EVOLUTION OF THE SIRIO IN-ORBIT STRATEGY

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ABSTRACT

This paper deals with the SIRIO in-orbit control and describes the experience gained in maneuvering the satellite during the nominal operational phase and during its extension.

Some considerations on the actual station-keeping strategy are made and an up-to-date report of the orbital maneuvers executed from December 1978 is presented. The on-board fuel budget is then given and commented.

Finally, the results achieved after more than two years of SIRIO maneuver system performance analyses are outlined.

1. Actual station-keeping strategy.

In ref.(1), the maneuvers performed to control the SIRIO flight during its first year of operations have been presented; it can be seen that maneuvers were performed to correct the S/C orbit when certain orbital elements moved close to the imposed limits, and no attempt was made to optimize the station-keeping maneuvers, to couple the North-South and West-East corrections, or to maximize the time spent by the satellite in its box, owing to the following reasons :

- at handover, the orbit inclination and node were such as to remain at least eight months within the imposed limits;
- the drift rate at that moment was such as to move the S/C out of the box in three months;
- improved acquaintance with APS performances was necessary.

In addition, longer experimentation of the attitude and orbit determination systems was desirable in order to be able to refine the methods used and to set up standard operative procedures to guarantee the full reliability and repeatability of the obtained results.

At the end of 1978 it was decided to perform, for the first time, the North/South-East/West combined maneuver; the mechanism of this maneuver is based on the following considerations.

To change the orbital plane inclination, when the S/C

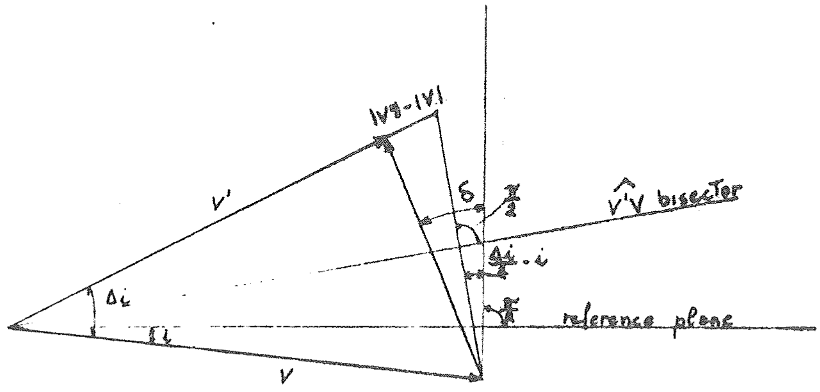
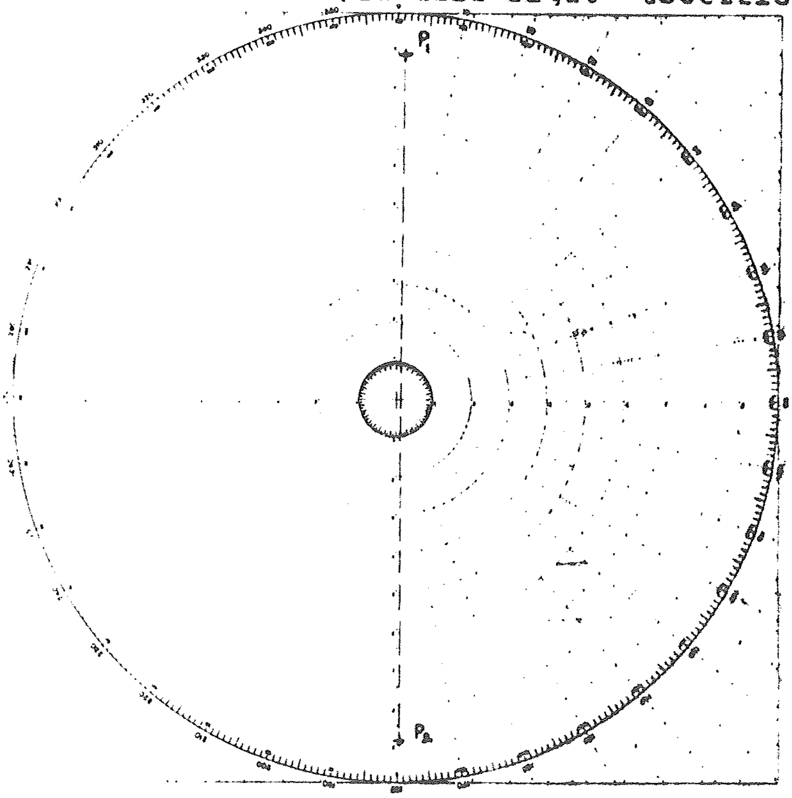


Fig. 4

It should be remembered that the above formula is applicable when ΔV and V vectors lie on the plane which is orthogonal to the reference plane. In Appendix B, a general case is investigated.

For geosynchronous orbits, to maximize the time during which the orbit inclination can be kept below a given value, the North/South maneuver is performed by rotating the node line by approximately a 180 degrees angle. The S/C spin axis alignment, to perform the combined North-South/East-West maneuver, is thus close to the target orbit normal. A method for the quick determination of this attitude is shown in Fig. 5, which represents the projection of the North Pole area of the celestial sphere in a linear polar diagram. The use of such a projection does not imply relevant errors in this case because of the very small S/C spin-axis colatitude angle. The line which connects the two points P1 and P2 (the initial and final orbit normal vectors), gives immediately the necessary S/C spin axis right ascension.

Fig. 5



initial and final orbit normals for 31.10.1979 orbital maneuver

2. Maneuvers report

In this section, the more significant parameters of the maneuvers performed to correct the SIRIO orbit during 1979 are presented.

In Tab. 1, the attitude trim maneuver parameters are shown. It must be noted that the imposed limits on the S/C attitude for the SIRIO mission and the tecnique used to maneuver the satellite (see section 1.) have meant that no specific attitude corrections were necessary during this period.

MANEUVER	DATE	IGNIT TIME	SYNC	QUADRANT	JET USED	DURATION	ATTITUDE (deg.)					
							INITIAL		FINAL PREDICTED		FINAL OBSERVED	
	D.M.Y.	H M S				(pulses)	R.A	DEC	RA	DEC	R A	DEC
ATTITUDE TRIM	3 5 1979	9 30 00	SUN	IV	TAA	2	48.0	-89.73	16.7	-89.73	NC	NC
ATTITUDE TRIM	30.10.1979	9.30.00	SUN	I	TAA	3	285.0	-89.92	6.0	-89.78	0.0	-89.78

Tab. 1

In the following table the North-South/East-West maneuver results are listed, while in Fig. 6 the S/C longitude and orbit inclination history are presented.

MANEUVER	DATE	IGNIT TIME	DURATION	Δ SPIN RATE (r.p.m.)		SPIN AXIS PRECESSION	CONVERGENCE PARAMETERS ORBIT INCLINATION AND NODE (deg.)						DRIFT RATE (deg/day E)			THRUST EFFICIENCY CALIB FACTORS	FUEL EXPEND
							INITIAL		FINAL PREDICTED		FINAL OBSERVED						
	D M Y	H M S	(sec)	predicted	observed	(deg.)	INCL	NODE	INCL	NODE	INCL	NODE	INITIAL	FINAL PREDIC	FINAL OBSER		(Kg)
NORTH/SOUTH-EAST/WEST STATION-KEEPING	4. 5.1979	4 17.17	152	-0 27	-0 27	0.0	0 201	91 32	0.184	269.89	0.185	272.08	-0.0167	0.0173	0 0180	0.95	2 312
NORTH/SOUTH-EAST/WEST STATION-KEEPING	31.10.1979	16.38.11	150	-0.19	-0.07	0.03	0.186	98.39	0.179	269.39	0.179	269.97	-0.0180	0.0087	0.0138	0.95	2 044

Tab. 2

For geosynchronous circular orbits, the velocity magnitude can be considered constant. Then

$$dD = -351.3\ (|V'| - |V|)$$

where dD is measured in deg/day East and V and V' in Km/sec.

Appendix B

Let us consider two vectors V and ΔV as shown in Fig.7. If V' is the resultant vector, it is clear that $|V'| - |V|$ depends on the γ angle.

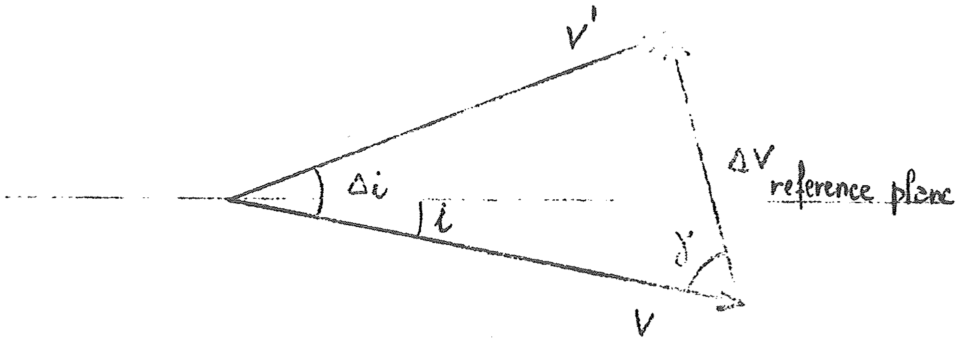


Fig. 7

If α_s and δ_s, r and -i are the right ascension and the declination of the ΔV and V vectors respectively, then:

$$\cos\gamma = \sin i \cdot \sin\delta_s + \cos i \cdot \cos\delta_s \cdot \cos(\alpha_s - r) \qquad (1)$$

If V and ΔV lie on the plane orthogonal to the reference plane, then

$$\alpha_s = r$$

Because of the magnitude of the considered angles the (1) can be written as follows:

$$\cos\gamma = c\,\cos(\alpha_s - r) + i$$

were c is the codeclination of the S/C spin axis.

Let δ be the codeclination of the spin axis causing the desired difference V' - V, in the case of $\alpha_s = r$. It must be noted that this difference remains constant for all the couples c and α_s such that:

$$c = \frac{\delta}{\cos(\alpha_s - r)}$$

References.

(1) N.Celandroni, A. Foni, S. Trumpy : Performance Evaluation of the SIRIO Maneuver System. ''Alta Frequenza'', June 1979.

(2) Theodore E. Sterne : An introduction to celestial Mechanics . London, 1960.

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