Mission Characterization
for the
Bell Laboratories Telstar 302 Communications Satellite

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for:
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List of Symbols and Abbreviations

a - semi-major axis
ACS - Attitude control system
AKM - Apogee kick motor
AT&T - American Telephone and Telegraph
CONUS - Continental United States
e - eccentricity
i - inclination
GEO - Geosynchronous orbit
GMT - Greenwich Mean Time
GTO - Geosynchronous transfer orbit
LEO - Low-earth orbit
nm - nautical mile
PAM - Perigee assist module
STS - Space Transportation System
? ?? ?argument of perigee
? ?? ?latitude of the ascending node?
?V - Delta velocity

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1.0 INTRODUCTION

In the mid 1980s, American Telephone & Telegraph (AT&T) revived the Telstar designation that was introduced in 1962 and 1963 for the first commercial communications spacecraft. AT&T's Bell Laboratories, responsible for the early Telstar success, was tasked to replace the Comstar satellites being leased by AT&T from Comsat General as the Comstars expired.

The Telstar 3 system was designed to consist of three satellites operating from geosynchronous orbit over the course of a ten year lifespan. This satellite constellation currently provides customers with communications ranging from simple telephony (i.e. telephone-call processing) to broadcast television to high-speed secure data transfer.

The Telstar 3 telecommunications network is one of the most successful communications ventures in history. The Telstar 302 (also referred to as the Telstar 3C) satellite is one of AT&T's Telstar 3 communications network spacecraft. A schematic of the vehicle appears in Figure 1. The characterization of the deployment of this satellite system will be the focus of the mission planning analysis presented in this paper.

2.0 MISSION CONTRAINTS

The primary mission contraints involved in the deployment of a geostationary communications satellite is placing the vehicle at the target longitude in a geosynchronous orbit while minimizing mission ?V. The spacecraft is assumed to begin in low-earth orbit (LEO). The transport of the communications satellite to LEO can be accomplished using a number of available boosters. The Telstar system used both the Delta 3920 and the Space Transportation System's Space Shuttle to place its spacecraft into LEO.

3.0 MISSION OVERVIEW

The Telstar 302 was launched from Kennedy Space Center on August 30, 1984 aboard the Space Shuttle Discovery launch vehicle mission SM-12. The Shuttle's low-earth parking orbit was at 160 nautical miles altitude, inclined at 28.5?. The Telstar package (the Telstar 302 communications satellite and a solid apogee kick motor) was launched from the Discovery on September 1, 1984 at 1320 Greenwich Mean Time (GMT). To ensure proper placement at the target longitude and to account for earth rotation during the GTO, the Telstar package was launched 100? west of target. The target longitude was 86? W (which was later moved to 96? W by ground control). Therefore, the Discovery launched the package at 346?? E. The Telstar was spun up to an initial 50 rpm before burning to enter the GTO. The entire vehicle was spun during this initial 45 minute parking orbit stabilization. The Telstar package was placed into the Geosynchronous Transfer Orbit (GTO) by a perigee-assist module (PAM-D) orbital transfer vehicle. At the apogee of the GTO, the solid rocket apogee kick motor (AKM) was fired to circularize the orbit at geosynchronous (GEO) altitude and to make the

required plane change from 28.5? to the nominal 0? inclination of GEO. The antenna section was despun after final orbit touchup. This entire process is summarized in Figure 2 and in Figure 3.

4.0 MISSION PARAMETERS

Table 1. Summary of Telstar 302 Mission Parameters

Characteristic	GTO	GEO
apogee altitude	36565 km	36,565 km
perigee altitude	296.32 km	34,775 km
semi-major axis (a)	24808.8 km	42,048 km
orbital period	648.14 min.	1430.14 min.
inclination (i)	28.5??	0.37?
eccentricity (e)	0.731	0.021
arg. of perigee (w)	15??	15?
eclipse time	N/A	72 min.
lat. of asc. node (?)	346??E	86??W
Orbit initial ?V burn	2450 m/s from PAM-D	1830 m/s from AKM
Total ?V (LEO to GEO)	N/A	4280 m/s

5.0 MISSION HARDWARE

The mission hardware includes the Telstar 302 spacecraft with a wet mass of 1225 kg (reduced to 653 kg on station). This vehicle includes the solid rocket apogee kick motor that inserts the 302 into GEO from the GTO. The Telstar package utilized the PAM-D vehicle to boost itself from LEO into the GTO. In addition, the assembly required a transportation system from the earth's surface to LEO. Telstar has used both the STS and the Delta 3920 for this function. Finally, the Telstar required ground support to track its progress and uplink command and telemetry. The Telstar system is supported on the ground by a primary satellite control facility at Hawley, PA. A second AT&T Satellite Management Facility is in Three Peaks, CA. Both centers support the Telstar 302 with 30 meter and 13 meter antenna dishes. These ground support centers can determine vehicle angular position to within 0.01? and range to within 15.0 meters. This data updates the inertial navigation system on the Telstar and dictates pointing and/or position corrections.

6.0 MISSION SUMMARY

The Telstar 302 communications satellite mission characterization provides a clear example of a mission designed to place a vehicle into geosynchronous orbit from low-earth orbit. The entire spacecraft and mission is constructed to support the singular objective of providing effective commercial communications. The strengths of this mission are its simplicity and the relative frequency that this mission is performed (i.e. significant experience in the field). The drawbacks are the high relative ?V required and the accuracy necessary for effective orbital insertion. Telstar's particular mission is benefited by its use of a solid AKM (which reduces the ?V necessary from GTO to GEO) and its spin stabilization (which reduces in-flight correction during insertion). The Telstar 302 also utilized existing technology for transportation into LEO. From that point, the mission planning successfully allowed it to move into GEO. The flexibility of this particularly important leg of the journey is evident in its use of two different boosters.

7.0 CONCLUSION

The Telstar 302 communications satellite is one of the most successful ventures in spacecraft history. At the halfway point in the vehicle's 10 year forcasted lifespan, the system has already paid for itself. In addition, a planned Telstar 304 was not deployed because the current three Telstars offered enough capacity for the commercial communications market. The use of careful mission planning and execution placed the Telstar at geosynchronous orbit without incident.

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FIGURES:

Figure 1. Telstar 302 Schematic

Figure 2. Telstar 302 Mission Sequence

FIGURES (cont.):

Figure 3. Telstar 302 Mission Summary