AIAA
R-060-1993

Recommended Practice

Recommended Practice for Reporting Earth-to-Orbit Mission Profiles

AIAA

AIAA
R-060-1993

Recommended Practice for Reporting Earth-to-Orbit Mission Profiles

Sponsor

American Institute of Aeronautics and Astronautics

Approved May 5, 1993

Abstract

This recommended practice defines initial and final state information such as specific launch point latitude, final orbit altitude and inclination for point-to-point comparison of the performance of launch vehicles. A chart format for describing the overall performance characteristic of a vehicle is also supplied. The intent of this standard is to provide a clear means of comparing the payload capabilities of different launch vehicles to satisfy the payload customer's needs when selecting an appropriate launch system.

Published by
American Institute of Aeronautics and Astronautics
370 L'Enfant Promenade, SW, Washington, DC 20024

Printed in the United States of America

CONTENTS

Foreword

This Recommended Practice for Reporting Earth-to-Orbit Mission Profiles has been sponsored by the American Institute of Aeronautics and Astronautics (AIAA) as a part of its Standards Program.

The AIAA Standards Procedures provides that all approved Standards, Recommended Practices and Guides are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any AIAA standards publication and no commitment to conform to or be guided by any standards report. In formulating, revising, and approving standards publications, the Committees on Standards will not consider patents which may apply to the subject matter. Prospective users of the publications are responsible for protecting themselves against liability for infringement of patents or copyrights, or both.

The AIAA Space Launch Systems Committee on Standards (SLS/CoS) evolved from a project committee within the Missile Systems Technical Committee. Early in its life, the SLS / CoS decided to emphasize the preparation of standards which would be useful to commercial space activities. This document is the first in a series to serve that purpose.

The following people were instrumental in the development of this Recommended Practice: Phillip Robidoux of Lockheed Missiles and Space Company, Inc. Missile Systems Division, for assembling and coordinating the document; Dennis Haas of Lockheed Missiles and Space Company, Inc. Space System Division for his inputs on orbit state parameters; Derek E. Lang of the Office of Commercial Space Transportation, Department of Transportation for keeping the standards committee informed on the activities of the US government and their regulatory concerns; Capt. Todd Freece of the US Air Force ESMC for first voicing his concerns as a launch vehicle customer and stating the need for this standard; finally, the AIAA Space Launch Systems Committee on Standards chaired by Todd J. Mosher for supporting and providing comments for inclusion in this project.

This document was approved by the Space Launch Systems Committee on Standards in March 1993.

The AIAA Standards Technical Council (A. H. Ghovanlou, Chairman) approved the document in May 1993.

1.0 INTRODUCTION

1.1 Purpose

The performance analyst, government regulatory agencies, vehicle manufacturers, and spacecraft communities need a standard set of orbit missions and launch sites to accommodate comparisons of launch vehicle payload capability. A set of common definitions allows easy comparisons when selecting launch configurations, setting and paying fees for launch services, and allowing measured quantitative comparison between vehicles and capabilities.

1.2 Scope

Definitions and terms used in vehicle performance comparisons are specified. Orbital profiles are specified for generating comparison missions (e.g., 185 km circular orbit from Cape Canaveral). A table of current launch site latitudes is provided. A performance chart format giving information of a system payload capability is also described.

2.0 LAUNCH-TO-ORBIT MISSIONS

Launch-to-orbit mission profiles are used when generating performance statements regarding the payload capability of a launch vehicle which carries a payload from the earth's surface into orbit. For purposes of comparison, payload capability is defined as payload separated mass.

These profiles form a suite of cases that should be used for comparing the capabilities of a launch vehicle system. A subset of all possible launch points are used to keep the number of cases manageable and to provide good point-to-point comparison.

When generating the performance quotation, a rotating earth should be used. Geophysical constants and atmospheric model should be referenced by the generator of the orbital cases. For example, the WGS-84 earth model and Jacchia J71 reference atmosphere are recommended for specifying these characteristics.

The launch-to-orbit profiles are stated below. Each final orbit mission has a name or type, perigee altitude, apogee altitude, inclination. It also has an argument of perigee (if applicable) and an associated launch site latitude or initial inclination for transfer orbits. All altitudes refer to local mean sea level.

2.1 Low Earth Orbit - ER

This low earth orbit mission launched due east from the Eastern Range (ER) at Cape Canaveral, Florida has the lowest altitude orbit.

Perigee Altitude	185 km	(100 nmi)
Apogee Altitude	185 km	(100 nmi)
Inclination	28.5 °	
Launch Latitude	28.5 °	

2.2 Low Earth Orbit - DoT

This low earth orbit mission launched from the Eastern Range (ER) at Cape Canaveral, Florida is the same mission specified by the US. Department of Transportation for computing the payload capability of a launch vehicle: the maximum payload to this orbit is used for calculating launch fees.

Perigee Altitude	277.8 km (150 nmi)
Apogee Altitude	277.8 km (150 nmi)
Inclination	28.5 °
Launch Latitude	28.5 °

2.3 Low Earth Orbit - WR

The low earth polar orbit mission launched in a southerly direction out of the Western Range (WR) at the Vandenberg Air Force Base, California.

Perigee Altitude	185 km (100 nmi)
Apogee Altitude	185 km (100 nmi)
Inclination	90.0 °
Launch Latitude	34.7 °

2.4 Molniya Orbit

This is a 12-hour period eccentric orbit at the critical inclination. A satellite will linger near two points in the northern hemisphere, separated 180 ° in longitude, each day.

Perigee Altitude	740 km	(400 nmi)
Apogee Altitude	39612 km	(21389 nmi)
Argument of Perigee	270 °	
Final Inclination	63.4 °	

2.5 Geostationary Transfer Orbit

The process of launching a satellite from the earth's surface into geostationary transfer orbit is usually accomplished in two steps. First, a launch occurs into a trajectory having an apogee altitude of approximately 185 km, with trajectory inclination of 28.5 °. Then through an orbital maneuver the payload achieves the final parameters given below. The orbit is further constrained to have the apogee occur over the equator.

Perigee Altitude	185 km	(100 nmi)
Apogee Altitude	35786 km	(19323 nmi)
Final Inclination	26.5 °	
Initial Inclination	28.5 °	
Launch Latitude	28.5 °	
Argument of Perigee	0 ° or 180 °	

2.6 Geostationary Orbit

The orbital transfer condition for the geostationary orbit is the circularizing of the transfer orbit along with changing the inclination of the orbit. This orbit has a 24-hour period which places the satellite over the equator at a desired longitude. It is commonly used for communication satellites.

Perigee Altitude	35786 km	(19323 nmi)
Apogee Altitude	35786 km	(19323 nmi)
Final Inclination	0.0 °	
Initial Inclination	26.5 °	
Launch Latitude	28.5 °	

2.7 Geostationary Transfer Orbit, Kourou

The process of launching a satellite from the earth's surface into geostationary transfer orbit from Kourou, French Guiana is usually accomplished in one step. A launch occurs into a ballistic-type trajectory having an apogee altitude of approximately 200 km, with trajectory inclination of 7.0 °. The orbit is further constrained to have the apogee occurring over the equator.

Perigee Altitude	200 km	(108 nmi)
Apogee Altitude	35786 km	(19323 nmi)
Inclination	7.0 °	
Launch Latitude	5.2 °	
Argument of Perigee	178 °	

2.8 Geostationary Orbit, Kourou

The orbital transfer conditions for the geostationary orbit is the circularizing of the transfer orbit along with changing the inclination of the orbit. These particular parameters are used for systems, launched from Kourou launch site.

Perigee Altitude	35786 km	(19323 nmi)
Apogee Altitude	35786 km	(19323 nmi)
Final Inclination	0.0 °	
Initial Inclination	7.0 °	
Launch Latitude	5.2 °	

2.9 Geosynchronous Orbit

This is a 24-hour period orbit for a satellite. It is used by systems that require a 24-hour period, but need not be stationary over the equator.

Perigee Altitude	23138 km	(12494 nmi)
Apogee Altitude	48435 km	(26153 nmi)
Inclination	45.0 °	
Launch Latitude	28.5 °	
Argument of Perigee	270 °	

2.10 Sun-Synchronous Orbit

This mission is launched in a southwesterly direction from the Western Range (WR) at Vandenberg Air Force Base, California. The inclination and circular altitude of this orbit are selected such that the regression of the orbit plane due to Earth oblateness matches the rate at which the Earth orbits the Sun.

Perigee Altitude	800 km (432 nmi)
Apogee Altitude	800 km (432 nmi)
Inclination	98.6 °
Launch Latitude	34.7 °

3.0 LAUNCH LATITUDES

A list of latitudes for several launch complexes in the world is supplied as a reference for the developer of performance quotes.

San Marco	2.9° S	Kenya (USA)
Kourou	5.2° N	French Guyana
Sriharikota	13.9° N	India
Xi Chang	28.2°N	China
Canaveral	28.5° N	USA
Tanegashima	30.2° N	Japan
Negev	31.0° N	Israel
Kagoshima	31.2° N	Japan
Vandenberg	34.7° N	USA
Wallops	37.9° N	USA
Jiuquan	40.7° N	China
Tyuratam	45.6° N	Russia
Kapustin Yar	48.4° N	Russia
Plesetsk	62.8° N	Russia

4.0 MISSION PERFORMANCE CHART

A format for displaying the payload-to-orbit performance of a launch system is described. The performance chart displays the maximum payload, defined as weight above the interface between the vehicle and the payload, to specified orbits for the useful span of inclinations. When developing these charts for a launch vehicle, the minimum inclination angle line shown should be equal to the minimum latitude from which the launch system would ever be launched.

The typical series of inclinations that will be used are, 7.0°, 28.5°, 45.0°, 55.0°, 63.4°, 90.0°, and 99.0°.

The sample performance chart shown in Figure 1 has three distinct regions; ballistic trajectories (orbits that intersect the earth), direct ascent elliptical orbits, and direct ascent circular orbits. The three lines for each inclination all intersect at the 185 km altitude point. The ballistic trajectories (earth-intersecting or fast-decaying orbits) have apogee altitudes of 185 km and perigee altitudes of 185 km or less. Direct ascent elliptic orbits will have perigee altitude of 185 km and apogee altitudes greater than 185 km. The direct ascent circular orbits will have altitudes greater than or equal to 185 km.

Other performance considerations should also be indicated on the chart. For example, identify the range imposed launch site inclination constraints. Scales should be adjusted for appropriate presentation.

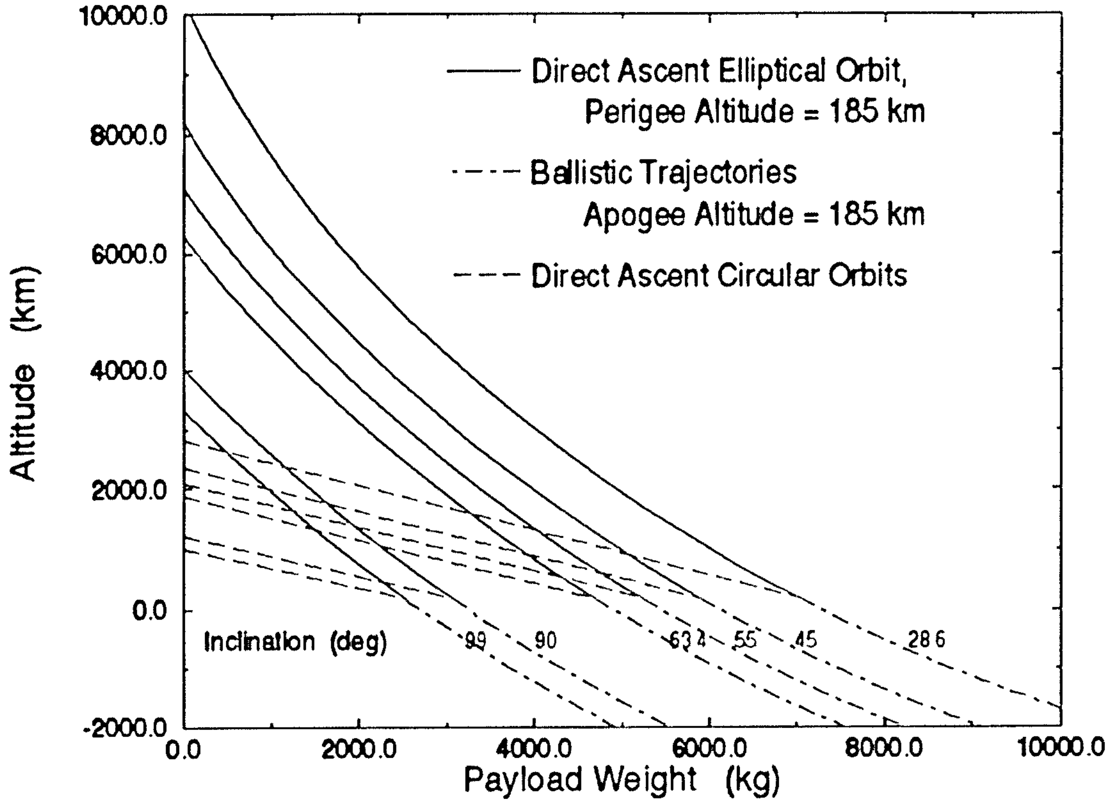

Figure 1 Booster Performance Chart

American Institute of Aeronautics and Astronautics

1801 Alexander Bell Drive, Suite 500
Reston, VA 20191-4344

ISBN 1-56347-418-2