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OVERVIEW OF BATTERY USAGE IN NASA/GSFC LEO AND GEO SPACECRAFTS

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Summary

A survey of the batteries used in the LEO and GEO missions at the Goddard Space Flight Center is described. For each spacecraft, a tentative launch date is given, along with relevant battery parameters including battery size and description, depth-of-discharge, predicted mission temperature, and life requirement.

Introduction

The Goddard Space Flight Center (GSFC) has a role to expand human knowledge of the Earth, its environment, the solar system, and the universe. As such, the Center has been at the forefront of space research and exploration through a myriad of spacecrafts, both low Earth orbiting (LEO) and geosynchronous Earth orbiting (GEO) vehicles. A number of these satellites are listed in Table 1 which shows the relevant battery parameters associated with each spacecraft. All the spacecrafts listed in the Table have baselined the nickel–cadmium batteries. All the cells used in these batteries are manufactured by Gates Aerospace Batteries (GAB) in Gainesville, Florida.

Battery usage

Cosmic Background Explorer (COBE) will be launched in July 1989 on a Delta rocket from the Western Test Range. COBE is an in-house program to study the big-bang theory. COBE was originally scheduled for a shuttle launch and it was designed with two 50 A h NASA Standard batteries containing 22 cells per battery. However, the launch vehicle was changed to a Delta rocket, and the whole spacecraft was redesigned to fit this vehicle. The battery design was changed to a modified 20 A h NASA Standard battery, 18 cells per battery. The battery usage profile is benign. The mission requirement is for 1 year of battery usage with a predicted mission depth-of-discharge (DOD) of 0 - 24% over one, 63-day eclipse season. The batteries

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TABLE 1

Outline of GSFC missions and associated battery parameters

Mission	Launch	Battery	Orbit
COBE	7/89	2 x 20 A h batteries 18 cells/battery	LEO/Polar 0 - 24% DOD, 63-day eclipse 1 year mission 16 - 22 °C
NOAA-D	12/89	2 x 26.5 A h batteries 17 cells/battery	LEO/Polar morning 0 - 24% DOD 2 year mission 5 °C
GRO	4/90	6 x 50 A h batteries 22 cells/battery	LEO 15% DOD 2.5 year mission 15 °C
GOES-I GOES-J GOES-K	5/90 11/91 5/92	2 x 12 A h batteries 28 cells/battery	GEO 60% DOD 5 year mission 7 °C
TDRS-E TDRS-F TDRS-G	12/90 12/92 5/94	3 x 40 A h batteries 24 cells/battery	GEO 50% DOD 10 year mission 5 °C
NOAA-I	5/91	3 x 26.5 A h batteries 17 cells/battery	LEO/Polar afternoon 18% DOD 2 year mission 5 °C
EUVE	8/91	3 x 50 A h batteries 22 cells/battery	LEO 15% DOD 3 year mission 15 °C
UARS	12/91	3 x 50 A h batteries 22 cells/battery	LEO, 56° inclination 0 - 24% DOD 3 year mission 10 - 16 °C

will be subjected to a temperature range of 16 - 22 °C. McDonnel-Douglas Company is the prime for the batteries.

The next GSFC spacecraft to be launched is National Oceanic and Atmospheric Administration satellite (NOAA-D) in December 1989 for weather observation purposes. This spacecraft is one of a series of NOAA weather satellites on which there is cooperation between GSFC and the National Oceanic and Atmospheric Administration. NOAA-D is in a LEO/

Polar morning orbit with a predicted mission DOD of 0 - 16%. There are two 26.5 A h batteries in the spacecraft, 17 cells per battery. The mission duration is 2 years with predicted mission temperature of 5 °C. The next spacecraft, NOAA-I, is scheduled to be launched in May 1989. NOAA-I will operate in a LEO/Polar afternoon orbit with 18% DOD, 5 °C predicted mission temperature, and a 2-year mission duration. It will have three, 26.5 A h batteries, 17 cells per battery. NOAA-J is planned for July 1992 launch, and NOAA-K, November 1993. The batteries planned for the NOAA-K, L, and M spacecrafts will utilize the GAB lightweight 50 A h Ni–Cd design with salient characteristics of the NASA Standard cell. General Electric-Astro, East Windsor, is the prime contractor for NOAA satellites.

After NOAA-D, Gamma Ray Observatory (GRO) will be launched from STS 37 in April 1990. The primary objective of the satellite is to study the gamma ray radiation phenomenon. The spacecraft is in a LEO orbit with predicted mission DOD of 15% at 15 °C. The battery requirement is for 2.5 years of operation. There are six NASA Standard 50 A h batteries in GRO, 22 cells per battery. These batteries are part of two modular power systems (MPS) made by McDonnel-Douglas Company, each MPS containing 3 batteries.

In July 1990, the first of the second generation Geostationary Operational Environmental Satellites (GOES) will be launched for weather observation purposes. This satellite, GOES-I, is in a GEO orbit with battery parameters of 60% DOD, 7 °C average temperature, and 5 years life requirement. There are two, 12 A h batteries in the spacecraft, 28 cells per battery. The remaining GOES have the same battery parameters. GOES-J is scheduled for November 1991 launch, and GOES-K, May 1992 launch. The launch dates for GOES-L and GOES-M have not been finalized. Ford Aerospace and Communications Company is the prime for GOES.

The last GSFC satellite scheduled for launch in 1990 is the Tracking and Data Relay Satellite (TDRS) in December 1990. TDRS-E will be launched to a GEO orbit for communication purposes. The spacecraft will contain three, 40 A h batteries, 24 cells per battery. Relevant battery parameters include the predicted mission DOD of 50%, mission temperature of 5 °C, and duration of 10 years. The next satellite, TDRS-F is scheduled for December 1992 launch, and TDRS-G, May 1994. The next generation of TDRS will probably utilize other cell designs such as advanced Ni–Cd or Ni–H_2 instead of the existing Ni–Cd design. TRW is the prime for the present generation of TDRS.

The first of the GSFC explorer platform satellites will be launched in August 1991. Extreme Ultraviolet Explorer (EUVE), which is in a LEO regime, will have one MPS which contains three NASA Standard 50 A h batteries. The batteries will be subjected to a predicted mission DOD of 15%, temperature of 15 °C, and life of 3 years.

Upper Atmosphere Research Satellite (UARS) is planned to be launched from STS 50 in December 1991 to study the Earth's ozone layer and other environmental concerns. This spacecraft is in a 56° inclination

LEO. Like EUVE, UARS contains one MPS. The predicted mission DOD is 0 - 24%, temperature, 10 - 16 °C, and mission duration, 3 years.

In addition to these missions, the GSFC has a number of Small Explorer satellites which will be launched from Scout rockets. Battery requirements for these spacecrafts have not yet been finalized.