TBE Technical Report CS92-TR-JSC-002

# THE FRAGMENTATION OF KOSMOS 2163

January 1992

Prepared for:

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Contract NAS 9-18209
DRD SE-1432T

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# The Fragmentation of Kosmos 2163

**Abstract:** On 6 December 1991 Kosmos 2163, a maneuverable Soviet spacecraft which had been in orbit for 58 days, experienced a major breakup at an altitude of approximately 210 km. Although numerous debris were created, the fragments decayed rapidly, leaving no long-term impact on the near-Earth environment. The assessed cause of the event is the deliberate detonation of an explosive device.

## Background

Kosmos 2163 (Satellite Number 21741, International Designator 1991-71A) was launched from the Baikonur Cosmodrome east of the Aral Sea in southwestern U.S.S.R. on 9 October 1991. A paraphrase of the launch announcement appeared in the 25 October 1991 edition of the Spacewarn Bulletin, published by the NASA Goddard Space Flight Center, as follows:

> "1991-071A Cosmos 2163 was launched on October 9, 1991 by the U.S.S.R. to continue space research. Initial orbital parameters: period 89.3 min, apogee 331 km, perigee 174 km, inclination 64.8 deg."

The Soyuz (SL-4) booster has a demonstrated payload capability of 7240 kg to a 200 km orbit at an inclination of 51.6 degrees. The higher altitude and inclination of Kosmos 2163 would result in an initial maximum mass of less than 7000 kg. Kosmos 2163 exhibited characteristics of a type of low altitude, maneuverable Kosmos satellites which appeared in the mid-1970's and recently have been flown at the rate of about 7-8 per year. Kosmos 2163 may have been the second of a new variant of this spacecraft class. The prototype was Kosmos 2031, which experienced a similar, major fragmentation in 1989 after a flight of

six weeks (see The Fragmentation of Kosmos 2031, TBE Technical Report CS89-TR-JSC-003).

This class of spacecraft performs several orbital adjustments throughout the mission, usually to restore the mildly eccentric orbit after a period of natural decay lasting 7-10 days. Occasionally, the spacecraft will reduce its mean altitude and eccentricity for a period of about three days before returning to its normal orbital parameters. Demonstrated $\Delta V$ capacity of this class of satellite is about 200 m/s for orbit corrections and 150 m/s for the de-orbit burn at the end of mission. Allowing for a small propellant reserve and attitude control requirements and assuming a specific impulse similar to other low altitude, maneuverable Soviet satellites, the total propellant mass may account for 800-1000 kg, leaving a maximum dry mass for Kosmos 2163 of about 6000 kg. The radar cross-section (C-band) of Kosmos 2163 was citedas 16.20 $m^2$ in the 18 October 1991 Satellite Catalog (SATCAT) weekly update, published by U.S. Space Command. The 20 December 1991 SATCAT update listed a UHF-band RCS of 29.98 $m^2$.

Between 9 October and 6 December, Kosmos 2163 performed nine major maneuver sequences, all but two of which raised the orbit of the spacecraft (Figure 1). The last maneuver occurred on 2 December. By 6 December Kosmos 2163 was nearing the end of its anticipated lifetime and was expected to be de-orbited and recovered in the Soviet Union within a few days.

**Breakup Event**

Radar observations made by the U.S. Space Surveillance Network (SSN) on 6 December revealed numerous uncorrelated targets (UCTs) in the vicinity of Kosmos 2163. The Naval Space Surveillance System (NAVSPASUR), whose headquarters at Dahlgren, Virginia, also acts as the Alternate Space Surveillance Center (ASSC), detected an

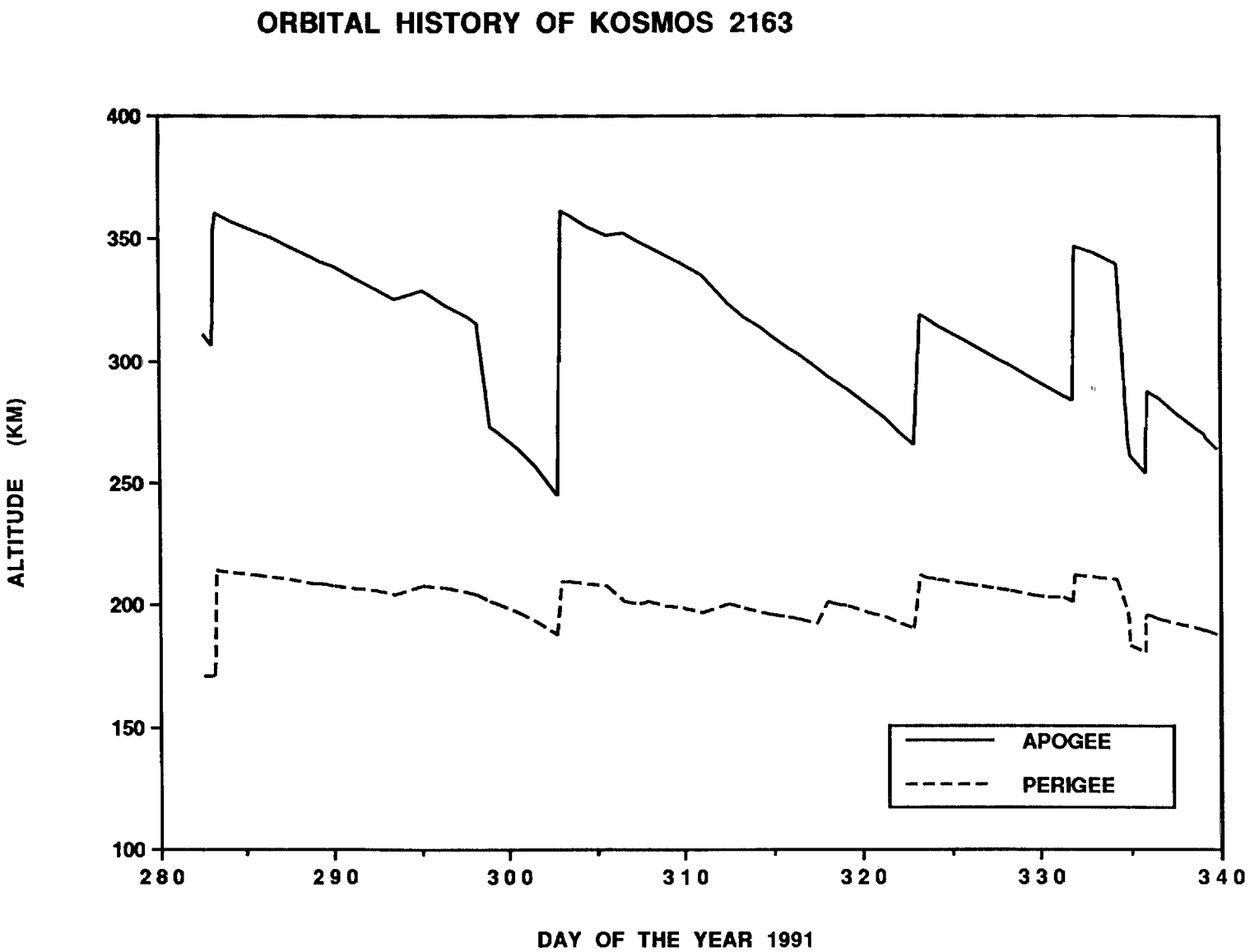


**Figure 1. Orbital History of Kosmos 2163**

estimated few dozen objects decaying rapidly from very low orbits. However, some debris exhibited orbital periods as much as 9.7 minutes greater than Kosmos 2163 prior to the breakup.

From five of the remaining debris, NAVSPASUR calculated a time for the breakup of 2020 and 50.8 seconds GMT on 6 December, corresponding to a location of 55.0N, 153.9E

```
1 21741U 91 71  A 91340.51933896  .00862876  35685-4  35926-3 0   195
2 21741  64.7678  37.7884 0054670 147.5032 213.3470 16.18797546   933.
```

Figure 2 represents the propagation of the above element set to the breakup revolution, using the USAF Space Command-validated SATRAK program. The event location near the Kamchatka peninsula is indicated with a star symbol. This location and orbit geometry are virtually identical with that of the Kosmos 2101 breakup on 30 November 1990 (Figure 3; see also The Fragmentation of Kosmos 2101, TBE Technical Report CS91-TR-JSC-002).

Table 1 contains the element sets of eight debris (6X,XXX series) epoched within 31 hours after the breakup event. Table 2 contains five element sets of debris (8X,XXX series) a few days after the event, including two with apogees near 1,200 km. No debris associated with this event were ever entered into the official satellite catalog. No radar cross-sectional (RCS) data on any debris object were found.

Figure 4 depicts the apogee and the perigee of each piece of debris (Gabbard diagram) as calculated from Table 1 and Table 2 using a mean Earth radius and no propagation. The fragment with the highest orbital period (98.7 minutes) is indicative of a posigrade $\Delta V$ component of approximately 270 m/s at the time of the event. Figure 5 further defines the debris cloud remnant by illustrating the range of orbital inclinations.

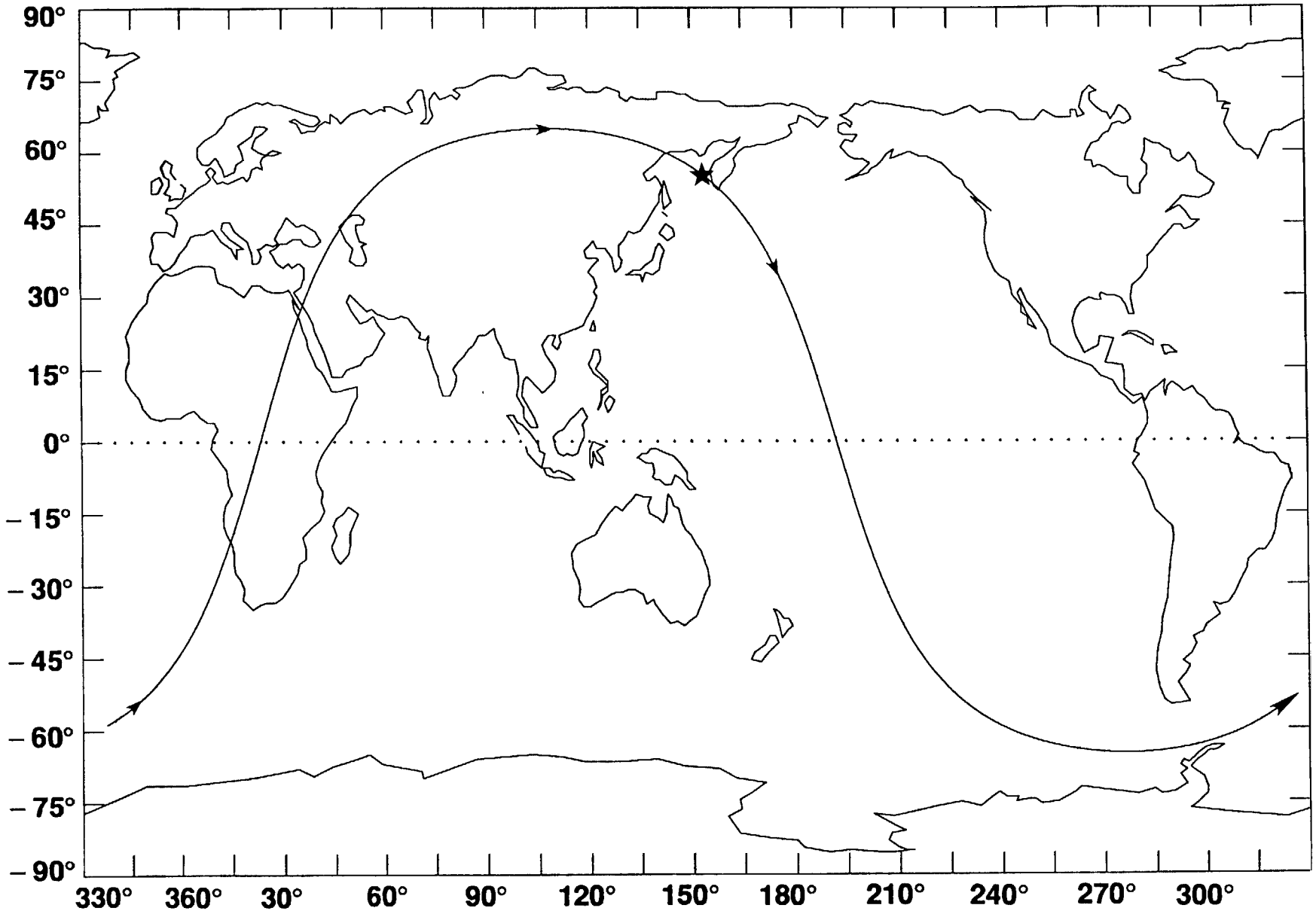


**Figure 2. Location of Fragmentation Event**

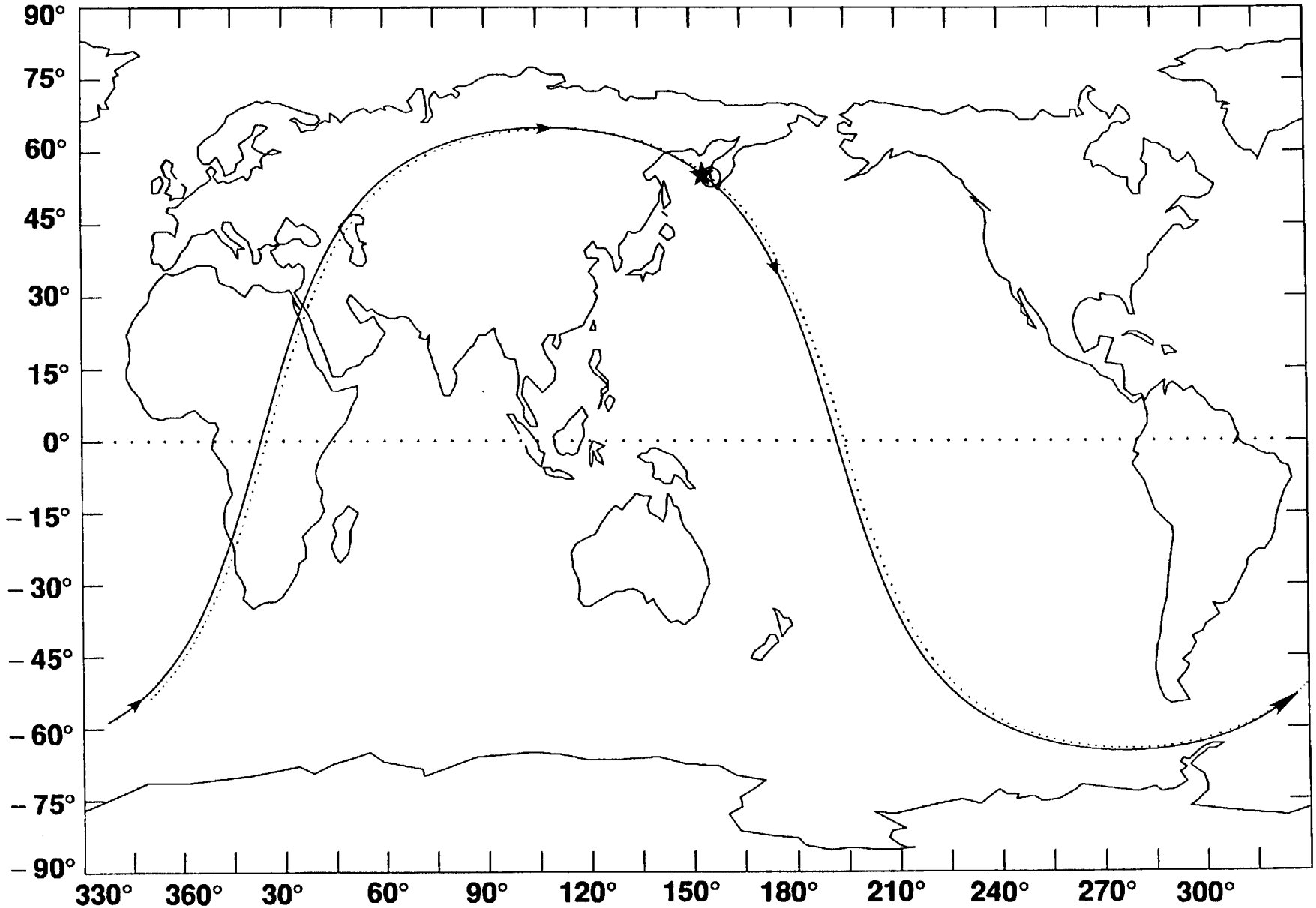


**Figure 3. Geometry of Kosmos 2163 versus Kosmos 2101 Events**

## Table 1. Early Debris Element Sets Epoched Within 31 Hours of Event

```
1 60001U           91341.56888677 0.01029127  36493-4  23969-3 0
2 60001  64.6520   33.9813 0066438 137.5774 227.8832 16.23163940
1 60002U           91342.16528359 0.28816092  34025-4  72925-3 0
2 60002  64.8521   31.5887 0216028 128.4912 251.1326 16.03362754
1 60003U           91341.59554091 0.00064031  30318-4  99999-4 0
2 60003  64.9108   33.8089 0318460 107.0567 265.0923 15.51698367
1 60004U           91341.20229002 0.46536452  34423-4  40413-1 0
2 60004  64.7350   36.5058 0094937 127.7392 227.8166 16.03622363
1 60005U           91341.26424197 0.59226525  36443-4  43121-2 0
2 60005  64.8818   34.5852 0073160 161.4365 207.9597 16.28668674
1 60006U           91341.19849677 0.15937561  37207-4  35379-3 0
2 60006  64.8193   35.4825 0155801  46.6746 310.7707 16.40830902
1 60007U           91341.26083250 0.05521443  35790-4  16773-2 0
2 60007  64.7415   35.0544 0067046 160.5645 200.0724 16.20372036
1 60008U           91341.20254938 0.93561757  34664-4  27820-1 0
2 60008  64.7410   35.4571 0109321 107.9113 253.3841 16.12998790
```

## Table 2. Analyst Satellite Debris Days After the Fragmentation

```
1 80005U           91343.52218745 0.00210187  33555-4  99999-4 0
2 80005  64.6970   27.6192 0171656  98.2323 263.8298 15.95927771
1 80006U           91345.60730367 -.01045605  29173-4 -11055-2 0
2 80006  64.6160   21.3239 0447373 116.2473 261.5432 15.26333044
1 80007U           91347.47943119 0.05046455  31978-4  41388-2 0
2 80007  64.5485   15.0230 0301494 112.9154 251.9792 15.61865244
1 80008U           91346.47465674 0.01317027  25384-4  25786-2 0
2 80008  64.6476   20.2504 0714247 111.6623 256.5488 14.59282383
1 80009U           91347.15940422 0.01313682  25112-4  26109-2 0
2 80009  64.6444   18.1922 0705649 111.4880 255.9089 14.61075171
```

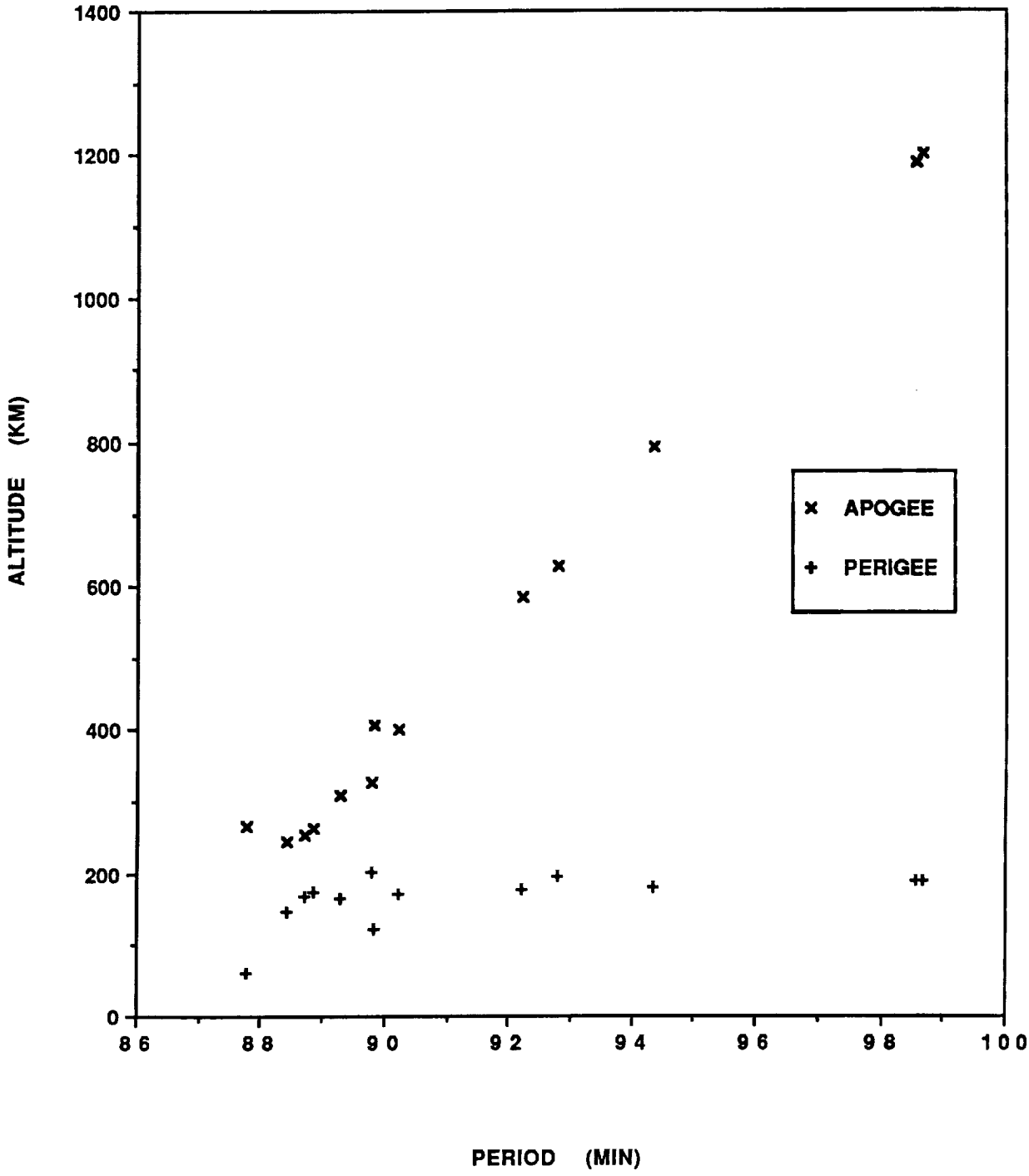


**Figure 4. Gabbard Diagram of Table 1 & 2 Element Sets**

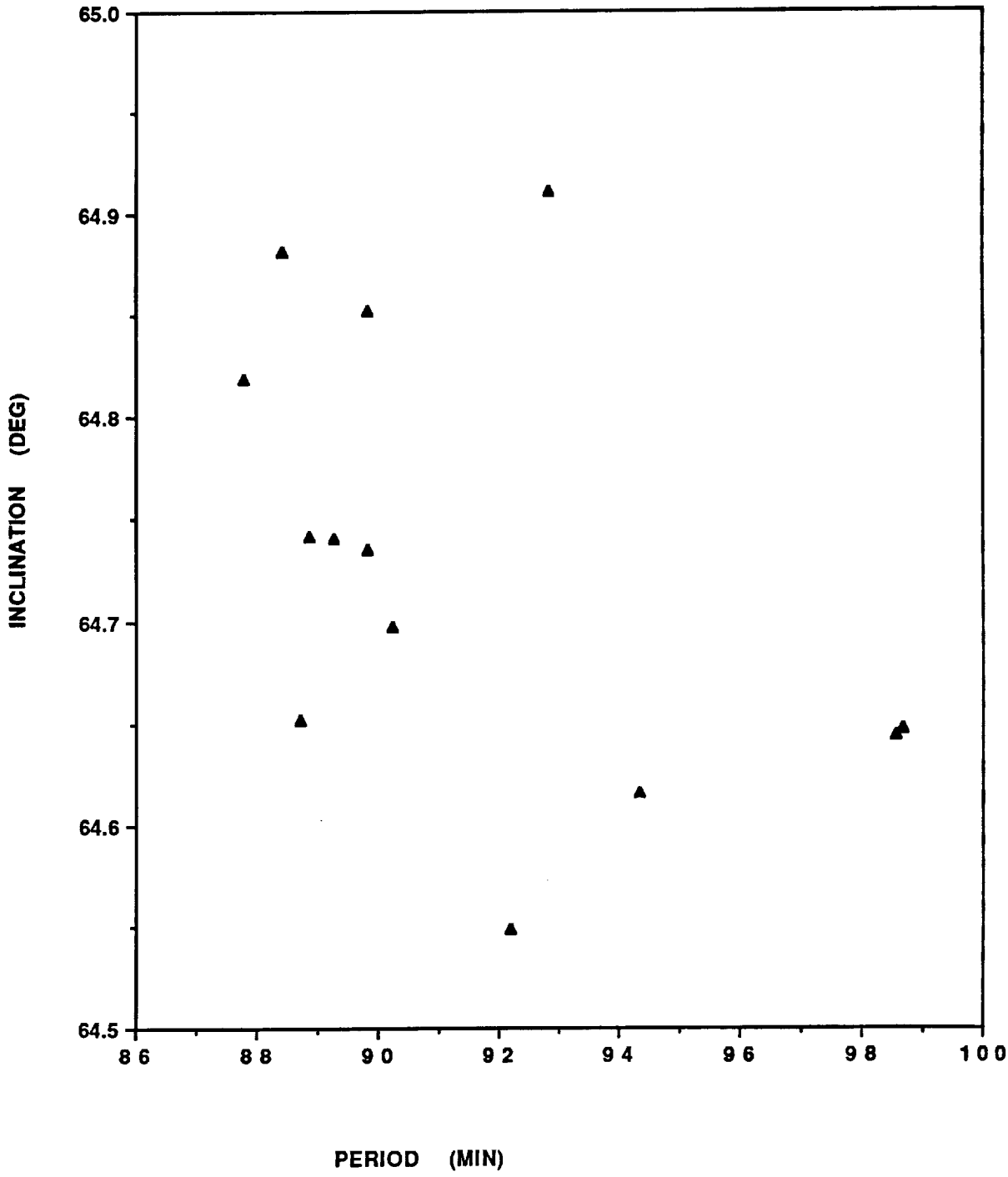


**Figure 5. Orbital Inclination Spread of Early Element Sets**

The breakup of Kosmos 2163 had no long-term effect on the near-Earth environment. All known and postulated debris probably decayed within several weeks of the event.

**Cause Assessment**

Kosmos 2163 appeared to be a member of a low altitude, maneuverable Kosmos class which had previously experienced major satellite breakups on at least eight missions since 1975: Kosmos 758 (Sep 75), Kosmos 844 (Jul 76), Kosmos 1654 (Jun 85), Kosmos 1866 (Jul 87), Kosmos 1916 (Feb 88), Kosmos 2030 (Jul 89), Kosmos 2031 (Aug 89), and Kosmos 2101 (Nov 90). Open source literature indicates that a portion of each spacecraft is designed for recovery in the Soviet Union at the end of mission.

Due to the assumed sensitive nature of the payload, an explosive package is believed to be carried on board the vehicle to assure self-destruction in the event of a spacecraft malfunction which would prevent a controlled reentry and recovery on Soviet territory. The Soviets have acknowledged that such a device was activated accidently on Kosmos 57 in 1965. Similar explosive fragmentations have been associated with recoverable Kosmos satellites with like objectives, dating back to Kosmos 50 in November, 1964.

The characteristics of the breakup of Kosmos 2163 are consistent with the other, apparently deliberate fragmentations noted above. In fact, the timing of the breakup shortly after passing near the U.S.S.R.'s spacecraft recovery area to the northeast of the Baikonur Cosmodrome matches the conditions of the three other breakups since 1988. The limited data on the Kosmos 2163 debris cloud are also consistent with breakups of other members of this satellite class.

The spatial density of the environment in the vicinity of the breakup was extremely low, suggesting that a collision-induced fragmentation was exceptionally unlikely. Although the possibility of a propulsion-related breakup cannot be ruled out, it is assessed as a substantially lower probability than a deliberate detonation.

# Appendix 1. NAVSPASUR Breakup Message

```
RCV MSG #     TIME      RADAY                                    RET MSG #      PRIORITY
  11821       2221      341/91                                     16607

1SW/CC/DO/LK/CV/XR/FM/CVC//KR//302//JPPSO//OSI//MAS/2163//TA//SVC//OPR------
3SW/CC/FM/LGM/PKB/LGS/LGT/SG/RM/IG//1003MSSG//MSI/AM/SP/MW/DE//AFSS/1013/RSC
DECA/AAFES/3423/DET4 AFOTEC/DET2 AFSC/DET25 SMALC/FSI/PRC/DET1 MES/18 SURS///

PATUZYUW RUCKSGG2377 3412039-UUUU--RUVHEMA.
ZNR UUUUU
P 072039Z DEC 91
FM NAVSPASUR DAHLGREN VA//30//
TO RUVESLA/HQ USSPACECOM PETERSON AFB CO//J3SS//
RUCIAEA/FTC WRIGHT PATTERSON AFB OH//XOOD//
RUCEAAA/HQ USSPACECOM CHEYENNE MOUNTAIN AFB CO//J3SOS/J20//
RUWOMSB/MILL STONE HILL RADAR WESTFORD MA
RUWTBCA/NASA JOHNSON SPACE CEN HOUSTON TX//SN3//
RUDMMIC/NAVMARINTCEN WASHINGTON DC//DA41//
RUVHEMA/PETERSON AFB CO//TELEDYNE BROWN ENGINEERING//
ZEN/COMNAVSPACECOM DAHLGREN VA//N2//
BT
UNCLAS //N03840//
FOR JOHNSON SPACE CENTER ATTN: R RAST
SUBJ:  SATELLITE SUPPORT
MSGID/GENADMIN/NAVSPASUR//
RMKS/1. DATA
 SUBJ: BREAKUP ANALYSIS
 1. ANALYSIS OF THE BREAKUP OF SCC NO. 21741
 YIELDS THE FOLLOWING TIME AND LOCATION OF BREAKUP BASED
 ON ELEMENT SETS GENERATED ON   5 ASSOCIATED PIECES:


PAGE 02 RUCKSGG2377 UNCLAS
 DATE/TIME         LAT(N)  LONG(E)  ALT(NM)  ST DEV(NM)
 911206 202050.8    55.0    153.9    112.1      10.8
//
BT
#2377  NNNN
```