SAO Special Report No. 237

BAKER-NUNN PHOTOGRAPHY OF THE INTELSAT 2-F2 APOGEE-MOTOR FIRING

Staff of the Smithsonian Astrophysical Observatory

Smithsonian Institution
Astrophysical Observatory
Cambridge, Massachusetts, 02138

ABSTRACT

The insertion of Intelsat 2-F2 into synchronous orbit was simultaneously photographed by three Baker-Nunn cameras, confirming apogee-motor firing.

A triangulation was performed that located the position of the satellite at the time of the firing.

BAKER-NUNN PHOTOGRAPHY OF THE INTELSAT 2-F2 APOGEE-MOTOR FIRING

by

Staff of the Smithsonian Astrophysical Observatory

1. INTRODUCTION

The Smithsonian Astrophysical Observatory (SAO) was requested by the NASA Goddard Space Flight Center to confirm optically the firing of the Intelsat 2-F2 fourth-stage apogee motor. The satellite was launched from Cape Kennedy on January 11, 1967, at $10^h55^m00^s.6$ UT and designated 6700101. The three-stage thrust-augmented Delta launch vehicle placed the payload and fourth-stage rocket into an elliptical orbit of $26^\circ.7$ inclination with an apogee of 36491 km and a perigee of 295 km. This "transfer" orbit had a period of 647 min so that apogee was reached twice each day, alternately over the mid-Atlantic and the mid-Pacific.

At spacecraft seventh apogee, at $10^h11^m33^s$ UT on January 14, 1967, the Aerojet General Mercury 1 solid-fuel apogee motor was fired for 16 sec, which successfully placed the Intelsat 2-F2 into a synchronous orbit of inclination near zero degrees.

2. PREDICTIONS

For predicting the seventh apogee burn for 6700101, the latest post-launch elements, from Goddard Space Flight Center, together with the scheduled burn time were used as input to the SCROGE (Fardon and Mills 6400 version) prediction program. Visibility of the seventh apogee burn was predicted at five stations: Organ Pass, New Mexico; Tokyo, Japan; Maui, Hawaii; Edwards, California; and Johnston Island. Satellite-position predictions in the standard 666 format were sent to the five stations for the planned ignition time.

This work was supported in part by Grant NsG 87-60 from the National Aeronautics and Space Administration.

3. OBSERVATIONS

Of the five Baker-Nunn cameras with predicted visibilities, three successfully photographed the event: station 5-Tokyo Astronomical Observatory, at Mitaka (near Tokyo), Japan (Figure 1); station 13-Edwards, California (Figure 2); and station 17-Johnston Island (mid-Pacific) (Figure 3). Station 5 recorded the rocket cloud on 36 frames of film for 1 min 43 sec. Station 13 recorded the cloud on 39 frames for 5 min 37 sec. Station 17 recorded the cloud on 9 frames for 4 min 55 sec.

4. SATELLITE POSITION DETERMINATION

Computations were based on the following terrestrial coordinates (Veis, 1963):

Station 05	Station 13
x = -3,946.703 km	= -2,450.030 km
y = +3,366.291 km	= -4,624.453 km
z = +3,698.849 km	= +3,635.072 km

The coordinates of station 05 are those given in the Smithsonian Institution Standard Earth (Köhnlein, 1966). The time for which the satellite position was determined was during the satellite apogee-motor firing, and was derived by the synthetic simultaneous observation method:

January 14, 1967, $10^h\ 11^m 42.997^s$ (UT 1)
(MJD 39504.4248032).

The satellite position in the adopted coordinate system is

x_s = -42,878.674 km

y_s = - 5,047.495

z_s = 39.374

Distance from geocenter = 43,174.755 km

Range from station 05 = 39,998.524 km

Range from station 13 = 40,590.433 km.

The coplanarity of vectors between stations, and from the stations to the satellite checks to 5×10^{-8}.

5. REFERENCES

KÖHNLEIN, W. J.

1966. Corrections to station coordinates and to nonzonal harmonics from Baker-Nunn observations. In Space Research VII, North-Holland Publ. Co., Amsterdam, in press.

VEIS, G.

1963. Precise aspects of terrestrial and celestial reference frames Smithsonian Astrophys. Obs. Spec. Rept. No. 123, 16 pp.

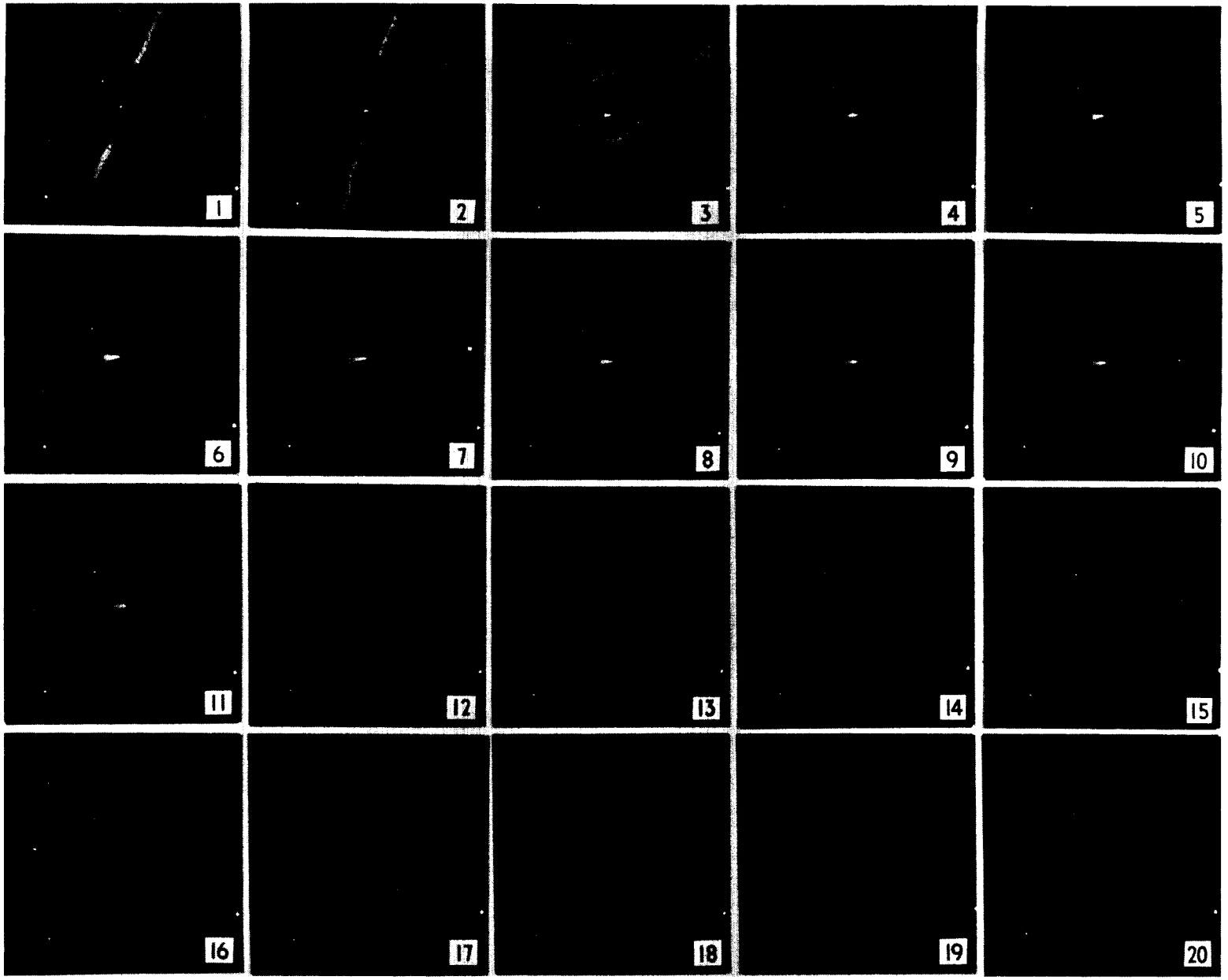
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Figure 1. Intelsat 2-F2 apogee-motor firing. Baker-Nunn photographs taken at Tokyo Astronomical Observatory, Mitaka, Japan.

Frame No.	Time (UT)	Remarks
1	$10^h11^m35^s$	2 sec after ignition
2	10 11 37	
3	10 11 39	
4	10 11 41	
5	10 11 43	
6	10 11 45	
7	10 11 47	
8	10 11 49	Engine burnout
9	10 11 51	
10	10 11 53	
11	10 11 55	
12	10 11 57	
13	10 11 59	
14	10 12 01	
15	10 12 03	
16	10 12 05	
17	10 12 07	
18	10 12 09	
19	10 12 11	
20	10 12 13	

All exposures are 0.4 sec. Times given are center exposure times.

Cloud position in Frame No. 1:

Time (WWV emitted) $10^h11^m34^s.997 \pm 0^s.002$

(1950.0) $\alpha = 06^h32^m13^s.759 \pm 0^s.113$

$\delta = -05° 14' 24''.20 \pm 2''.00.$

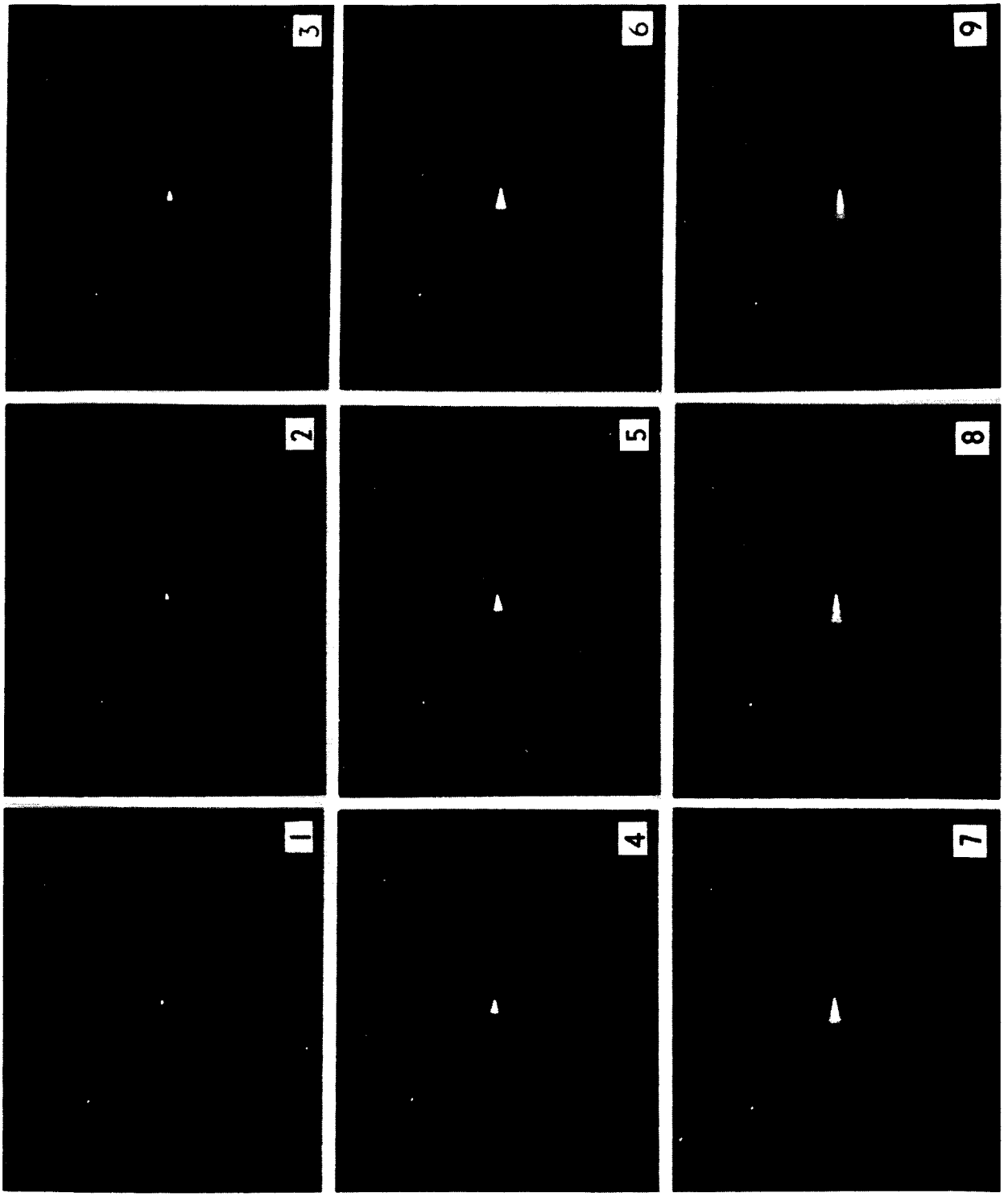
3
6
9
2
5
8
1
4
7

Figure 2. Intelsat 2-F2 apogee-motor firing. Baker-Nunn photographs taken at Edwards, California.

Frame No.	Time (UT)	Remarks
1	$10^h11^m35^s$	2 sec after ignition
2	10 11 37	
3	10 11 39	
4	10 11 41	
5	10 11 43	
6	10 11 45	
7	10 11 47	
8	10 11 49	Engine burnout
9	10 11 51	

All exposures are 0.4 sec.

Cloud position in Frame No. 1:

Time (WWV emitted) $10^h11^m34^s.998 \pm 0^s.002$

(1950.0) $\alpha = 05^h45^m52^s.814 \pm 0^s.133$

$\delta = -05° 05' 40''.63 \pm 2''.00.$

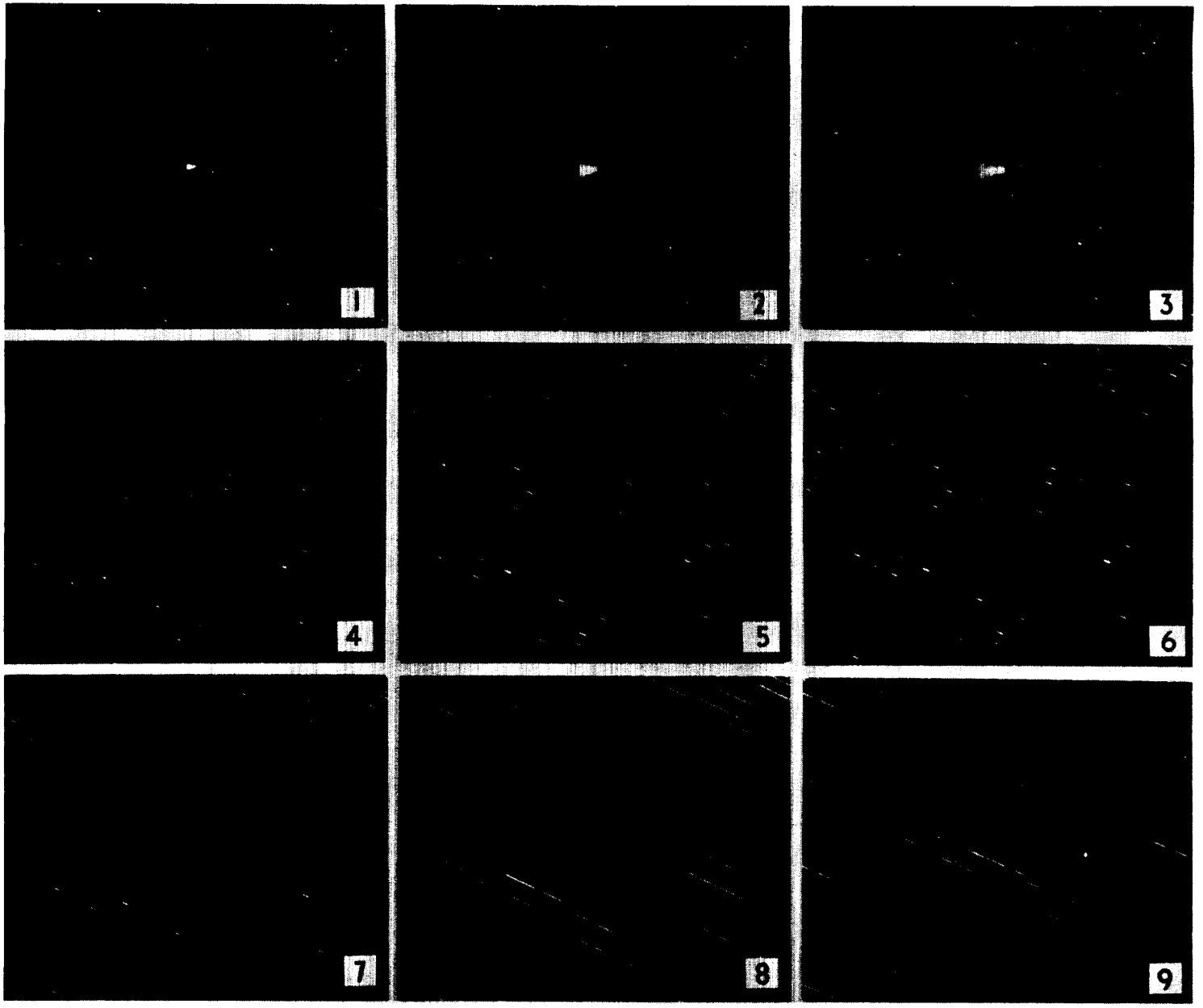
1
2
3
4
5
6
7
8
9

Figure 3. Intelsat 2-F2 apogee-motor firing. Baker-Nunn photograph taken at Johnston Island.

Frame No.	Time (UT)	Remarks
1	$10^h11^m42^s$	9 sec after ignition; 3.2-sec exposure
2	10 11 58	9 sec after engine burnout; 3.2-sec exposure
3	10 12 14	3.2-sec exposure
4	10 12 30	3.2-sec exposure
5	~10 12 49	~6-sec exposure
6	10 13 09	~6-sec exposure
7	~10 13 25	~6-sec exposure
8	~10 15 02	~90-sec exposure
9	~10 16 37	~90-sec exposure

Encircled object to left of cloud in Frames Nos. 1-7 is an unidentified object.

Cloud position in Frames No. 1:

Time January 14, 1967 $10^h11^m41^s.891 \pm 0^s.002$

(1950.0) $\alpha = 06^h07^m54^s.265 \pm 0^s.267$

$\delta = -02^\circ 45' 20''.27 \pm 4''.00.$