

RECOMMENDATION 670-1

FLEXIBILITY IN THE POSITIONING OF SATELLITES
AS A DESIGN OBJECTIVE

(Question 48/4)

(1990-1992)

The CCIR,

considering

- a) that flexibility in the positioning of satellites can increase the efficiency of the geostationary orbit;
- b) that flexible satellite positioning can, in some circumstances, increase the likelihood of successful frequency coordination;
- c) that repositioning can impact on the design of satellites as regards lifetime and the trade-off between coverage area and performance;
- d) that the repositioning of satellites will impact on earth segment operations and may require large numbers of non-tracking earth stations to be repointed;
- e) that the frequency of the repositioning should be limited so as to minimize disruption to the services being supported;
- f) that changing the order of satellites within a given arc of the geostationary-satellite orbit is likely to be more onerous than changing their spacings by a small amount;
- g) that the feasibility of accepting repositioning rather than some other means will depend upon the character of the affected earth and space stations;
- h) the analyses contained in Annexes 1 and 2,

recommends

1. that satellites for new networks in the fixed-satellite service should be designed to have the flexibility to operate within $\pm 2^\circ$ of their nominal orbital position, or to the extent of their service arc, whichever is less;
2. that the following Notes be regarded as part of this Recommendation.

Note 1 – Administrations are encouraged to develop new satellite technology to permit satellites to operate within $\pm 5^\circ$ of their nominal orbital position, or to the extent of their service arc, whichever is less;

Note 2 – New networks are defined as networks for which the advance publication data is after 1990.

ANNEX 1

Flexibility in the positioning of satellites

1. Introduction

Satellite relocations are technically and operationally feasible and have already been demonstrated on various classes of satellites. However, flexibility of orbit location does present technical and operational difficulties. The potential advantages and the difficulties of satellite re-positioning are discussed in this annex.

Two different forms of relocation have been considered, namely:

- a) a reduction in the existing spacing of satellites in the orbit; and
- b) a complete reappraisal of the sequence of satellites in an orbital arc.

An advantage of a) is that satellites could, if necessary, continue to transmit to tracked earth stations during the relocation process, since the paths of the satellites would not cross. The main disadvantage of this scheme is that it requires several satellites to move. Though scheme b) may require fewer satellites to move, those which did move would likely to be moved further, and would therefore suffer penalties in terms of service outages, fuel burn and change of coverage areas which are unlikely to be operationally acceptable.

2. Orbit efficiency and system considerations

It should be noted that it is not possible to say with certainty which geographical areas would need to be covered at some time in the future from a given part of the orbit. Full advantage could therefore be taken of this means of optimizing the use of the orbit only if networks were designed so that their satellites could be relocated, if necessary, within a service arc after having been put into service. This ability to relocate satellites after they have entered service could also be of great value in allowing room to be found in orbit for new satellites for unforeseen networks. Such relocation may be more cost-effective than alternative technical solutions – such as improved earth-station antennas or new, sophisticated, modulation techniques.

However, it is at present difficult to ascertain the technical feasibility and cost effectiveness of building satellite system networks to achieve substantial orbit position flexibility. Relocating a satellite within its service arc should be acceptable during the paper design phase, whereas during the development and construction phase, orbit changes should be confined to predetermined limits where the technical and cost penalties are reasonable (and acceptable). This can only be determined on an individual basis. At present, a relocation capability of satellites of $\pm 2^\circ$ from the nominal orbital positions appears feasible. Operational systems should not be moved in orbit unless done voluntarily, and any increased interference imposed by the need for accommodating new systems should be guided by the Recommendations of the CCIR.

3. Potential problems associated with satellite re-positioning

3.1 Service arc limitations

It may be necessary for a satellite to be moved from one orbital position to another within its service arc after entry into service in order to permit the access of a new network. The improvement in access to the orbit obtained in this way will be greater if the service arc is long. However, the provision of a long service arc may have a significant effect on the optimum design of a network, particularly satellite spot beam antennas, and it may have some impact on performance.

The service arc of satellites serving areas which are very extensive in longitude would be short because their visible arc is small. A possible way of extending the service arc is the subdivision of the service area between two satellites, well separated in orbit and connected by inter-satellite links. However, such a method would be costly.

It has been observed that multi-purpose satellites may provide services in addition to those of the fixed-satellite service and these other applications may determine the orbital position required. For meteorological services, for example, the concept of visible arc may not be relevant.

3.2 *Earth-station antennas*

A change in satellite location would require adjustment to earth-station antenna pointing direction and (for linear polarization) adjustment of the plane of polarization. However, with small earth-station antennas and with satellites kept on station to within $\pm 0.1^\circ$ East-West and North-South, earth-station antennas may not need to be steered to track the satellite in normal operation. Many small earth stations will not have technical staff permanently assigned to them. An increasing number of networks will be limited to manual antenna tracking and only a limited range of adjustment of the beam pointing direction. Thus, even a small change in satellite position could present severe mechanical and operational problems and might involve visits by technical staff to all earth stations in the network and interruptions to service. Antenna foundations should be designed to allow for worst-case changes in pointing direction as appropriate for each earth station site and service arc.

Changes in earth-station antenna elevation might affect the clear-sky G/T and the severity of propagation degradations. Such effects may be significant in climates where rain is heavy and the angle of elevation at the earth station is low. The up-link and down-link e.i.r.p. margins should be increased where necessary to take account of the possible need to move the satellite. The impact on system margins due to decreased elevation angles can be significant depending on the frequency of operation.

Changes in earth-station antenna elevation, azimuth and e.i.r.p. might invalidate coordination with terrestrial radio stations operating in the same frequency bands. It would, therefore, be desirable to take into account possible future satellite movements in the initial frequency coordination process.

Changes in elevation are accompanied by a change in azimuth also. The change can range from a very small value, for earth stations at high latitudes, to 180° for earth stations on the equator and near the sub-satellite point. From a system point of view, however, it is the elevation angle changes which are the more significant since these will impact on path loss variations, and fade margins required under fading conditions.

3.3 *Earth station repointing*

3.3.1 *General*

The most obvious impact on the earth station network would be the need for changes to the antenna pointing and polarization angle settings. This is only considered a significant problem for antennas which lack tracking capability. Movement of the order of 10° in bands shared with the terrestrial network may cause coordination problems.

3.3.2 *Repointing of very small antennas*

The e.i.r.p. of satellites in the FSS are increasing and soon it may become possible to employ ground receivers with antennas of less than 1 m in diameter. The ease with which people with little or no experience could repoint antennas depends very much on the size and type of antenna used. However, the need for polarization adjustments would present a problem unless circular polarization were used.

3.3.3 *Repointing of 1-2 m antennas*

In the case of medium power satellites, ground receivers with antennas between 1 and 2 m in diameter which have no tracking capabilities are typically used.

With such antennas it would be necessary to change the antenna pointing and polarization orientation for linearly polarized transmissions. Polar mounted antennas greatly simplify the job of moving between different satellite positions and are also being increasingly used in conjunction with automatic repointing and polarization adjustment equipment.