of the Concentration Profiles of Injected Coolant in the Boundary Layer of a Hypersonic Stream (SRD) R.R.Howell, MS 208

To reduce the high surface temperatures resulting from hypersonic flight, it may be necessary to cool certain external surfaces of the aircraft structure by injection of a gaseous coolant. Analytical and experimental studies will be performed to determine the concentration profiles of a gaseous coolant injected into the boundary layer of a hypersonic stream and to determine the optimum coolant flow requirements for full scale vehicles. An existing 3-foot diameter, 20-degree cone may be used for these studies in the Langley 8-Foot High Temperature Structures Tunnel.

Heat-Transfer Characteristics of a Fibrous or Porous Insulation in the Presence of a Transpiring Gas (SRD) M.S.Anderson, MS 208

The aim of this study is to determine analytically the heat-transfer characteristics of fibrous or porous insulation as a function of the flow
AERODYNAMIC HEATING (Cont'd.)

rate of a transpiring purge gas. The results of the study will provide a more realistic basis for the design of thermal protection systems for cryogenic tankage of hypersonic vehicles.
AERODYNAMICS, HYPERSONIC

Low-Reynolds-Number Effects at Hypersonic Speeds (APD) W.B. Boatright, MS 130
Experimental and theoretical research is in progress to improve prediction of low-Reynolds-number viscous effects on hypersonic aerodynamics. For experiments, electric-arc heated facilities are available for experiments simulating the 200,000 to 300,000 foot altitude range at Mach numbers from 10 to 17.

Hypervelocity Flow Field Analyses (AMPD) C.B. Rumsey, MS 214
Detailed flow-field analyses are being developed for use in studies of reentry configurations and reentry environment for interplanetary missions. The interaction of shock-layer radiation with the flow field, including effects due to radiation cooling of the shock layer, self-absorption of radiation within the shock layer, and absorption by injected ablation products are problems of concern.

Hypersonic Aerodynamics with Mass Transfer Cooling (APD) W.B. Boatright, MS 130
Experimental and theoretical research in progress is aimed toward evaluation of mass transfer cooling schemes and their effects on hypersonic boundary layers, induced pressures, and heat transfer. Ablation, transpiration, and injection cooling are being considered. Hypersonic, electric-arc heated wind tunnels are available for experimental research.

Flow Diagnostics in Hypervelocity Flows (APD) W.B. Boatright, MS 130
Experimental and theoretical research is in progress on developing instrumentation and test techniques for detecting and measuring degree of nonequilibrium chemical species distributions, and flow properties in high enthalpy hypersonic flow fields generated by arc-heated facilities. Langmuir probe, microwave, electron beam and spectrographic equipment are available.
Skin Friction Measurements in Hypersonic Boundary Layers (APD)  
R.W. Rainey, MS 408

Techniques of measuring the local skin friction on arbitrary shapes in a hypersonic flow are being sought. Application of Preston and Stanton tubes is being considered. The goal of this effort is to be able to define the fraction of the total drag of hypersonic vehicles that is skin friction.

Hypersonic Research on Lifting-Body Entry Vehicles (APD)  
R.W. Rainey, MS 408

Aerodynamic studies are being conducted of hypersonic lifting-body entry vehicles with maximum lift-drag ratios from about 1 to 3. Analytical techniques are used to determine effects upon performance, stability and control of configuration variables as well as to calculate the vehicle characteristics. Experimental results are used to evaluate the theoretical approaches and to provide information not attainable or unfeasible by analytical techniques. Both basic shapes (such as cones and cone-cone-frustrums) and complex configurations are under study with and without mass addition to certain local areas.

Fundamental Hypersonic Boundary Layers (APD)  
J.C. Dunavant, MS 408

Studies are being conducted of laminar hypersonic boundary layers. The effects of mass addition upon the heating of the surface where the fluid is injected and upon the heating of the downstream surfaces for both the attached and separated boundary layers are of interest. The effects of surface gaps in the separated-flow regime upon surface pressures and
AERODYNAMICS, HYPERSONIC (Cont'd.)

heating are being studied. Effects of pressure gradients, nose bluntness and well temperature upon boundary-layer transition and profiles are of concern.

The turbulent hypersonic boundary layer is of interest, particularly the analytical techniques to determine the turbulent heating rates and the effects of wall temperature and pressure gradients upon boundary-layer separation.

Mass Addition and Downstream Effects (APD) J.C. Dunavant, MS 408

Presently available solutions to the laminar boundary layer with mass addition are limited by constraints and simplifying assumptions in the analyses. Turbulent boundary-layer solutions with mass addition are not known to exist. Refinement in mass addition boundary-layer theory is desired to predict heating and boundary-layer growth to hypersonic vehicles. Currently the equations for a hypersonic laminar boundary layer with a transpiring foreign gas are being solved including the effects of thermal diffusion and diffusion thermodynamics. Further solutions are desired particularly in the areas of nonsimilar solutions and downstream effects.

Flow Field Investigation of the Highly Swept Delta Wing (APD) M.H. Bertram, MS 130

The highly swept delta wing, which remains of interest for a variety of classes of hypersonic vehicles, will be examined experimentally over a large range of Reynolds numbers and the flow field will be predicted by analytical methods. The lee surface behavior, which is often complicated by the presence of vortices, will be investigated in depth. Effects on the flow field of leading-edge bluntness, leading-edge shock detachment and viscous interaction will be studied.
AERODYNAMICS, HYPERSONIC (Cont'd.)

Research on Definition of Hypersonic Cruise Vehicles (APD)  
C.H. McLellan, MS 243

Studies are underway to define and analyze configurations of hypersonic-cruise vehicles. These early studies will develop a technical basis for the eventual design of vehicles such as a hypersonic transport. Opportunities are available for original work in many areas including the following:
Definition of complete configurations with consideration of the strong interaction between aerodynamics, propulsion, structures and efficiency; studies of the propulsion system and its reactions with the remainder of the airplane; development of theoretical aerodynamic prediction methods for hypersonic speeds which account for the interference between components such as wings and bodies; and development of methods of extrapolating the ground facility results to flight. (The ground facility results normally have laminar or transitional boundary layers in contrast to the turbulent ones in flight.)

Transition Fixing at Hypersonic Speeds (APD)  
P.C. Stainback, MS 161

The flight of high performance vehicles at hypersonic speed has increased the need for obtaining turbulent boundary-layer data in ground facilities. Since most high-speed ground facilities have limited Reynolds number capability, it will be often necessary to trip the hypersonic laminar boundary layer in order to obtain turbulent data. Tripping the boundary layer on wind tunnel models at subsonic-and supersonic speeds has proven successful in predicting the turbulent boundary-layer characteristics of full-scale vehicles up to a Mach number of 3, however, as the speed increases it becomes more difficult to trip the laminar boundary layer. Therefore, before hypersonic vehicle characteristics can be obtained in ground facilities with the proper turbulent boundary layer over its surface, some effective way must be found to trip the hypersonic laminar boundary...
layer without introducing extraneous disturbances in the tripped flow. At present there are several wind tunnels in the Mach number range from 6 to 10 available at the Langley Research Center for conducting transition fixing investigations.
Air-Intakes for Supersonic Aircraft (FSRD)  
R.H. Wright, MS 359

Improved methods for analysis of the operating characteristics of engine air intakes for supersonic aircraft is sought. Problems under study include instabilities due to interactions of engine-induced disturbances with the primary inlet shock-wave system and efficiency losses at off-design operation conditions. Results of such theoretical studies will lead to more rational design of air inlets and integration of the total engine installation with the airframe of supersonic aircraft.

Jet Exit Aerodynamics (FSRD)  
B.W. Corson, MS 189

Problem areas under study include aircraft propulsion system installation effects on airframe flow field and on exhaust nozzle performance, including effects of nozzle installation on afterbody drag. In some of these investigations, wind-tunnel tests of jet-powered models are made wherein the effects of jet operation on complete aircraft aerodynamics and stability and control are measured. Off-design engine and nozzle operation is a primary variable in this research.

Problems under study in this area related to spacecraft include those arising in launch vehicles, for example, jet-airstream entrainment and base drag, exhaust-gas recirculation and base heating and overall jet-airstream effects on hinge moments. Also, escape-rocket operation for manned spacecraft introduces critical effects which must be considered.
AERODYNAMICS OF INTERNAL FLOW SYSTEMS (Cont'd.)

Turbulent Boundary Layers (APD) J.R. Henry, MS 168

The development of analytical procedures for predicting the growth of turbulent boundary layers at hypersonic Mach numbers under real gas conditions with high heat transfer to the wall and continuous pressure gradient, and with shock impingement effects is of major interest. The development of a universal velocity profile relation applicable to turbulent boundary layers with heat transfer is needed. This technology is of particular interest in the hypersonic air intake area.
AERODYNAMICS, LOW SPEED

Reynolds-Number Effects on Subsonic Bodies (FSRD)

Analytical procedures, including viscous effects, are sought for calculating the aerodynamic forces at subsonic speeds on two- and three-dimensional bodies of arbitrary cross section. Wherein experiments show large effects of Reynolds number on body-force characteristics, available theory is generally limited to idealized potential flow. An approach to the problem might be through development of high-speed computer techniques to solve first in some iterative process the two-dimensional body combined boundary-layer potential-flow case, then progress to the three-dimensional case.

Studies of Wing Leading-Edge Vortex-Flow (FSRD)

Studies are in progress on leading-edge vortex flow which exists on wings having swept leading edges, including development of such flows as a function of angle of attack, wing sweep and leading-edge shape, etc., and their consequent effects on lift, drag and induced flow fields at both subsonic and supersonic speeds. Theoretical work in the past has been limited generally to slender delta wings in conical flow and the methods developed are limited in application. Improved analytical methods are sought, especially with regard to load distribution, extended to cover the non-slender cases and planforms of arrow and composite types.
AERODYNAMICS, SUPERSONIC

General Supersonic Aerodynamics Research (FSRD)  F.E. McLean, MS 406

For a number of years Langley has conducted basic theoretical and experimental research in the supersonic speed regime. The goal of this research is to obtain a better understanding of the aerodynamic factors which influence supersonic flight and to translate this better understanding into a form which can be rapidly used by an airplane designer. Theoretical procedures are developed to consider such aerodynamic variables as boundary-layer flow, supersonic wing design and component interference. Carefully designed experimental programs and models are then evolved to verify the theoretical concepts in several supersonic wind tunnels. High-speed digital computer programs are evolved from the research for direct use by the airplane designer.
Currently one of the areas of aeronautical research being vigorously explored is aimed at obtaining high aerodynamic efficiency (high L/D) at Mach numbers close to one (to \( M = 0.98 \)). Although experiments indicate that airplanes flying at these speeds may have higher efficiencies than supersonic airplanes, little theory is available for analysis and guidance. For example, no theoretical approach with mixed sub- and supersonic flow exists for estimating overall wing characteristics. The next step beyond the advanced mixed-flow theory approaches would be the study of means for reducing the induced drag. Since the fuselage skin/drag will be a large fraction of the total drag for high volume fuselages, advanced approaches to 3-D boundary layers at transonic speeds are also sought. Advances in each of these areas should accelerate development of \( M \rightarrow 1 \) airplanes.

Fundamental studies are underway toward the development of methods for prediction of boundary-layer properties in mixed sub- and supersonic flows including boundary-layer growth through shocks, location of shocks and separation effects and criteria. Such research is of particular interest as related to transonic wind-tunnel studies of models of very large transonic aircraft wherein it is desired to develop methods for simulation of the very high flight Reynolds numbers and consequent effects thereof.
Flutter (DLD)  
A.G. Rainey, MS 340

Opportunities exist for experimental and theoretical research on aircraft flutter, including the structural and aerodynamic aspects of wings and large external stores, body flexibility, panel flutter, and propeller whirl. These problems encompass the entire flight spectrum from subsonic to hypersonic speeds.

Power Spectral Density Gust Analysis (DLD)  
K.G. Pratt, MS 340

Research efforts to reduce the uncertainties in application of power spectral density methods to the estimation of design values of gust loads on airplanes are in progress. The uncertainties under study include: (1) the value or values of the scale of atmospheric turbulence, L; (2) the effect of sample size on the accuracy of the measured root-mean-square turbulence velocity and on the shape of the power spectrum; (3) the adequacy of approximating a non-stationary process by a continuously varying standard deviation of turbulence velocities; and (4) the determination of the average number of zero crossings per unit time from theoretical response power spectra.

Gust Loads on T-Tails (DLD)  
K.G. Pratt, MS 340

Airplanes having T-tails may have some special turbulence response problems. The probability of a deep stall induced by flight in turbulence needs examining. Improved methods for determining the loads on the tail structure due to a combination of vertical and lateral turbulence velocities are sought for all airplane configurations.
AEROSPACE VEHICLE DYNAMIC RESPONSE (Cont'd.)

Model Excitation Methods (DLD) F.T. Abbott, Jr., MS 340

Experimental wind tunnel investigation of aircraft loads and dynamic stability problems through the use of scaled models offers important advantages. Development of optimum methods of producing the types of excitation inputs required is sought.

Structural Dynamics (DLD) J.P. Raney, MS 244

Theoretical and experimental programs are being directed toward developing improved methods of structural dynamics analysis with emphasis on shell structures. Efficient techniques for computing the vibrational characteristics of complex structures are being sought. Practical methods of computing the response of complex structures to transient loads are being studied with some emphasis on shapes not possessing rotational symmetry. The nonlinear behavior of shells, eccentric stiffening, and effects of imperfections are being studied. Areas of application include the dynamic response of spacecraft, atmospheric entry vehicles, and orbiting laboratories.

Gust Response of V/STOL Aircraft (DLD) A.G. Rainey, MS 340

General research on V/STOL aircraft problems has shown the need for developing more refined analytical methods of handling the gust-response problems for operations near the ground. The problem arises from the high-turbulence intensity near the ground and is especially critical for configurations with marginal stability and control characteristics.
The study of sonic boom phenomena involving the generation and propagation of airplane shock fields has been the subject of continuous research at Langley for a number of years. Both experimental and analytic approaches are used in exploring the manner in which airplane pressure fields are formed and the manner in which the separate disturbances from airplane components coalesce to form a shock field far from the airplane which gives rise to the sonic boom problem. This research has a two-fold objective; first, to develop accurate and rapid methods of predicting pressure fields and, second, to devise means of minimizing the magnitude of the disturbance. The phenomena of transmission of a shock wave through a dynamic atmosphere which is nonuniform in temperature and pressure is also under study. Because of the close association of sonic boom phenomena with aircraft aerodynamics, the work is carried out by a group of researchers thoroughly familiar with supersonic aerodynamics.

In application of the theoretical prediction methods, extensive use is made of high-speed digital computing machines. Wind-tunnel tests of small models which have been and continue to be an integral part of the research program provide data for use in examining the correlation of theory and experiment. Data from flight test programs are also employed to that purpose. While these studies for the supersonic speed range will continue, efforts are also being made to begin exploration in the hypersonic speed regime.
AIRCRAFT NOISE AND ACOUSTICS (Cont'd.)

Perceived noise level, or Pndb, is a parameter formed by integrating a weighted variation of noise intensity as a function of noise frequency. The weighting is selected in an attempt to take account of the relative objectionableness of noise to humans over the frequency range. The parameter is incapable of handling other aspects important to subjective response such as noise at discrete frequencies and the effect of exposure time. Research to find a more adequate parameter is required.

Acoustic Duct Treatment (DLD) H.H. Hubbard, MS 239

Research is in progress on materials and conceptual designs for acoustic liners of ducts having high subsonic air flow velocities. Materials and designs are sought which will provide broad band noise reductions and which will also have acceptable structural integrity, maintainability and reasonable life. A particular application is in the inlets and fan discharge ducts of commercial type turbofan engines.

Noise Source Studies (DLD) H.H. Hubbard, MS 239

This research involves the generation and prediction of the broad band and discrete tone noise components from such propulsion units as compressors, fans, rotors, and propellers. Particular emphasis is on the flight operating conditions for which the intake flow patterns may not be uniform.

Response of Building Structures (DLD) H.H. Hubbard, MS 239

This research involves the response of built-up (nonhomogeneous) structures to complex acoustic loadings from sonic booms and aircraft-flyover noise.
The three-dimensional effects of the structure are important as is the air coupling due to wave action in the room cavities.

Aerodynamic Noise (DLD)  
H.H. Hubbard, MS 239

This research involves the generation of noise from jets, aircraft boundary layers, and air flows over stationary blades and vanes. Particular emphasis is placed on the prediction of aerodynamically induced loads on structures in flight over a range of Mach numbers up to hypersonic and the associated response of such flight structures.
Pilot-Aircraft System Analysis (FMTD) J.F. Garren, MS 249

In predicting desirable aircraft handling characteristics, fundamental approaches are sought in which the pilot is treated as an element in the control system. Various mathematical models of the pilot have been developed, but they have not been adequately correlated with flight results. Handling qualities data recently obtained here with the variable-stability helicopter should provide a suitable basis for such an analysis. Engineering test-pilot personnel who conduct these flight investigations will be available for consultation.

Theoretical Studies of Aircraft Response (FSRD) H.G. Wiley, MS 404

Theoretical analyses of the dynamic flight response of aircraft involve studies of such factors as configuration and mass characteristics to define the sensitivity of the classical stability modes to changes in stability derivatives. Extended studies are sought which will consider various classes of aircraft including supersonic transports, and large, advanced technology subsonic transport aircraft. Results of these classical dynamic stability studies will be extended by means of closed-loop system analyses of the handling qualities of the aircraft to permit an evaluation of possible pertinent piloting factors for the various classes of aircraft. Analyses will be made to determine the effects on aircraft response of nonlinear static and dynamic stability derivatives determined experimentally for various classes of aircraft. The studies will aid in defining possible critical configuration variables. Additional studies will attempt to correlate nonlinear dynamic derivatives with the more readily available static stability derivatives for various types of aircraft.
Analytical Models for Subsonic Load Distribution and Static and Dynamic Stability Derivatives of Aircraft Configurations (FSRD)  W.B. Kemp, Jr., MS 404

Research in progress involves the development of methods for the use of digital computing facilities to obtain numerical solutions for aerodynamic load distribution and static and dynamic stability derivatives of lifting wing-body-tail configurations in subsonic potential flow. Development fundamental approaches are sought for application to the calculation of loads on wing-body-tail combinations in sideslipping, pitching, yawing and rolling motions with due consideration of mutual interference. The ability of numerical computing methods to satisfy simultaneously a large number of boundary conditions is utilized in the methods.

Procedures developed will be applicable to detailed load distribution studies and lifting surface design as well as to calculation of static and dynamic stability derivatives.
General Improvements for Helicopters (FMTD)  
R.J. Huston, MS 249

Work in progress includes: Flight investigation of hingeless rotor loads and dynamics; analytical investigation of coupled-blade flap-lag dynamic response of generalized articulated and hingeless rotors; flight and analytical investigation of flight dynamics of compound helicopter; and analytical investigation of effect on blade dynamics and loads of blade impact into high vorticity area trailed from adjacent rotor blade.

Areas that need theoretical and experimental treatment include: Expansion of performance prediction methods to include three-dimensional effects; development of methods of control of the blade tip-vortex directed at providing improvements in control of rotor noise, blade stresses, and vibration.

Extension of Theory for Helicopter Ground Resonance to Include Blade Aerodynamics and Hingeless Rotors (FMTD)  
R.J. Huston, MS 249

Development of equations of motion for helicopters with the blade inplane bending frequency below the rotor rotational frequency are sought. Various levels of blade root flexibility will be investigated, from fully articulated to the cantilevered blade "hingeless rotor."

Terms representing coupling between blade motions and aerodynamic forces are to be included, such as: blade flapwise displacement and velocity with blade feathering; blade chordwise position and velocity with blade feathering; coupling due to noncoincident mass and elastic axes of blades. Equations are to provide for elastic restraint of the helicopter (as occurs when the aircraft is resting on the landing gear) and for aerodynamic and inertial restraint (as in flight) where a type of instability called "air resonance" may occur.
Rotor Blade Tip-Vortex Interference (FMTD)  

J.F. Ward, MS 249

The rolled-up tip-vortex shed from the tip of a lifting rotor blade has been identified in a number of research investigations as a principal source of rotor-airframe vibration, noise and oscillatory stresses. The unsteady aerodynamics and the accompanying dynamics associated with tip-vortex interference for a given aircraft in level flight have been shown to be systematic, rather than random, in nature. To date, there is little information on the actual mechanism of rotating blade tip-vortex generation and the interference effects on the unsteady aerodynamic environment of following blades, especially at moderate to high forward speeds. The rotor blade tip-vortex phenomenon must be more clearly understood in order to deal with alleviation of the problem, and to provide useful analytical methods for improved rotor system design.
Equations of Orbital Motion (SMD)  
M.J. Queijo, MS 312

Basic studies in celestial mechanics are used as a starting point to find simple sets of equations that will be useful in space navigation and guidance problems. Linear and higher order solutions are examined to find the regions of usefulness and the cause of the breakdown of the approximations; this knowledge is then used in a study to extend the region of usefulness of these equations.

Physics of the Moon and Planets (SMD)  
W.H. Michael, Jr. MS 304

Data are now becoming available, from analyses at Langley Research Center, on the properties of the gravitational field of the moon, the moments of inertia of the moon, and related parameters. These and other available data provide new information for application to additional research on the internal and external properties of the moon, and to new theories and hypotheses on the origin and history of the moon and, perhaps, of other planets. Additional research is needed in the general areas of: determination of the mass and density distribution in the lunar interior; application of results to the rotational properties of the moon, including physical librations, and correlations with present knowledge; possible correlations between mass distribution and surface features on the moon; studies of internal processes in the moon, existing and historical; and analyses of relation and correlation between photographic data of the lunar surface and internal properties.
Orbit and Parameter Determination from Analysis of Spacecraft Tracking Data (SMD) W.H. Michael, Jr. MS 304

Analysis of tracking data from the Lunar Orbiter spacecraft, for determination of the gravitational field of the moon and related parameters, is in progress, and preliminary results are now available. Additional research is needed in the following categories: extension of the analyses to determination of additional parameters derivable from the tracking data; mathematical developments in parameter determination, including such items as representation of the gravitational field in other than spherical harmonics for possible reduction of correlations; application of techniques to other planets and including, for example, determination of atmospheric properties of Mars; and applications, in conjunction with photogrammetric techniques, for direct determination of the figure of the moon.
Research is being conducted on the synthesis, characterization and evaluation of polymers of utility to aerospace programs. Emphasis has been placed on but not limited to aromatic and heteroaromatic systems. Studies include exploratory syntheses of new polymer systems, and the determination of the rates and mechanisms of their formation. A broad range of characterization methods such as infrared and ultraviolet spectroscopy, viscoelastic behavior, osmotic pressure molecular weight, and mechanical properties are used to correlate polymer structure with physical and chemical properties. The pyrolysis and radiolysis of polymers are studied in an attempt to predict their behavior and improve their stability to these environments. Programmed thermogravimetric analyzers and electron and proton accelerators are available for use in this work.
COMBUSTION AND HI-TEMPERATURE REACTIONS

Shock Tube Reactions (AMPD)
C.J. Jachimowski, MS 214

The effectiveness of an ablative material depends in part on the rate at which the gaseous ablative products may react in the boundary layer. Major experimental effort is being directed towards the study of the reactions of air components with simple hydrocarbon molecules. The studies are being conducted with a shock tube using spectroscopic techniques to monitor reacting species.

Flash Photolysis and Pyrolysis (AMPD)
A.R. Saunders, MS 217

Experimental studies are conducted in order to elucidate the mechanisms of fast reactions in homogeneous and heterogeneous systems. Kinetic spectroscopy, flash and laser heating, radiation assisted combustion in combination with time resolved rapid-scan infrared, visible optical spectroscopy and mass spectrometry are some of the experimental techniques used in this work.

Rocket Combustion Theory (AMPD)
A.R. Saunders, MS 217

Theoretical descriptions of the steady state and transient modes of combustion and surface regression are developed utilizing analytical and numerical solutions of the chemical kinetic and transport equations for reactive flows applied to laminar and turbulent flame theory. Computer simulation of combustion modulation and instabilities in heterogeneous combustion are of special interest.

Fluid Physics of Reactive Flow Systems (AMPD)
A.R. Saunders, MS 217

Experimental studies of flow in homogeneous and heterogeneous laminar and turbulent flames are currently in progress. Optical and mass spectrometer and fluid dynamic probing techniques are applied in conjunction with radiation assisted combustion in order to study the structure of heterogeneous flames.
Supersonic Combustion (APD)  
J.R. Henry, MS 168

Analytical and experimental investigations of supersonic flows involving exothermic chemical reactions are in progress. Emphasis is placed on identifying and answering fundamental questions related to the design of combustors for hypersonic propulsion systems. Problem areas in general include analytical and experimental investigations of fuel injection, penetration and mixing, ignition delay and reaction history, and supersonic flame propagation.

Turbulent Mixing (APD)  
J.R. Henry, MS 168

Theoretical and experimental investigations of mixing in turbulent compressible flow fields with dissimilar streams and in the presence of pressure gradients is underway. Emphasis is being placed upon the particular model of eddy viscosity employed in a given analysis and upon mixing with large density gradients.
The Langley Research Center is replacing its present digital computers with a large multiprocessor complex. The complex will consist of three central processors, each with its own private memory, and a large shared core memory, backed up by disk and bulk storage devices. A peripheral pool consisting of card readers, punches, printers and magnetic tape units can be assigned through program control to any of the processors. A number of cathode-ray-tube consoles are provided for both computer management and problem solving applications. Analog-to-digital and digital-to-analog conversion equipment will be available for use with the computers in real-time flight simulation studies. The availability of this equipment not only presents challenging problems in the development of advanced operating techniques, but also provides a unique environment for research in the computer sciences. Areas of particular interest are outlined below:

(a) **Programming languages.** Generalized, user-oriented applications programs (e.g. aerodynamics, orbital mechanics, and structures) require specification of the problem requirements within the framework of the program. Programs developed for use with cathode-ray-tube consoles must be customized to meet each application's control requirements. The development of high level compilers which allow the natural description of these requirements will facilitate the use of such generalized programs.

(b) **Graphics.** The use of multiprogramming in large-scale computing systems makes practical the use of cathode-ray-tube displays and various input devices as on-line aids to the solution of scientific and engineering problems. Techniques are required which permit effective communication between user oriented
COMPUTER TECHNIQUES AND APPLICATIONS (Cont'd.)

(applications) programs and the researcher.

(c) Investigation of reentrant subroutines for multiprogram computer systems.- Conventional techniques require association of several routines with each program in a multiprogram system. Total memory requirements can be reduced significantly by the application of routines which are designed for simultaneous use by several programs.

(d) Data management and file structuring.- Computer based information systems are characterized by large volumes of data contained in random access storage devices. These data must be continually added to, changed, and consulted to provide reports on a periodic as well as an "on-demand" inquiry basis. Research is required in the cataloging and structuring of the data base to develop techniques for the creation of open ended files which facilitate updating and rapid inquiry response.

Computerized Control Systems (IRD) C.H. Russell, MS 238

In support of various experimental laboratory research activities at Langley, advanced engineering development of digital systems is in progress toward obtaining of new pattern recognition techniques to facilitate data compression, high-speed encoding (100 megahertz) techniques having good differential linearity, coding techniques to facilitate simultaneous sharing of one computer by several experimenters on a real-time basis, and real-time control systems technology.
The theory of model universes is used to obtain relationships between theoretical universes and observational data. The numerical problem of obtaining parameters to define a model universe from observational data is investigated to determine the best methods for handling the data and the computing methods that should be used. Assumptions made concerning data and the theoretical model are also evaluated. Model improvement is also investigated. The use and interpretation of quasi-stellar radio sources in cosmology is studied. So far, only those models of the universe based on general relativity are under investigation and the work should be extended to cover models from other theories of gravitation. Time scale studies based on stellar evolution are important in this project.
Optimal Attitude Control of Manned Spacecraft (AMPD)  

P.R. Kurzhals, MS 350

The attitude control systems and associated control laws for manned spacecraft and for large manned orbiting space stations are being developed. Present effort involves the use of control moment gyro systems as prime movers for attitude maneuvers in space and as active damping systems where accurate stable fine pointing is required. Systems with lower threshold torque, faster response, higher momentum capacity, and optimal control laws are being investigated. Further effort includes studies of actual mission profiles using prototype control and stabilization hardware coupled with real time digital computer simulation of flexible spacecraft dynamics and internal (crew motion) and external disturbance inputs. Available for experimental research are a 60-foot spherical attitude control system test chamber containing simulated solar and planetary targets, a servo-driven test bed capable of handling full-scale control systems, and an extensive computer complex.

Linguistics and Information Displays (SMD)  

P.A. Gainer, MS 250

Instruments for information display in man-machine systems are symbolic representations of the state of the system. As such, they ought to have something in common with language and may be amenable to study by some of the methods used in the study of linguistics. The main question to be answered is why can certain tasks be performed by reference to the "real" world but not by reference to instruments which seem to present all necessary information? Application of results is to manned aerospace systems. Experimental programs include measurement and analysis of eye movements of subjects performing
control tasks. Theoretical work needs to be done in describing instrument displays in terms of task requirements, taking into account the needs of human operators for order and redundancy.

Digital and analog computing facilities, simulators of aircraft and space vehicle systems, and a versatile electronic display generator are among the facilities available.

Psychology of Manual Control (SMD)  
P.A. Gainer, MS 250

Perception, apperception, vigilance, attention, incentive, motivation, personality all enter into the performance of manual control tasks. The qualities, capabilities and influence covered by these terms tend to be studied separately, even though they may interact in determining how a particular operation will perform a given task. Analyses of tracking performance to obtain quasi-linear transfer functions representing the subject have shown that there are differences in the way different subjects go about the same nominal task. Recently developed methods of characterizing human operators in terms of finite-state machines are more sensitive to these inter-subject differences. The real question is under what circumstances are these differences significant? Research will be conducted to find out if individuals perform differently because of physiological differences, or because of personal goals superimposed on the specified goals of a task, or because of different concepts of the system being controlled.
Research approaches are sought wherein one would formulate the design problem for automatic stability augmentation systems as a nonlinear programming problem and develop iterative digital computer routines for solution of example problems.

Conventional design techniques for automatic stability augmentation systems for spacecraft are based on the response-analysis techniques which were developed for single input – single output dynamic systems, such as electrical networks and servos. The inadequacy of these techniques is clear when one considers, for example, the mathematical formulation of generally accepted handling-qualities constraints for manual aircraft. These can be expressed as inequality constraints involving not only the characteristic roots of the system, but also other dynamic response parameters related to all the response variables and to the coupling between these variables.

In order to satisfy these numerous constraints with a minimum amount of feedback control, one is led to a problem known in mathematics as a "constrained minimization" problem, in which both equality and inequality constraints occur. This problem is similar to, but somewhat more general than, the class of problems which are referred to as "nonlinear programming" problems. Research is needed to extend the digital programs which have been developed for the iterative solution of nonlinear programming problems to the solution of this more general class of problem. This research would hopefully lead to logical, computer-aided design techniques for such systems, based directly on satisfying realistic sets of requirements.
GUIDANCE AND CONTROL OF AEROSPACE VEHICLES (Cont'd.)

Digital Computer Design of Aircraft Configurations (SMD)  A.A. Schy, MS 248

Research is in progress to formulate digital computer subroutines for numerical solution of the partial differential equations of aerodynamic flow to obtain the forces and moments on aircraft as functions of a finite number of configuration parameters. These solutions are applied in additional subroutines to solve for significant aircraft performance, stability, and component-load functions in terms of these parameters. Using these parameters as the independent variables and the above subroutines, an iterative digital computer program is developed to find the optimal configuration parameters extremizing a specified aircraft-performance function, while obeying inequality restraints on other functions such as other performance functions, stability criteria, loads, sensitivity to parameter variation, etc.
GUIDANCE AND CONTROL OF AEROSPACE VEHICLES (Cont'd.)

Automatic Flight Control Systems (SMD)  M.T. Moul, MS 304
Research is in progress on flying qualities of and stability augmentation system design concepts for advanced vehicle configurations. Applications of modern control theory to problems in aircraft flying qualities and stability augmentation and flight control systems design are sought. Techniques and methods developed would provide a capability for synthesizing multi-loop and nonlinear control systems.

Flight Path and Mission Optimization, Control, and Stability (SMD)  J.R. Elliott, MS 304
Research is being directed toward the improvement of methods for performing trajectory and mission optimization studies and the development and use of optimal control and stability theory. New and improved techniques for the numerical solution of two point boundary value problems are being developed. Methods for the practical design of adaptive and stability augmentation systems are being studied. New contributions in the field of both classical and modern optimization and control theories are being sought. These programs are being conducted in conjunction with the development of computer programs for the flight path optimization of both aircraft and spacecraft, the development of conceptual attitude control and guidance systems, and new applications of optimal control theory.

Guidance and Control (FID)  H.J.E. Reid, Jr., MS 494
Studies are being conducted on the development of advanced spacecraft control systems and sensors; for example, the stabilization of space telescopes to 0.1 sec. of arc. The use of advanced information processing and modern control theory to enhance basic sensor accuracy, to negate the nonlinear effects, and to stabilize bending nodes are typical problems being studied and tested.
INSTRUMENTATION

Thin Films (FID)  D.E. McIver, MS 474
The electrical and optical properties of both evaporated and sputtered thin films are being investigated for possible sensor applications. One area involves the development of a low thermal mass thermistor for high altitude meteorological applications.

Planetary Atmospheric Density Measurement by Gamma Ray Scattering Techniques (FID)  C.A. Gurtler, MS 477
Gamma ray scattering techniques have shown promise in the measurement of the density of unknown planetary atmospheres, such as that of Mars. The gamma ray technique is promising because of its high energy - it requires no window in the vehicle heat shield. Mathematical models of gamma ray scattering from a radioactive source are sought.

Vacuum UV Flight Sensors (FID)  D.E. McIver, MS 474
Research is in progress to develop flight-qualified radiation sensors for the vacuum ultraviolet. These sensors are needed in current and future programs such as planetary exploration, orbiting astronomy, and reentry physics.
INSTRUMENTATION (Cont'd.)

**Measurement of Extremely High Vacuum and Space Gas Composition (IRD)**

P. Yeager, MS 234

Increased theoretical and experimental research effort is sought toward the development and improvement of methods and techniques for the measurement of the environment of interplanetary space. Areas of specialization include ion and electron impact phenomena, ion and electron trajectory analysis in electric and magnetic fields, adsorption and desorption of gases in atomic and molecular states from surfaces, molecular beaming, statistical analysis of rarified gas behavior, current measurement below the picoampere region, pulse counting techniques, and tunnel emitter cathodes. Results will be applied to total pressure gages and mass spectrometer residual and contaminant gas analysis. Special consideration will be given to unique ideas and techniques for total or partial pressure measurements.

**Turbulence Measurement in Laboratory Facilities (IRD)**

E.L. Bryant, MS 238

Present methods (e.g., hot-wire probes) for measuring boundary-layer turbulence in hypersonic test facilities are severely limited in frequency response. Improvement of these methods, or development of new approaches yielding response up to one megahertz, is sought to support boundary-layer research. Specialists and equipment are available for support of development of intricate transducers and electronic circuitry.
Transient spectroscopic instrumentation techniques are being investigated for use in analyzing high energy gas streams and combustion products. Some of the desired measurements are gas temperatures, spectral content of high energy gas radiation, composition of gas, and amount impurities in these gases. Specific problems include quantitative energy measurements in the visible and ultraviolet portion of the spectrum, calibration sources and techniques, wavelength resolution, and the microsecond time resolution imposed by impulse type facilities.

Hypersonic flight in atmospheres implies generation of high temperatures in structures of the vehicle. Improved means are sought to measure strain in such structures when the structural elements are at elevated temperatures.
INSTRUMENTATION (Cont'd.)

Fast Response Force Instrumentation (IRD)  J.F. Guarino, MS 238

Studies being conducted in shock tubes and shock tunnels on planetary impact probes necessitate development of extremely fast response instruments. The impulsive operating nature of these research facilities requires that aerodynamic forces be measured during the course of a $100 \times 10^{-6}$ second test. The response requirements here dictate the use of special force balance techniques, perhaps employing piezoelectric and piezoresistive crystals. Development of this class of transducer requires simultaneous development of impulsive calibration techniques to establish instrument performance characteristics.

Properties of Semiconductors (IRD)  I.S. Hoffman, MS 238

Research effort is sought toward improving the temperature dependent properties of semiconductor strain gages by high energy radiation means. Such effort should seek to extend the useful range of the radiation method by combination with controlled incorporation of impurities in the crystal through evaporation, diffusion, etc. The mechanical strain sensitivity of metal-oxide semiconductors and other semiconductor devices and methods for enhancing these properties needs investigation. Apparatus for conducting this work is available.
Laser Applications (IRD) C.C. Laney, MS 475

(a) A theoretical and laboratory investigation is underway to determine the production and character of efficient second harmonic generation at the shorter optical wavelengths. Research requirements for laser sources toward the blue-green portion of the spectrum have been established for parametric amplifiers, photographic applications, holography, and certain underwater applications. Research and advanced engineering effort is sought to improve the efficiency and application possibilities of second harmonic generators.

(b) Theoretical and experimental work is being carried out to develop pulsed holographic techniques which require advanced research to obtain improved Q-switched laser coherency and to develop excitation systems for synchronizing high powered laser outputs to within a few microseconds. Holographic systems are envisioned to photograph mil size particles traveling at speeds above 10,000 ft/second.

Fatigue Detection (IRD) E.L. Bryant, MS 238

Structural fatigue studies require measurements of the initiation and progress of cracks in test specimens. Present visual techniques are time consuming and inadequate for much of the work. Both theoretical and applied research leading to useful instrumentation is needed.
LIFE SUPPORT SYSTEMS FOR SPACE

Bioscience and Biotechnology (AMPD)  J. Scow, MS 310

This program includes basic and applied research on man's requirements for long duration space flight, technology for life support systems, man-machine integration, protective measures and in-flight biomedical experimentation, including physiological, psychological and bioengineering requirements for medical monitoring and support for manned missions. Special emphasis is placed on study of physiology, psychology, toxicology and microbiology as related to man in closed confined environments. Established optimal work-rest cycles is considered by several different disciplines.

Integrated Life Support Systems (AMPD)  W.D. Hypes, MS 350

Research is being conducted to provide integrated regenerative life support systems for long duration manned space missions. Various life support techniques and subsystems are examined, selected components are assembled into a working system, and the complete system is evaluated under operational conditions. Subsystems included are atmospheric control, water management, nutritional support, waste management, personal hygiene, and thermal control. Complementary research is underway on manned space cabin atmospheric trace contaminant identification, effects and control. Current research utilizes a full-scale working model of a regenerative life support system capable of supporting a four-man crew for a period of one year with 60-to-90-day resupply intervals.
MAGNETOPLASMODYNAMICS

High-Density Linear Plasma Accelerator Research (APD)  G.P. Wood, MS 160

Research and development is being conducted on a high-speed steady-flow facility for aerodynamic testing at reentry velocities using a linear plasma accelerator. A pilot model has achieved 6000 m/s, and nearing completion is a 20 megawatt facility designed to achieve 13,000 m/s at a density corresponding to an altitude of 53 km. Extensive diagnostics of the properties of the high-speed flow are conducted. Theoretical studies include analysis to determine more accurately accelerator characteristics. Areas of interest and study are concerned with current distribution to segmented electrodes, determination of nonequilibrium ionization, electron concentration, and effective conductivity.

Dynamical Evolution of Stellar Systems (APD)  F.Hohl, MS 160

A program is in progress to investigate the evolution of self-gravitating stellar systems that can be treated as collisionless. Such systems are described by the Vlasov-Poisson equations and these are investigated for specific configurations. High-speed electronic computers are used to perform "numerical experiments" simulating stellar systems; increased effort is needed to extend computational techniques to multi-dimensional cases with more particles.

Satellite Ionosphere Interaction (APD)  F.Hohl, MS 160

Research on the interaction of satellites with a rarefied partially ionized atmosphere is in progress. The charge and potential distribution near the satellite and especially the structure of the wake are of interest. Also, the excitation of plasma waves is being investigated.
Plasma Spectroscopy (APD)  

(a) Magnetic compression experiment.- A theta-pinch magnetic compression experiment powered by a one-megajoule, 20 khz capacitor bank and auxiliary banks is used to generate a plasma for spectroscopic measurements from the visible to soft x-rays for the purpose of line identification and measurements of basic atomic properties of highly ionized elements, particularly those of interest in the physics of the solar corona. Effort is needed to extend the results to include determination of cross sections and transition probabilities. Spectroscopic equipment, data reduction facilities and equipment for supporting experiments are available.  

(b) Line broadening of spectral lines in a plasma.- Experimental work on the broadening of ion lines in a high density T-tube plasma is being carried out. A theoretical investigation of Stark broadening for neutral and ionic isolated lines including Debye shielding is in progress. Extensive computer programs are available. Supporting research includes computation of f-values and tables of energy levels.

Fluid Mechanics and Chemical Kinetics of Entry Plasmas (APD)  

Research is in progress to determine the plasma properties in the viscous layer near the body surface and in the inviscid shock layer surrounding planetary entry spacecraft. A typical approach determines the composition and fluid properties, usually assuming continuum flow, in terms of the entry flight parameters, body configuration, and atmospheric constituents. Nonequilibrium chemical kinetics play an important role in the determination of both fluid-flow properties and the degree of ionization. Improvement of existing methods
and development of new ones are sought in which the viscous flow regions may be treated with inclusion of vorticity effects, surface chemistry and wall blowing effects due to ablation. In the lower Reynolds number regime, methods are needed for treating the shock layer as a merged viscous-inviscid layer with coupled nonequilibrium chemistry. The plasma parameters of particular interest are free-electron concentration and electron collision frequency, as an input to the problem of EM-wave propagation across the plasma.

**EM Propagation Through Entry Plasmas (APD)**

C.T. Swift, MS 160

Theoretical and experimental research is in progress to determine the antenna characteristics when the radiating element is submerged in, or coated by, a plasma such as occurs in spacecraft planetary entry. It is necessary to determine, for a given antenna configuration, the effects of the plasma on the antenna impedance and tuning as the input to determination of the far-field signal-strength pattern. It is also desirable to determine ways of using this knowledge as a means of plasma diagnosis, wherein measured changes in antenna properties can be interpreted in terms of the plasma characteristics.

**Geomagnetospheric Phenomena (APD)**

D. Adamson, MS 160

(a) Determination of collisional cross sections of charged and neutral particles. A knowledge of the variation of plasma parameters with altitude is needed in many theoretical geophysical studies and plasma conductivities must be rated among the most significant of such parameters. The major source of uncertainty lies in the estimation of collisional cross sections between charged particles and neutrals, thus formulas used by different authors may yield answers differing by an order of magnitude or more.
(b) **Polarization effects within inhomogeneities in the magnetosphere.** - During periods of geomagnetic activity, hot plasma is dumped into localized regions of the magnetosphere. Electrons and protons drift east and west respectively and will generate a polarization electric field within the cloud interior which, taken in conjunction with the magnetic field, will tend to push the cloud outwards. The build up of polarization charge will be inhibited by the migration of electrons along the magnetic field lines. A similar effect is expected when ionized clouds are released in space and thus provide us with an opportunity to observe the phenomena under controlled conditions.

(c) **Turbulence and diffusion effects in the magnetosphere.** - One of the basic questions in magnetospheric physics is related to the manner in which charged particles are energized once they have gained entry into the magnetosphere. Various kinds of magnetospheric instabilities leading to plasma heating have been proposed. The use of ionized clouds released in space as a means of investigating various instability modes is being studied.

Turbulence in the magnetosphere has important geophysical implications inasmuch as the plasma will no longer be constrained to move with the field lines but will tend to diffuse across them. Hopefully, the development of more responsive magnetometers will shortly provide reliable data on the power spectra of the fluctuations. In the meanwhile, research is being directed toward the problem of diffusion of charged particles in a magnetic field which is subject to simultaneous spatial and temporal variations.

*Experiment and Theory for Production and Use of High Velocity Plasma Streams (APD)*

R.V. Hess, MS 160

Plasmas are produced and accelerated with coaxial accelerators, for example, MPD arcs, using external- and self-magnetic fields. The accelerators operate in the continuous (steady) mode, from 1 to 100 kw, and the pulsed mode, from
100 kw to 100 mw, with pulses from microseconds to milliseconds. The research in plasma production with these accelerators is closely related to that for homopolar devices studied for fusion. The high velocity plasma streams have application to electric propulsion, laboratory simulation of solar wind interaction with the magnetosphere and to simulation of planetary reentry. Expansion of research is in progress to high power pulsed operation using capacitors; 150 mw ruby lasers are also available for possible research application.

**Basic Studies of Plasma Instabilities, Turbulence and Ionization Phenomena (APD)**

R.V. Hess, MS 160

Experimental and theoretical studies are being made of instabilities in electric and magnetic fields, perpendicular, at an angle and parallel to each other. The comparative influence of coherent and turbulent effects on enhanced conduction and diffusion across magnetic fields is evaluated. The possible role of oscillations in producing enhanced ionization effects is evaluated and contrasted with collision effects. Various approaches for control of instabilities and oscillations are being investigated. The studies apply to the production and acceleration of plasmas, to the nature of possible disturbances in the high velocity streams and to the interaction of these streams with magnetic fields.

Expansion of research is sought for study of instabilities and ionization at higher powers, magnetic fields and plasma pressures and for the interaction of high velocity plasma streams with magnetic fields to evaluate collisionless shocks.

**Plasma Diagnostics (APD)**

R.V. Hess, MS 160

A successful solution of the problems in the preceding statements requires a great variety of diagnostic techniques. Langmuir probes are used for measurements of steady and oscillatory values of plasma-potential, density, electron temperature, and velocity. Time-of-flight techniques using the propagation of natural and
artificial disturbances (sparks, lasers) are studied for determination of velocities and study of wave phenomena. Faraday cups and mass spectrometers are adapted to measure velocities and energies of ion species in plasma streams. Current distributions are determined with magnetic probes (Hall element and Rogowski loops). Spectroscopic measurements are used to determine abundance of plasma constituents temperatures and velocities; the sensitivity of velocity measurements is increased by use of special spectroscopic techniques. Expansion of research is sought for application of lasers as diagnostic tools.
Atmospheric Physics (AMPD)  
T.B. McKee, MS 214A

Viewing the atmosphere tangentially from outside offers a unique technique for studying the atmosphere. This technique is being used to study thermal emissions from the atmosphere. Typical uses of information are to determine atmospheric temperature structure and distribution of constituents with altitude. Experimental measurements in the 14-16μ CO₂ band and 20-35μ H₂O band are in progress.

Wind Structure in Planetary Atmospheres (DLD)  
Robert M. Henry, MS 240

Atmospheric winds and wind variations are a source of loads and control disturbances for aerospace vehicles. The wind inputs constitute a major design constraint for vehicles operating in the earth’s atmosphere, and they are expected to be of similar importance in the atmospheres of other planets. Knowledge of winds on other planets, however, is far from adequate for design purposes. Research is needed for a better understanding of planetary wind patterns and for applying existing observations and theory to vehicle design problems.

Kinetic-Theory Extensions Applicable in Atmospheric Research (DLD)  
R.A. Hord, MS 240

Recent problems in aerospace research, such as the theoretical problems associated with the dynamics of the upper atmosphere and with chemical releases in the upper atmosphere, have incited further development of the kinetic theory of gases which are not necessarily near equilibrium. The theory involves both chemical kinetics and transport processes in mixtures of rapidly interdiffusing gases.
High Altitude Clear Air Turbulence (DLD)  
H.B. Tolefson, MS 240

The goal of this research is to obtain a better understanding of the nature of clear air turbulence and the factors leading to its formation at altitudes near 10 km and to translate this understanding into a form which can be used by the airplane and space vehicle designer. Items of interest include (a) the energy exchange process leading to generation of turbulence in clear air and at high altitudes; (b) the spectral characteristics of clear air turbulence which is caused by jet stream, mountain wave, or other effects; (c) large isolated gust phenomena in clear air; and (d) the remote detection and measurement of clear air turbulence. Particular emphasis is on the flight operating conditions of the supersonic transport.

Dynamics of the High Atmosphere (DLD)  
H.B. Tolefson, MS 240

A new insight into the temperature and circulation patterns of the atmosphere at altitudes from 25 to 60 km is being obtained from meteorological rocket measurements taken from various locations within the northern hemisphere. One important observation is the gross thermal response of this region of the atmosphere to the diurnal solar heat input and the associated tidal wind field. Another observation is that the stratospheric heating which disturbs the atmosphere to a large extent at 30 km and later influences surface weather has been found to exist with more intensity at 55 km. Continued analysis of these data is needed to provide a better understanding of the complex dynamic processes of the upper atmosphere and to form a basis for predicting surface weather.
Expansion of theoretical and experimental research underway to define hypersonic flow field species distributions and flow properties with gas mixtures is sought. Research is applicable to hypervelocity nozzles for planetary gas simulation, nonequilibrium flow around bodies, and gaseous ablation products in flow fields of entry vehicles. Experimental equipment includes electric-arc-heated hypersonic wind tunnels, electron beam, and spectrographic equipment.
Exploratory studies of electrically controlled absorption of light and the diffusion of optically excited carriers are being conducted with zinc sulfide type semiconducting compounds. These two phenomena are being investigated over a wavelength range from the near infrared into the vacuum ultraviolet and at temperatures from liquid hydrogen to room temperature. Adjustments of bulk and surface properties by doping or by adsorbed layers are being studied to ascertain the mechanisms of each phenomenon.

Basic studies of the optical and electrical properties of elemental semiconductors containing various chemical impurities are being conducted. Impurities include groups I and II elements such as lithium and magnesium. Modifications of band structure due to excited impurity states are also of interest.
In carrying out its broad mission of manned space flight, it is necessary for reasons of safety and economy that NASA make extensive use of simulators. The development of these research simulators involves many areas of technology and the physical sciences coupled with human factors such as visual acuity, perception, response, etc., thus large opportunities exist for ingenuity and invention of new concepts of simulation. It is clear that closest realism of vision, sound, etc. comes with great expense and complexity, thus the continuing problem exists to minimize the useful degree of realism actually required for a given simulation problem.
The spectral region from millimeter to optical wavelengths is being studied to determine its potential for space communications. Both theoretical and experimental research are needed to identify natural and practical limitations to space applications.

Analytical and experimental investigations into the electromagnetic theory aspects of the interaction of antennas with plasma are being conducted. Extensive laboratory facilities for both pattern and impedance measurement in or out of the plasma environment are available.

Injection of electrophyllic fluids into ionized flow fields is being studied as possible solution to the entry communications blackout problem. Experimental and theoretical studies of electrophyllic-plasma interactions need to be expanded.
A variety of research programs are being conducted on the effects of the space environment on materials and components. The programs include experimental investigations on the behavior of materials on exposure to the various environmental features (both singly and in combinations) and analytical descriptions of the measured effects. The mechanisms of degradation are elucidated by developing phenomenological models with the aim of predicting behavior of materials. Typical current research programs include behavior of clean surfaces in ultrahigh vacuum, vacuum effects on the thermal and mechanical properties of organic materials and exploration of phenomena and mechanisms associated with meteoroid impact. Unique experimental facilities are available which include ultrahigh vacuum facilities with vacuum capabilities to $10^{-12}$ torr, hypervelocity accelerators with velocity capabilities approaching 30 kilometers per second, solar simulators, and diagnostic and supporting equipment.
Hypervelocity Impact Research (SRD)  
R.G. Thomson, MS 400

Research is being undertaken to define and evaluate the influence of meteoroid environment on space structures. A coordinated research effort consisting of both theoretical analyses and experimental investigations is being pursued for the dual purpose of understanding the basic phenomena involved in hypervelocity impact and the application of the knowledge gained to the development of design procedures for practical meteoroid resisting structures. This is being accomplished through the use of analyses of mathematical models and through the use of large scale computer programs. Results of these studies are then verified through experimental programs carried out in exploding foil and light gas gun facilities.

Radiation Damage in Glass (FID)  
D.E. McIver, MS 474

Radiation-produced color centers in optical glasses are being investigated to provide a fundamental understanding of space radiation effects on optical components. These investigations have been limited to infrared absorption studies. The need exists to expand the effort to include electron paramagnetic resonance studies.
Radiation Effects on Semiconductor Devices (IRD)  C. Gross, MS 234

Research is being conducted to determine the effects of ionizing space radiation on solid state devices such as radiation detectors, transistors, and other solid state electronic components. The primary objective of this research is to improve presently available components. Theoretical work is supported by experimental studies in well equipped laboratories that have available equipment for solid state sample preparation and such advanced analytical tools as electron microscope, electron paramagnetic resonance and nuclear magnetic resonance spectroscopy, x-ray diffraction, and infrared spectroscopy. Radiation effects test programs utilize the newly completed Space Radiation Effects Laboratory which has available two electron accelerators and a 600 MeV synchrocyclotron.
SPACE ENVIRONMENTAL EFFECTS (Cont'd.)

Radiation Resistance of Semiconductor Materials (IRD)  C. Gross, MS 234

In the area of radiation damage to semiconductors, the significant problem areas being investigated are the effects of radiation on bulk properties and surfaces. Theoretical and experimental studies of radiation-induced damage to semiconductor surfaces are needed for determining the microscopic mechanisms which are responsible for observed surface velocity changes. Models are developed and metal-oxide semiconductor devices are fabricated to determine a correlation between velocity, potential, surface state density, and radiation dose. The radiation resistance of the more promising metal-nitride semiconductors also needs to be investigated.

Investigations of the effects of radiation on the bulk properties of semiconductors are specifically aimed at determining the defect production rate in silicon as a function of chemical impurities. Studies of the effects of specified amounts of dopants in base materials would be aimed at establishing reasons for the observed variations in damage rates in semiconductors produced by the same techniques.

Interaction of Particulate Radiation with Spacecraft  J.J. Singh, MS 234

Materials (IRD)

The interactions of radiation with materials are experimentally investigated to determine the energy and angular distribution of electrons transmitted through thick material targets and the secondary radiation yield from high energy proton bombardment of light elements. Current programs include
SPACE ENVIRONMENTAL EFFECTS (Cont'd.)

Interaction of Particulate Radiation with Spacecraft Materials (cont'd.)

measurements of electrons transmitted through silicon targets of thickness ranging from 10 percent to 80 percent of the practical range at 3 MeV and 4 MeV. The work with high energy protons includes the measurement of the neutron yield in the energy range 0-50 MeV from $\text{Al}(p,xn)$ reaction at the proton energies of 300 MeV and 600 MeV. Measurements are also made to determine the relative importance of direct and evaporation processes in producing low and medium energy neutrons. Additional research in these domains is sought.
Improved Batteries for Space Applications (FID)  J.L.Patterson, MS 472

Data on advanced developmental batteries is being obtained experimentally to provide information for the design of spacecraft power systems and to identify areas where design improvements are needed. Efforts are being made to improve existing battery designs and develop batteries for special applications. Present emphasis is on the development of sealed, lightweight batteries capable of withstanding thermal sterilization.

Application of Semiconductor Devices for Power Generation (FID)  J.L.Patterson, MS 472

Advanced engineering studies of the application of photovoltaic solar cells and thermoelectric elements to spacecraft are being made. Data on advanced developmental devices, needed for the design of spacecraft power systems, is being obtained experimentally, and parametric studies are being made to provide optimum design criteria. Present emphasis is on investigations to define and minimize the effects of the space radiation environment.
**Advanced Filamentary Composite Materials (SRD)**

George W. Zender, Ms 188A

Experimental studies of advanced filamentary composites are being made to define the failure mechanisms and bonding characteristics between the filaments and matrix. Included is an investigation of space environmental effects on the performance of advanced filamentary composites. Improved techniques will be developed for measurement of mechanical and physical properties of advanced filaments and composites.

**Stress Corrosion of Structural Materials (SRD)**

C.R. Manning, Jr., MS 188A

The mechanisms of stress corrosion cracking of current structural materials in the presence of various corrodents are being explored. Susceptible materials are identified by metallurgical techniques, and methods will be developed for detecting and estimating the magnitude of stress corrosion damage. Stress corrosion damage will be analyzed using established methods of fracture mechanics.

**Techniques for Effluent Gas Analysis (SRD)**

L.F. Vosteen, MS 206

The determination of the composition of gaseous products which evolve from ablative compounds during thermal decomposition is required for effective ablation analyses. The applicability of techniques such as matrix isolation, gas chromatography, and mass spectroscopy will be investigated and will be further developed in conjunction with thermogravimetric analysis (TGA), differential thermal analysis (DTA), and elemental analysis to describe the degradation kinetics and processes of ablative composites.
The Structures Research Division is actively engaged in a comprehensive program of basic research on the fatigue behavior of advanced structural materials and structural components representative of aircraft and spacecraft structures. Several facets of this program are:

**Metallurgical Parameters.** Evaluate fatigue crack propagation and residual static strength properties for specially-prepared aluminum alloys. Identify the effects of detailed chemistry, heat-treatment, microstructure, stress level and environment on these properties. Observe metallurgical effects by optical microscopy, transmission-electron microscopy, and electron-fractography to aid in understanding the basic phenomenon.

**Random Loading.** Develop methods of analysis for fatigue behavior under the complex time histories of stress. Conduct experimental investigations to demonstrate applicability of the analytical methods. Explore limits of applicability as regarding complexity of specimen, non-Gaussian stress encounters, and varying mean stresses.

**Local Stresses and Strains.** Investigate the effects of plastic action on the stress and strain distributions around notches and cracks in specimens subjected to repeated loading. Develop analytical procedures for anticipating the fatigue behavior of practical parts in a simulated service environment.

**Structural Design.** Investigate the relative merits of safe-life and fail-safe design philosophies for a representative, but simple structural joint. Identify the fail-safe characteristics before and after significant fatigue exposure of the joint. Develop methods for an optimum design.
Inelastic Discontinuity Stress Analysis of Cylindrical Shells (SRD)  
H.G. McComb, MS 188c

A specific research problem involves extension of classical discontinuity stress analysis of shells of revolution into the plastic range or the development of a numerical method for efficient calculation of discontinuity stresses in the plastic range. Of special interest are stresses due to eccentric mismatch of shell sections at joints.

Accuracy of Finite Element Methods in Structural Analysis (SRD)  
R.E. Fulton, MS 183

An investigation will be made of the accuracy of various finite element formulations, including curved elements, in the application of finite element methods to the analysis of plate, shell and three-dimensional continuum problems. Studies might deal with the theoretical development of new finite element stiffness or flexibility matrices, assessment of the adequacy of those given in the literature, development of methods for assessing reliability, or development of ways for improving accuracy without refining grid patterns.
Analysis of Inflatable Landing Impact Absorbers (SRD)  H.G. McComb, MS 188C  
Experiments to date indicate that impact attenuation may be achieved efficiently by pneumatic devices which dissipate energy on impact by controlled flow of gas through vented or porous compartmenting walls. Successful design of such devices required improved understanding of the processes involved and development of the ability to predict performance and strength. Thermodynamic and structural analyses will be performed to complement experimental work already in progress. An analytical investigation will be made of stresses in deployable partitioned pneumatic impact attenuation devices of generally spherical and toroidal geometry. The purpose of this work is to determine critical design parameters relating strength, weight, and functional performance of such devices.

Nonlinear Finite Element Structural Analysis (SRD)  R.E. Fulton, MS 185  
Research will be carried out on the application of finite element methods to the solution of nonlinear plate, shell, and three-dimensional continuum problems. Studies will deal with the necessary theoretical developments as well as the solution to representative problems in such areas as buckling, finite deflections and plastic behavior. Work will include the development of new finite elements or the assessment of existing ones in the literature as well as the development of numerical techniques for efficiently obtaining accurate solutions to finite element problems on a digital computer.
Numerical Methods of Structural Design (SRD)  R.E.Fulton, MS 183

Research will be carried out on the development of efficient ways to utilize new third generation digital computers in the design of aeronautical or aerospace structural systems. Research may deal with the utilization of mathematical programming and optimization methods to automatically synthesize structural designs subject to multiple design loads and practical constraints. Research may also deal with the development of methods for using computers as an integral part of man-directed design process including possible development of new programming languages well suited for aeronautical or aerospace structural design requirements. In both of the above areas the analyses used as part of the design cycles will be those typical of practical aeronautical or aerospace structural design and commensurate with the present state of the art for structural analysis.

Dynamic Buckling Studies (SRD)  R.E.Fulton, MS 183

Fundamental investigations of the buckling of structures subjected to transient loads will be carried out. Work may include such things as the definition of dynamic buckling, the application of dynamic stability criteria including initial imperfections, and the utilization of numerical methods and digital computers to calculate practical instability of structural systems.
Numerical Methods for Shell Analysis (SRD)  R.E. Fulton, MS 188C

Research will be carried out on the development of methods for determining numerical solutions to shell analysis problems on a digital computer. Work may deal with the linear or nonlinear behavior of arbitrarily shaped stiffened or unstiffened shell structures subjected to static or dynamic loads. The research will include the formulation of the appropriate governing partial differential equations in a form suitable for numerical solutions as well as the determination of an accurate and efficient solution to these equations on a digital computer.

Aircraft Fuel System Design for Crashworthiness (SRD)  H.G. McComb, MS 188C

Analytical and experimental studies will be performed to aid in the development of aircraft fuel system designs which minimize fire hazards in the event of a mild crash. One facet will involve studies of stresses, deformations, and failures of long, liquid-filled tubes (representing fuel lines) under impact conditions to evaluate effects of support elasticity and damping in preventing rupture. Another area will be the study of conceptual fuel tank designs which would permit large deformations under impact loading without rupturing. A composite consisting of a high strength knitted fabric coated with neoprene might serve this purpose. This research will contribute to improvements in crashworthiness of aircraft structures.
TEST FACILITIES, HIGH TEMPERATURE

The Utilization of Gas Lasers to Simulate Entry Radiative Heating (SRD)

George M. Stokes, MS 206

A study will be made of the feasibility of simulating the heating produced by the radiating gas caps of vehicles entering planetary atmospheres at high velocities. The manner in which heat shield materials absorb and respond to the narrow band, infrared emission of gas lasers is a primary concern. The practical aspects of combining laser sources with conventional arc-heated wind tunnels to produce a unit which can provide combined radiative and convective heating also will be investigated.

High Intensity Magnetic Field for Electric Arc Heaters (SRD)

George M. Stokes, MS 206

The state-of-the-art of producing compact high intensity magnetic fields (30,000-50,000 gauss), capable of utilization for the rapid rotation of electric arcs with subsequent minimization of electrode erosion, will be defined. Studies will be made of new configurations for conventional methods and also new concepts, such as superconductors, with the objective of developing compact high intensity devices which may be integral parts of electrodes subjected to high heat loads imposed by arc roots and high temperature gases.
TEST FACILITIES, HIGH TEMPERATURE (Cont'd.)

Rotary-Arc-Heater-Accelerator Development (APD) . W.B. Boatright, MS 130

Theoretical and experimental research is in progress on high-powered electric arc characteristics with cross-flow and strong magnetic field interactions. Experimental apparatus includes heater-accelerator with electromagnetically driven vortex with arc rotational speeds of 27,000 revolutions per second. Direct current power up to 20 megawatts available and extensive vacuum and pressure equipment.