A Handover Modelling for Globe Cover Telecommunications

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Abstract
The use of different satellite systems throughout the world has known a wide expansion, not only by the services it proposes, but by the large scale communication networks as it is possible to communicate in any point around the globe.
Nowadays the increasing importance of the telecommunications systems in the satellite domains relies on the Low Earth Orbit (LEO) satellites.
The aim of this paper is a main main survey of the communications networks with a particular concern of the satellite constellations constitutions and the different interfering factors: the orbit numbers, the satellite numbers in each orbit, the altitude, hence modelling the HANDOVER problems.

Keywords: *handover; cover; satellite systems; networks; modelling; triggering probability*

1 Introduction

The satellite systems based on the Low Earth Orbit (LEO) satellites have a major advantage over the earth (land) networks as far as the globe cover is concerned.
They allow the users to have at their disposal telecommunication services extended over a very large zone and to be able to carry on a communication while moving in regions that are not covered by the land systems such as the GSM. However, these systems are characterized by a very high rate of Handover temptations which can significantly deteriorate their performances.
The orbit altitude is considered as an essential element of the network. The constellations are defined with

1-1 High Earth-Orbit (HEO)

They are elliptic orbits at about 500 km altitude and an apogee at about 50000 km altitude and have a 63° inclination.

1-2 Geostationary orbits (GEO)

The geostationary orbits have a circular orbit of 42164Km radius in a plane in the neighbourhood of the equator and their angular speed is equal to the earth rotation.

1-3 Medium Earth-Orbits (MEO)

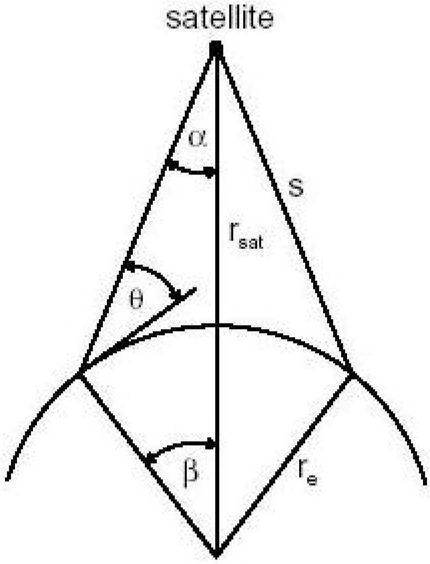
The **Medium Earth-Orbit have an altitude of about**10000Km and a 50°, the satellite revolution period is 6hours with a constellation of 10 to 15 satellites we can assure a global cover of the earth.

1-4 Low earth-orbits (LEO)

They are orbits situated at an altitude comprised between a few hundreds kilometres and 2000 km from the earth surface with a signal propagation delay of the order of 10 to 20ms.

2 Earth cover notion

The cover is the land zone covered by the satellite also called print:



α	*Opening angle*
β	*Cover angle*
θ	*Elevation angle*
H	*Satellite altitude*
re	*Average value of the earth radius*
rsat	*H+re*

We can express the cover angle β and the Opening angle α according to the elevation angle θ and the satellite altitude H:

$\beta = \arccos (r_e \cos\theta / H + r_e) - \theta$…………….. (1)

$\alpha = \arcsin (r_e \cos\theta / H + r_e)$……………….. (2)

The satellite cover zone is: W=2reβ.

The satellite effective print is: $A = 2\pi (re)^2 (1 - \cos\theta)$

We have plotted, on the figure.1, the variation of the angle β and α (cover, opening) versus the altitude H and we notice that the altitude H is proportional to the angle β and inversely proportional toα. A calculation example with θ=30°:

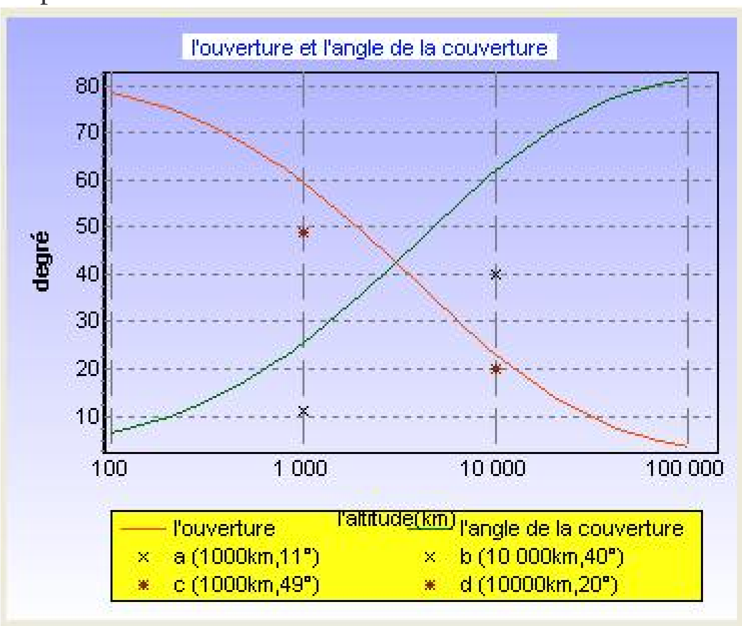


Figure.1: the cover angle β and the Opening angle α according to the elevation angle θ and the satellite altitude H

The figure.2 shows the satellite cover according to the satellite altitude H:

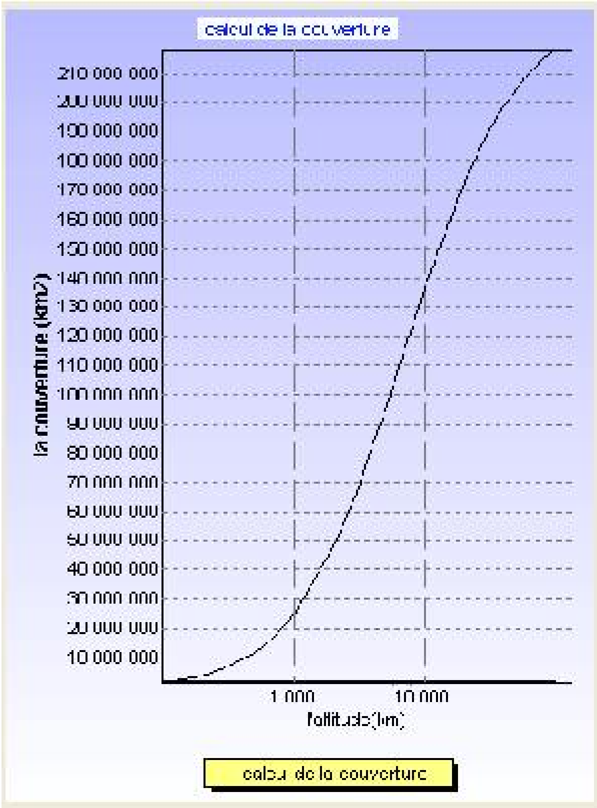


Figure.2: the satellites cover according to the satellite altitude H.

<u>Theoretical case:</u>

	θ(°)	H (Km)	β (°)	α (°)
MEO	30	10000	40	20
LEO	30	1000	11	49

<u>Practical case:</u>

	θ(°)	H (Km)	β (°)	α (°)
MEO	30	10000	40	20
LEO	30	1000	11	48

3 The satellite number necessary for a world cover

The satellite constellation setting in an orbit requires the knowledge of several parameters such as: the satellite number for each constellation.
For this purpose many studies have been carried out on the basis of communications systems modelling.
Two methods can be approached:
- A direct calculation :

In order to cover the whole earth surface in telecommunication systems, the prints must overlap.

For any constellation we consider the largest possible effective print of satellite as the largest hexagon inside the print.
The angle expression is given by:
Tang $\psi=(1/2\sqrt{3}\times\beta)\div(1/2\beta\cos\beta)=\sqrt{3}/\cos\beta$
With $\sigma = 2\psi\ 2/3\ \pi$, the spherical excess of spherical triangles.
We will give the hexagon surface: Ahex=$6r_e^2\ \sigma$.
So in order to cover the whole earth surface, we have got (n) satellites: $n=4\pi r_e^2/$ Ah ex $= \pi/3\psi-\pi$.

$n=\pi/3\psi-\pi$………… (3)
Let us plot on the figure.3 the required number of satellites to assure a global cover as a function of the altitude with different angles θ :

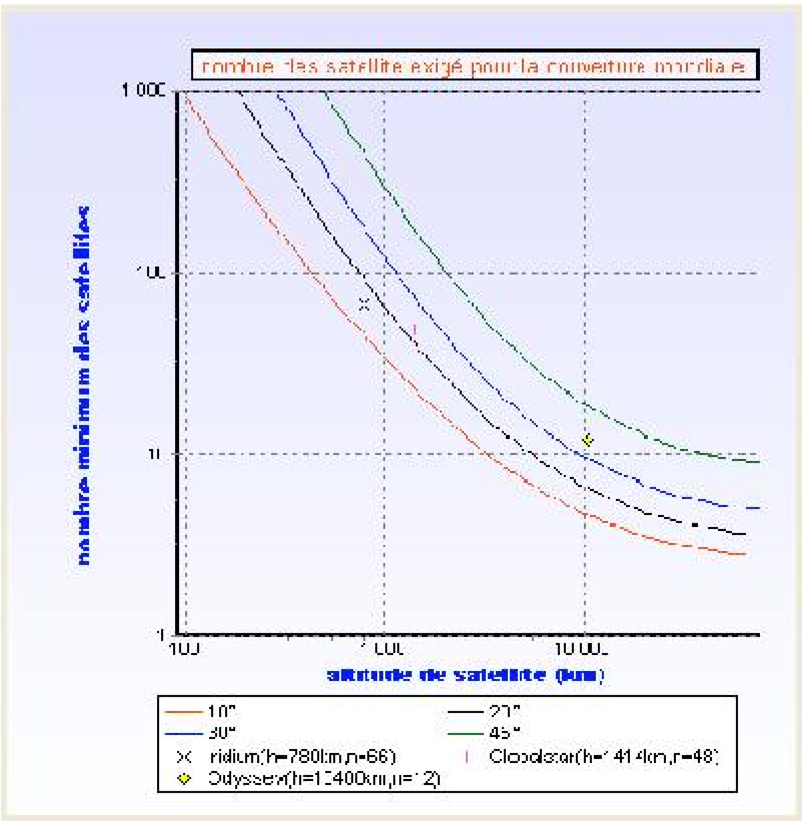


Figure.3: the required number of satellites as a function of the altitude with different angles θ.

- An indirecte calculation :
In this method, to calculate the satellites number that assures the largest earth print, there are two intervening elements:
-The necessary orbit number (m).
-The satellite number for each orbit (k).

With : **n=m.k**………………… .(4)

4 The necessary orbit number required for a world cover

In the case of mobile satellites the satellite orbit number must be determined with two conditions:

-The cover of a satellite under the equator.

- At least two satellites in each orbit.

We may then give the **orbit number for a world cover:**

m=2 π/3β…………………. (5)

We show on figure.4 the necessary orbit number required for a world cover as a function of the altitude with different θ angle:

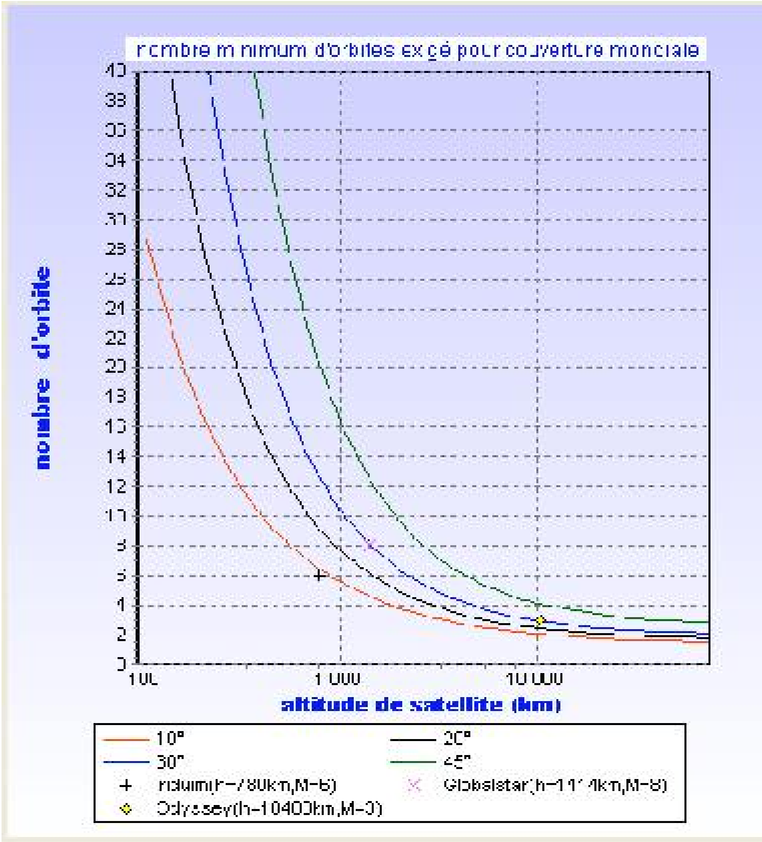


Figure.4: the orbit number required for a world cover as a function of the altitude with different θ angle.

5 The satellite number for each orbit

In each orbit concerning the polar constellations we can give a more realistic estimation of a satellite number (k) in order to have a world cover:

K=2 π/ $\sqrt{3\beta}$ ……………….. (6)

The figure.5 shows the variations of the satellite number according to the altitude H (km) for different elevation angles for polar systems.

In order to improve the service quality of a telecommunications systems, we must assume a satellite constellation. This enables us to strongly reduce the signal powers and the signal propagation times.

Hence for GEO systems, three satellites are sufficient enough to realize a global earth covers, but satellite LEO systems require dozens of satellites.

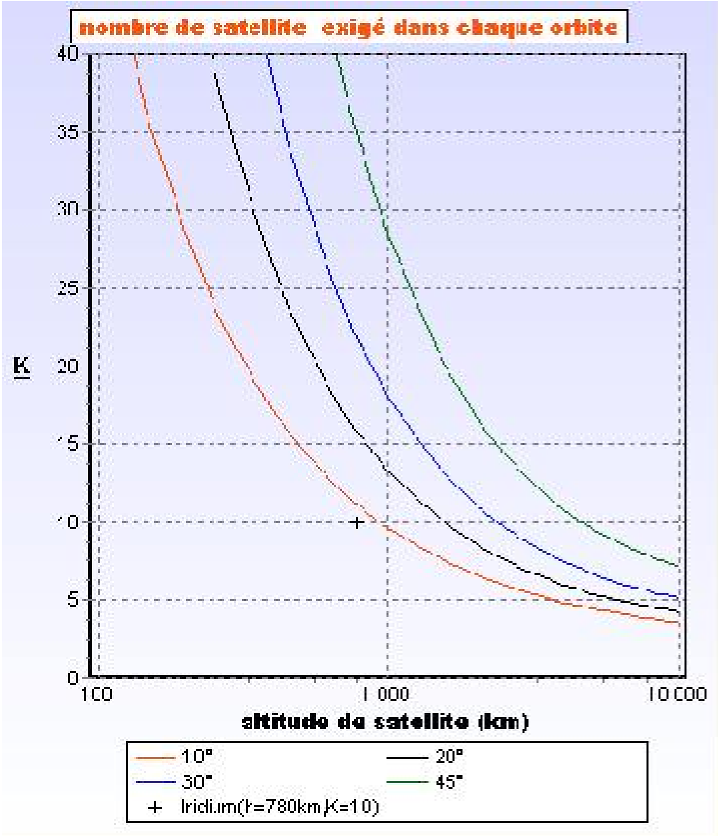


Figure.5: the variations of the satellite number according to the altitude H (km) for different elevation angles for polar systems.

6 The Handover

Among the main problems met in the telecommunications is the communication switch from a satellite to another. This occurs when the first satellite can't cover the user as he enters in the next satellite zone [6,7].

This technical operation consisting in a communication exchange from a satellite to another is called the Handover.

Up to now, many surveys about the Handover have been carried out to improve this technical operation. The purpose is to improve the technology in order to better manage the Handover by eliminating the telecommunication interruption risks while crossing from a satellite zone to another.

The Handover triggering probability in a source cell for any communication is given by:

$$P_{h1} = 1 - e^{-\lambda}/\lambda \quad \text{.................................} (7)$$

The Handover triggering probability in a transit cell for any communication is given by:

$$P_{h2} = e^{-\lambda} \quad \text{.............................} (8)$$

Where λ **is the** movement factor:

$$\lambda = 2\, R_{cell}/V_{orb}\, .\, T_m \quad \text{................} (9)$$

R_{cell} **:** hexagon half circle.

T_m : call duration.

V_{orb} : the satellite speed in an orbit.

$$V_{orb} = \sqrt{\mu \div R + h} \quad \text{..........} (10)$$

μ : 3.986 10^{14} $m^3 s^{-2}$ gravitation factor.

The average number of Handover triggering is:

K= $P_{h1}/1 - P_{h1}$………………….. (11)

The variations of the Handover triggering average number as a function of the Handover triggering probability is shown on the figure.6.

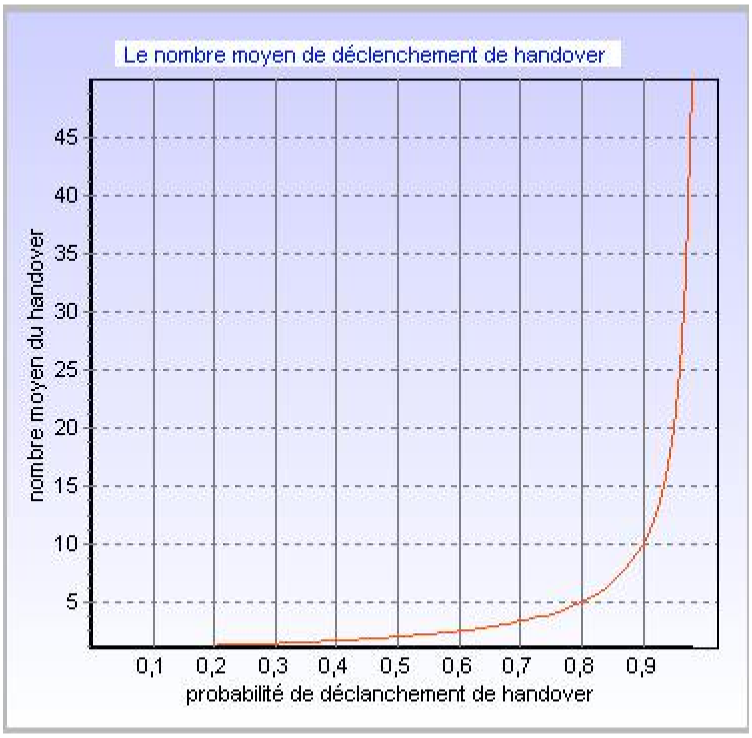


Figure.6: variations of the Handover triggering average number as a function of the Handover triggering probability

7 CONCLUSION

In order not to lose the information i.e to make sure to maintain the communication uninterrupted between two satellite zones, the Handover triggering average number must be comprised between two values: K superior and Kinferior.

The results shown on the figures (1-6) were obtained by software elaborated in our research laboratory; however the perspectives of future work is to develop the software to better handle the Handover triggering average number and reduce the telecommunication interruption risks and this to provide a better communication quality.

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