NASA/TM—2001–210795

FY 2000 Scientific and Technical Reports, Articles, Papers, and Presentations

Compiled by
J.E. Turner Waits
Marshall Space Flight Center, Marshall Space Flight Center, Alabama

January 2001

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GEORGE C. MARSHALL SPACE FLIGHT CENTER
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FY 2000 SCIENTIFIC AND TECHNICAL REPORTS,
ARTICLES, PAPERS, AND PRESENTATIONS

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TM–1999–209732 October 1999
Construction of a Chemical Sensor/Instrumentation Package Using Fiber Optic and Miniaturization Technology (MSFC Center Director's Discretionary Fund Final Report, Project No. 97–12). R.L. Newton. Materials, Processes, and Manufacturing Department. 19990111739N

The objective of this research was to construct a chemical sensor/instrumentation package that was smaller in weight and volume than conventional instrumentation. This reduction in weight and volume is needed to assist in further reducing the cost of launching payloads into space. To accomplish this, fiber optic sensors, miniaturized spectrometers, and wireless modems were employed. The system was evaluated using iodine as a calibration analyte.

TM–1999–209757 November 1999
NASA's Microgravity Research Program 1998 Annual Report. D. Woodard, Editor. Microgravity Research Program Office. 20000014137N

The Fiscal Year 1998 Annual Report describes key elements of the NASA Microgravity Research Program. The Program's goals, approach taken to achieve those goals, and program resources are summarized. A review of the Program's status at the end of FY 1998 and highlights of the ground- and flight-based research are provided.

TM–1999–209762 November 1999
Low-Pressure Gas Effects on the Potency of an Electron Beam Against Ceramic Cloth. A.C. Nunes, Jr., C.K. Russell, F.R. Zimmerman, and J.M. Fragomeni.* Materials and Processes Laboratory and *Ohio University. 20000010545N

An 8–kv electron beam with a current in the neighborhood of 100 mA from the Ukrainian space welding "Universal Hand Tool" (UHT) burned holes in Nextel AF–62 ceramic cloth designed to withstand temperatures up to 1,427 °C. The burnthrough time was on the order of 8 sec at standoff distances between UHT and cloth ranging from 6–24 in. At both closer (2 in.) and farther (48 in.) standoff distances the potency of the beam against the cloth declined and the burnthrough time went up significantly.

Prior to the test it had been expected that the beam would lay down a static charge on the cloth and be deflected without damaging the cloth. The burnthrough is thought to be an effect of partial transmission of beam power by a stream of positive ions generated by the high-voltage electron beam from contaminant gas in the "vacuum" chamber. A rough quantitative theoretical computation appears to substantiate this possibility.

TM–1999–209788 December 1999
Unmanned Vehicle Guidance Using Video Camera/Vehicle Model (MSFC Center Director's Discretionary Fund Final Report, Project 97–23). T. Sutherland. Avionics Department. 20000011914N

A video guidance sensor (VGS) system has flown on both STS–87 and STS–95 to validate a single camera/target concept for vehicle navigation. The main part of the image algorithm was the subtraction of two consecutive images using software. For a nominal size image of 256×256 pixels this subtraction can take a large portion of the time between successive frames in standard rate video, leaving very little time for other computations. The purpose of this project was to integrate the software subtraction into hardware to speed up the subtraction process and allow for more complex algorithms to be performed, both in hardware and software.

TM–1999–209876 December 1999
Friction Stir Welding for Aluminum Metal Matrix Composites (MMC's) (MSFC Center Director's Discretionary Fund Final Report, Project No. 98–09). J.A. Lee, R.W. Carter, and J. Ding. Materials, Processes, and Manufacturing Department. 2000004679N

This technical memorandum describes an investigation of using friction stir welding (FSW) process for joining a variety of aluminum metal matrix composites (MMC's) reinforced with discontinuous silicon carbide (SiC) particulate and functional gradient materials. Preliminary results show that FSW is feasible to weld aluminum MMC to MMC or to aluminum-lithium 2195 if the SiC reinforcement is <25 percent by volume fraction. However, a softening in the heat-affected zone was observed and is known to be one of the major limiting factors for joint strength. The pin tool's material is made from a low-cost steel tool H–13 material,

and the pin tool's wear was excessive such that the pin tool length has to be manually adjusted for every 5 ft of weldment. Initially, boron-carbide coating was developed for pin tools, but it did not show a significant improvement in wear resistance. Basically, FSW is applicable mainly for butt joining of flat plates. Therefore, FSW of cylindrical articles such as a flange to a duct with practical diameters ranging from 2–5 in. must be fully demonstrated and compared with other proven MMC joining techniques for cylindrical articles.

TM–1999–209877 December 1999
Information Flow in the Launch Vehicle Design/Analysis Process. W.R. Humphries, Sr., W. Holland,* and R. Bishop.* Flight Systems Department and *Sverdrup Technology, Inc. 20000012425N

This paper describes the results of a team effort aimed at defining the information flow between disciplines at the Marshall Space Flight Center (MSFC) engaged in the design of space launch vehicles. The information flow is modeled at a first level and is described using three types of templates: an N×N diagram, discipline flow diagrams, and discipline task descriptions. It is intended to provide engineers with an understanding of the connections between what they do and where it fits in the overall design process of the project. It is also intended to provide design managers with a better understanding of information flow in the launch vehicle design cycle.

TM–2000–209907 February 2000
Double-Plate Penetration Equations. K.B. Hayashida and J.H. Robinson. Structures, Mechanics, and Thermal Department. 20000032469N

This report compares seven double-plate penetration predictor equations for accuracy and effectiveness of a shield design. Three of the seven are the Johnson Space Center original, modified, and new Cour-Palais equations. The other four are the Nysmith, Lundeberg-Stern-Bristow, Burch, and Wilkinson equations. These equations, except the Wilkinson equation, were derived from test results, with the velocities ranging up to 8 km/sec. Spreadsheet software calculated the projectile diameters for various velocities for the different equations. The results were plotted on projectile diameter versus velocity graphs for the expected orbital debris impact velocities ranging from 2 to 15 km/sec. The new Cour-Palais double-plate penetration equation was compared to the modified Cour-Palais single-plate penetration equation. Then the predictions from each of the seven double-plate penetration equations were compared with test results performed at the NASA Marshall Space Flight Center. Because the different equations predict a wide range of projectile diameters at any given velocity, it is very difficult to choose the "right" prediction equation for shield configurations other than those exactly used in the equations' development. Although developed for various materials, the penetration equations alone cannot be relied upon to accurately predict the effectiveness of a shield without using hypervelocity impact tests to verify the design.

TM–2000–209962 February 2000
Observation of Individual Fluorine Atoms From Highly Oriented Poly(tetrafluoroethylene) Films by Atomic Force Microscopy. J.A. Lee. Materials and Processes Laboratory. 20000032164N

Direct observation of the film thickness, molecular structure, and individual fluorine atoms from highly oriented poly(tetrafluoroethylene) (PTFE) films were achieved using atomic force microscopy (AFM). A thin PTFE film is mechanically deposited onto a smooth glass substrate at specific temperatures by a friction-transfer technique. Atomic resolution images of these films show that the chain-like helical structures of the PTFE macromolecules are aligned parallel to each other with an intermolecular spacing of 5.72 Å, and individual fluorine atoms are clearly observed along these twisted molecular chains with an interatomic spacing of 2.75 Å. Furthermore, the first direct AFM measurements for the radius of the fluorine-helix and of the carbon-helix in subangstrom scale are reported as 1.7 and 0.54 Å respectively.

TM–2000–210014 February 2000
Degradation Factor Approach for Impacted Composite Structural Assessment (MSFC Center Director's Discretionary Fund Final Report, Project No. 96–17). R. Ortega, J.M. Price, and D. Fox. Structures, Mechanics, and Thermal Department. 20000025237N

This technical memorandum documents the results of the research to develop a concept for assessing the structural integrity of impacted composite structures using the strength degradation factor in conjunction with

available finite element tools. For this purpose, a literature search was conducted, a plan for conducting impact testing on two laminates was developed, and a finite element model of the impact process was created. Specimens for the impact testing were fabricated to support the impact testing plan.

TM—2000–210076 February 2000
Test Report for NASA MSFC Support of the Linear Aerospike SR–71 Experiment (LASRE). S.K. Elam. Subsystem and Component Development Department. 20000037777N

The Linear Aerospike SR–71 Experiment (LASRE) was performed in support of the Reusable Launch Vehicle (RLV) program to help develop a linear aerospike engine. The objective of this program was to operate a small aerospike engine at various speeds and altitudes to determine how slipstreams affect the engine's performance. The joint program between government and industry included NASA's Dryden Flight Research Center, the Air Force's Phillips Laboratory, NASA's Marshall Space Flight Center, Lockheed Martin Skunkworks, Lockheed-Martin Astronautics, and Rocketdyne Division of Boeing North American. Ground testing of the LASRE engine produced two successful hot-fire tests, along with numerous cold flows to verify sequencing and operation before mounting the assembly on the SR–71.Once installed on the aircraft, flight testing performed several cold flows on the engine system at altitudes ranging from 30,000 to 50,000 feet and Mach numbers ranging from 0.9 to 1.5. The program was terminated before conducting hot-fires in flight because excessive leaks in the propellant supply systems could not be fixed to meet required safety levels without significant program cost and schedule impacts.

TM—2000–210128 March 2000
Rapid Production of Composite Prototype Hardware (MSFC Center Director's Discretionary Fund Final Report, Project No. 96–02). T.K. DeLay. Materials, Processes, and Manufacturing Department. 20000050473N

The objective of this research was to provide a mechanism to cost-effectively produce composite hardware prototypes. The task was to take a hands-on approach to developing new technologies that could benefit multiple future programs.

TM—2000–210129 March 2000
Magnetically Actuated Propellant Orientation Experiment, Controlling Fluid Motion With Magnetic Fields in a Low-Gravity Environment (MSFC Center Director's Discretionary Fund Final Report, Project No. 93–18). J.J. Martin and J.B. Holt. Propulsion Research Center. 20000036592N

This report details the results of a series of fluid motion experiments to investigate the use of magnets to orient fluids in a low-gravity environment. The fluid of interest for this project was liquid oxygen (LO_2) since it exhibits a paramagnetic behavior (is attracted to magnetic fields). However, due to safety and handling concerns, a water-based ferromagnetic mixture (produced by Ferrofluidics Corporation) was selected to simplify procedures. Three ferromagnetic fluid mixture strengths and a nonmagnetic water baseline were tested using three different initial fluid positions with respect to the magnet. Experiment accelerometer data were used with a modified computational fluid dynamics code termed CFX–4 (by AEA Technologies) to predict fluid motion. These predictions compared favorably with experiment video data, verifying the code's ability to predict fluid motion with and without magnetic influences. Additional predictions were generated for LO_2 with the same test conditions and geometries used in the testing. Test hardware consisted of a cylindrical Plexiglas tank (6–in. bore with 10–in length), a 6,000–G rare Earth magnet (10–in. ring), three-axis accelerometer package, and a video recorder system. All tests were conducted aboard the NASA Reduced-Gravity Workshop, a KC–135A aircraft.

TM—2000–210130 March 2000
FY 1999 Scientific and Technical Reports, Articles, Papers, and Presentations. J.E. Turner Waits, Compiler. Information Services Department. 20000043603N

This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY99. It also includes papers of MSFC contractors.

All of the NASA series reports may be obtained from the NASA Center for Aerospace Information (CASI), 7121 Standard Drive, Hanover, MD 21076–1320.

The information in this report may be of value to the scientific and engineering community in determining

what information has been published and what is available.

TM—1999–210131 May 1999
Analysis and Assessment of Peak Lightning Current Probabilities at the NASA Kennedy Space Center. D.L. Johnson and W.W. Vaughan,* Systems Analysis and Integration Laboratory, *University of Alabama in Huntsville. 20000039434N

This technical memorandum presents a summary by the Electromagnetics and Aerospace Environments Branch at the Marshall Space Flight Center of lightning characteristics and lightning criteria for the protection of aerospace vehicles. Probability estimates are included for certain lightning strikes (peak currents of 200, 100, and 50 kA) applicable to the National Aeronautics and Space Administration Space Shuttle at the Kennedy Space Center, Florida during rollout, on-pad and boost/launch phases. Results of an extensive literature search to compile information on this subject are presented in order to answer key questions posed by the Space Shuttle Program Office at the Johnson Space Center concerning peak lightning current probabilities if a vehicle is hit by a lightning cloud-to-ground stroke. Vehicle-triggered lightning probability estimates for the aforementioned peak currents are still being worked. Section 4.5, however, does provide some insight on estimating these same peaks.

TM—2000–210200 January 2000
A Review of Electrical Impedance Spectrometry Methods for Parametric Estimation of Physiologic Fluid Volumes (MSFC Center Director's Discretionary Fund Final Report, Project No. 96–03). B. Dewberry. Avionics Department. 20000038205N

Electrical impedance spectrometry involves measurement of the complex resistance of a load at multiple frequencies. With this information in the form of impedance magnitude and phase, or resistance and reactance, basic structure or function of the load can be estimated. The "load" targeted for measurement and estimation in this study consisted of the water-bearing tissues of the human calf. It was proposed and verified that by measuring the electrical impedance of the human calf and fitting this data to a model of fluid compartments, the lumped-model volume of intracellular and extracellular spaces could be estimated. By performing this estimation over time, the volume dynamics during application of stimuli which affect the direction of gravity can be viewed. The resulting data can form a basis for further modeling and verification of cardiovascular and compartmental modeling of fluid reactions to microgravity as well as countermeasures to the headward shift of fluid during head-down tilt or spaceflight.

TM—2000–210252 May 2000
Mechanical Property Allowables Generated for the Solid Rocket Booster Composite Nose Cap. A.J. Hodge. Materials, Processes, and Manufacturing Department. 20000060843N

Mechanical property characterization was performed on AS4/3501–6 graphite/epoxy and SC350G syntactic foam for the SRB Composite Nose Cap Shuttle Upgrades Project. Lamina level properties for the graphite/epoxy were determined at room temperature, 240 °F, 350 °F, 480 °F, 600 °F, and 350 °F after a cycle to 600 °F. Graphite/epoxy samples were moisture conditioned prior to testing. The syntactic foam material was tested at room temperature, 350 °F and 480 °F. A high-temperature test facility was developed at MSFC. Testing was performed with quartz lamp heaters and high resistance heater strips. The thermal history profile of the nose cap was simulated in order to test materials at various times during launch. A correlation study was performed with Southern Research Institute to confirm the test methodology and validity of test results. A-basis allowables were generated from the results of testing on three lots of material.

TM—2000–210279 May 2000
Mars Global Reference Atmospheric Model 2000 Version (Mars-GRAM 2000): Users Guide. C.G. Justus* and B.F. James. Engineering Systems Department and *Computer Sciences Corporation.

This report presents Mars Global Reference Atmospheric Model 2000 Version (Mars-GRAM 2000) and its new features. All parameterizations for temperature, pressure, density, and winds versus height, latitude, longitude, time of day, and Ls have been replaced by input data tables from NASA Ames Mars General Circulation Model (MGCM) for the surface through 80-km altitude and the University of Arizona Mars Thermosphere General Circulation Model (MTGCM) for 80 to 170 km. A modified Stewart thermospheric model

is still used for higher altitudes and for dependence on solar activity. "Climate factors" to tune for agreement with GCM data are no longer needed. Adjustment of exospheric temperature is still an option. Consistent with observations from Mars Global Surveyor, a new longitude-dependent wave model is included with user input to specify waves having 1 to 3 wavelengths around the planet. A simplified perturbation model has been substituted for the earlier one. An input switch allows users to select either East or West longitude positive. This memorandum includes instructions on obtaining Mars-GRAM source code and data files and for running the program. It also provides sample input and output and an example for incorporating Mars-GRAM as an atmospheric subroutine in a trajectory code.

TM—2000–210331 June 2000

Loads Combination Research at Marshall Space Flight Center. R. Ferebee. Structures, Mechanics, and Thermal Department. 20000068925N

This is the result of a study conducted by the Structural Dynamics Division of the Marshall Space Flight Center concerning the combination of low- and high-frequency dynamic loads for spacecraft design. Low-frequency transient loads are combined with high frequency acoustically induced loads to arrive at a limit load, for design purposes. Different methods are used for combining the loads which can lead to considerable variation in limit loads, depending on which NASA Center did the calculation. This study investigates several different combination methods and compares the combination methods with Spacelab 1 flight data. In addition, the relative timing of low- and high-frequency loads is examined.

TM—2000–210384 June 2000

Application of Rapid Prototyping to the Investment Casting of Test Hardware (MSFC Center Director's Discretionary Fund Final Report, Project No. 98–08). K.G. Cooper and D. Wells. Materials, Processes, and Manufacturing Department.

Investment casting masters of a selected propulsion hardware component, a fuel pump housing, were rapid prototyped on the several processes in-house, along with the new Z-Corp process acquired through this project. Also, tensile samples were prototyped and cast using the same significant parameters. The models were then shelled in-house using a commercial grade zircon-based slurry and stucco technique. Next the shelled models were fired and cast by our in-house foundry contractor (IITRI), with NASA–23, a commonly used test hardware metal. The cast models are compared by their surface finish and overall appearance (i.e., the occurrence of pitting, warping, etc.), as well as dimensional accuracy.

TM—2000–210385 July 2000

Science Directorate Publications and Presentations. January 1–December 31, 1999. F.G. Summers, Compiler. Science Directorate.

This document lists the significant publications and presentations of the Science Directorate during the period January 1–December 31, 1999. Entries in the main part of the document are categorized according to NASA Reports (arranged by report number), Open Literature, and Presentations (arranged alphabetically by title). Most of the articles listed under Open Literature have appeared in refereed professional journals, books, monographs, or conference proceedings. Although many published abstracts are eventually expanded into full papers for publication in scientific and technical journals, they are often sufficiently comprehensive to include the significant results of the research reported. Therefore, published abstracts are listed separately in a section under Open Literature. Questions or requests for additional information about the entries in this report should be directed to M. Franklin Rose (SD01: (256) 544–7721) or to one of the authors.

TM—2000–210482 September 2000

A Damage Resistance Comparison Between Candidate Polymer Matrix Composite Feedline Materials. A.T. Nettles. Materials, Manufacturing, and Processes Department.

As part of NASA's focused technology programs for future reusable launch vehicles, a task is underway to study the feasibility of using the polymer matrix composite feedlines instead of metal ones on propulsion systems. This is desirable to reduce weight and manufacturing costs. The task consists of comparing several prototype composite feedlines made by various methods. These methods are electron-beam curing, standard hand lay-up and autoclave cure, solvent assisted resin transfer molding, and thermoplastic tape laying. One of the critical technology drivers for composite

components is resistance to foreign objects damage. This paper presents results of an experimental study of the damage resistance of the candidate materials that the prototype feedlines are manufactured from. The materials examined all have a 5-harness weave of IM7 as the fiber constituent (except for the thermoplastic, which is unidirectional tape laid up in a bidirectional configuration). The resins tested were 977–6, PR 520, SE–SA–1, RS–E3 (e-beam curable), Cycom 823 and PEEK. The results showed that the 977–6 and PEEK were the most damage resistant in all tested cases.

TM—2000–210558 August 2000

Application of Rapid Prototyping and Wire Arc Spray to the Fabrication of Injection Mold Tools (MSFC Center Director's Discretionary Fund Final Report, Project No. 99–05). K.G. Cooper. Materials, Processes, and Manufacturing Department.

Rapid prototyping (RP) is a layer-by-layer-based additive manufacturing process for constructing three-dimensional representations of a computer design from a wax, plastic, or similar material. Wire arc spray (WAS) is a metal spray forming technique, which deposits thin layers of metal onto a substrate or pattern. Marshall Space Flight Center currently has both capabilities in-house, and this project proposed merging the two processes into an innovative manufacturing technique, in which intermediate injection molding tool halves were to be fabricated with RP and WAS metal forming.

TP—1999–209763 December 1999

Space Environment Effects: Model for Emission of Solar Protons (ESP)—Cumulative and Worst-Case Event Fluences. M.A. Xapsos,* J.L. Barth,** E.G. Stassinopoulos,** E.A. Burke,*** and G.B. Gee.**** *Naval Research Laboratory, **NASA Goddard Space Flight Center, ***Consultant, and ****SGT, Inc. 20000017924N

The effects that solar proton events have on microelectronics and solar arrays are important considerations for spacecraft in geostationary and polar orbits and for interplanetary missions. Designers of spacecraft and mission planners are required to assess the performance of microelectronic systems under a variety of conditions. A number of useful approaches exist for predicting information about solar proton event fluences and, to a lesser extent, peak fluxes. This includes the cumulative fluence over the course of a mission, the fluence of a worst-case event during a mission, the frequency distribution of event fluences, and the frequency distribution of large peak fluxes.

Naval Research Laboratory (NRL) and NASA Goddard Space Flight Center, under the sponsorship of NASA's Space Environments and Effects (SEE) Program, have developed a new model for predicting cumulative solar proton fluences and worst-case solar proton events as functions of mission duration and user confidence level. This model is called the Emission of Solar Protons (ESP) model.

TP—2000–209901 February 2000

Atlas of Microorganisms From Ancient Phosphorites of Khubsugul (Mongolia). E.A. Zhegallo, A.Y. Rozanov, G.T. Ushatinskaya, R.B. Hoover, L.M. Gerasimenko, and A.L. Ragozina. Space Science Department. 20000033858N

A photographic atlas of scanning electron microscope (SEM) images of Cambrian (Tommotian) microfossils from the phosphorites of Khubsugul, Mongolia is presented. SEM images of modern cyanobacteria and bacteria are provided for comparison. The importance of bacterial fossils and morphological biomarkers to astrobiology and the understanding of the origin of phosphorites is considered.

TP—2000–209902 January 2000

Comprehensive Design Reliability Activities for Aerospace Propulsion Systems. R.L. Christenson, M.R. Whitley, and K.C. Knight.* Advanced Concepts Department and *Sverdrup Technology. 20000021229N

This technical publication describes the methodology, model, software tool, input data, and analysis results that support aerospace design reliability studies. The focus of these activities is on propulsion systems mechanical design reliability. The goal of these activities is to support design from a reliability perspective. Paralleling performance analyses in schedule and method, this requires the proper use of metrics in a validated reliability model useful for design, sensitivity, and trade studies. Design reliability analysis in this view is one of several critical design functions.

A design reliability method is detailed and two example analyses are provided—one qualitative and the other quantitative. The use of aerospace and commercial data sources for quantification is discussed and sources listed. A tool that was developed to support both types of analyses is presented. Finally, special topics discussed include the development of design criteria, issues of reliability quantification, quality control, and reliability verification.

TP—2000–209905 February 2000

Modeling of Nonacoustic Combustion Instability in Simulations of Hybrid Motor Tests. M. Rocker. Advanced Space Transportation Program. 20000052472N

A transient model of a hybrid motor was formulated to study the cause and elimination of nonacoustic combustion instability. The transient model was used to simulate four key tests out of a series of seventeen hybrid motor tests conducted by Thiokol, Rocketdyne, and Martin Marietta at NASA Marshall Space Flight Center (MSFC). The tests were performed under the Hybrid Propulsion Technology for Launch Vehicle Boosters (HPTLVB) program. The first test resulted in stable combustion. The second test resulted in large-amplitude, 6.5–Hz chamber pressure oscillations that gradually damped away by the end of the test. The third test resulted in large-amplitude, 7.5–Hz chamber pressure oscillations that were sustained throughout the test. The

seventh test resulted in elimination of combustion instability with the installation of an orifice immediately upstream of the injector. Formulation and implementation of the model are the scope of this presentation.

The current model is an independent continuation of modeling presented previously by joint Thiokol-Rocketdyne collaborators Boardman, Hawkins, Wassom, and Claflin. The previous model simulated an unstable independent research and development (IR&D) hybrid motor test performed by Thiokol. There was very good agreement between the model and test data. Like the previous model, the current model was developed using Matrix-x simulation software. However, tests performed at MSFC under the HPTLVB program were actually simulated.

In the current model, the hybrid motor, consisting of the liquid oxygen (lox) injector, the multiport solid fuel grain, and nozzle, was simulated. The lox feedsystem, consisting of the tank, venturi, valve, and feed lines, was also simulated in the model. All components of the hybrid motor and lox feedsystem are treated by a lumped-parameter approach.

Agreement between the results of the transient model and actual test data was very good. This agreement between simulated and actual test data indicted that the combustion instability in the hybrid motor was due to two causes: 1. A lox feedsystem of insufficient stiffness, and 2. A lox injector with an impedance or pressure drop that was too low to provide damping against the feedsystem oscillations. Also, it was discovered that testing with a new grain of solid fuel sustained the combustion instability. However, testing with a used grain of solid fuel caused the combustion instability to gradually decay.

TP—2000–209960 February 2000

El Niño During the 1990's: Harbinger of Climatic Change or Normal Fluctuation? R.M. Wilson. Space Science Department. 20000032093N

Today, El Niño refers to the extreme warming episodes of the globally effective, coupled ocean-atmospheric interaction commonly known as ENSO (i.e., "El Niño-Southern Oscillation"). Concerning its observed decadal frequency and severity, El Niño during the 1990's has often been regarded as being anomalous. Results of analysis reported herein, however, appear to mitigate this belief.

TP—2000–209961 February 2000

On the Bimodality of ENSO Cycle Extremes. R.M. Wilson. Space Science Department. 20000032525N

On the basis of sea surface temperature in the El Niño 3.4 region (5° N.–5° S., 120°–170° W.) during the interval of 1950–1997, Kevin Trenberth previously has identified some 16 El Niño and 10 La Niña, these 26 events representing the extremes of the quasi-periodic El Niño-Southern Oscillation (ENSO) cycle. Runs testing shows that the duration, recurrence period, and sequencing of these extremes vary randomly. Hence, the decade of the 1900's, especially for El Niño, is not significantly different from that of previous decadal epochs, at least, on the basis of the frequency of onsets of ENSO extremes. Additionally, the distribution of duration for both El Niño and La Niña looks strikingly bimodal, each consisting of two preferred modes, about 8- and 16-mo long for El Niño and about 9- and 18-mo long for La Niña, as does the distribution of the recurrence period for El Niño, consisting of two preferred modes about 21- and 50-mo long. Scatterplots of the recurrence period versus duration for El Niño are found to be statistically important, displaying preferential associations that link shorter (longer) duration with shorter (longer) recurrence periods. Because the last onset of El Niño occurred in April 1997 and the event was of longer than average duration, onset of the next anticipated El Niño is not expected until February 2000 or later.

TP—2000–210074 February 2000

Effect of Crystal Orientation on Analysis of Single-Crystal, Nickel-Based Turbine Blade Superalloys. G.R. Swanson and N.K. Arakere.* Structures, Mechanics, and Thermal Department and *University of Florida. 20000037784N

High-cycle fatigue-induced failures in turbine and turbopump blades is a pervasive problem. Single-crystal nickel turbine blades are used because of their superior creep, stress rupture, melt resistance, and thermomechanical fatigue capabilities. Single-crystal materials have highly orthotropic properties making the position of the crystal lattice relative to the part geometry a significant and complicating factor. A fatigue failure criterion based on the maximum shear stress amplitude on the 24 octahedral and 6 cube slip systems is presented for single-crystal nickel superalloys (FCC

crystal). This criterion greatly reduces the scatter in uniaxial fatigue data for PWA 1493 at 1,200 °F in air. Additionally, single-crystal turbine blades used in the Space Shuttle main engine high pressure fuel turbopump/alternate turbopump are modeled using a three-dimensional finite element (FE) model. This model accounts for material orthotrophy and crystal orientation. Fatigue life of the blade tip is computed using FE stress results and the failure criterion that was developed. Stress analysis results in the blade attachment region are also presented. Results demonstrate that control of crystallographic orientation has the potential to significantly increase a component's resistance to fatigue crack growth without adding additional weight or cost.

TP—2000–210075 March 2000

Laser Transmission Measurements of Soot Extinction Coefficients in the Exhaust Plume of the X–34 60k-lb Thrust Fastrac Rocket Engine. C.C. Dobson, R.H. Eskridge, and M.H. Lee. Propulsion Research Center. 20000044344N

A four-channel laser transmissometer has been used to probe the soot content of the exhaust plume of the X–34 60k–lb thrust Fastrac rocket engine at NASA's Marshall Space Flight Center. The transmission measurements were made at an axial location ≈1.65 nozzle diameters from the exit plane and are interpreted in terms of homogeneous radial zones to yield extinction coefficients from 0.5–8.4 per meter. The corresponding soot mass density, spatially averaged over the plume cross section, is, for Rayleigh particles ≈0.7 μg cm^{-3}, and alternative particle distributions are briefly considered. Absolute plume radiance at the laser wavelength (515 nm) is estimated from the data at ≈2,200 K equivalent blackbody temperature, and temporal correlations in emission from several spatial locations are noted.

TP—2000–210386 July 2000

The Use of Ferrofluids to Model Materials Processing (MSFC Center Director's Discretionary Fund Final Report, Project No. 98–12). F. Leslie and N. Ramachandran.* Microgravity Science and Applications Department and *Universities Space Research Association.

Many crystals grown in space have structural flaws believed to result from convective motions during the growth phase. The character of these instabilities is not well understood but is associated with thermal and solutal density variations near the solidification interface in the presence of residual gravity and g-jitter. To study these instabilities in a separate, controlled space experiment, a concentration gradient would first have to be artificially established in a timely manner as an initial condition. This is generally difficult to accomplish in a microgravity environment because the momentum of the fluid injected into a test cell tends to swirl around and mix in the absence of a restoring force. The use of magnetic fields to control the motion and position of liquids has received recent, growing interest. The possibility of using the force exerted by a nonuniform magnetic field on a ferrofluid to not only achieve fluid manipulation but also to actively control fluid motion makes it an attractive candidate for space applications. This paper describes a technique for quickly establishing a linear or exponential fluid concentration gradient using a magnetic field in place of gravity to stabilize the deployment. Also discussed is a photometric technique for measuring the concentration profile using light attenuation. Although any range of concentrations can be realized, photometric constraints impose some limitations on measurements. Results of the ground-based experiments indicate that the species distribution is within 3 percent of the predicted value.

TP—2000–210387 July 2000

Thermodynamic Cycle Analysis of Magnetohydrodynamic-Bypass Hypersonic Airbreathing Engines. R.J. Litchford, J.W. Cole, V.A. Bityurin,* and J.T. Lineberry.**Space Transportation Directorate, *Institute of High Temperatures, Russian Academy of Science, and **LyTEC.

The prospects for realizing a magnetohydrodynamic-(MHD-) bypass hypersonic airbreathing engine are examined from the standpoint of fundamental thermodynamic feasibility. The MHD-bypass engine, first proposed as part of the Russian AJAX vehicle concept, is based on the idea of redistributing energy between various stages of the propulsion system flow train. The system uses an MHD generator to extract a portion of the aerodynamic heating energy from the inlet and an MHD accelerator to reintroduce this power as kinetic energy in the exhaust stream. In this way, the combustor entrance Mach number can be limited to a specified value even as the flight Mach number increases. Thus, the fuel and air can be efficiently mixed and burned within a practical combustor length, and the flight Mach number operating

envelope can be extended. In this paper, we quantitatively assess the performance potential and scientific feasibility of MHD-bypass engines using a simplified thermodynamic analysis. This cycle analysis, based on a thermally and calorically perfect gas, incorporates a coupled MHD generator-accelerator system and accounts for aerodynamic losses and thermodynamic process efficiencies in the various engine components. It is found that the flight Mach number range can be significantly extended: however, overall performance is hampered by nonsentropic losses in the MHD devices.

TP—2000–210481 August 2000

A Comparison of Quasi-Static Indentation to Low-Velocity Impact. A.T. Nettles and M.J. Douglas.* Materials, Manufacturing, and Processes Department and *Old Dominion University.

A static test method for modeling low-velocity foreign object impact events to composites would prove to be very beneficial to researchers since much more data can be obtained from a static test than from an impact test. In order to examine if this is feasible, a series of static indentation and low-velocity impact tests were carried out and compared. Square specimens of many sizes and thicknesses were utilized to cover the array of types of low-velocity impact events. Laminates with $\pi/4$ stacking sequence were employed since this is by far the most common type of engineering laminate. Three distinct flexural rigidities under two different boundary conditions were tested in order to obtain damage ranging from that due to large deflection to contact stresses and levels in-between to examine if the static indentation-impact comparisons are valid under the spectrum of damage modes that can be experienced. Comparisons between static indentation and low-velocity impact tests were based on the maximum applied transverse load. The dependent parameters examined included dent depth, back surface crack length, delamination area, and to a limited extent, load-deflection behavior. Results showed that no distinct differences could be seen between the static indentation tests and the low-velocity impact tests, indicating that static indentation can be used to represent a low-velocity impact event.

SP—1999–4313 November 1999

Power to Explore—A History of Marshall Space Flight Center 1960–1990. A.J. Dunar* and S.P. Waring,* Internal Relations and Communications Department and *University of Alabama in Huntsville. 20000040071N

This history covers the period from 1960 until 1990. It traces the history of the Marshall Space Flight Center in Huntsville, Alabama. The authors treat the Center's technological contributions to the Nation's space program. They also review the Center's cultural and institutional history.

CP—2000–209758 November 1999
Tenth Biennial Coherent Laser Radar Technology. M.J. Kavaya, Compiler. Earth Science Department.
20000012951N

The tenth conference on coherent laser radar technology and applications is the latest in a series beginning in 1980 which provides a forum for exchange of information on recent events current status, and future directions of coherent laser radar (or lidar or lader) technology and applications. This conference emphasizes the latest advancement in the coherent laser radar field, including theory, modeling, components, systems, instrumentation, measurements, calibration, data processing techniques, operational uses, and comparisons with other remote sensing technologies.

CP—2000–209959 May 2000
The 1999 NASA Aerospace Battery Workshop. J.C. Brewer, Compiler.

This document contains the proceedings of the 32nd annual NASA Aerospace Battery Workshop, hosted by the Marshall Space Flight Center on November 16–18, 1999. The workshop was attended by scientists and engineers from various agencies of the U.S. Government, aerospace contractors, and battery manufacturers, as well as international participation in like kind from a number of countries around the world. The subjects covered included nickel-hydrogen, nickel-cadmium, lithium-ion, and silver-zinc technologies.

CP—2000–210428 August 2000
National Forum on the Future Development of Space. D. Dooling,* Compiler; D.V. Smitherman, Jr., Editor. Advanced Projects Office and *D2 Associates.

The exploration of space has been a successful national priority for decades. We have landed on the Moon, built the Shuttle, and are building the *International Space Station*. But, we have only just begun to develop the real commercial potential of space. How large is this potential for the broader business community? What are the technology, policy, and business strategies required to harvest real business value from space? How can we as policymakers, investors, researchers, and business leaders ensure that the commercial development of space advances at a pace and breadth that brings the most benefit to the national economy? To address these related questions, NASA and the U.S. Chamber of Commerce cosponsored a 1-day National Forum on the Future Development of Space, held March 16, 1999, in Washington, D.C. at the U.S. Chamber Headquarters. This report documents the key findings from this forum.

CP—2000–210429 August 2000
Space Elevators. An Advanced Earth-Space Infrastructure for the New Millennium. D.V. Smitherman, Jr., Compiler. Advanced Projects Office.

A space elevator is a physical connection from the surface of the Earth to a geostationary Earth orbit (GEO) above the Earth ≈35.786 km in altitude. Its center of mass is at the geostationary point such that it has a 24-hr orbit and stays over the same point above the equator as the Earth rotates on its axis. The vision is that a space elevator would be utilized as a transportation and utility system for moving people, payloads, power, and gases between the surface of the Earth and space. It makes the physical connection from Earth to space in the same way a bridge connects two cities across a body of water. The Earth-to-GEO space elevator is not feasible today, but could be an important concept for the future development of space in the latter part of the 21st century. It has the potential to provide mass transportation to space in the same way highways, railroads, power lines, and pipelines provide mass transportation across the Earth's surface. The low energy requirements for moving payloads up and down the elevator could make it possible to achieve cost to orbit <$10/kg. This potential for low-cost mass transportation to space makes consideration of the technology paths required for space elevator construction very important today. The technology paths are beneficial to many other developments and can yield incremental benefits as progress is made toward making space elevator construction feasible. A number of issues were raised and resolved during the workshop that have helped to bring the space elevator concept out of the realm of science fiction and into the realm of possibility. It was found that the space elevator concept is incredibly large and complex, but no issues were without some obvious course of resolution. Given proper planning for the development of critical technologies, it appears that space elevator construction could become feasible.

CR—1999–209254 October 1999
Vehicle/Atmosphere Interaction Glows: Far Ultraviolet, Visible, and Infrared. NAS8–40579. University of Illinois. 20000021450N

CR—2000–209879 January 2000
TRAP/SEE Code Users Manual for Predicting Trapped Radiation Environments. NAS8–40294. Science Applications International Corporation (SAIC). 20000025054N

CR—2000–209906 February 2000
Investigation Into the Effects of Microsecond Power Line Transients on Line-Connected Capacitors. H–29919D. EMC Compliance. 20000028367N

CR—2000–210017 August 2000
Integrated Circuit Electromagnetic Immunity Handbook. J.G. Sketoe. Space Environments and Effects (SEE) Program.

CR—2000–210071 March 2000
Trapped Radiation Model Uncertainties: Model—Data and Model—Model Comparisons. NAS8–40294. Science Applications International Corporation (SAIC). 20000032457N

CR—2000–210072 March 2000
Evaluation of Trapped Radiation Model Uncertainties for Spacecraft Design. NAS8–40294. Science Applications International Corporation (SAIC). 20000032181N

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(Available only from authors. Dates are presentation dates.)

ABDELDAYEM, H. USRA
PALEY, M.S. USRA
WITHEROW, W.K. SD47
FRAZIER, D.O. SD47
Nonlinear Optical Properties and Applications of Polydiacetylene. For presentation at SPIE, San Jose, CA, January 20–23, 2000.

ADAMS, J.H. SD50
BASHINDZHAGYAN, G. Moscow State University
BASHINDZHAGYAN, P. Moscow State University
CHILINGARIAN, A. Yerevan Physics Institute
DRURY, L. Dublin Institute
EGOROV, N. Russian Research Institute
GOLUBKOV, S. Russian Research Institute
KOROTKOVA, N. Moscow State University
PANASYUK, M. Moscow State University
ET AL.
An Instrument to Measure Elemental Energy Spectra of Cosmic Ray Nuclei up to 10 16 ev. For presentation at 33rd COSPAR Conference, Warsaw, Poland, July 16–23, 2000.

ADAMS, J.L. SD50
SIMMONS, E. SD50
HAGYARD, M.J. SD50
NEWTON, E.K. SD50
BERO, E. SD50
Education and Public Outreach to Support the HESSI Mission: Raising Public Awareness. For presentation at American Astronomical Society, Atlanta, GA, January 14, 2000.

ALEXANDER, R.A. TD31
COLEMAN, H.W. UAH
Thermal Characterization of a Direct Gain Solar Thermal Engine. For publication in AIAA Journal of Spacecraft and Rockets, 1999/2000.

ALTSTATT, R.L. SverdrupTechnology
EDWARDS, D.L. ED31
Modeling Natural Space Ionizing Radiation Effects on External Materials. For presentation at Photonics for Space Environments VII Conference, San Diego, CA, July 30–August 4, 2000.

ANDERSON, D.M. TD20
NASA's Integrated Space Transportation Plan. For presentation at 36th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Huntsville, AL, July16–19, 2000.

ANDERSON, W.E. TD61
BUTLER, K. Boeing
CROCKETT, D. Orbital Sciences Corp.
LEWIS, T. Orbital Sciences Corp.
MCNEAL, C. TD15
Peroxide Propulsion at the Turn of the Century. For presentation at Fourth International Symposium on Liquid Space Propulsion, Heilbronn, Germany, March 13, 2000.

ANILKUMAR, A.V. Vanderbilt University
BHOWMICK, J. Vanderbilt University
GRUGEL, R.N. SD47
Utilizing Controlled Vibrations in a Microgravity Environment to Understand and Promote Microstructural Homogeneity During Floating-Zone Crystal Growth. For presentation at Materials Science Conference, Huntsville, AL, June 7, 2000.

ANILKUMAR, A.V. Vanderbilt University
GRUGEL, R.N. SD47
LEE, C.P. Vanderbilt University
Role of Vibration-Induced Streaming in Float-Zone Crystal Growth. For presentation at AIAA Aerospace Science Meeting, Reno, NV, January 8–12, 2001.

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ARAKERE, N.K. University of Florida
SWANSON, G.R. ED22
Effect of Crystal Orientation on Fatigue Failure of Single Crystal Nickel Base Turbine Blade Superalloys. For presentation at ASME TURBO EXPO 2000, 45th ASME International Gas Turbine and Aeroengine Technical Congress, Expo and Users Symposium, Munich, Germany, May 8–11, 2000.

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SWANSON, G.R. ED22
Fretting Stresses in Single Crystal Superalloy Turbine Blade Attachments. For presentation at International Joint Tribology Conference, Seattle, Washington, October 1–4, 2000.

AUSTIN, R.E. TD13
ISHMAEL, S.D. Dryden Flight Research Center

LACEFIELD, C. Lockheed Martin
X–33, Demonstrating Revolutionary Operations for VentureStar.™ For presentation at 51st International Astronautical Congress, Rio de Janeiro, Brazil, October 2–6, 2000.

AUSTIN, R.E. TD13
RISING, J.J. Lockheed Martin
X–33, Leading the Way to VentureStar™ in this Decade. For presentation at 51st International Astronautical Congress, Rio de Janeiro, Brazil, October 2–6, 2000.

BAILEY, M.D. TD11
BOWER, M.V. UAH
Polar Plate Theory for Orthogonal Anisotropy. For presentation at the 51st International Astronautical Congress, Rio de Janeiro, Brazil, October 2–6, 2000.

BALLARD, R.O. TD51
OLIVE, T. TD51
Development Status of the NASA MC–1 (Fastrac) Engine. For presentation at the 36th AIAA Joint Propulsion Conference, Huntsville, AL, July 17–19, 2000.

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YELLESWARAPU, C. Alabama A&M University
SHARMA, A. Alabama A&M University
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PENN, B. SD47
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Black Holes, Wormholes, and Future Space Propulsion. For presentation at SWE Conference, Washington, D.C., June 27–July 1, 2000.

BASHINDZHAGYAN, G. Moscow State University
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On Measuring Cosmic Ray Energy Spectra With the Rapidity Distributions. For presentation at American Physical Society Meeting, Long Beach, CA. April 30, 2000.

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Marshall Space Flight Center Telescience Support Center (MSFC TSC) Operations Concept. For presentation at STAIF 2000, Albuquerque, NM, January 30–February 3, 2000.

BEDROSSIAN, H. Lockheed Martin
TINKER, M.L. ED21
HIDALGO, H. ED21
Ground Vibration Test Planning and Pretest Analysis for the X–33 Vehicle. For presentation at AIAA Dynamics Specialists Conference, Atlanta, GA, April 3–6, 2000.

BEECH, G.S. ED42
HAMPTON, R.D. UAH
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BERNSTEIN, E.L. ED33
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The Plastic Flow Field in the Vicinity of the Pin-Tool During Friction Stir Welding. For publication in Welding Journal, 2000.

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RACZ, L.M. Tufts University
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Mathematical Modeling of an Oscillating Droplet. For publication in International Journal of Numerical Methods for Heat and Fluid Flow, 2000.

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Computed Tomography Analysis of Fastrac Composite Thrust Chamber Assemblies. For presentation at the 36th AIAA/ASME/SAE/ASEE Conference, Huntsville, AL, July 17–19, 2000.

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SHAH, S.
KAUL, R.
SMITHERS, G.A.
WATSON, M.

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WANG, T. Vanderbilt University
Effects of End-Wall Vibration on Oscillatory Thermocapillary Flow. For presentation at TMS Conference, Nashville, TN, March 13, 2000.

BLACKWELL, T. UAH
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KESTER, T.J. SD70
Metrology of Optical Beam Expander for Space Readiness Coherent Lidar Experiment (SPARCLE). For presentation at OSA Optical Fabrication and Testing Topical Meeting, Quebec City, Canada, June 18–22, 2000.

BLACKWELL, W.C. Sverdrup Technology
MINOW, J.I. Sverdrup Technology
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HARDAGE, D.M. ED03
SUGGS, R.M. ED44
Charged Particle Environment for NGST: Model Development. For presentation at Astronomical Telescopes and Instrumentation 2000, Munich, Germany, March 27–31, 2000.

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BLAKESLEE, R.J. SD60
BAILEY, J. SD60
KOSHAK, W.J. SD60
The Rondonia Lightning Detection Network: Network Description, Science Objectives, Data Processing/ Archival Methodology, and First Results. For presentation at 1999 Fall AGU Meeting, San Francisco, CA, December 13–17, 1999.

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CRAMER, J. Global Atmospherics
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CHATTOPADHYAY, K. Fisk University
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ROSS, R. Lockheed Martin
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CUTTEN, D.R. UAH
HOWELL, J.N. NOAA
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ROZANOV, A.Y. Russian Academy of Science
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LEHMAN, M. Penn State University
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BELYEU, R.L. Hernandez Engineering
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PALMITER, C. Sverdrup Technology
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SCHNEIDER, T.A. ED31
VAUGHN, J.A. ED31
CARRUTH, M.R., JR. ED31
EDWARDS, D.L. ED31
HEARD, J.W. ED31
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SCHORR, A.A. MP51
ENDICOTT, J.B.
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SCHROCK, K. ED18
FREESTONE, T. ED18
BELL, L. ED18
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DAVID, L.P. Smithsonian
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SHADOAN, M.D. TD61
SPARKS, D.L. TD62

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ZISSA, D. SD50
CASH, W. SD50
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JACKSON, M. TD55
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KUMMEROW, C.D.
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CLARK, A. ED44
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WANG, J.R.
HEYMSFIELD, G.M.
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TINKER, M.L. ED21
LASSITER, J.O. ED27
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BURGER, A. Fisk University
DUDLEY, M. State U of New York
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LONDON, J.R., III TD14
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ANTIPIN, M.Y.
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