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**Final Report
for NAG 3-904**

**Improved Large Perturbation Propulsion Models for Control System Design
(1988-89)**

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**Large Perturbation Models of High Velocity Propulsion Systems (1989-
1990)**

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Reduced Order Propulsion Models for Control System Design (1990-1991)

by

**Tom T. Hartley
J. Alex DeAbreu-Garcia
Department of Electrical Engineering
The University of Akron
Akron, OH 44325-3904
216-972-7649**

for

**The Advanced Control Technology Branch
MS 77-1
The NASA Lewis Research Center
21000 Brookpark Rd.
Cleveland, OH 44135**

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(NASA-CR-190148) IMPROVED LARGE
PERTURBATION PROPULSION MODELS FOR CONTROL
SYSTEM DESIGN (1988-1989) AND LARGE
PERTURBATION MODELS OF HIGH VELOCITY
PROPULSION SYSTEMS (1989-1990) AND REDUCED
G3/34

December, 1991



Contents

1. Overview: "A Hierarchy for Modeling High Speed Propulsion Systems," T.T. Hartley, J.A. DeAbreu-Garcia, December, 1991.
2. Summary of Results Generated by Grant NAG 3-904.

Journal Articles

3. "Approximate Truncated Balanced Realizations for Reducing Infinite Dimensional Systems," T.T. Hartley & J.A. DeAbreu-Garcia, submitted to the Journal of The Franklin Institute, January 1992, in revision.
4. "A Fundamental Theorem for the Model Reduction of Nonlinear Systems," F. Mossayebi, T.T. Hartley, & J.A. DeAbreu-Garcia, The Journal of The Franklin Institute, Vol. 329, No. 1, pp 145-153.

Abstracts in Journals

5. "Functional Observers for Spatially Distributed Systems," T.T. Hartley & Lei Xia, Ohio Academy of Science Journal and Spring Meeting, Vol. 92, No. 2, April 1992.
6. "The Simulation and Model Reduction of Gasdynamic Systems," S. Immel, Ohio Academy of Science Journal and Spring Meeting, Vol. 92, No. 2, April 1992.
7. "A Hierarchy for Modeling High Speed Propulsion Systems," T.T. Hartley, Ohio Academy of Science Journal and Spring Meeting, Vol.91, No. 2, pp 67, April 1991.

Conference Papers

8. "Physical Lumping Methods for Developing Linear Reduced Models for High Speed Propulsion Systems," S. Immel, T.T. Hartley, & J.A. DeAbreu-Garcia, submitted to the IEEE Conference on Control Applications, January, 1992.
9. "Modeling of Linear Isentropic Flow Systems," A. Sarantopoulos & T.T. Hartley, Proc. IEEE International Conference on Systems Engineering, Dayton, August, 1991.
10. "Modeling and Simulation of a Heat Exchanger," L. Xia, J.A. DeAbreu-Garcia & T.T. Hartley, Proc. IEEE International Conference on Systems Engineering, Dayton, August, 1991.
11. "Temperature Control in Continuous Furnace by Structural Diagram Method," L. Xia & T.T. Hartley, Proc. 1991 American Control Conference, Boston, 1991.
12. "Reduced Order Modeling for Distributed Parameter Systems," B. Dariush & T.T. Hartley, Proc. 1991 Pittsburgh Conf. on Modeling and Simulation, May, 1991.

Technical Reports

Reviewed Reports:

13. "Exact and Approximate Solutions to the Oblique Shock Equations for Real-Time Simulation," T.T. Hartley, R. Brandis, & F. Mossayebi, NASA Contractors Report 187173, August 1991.

General Reports:

14. "A Simple Method for Simulating Gasdynamic Systems," T.T. Hartley, Internal Report, On file with T.T. Hartley (U. of Akron) or Kevin Melcher (NASA Lewis).