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APOLLO APPLICATIONS PROGRAM TWO-AND-ONE-HALF-STAGES-TO-ORBIT TRACKING ANALYSIS

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TWO-AND-ONE-HALF-STAGES-TO-ORBIT TRACKING ANALYSIS

By Melvin R. Rother and R. Leroy McHenry
Guidance and Performance Branch

August 28, 1969

MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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APOLLO APPLICATIONS PROGRAM

TWO-AND-ONE-HALF-STAGES-TO-ORBIT TRACKING ANALYSIS

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1.0 SUMMARY

The results of a tracking study of the two-and-one-half-stages-to-orbit (THSO) maneuver are documented in this note. From the results, it can be seen that adequate tracking coverage (continous coverage from lift-off to insertion plus 3 min) can be acheived for orbits with inclinations of 33°, 35°, and 37° for a northerly launch by use of one ship in conjunction with the Manned Space Flight Network (MSFN) ground stations in the vicinity of the Cape. These stations include Merritt Island, Grand Bahama, Bermuda, and Grand Turk. For the study, it was assumed that Antigua will not be available.

Coverage is marginal for orbits with inclinations of 50° for a northerly launch and 33°, 35°, 37°, and 50° for southerly launches in that the maximum continous coverage extends only approximately 2 minutes past insertion.

2.0 INTRODUCTION

The study presented in this note was requested in reference 1 and is designed to show whether or not the MSFN stations (excluding Antigua) and one ship are adequate to track the THSO maneuver planned for the Apollo Applications Program (AAP). The THSO trajectory used in this study is the nominal case described in reference 2 and results in an 81- by 120-n. mi. orbit. The initial request was for data for orbits with inclinations of 33°, 35°, and 37° for both northerly and southerly launches. However, with the advent of the dry workshop, 50° inclination orbits were also included in the study.

The basic communication constraint during the launch phase is that visibility of the vehicle above a 5° elevation angle is required continuously throughout the powered flight and for a sufficient period

immediatley following insertion for orbit determination and the making of a GO/NO-GO decision. The postinsertion period is nominally defined as 3 minutes. To satisfy the basic communication requirement, it is assumed that it is sufficient that one station view the vehicle above a 5° elevation at any given time.

3.0 DISCUSSION

To generate the results of this study, the following assumptions and constraints were made.

a. Only one tracking ship will be available for the launch to insertion phase of the AAP missions.

b. All of the MSFN stations in the vicinity of the Cape will be available except the Antigua station.

c. The tracking ship has an altitude of 0, slant range capability of 23 400 n. mi., and requires a minimum elevation angle of 5°.

d. The nominal orbit is 81 by 120 n. mi.

e. Adequate coverage requires that at least one station view the vehicle above 5° elevation at any time.

For the 33°, 35°, and 37° inclination cases, it was assumed that the ship would be located on the groundtrack of the 35° case for all three cases for both the northerly and southerly launches. For the 50° inclination orbits that result from both northerly and southerly launches, it was assumed that the ship is on the groundtracks of the respective orbits.

The groundtracks and coverages of the northerly launches are shown in figure 1. In the figure are shown the coverage extended by Bermuda and ships on the groundtracks of the 35° and 50° orbits. Merritt Island, Bermuda, and a ship located at latitude 35.17° N and longitude 44.05° W combine to provide continuous coverage from lift-off to SPS insertion plus 3 minutes for the 33°, 35°, and 37° northerly cases. However, the same stations with the ship at latitude 45.0° N and longitude 53.5° W provide continuous coverage only from lift-off to approximately 2 minutes past SPS cutoff for the 50° inclination orbit.

The same type of data that were shown in figure 1 are presented in figure 2 for the southerly launches. Merritt Island, Grand Turk, and a

ship at latitude 15.6° N and longitude 55.4° W provide continuous coverage from lift-off to SPS cutoff plus approximately 2 minutes. The same stations with the ship at latitude 7.25° N and longitude 61.75° W provide coverage for the 50° case from lift-off to SPS cutoff plus approximately 2 minutes.

Range, azimuth, and elevation data for Bermuda and the ships on the 35° and 50° groundtracks for the northerly launches are presented in figures 3, 4, and 5. The same type of date are presented in figures 6, 7, and 8 for the southerly launches.

Note from figure 1 that any inclination orbit between 33° and 50° that results from a northerly launch will have between 2 and 3 minutes of postinsertion coverage. Corresponding orbits that result from a southerly launch will have a maximum of only 2 minutes coverage past insertion as shown in figure 2.

The distance between the ship locations for the 35° orbits for northerly and southerly launches is approximately 1360 n. mi. This distance prevents the consideration of both northerly and southerly launches on the same day if the ship would have to be moved.

4.0 CONCLUSION

Continuous coverage is available by use of the MSFN stations and one ship for lift-off to insertion plus 3 minutes for northerly launches that result in orbits with 33°, 35°, and 37° inclinations. The coverage decreases to insertion plus 2 minutes as the inclination increases to 50°. The maximum coverage for southerly launches into orbits of 33° to 50° inclinations is approximately from lift-off to insertion plus 2 minutes.

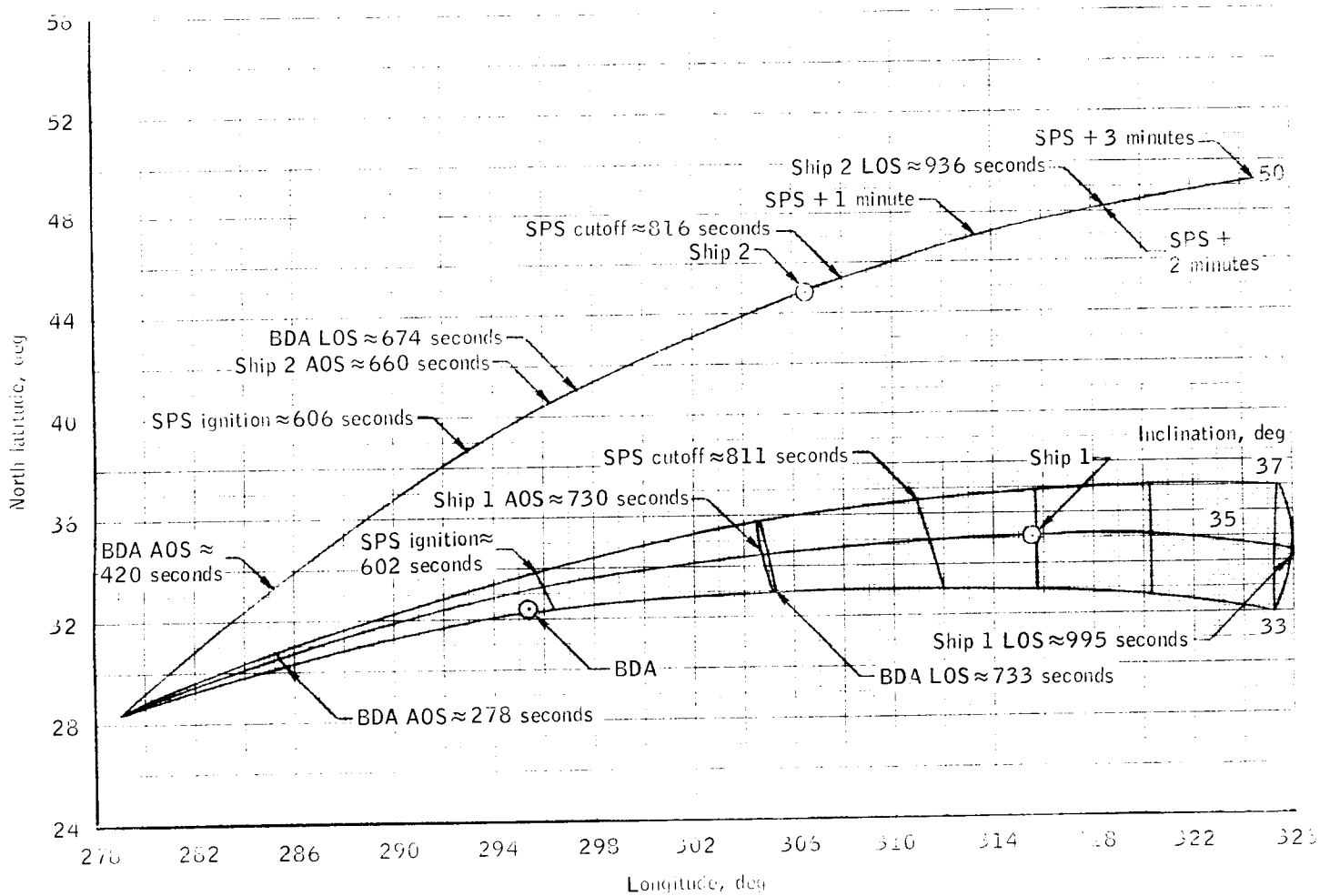


Figure 1.- Tracking coverage for northerly launches of THSO.

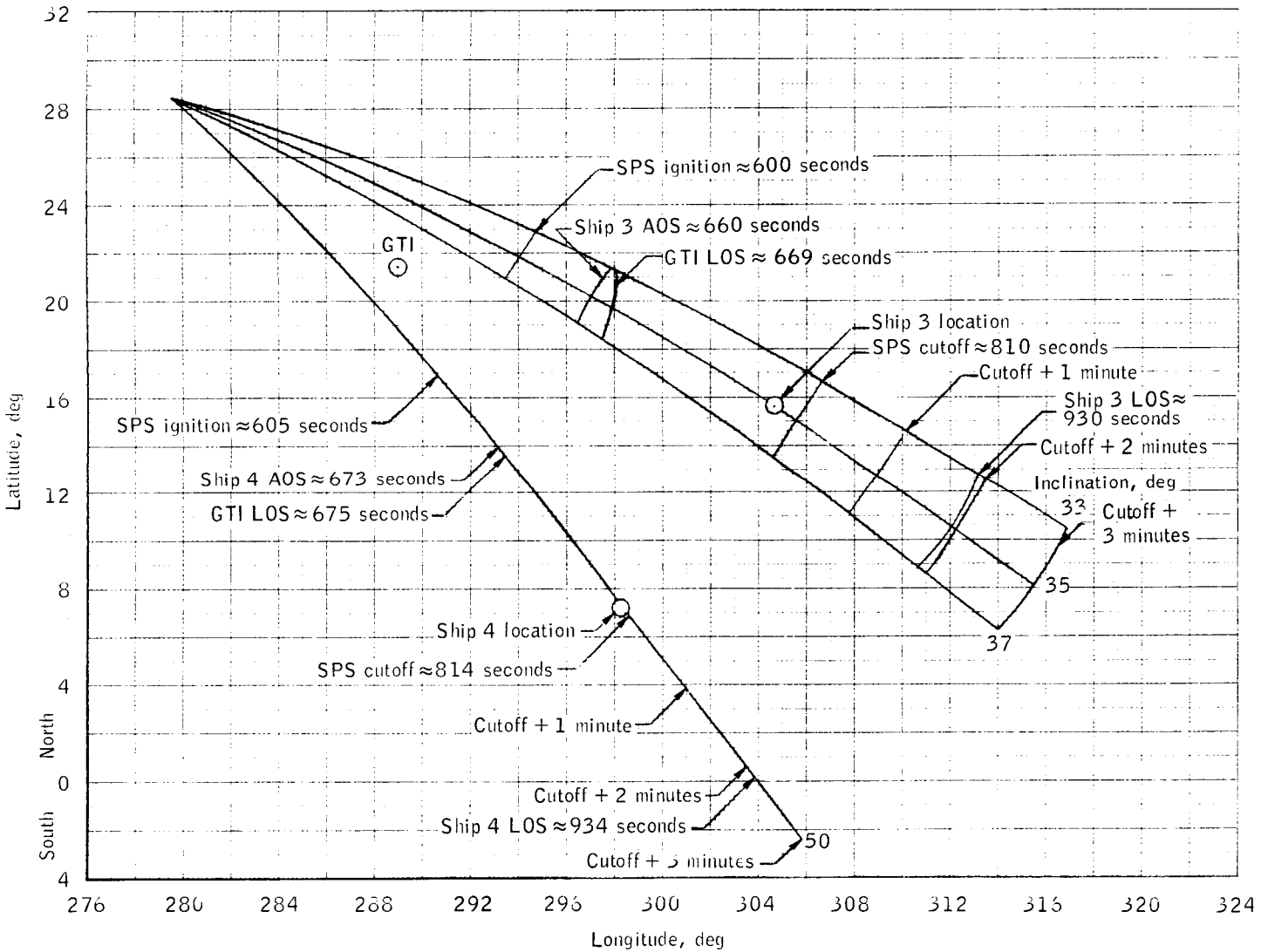
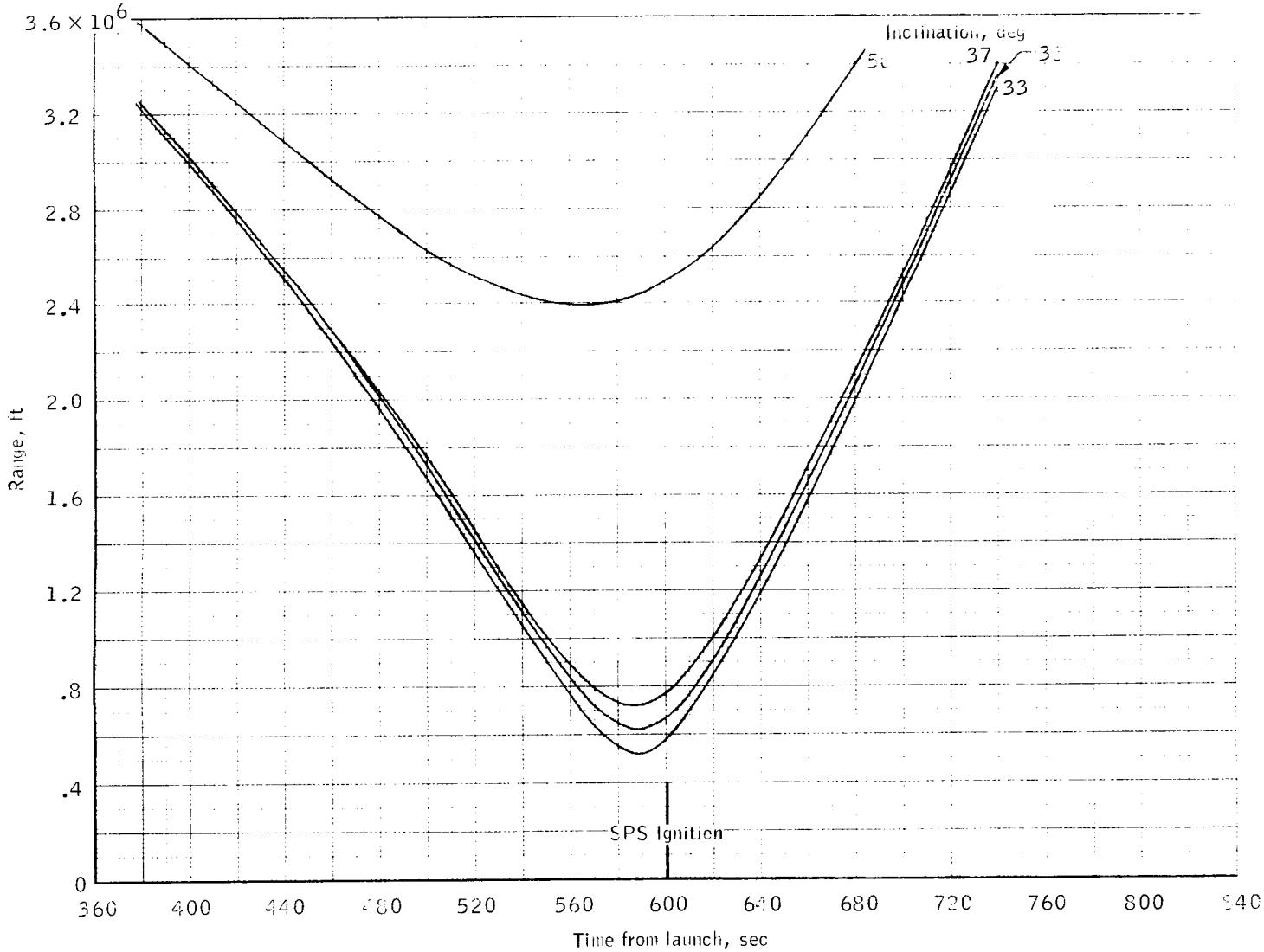
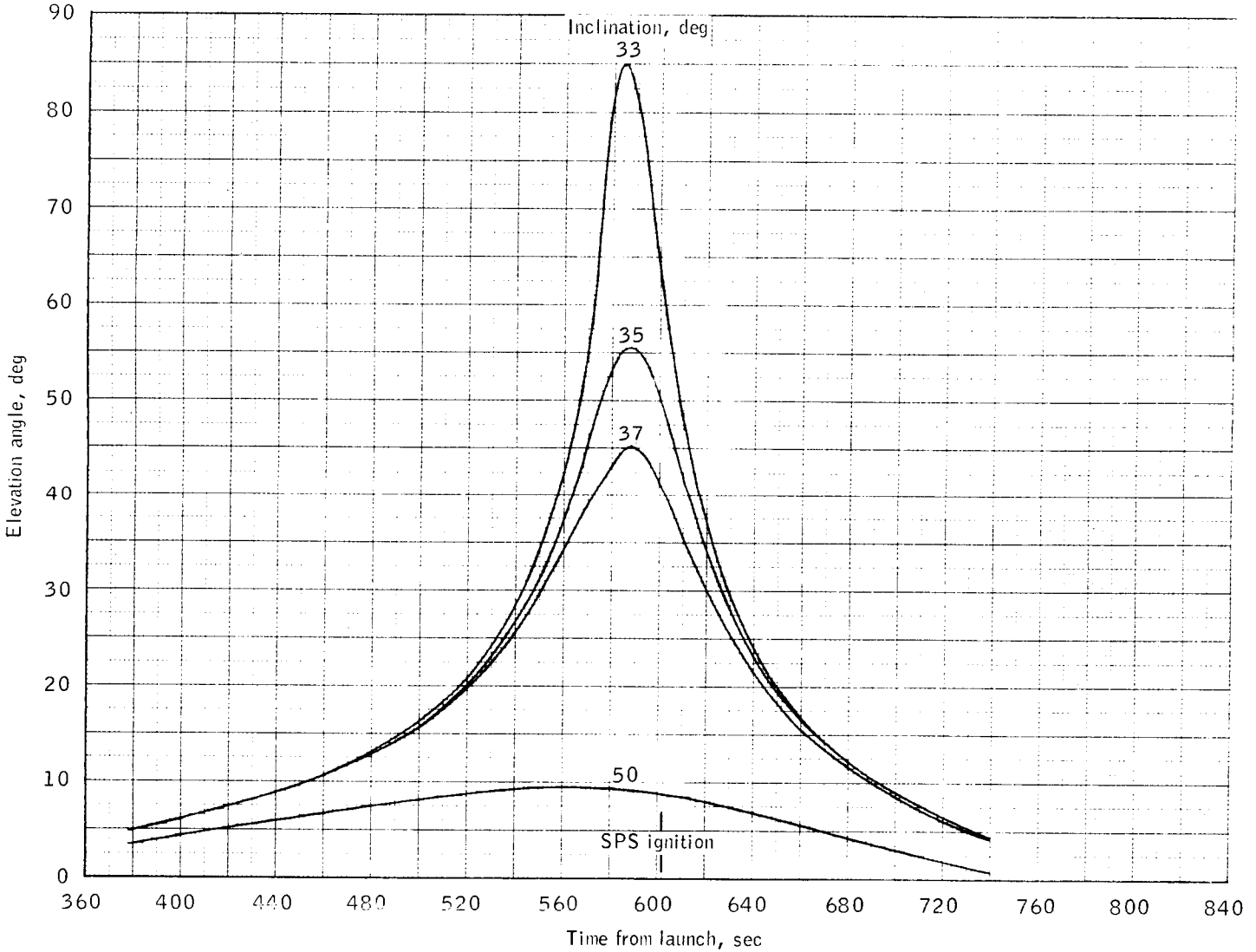


Figure 2.- Tracking coverage for southerly launches of THSO.



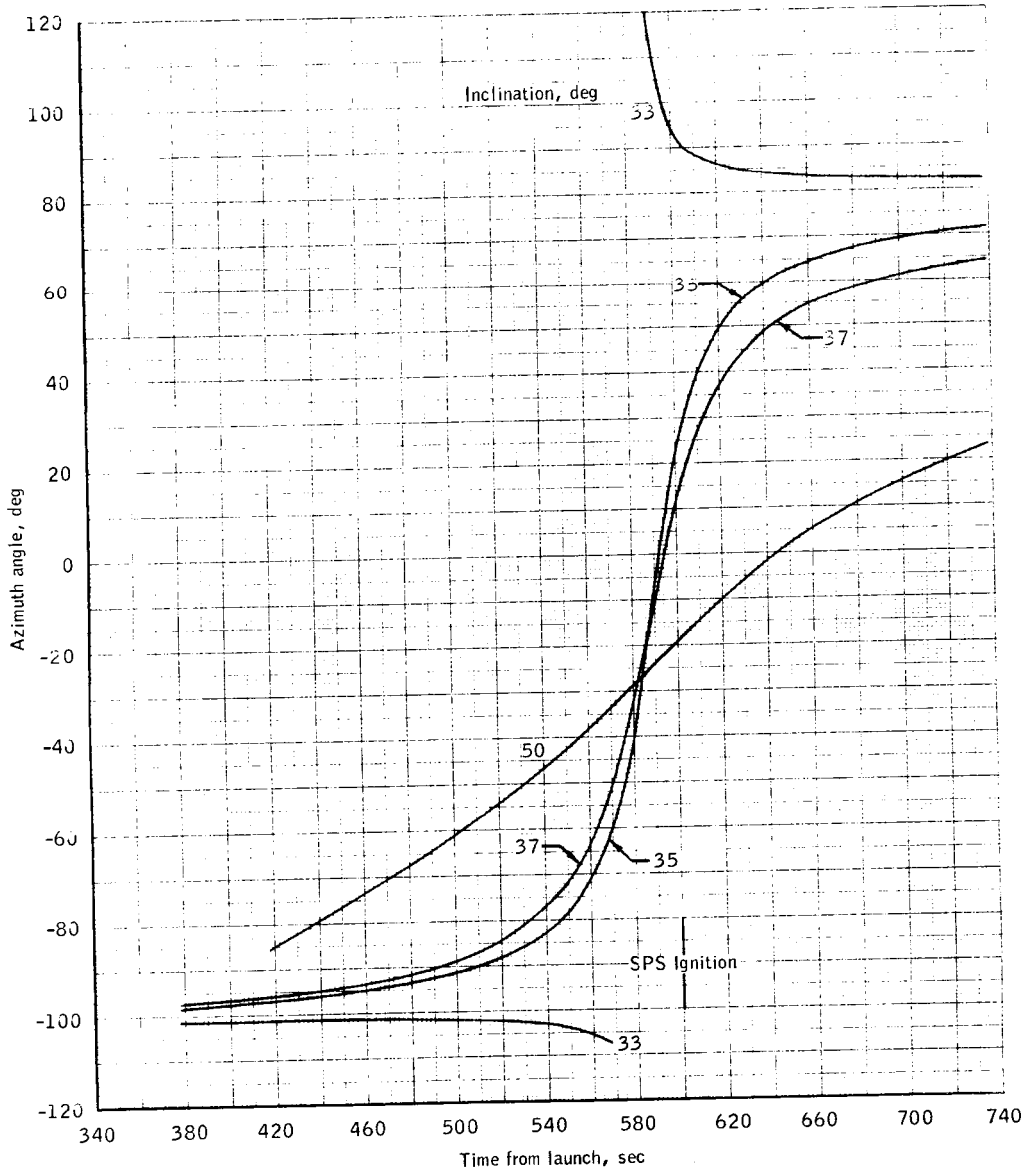
(a) Range.

Figure 3.- Range, elevation angle, and azimuth angle for Bermuda tracking of northerly launch azimuths.



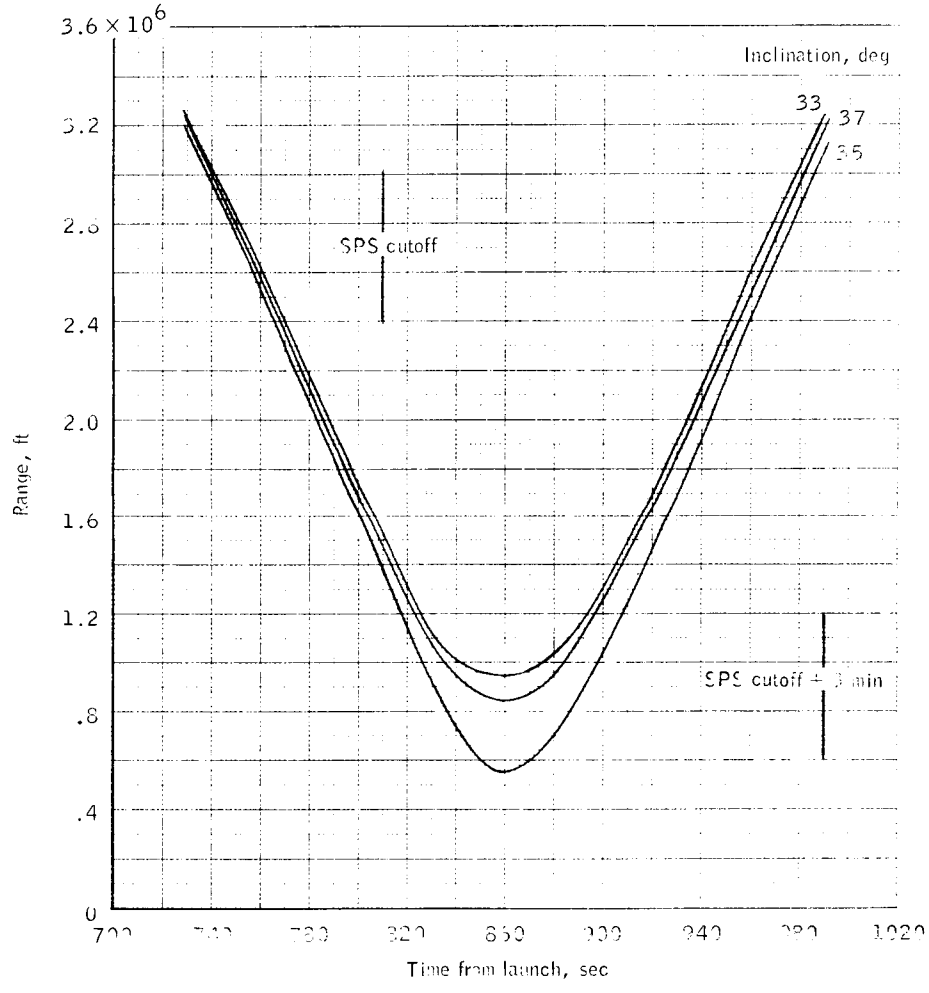
(b) Elevation angle.

Figure 3.- Continued.



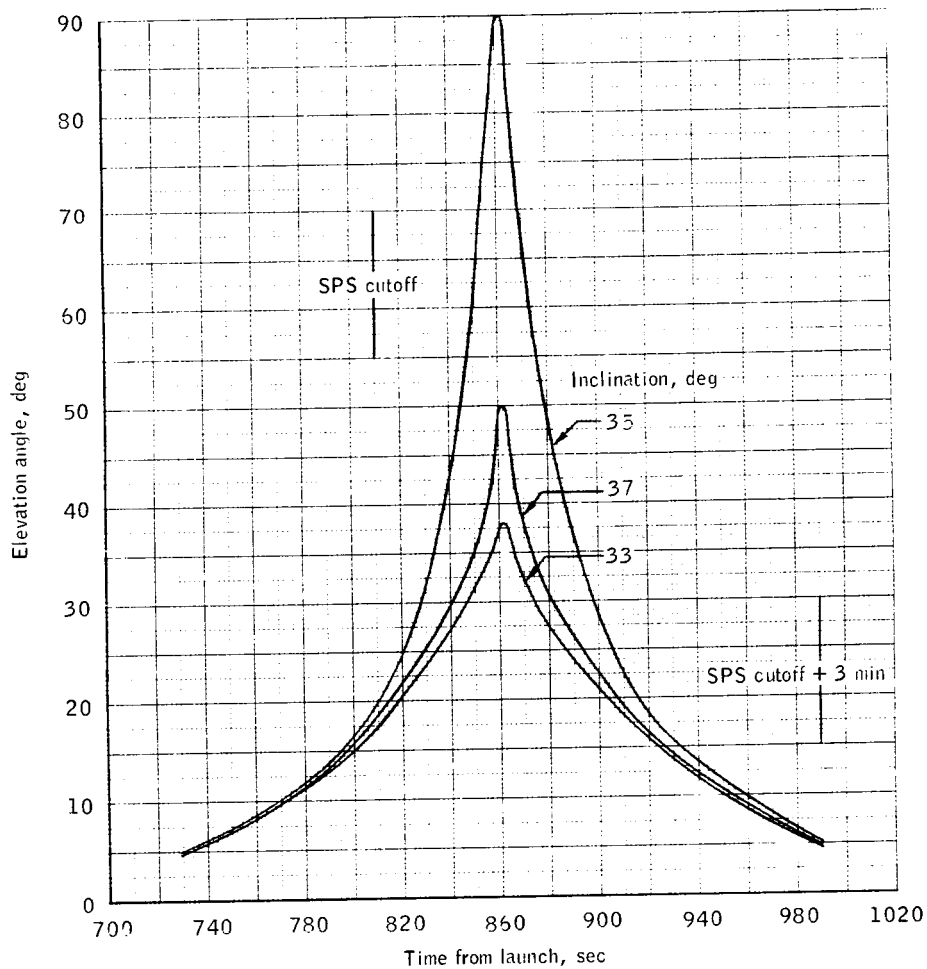
(c) Azimuth angle.

Figure 3.- Concluded.



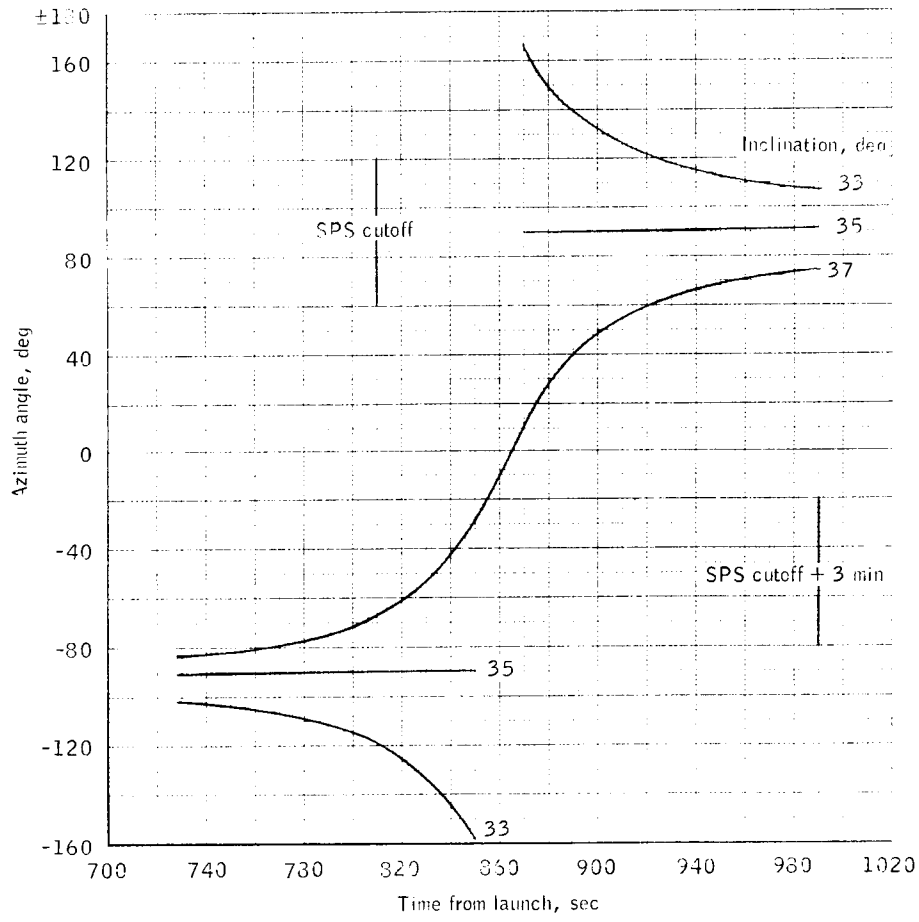
(a) Range.

Figure 4.- Range, elevation angle, and azimuth angle for Ship 1 tracking of 63.5°, 67°, and 71° northerly azimuths; 37°, 35°, and 33° inclinations, respectively.



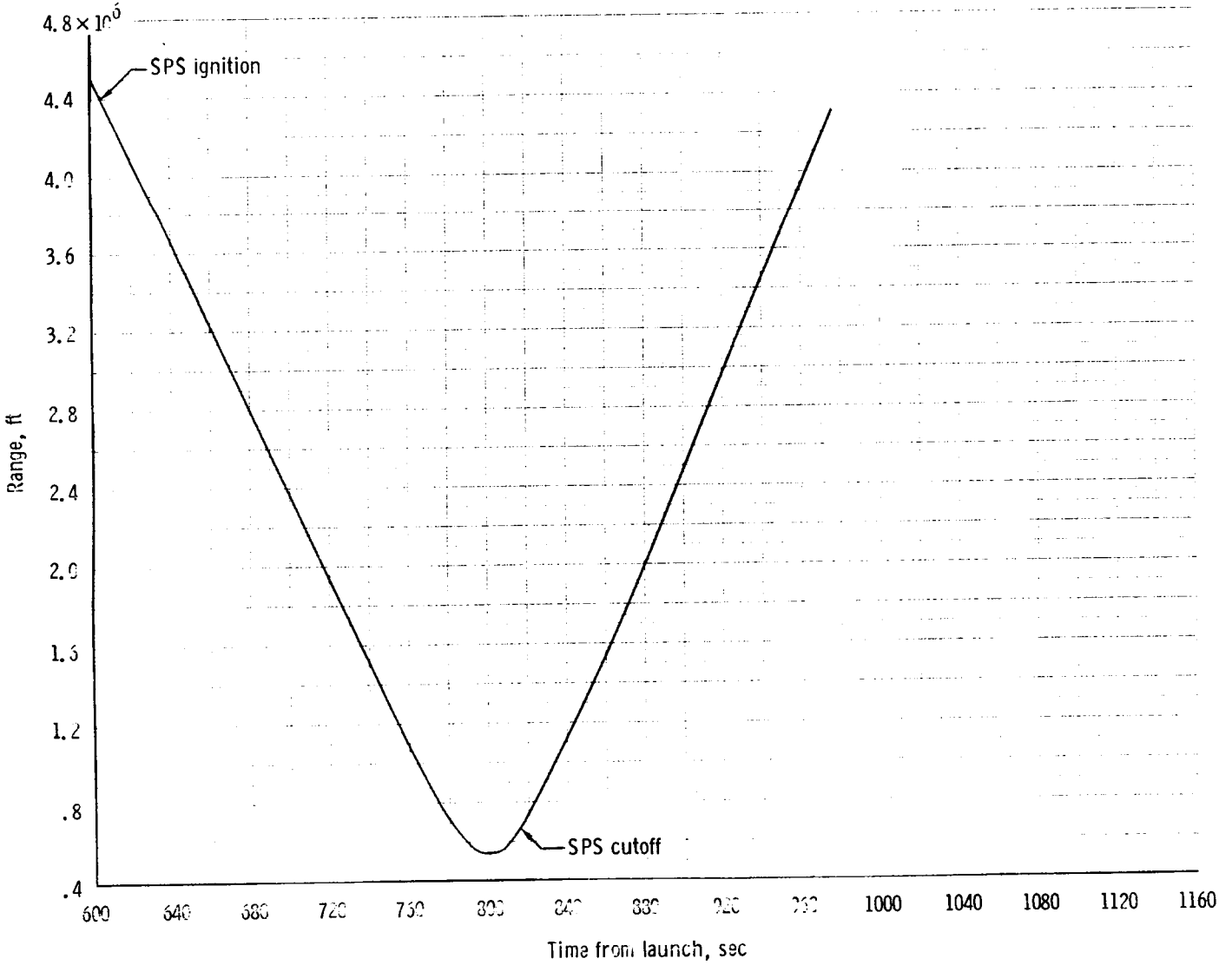
(b) Elevation angle.

Figure 4.- Continued.



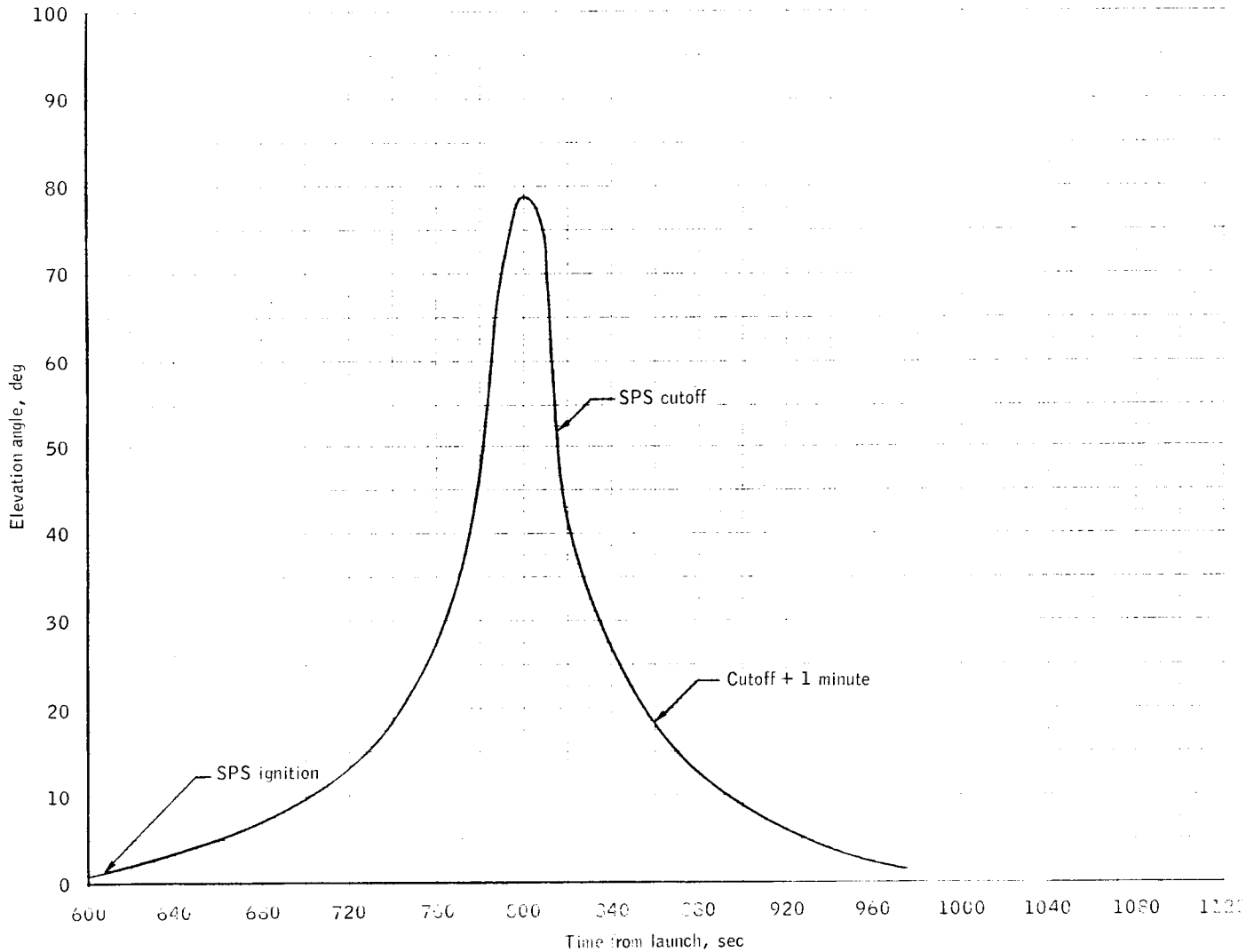
(c) Azimuth angle.

Figure 4.- Concluded.



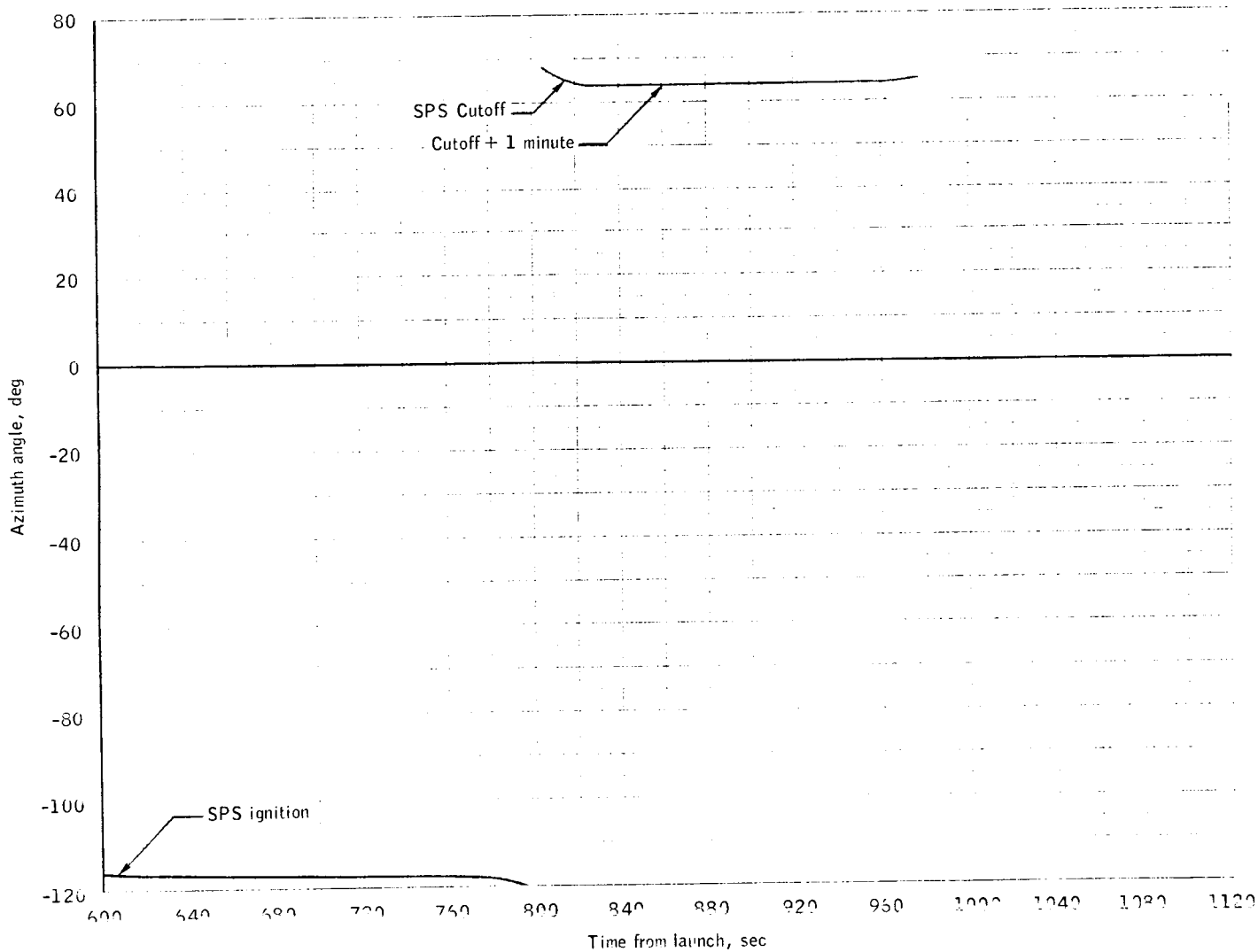
(a) Range.

Figure 5. - Range, elevation angle, and azimuth angle of Ship 2 tracking of 44.5 northerly launch azimuth; 50° inclination.



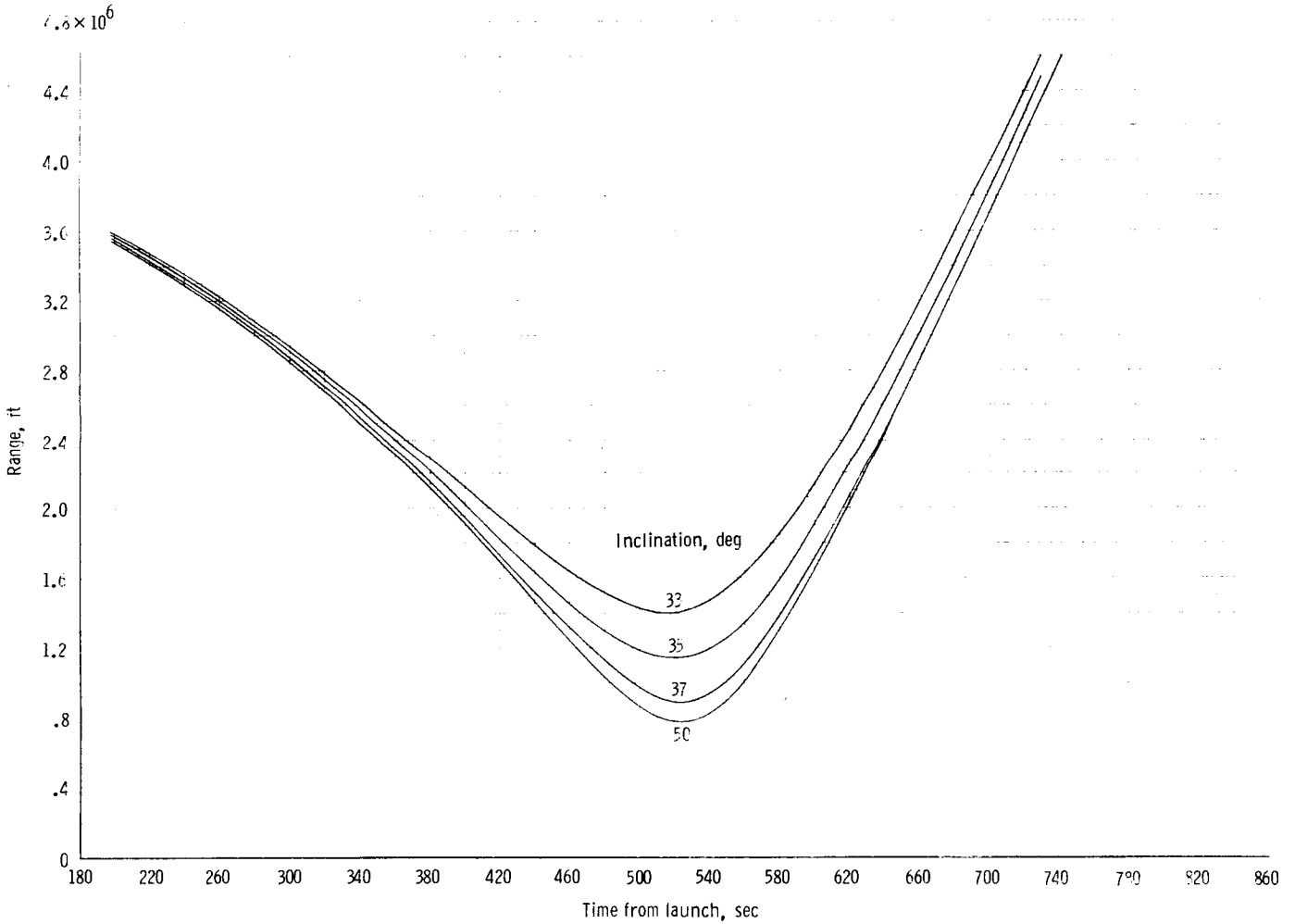
(b) Elevation angle.

Figure 5.- Continued.



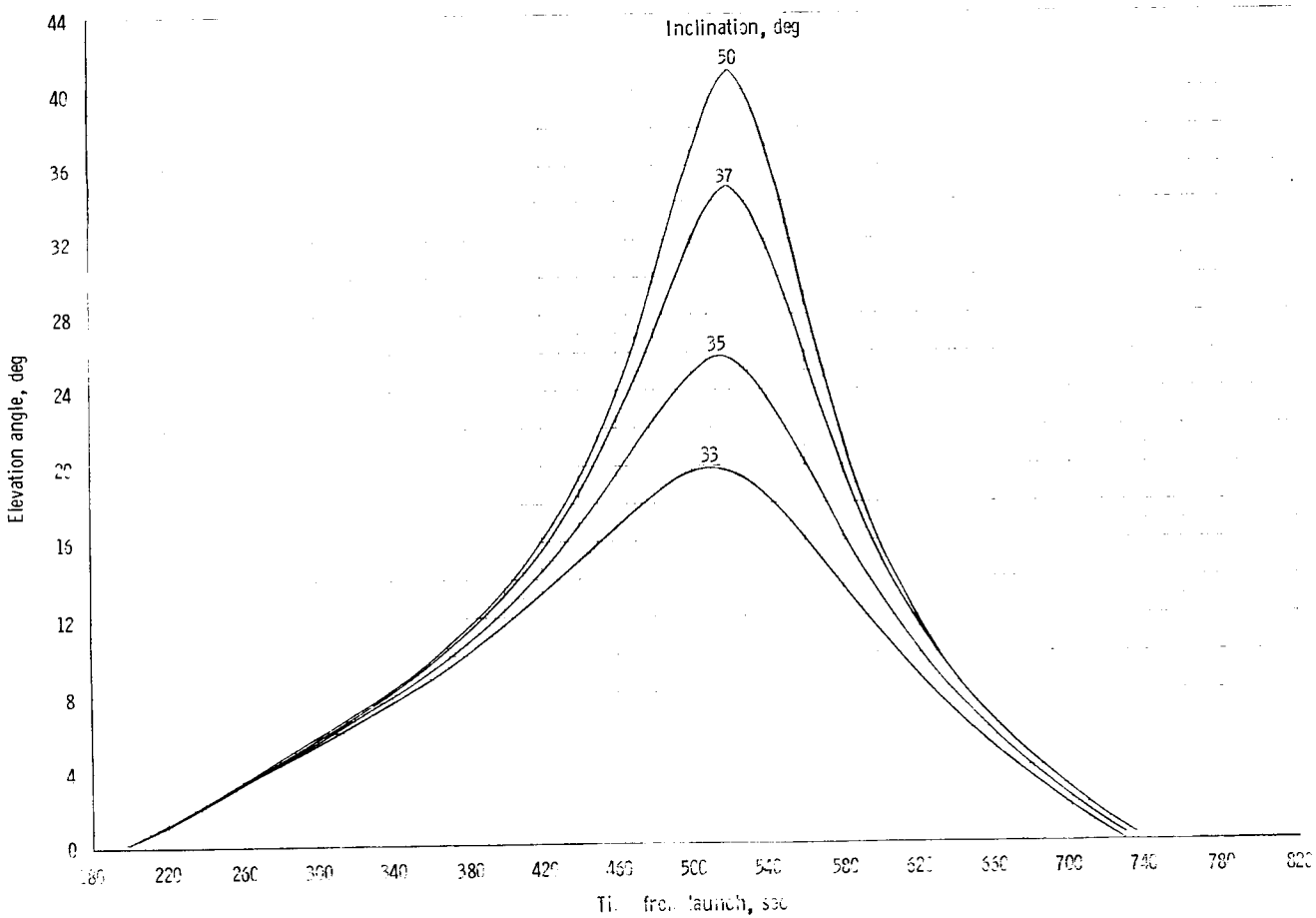
(c) Azimuth angle.

Figure 5.- Concluded.



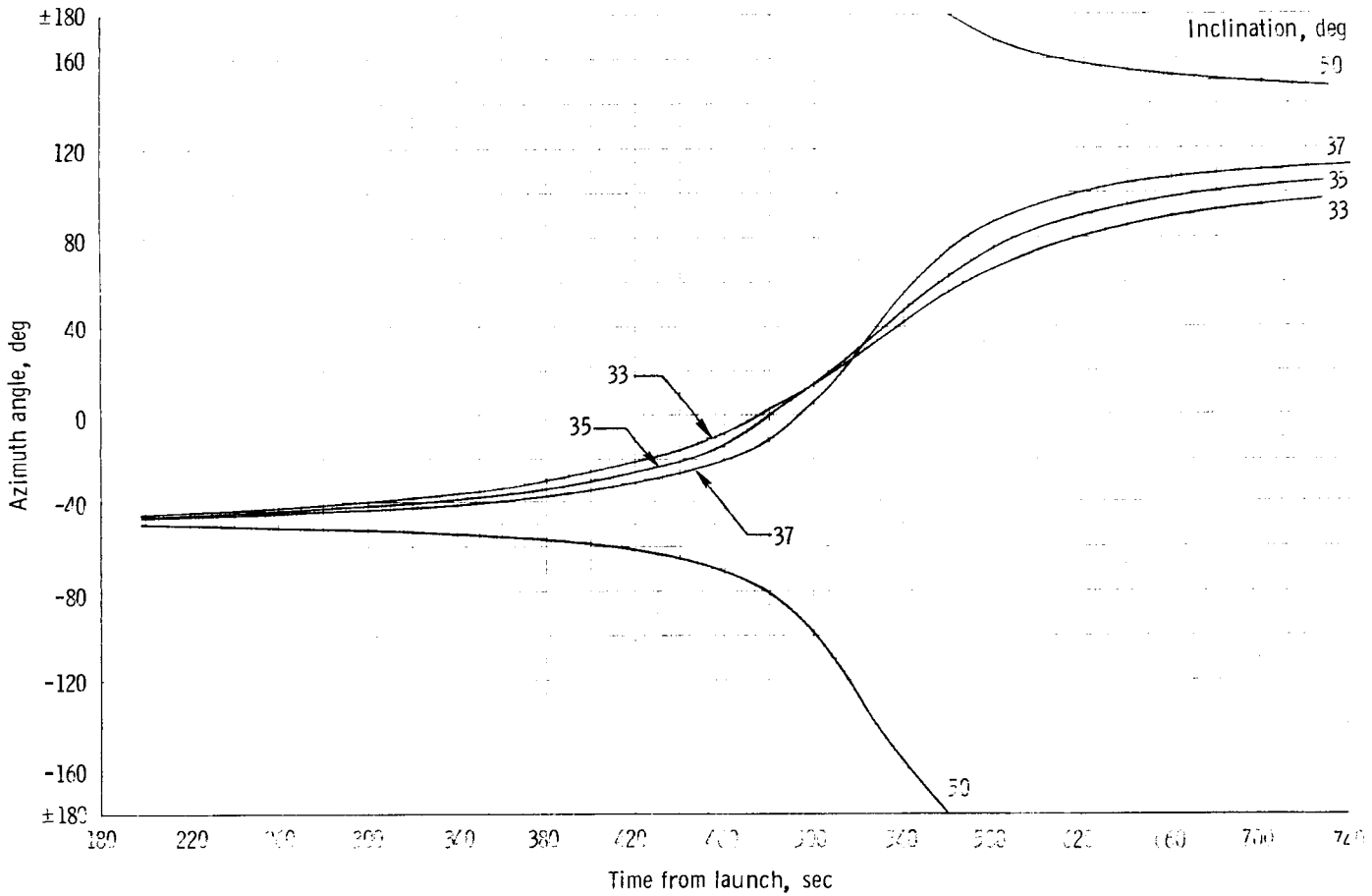
(a) Range.

Figure 6. - Range, elevation angle, and azimuth angle of Grand Turk Island tracking of southerly launch azimuths.



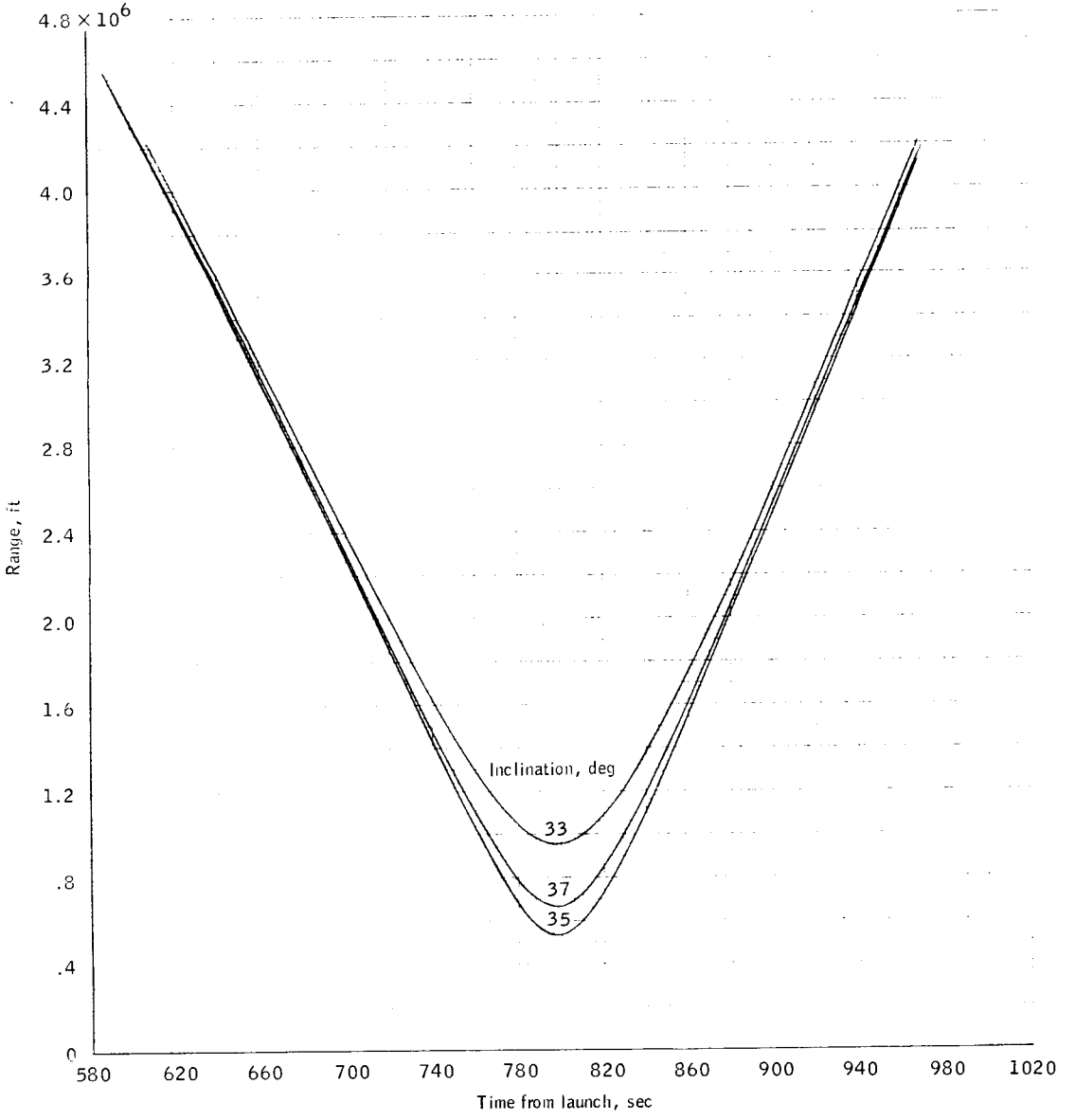
(b) Elevation angle.

Figure 6. - Continued.



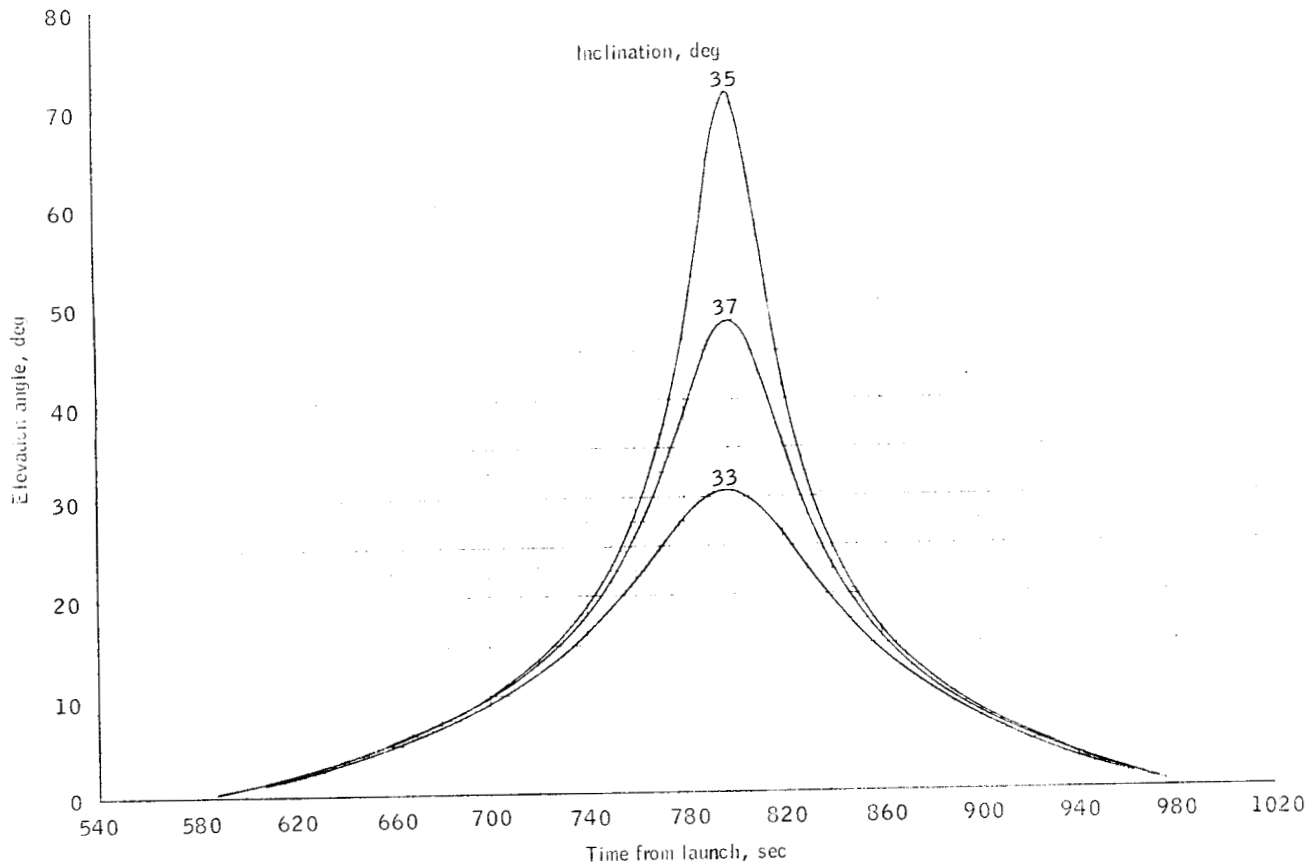
(c) Azimuth angle.

Figure 6. - Concluded.



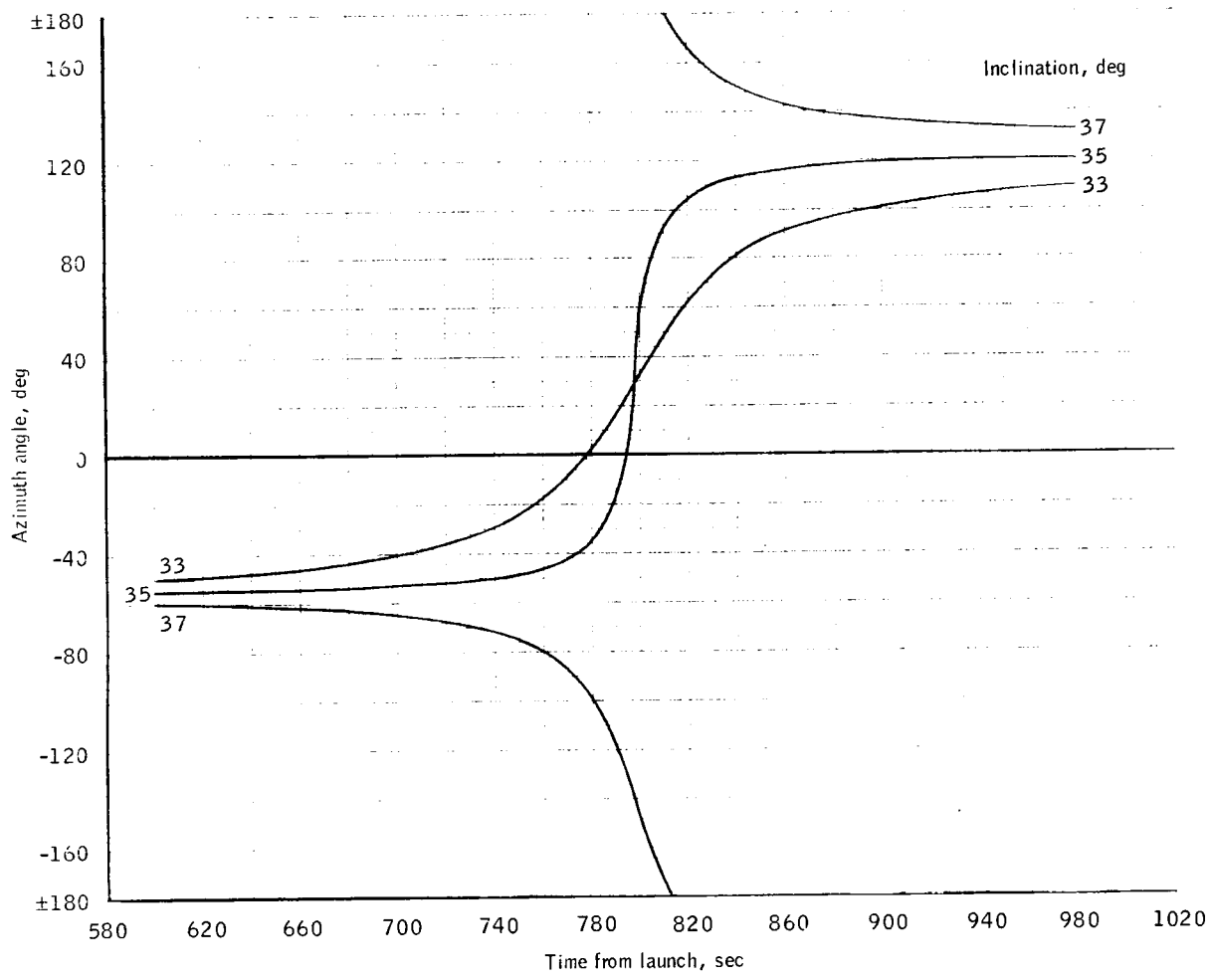
(a) Range.

Figure 7.- Range, elevation angle, azimuth angle of Ship 3 tracking of 108°, 112°, and 115°, southerly launch azimuths; 33°, 35°, and 37° inclinations respectively.



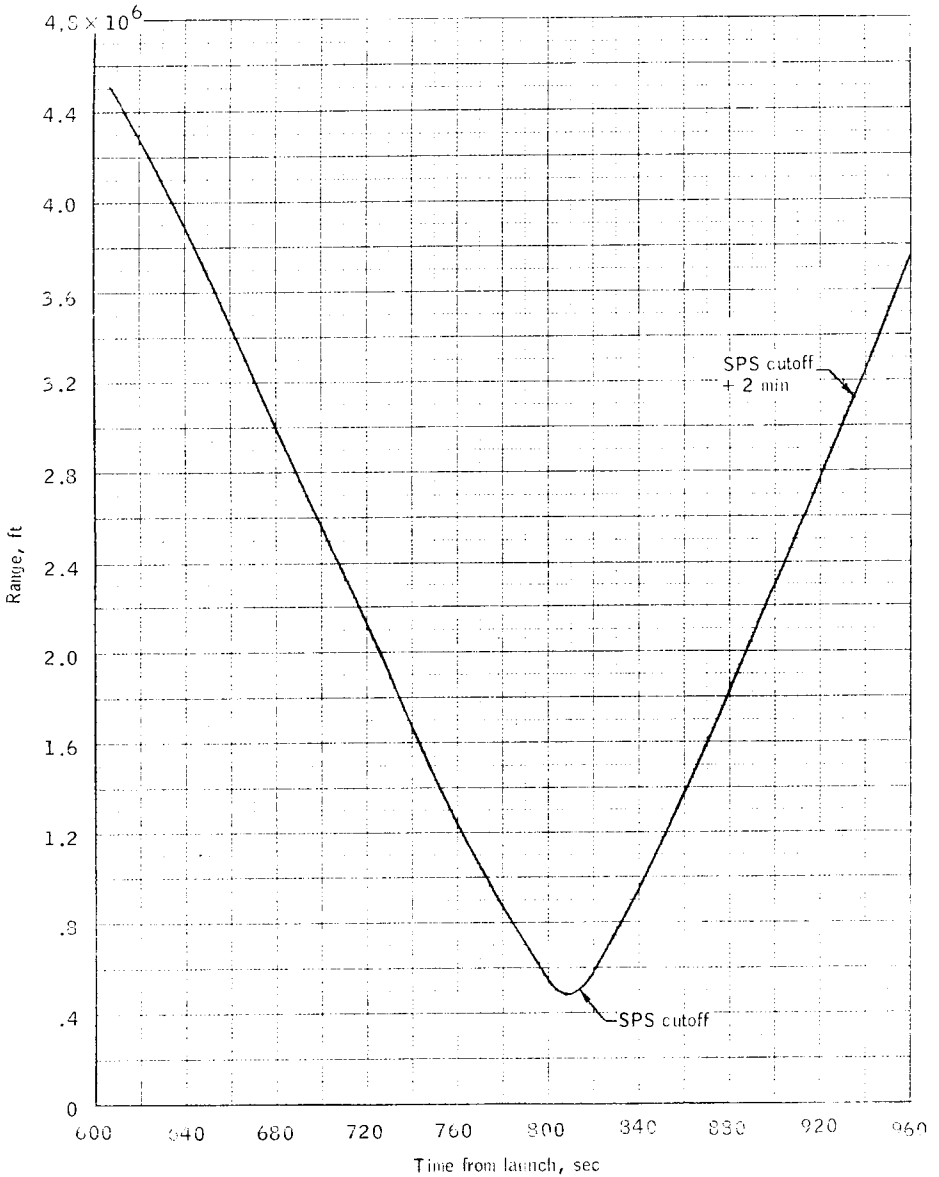
(b) Elevation angle.

Figure 7.- Continued.



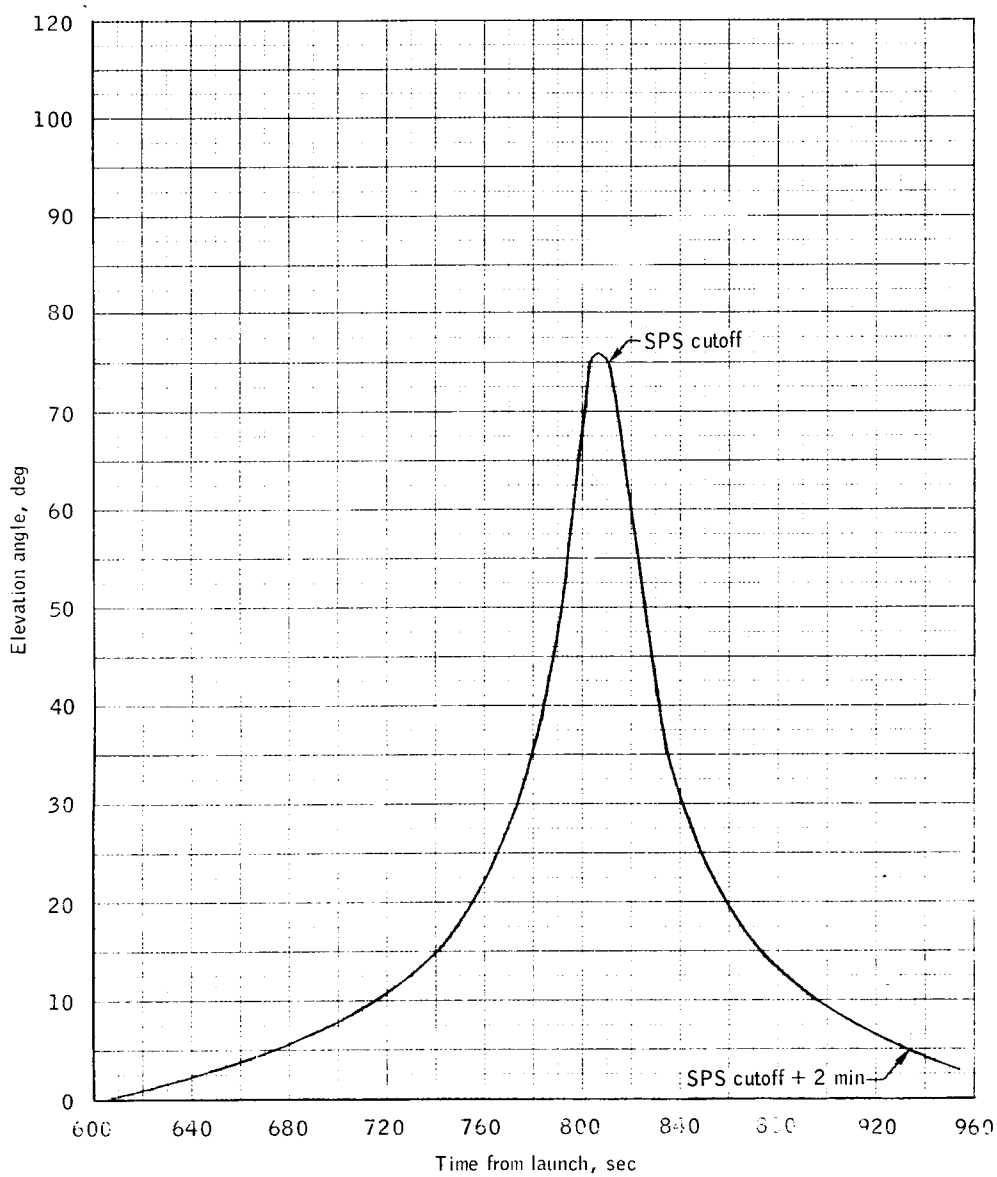
(c) Azimuth angle.

Figure 7.- Concluded.



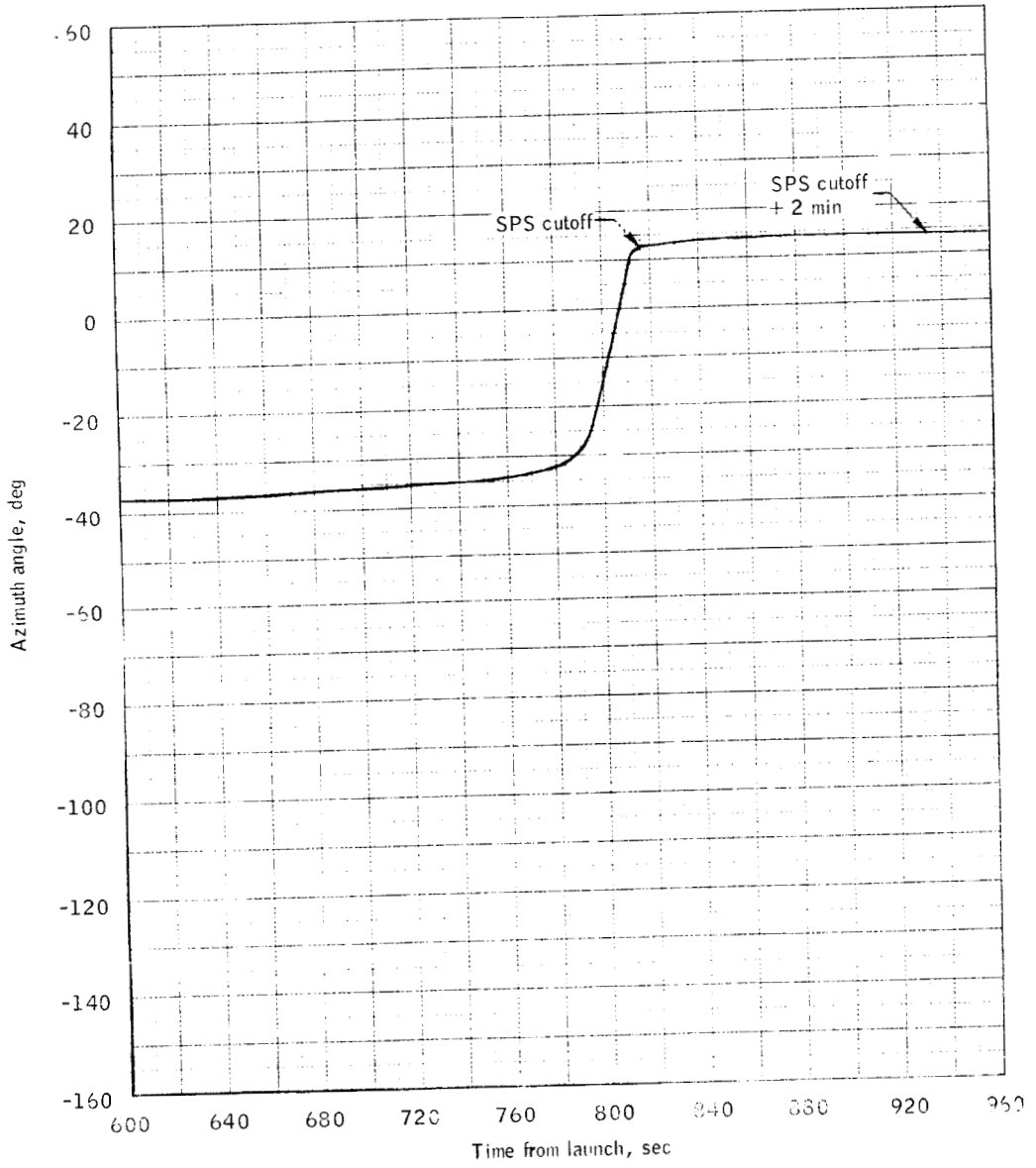
(a) Range.

Figure 8.- Range, elevation angle, azimuth angle, of Ship 4 tracking 134° southerly launch azimuth; 50° inclination.



(b) Elevation angle.

Figure 8.- Continued.



(c) Azimuth angle.

Figure 3.- Concluded.

REFERENCES

1. MPSO: MPAD Action Documentation AAP-93. May 9, 1969.

2. Aerospace Physics Branch, Chrysler Corporation Space Division: Part I, AAP-1 SPS Insertion Launch Vehicle Nominal Trajectories for Range Safety Analysis. MSFC Document TD-R-AERO-11-(DA) (TN-AP-69-376). March 10, 1969.