Japanese Aerospace Literature
This month: *Mathematical Models*

N95-20986 Construction of non-critical string field theory by transfer matrix formalism in dynamical triangulation. Y. WATABIKI, Tokyo Univ., Tanashi (Japan). Inst. for Nuclear Study. Documents available from Aeroplus Dispatch.

We propose a new method which analyzes the dynamical triangulation from the viewpoint of the non-critical string field theory. By using the transfer matrix formalism, we construct the non-critical string field theory (including c greater than 1 cases) at the discrete level. For pure quantum gravity, we succeed in taking the continuum limit and obtain the $c = 0$ non-critical string field theory at the continuous level. We also study about the universality of the non-critical string field theory.

A94-28788 Preliminary tests of a transonic flutter control wing model. K. FUJII, Y. ANDO, H. MATSUSHITA, M. HASHIDATE, K. SUZUKI, Y. KOMASTU, S. SUZUKI, M. SUZUKI, and A. KOIKE (National Aerospace Lab., Chofu, Japan), In *Aircraft Symposium*, 30th, Tsukuba, Japan, Sept. 30–Oct. 2, 1992, Proceedings (A94-28718 09-01), Tokyo, Japan Society for Aeronautical and Space Sciences, 1992, pp. 474–477. In Japanese. 3 Refs. Documents available from Aeroplus Dispatch.

Studies on active control technology (ACT) for aeroelastic systems at NAL are expanded to transonic flutter control. A cantilevered wing model for transonic wind tunnel tests was constructed and preliminary tests were made. From vibration tests and load tests results, structural characteristics were obtained through which a mathematical structural model could be tuned for consistency. Static and dynamic aerodynamic characteristics were obtained from wind tunnel tests. The flutter boundary was predicted by processing of data on wing responses to turbulence. (Author)

A94-28194 Computational and experimental fracture mechanics—Developments in Japan. H. NISITANI, ED. (Kyushu Univ., Fukuoka, Japan), Southampton, United Kingdom and Boston, MA, Computational Mechanics Publications (Topics in Engineering. Vol. 16), 1994, p. 446 (For individual items see A94-28195 to A94-28203). Documents available from Aeroplus Dispatch.

Two adaptive schemes for controlling the end-effector impedance of dexterous manipulators are described. Each control system consists of two subsystems: a simple 'filter' which characterizes the desired dynamic relationship between the end-effector position and the environmental contact force and modifies the reference trajectory according to this relationship, and an adaptive controller which produces the control input required to track this modified trajectory. The proposed controllers are very general and computationally efficient since they do not require knowledge of either the mathematical model or the parameter values of the robot dynamics of the environment, and are implemented without calculation of the robot inverse kinematic transformation. It is shown that control strategies are globally stable in the presence of bounded disturbances, and the size of the tracking errors can be made arbitrarily small. It is also shown that the impedance controllers can be modified to provide accurate force regulation in the presence of uncertainty regarding the location and stiffness of the environment.

A95-12504 Hybrid verification method for thermal design on spacecraft. Y. KOBAYASHI (Tsukuba, Univ., Japan), A. OHNISHI (Inst. of Space and Astronautical Science, Sagamihara, Japan), and S. HAYASHIGUCHI (IBM Japan, Tokyo), In *International Symposium on Space Technology and Science*, 18th, Kagoshima, Japan, May 17–22, 1992, Proceedings. Vol. 1 (A95-12376 01-12), Tokyo, Japan, AGNE Publishing, Inc., 1992, pp. 873–878. 4 Refs. Documents available from Aeroplus Dispatch.

An effective thermal verification method for spacecraft is introduced, in which their partial model or structural segment can be used in testing in case of spacecraft with large scale structure. The essence of this concept is to evaluate the thermal design of the spacecraft by integrating a thermal vacuum test into the thermal analyses system as a data-generating subroutine. The measured temperature data are used for modification of the thermal mathematical model, which in turn determines a new test condition to generate data for refining the thermal mathematical model. In reality the verification process is a kind of numerical simulation using the in situ temperature measurements obtained from the thermal vacuum test run simultaneously with the simulation. This 'hybrid simulation' process will be terminated when the mathematical model is finalized and the hardware design, including possible design change, is determined. This new method will be able to evaluate thermal design of a large-scale spacecraft with reasonable precision. (Author)

A95-12441 Dynamics of space structures with nonlinear joints. H. FURUYA (Nagoya Univ., Japan), in *International Symposium on Space Technology and Science*, 18th, Kagoshima, Japan, May 17–22, 1992, Proceedings. Vol. 1 (A95-12376 01-12), Tokyo, Japan, AGNE Publishing, Inc., 1992, pp. 467–472. 9 Refs. Documents available from Aeroplus Dispatch.

A mathematical model is presented for dynamical analysis of chainlike multibody structures with nonlinear joints in a low-gravity environment. The procedure takes into account the geometrical effects of clearance, nonlinear force-displacement relations, and friction effects in the joints. Numerical examples of a uniform slender body attached to a moving base are used to investigate the characteristics of multibody systems with nonlinear joints.

A94-36990 Mathematical models for modal analysis of a tip-fin wing. K. IWASAKI (National Aerospace Lab., Tokyo, Japan), In *Aircraft Symposium*, 31st, Gifu, Japan, Nov. 10–12, 1993, Proceedings (A94-36967 12-01), Tokyo, Japan Society for Aeronautical and Space Sciences, 1993, pp. 182–185. In Japanese. Documents available from Aeroplus Dispatch.

Research for the development of a winged space vehicle is being conducted in Japan. To investigation the dynamic characteristics of vehicle structures, a cantilevered-wing model with a tip-fin and a planner-wing model were made for the vibration and wind tunnel tests. Mathematical models for flutter analysis were obtained by the finite element method. In this paper, comparisons are made between the results of the vibration test and those of the analysis. The analysis of the mathematical model shows good agreement with the experiments. (Author)

A94-36978 NAL research activities on active control of aeroelastic systems. H. MATSUSHITA (National Aerospace Lab., Tokyo, Japan), In *Aircraft Symposium*, 31st, Gifu, Japan, Nov. 10–12, 1993, Proceedings (A94-36967 12-01), Tokyo, Japan Society for Aeronautical and Space Sciences, 1993, pp. 98–101. 22 Refs. Documents available from Aeroplus Dispatch.

This paper reviews NAL research activity on verification studies, in wind tunnels, of the proposed synthesis method of active aeroelastic system. The proposed method begins with constructing a mathematical model of a flexible aircraft with control surfaces in finite state by a structural dynamics analysis and CFD unsteady aerodynamic analysis with a modal truncation and a finite dimensional approximation to the unsteady aerodynamics. Based on the finite state math model, the optimal design method of LQG is applied to obtain the optimal feedback control laws. The final step of an order reduction leads practical low order control laws. The method was applied to gust load alleviation and flutter control system design problems and tested in wind tunnels. Throughout these tests the present synthesis method has been refined and validated in its effectiveness. (Author)

A94-31739 Transonic flutter control of a high aspect ratio wing—Mathematical modeling, control law design and wind tunnel tests. H. MATSUSHITA, M. HASHIDATE, K. SAITOH, Y. ANDO, K. FUJII, K. SUZUKI (National Aerospace Lab., Tokyo, Japan), and D. H. BALDELLI (Nagoya Univ., Japan), In *ICAS, Congress*, 19th, Anaheim, CA, Sept. 18–23, 1994, Proceedings. Vol. 3 (A94-31534 10-01), Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1994, pp. 2070–2079. 16 Refs. Documents available from Aeroplus Dispatch.

A promise and a limitation of a linear control for transonic limit-cycle flutter is investigated analytically, supported by wind tunnel test verification. A mathematical model simulating a transonic flutter of a wind tunnel aeroelastic model with control surfaces is derived by a linear structural and aerodynamic analysis. A finite element structural analysis and Doublet Point unsteady aerodynamic analysis, tuned by a ground vibration test and a wind tunnel flutter test, yield a math model which can predict experimental flutter characteristics with a certain discrepancy. Control laws with robust stability are synthesized based on the linear model and a control law attained experimentally 11.4 percent increase in the flutter dynamic pressure. (Author)

A94-31679 Fundamental wind tunnel experiments on tip-fin flutter. T. UEDA, T. SOTOZAKI, and K. IWASAKI (National Aerospace Lab., Mitaka, Japan), In *ICAS, Congress*, 19th, Anaheim, CA, Sept. 18–23, 1994, Proceedings. Vol. 2 (A94-31534 10-01), Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1994, pp. 1451–1458. 4 Refs. Documents available from Aeroplus Dispatch.

The baseline of H-II Orbiting Plane (HOPE) has a large fin at the tip of its cropped delta wing. During its mission, which begins with vertical launch by H-II rocket and ends at horizontal landing, it will encounter severe circumstances for the airframe structure. One of the design issues of the structure is flutter, as it has wings like airplanes. To investigate the fundamental characteristics of flutter for this configuration, a simple wing model with a vertical fin was made and tested in a low-speed wind tunnel. This paper describes the vibration tests, wind tunnel experiments, and the flutter calculations for this model. A unique tool for modal survey tests is also described. (Author)

N94-27966 A laboratory test on construction of ice domes and their load-carrying capacity (Aisu Domu Mokei No Shisaku To Kyodo Shiken). T. HANNUKI, K. ISHIZAWA (National Inst. of Polar Research, Tokyo, Japan.), K. FUTAMI, and K. TSUKUI, In *National Inst. of Polar Research, Antarctic Record*, Vol. 36, No. 2 pp. 203–226 (SEE N94-27963 07-46). Documents available from Aeroplus Dispatch.

Ice domes will be useful as a shelter of depot and laboratory space without heating systems which will be constructed on the ice field in the Arctic or Antarctic. Efficacious use of ice domes is discussed for facilities of research camp in the Antarctic. Some experiments on construction technique of ice domes and their load-carrying capacity were carried out in a low temperature laboratory. It was confirmed experimentally that ice domes could be made by spraying water onto a spherically inflated membrane form under the condition of holding a temperature below −18°C. Mechanical property of artificial ice made in the laboratory was examined by some bending tests of simply supported ice beams so as to discuss a constitutive model of ice for numerical analysis. Load-carrying capacity and creep behavior of ice dome models

were examined in the laboratory and analytical models of ice structure for a numerical procedure of the design were discussed and compared with the tests. A usefulness of elastic-plastic model for the mechanical behavior of ice structures in a short term loading and a convenience of Maxwell model for the long time creep of ice structure were confirmed in the discussion. These laboratory tests and analytical applications led to the first step of realization of the ice dome construction in the Antarctic. (Author)

A94-23600 Dynamic loads on Mu-series satellite launch vehicles at lift-off. K. KISHI (Nissan Aerospace Engineering Co., Ltd., Tokyo, Japan), J. ONODA, K. MINESUGI (Inst. of Space and Astronautical Science, Sagamihara, Japan), and M. NAKAMURA (Nissan Motor Co., Ltd., Tokyo, Japan), In *AIAA Dynamics Specialists Conference*, Hilton Head, SC, April 21, 22, 1994, Technical Papers (A94-23572 06-39), Washington, DC, American Institute of Aeronautics and Astronautics, 1994, pp. 276–284. Documents available from Aeroplus Dispatch.

All the Mu series satellite launch vehicles are launched in an inclined position by using a rocket launcher. This paper studies on the dynamic bending load on two types of Mu vehicles at the inclined lift-off. Although the investigation is based on a simple model of the vehicle and the rocket launcher, the simulation results substantially coincide with actual flight data. The investigation shows that the lift-off bending load can be so large that it can dominate the design bending load of various section of the vehicle including the upper stage structures. The lift-off load is shown to be sensitive to the variation of parameters in some cases. A procedure to establish the design lift-off load is outlined which takes account of the sensitivity of the load to the parameter variation and the ambiguity of the parameters at the initial design phase. (Author (revised))

A94-23574 Structural dynamics of the deployable wire antenna system and the GEOTAIL on-orbit operation. Y. MORITA, M. HINADA (Inst. of Space and Astronautical Science, Sagamihara, Japan), T. NOZUE, and Y. TAKETOMO (Hitachi, Ltd., Kanagawa, Japan), In *AIAA Dynamics Specialists Conference*, Hilton Head, SC, April 21, 22, 1994, Technical Papers (A94-23572 06-39), Washington, DC, American Institute of Aeronautics and Astronautics, 1994, pp. 17–25. 6 Refs. Documents available from Aeroplus Dispatch.

Even at the recent stage of space activities, deployment of structures in space is still among the most difficult, showing several examples of failure and incompleteness due to technical and mechanical problems over past years. Emergency operations were actually executed for both the wire antenna deployment and the mast extension aboard the GEOTAIL spacecraft to finally get their complete configurations. The problem is further accentuated by the dimensions and flexibility of the wire antennas possibly resulting in wire vibrations as well as satellite attitude perturbations through in-orbit events scheduled such as antenna and mast deployment, spin up and down operations, and attitude and orbit maneuver, which may lead to distortion of the attitude control accuracy and the scientific observation environment. In the study, in-orbit operations associated with the wire deployment and the mast extension are reviewed, and some of the typical flight data of practical importance are analyzed to reveal effects of such operations on the system response. To that end, an efficient algorithm for formulating equations of motion for this class of flexible systems has been established in a relatively general fashion. (Author)

N94-13659 The study on large space structure assembly technology: The study on deployable truss structure, part 2 and 3 (Oogata kouzoubutsu kumitate gijutsu no kenkyuu: Tenkai kumitate kouzou no kenkyuu). Technical Progress Report, FY 1990–1991. National Space Development Agency, Ibaraki (Japan). Thermal and Structural Engineering Lab. Documents available from Aeroplus Dispatch.

An overview of the results of the study on large structure assembly technology is presented. The following aspects of the study are outlined: (1) overall scheme of technology development for assembling and constructing large structure operated on orbit; (2) a brief description of the development from FY (Fiscal Year) 1998 through FY 1991; (3) design study on system and element technologies; (4) simulation analysis, including studies on the analytic software and mathematical model, and problems in analyzing technology; (5) ground test; (6) survey on the next generation structural materials; and (7) concept of on-orbit validation experiment. (Author)

N94-10481 Flow analysis around ONERA model M5 configuration. T. KAIDEN and J. OGINO, In *NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry*, pp. 71, 72 (SEE N94-10466 01-02). Documents available from Aeroplus Dispatch.

Flow analysis around the ONERA Model M5 Configuration is presented. The governing equation is the thin-layer Reynolds-averaged Navier-Stokes equation. The code is based on the scalar pentadiagonal ADI scheme with nonlinear artificial dissipation model and local time stepping. The turbulence modeling is also added as the algebraic model of Baldwin-Lomax type. The grid system for this configuration is generated utilizing the algebraic interpolation. The computations with 1,221,500 points are performed on a Fujitsu VP-2600. (Author (revised))

N94-10478 Flow analysis around ONERA model M5 configuration. T. KISHIMOTO, In *NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry*, pp. 65, 66 (SEE N94-10466 01-02). Documents available from Aeroplus Dispatch.

Numerical simulation of transonic flow around the ONERA model M5 configuration have been carried out by solving Navier–Stokes equations. The numerical grid used in this analysis is generated by an algebraic method with a multi-block transformation. The grid generation around the given configuration consists of more than 5 million points. We adopt as governing equations Reynolds-averaged thin-layer approximate Navier–Stokes equations with a q-omega two equation turbulence model for a turbulent viscous flow. These equations are solved by an implicit finite volume TVD upwind scheme with Roe's approximate Riemann solver to estimate convective fluxes. (Author (revised))

N94-10477 Flow analysis around ONERA model M5 configuration. T. YAMAZAKI, K. HIGAKI, Y. KOSHIOKA, and K. TANAKA, In *NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry*, pp. 63, 64 (SEE N94-10466 01-02). Documents available from Aeroplus Dispatch.

Navier–Stokes code was used for flow analysis around the ONERA Model M5 configuration. This code utilizes the LU-ADI scheme and an algebraic turbulence model that was proposed by B.S. Baldwin and H. Lomax. The body surface grid used for this analysis was obtained by using the Master Dimension System, and the whole grid system was constructed in C-H type topology. The results of this analysis are in good agreement with wind tunnel test results. (Author (revised))

N94-10474 Aerodynamic characteristics analysis of Garabedian-Korn 75-06-12 airfoil. T. KAIDEN, and J. OGINO, In *NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry*, pp. 17, 18 (SEE N94-10466 01-02). Documents available from Aeroplus Dispatch.

Aerodynamic characteristics analysis of Garabedian-Korn 75-06-12 airfoil is presented. The governing equation is the thin layer Reynolds-averaged Navier–Stokes equation. The code is based on scalar pentadiagonal ADI scheme with a nonlinear artificial dissipation model and local time stepping. The turbulence modeling is added as the algebraic model of Baldwin-Lomax type. The grid system for the airfoil as C-type is generated solving the parabolic equation. The computations with 20,230 points are performed on a Convex 220. (Author (revised))

N94-10471 Aerodynamic characteristics analysis of Garabedian-Korn 75-06-12 airfoils: Computation using Baldwin-Lomax turbulence model. E. SHIMA and K. EGAMI, In *NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry*, pp. 11, 12 (SEE N94-10466 01-02). Documents available from Aeroplus Dispatch.

Flow around a Garabedian-Korn 75-06-12 Airfoil is simulated numerically using Navier–Stokes equations. Baldwin-Lomax's algebraic turbulence model is adopted, but wake modeling is not used because it was shown by the previous investigation that turbulence viscosity in wake region has only little influence on pressure distribution and boundary layer characteristics. The equations are computed by the cell centered finite volume method using an implicit upwind scheme. C-type grid, which is generated algebraicly by the transfinite interpolation, is used. The large linear equations arising from the implicit scheme are solved approximately using the multi-color Gauss-Seidel method. Numerical experiments show that optimum inner iteration for rapid convergence is about 10. (Author (revised))

N94-10468 Aerodynamic characteristics analysis of Garabedian-Korn 75-06-12 airfoil. A. E. SAKYA and Y. NAKAMURA, In *NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry*, pp. 5, 6 (SEE N94-10466 01-02). Documents available from Aeroplus Dispatch.

A Navier–Stokes code based on the implicit Yee-Harten TVD scheme is applied to compute the aerodynamic characteristics of Garabedian-Korn GK 75-06-12 airfoil at transonic speed. The algebraic turbulence model is employed to close the system of equations. (Author)

A93-48345 A method of wind shear detection for powered-lift STOL aircraft. K. FUNABIKI, T. BANDO, K. TANAKA (National Aerospace Lab., Tokyo, Japan), C. S. HYNES, and G. H. HARDY (NASA, Ames Research Center, Moffett Field, CA), In *AIAA Atmospheric Flight Mechanics Conference*, Monterey, CA, Aug. 9–11, 1993, Technical Papers (A93-48301 20-08). Washington, American Institute of Aeronautics and Astronautics, 1993, pp. 442–447. 5 Refs. Documents available from Aeroplus Dispatch.

A new wind shear warning system for powered-lift STOL aircraft was evaluated by using a flight simulator. Wind shear warning systems for CTOL aircraft have been designed to detect horizontal shear only. Because the approach air speed of STOL aircraft is lower than that for CTOL aircraft, STOL aircraft are more vulnerable to vertical wind due to (1) a gradient of horizontal shear that is smaller for STOL than for CTOL aircraft because of slower airspeed; (2) STOL aircraft spend longer time in a downdraft; and (3) vertical wind causes a more radical change in the STOL aircraft's flight path because of its lower airspeed. In order to detect the vertical wind, the wind shear warning system proposed calculates the difference between potential flight path measured on-board during shear traversal and trimmed flight path estimated from aircraft status. The most characteristic feature of this new system is that it utilizes only inertial information and pitot-static airspeed data; this yields a convenient means of on-board implementation. Simulation test results confirm that the new system can detect the vertical shear. (Author (revised))