

REPORT 808-3*

BROADCASTING-SATELLITE SERVICE

Space-segment technology

(Question 2/10 and 11, Study Programme 2K/10 and 11)

(1978-1982-1986-1990)

1. Introduction

1.1 General

The large coverage area possible from a satellite-borne radio transmitter, especially on a satellite in the geostationary orbit, and the supporting technology which is available at present, will make possible the establishment of a broadcasting service to the general public. An earth-station transmitter could direct programme material to the satellite which, in turn, would broadcast this material over a wide area to individual or community receivers.

The technology applicable to the space segment of the broadcasting-satellite service is similar in many respects to the technology applicable to other satellite services. In a few areas, however, the technology needed for the broadcasting-satellite service will differ from that required in other services, and will require specialized research and development. These specialized areas include the generation of high RF power, high efficiency radio frequency generators, effective methods of heat conduction and dissipation from these high power RF sources, and the design and development of spacecraft antennas having low side-lobe levels and asymmetrically shaped beams.

The following sections of this Report are confined to discussions of these aspects of satellite design technology, apart from the last three mentioned above.

2. Primary power (see also Report 673)

2.1 Solar arrays

As a result of the increase in power requirements, attention has been directed to the use of light-weight sun-oriented arrays. Most of the interest is centred around photo-voltaic cells mounted on a flexible substrate which is either folded, or rolled on a drum during launch and transfer orbit [Ray and Winicor, 1966]. Deployment methods take several forms, as indicated in Annex I.

A 1.5 kW roll-out array has been successfully flight tested. Present estimates suggest that a reliable 12 kW (decreasing to 10 kW at the end of five years) roll-out array could be designed. The performance characteristics which might be expected from new developments in light-weight, deployable solar array technology are summarized in Annex I.

The ratio of primary power capability to the mass of broadcasting satellites in the geostationary orbit is dependent to some extent upon the attitude stabilization utilized (spin stabilized or 3-axis stabilized). A spin stabilized spacecraft in general will require more mass than a 3-axis stabilized spacecraft to provide equal prime power. Figure 1 shows the beginning of life; prime power and in-orbit mass for several representative spacecraft. The ratio of "beginning-of-life" to "end-of-life" power for a lifetime of 7 years is of the order of 1.3 to 1. The figure also indicates the approximate date at which the particular design was "frozen". The higher ratio of prime power capability-to-mass for the CTS and BSE spacecraft compared with the other examples results from the fact that they do not carry multiple transponders and the associated filters.

A solar array does not provide power during passage in the shadow of the Earth or of the Moon. With a geostationary satellite there is one Earth solar eclipse each day, but only within the periods of approximately 27 February to 12 April and 1 September to 15 October. Near the centre of these periods, the eclipse lasts about seventy minutes about midnight at the satellite longitude; the duration is less towards the beginning and end of the periods (see Fig. 2). In the case of longer eclipses, sufficient warm-up time must be allowed after the end of the eclipse. In the past, about half an hour has been required.

* This Report should be brought to the attention of Study Group 4.

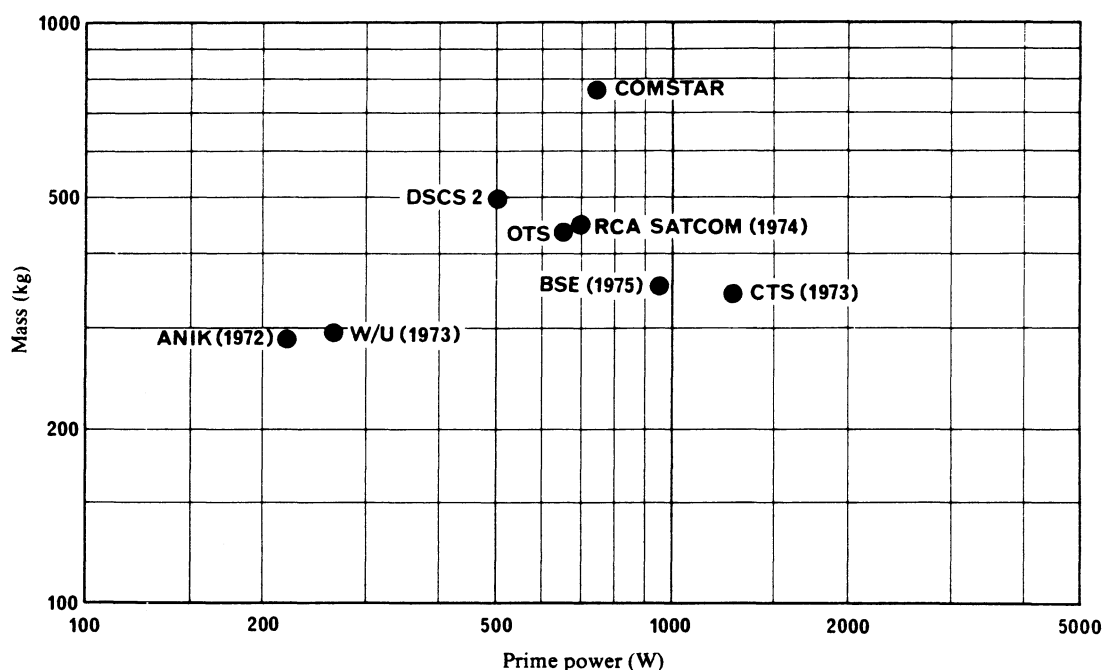


FIGURE 1 — Relationships between in-orbit mass and prime power at beginning of life

COMSTAR (COMSAT General + AT&T satellite)
 CTS (Communications Technology Satellite)
 BSE (Japanese experimental broadcasting satellite)
 W/U (Western Union WESTAR)
 ANIK (Canadian communications satellite)
 DSCS (Defense Satellite Communications System)
 OTS (Orbiting Test Satellite)
 RCA SATCOM (RCA Americom satellite)

Note. — Dates in parentheses indicate approximate date at which the design was finalized.

Eclipses due to Moon shadow are not as regular in terms of times of occurrence, duration, and depth as Earth solar eclipses. The number of Moon solar eclipse occurrences per orbital location per year ranges from zero to four with an average of two per year; eclipses can occur twice within a twenty-four hour period. The duration of eclipses ranges from a few minutes to over two hours with an average duration of about forty minutes. Special problems in connection with battery recharging and spacecraft thermal reliability could arise when Moon solar eclipses of long duration and appreciable depth occur during the same period as Earth solar eclipses. It is possible to predict the characteristics of Moon shadow events with reasonable accuracy. Table I gives a prediction for the period 1981 to 1990 for orbital position 110° longitude. Because of the irregular nature of the Earth and Moon orbits, recurrence of similar Moon solar eclipses occurs at a minimum of one Saros cycle (approximately 18 years) and can be as long as three Saros cycles [Ehara, 1979; CCIR, 1978-82a; Siocos, 1981]. Table II gives the timetable of Moon solar eclipse occurrences for 19° W for the 18-year period, 1983-2000, while Fig. 3 provides information on their distribution of occurrence in terms of time of day and duration [CCIR, 1982-86a].

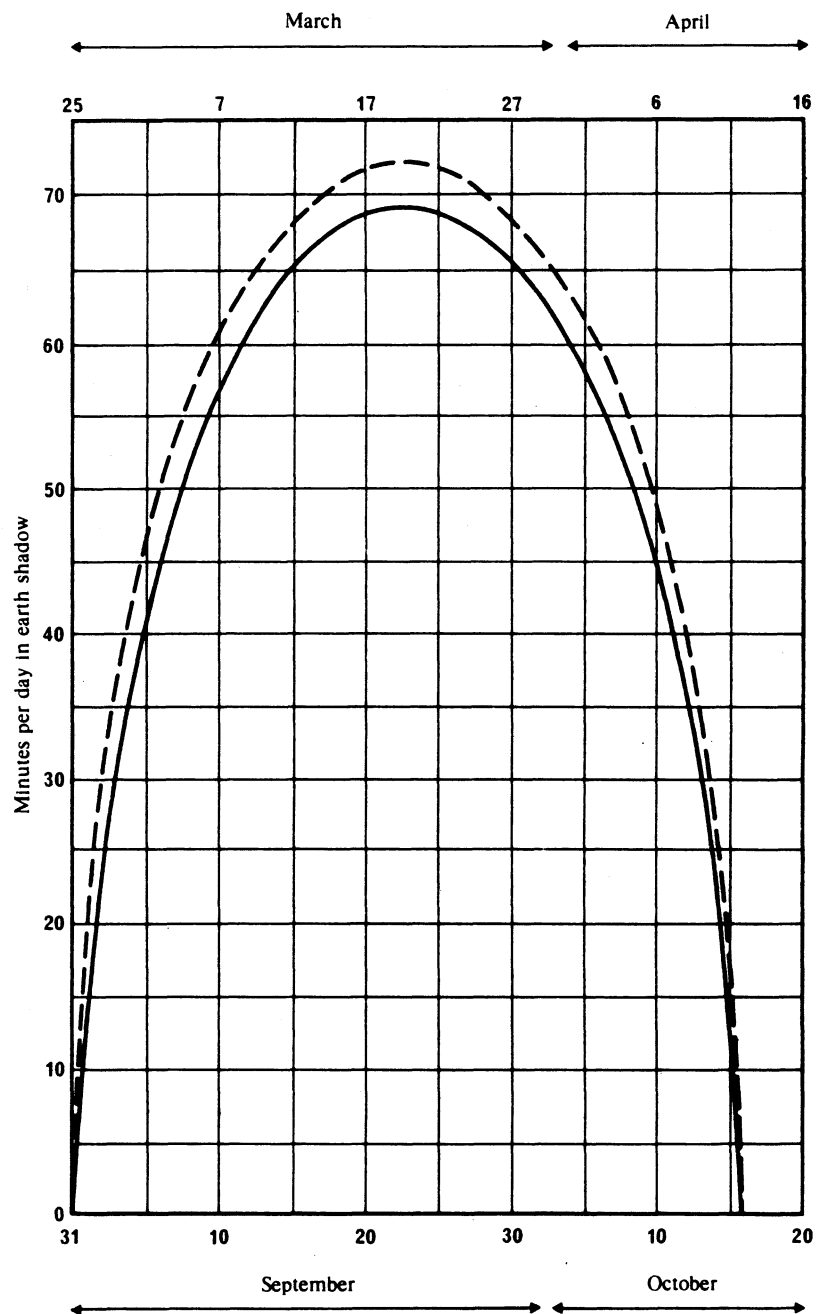
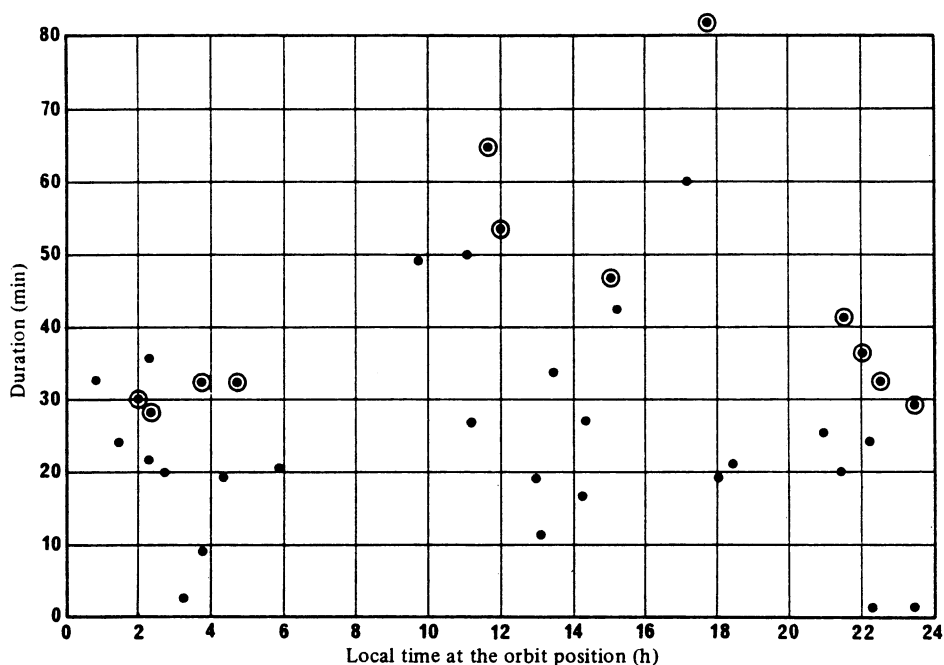


FIGURE 2 — Shadow time during equinoctial periods in the synchronous orbit

— Full eclipse
 - - - Partial eclipse

FIGURE 3 – *Distribution of Moon solar eclipses (19° W)*

- 0-50% shadowing
- ⊙ 50-100% shadowing

TABLE I – *Predicted Moon solar eclipses at geostationary-satellite orbit.
Position: 110° E longitude*

Date	Entrance time (UT)	Duration (min)	Shadowing (%)
1981 January 6	0252	56	85
February 5	0832	102	86
July 30	1924	30	39
December 26	0134	66	96
1982 January 24	1926	32	35
1983 January 13	1926	22	11
January 14	1330	38	61
July 10	1524	14	9
November 5	0802	140	62
1984 May 1	0516	44	40
1985 April 20	0450	20	4
October 14	1250	38	69
1986 April 9	1354	34	43
1987 February 28	1054	66	44
March 29	1538	28	59
April 27	1856	26	19
September 23	0448	42	47
1988 August 12	1516	32	69
September 11	0404	44	56
1989 August 1	1622	10	3
August 31	0340	38	30
1990 July 21	1902	28	48