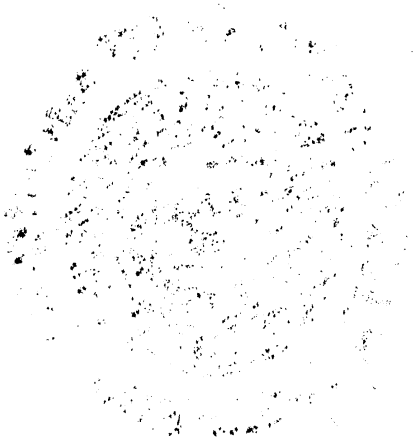
THE UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING
Department of Aeronautical and Astronautical Engineering

QUARTERLY PROGRESS REPORT

for January, February, March 1962

by
Elmer G. Gilbert

ORA Project 04487



Prepared for George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Huntsville, Alabama

under
Contract No. NAS8-1569

administered by
The University of Michigan Office of Research Administration
Ann Arbor, Michigan

1. Introduction

This report describes work accomplished in the period of January through March 1962 in the contractor's research program on various aspects of space vehicle booster control systems.

The study of recovery regions of linear systems with limited control effort described herein is by doctoral student Joseph L. LeMay under the supervision of Professor Elmer G. Gilbert.

2. Regions of Recoverability of Linear Systems with Input Constraints

Concepts of a more general nature have been applied to what is essentially the same problem as that described in the previous progress report. We study a system described by a general linear differential equation with an input constrained to be in a specified set Ω. The set Ω is assumed to be compact and convex. The set of states which can be driven to the origin is called the maximum region of recoverability, RRM (t, t_o). This set is a function of two variables--starting time t_o and stopping time t. In the constant coefficient case, RRM(T) depends only on elapsed time T. The results for RRM(T) of the previous report assumed implicitly that T was arbitrarily large.

It has been shown that RRM(t, t_o) is compact and convex and does not diminish in size as t increases. Another result is a necessary and sufficient condition that RRM(∞, t_o) be the whole state space*.

For the constant case this condition requires the eigenvalue real parts to be non-positive.

Some computational procedures for determining RRM(t, t_o) and bounds thereof have been developed. Work on determining RRM(T) for the yaw (pitch) control of a space vehicle booster (in actual coordinates) is in progress.

*Some of these results exist elsewhere.

3. Simplified Stability Analysis of Booster Control System

Professional degree student Guy H. Risley, Jr. began work under Professor Edward O. Gilbert on a simplified method of stability analysis for the booster control system. Based on the method of Krylov and Bogoliubov, it should be useful in determining the damping of both structural and slosh modes.

Statement of Man-Hours Expended
and
Summary of Expenditures
for January, February, March 1962

	January 1962	February 1962	March 1962	Three Month Period
Man-Hours Expended				
Faculty Participants	46	46	66	158
Graduate Students	83	88	80	251
Total	129	134	146	409
Salaries and Wages				
Faculty Participants	$403.61	$447.73	$601.90	$1,453.24
Graduate Students	269.75	330.00	300.00	899.75
Total	$673.36	$777.73	$901.90	$2,352.99
Overhead	$336.68	$396.37	$453.00	$1,186.05
Materials and Supplies	3.65	1.00	8.14	12.79
Reports	0.00	15.00	4.10	19.10
Travel	0.00	0.00	0.00	0.00
Totals	$1,013.69	$1,190.10	$1,367.14	$3,570.93