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HISTORY OF ON-ORBIT SATELLITE FRAGMENTATIONS

Sixth Edition
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Preface to the Sixth Edition

The first edition of the History of On-Orbit Satellite Fragmentations was published by Teledyne Brown Engineering (TBE) in August, 1984, under the sponsorship of the NASA Johnson Space Center and with the cooperation of USAF Space Command and the U.S. Army Ballistic Missile Command. The objective was to bring together for the first time all known information about the 75 satellites which had at that time experienced noticeable breakups. Revised and up-dated editions were released in February, 1986, and October, 1987.

A major upgrade resulting in the present format was published in January, 1990, covering the period through 4 October 1989. For the next twelve months no satellite fragmentations were observed. With the onset of solar maximum and its primary peak in the summer of 1989 and a secondary rise during the winter of 1990-1991, the total Earth satellite population steadily declined with the preferential decay of satellite fragmentation debris due to the characteristicly higher area-to-mass ratios. By 4 October 1990 more than 250 additional cataloged fragmentation debris had reentered the Earth's atmosphere, reducing the overall proportion of fragmentation debris in the total satellite population from 45% to 42%.

Unfortunately, during the next year and a half twelve satellites were involved in detected fragmentations, including major breakups of two discarded rocket bodies. Without these new events the fragmentation debris portion of the Earth satellite population would have continued to fall. Presently, satellite fragmentation debris account for 41.5% of the on-orbit population.

The fifth edition of this report continued the new format created in the fourth edition, documenting the status of the fragmentation population through April, 1991. The sixth edition updates information presented in the fifth.

New information on fragmentation events is now coming to light since the disassociation of the Soviet Union. At least one previously undetected breakup in geostationary orbit has been identified and several unknown event causes have been clarified from the new information which has been released. Failure mechanisms have been identified or confirmed by Russian scientists, and additional information on the Cosmos 1275 event further supports the supposition that an on-orbit collision with an unknown object was the likely failure mechanism. This volume will continue to reference satellites belonging to the old Soviet empire as "USSR" to remain compatible with the present nomenclature utilized in the USSPACECOM Satellite Catalog.

TBE wishes to acknowledge the long-term and vital contributions of the Naval Space Surveillance System (NAVSPASUR) and its dedicated personnel in Dahlgren, Virginia, not only to the U.S. Space Surveillance Network (SSN) where it is recognized as the pre-eminent authority on satellite fragmentations but also to TBE directly during the past thirteen years. This volume is also indebted to the personnel and activities of the North American Aerospace Defense Command (NORAD), the former USAF Aerospace Defense Command (ADCOM), the USAF Space Command, and the United States Space Command. The Royal Aerospace Establishment in the United Kingdom has also been quite helpful over the years by providing data on specific events as well as via the internationally respected RAE Table of Earth Satellites. Special recognition is due to Mr. John Gabbard, formerly with NORAD/ADCOM and TBE, without whose pioneering work in the field of satellite fragmentations this volume would not be possible.

This is the sixth edition of this compilation. Over the years seven authors have contributed significantly to the data and analysis presented herein. The dates and authors of the previous editions are listed below. The fourth edition represents a

complete rewrite of the entire document and where the present format was first used. TBE acknowledges the considerable contributions of Nicholas Johnson to each of the previous editions of this document and in particular to the entire field of study of orbital man-made debris.

First Edition, August 1984	N. L. Johnson J. R. Gabbard G. T. DeVere E. E. Johnson
Second Edition, February 1986	N. L. Johnson J. R. Gabbard R. L. Kling, Jr. T. W. Jones
Third Edition, October 1987	N. L. Johnson D. J. Nauer
Fourth Edition, January 1990	N. L. Johnson D. J. Nauer
Fifth Edition, July 1991	N. L. Johnson
Sixth Edition, July 1992	D. J. Nauer

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1.0 INTRODUCTION

Since the first serious satellite fragmentation occurred in June, 1961, and instantaneously increased the total Earth satellite population by more than 400%, the issue of space operations within the finite region of space around the Earth has been the subject of increasing interest and concern. The prolific satellite fragmentations of the 1970's and the marked increase in the number of fragmentations in the 1980's served to widen international research into the characteristics and consequences of such events. Plans for large, manned space stations in the next decade and beyond demand a better understanding of the hazards of the dynamic Earth satellite population.

The contribution of satellite fragmentations to the growth of the Earth satellite population is complex and varied. The majority of detectable fragmentation debris have already fallen out of orbit, and the effects of 40% of all fragmentations have completely disappeared. On the other hand, just 10 of more than 3300 space missions flown since 1957 are responsible for 26% of all cataloged artificial Earth satellites presently in orbit (Figure 1.1). Moreover, the sources of 9 of these 10 fragmentations were discarded rocket bodies which had operated as designed but later broke-up. The primary factors affecting the growth of the true Earth satellite population are the international space launch rate, satellite fragmentations, and solar activity. As of 1 April 1992, the largest element of the cataloged Earth satellite population continued to be fragmentation debris (Figure 1.2).

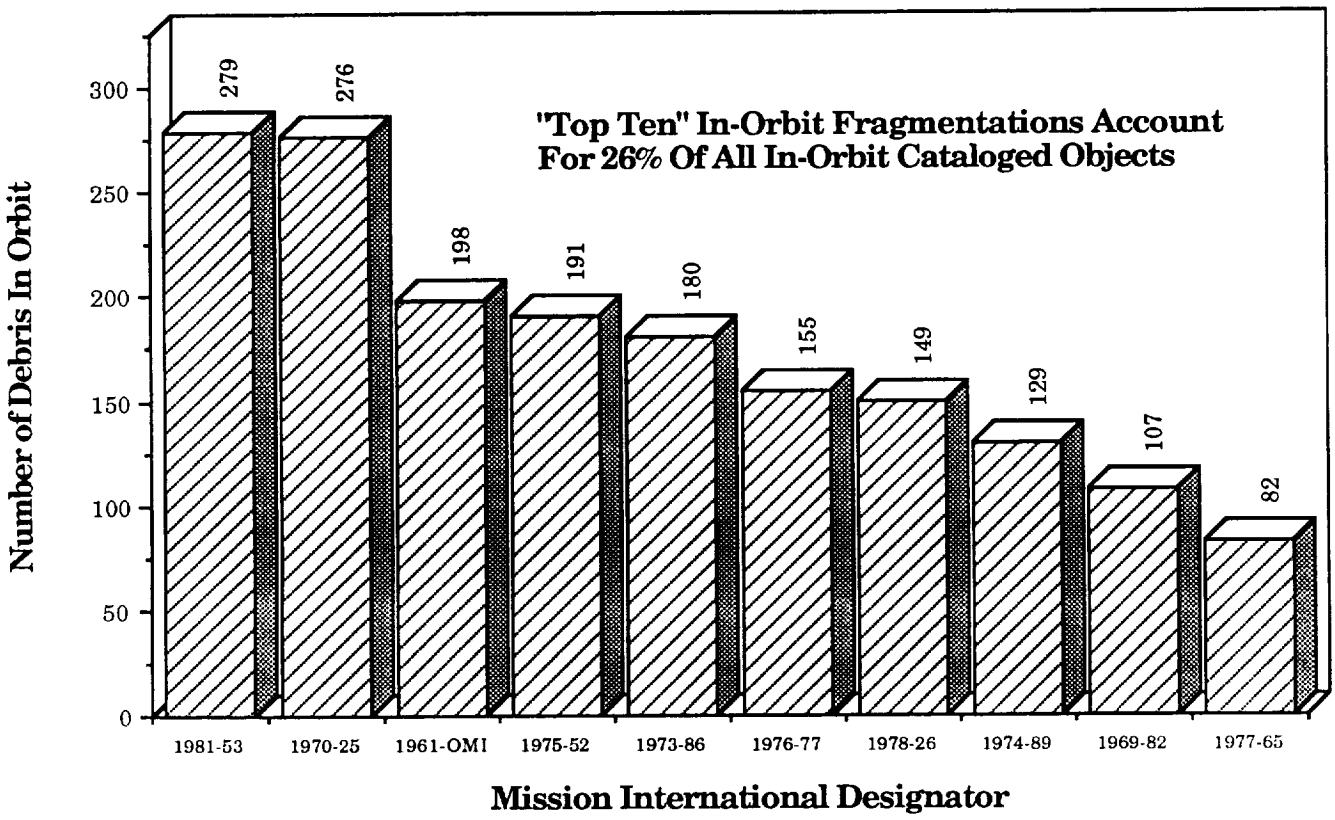


Figure 1.1 Magnitude of the ten largest debris clouds in orbit in April, 1992.

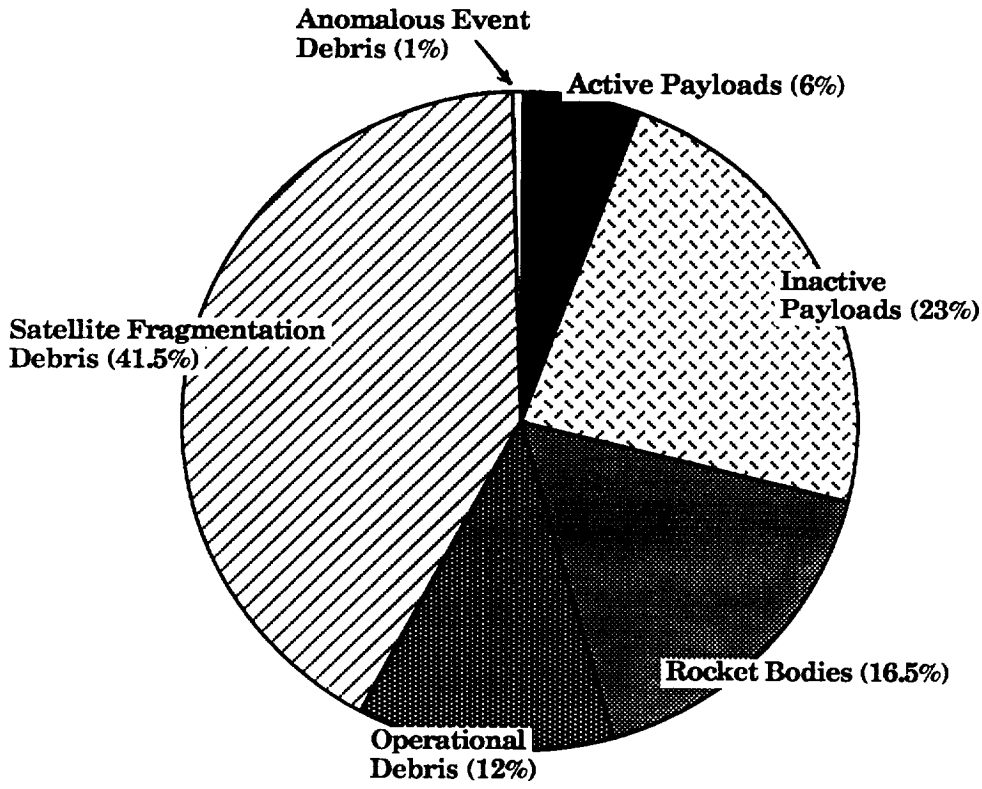


Figure 1.2 Relative segments of the cataloged in-orbit Earth satellite population.

In this volume, satellite fragmentations are categorized by their assessed nature and to a lesser degree by their effect on the near-Earth space environment. A **satellite breakup** is the usually destructive disassociation of an orbital payload, rocket body, or structure, often with a wide range of ejecta velocities. A satellite breakup may be accidental or the result of intentional actions, e.g., due to a propulsion system malfunction or a space weapons test, respectively. An **anomalous event** is the unplanned separation, usually at low velocity, of one or more detectable objects from a satellite which remains essentially intact. Anomalous events can be caused by material deterioration of items such as thermal blankets, protective shields, or solar panels. As a general rule, a satellite breakup will produce considerably more debris, both trackable and non-trackable, than an anomalous event. From one perspective, satellite breakups may be viewed as a measure of the effects of man's activity on the environment, while anomalous events may be a measure of the effects of the environment on man-made objects.

Operational debris results from the release of objects, usually in small numbers, during normal on-orbit operations. Objects ejected during the deployment, activation, and de-orbit of payloads and during manned operations are examples of operational debris. Usually operational debris from a single launch are few in number, but extreme examples occasionally arise, such as the 200 objects from the Salyut 7 space station or the more than 130 objects from the Westford Needles experiment. Although operational debris represent a significant portion (over 12%) of all satellites today and therefore are a legitimate subject in the study of methods to retard the growth of the Earth satellite population, identification of the thousands of operational debris events is beyond the scope of this report.

Although all fragmentations are described by the number of debris cataloged and the number of cataloged debris remaining in orbit, these parameters are poor measures of merit and should be used with extreme caution when undertaking comparative analyses. The sensitivity of the SSN, and hence the degree to which debris will be detected and cataloged, is highly dependent upon satellite altitude and to a lesser degree on satellite inclination. As a rule of thumb, low altitude cataloged debris are assessed to be larger than 10 cm in diameter. At higher altitudes objects less than 1 m in diameter may be undetectable. Individual object sensitivities may vary dramatically from this simple generalization. Debris counts for fragmentations occurring in highly elliptical orbits near 63 degrees inclination (Molniya-type) are traditionally low, in part due to stable perigees situated deep in the Southern Hemisphere beyond SSN coverages. During a special surveillance session in 1987, as many as 250 uncataloged objects were observed in low inclination, highly elliptical orbits, but reliable tracking and parent identification were not achieved. The recent disclosure by the Russian Government of the Ekran 2 battery explosion on 25 June 1978 is the first known fragmentation in geostationary orbit. This event was not detected by the SSN and no associated debris objects have since been cataloged with this event. The explosion was recorded optically by the Soviets and released by the Russians. Cataloging errors, e.g. identification of an object with the wrong parent satellite, are normally not explicitly noted in this volume since many errors have been or may be corrected.

For fragmentations at very low altitudes, i.e. below 400 km, much of the debris may reenter before detection, identification, and cataloging can be completed. For example, when the debris cloud from Cosmos 1813 passed over a single SSN radar, a total of 846 individual fragments could be discerned. However, the total number of debris officially cataloged only reached 194. Likewise, more than 380 fragments are known to have been injected into Earth orbits (an equal number probably were sent on reentry trajectories) following the USA 19 test, but only 18 debris were entered into the official satellite catalog. Where appropriate, these differences are noted in the two-page modules of Section 2.

A number of data sources were employed in the compilation of this volume. However, nearly all are derived from observations collected by the U.S. SSN. The most frequently used sources were the official U.S. Satellite Catalog (issues for 1964 to present), full satellite catalog element set databases taken directly from Cheyenne Mountain computer systems, specific element set retrievals from the Historical Data System (HDS), element sets of specific debris clouds as maintained by NAVSPASUR, and raw radar observations from the PARCS and FPS-85 (Eglin) sites. Some of these databases include element set data on debris prior to official cataloging actions, i.e. from the analyst satellite catalog or 8X,XXX series. In addition, throughout this volume the Cheyenne Mountain organization responsible for managing satellite orbital data is referred to only as the U.S. Space Surveillance Center (SSC), but has been designated during different periods as the NORAD Space Surveillance Center (NSSC), the Space Computational Center (SCC), and the Space Defense Center (SDC).

Due to the variety of sources and geodetic models used to create satellite orbital element sets, all altitudes cited within this volume are presented to the nearest 5 km, referenced to a mean Earth of radius 6378.145 km. Higher precision values are not warranted for the scope of analyses suitable from other data in this volume. Complete base element sets are provided, but manipulations of these data, in particular satellite propagations, should be performed only with validated, SCC-derived software, such as the IBM-compatible SATRAK astrodynamics toolkit. Long term propagations of these elements are not appropriate regardless of the propagation technique applied and are discouraged.

2.0 SATELLITE BREAKUPS

This section summarizes the present fragmentation environment and describes each individual breakup in the standard fourth edition format. The number of breakups continue to grow, although the breakup rate has slackened during the late 80s and early 90s. Although some recent breakups are a legacy to older on-orbit practices (e.g. Nimbus 6 R/B), it is expected that fragmentations will continue, albeit at a reduced rate, into the forseeable future.

2.1 Background and Status

By far the most important category of satellite fragmentations is satellite breakups, which now account for 42% of the total cataloged Earth satellite population of 6820 objects. Since 1961 a total of 108 satellites are believed to have broken up (Tables 2.1 and 2.2).

The primary causes of satellite breakups (Figure 2.1) are deliberate actions and propulsion-related events, although the cause for about one in four breakups remains uncertain. Recent disclosures by the Russian Government reinforced suspicions that Cosmos 1275 was an accidental collision, the first assessment of its type. Alternately, the fragmentation of Cosmos 1823, another candidate accidental on-orbit collision, has been categorized in prior editions of this document under the "Unknown" cause classification. Recent data from the Russian Govenrment has now identified the failure mechanism of this satellite to be a battery failure under the "Electrical" cause classification. This document will continue to carry fragmentations causes as unknown until a strong case can be made for one of the other cause classifications. Deliberate actions are the most frequent cause, often associated with weapons testing or other activities related to national security; but on the average, the resulting debris from deliberate actions is short-lived (Figures 2.2 and 2.3). Propulsion-related breakups include catastrophic malfunctions during orbital injection or maneuvers, subsequent explosions based on residual propellants, and failures of active attitude control systems. Breakups of rocket bodies due to propulsion failures are usually more prolific and produce longer-lived debris than the intentional destructions of payloads, often due to the higher altitudes of the malfunctioning rocket bodies rather than the mechanics of the explosive event. Although it may appear obvious that a rocket body fragmentation should be classified under the "Propulsion-related" cause category, rocket body events are carried as "Unknown" until a failure mechanism is identified for that rocket body design and is associated with a given rocket body event.

The rate of satellite breakups increased noticeably in the 1970's and again in the 1980's (Figure 2.4). However, the long-term effects of these 1980's events were mitigated by the reduced average number of debris generated per event and the relatively short debris lifetimes. More importantly, increased awareness of the potential hazards of orbital debris may be responsible for the elimination or marked curtailment of many breakup causes by the end of the 1980's, e.g. Delta second stages, weapons testing, and Cosmos 699- and 862-type events. Together, these four programs were responsible for one-half of all satellite breakups in the decade of the 1980's. The quick response of Arianespace and the European Space Agency to the breakup of an Ariane third stage in 1986 is indicative of a desire by most space-faring organizations to operate in near-Earth space responsibly. The number of satellite breakups and the remaining debris by country or organization are indicated in Figures 2.5 and 2.6. Finally, Figure 2.7 vividly illustrates that satellite breakup debris remaining in orbit today have primarily originated from rocket bodies.

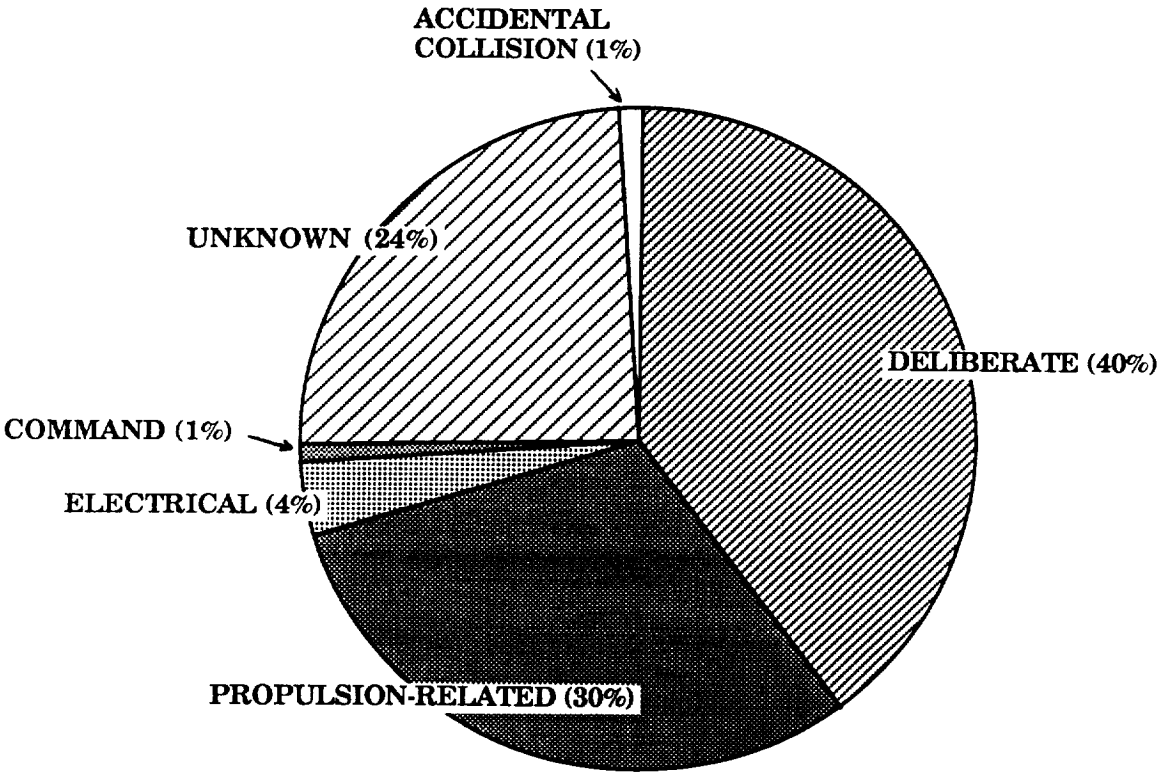


Figure 2.1 Causes of known satellite breakups.

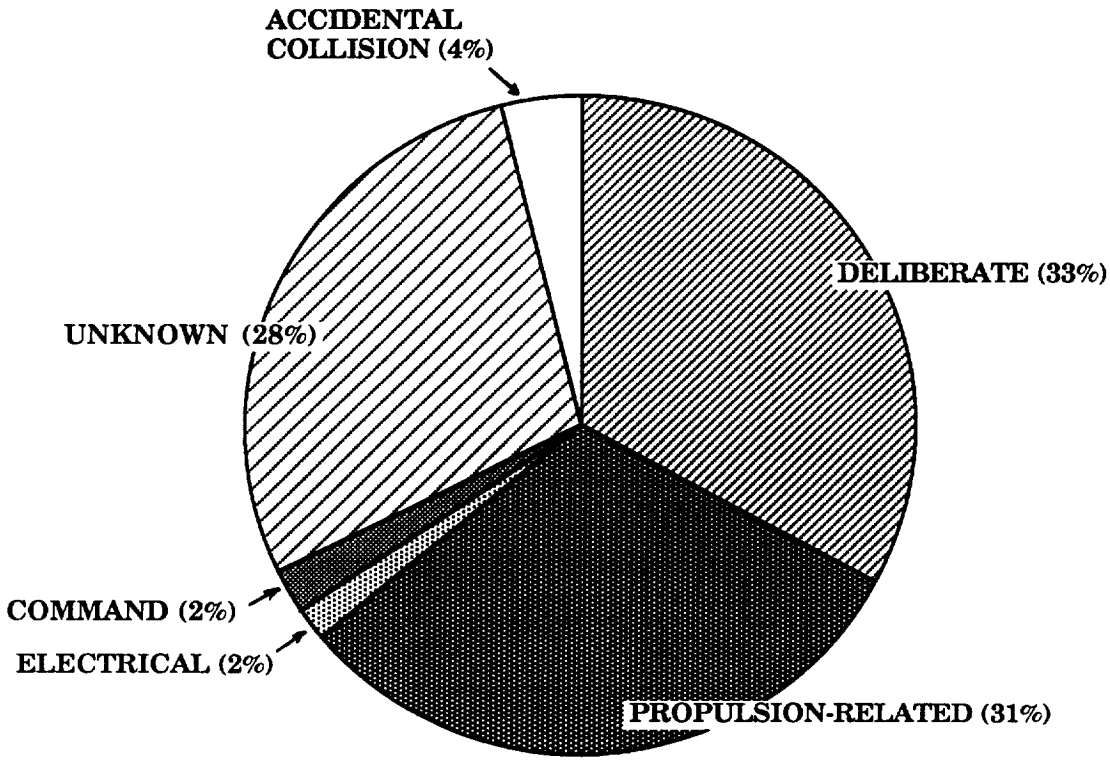


Figure 2.2 Proportion of all cataloged satellite breakup debris.

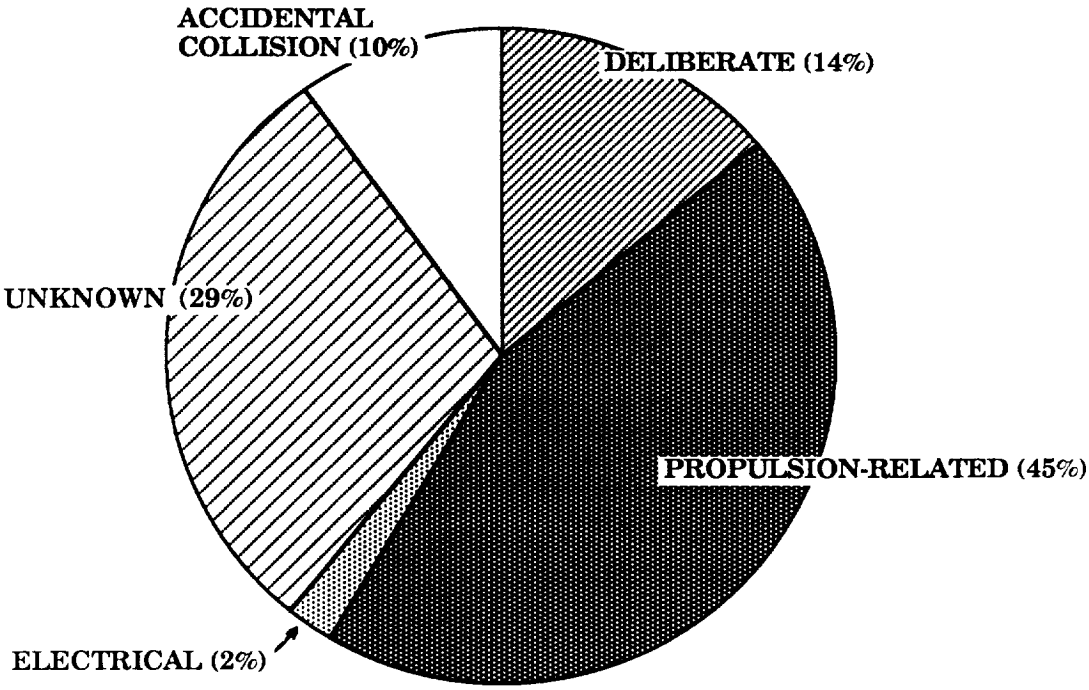


Figure 2.3 Proportion of cataloged satellite breakup debris remaining in orbit.

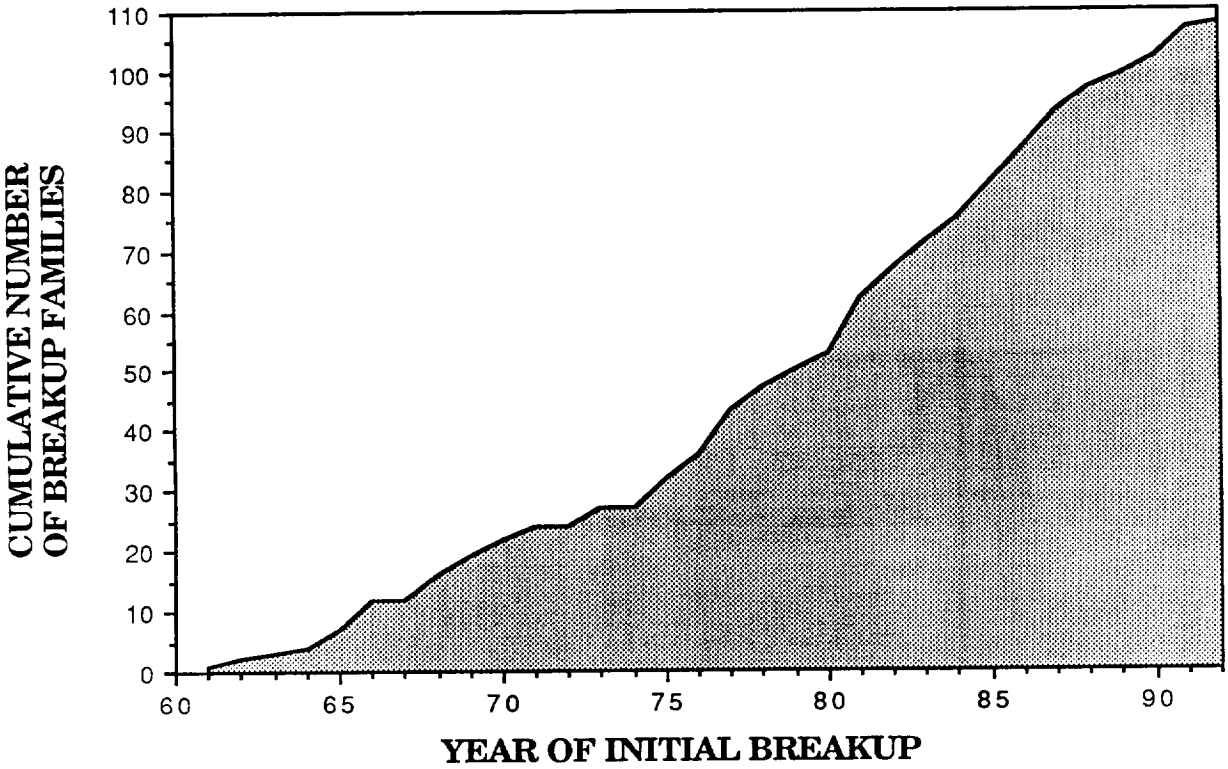


Figure 2.4 Chronological history of satellite breakups.

The remainder of this section devotes two pages to each identified satellite breakup. Each satellite is listed by common name, international designator, and satellite number. The satellite is then described in terms of type, ownership, launch date, and physical characteristics. The third grouping defines the breakup event by time, location, altitude, and assessed cause. In almost all cases, the calculated time of the event has been determined by NAVSPASUR. The last available element set for the satellite prior to the breakup is provided next. If the breakup occurred soon after launch or after a maneuver and before an element set could be generated, the most appropriate post-event element set is given. Basic characteristics of the cataloged debris cloud, including total number of fragments cataloged by 1 April 1992, the number of debris remaining in orbit on that date, and the maximum observed changes in the orbital period (ΔP) and inclination (ΔI), referenced to the parent's pre-event element set, are summarized. The reader is reminded that for a given event, the magnitudes of the resultant ΔP and ΔI are a function of the satellite's latitude and altitude. Comparisons of these values from one event to another cannot be made directly. Additionally, inclination changes measure only one portion of the fragmentation orbital plane change. Changes in Right Ascension also occur in most events and can account for some plane change fragmentation energy. Objects from the launch not associated with the breakup are not included in these counts (see Section 5.0). As previously noted, the number of cataloged debris is often an unreliable description of the breakup. Whenever uncataloged data provide a better assessment of ΔP and ΔI, these values are listed with a footnote.

A general summary of the event, actions leading to the event, debris cataloging progress, and evaluations of the event are collected under the Comments heading. Documents which relate directly to the subject breakup or to breakups of satellites of this type are then listed. All references in this volume are archived at the TBE Colorado Springs Office. Finally, a Gabbard diagram of the early debris cloud prior to perturbative effects, if the data were available, is reconstructed. These diagrams often include uncataloged as well as cataloged debris data. When used correctly, Gabbard diagrams can provide important insights into the features of the fragmentation.

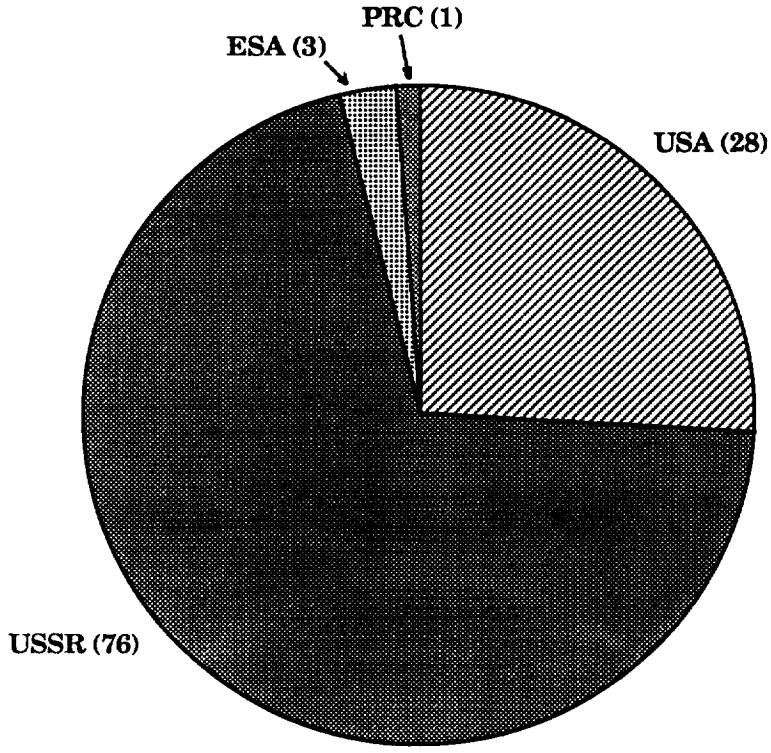


Figure 2.5 Sources of satellite breakups by owner.

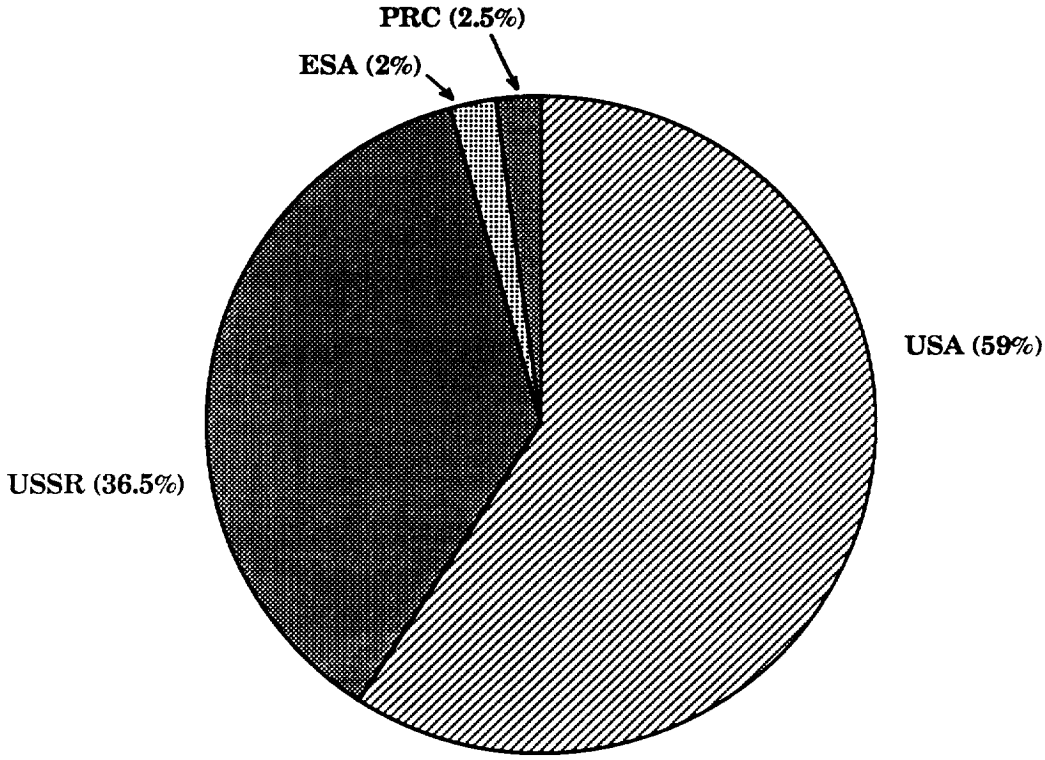


Figure 2.6 Proportion of satellite breakup debris remaining in orbit.

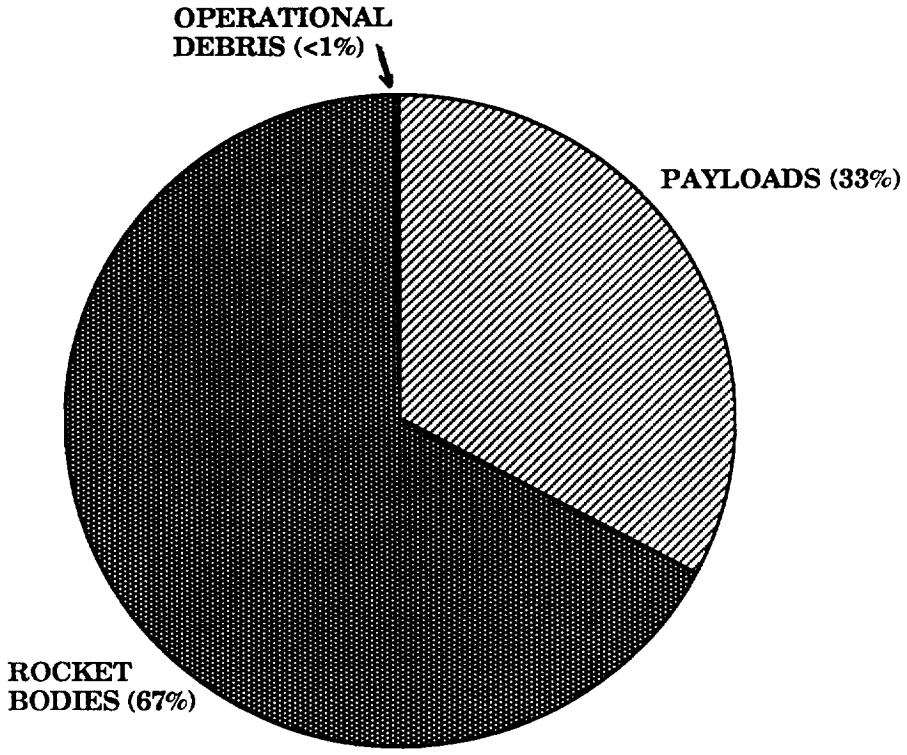


Figure 2.7 Sources of satellite breakup debris by satellite type.

TABLE 2.1 HISTORY OF SATELLITE BREAKUPS BY LAUNCH DATE (As of 1 April 1992)

NAME	INTERNATIONAL DESIGNATOR	CATALOG NUMBER	LAUNCH DATE	EVENT DATE	DEBRIS CATALOGED	DEBRIS LEFT	APOGEE (KM)	PERIGEE (KM)	INCLINATION (DEG)	ASSESED CAUSE	COMMENT
TRANSIT 4A R/B	1961-OMI 3	118	29-Jun-61	29-Jun-61	296	198	995	880	66.8	PROPULSION	ABLESTAR STAGE
SPUTNIK 29	1962-B IOT 1	443	24-Oct-62	29-Oct-62	24	0	260	200	65.1	PROPULSION	SL-6 FINAL STAGE
ATLAS CENTAUR 2	1963-47A	694	27-Nov-63	27-Nov-63	19	10	1785	475	30.3	PROPULSION	CENTAUR STAGE
COSMOS 50	1964-70A	919	28-Oct-64	5-Nov-64	96	0	220	175	51.2	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 57	1965-12A	1093	22-Feb-65	22-Feb-65	167	0	425	165	64.8	COMMAND	INADVERTENT DESTRUCTION
COSMOS 61-63 R/B	1965-20D	1270	15-Mar-65	15-Mar-65	147	22	1825	260	56.1	UNKNOWN	SL-8 FINAL STAGE
OV2-1/LCS 2 R/B	1965-82B	1640	15-Oct-65	15-Oct-65	469	57	790	710	32.2	PROPULSION	TITAN 3C-4 TRANSTAGE
OPS 3031	1966-12C	2015	15-Feb-66	15-Feb-66	38	0	270	150	96.5	UNKNOWN	
GEMINI 9 ATDA R/B	1966-46B	2188	1-Jun-66	Mid-Jun-66	51	0	275	240	28.8	UNKNOWN	ATLAS CORE STAGE
PAGEOS	1966-56A	2253	24-Jun-66	12-Jul-75 20-Jan-76 10-Sep-76 Mid-Jun-78 Mid-Sep-84 Mid-Dec-85	79	3	5170 5425	3200 2935	85.3 85.1	UNKNOWN UNKNOWN UNKNOWN UNKNOWN UNKNOWN UNKNOWN	NUMEROUS OTHER EVENTS
AS-203	1966-59A	2289	5-Jul-66	5-Jul-66	34	0	215	185	32.0	DELIBERATE	SATURN SIVB STAGE
USSR UNKNOWN 1	1966-88A	2437	17-Sep-66	17-Sep-66	53	0	855	140	49.6	UNKNOWN	
USSR UNKNOWN 2	1966-101A	2536	2-Nov-66	2-Nov-66	41	0	885	145	49.6	UNKNOWN	
APOLLO 6 R/B (S4B)	1968-25B	3171	4-Apr-68	13-Apr-68	16	0	360	200	32.6	PROPULSION	SATURN SIVB STAGE
OV2-5 R/B	1968-81 E	3432	76-Sep-68	21-Feb-92	1	1	35812	35102	11.9	UNKNOWN	
COSMOS 248	1968-90A	3503	19-Oct-68	1-Nov-68	5	0	545	475	62.2	DELIBERATE	TEST
COSMOS 249	1968-91A	3504	20-Oct-68	20-Oct-68	109	57	2165	490	62.3	DELIBERATE	TEST
COSMOS 252	1968-97A	3530	1-Nov-68	1-Nov-68	140	53	2140	535	62.3	DELIBERATE	TEST
METEOR 1-1 R/B	1969-29B	3836	26-Mar-69	28-Mar-69	37	0	850	460	81.2	UNKNOWN	SL-3 FINAL STAGE
INTELSAT 3 F-5 R/B	1969-64B	4052	26-Jul-69	26-Jul-69	26	1	5445	270	30.4	PROPULSION	TE 364-4 STAGE
OPS 7613 R/B	1969-82AB	4159	30-Sep-69	4-Oct-69	260	107	940	905	70.0	UNKNOWN	AGENA D STAGE

TABLE 2.1 HISTORY OF SATELLITE BREAKUPS BY LAUNCH DATE (continued)

NAME	INTERNATIONAL DESIGNATOR	CATALOG NUMBER	LAUNCH DATE	EVENT DATE	DEBRIS CATALOGED	DEBRIS LEFT	APOGEE (KM)	PERIGEE (KM)	INCLINATION (DEG)	ASSESED CAUSE	COMMENT
NIMBUS 4 R/B	1970-25C	4367	8-Apr-70	17-Oct-70	370	276	1085	1065	99.9	UNKNOWN	AGENA D STAGE
		4601		23-Jan-85						UNKNOWN	2 ADDITIONAL OBJECTS
		4649		17-Dec-85						UNKNOWN	3 ADDITIONAL OBJECTS
		4610		2-Sep-86						UNKNOWN	2 ADDITIONAL OBJECTS
		4601		23-Dec-91						UNKNOWN	5 ADDITIONAL OBJECTS
COSMOS 374	1970-89A	4594	23-Oct-70	23-Oct-70	103	39	2130	530	62.9	DELIBERATE	TEST
COSMOS 375	1970-91A	4598	30-Oct-70	30-Oct-70	47	27	2100	525	62.8	DELIBERATE	TEST
COSMOS 397	1971-15A	4964	25-Feb-71	25-Feb-71	116	63	2200	575	65.8	DELIBERATE	TEST
COSMOS 462	1971-106A	5646	3-Dec-71	3-Dec-71	25	0	1800	230	65.7	DELIBERATE	TEST
LANDSAT 1 R/B	1972-58B	6127	23-Jul-72	22-May-75	226	55	910	635	98.3	PROPULSION	DELTA SECOND STAGE
SALYUT 2 R/B	1973-17B	6399	3-Apr-73	3-Apr-73	25	0	245	195	51.5	UNKNOWN	SL-13 FINAL STAGE
COSMOS 554	1973-21A	6432	19-Apr-73	6-May-73	195	0	350	170	72.9	DELIBERATE	PAYLOAD RECOVERY FAILURE
NOAA 3 R/B	1973-86B	6921	6-Nov-73	28-Dec-73	197	180	1510	1500	102.1	PROPULSION	DELTA SECOND STAGE
NOAA 4 R/B	1974-89D	7532	15-Nov-74	20-Aug-75	147	129	1460	1445	101.7	PROPULSION	DELTA SECOND STAGE
COSMOS 699	1974-103A	7587	24-Dec-74	17-Apr-75	50	0	445	425	65.0	DELIBERATE	FIRST OF COSMOS 699 CLASS
				2-Aug-75			440	415	65.0	DELIBERATE	
LANDSAT 2 R/B	1975-04B	7616	22-Jan-75	9-Feb-76	207	43	915	740	97.8	UNKNOWN	DELTA SECOND STAGE
				19-Jun-76			910	745	97.7	PROPULSION	
NIMBUS 6 R/B	1975-52B	7946	12-Jun-75	1-May-91	233	191	1103	1093	99.6	PROPULSION	DELTA SECOND STAGE
COSMOS 758	1975-80A	8191	5-Sep-75	6-Sep-75	76	0	325	175	67.1	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 777	1975-102A	8416	29-Oct-75	25-Jan-76	62	0	440	430	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 838	1976-63A	8932	2-Jul-76	17-May-77	40	0	445	415	65.1	DELIBERATE	COSMOS 699 CLASS
COSMOS 839	1976-67A	9011	8-Jul-76	29-Sep-77	69	66	2100	980	65.9	UNKNOWN	FIRST OF COSMOS 839 CLASS
COSMOS 844	1976-72A	9046	22-Jul-76	25-Jul-76	248	0	355	170	67.1	DELIBERATE	PAYLOAD RECOVERY FAILURE
NOAA 5 R/B	1976-77B	9063	29-Jul-76	24-Dec-77	159	155	1520	1505	102.0	PROPULSION	DELTA SECOND STAGE
COSMOS 862	1976-105A	9495	22-Oct-76	15-Mar-77	11	11	39645	765	63.2	PROPULSION	FIRST OF COSMOS 862 CLASS
COSMOS 880	1976-120A	9601	9-Dec-76	27-Nov-78	49	2	620	550	65.8	UNKNOWN	COSMOS 839 CLASS
COSMOS 886	1976-126A	9634	27-Dec-76	27-Dec-76	76	63	2295	595	65.8	DELIBERATE	TEST

TABLE 2.1 HISTORY OF SATELLITE BREAKUPS BY LAUNCH DATE (continued)

NAME	INTERNATIONAL DESIGNATOR	CATALOG NUMBER	LAUNCH DATE	EVENT DATE	DEBRIS CATALOGED	DEBRIS LEFT	APOGEE (KM)	PERIGEE (KM)	INCLINATION (DEG)	ASSESED CAUSE	COMMENT
COSMOS 903	1977-27A	9911	11-Apr-77	8-Jun-78	2	2	39035	1325	63.2	PROPULSION	COSMOS 862 CLASS
COSMOS 917	1977-47A	10059	16-Jun-77	30-Mar-79	1	1	38725	1645	62.9	PROPULSION	COSMOS 862 CLASS
HIMAWARI 1 R/B	1977-65B	10144	14-Jul-77	14-Jul-77	169	82	2025	535	29.0	PROPULSION	DELTA SECOND STAGE
COSMOS 931	1977-68A	10150	20-Jul-77	24-Oct-77	6	5	39665	680	62.9	PROPULSION	COSMOS 862 CLASS
EKRAN 2	1977-92A	10365	20-Sep-77	25-Jun-78	1	1	35798	35786	0.1	ELECTRICAL	Ni H2 BATTERY MALFUNCTION
COSMOS 970	1977-121A	10531	21-Dec-77	21-Dec-77	70	68	1140	945	65.8	DELIBERATE	TEST
LANDSAT 3 R/B	1978-26C	10704	5-Mar-78	27-Jan-81	208	149	910	900	98.8	PROPULSION	DELTA SECOND STAGE
COSMOS 1030	1978-83A	11015	6-Sep-78	10-Oct-78	4	4	39760	665	62.8	PROPULSION	COSMOS 862 CLASS
NIMBUS 7 R/B	1978-98B	11081	24-Oct-78	26-Dec-81	1	1	955	935	99.3	UNKNOWN	DELTA SECOND STAGE
COSMOS 1045 R/B	1978-100D	11087	26-Oct-78	9-May-88	42	42	1705	1685	82.6	UNKNOWN	SL-14 FINAL STAGE
P-78 (SOLWIND)	1979-17A	11278	24-Feb-79	13-Sep-85	285	12	545	515	97.6	DELIBERATE	TEST
COSMOS 1094	1979-33A	11333	18-Apr-79	17-Sep-79	1	0	405	380	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1109	1979-58A	11417	27-Jun-79	Mid-Feb-80	6	6	39425	960	63.3	PROPULSION	COSMOS 862 CLASS
COSMOS 1124	1979-77A	11509	28-Aug-79	9-Sep-79	5	5	39795	570	63.0	PROPULSION	COSMOS 862 CLASS
CAT R/B	1979-104B	11659	24-Dec-79	Apr-80	1	0	33140	180	17.9	UNKNOWN	ARIANE 1 FINAL STAGE
COSMOS 1167	1980-21A	11729	14-Mar-80	15-Jul-81	12	0	450	355	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1174	1980-30A	11765	18-Apr-80	18-Apr-80	46	11	1660	380	66.1	DELIBERATE	TEST
COSMOS 1191	1980-57A	11871	2-Jul-80	14-May-81	2	2	39255	1110	62.6	PROPULSION	COSMOS 862 CLASS
COSMOS 1220	1980-89A	12054	4-Nov-80	20-Jun-82	78	1	885	570	65.0	DELIBERATE	COSMOS 699 CLASS
				25-Aug-82			885	565	65.0	DELIBERATE	
COSMOS 1247	1981-16A	12303	19-Feb-81	20-Oct-81	4	4	39390	970	63.0	PROPULSION	COSMOS 862 CLASS
COSMOS 1260	1981-28A	12364	20-Mar-81	8-May-82	68	1	750	450	65.0	DELIBERATE	COSMOS 699 CLASS
				10-Aug-82			750	445	65.0	DELIBERATE	
COSMOS 1261	1981-31A	12376	31-Mar-81	Apr/May-81	4	4	39765	610	63.0	PROPULSION	COSMOS 862 CLASS
COSMOS 1275	1981-53A	12504	4-Jun-81	24-Jul-81	306	279	1015	960	83.0	COLLISION	UNPLANNED IMPACT
COSMOS 1278	1981-58A	12547	19-Jun-81	Early-Dec-86	2	2	37690	2665	67.1	PROPULSION	COSMOS 862 CLASS

TABLE 2.1 HISTORY OF SATELLITE BREAKUPS BY LAUNCH DATE (continued)

NAME	INTERNATIONAL DESIGNATOR	CATALOG NUMBER	LAUNCH DATE	EVENT DATE	DEBRIS CATALOGED	DEBRIS LEFT	APOGEE (KM)	PERIGEE (KM)	INCLINATION (DEG)	ASSESED CAUSE	COMMENT
COSMOS 1285	1981-71A	12627	4-Aug-81	21-Nov-81	3	3	40100	720	63.1	PROPULSION	COSMOS 862 CLASS
COSMOS 1286	1981-72A	12631	4-Aug-81	29-Sep-82	2	0	325	300	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1305 R/B	1981-88F	12827	11-Sep-81	11-Sep-81	3	3	13795	605	62.8	PROPULSION	SL-6 FINAL STAGE
COSMOS 1306	1981-89A	12828	14-Sep-81	12-Jul-82	8	0	405	380	64.9	DELIBERATE	COSMOS 699 CLASS
				18-Sep-82			370	370	64.9	DELIBERATE	
COSMOS 1317	1981-108A	12933	31-Oct-81	Late-Jan-84	4	4	39055	1315	62.8	PROPULSION	COSMOS 862 CLASS
COSMOS 1355	1982-38A	13150	29-Apr-82	8-Aug-83	29	0	395	360	65.1	DELIBERATE	COSMOS 699 CLASS
				1-Feb-84			320	305	65.0	DELIBERATE	
				20-Feb-84			290	270	65.0	DELIBERATE	
COSMOS 1375	1982-55A	13259	6-Jun-82	21-Oct-85	58	57	1000	990	65.8	UNKNOWN	COSMOS 839 CLASS
COSMOS 1405	1982-88A	13508	4-Sep-82	20-Dec-83	32	0	340	310	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1423 R/B	1982-115E	13696	8-Dec-82	8-Dec-82	29	0	427	235	62.9	PROPULSION	SL-6 FINAL STAGE
ASTRON DEB	1983-20B	13902	23-Mar-83	3-Sep-84	1	0	1230	220	51.5	UNKNOWN	SL-12 FINAL STAGE DEBRIS
NOAA 8	1983-22A	13923	28-Mar-83	30-Dec-85	7	1	830	805	98.6	ELECTRICAL	BATTERY MALFUNCTION
COSMOS 1456	1983-38A	14034	25-Apr-83	13-Aug-83	4	4	39630	730	63.3	PROPULSION	COSMOS 862 CLASS
COSMOS 1461	1983-44A	14064	7-May-83	11-Mar-85	158	3	890	570	65.0	DELIBERATE	COSMOS 699 CLASS
				13-May-85			885	570	65.0	DELIBERATE	
COSMOS 1481	1983-70A	14182	8-Jul-83	9-Jul-83	3	3	39225	625	62.9	PROPULSION	COSMOS 862 CLASS
COSMOS 1519-21 DEB	1983-127H	14608	29-Dec-83	4-Feb-91	4	4	18805	340	51.9	UNKNOWN	SL-12 FINAL STAGE DEBRIS
PALAPA B2 R/B	1984-11E	14693	3-Feb-84	6-Feb-84	3	1	285	275	28.5	PROPULSION	PAM-D UPPER STAGE (See WESTAR 6 R/B)
WESTAR 6 R/B	1984-11F	14694	3-Feb-84	3-Feb-84	14	1	310	305	28.5	PROPULSION	PAM-D UPPER STAGE (See PALAPA B2 R/B)
COSMOS 1588	1984-83A	15167	7-Aug-84	23-Feb-86	45	0	440	410	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1646	1985-30A	15653	18-Apr-85	20-Nov-87	24	0	410	385	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1654	1985-39A	15734	23-May-85	21-Jun-85	18	0	300	185	64.9	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 1656 DEB	1985-42E	15773	30-May-85	5-Jan-88	6	6	860	810	66.6	UNKNOWN	SL-12 FINAL STAGE DEBRIS

TABLE 2.1 HISTORY OF SATELLITE BREAKUPS BY LAUNCH DATE (concluded)

NAME	INTERNATIONAL DESIGNATOR	CATALOG NUMBER	LAUNCH DATE	EVENT DATE	DEBRIS CATALOGED	DEBRIS LEFT	APOGEE (KM)	PERIGEE (KM)	INCLINATION (DEG)	ASSESED CAUSE	COMMENT
COSMOS 1682	1985-82A	16054	19-Sep-85	18-Dec-86	23	0	475	385	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1691	1985-94B	16139	9-Oct-85	22-Nov-85	14	11	1415	1410	82.6	ELECTRICAL	Ni H2 BATTERY MALFUNCTION
COSMOS 1710-2 DEB	1985-118L	16446	24-Dec-85	29-Dec-91	1	1	18886	654	65.3	UNKNOWN	SL-12 FINAL STAGE DEBRIS
SPOT 1 R/B	1986-19C	16615	22-Feb-86	13-Nov-86	489	59	835	805	98.7	UNKNOWN	ARIANE 1 FINAL STAGE
COSMOS 1769	1986-59A	16895	4-Aug-86	21-Sep-87	4	0	445	310	65.0	DELIBERATE	COSMOS 699 CLASS
USA 19	1986-69A	16937	5-Sep-86	5-Sep-86	13	0	745	210	39.1	DELIBERATE	TEST (SEE ALSO USA 19 R/B)
USA 19 R/B	1986-69B	16938	5-Sep-86	5-Sep-86	5	0	610	220	22.8	DELIBERATE	TEST (SEE ALSO USA 19)
COSMOS 1813	1987-04A	17297	15-Jan-87	29-Jan-87	194	0	415	360	72.8	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 1823	1987-20A	17535	20-Feb-87	17-Dec-87	110	49	1525	1480	73.6	ELECTRICAL	Ni H2 BATTERY MALFUNCTION
COSMOS 1866	1987-59A	18184	9-Jul-87	26-Jul-87	9	0	255	155	67.1	DELIBERATE	PAYLOAD RECOVERY FAILURE
AUSSAT/ECS R/B	1987-78C	18352	16-Sep-87	Mid-Sep-87	2	2	36515	245	6.9	UNKNOWN	ARIANE 3 FINAL STAGE
COSMOS 1906	1987-108A	18713	26-Dec-87	31-Jan-88	37	0	265	245	82.6	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 1916	1988-07A	18823	3-Feb-88	27-Feb-88	1	0	230	150	64.8	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 2030	1989-54A	20124	12-Jul-89	28-Jul-89	1	0	215	150	67.1	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 2031	1989-56A	20136	18-Jul-89	31-Aug-89	9	0	365	240	50.5	DELIBERATE	PAYLOAD RECOVERY FAILURE
FENGYUN 1-2 R/B	1990-81D	20791	3-Sep-90	4-Oct-90	73	70	895	880	98.9	UNKNOWN	CZ-4A FINAL STAGE
COSMOS 2101	1990-87A	20828	1-Oct-90	30-Nov-90	4	0	280	195	64.8	DELIBERATE	PAYLOAD RECOVERY FAILURE
USA 68	1990-105A	20978	1-Dec-90	1-Dec-90	29	6	850	610	98.9	PROPULSION	TE-M-364-15 UPPER STAGE
COSMOS 2125-32 R/B	1991-09J	21108	12-Feb-91	5-Mar-91	70	70	1725	1460	74.0	UNKNOWN	SL-8 FINAL STAGE; UP TO 9 OTHER MINOR EVENTS
COSMOS 2163	1991-71A	21741	9-Oct-91	6-Dec-91	1	0	259	187	64.8	DELIBERATE	PAYLOAD RECOVERY FAILURE
				TOTAL	7707	2849					

TABLE 2.2 HISTORY OF SATELLITE BREAKUPS BY EVENT DATE (As of 1 April 1992)

NAME	INTERNATIONAL DESIGNATOR	CATALOG NUMBER	LAUNCH DATE	EVENT DATE	DEBRIS CATALOGED	DEBRIS LEFT	APOGEE (KM)	PERIGEE (KM)	INCLINATION (DEG)	ASSESED CAUSE	COMMENT
TRANSIT 4A R/B	1961-OMI 3	118	29-Jun-61	29-Jun-61	296	198	995	880	66.8	PROPULSION	ABLESTAR STAGE
SPUTNIK 29	1962-B IOT 1	443	24-Oct-62	29-Oct-62	24	0	260	200	65.1	PROPULSION	SL-6 FINAL STAGE
ATLAS CENTAUR 2	1963-47A	694	27-Nov-63	27-Nov-63	19	10	1785	475	30.3	PROPULSION	CENTAUR STAGE
COSMOS 50	1964-70A	919	28-Oct-64	5-Nov-64	96	0	220	175	51.2	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 57	1965-12A	1093	22-Feb-65	22-Feb-65	167	0	425	165	64.8	COMMAND	INADVERTENT DESTRUCTION
COSMOS 61-63 R/B	1965-20D	1270	15-Mar-65	15-Mar-65	147	22	1825	260	56.1	UNKNOWN	SL-8 FINAL STAGE
OV2-1/LCS 2 R/B	1965-82B	1640	15-Oct-65	15-Oct-65	469	57	790	710	32.2	PROPULSION	TITAN 3C-4 TRANSTAGE
OPS 3031	1966-12C	2015	15-Feb-66	15-Feb-66	38	0	270	150	96.5	UNKNOWN	
GEMINI 9 ATDA R/B	1966-46B	2188	1-Jun-66	Mid-Jun-66	51	0	275	240	28.8	UNKNOWN	ATLAS CORE STAGE
AS-203	1966-59A	2289	5-Jul-66	5-Jul-66	34	0	215	185	32.0	DELIBERATE	SATURN SIVB STAGE
USSR UNKNOWN 1	1966-88A	2437	17-Sep-66	17-Sep-66	53	0	855	140	49.6	UNKNOWN	
USSR UNKNOWN 2	1966-101A	2536	2-Nov-66	2-Nov-66	41	0	885	145	49.6	UNKNOWN	
APOLLO 6 R/B (S4B)	1968-25B	3171	4-Apr-68	13-Apr-68	16	0	360	200	32.6	PROPULSION	SATURN SIVB STAGE
COSMOS 249	1968-91A	3504	20-Oct-68	20-Oct-68	109	57	2165	490	62.3	DELIBERATE	TEST
COSMOS 248	1968-90A	3503	19-Oct-68	1-Nov-68	5	0	545	475	62.2	DELIBERATE	TEST
COSMOS 252	1968-97A	3530	1-Nov-68	1-Nov-68	140	53	2140	535	62.3	DELIBERATE	TEST
METEOR 1-1 R/B	1969-29B	3836	26-Mar-69	28-Mar-69	37	0	850	460	81.2	UNKNOWN	SL-3 FINAL STAGE
INTELSAT 3 F-5 R/B	1969-64B	4052	26-Jul-69	26-Jul-69	26	1	5445	270	30.4	PROPULSION	TE 364-4 STAGE
OPS 7613 R/B	1969-82AB	4159	30-Sep-69	4-Oct-69	260	107	940	905	70.0	UNKNOWN	AGENA D STAGE
NIMBUS 4 R/B	1970-25C	4367	8-Apr-70	17-Oct-70	370	276	1085	1065	99.9	UNKNOWN	AGENA D STAGE
		4601		23-Jan-85						UNKNOWN	2 ADDITIONAL OBJECTS
		4649		17-Dec-85						UNKNOWN	3 ADDITIONAL OBJECTS
		4610		2-Sep-86						UNKNOWN	2 ADDITIONAL OBJECTS
		4601		23-Dec-91						UNKNOWN	5 ADDITIONAL OBJECTS
COSMOS 374	1970-89A	4594	23-Oct-70	23-Oct-70	103	39	2130	530	62.9	DELIBERATE	TEST
COSMOS 375	1970-91A	4598	30-Oct-70	30-Oct-70	47	27	2100	525	62.8	DELIBERATE	TEST

TABLE 2.2 HISTORY OF SATELLITE BREAKUPS BY EVENT DATE (continued)

NAME	INTERNATIONAL DESIGNATOR	CATALOG NUMBER	LAUNCH DATE	EVENT DATE	DEBRIS CATALOGED	DEBRIS LEFT	APOGEE (KM)	PERIGEE (KM)	INCLINATION (DEG)	ASSESED CAUSE	COMMENT
COSMOS 397	1971-15A	4964	25-Feb-71	25-Feb-71	116	63	2200	575	65.8	DELIBERATE	TEST
COSMOS 462	1971-106A	5646	3-Dec-71	3-Dec-71	25	0	1800	230	65.7	DELIBERATE	TEST
SALYUT 2 R/B	1973-17B	6399	3-Apr-73	3-Apr-73	25	0	245	195	51.5	UNKNOWN	SL-13 FINAL STAGE
COSMOS 554	1973-21A	6432	19-Apr-73	6-May-73	195	0	350	170	72.9	DELIBERATE	PAYLOAD RECOVERY FAILURE
NOAA 3 R/B	1973-86B	6921	6-Nov-73	28-Dec-73	197	180	1510	1500	102.1	PROPULSION	DELTA SECOND STAGE
COSMOS 699	1974-103A	7587	24-Dec-74	17-Apr-75	50	0	445	425	65.0	DELIBERATE	FIRST OF COSMOS 699 CLASS
				2-Aug-75			440	415	65.0	DELIBERATE	
LANDSAT 1 R/B	1972-58B	6127	23-Jul-72	22-May-75	226	55	910	635	98.3	PROPULSION	DELTA SECOND STAGE
PAGEOS	1966-56A	2253	24-Jun-66	12-Jul-75	79	3	5170	3200	85.3	UNKNOWN	NUMEROUS OTHER EVENTS
				20-Jan-76			5425	2935	85.1	UNKNOWN	
				10-Sep-76						UNKNOWN	
				Mid-Jun-78						UNKNOWN	
				Mid-Sep-84						UNKNOWN	
				Mid-Dec-85						UNKNOWN	
NOAA 4 R/B	1974-89D	7532	15-Nov-74	20-Aug-75	147	129	1460	1445	101.7	PROPULSION	DELTA SECOND STAGE
COSMOS 758	1975-80A	8191	5-Sep-75	6-Sep-75	76	0	325	175	67.1	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 777	1975-102A	8416	29-Oct-75	25-Jan-76	62	0	440	430	65.0	DELIBERATE	COSMOS 699 CLASS
LANDSAT 2 R/B	1975-04B	7616	22-Jan-75	9-Feb-76	207	43	915	740	97.8	UNKNOWN	DELTA SECOND STAGE
				19-Jun-76			910	745	97.7	PROPULSION	
COSMOS 844	1976-72A	9046	22-Jul-76	25-Jul-76	248	0	355	170	67.1	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 886	1976-126A	9634	27-Dec-76	27-Dec-76	76	63	2295	595	65.8	DELIBERATE	TEST
COSMOS 862	1976-105A	9495	22-Oct-76	15-Mar-77	11	11	39645	765	63.2	PROPULSION	FIRST OF COSMOS 862 CLASS
COSMOS 838	1976-63A	8932	2-Jul-76	17-May-77	40	0	445	415	65.1	DELIBERATE	COSMOS 699 CLASS
HIMAWARI 1 R/B	1977-65B	10144	14-Jul-77	14-Jul-77	169	82	2025	535	29.0	PROPULSION	DELTA SECOND STAGE
COSMOS 839	1976-67A	9011	8-Jul-76	29-Sep-77	69	66	2100	980	65.9	UNKNOWN	FIRST OF COSMOS 839 CLASS
COSMOS 931	1977-68A	10150	20-Jul-77	24-Oct-77	6	5	39665	680	62.9	PROPULSION	COSMOS 862 CLASS
COSMOS 970	1977-121A	10531	21-Dec-77	21-Dec-77	70	68	1140	945	65.8	DELIBERATE	TEST
NOAA 5 R/B	1976-77B	9063	29-Jul-76	24-Dec-77	159	155	1520	1505	102.0	PROPULSION	DELTA SECOND STAGE

TABLE 2.2 HISTORY OF SATELLITE BREAKUPS BY EVENT DATE (concluded)

NAME	INTERNATIONAL DESIGNATOR	CATALOG NUMBER	LAUNCH DATE	EVENT DATE	DEBRIS CATALOGED	DEBRIS LEFT	APOGEE (KM)	PERIGEE (KM)	INCLINATION (DEG)	ASSESED CAUSE	COMMENT
COSMOS 903	1977-27A	9911	11-Apr-77	8-Jun-78	2	2	39035	1325	63.2	PROPULSION	COSMOS 862 CLASS
EKRAN 2	1977-92A	10365	20-Sep-77	25-Jun-78	1	1	35798	35786	0.1	ELECTRICAL	Ni H2 BATTERY MALFUNCTION
COSMOS 1030	1978-83A	11015	6-Sep-78	10-Oct-78	4	4	39760	665	62.8	PROPULSION	COSMOS 862 CLASS
COSMOS 880	1976-120A	9601	9-Dec-76	27-Nov-78	49	2	620	550	65.8	UNKNOWN	COSMOS 839 CLASS
COSMOS 917	1977-47A	10059	16-Jun-77	30-Mar-79	1	1	38725	1645	62.9	PROPULSION	COSMOS 862 CLASS
COSMOS 1124	1979-77A	11509	28-Aug-79	9-Sep-79	5	5	39795	570	63.0	PROPULSION	COSMOS 862 CLASS
COSMOS 1094	1979-33A	11333	18-Apr-79	17-Sep-79	1	0	405	380	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1109	1979-58A	11417	27-Jun-79	Mid-Feb-80	6	6	39425	960	63.3	PROPULSION	COSMOS 862 CLASS
CAT R/B	1979-104B	11659	24-Dec-79	Apr-80	1	0	33140	180	17.9	UNKNOWN	ARIANE 1 FINAL STAGE
COSMOS 1174	1980-30A	11765	18-Apr-80	18-Apr-80	46	11	1660	380	66.1	DELIBERATE	TEST
LANDSAT 3 R/B	1978-26C	10704	5-Mar-78	27-Jan-81	208	149	910	900	98.8	PROPULSION	DELTA SECOND STAGE
COSMOS 1261	1981-31A	12376	31-Mar-81	Apr/May-81	4	4	39765	610	63.0	PROPULSION	COSMOS 862 CLASS
COSMOS 1191	1980-57A	11871	2-Jul-80	14-May-81	2	2	39255	1110	62.6	PROPULSION	COSMOS 862 CLASS
COSMOS 1167	1980-21A	11729	14-Mar-80	15-Jul-81	12	0	450	355	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1275	1981-53A	12504	4-Jun-81	24-Jul-81	306	279	1015	960	83.0	COLLISION	UNPLANNED IMPACT
COSMOS 1305 R/B	1981-88F	12827	11-Sep-81	11-Sep-81	3	3	13795	605	62.8	PROPULSION	SL-6 FINAL STAGE
COSMOS 1247	1981-16A	12303	19-Feb-81	20-Oct-81	4	4	39390	970	63.0	PROPULSION	COSMOS 862 CLASS
COSMOS 1285	1981-71A	12627	4-Aug-81	21-Nov-81	3	3	40100	720	63.1	PROPULSION	COSMOS 862 CLASS
NIMBUS 7 R/B	1978-98B	11081	24-Oct-78	26-Dec-81	1	1	955	935	99.3	UNKNOWN	DELTA SECOND STAGE
COSMOS 1260	1981-28A	12364	20-Mar-81	8-May-82	68	1	750	450	65.0	DELIBERATE	COSMOS 699 CLASS
				10-Aug-82			750	445	65.0	DELIBERATE	
COSMOS 1220	1980-89A	12054	4-Nov-80	20-Jun-82	78	1	885	570	65.0	DELIBERATE	COSMOS 699 CLASS
				25-Aug-82			885	565	65.0	DELIBERATE	
COSMOS 1306	1981-89A	12828	14-Sep-81	12-Jul-82	8	0	405	380	64.9	DELIBERATE	COSMOS 699 CLASS
				18-Sep-82			370	370	64.9	DELIBERATE	
COSMOS 1286	1981-72A	12631	4-Aug-81	29-Sep-82	2	0	325	300	65.0	DELIBERATE	COSMOS 699 CLASS

TABLE 2.2 HISTORY OF SATELLITE BREAKUPS BY EVENT DATE (continued)

NAME	INTERNATIONAL DESIGNATOR	CATALOG NUMBER	LAUNCH DATE	EVENT DATE	DEBRIS CATALOGED	DEBRIS LEFT	APOGEE (KM)	PERIGEE (KM)	INCLINATION (DEG)	ASSESED CAUSE	COMMENT
COSMOS 1423 R/B	1982-115E	13696	8-Dec-82	8-Dec-82	29	0	427	235	62.9	PROPULSION	SL-6 FINAL STAGE
COSMOS 1481	1983-70A	14182	8-Jul-83	9-Jul-83	3	3	39225	625	62.9	PROPULSION	COSMOS 862 CLASS
COSMOS 1355	1982-38A	13150	29-Apr-82	8-Aug-83	29	0	395	360	65.1	DELIBERATE	COSMOS 699 CLASS
				1-Feb-84			320	305	65.0	DELIBERATE	
				20-Feb-84			290	270	65.0	DELIBERATE	
COSMOS 1456	1983-38A	14034	25-Apr-83	13-Aug-83	4	4	39630	730	63.3	PROPULSION	COSMOS 862 CLASS
COSMOS 1405	1982-88A	13508	4-Sep-82	20-Dec-83	32	0	340	310	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1317	1981-108A	12933	31-Oct-81	Late-Jan-84	4	4	39055	1315	62.8	PROPULSION	COSMOS 862 CLASS
WESTAR 6 R/B	1984-11F	14694	3-Feb-84	3-Feb-84	14	1	310	305	28.5	PROPULSION	PAM-D UPPER STAGE
PALAPA B2 R/B	1984-11E	14693	3-Feb-84	6-Feb-84	3	1	285	275	28.5	PROPULSION	PAM-D UPPER STAGE
ASTRON DEB	1983-20B	13902	23-Mar-83	3-Sep-84	1	0	1230	220	51.5	UNKNOWN	SL-12 FINAL STAGE DEBRIS
COSMOS 1461	1983-44A	14064	7-May-83	11-Mar-85	158	3	890	570	65.0	DELIBERATE	COSMOS 699 CLASS
				13-May-85			885	570	65.0	DELIBERATE	
COSMOS 1654	1985-39A	15734	23-May-85	21-Jun-85	18	0	300	185	64.9	DELIBERATE	PAYLOAD RECOVERY FAILURE
P-78 (SOLWIND)	1979-17A	11278	24-Feb-79	13-Sep-85	285	12	545	515	97.6	DELIBERATE	TEST
COSMOS 1375	1982-55A	13259	6-Jun-82	21-Oct-85	58	57	1000	990	65.8	UNKNOWN	COSMOS 839 CLASS
COSMOS 1691	1985-94B	16139	9-Oct-85	22-Nov-85	14	11	1415	1410	82.6	ELECTRICAL	Ni H2 BATTERY MALFUNCTION
NOAA 8	1983-22A	13923	28-Mar-83	30-Dec-85	7	1	830	805	98.6	ELECTRICAL	BATTERY MALFUNCTION
COSMOS 1588	1984-83A	15167	7-Aug-84	23-Feb-86	45	0	440	410	65.0	DELIBERATE	COSMOS 699 CLASS
USA 19	1986-69A	16937	5-Sep-86	5-Sep-86	13	0	745	210	39.1	DELIBERATE	TEST (SEE ALSO USA 19 R/B)
USA 19 R/B	1986-69B	16938	5-Sep-86	5-Sep-86	5	0	610	220	22.8	DELIBERATE	TEST (SEE ALSO USA 19)
SPOT 1 R/B	1986-19C	16615	22-Feb-86	13-Nov-86	489	59	835	805	98.7	UNKNOWN	ARIANE 1 FINAL STAGE
COSMOS 1278	1981-58A	12547	19-Jun-81	Early-Dec-86	2	2	37690	2665	67.1	PROPULSION	COSMOS 862 CLASS
COSMOS 1682	1985-82A	16054	19-Sep-85	18-Dec-86	23	0	475	385	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1813	1987-04A	17297	15-Jan-87	29-Jan-87	194	0	415	360	72.8	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 1866	1987-59A	18184	9-Jul-87	26-Jul-87	9	0	255	155	67.1	DELIBERATE	PAYLOAD RECOVERY FAILURE

TABLE 2.2 HISTORY OF SATELLITE BREAKUPS BY EVENT DATE (continued)

NAME	INTERNATIONAL DESIGNATOR	CATALOG NUMBER	LAUNCH DATE	EVENT DATE	DEBRIS CATALOGED	DEBRIS LEFT	APOGEE (KM)	PERIGEE (KM)	INCLINATION (DEG)	ASSESED CAUSE	COMMENT
AUSSAT/ECS R/B	1987-78C	18352	16-Sep-87	Mid-Sep-87	2	2	36515	245	6.9	UNKNOWN	ARIANE 3 FINAL STAGE
COSMOS 1769	1986-59A	16895	4-Aug-86	21-Sep-87	4	0	445	310	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1646	1985-30A	15653	18-Apr-85	20-Nov-87	24	0	410	385	65.0	DELIBERATE	COSMOS 699 CLASS
COSMOS 1823	1987-20A	17535	20-Feb-87	17-Dec-87	110	49	1525	1480	73.6	ELECTRICAL	Ni H2 BATTERY MALFUNCTION
COSMOS 1656 DEB	1985-42E	15773	30-May-85	5-Jan-88	6	6	860	810	66.6	UNKNOWN	SL-12 FINAL STAGE DEBRIS
COSMOS 1906	1987-108A	18713	26-Dec-87	31-Jan-88	37	0	265	245	82.6	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 1916	1988-07A	18823	3-Feb-88	27-Feb-88	1	0	230	150	64.8	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 1045 R/B	1978-100D	11087	26-Oct-78	9-May-88	42	42	1705	1685	82.6	UNKNOWN	SL-14 FINAL STAGE
COSMOS 2030	1989-54A	20124	12-Jul-89	28-Jul-89	1	0	215	150	67.1	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 2031	1989-56A	20136	18-Jul-89	31-Aug-89	9	0	365	240	50.5	DELIBERATE	PAYLOAD RECOVERY FAILURE
FENGYUN 1-2 R/B	1990-81D	20791	3-Sep-90	4-Oct-90	73	70	895	880	98.9	UNKNOWN	CZ-4A FINAL STAGE
COSMOS 2101	1990-87A	20828	1-Oct-90	30-Nov-90	4	0	280	195	64.8	DELIBERATE	PAYLOAD RECOVERY FAILURE
USA 68	1990-105A	20978	1-Dec-90	1-Dec-90	29	6	850	610	98.9	PROPULSION	TE-M-364-15 UPPER STAGE
COSMOS 1519-21 DEB	1983-127H	14608	29-Dec-83	4-Feb-91	4	4	18805	340	51.9	UNKNOWN	SL-12 FINAL STAGE DEBRIS
COSMOS 2125-32 R/B	1991-09J	21108	12-Feb-91	5-Mar-91	70	70	1725	1460	74.0	UNKNOWN	SL-8 FINAL STAGE; UP TO 9
NIMBUS 6 R/B	1975-52B	7946	12-Jun-75	1-May-91	233	191	1103	1093	99.6	PROPULSION	DELTA SECOND STAGE
COSMOS 2163	1991-71A	21741	9-Oct-91	6-Dec-91	1	0	259	187	64.8	DELIBERATE	PAYLOAD RECOVERY FAILURE
COSMOS 1710-2 DEB	1985-118L	16446	24-Dec-85	29-Dec-91	1	1	18886	654	65.3	UNKNOWN	SL-12 FINAL STAGE DEBRIS
OV2-5 R/B	1968-81 E	3432	76-Sep-68	21-Feb-92	1	1	35812	35102	11.9	UNKNOWN	
				TOTAL	7707	2849					

2.2 IDENTIFIED SATELLITE BREAKUPS

SATELLITE DATA

TYPE:	Ablestar Stage
OWNER:	US
LAUNCH DATE:	29.18 Jun 1961
DRY MASS (KG):	625
MAIN BODY:	Flaired Cylinder; 1.6 m by 4.8 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	On-board propellants, range safety device

EVENT DATA

DATE:	29 Jun 1961	LOCATION:	28N, 254E (dsc)
TIME:	0608 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	990 km		

POST-EVENT ELEMENTS

EPOCH:	61187.36647288	MEAN ANOMALY:	72.1786
RIGHT ASCENSION:	79.1120	MEAN MOTION:	13.86864257
INCLINATION:	66.8199	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.0078181	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	288.2398	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	296	MAXIMUM ΔP:	15.5 min
DEBRIS IN ORBIT:	198	MAXIMUM ΔI:	1.3 deg

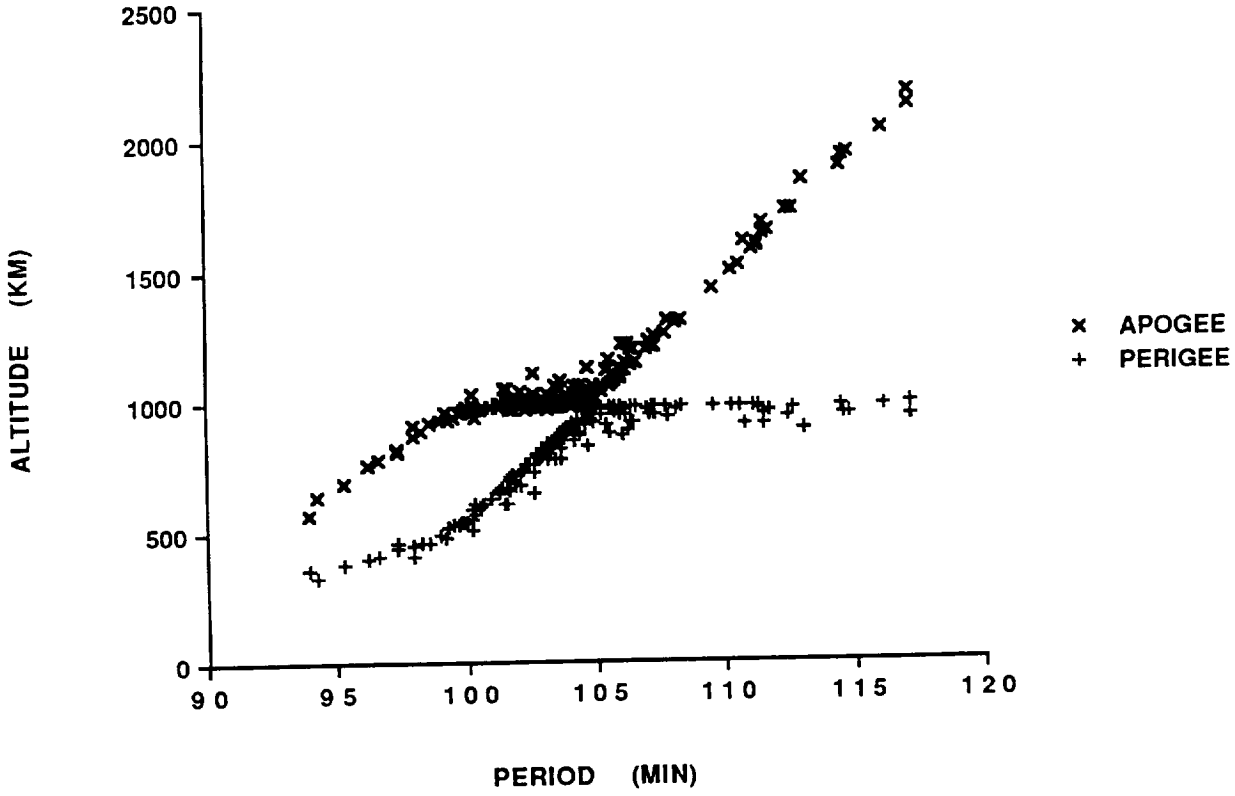
COMMENTS

This is the first known satellite fragmentation. The Ablestar stage performed two main burns and a small payload separation retro burn to successfully deploy three payloads (Transit 4A, Injun, and Solrad 3), although the Injun and Solrad 3 satellites did not separate from one another as planned. The event occurred approximately 77 minutes after orbital insertion and was photographically imaged by the Organ Pass, NM, Baker-Nunn camera system. Fragmentation coincided with cessation of the 378 MHz beacon on the Ablestar stage at 0608:10 GMT. At the time of the event, 100 kg of hypergolic propellants remained on board. This was the first time an Ablestar stage did not vent the fuel tank during payload separation. After a thorough investigation, fuel venting was recommended for future missions. No reliable elements are available prior to the event. Elements above are for one of the payloads with parameters believed to be very similar to those for the Ablestar at the time of the event.

REFERENCE DOCUMENTS

Transit 4-A Ablestar Vehicle Fragmentation Study (Preliminary), Report TOR-930(2102)-6, Flight Test Planning and Evaluation Department, Transit Program Office, USAF Systems Command, Inglewood, 28 August 1961.

Description, Operation and Performance of Ablestar Stage AJ10-104S, S/N 008 (Transit 4-A), T.W. Fehr and J.K. Stark, Preport No. 2102, Spacecraft Division, Aerojet-General Corporation, Azusa, October 1961.



Transit 4A R/B debris cloud of 201 cataloged fragments in May 1964 as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload and R/B(s) (?)
OWNER:	USSR
LAUNCH DATE:	24.75 Oct 1962
DRY MASS (KG):	3900-6200
MAIN BODY:	Cylinder; 2.7 m by 7-16 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Unknown at time of event
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	29 Oct 1962	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	~200 km		

PRE-EVENT ELEMENTS

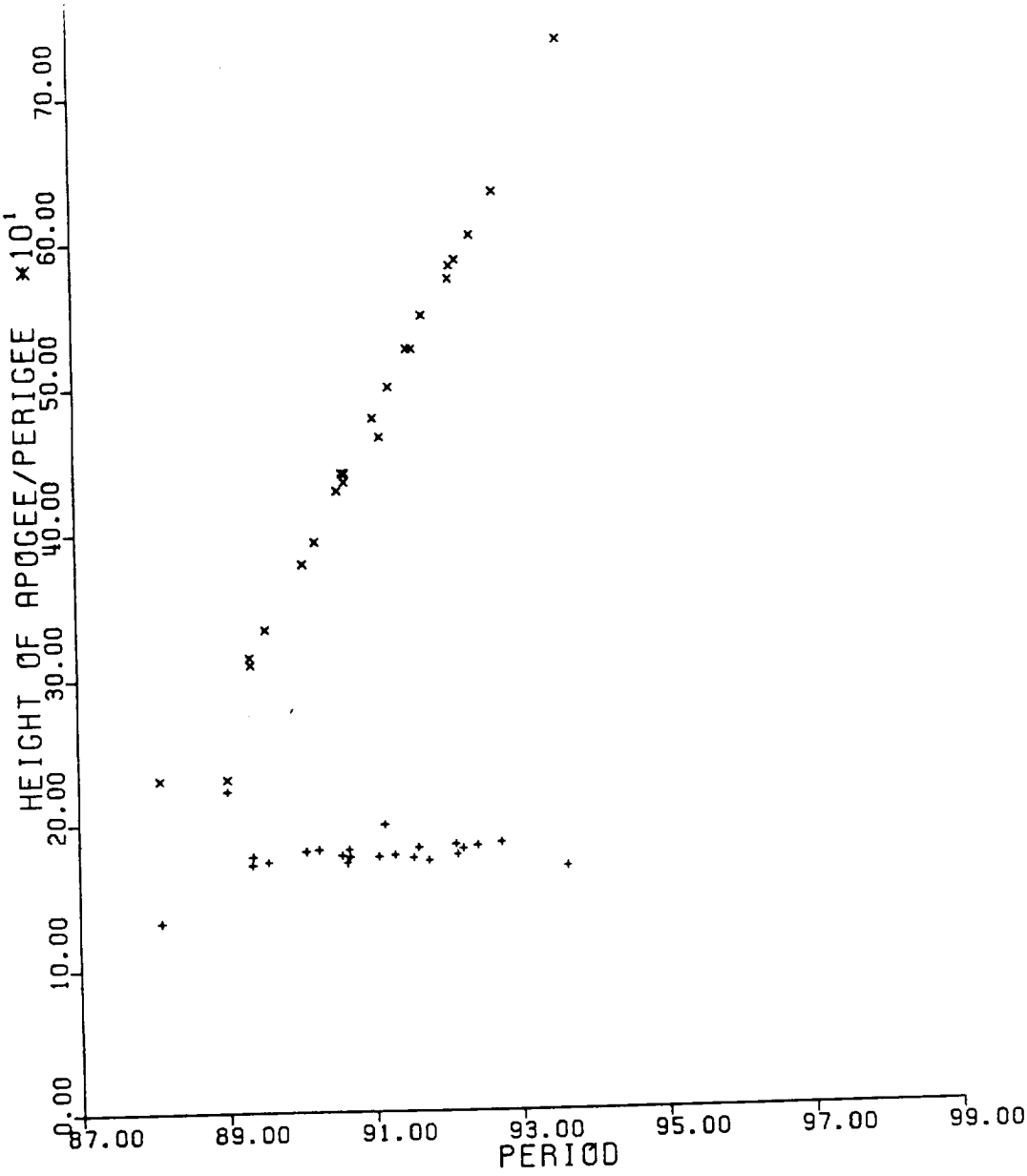
EPOCH:	62297.80327270	MEAN ANOMALY:	229.0409
RIGHT ASCENSION:	336.4972	MEAN MOTION:	16.15589719
INCLINATION:	65.1128	MEAN MOTION DOT/2:	.01124103
ECCENTRICITY:	.0044520	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	92.2650	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	24	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.6 deg

COMMENTS

Sputnik 29 (also known as Sputnik 22) was not acknowledged at launch by the USSR and was probably a Mars probe which failed to leave Earth orbit. This was apparently the fourth orbital failure of the SL-6 since 25 August 1962. No SL-6 orbital (3rd) stage nor final (4th) stage was cataloged after launch. Possible that orbital and final stages never separated. Sputnik 29 was officially decayed 29 October 1962 but no debris were cataloged before 11 November. Consequently, ΔP cannot be calculated. Source of the fragmentation was probably the fully-fueled SL-6 final stage.



Sputnik 29 debris cloud of 23 fragments cataloged by mid-December 1962 as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Centaur Stage
OWNER:	US
LAUNCH DATE:	27.79 Nov 1963
DRY MASS (KG):	4600
MAIN BODY:	Cylinder; 3 m by 9 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Unknown at time of the event
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	27 Nov 1963	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	Unknown		

POST-EVENT ELEMENTS

EPOCH:	63336.85832214	MEAN ANOMALY:	213.1623
RIGHT ASCENSION:	135.1828	MEAN MOTION:	13.34437775
INCLINATION:	30.3440	MEAN MOTION DOT/2:	.00003262
ECCENTRICITY:	.0869282	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	151.8246	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

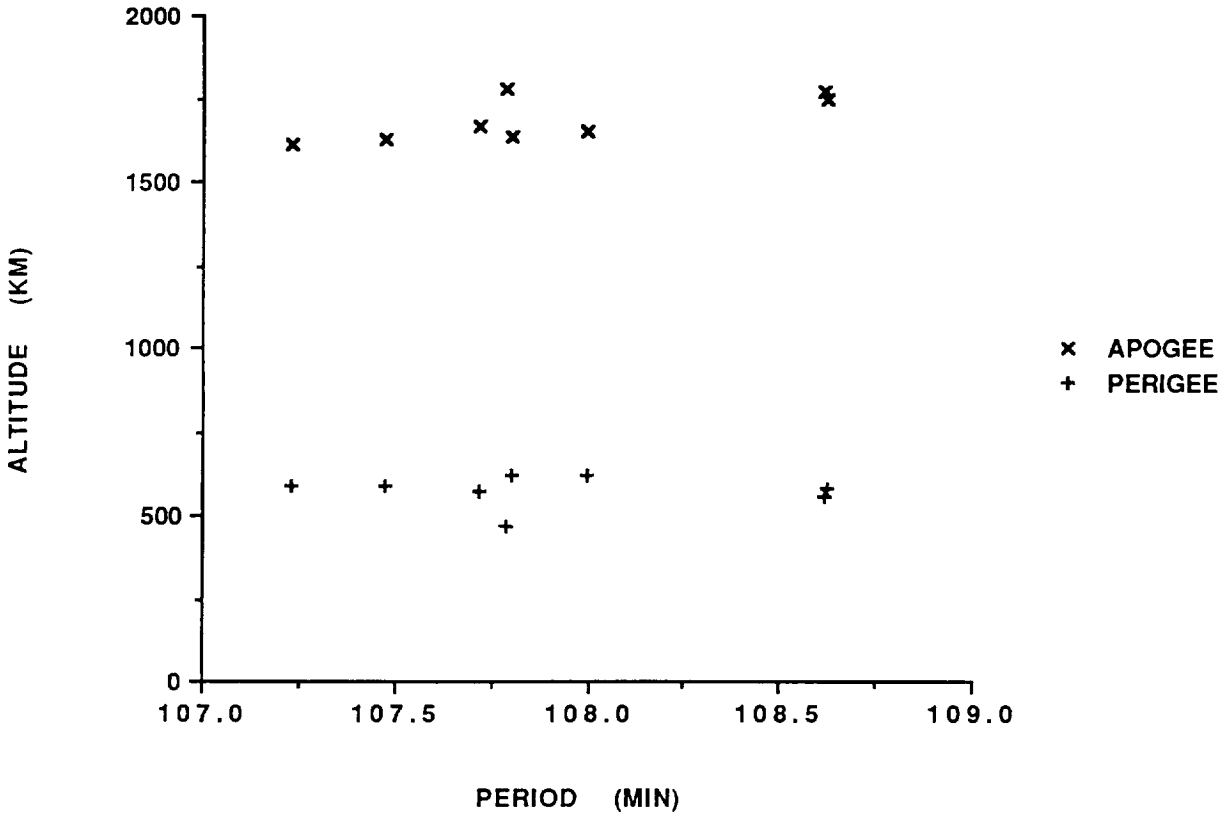
DEBRIS CATALOGED:	19	MAXIMUM ΔP:	0.9 min
DEBRIS IN ORBIT:	10	MAXIMUM ΔI:	0.4 deg

COMMENTS

First Centaur stage to reach Earth orbit. No payload was carried. After orbital insertion, residual liquid hydrogen vaporized, resulting in an increase in tank pressurization. Venting via an aft tube then induced a pin-wheel tumble which reached 48 rpm a little more than one hour after launch. At the beginning of the third orbit insulation blankets around the Centaur stage were thrown off. Subsequent Centaur missions were not subject to this phenomenon which was caused by the unique configuration of Atlas Centaur 2. First six fragments were cataloged within one week of launch. Centaur stage retains large radar cross-section, while all debris are substantially smaller.

REFERENCE DOCUMENTS

Supplementary Information on AC-2 Post-Injection Flight Events, W.S. Hicks, Memorandum BXN63-521, 27 December 1963.



Atlas Centaur 2 debris cloud of 8 fragments five months after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	28.45 Oct 1964
DRY MASS (KG):	4700 (approx.)
MAIN BODY:	Sphere-Cone; 2.4 m by 4.3 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, 10 kg TNT explosive charge

EVENT DATA

DATE:	5 Nov 1964	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	~200 km		

PRE-EVENT ELEMENTS

EPOCH:	64303.72916435	MEAN ANOMALY:	46.7488
RIGHT ASCENSION:	198.5952	MEAN MOTION:	16.23335350
INCLINATION:	51.2318	MEAN MOTION DOT/2:	.00269057
ECCENTRICITY:	.0034483	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	312.9624	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	96	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	Unknown

COMMENTS

Spacecraft was apparently destroyed after a malfunction prevented reentry and landing in the Soviet Union. First of 11 incidents of this type. Event occurred on the anticipated day of recovery. All debris were cataloged without elements. A probable fragment from this event reentered on 12 November 1964, landing in Malawi. See cited reference below.

REFERENCE DOCUMENTS

The Examination of a Sample of Space Debris, P.H.H. Bishop and K.F. Rogers, Technical Report 65165, Royal Aircraft Establishment, Farnborough Hants, August 1965.

Insufficient data to construct a Gabbard diagram.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	22.32 Feb 1965
DRY MASS (KG):	5500 (approx.)
MAIN BODY:	Cone-Sphere-Cone; 2.4 m by 6 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, 10 kg TNT explosive charge

EVENT DATA

DATE:	22 Feb 1965	LOCATION:	64S, 284E (asc)
TIME:	0957 GMT	ASSESSED CAUSE:	Command
ALTITUDE:	380 km		

POST-EVENT ELEMENTS

EPOCH:	65056.64509999	MEAN ANOMALY:	293.2095
RIGHT ASCENSION:	288.1532	MEAN MOTION:	15.92461677
INCLINATION:	64.7411	MEAN MOTION DOT/2:	.01501524
ECCENTRICITY:	.0182240	MEAN MOTION DOT DOT/6:	.0048063
ARG. OF PERIGEE:	68.7266	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	167	MAXIMUM ΔP:	4.4 min
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.9 deg

COMMENTS

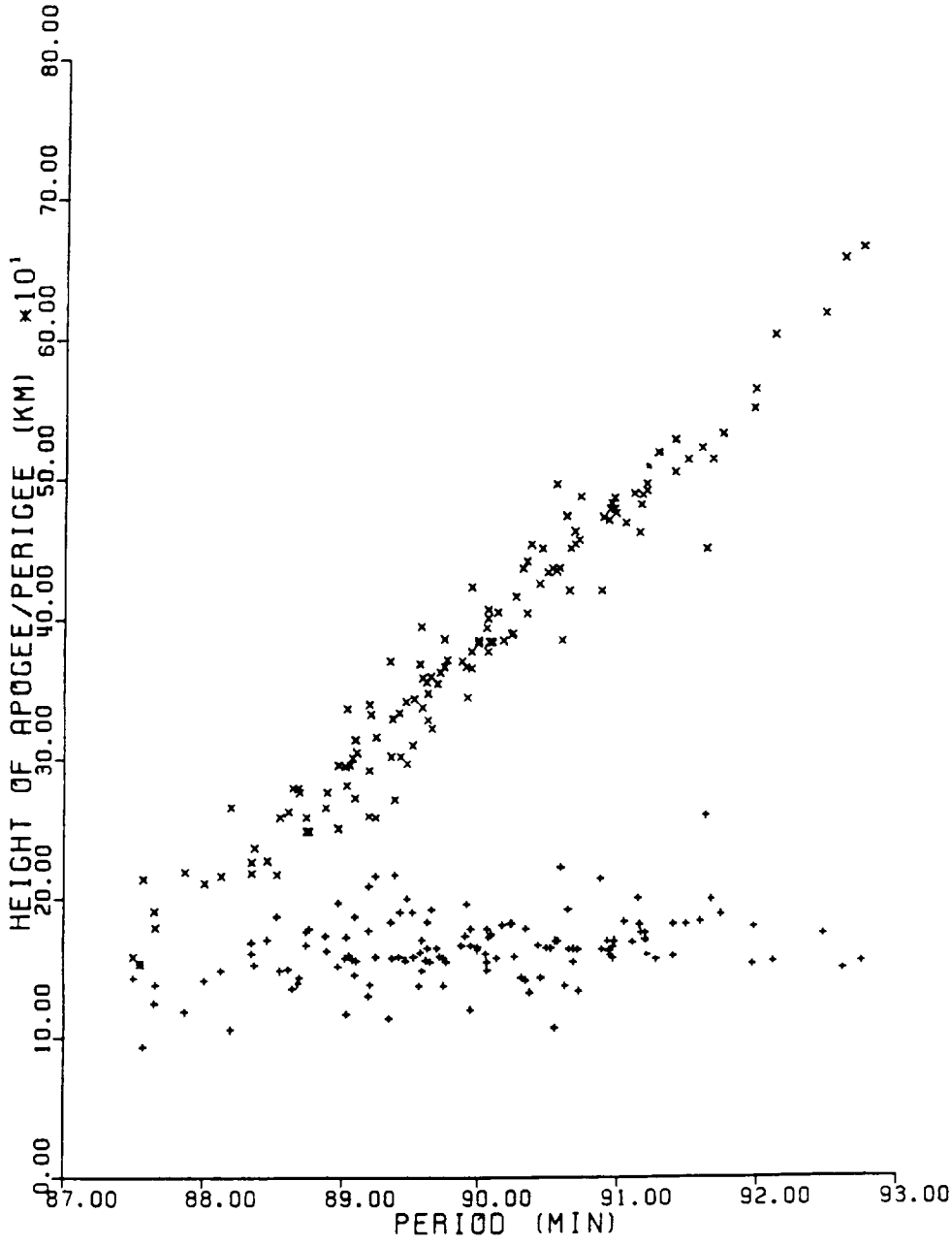
Cosmos 57 was an unmanned precursor for the manned Voskhod 2 mission which took place in March 1965. Spacecraft fragmented a little more than two hours after launch when operational ground instructions were misinterpreted by the on-board command system and the self-destruct system was activated. No elements available for Cosmos 57, but the rocket body elements are provided above. The Royal Aircraft Establishment published the following parameters for Cosmos 57 for 22.4 February: 165 km by 427 km, 64.74 deg inclination, 64 deg argument of perigee. A total of 35 debris were cataloged without elements. Event may have occurred a little later than the time calculated above.

REFERENCE DOCUMENTS

The 1093 Breakup, D.J. Watson, BMEWS-ADC Systems Engineering Memorandum BSM-1000-16, 16 June 1965.

"To Save Man: A Conversation with the General Designer of Life-Support and Rescue Systems, Hero of Socialist Labor G.I. Severin", Pravda, Moscow, 26 June 1989, p. 4.

"Pages From a Diary: He Soared Freely Above the Earth", Sovetskaya Rossiya, Moscow, 17 March 1990, p. 6.



Cosmos 57 debris cloud of 132 fragments cataloged within one month of the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	SL-8 Final Stage
OWNER:	USSR
LAUNCH DATE:	15.46 Mar 1965
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 2.4 m by 5 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None at time of event
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	15 Mar 1965	LOCATION:	51S, 162E (dsc)
TIME:	1714 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	1640 km		

POST-EVENT ELEMENTS

EPOCH:	65074.89183830	MEAN ANOMALY:	265.7165
RIGHT ASCENSION:	357.3218	MEAN MOTION:	13.57884745
INCLINATION:	56.0538	MEAN MOTION DOT/2:	.00231832
ECCENTRICITY:	.1056119	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	106.1560	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

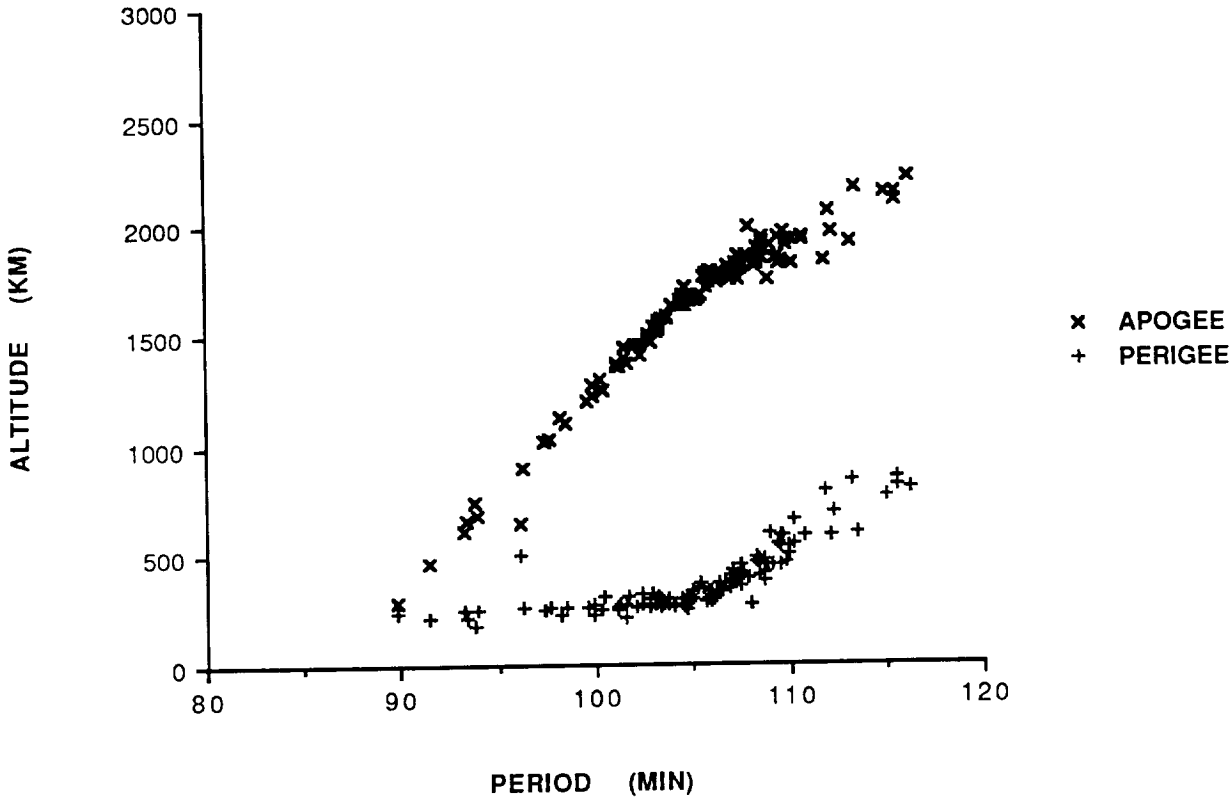
DEBRIS CATALOGED:	147	MAXIMUM ΔP:	10.3 min
DEBRIS IN ORBIT:	22	MAXIMUM ΔI:	0.4 deg

COMMENTS

This is the only confirmed case of the fragmentation of the SL-8 final stage. This was the third mission to deploy three payloads and was a repeat of the Cosmos 54-56 mission three weeks earlier. The event occurred a little more than 6 hours after the successful deployment of the three payloads. Elements above are the first developed for the rocket body and are about 4 hours after the event. Official debris cataloging did not begin for six weeks.

REFERENCE DOCUMENTS

"Fragmentations of Asteroids and Artificial Satellites in Orbit", W. Wiesel, Icarus, Vol. 34, 1978, pp. 99-116.



Cosmos 61-63 R/B debris cloud of 113 fragments eight months after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Titan 3C-4 Transtage
OWNER:	US
LAUNCH DATE:	15.72 Oct 1965
DRY MASS (KG):	1500 (?)
MAIN BODY:	Cylinder; 3 m by 6 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	15 Oct 1965	LOCATION:	22S, 108E (asc)
TIME:	1820 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	740 km		

POST-EVENT ELEMENTS

EPOCH:	65361.23126396	MEAN ANOMALY:	237.1066
RIGHT ASCENSION:	21.5316	MEAN MOTION:	14.54928550
INCLINATION:	32.1697	MEAN MOTION DOT/2:	.00000268
ECCENTRICITY:	.0072678	MEAN MOTION DOT DOT/6:	.071801
ARG. OF PERIGEE:	123.6068	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

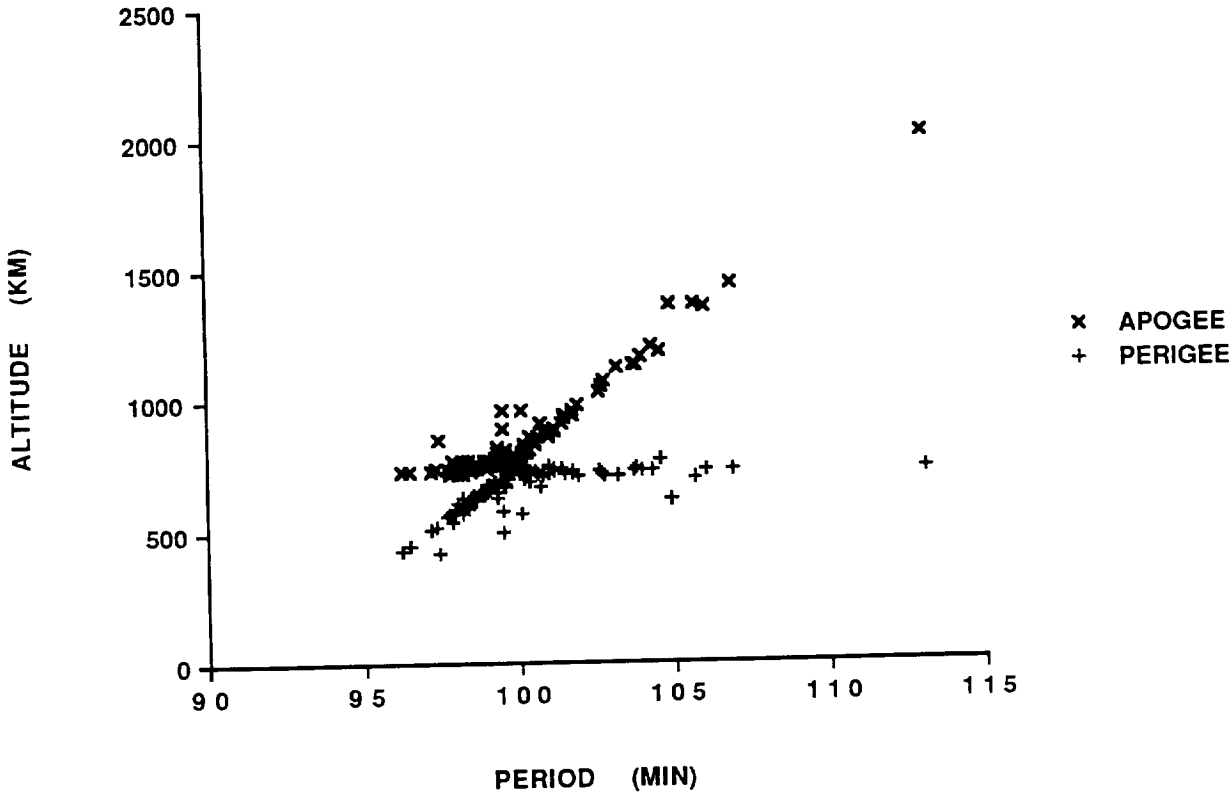
DEBRIS CATALOGED:	469	MAXIMUM ΔP:	4.1 min
DEBRIS IN ORBIT:	57	MAXIMUM ΔI:	1.4 deg

COMMENTS

This was the second test of the Titan 3C-4 Transtage with AJ10-138 engine using hypergolic propellants. Event occurred one-half revolution after launch following second ignition which may have been accompanied with vehicle tumbling. LCS 2 payload was to have been deployed at 735 km circular while OV2-1 was to have been released later in an orbit of 735 km by about 7400 km. Transtage also malfunctioned on next mission in December 1965. Rocket body not officially identified; main remnant may be satellite 1822.

REFERENCE DOCUMENTS

TRW Space Log, Winter 1965-66, Vol. 5, No. 4, T.L. Branigan, ed., TRW Systems, Redondo Beach, 1966, pp. 15-17.



OV2-1/LCS 2 R/B debris cloud of 103 cataloged fragments six weeks after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	US
LAUNCH DATE:	15.85 Feb 1966
DRY MASS (KG):	4
MAIN BODY:	Sphere; 0.3 m diameter
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	15 Feb 1966	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Unknown
ALTITUDE:	~200 km		

POST-EVENT ELEMENTS

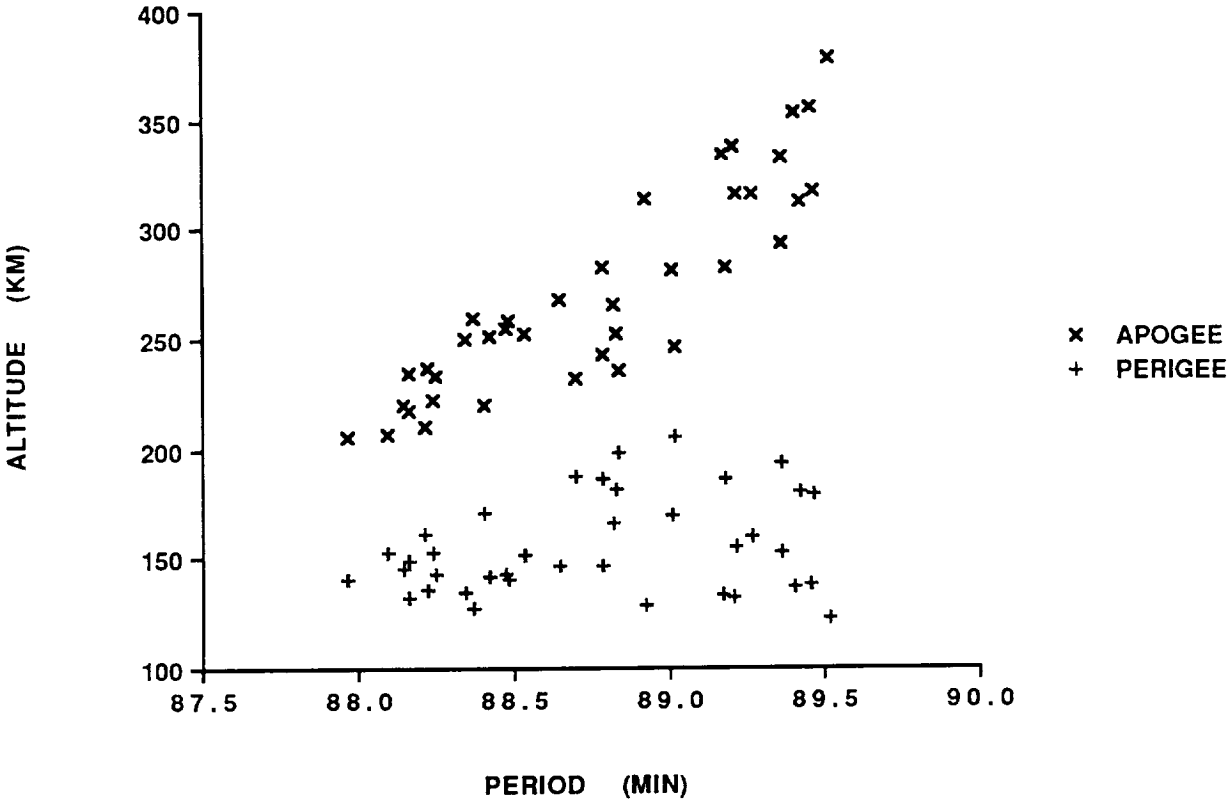
EPOCH:	66047.01671304	MEAN ANOMALY:	234.6777
RIGHT ASCENSION:	148.6481	MEAN MOTION:	16.20030654
INCLINATION:	96.5380	MEAN MOTION DOT/2:	.01298049
ECCENTRICITY:	.0108362	MEAN MOTION DOT DOT/6:	.0053719
ARG. OF PERIGEE:	126.3670	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	38	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.6 deg

COMMENTS

OPS 3031 was an inflated sphere also known as Bluebell 2. It was deployed from satellite 2012 which was an Agena D stage carrying a separate payload. Elements above are for satellite 2012. Debris cataloging began 19 February after many debris had already decayed. Consequently, ΔP cannot be calculated. OPS 3031 and all debris decayed within one week of launch.



OPS 3031 debris cloud of 38 fragments as initially cataloged by U.S. Space Surveillance Center during February, 1966.

SATELLITE DATA

TYPE:	Atlas Core Stage
OWNER:	US
LAUNCH DATE:	1.63 Jun 1966
DRY MASS (KG):	3400
MAIN BODY:	Cylinder; 3 m by 20 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	Mid-Jun 1966	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Unknown
ALTITUDE	~250 km		

PRE-EVENT ELEMENTS

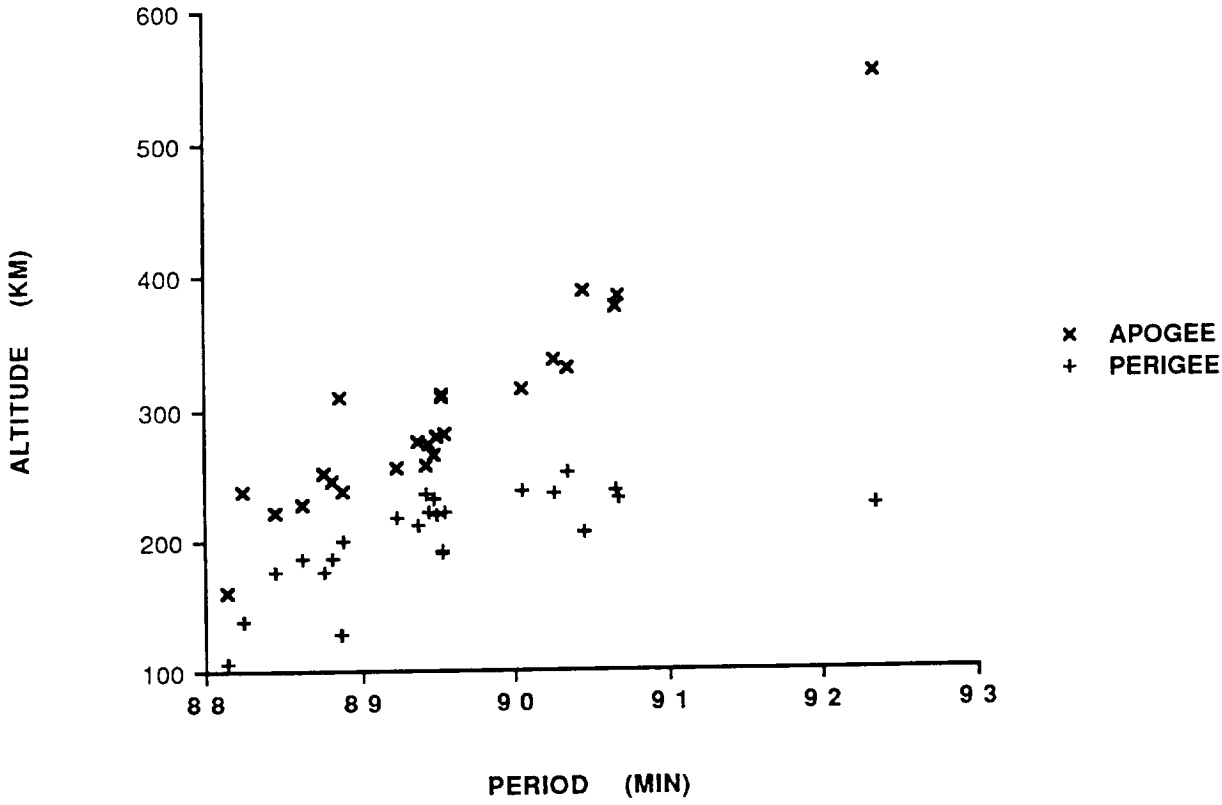
EPOCH:	66164.96883397	MEAN ANOMALY:	224.9775
RIGHT ASCENSION:	223.9064	MEAN MOTION:	16.05545399
INCLINATION:	28.7968	MEAN MOTION DOT/2:	.00654808
ECCENTRICITY:	.0025152	MEAN MOTION DOT DOT/6:	.0010778
ARG. OF PERIGEE:	135.2510	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	51	MAXIMUM ΔP:	5.5 min
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	1.5 deg

COMMENTS

This stage successfully deployed the Augmented Target Docking Adapter (ATDA) for the Gemini 9 mission. The elements above are the last available for the rocket body. Debris cataloging began on 21 June. Debris decay dates ranged from 21 June to 4 July with the rocket body officially decaying on 22 June. A review of NASA archives for this mission revealed no documented anomaly with the Atlas booster. Discussions in 1989 with General Dynamics personnel involved in the mission also failed to uncover any knowledge of the event.



Gemini 9 ATDA R/B debris cloud of 24 fragments cataloged between 21 and 24 June as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	US
LAUNCH DATE:	24.01 Jun 1966
DRY MASS (KG):	55
MAIN BODY:	Sphere; 30 m diameter
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None
ENERGY SOURCES:	None

EVENT DATA (1)

DATE:	12 Jul 1975	LOCATION:	67N, 135E (dsc)
TIME:	2248 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	5145 km		

PRE-EVENT ELEMENTS (1)

EPOCH:	75192.78059719	MEAN ANOMALY:	67.9594
RIGHT ASCENSION:	238.7429	MEAN MOTION:	7.99684492
INCLINATION:	85.2811	MEAN MOTION DOT/2:	.00001217
ECCENTRICITY:	.0931904	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	281.8264	BSTAR:	.77087

EVENT DATA (2)

DATE:	20 Jan 1976	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Unknown
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS (2)

EPOCH:	76019.86486339	MEAN ANOMALY:	305.5539
RIGHT ASCENSION:	209.8639	MEAN MOTION:	8.00368182
INCLINATION:	85.0720	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.1179567	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	66.4633	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	79	MAXIMUM ΔP:	0.1 min*
DEBRIS IN ORBIT:	3	MAXIMUM ΔI:	0.7 deg*

*Based on 1st event data

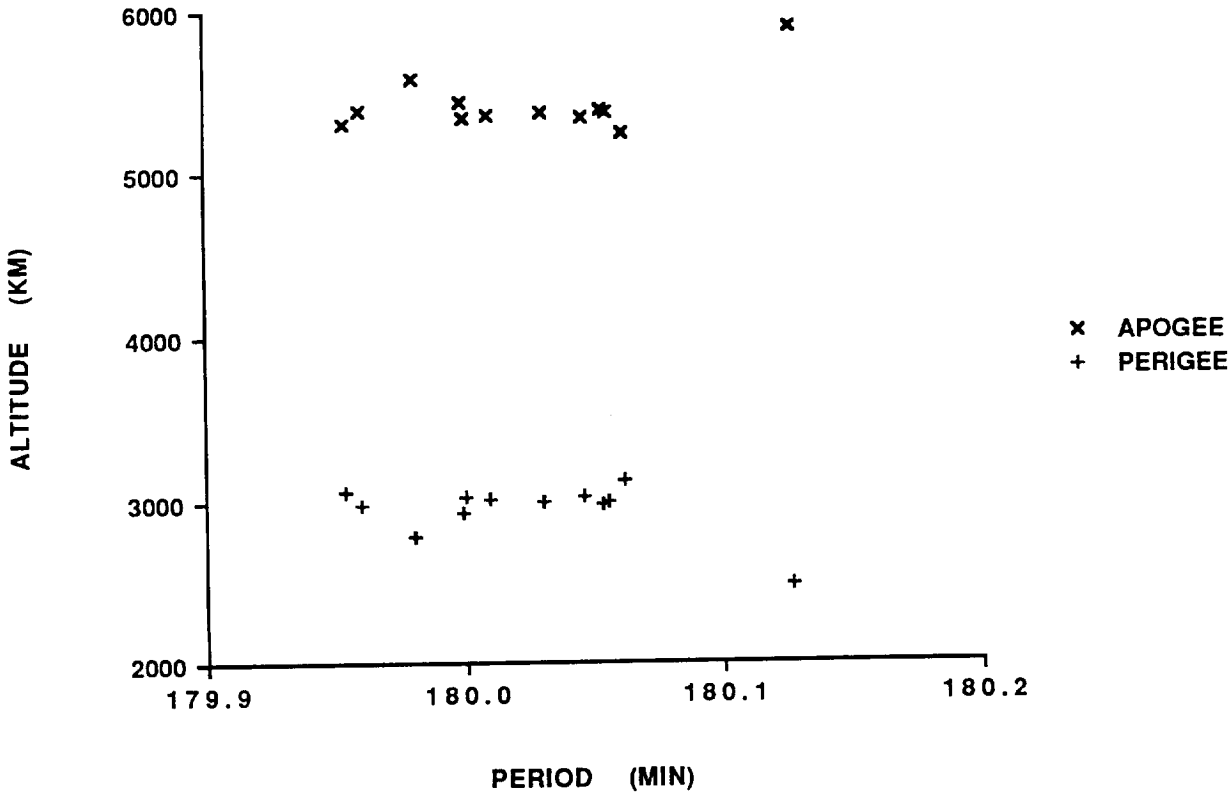
COMMENTS

PAGEOS (Passive Geodetic Earth-Orbiting Satellite) was an inflated balloon made of thin mylar with an aluminum coating. The first fragmentation event occurred nine years after launch and resulted in 11 new cataloged objects. The second event was detected by D.G. King-Hele of the RAE, and

NAVSPASUR confirmed 44 additional fragments. By August 1976 no additional debris had been cataloged but 19 objects were being tracked in orbits with mean motions near 8 and eccentricities between 0.16 and 0.34. Due to the character of PAGEOS and its subsequent debris, natural perturbations had little effect on orbital period but strongly increased eccentricity by simultaneously lowering perigee and raising apogee. About 10 September 1976 one of the 19 unofficial objects is believed to have broken up into perhaps more than 250 new pieces, none of which were cataloged prior to reentry. Eighteen objects were later cataloged during 7-8 October 1976. On the first anniversary of the second fragmentation (20 Jan 1977), 45 fragments were cataloged without elements and immediately decayed administratively. Additional fragmentations are suspected to have taken place in June 1978, September 1984, and December 1985. Historically, radar tracking of PAGEOS debris has been extremely difficult and cross-tagging frequent. Cause for the second and subsequent events may be material deterioration under environmental stress.

REFERENCE DOCUMENTS

Spacetrack System Data Related to Some Non-Routine Events Through May 1981, J.R. Gabbard, Technical Memorandum 81-6, DCS/Plans, Hdqtrs NORAD/ADCOM, Colorado Springs, 30 June 1981.



PAGEOS debris cloud of 12 fragments five weeks after the first event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Saturn SIVB Stage
OWNER:	US
LAUNCH DATE:	5.62 Jul 1966
DRY MASS (KG):	26,600
MAIN BODY:	Cylinder; 6.6 m by 28.3 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	Attitude control and pressurization systems

EVENT DATA

DATE:	5 Jul 1966	LOCATION:	20N, 277E (dsc)
TIME:	2111 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	205 km		

PRE-EVENT ELEMENTS

EPOCH:	66186.73481847	MEAN ANOMALY:	353.9219
RIGHT ASCENSION:	5.5870	MEAN MOTION:	16.27379993
INCLINATION:	31.9810	MEAN MOTION DOT/2:	.03796193
ECCENTRICITY:	.0022272	MEAN MOTION DOT DOT/6:	.17429
ARG. OF PERIGEE:	6.1632	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

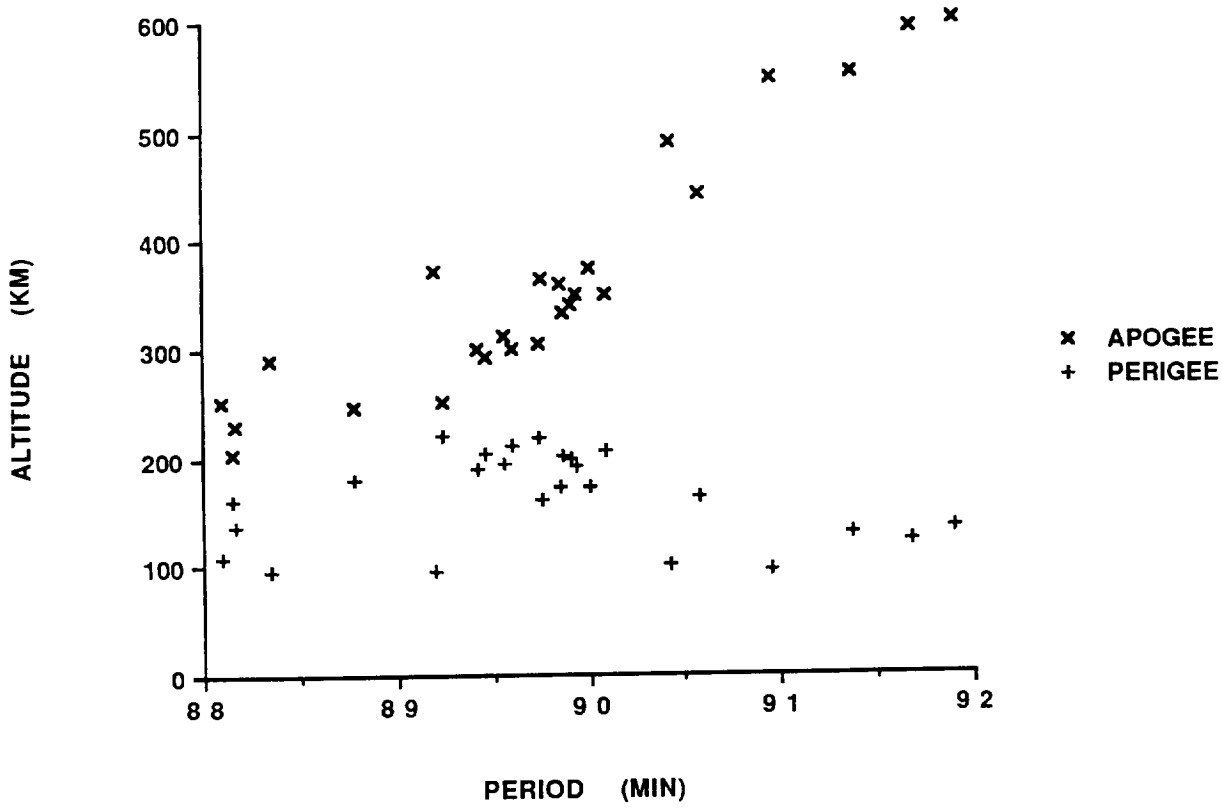
DEBRIS CATALOGED:	34	MAXIMUM ΔP:	3.5 min
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	1.4 deg

COMMENTS

This was the second flight of the SIVB stage. After orbital insertion, the vehicle was intentionally subjected to dynamic integrity tests, including high gravity loadings during attitude control maneuvers and high pressure tests. The vehicle finally brokeup after exceeding structural design limits with a propellant tank bulkhead differential pressure in excess of 23.7 N/cm^2. The fragmentation occurred early on the fifth revolution. Elements for the first fragments were not cataloged until 8 July.

REFERENCE DOCUMENTS

Saturn AS-203 Evaluation Bulletin, No. 2, R-AERO-F-142-66, J.P. Lindberg, NASA Marshall Space Flight Center, Alabama, 21 July 1966.



AS-203 debris cloud of 25 fragments using orbits developed within one week of the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Unknown
OWNER:	USSR
LAUNCH DATE:	17.94 Sep 1966
DRY MASS (KG):	Unknown
MAIN BODY:	Unknown
MAJOR APPENDAGES:	Unknown
ATTITUDE CONTROL:	Unknown
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	17 Sep 1966	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Unknown
ALTITUDE:	~300 km		

POST-EVENT ELEMENTS

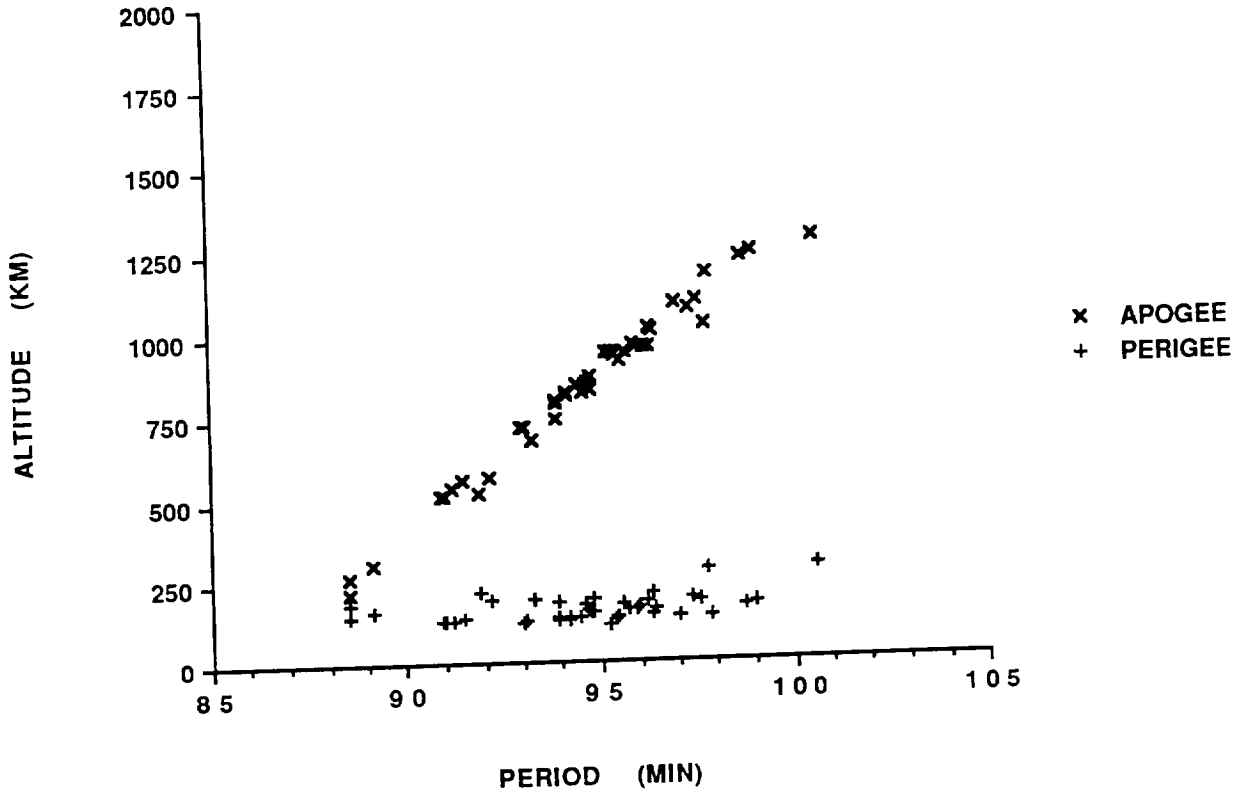
EPOCH:	66261.0	MEAN ANOMALY:	283
RIGHT ASCENSION:	338	MEAN MOTION:	14.879
INCLINATION:	49.63	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.063	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	83	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	53	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	Unknown

COMMENTS

This was the first of two missions of this type flown in 1966 and not acknowledged by the USSR. It is sometimes referred to as Cosmos U1. The identity of the parent orbit is uncertain. Satellite 2437 was the first cataloged fragment. The above elements are taken or derived from the RAE Table of Earth Satellites. The debris distribution is consistent with a fragmentation near 300 km. USSR Unknown 1 and 2 may be related to a series of Cosmos flights with similar orbital parameters conducted during 1967-1971 beginning with Cosmos 139.



USSR Unknown 1 debris cloud of 44 fragments cataloged by 5 October 1966 as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Unknown
OWNER:	USSR
LAUNCH DATE:	2.03 Nov 1966
DRY MASS (KG):	Unknown
MAIN BODY:	Unknown
MAJOR APPENDAGES:	Unknown
ATTITUDE CONTROL:	Unknown
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	2 Nov 1966	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Unknown
ALTITUDE:	~225 km		

POST-EVENT ELEMENTS

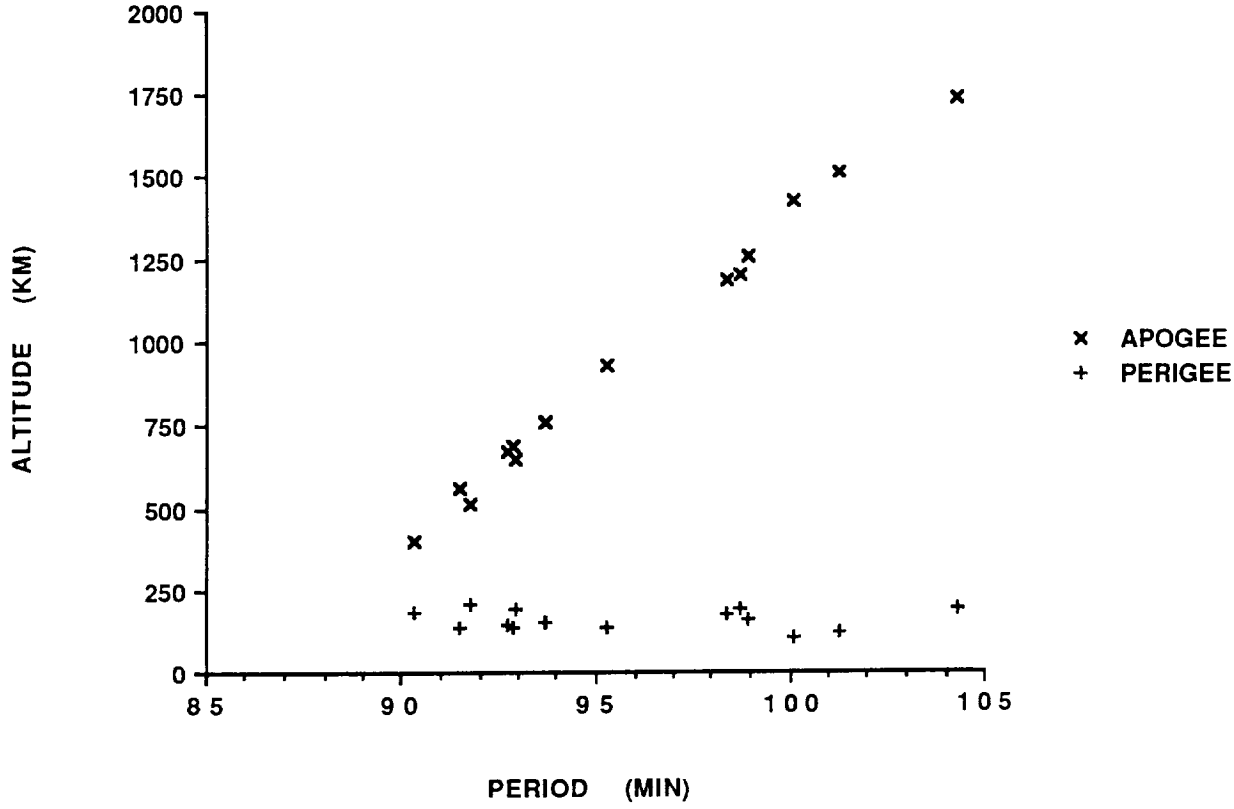
EPOCH:	66309.99121234	MEAN ANOMALY:	265.7893
RIGHT ASCENSION:	35.2944	MEAN MOTION:	15.17033022
INCLINATION:	49.5617	MEAN MOTION DOT/2:	.01866914
ECCENTRICITY:	.05339049	MEAN MOTION DOT DOT/6:	.0043309
ARG. OF PERIGEE:	100.3324	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	41	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	Unknown

COMMENTS

This was the second mission of this type flown in 1966 and not acknowledged by the USSR. It is sometimes referred to as Cosmos U2. No elements were cataloged until three days after the launch. The identity of the parent orbit is uncertain. Satellite 2536 was the first object cataloged and was near the center of the debris cloud. The debris distribution is consistent with a fragmentation near 225 km. USSR Unknown 1 and 2 may be related to a series of Cosmos flights with similar orbital parameters conducted during 1967-1971 beginning with Cosmos 139.



USSR Unknown 2 debris cloud composed of 14 different orbits as developed by the U.S. Space Surveillance Center within one week of the event.

SATELLITE DATA

TYPE:	Saturn SIVB Stage
OWNER:	US
LAUNCH DATE:	4.50 Apr 1968
DRY MASS (KG):	30,000 (?)
MAIN BODY:	Cylinder; 6.6 m by 30 m (?)
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	13 Apr 1968	LOCATION:	32N, 245E (asc)
TIME:	1054 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	330 km		

PRE-EVENT ELEMENTS

EPOCH:	68103.56521409	MEAN ANOMALY:	151.0074
RIGHT ASCENSION:	177.3270	MEAN MOTION:	15.97292993
INCLINATION:	32.5869	MEAN MOTION DOT/2:	.00302835
ECCENTRICITY:	.0120930	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	208.3921	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

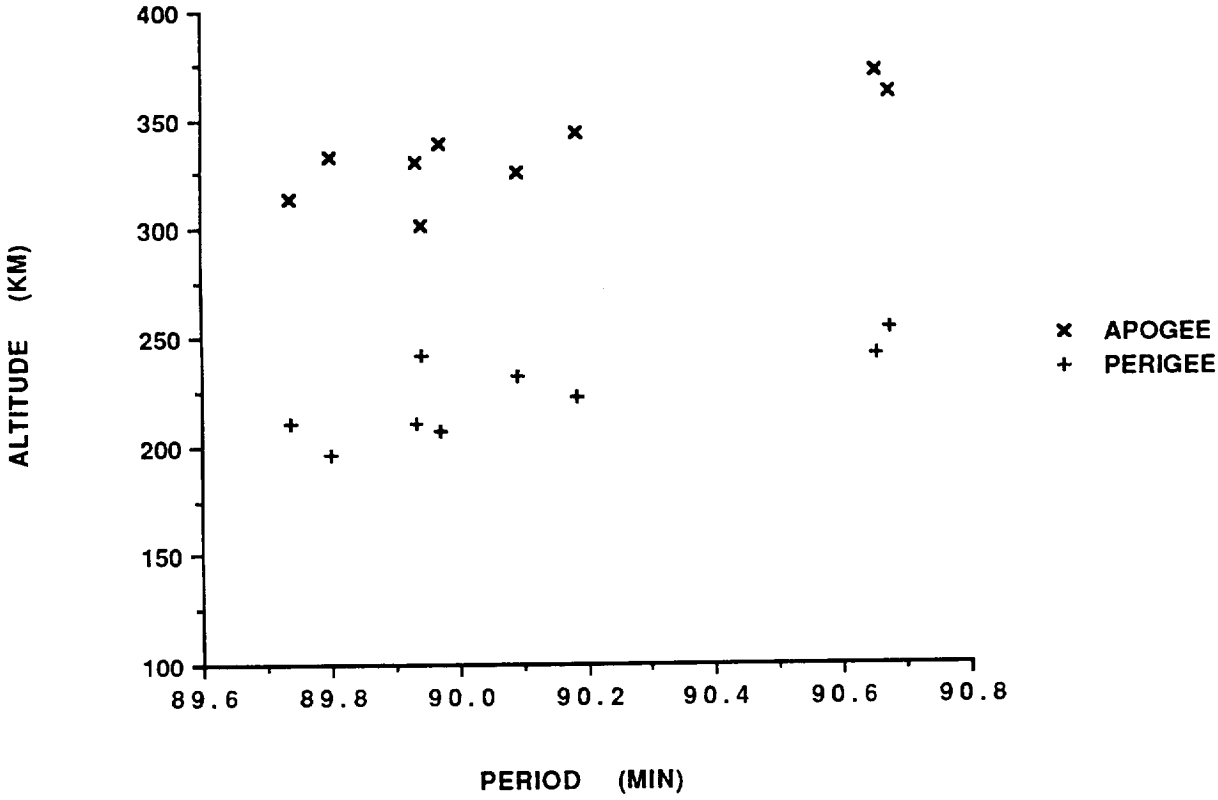
DEBRIS CATALOGED:	16	MAXIMUM ΔP:	0.7 min
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.1 deg

COMMENTS

This Saturn SIVB Stage was fitted with a 11,800 kg mock Lunar Module (LM). The SIVB stage was programmed for a second firing to place the Apollo 6 vehicle into a more eccentric orbit, but the restart did not occur. The Apollo 6 payload was separated, leaving the SIVB stage and the LM in a low Earth orbit. Vaporization and venting of residual liquid oxygen induced a tumble to the SIVB stage which reached 30 rpm by 13 April. On this date the axial loads on the LM attach strap fittings and support struts were exceeded, resulting in separation of the LM from the SIVB along with numerous debris. Five fragments were cataloged without elements.

REFERENCE DOCUMENTS

Apollo 6 Mission Anomaly Report No. 6, Unexpected Structural Indications During Launch Phase (Review Copy), MSC-PT-R-68-22, prepared by Apollo 6 Mission Evaluation Team, Marshall Space Flight Center, Alabama, and Manned Spacecraft Center, Texas, 1968.



Apollo 6 R/B debris cloud of 9 fragments four days after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Titan 3C Transtage
OWNER:	US
LAUNCH DATE:	26.32 Sep 1968
DRY MASS (KG):	1,500 (?)
MAIN BODY:	Cylinder; 3.0 m by 6.0 m (approx.)
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	21 Feb 1992	LOCATION:	Unknown (~ 197E)
TIME:	Unknown	ASSESSED CAUSE:	Unknwon
ALTITUDE:	~ 35600		

PRE-EVENT ELEMENTS

EPOCH:	92043.23217642	MEAN ANOMALY:	284.5600
RIGHT ASCENSION:	21.8025	MEAN MOTION:	1.01459126
INCLINATION:	11.9035	MEAN MOTION DOT/2:	.00000174
ECCENTRICITY:	.0084771	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	76.2786	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	1	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	1	MAXIMUM ΔI:	Unknown

COMMENTS

This was the second major fragmentation of a Titan 3C Transtage (the first was 1965-082B). This transtage released ERS-28 (also known as OV5-2) in high-e ascent orbit, then released LES-6 and ERS-21 (also known as OV5-4) in synchronous orbit, before slightly decelerating and releasing OV2-5 into a slightly lower orbit. This rocket body successfully completed its mission and remained on-orbit for 281 months before fragmenting. Mr. Bob Brock, operating the Maui GEODSS sensor, observed this transtage as it fragmented, liberating a reported 20 objects. No orbital data on any fragments have been generated by the Space Surveillance Center.

REFERENCE DOCUMENTS

TRW Space Log, Winter 1968-69 edition, Vol. 8, No. 4, H. T. Seaborn, ed., TRW Systems Group, Redondo Beach, pp. 32-35.

Insufficient Data to construct a Gabbard Diagram

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	19.18 Oct 1968
DRY MASS (KG):	1000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 2 m (?)
MAJOR APPENDAGES:	Unknown
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	1 Nov 1968	LOCATION:	55N, 104E (dsc)
TIME:	0412 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	540 km		

PRE-EVENT ELEMENTS

EPOCH:	68304.83833772	MEAN ANOMALY:	61.1261
RIGHT ASCENSION:	82.2502	MEAN MOTION:	15.19330723
INCLINATION:	62.2495	MEAN MOTION DOT/2:	.00016932
ECCENTRICITY:	.0050333	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	298.4670	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	5	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.1 deg

COMMENTS

Cosmos 248 was the target of rendezvous for the Cosmos 249 and Cosmos 252 tests. Calculations suggest the few fragments detected from Cosmos 248 were released within ten minutes of the Cosmos 252 event which took place in the vicinity of Cosmos 248. The four observed fragments were not cataloged until 4-6 weeks after the event, preventing an accurate assessment of the event due to drag effects. It is possible that the Cosmos 248 event occurred immediately after the rendezvous and was a direct result of interaction with Cosmos 252 debris.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 2): Soviet Anti-Satellite Program", N.L. Johnson, Journal of the British Interplanetary Society, August 1983, pp. 357-362.

Insufficient data to construct a Gabbard diagram.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	20.17 Oct 1968
DRY MASS (KG):	1000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 2 m (?)
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	20 Oct 1968	LOCATION:	57S, 181E (asc)
TIME:	1427 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	1995 km		

POST-EVENT ELEMENTS

EPOCH:	68294.85197372	MEAN ANOMALY:	295.3555
RIGHT ASCENSION:	118.4255	MEAN MOTION:	12.83515528
INCLINATION:	62.3313	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.1088260	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	76.6147	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

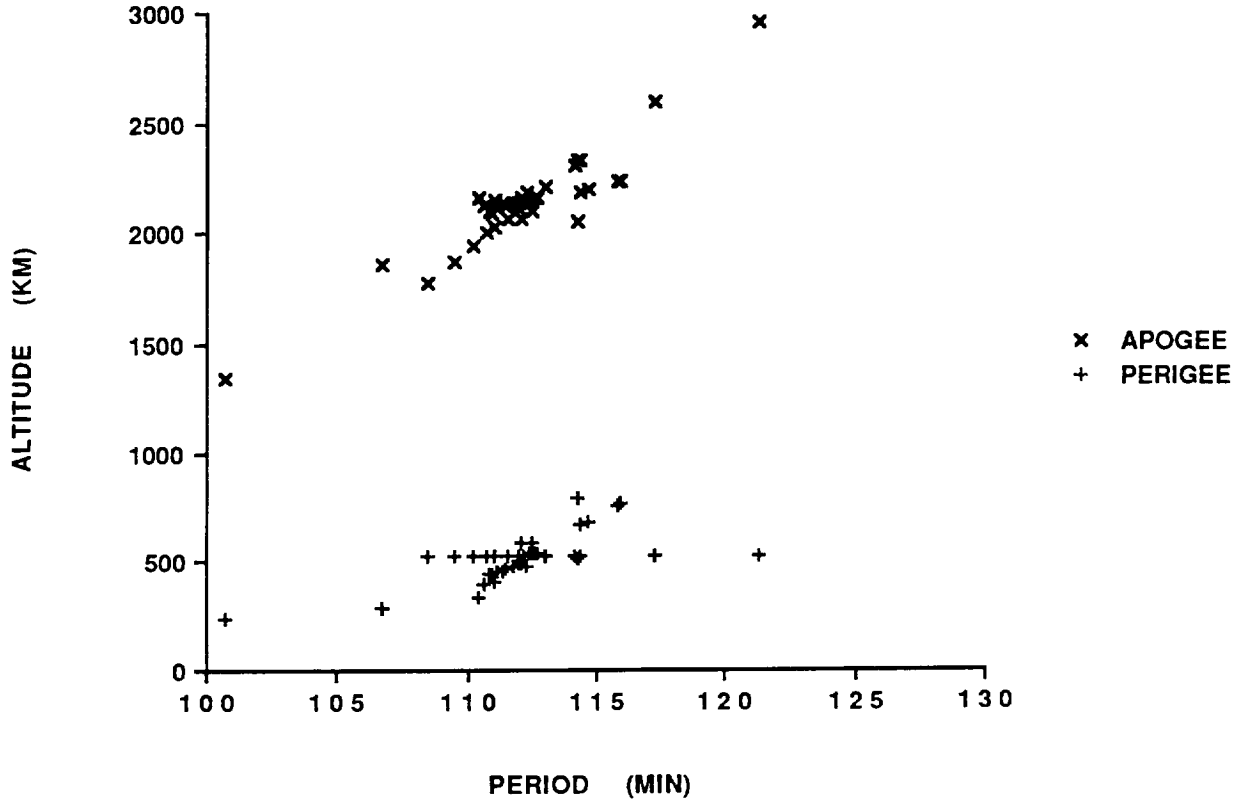
DEBRIS CATALOGED:	109	MAXIMUM ΔP:	3.9 min
DEBRIS IN ORBIT:	57	MAXIMUM ΔI:	0.4 deg

COMMENTS

Cosmos 249 was the first of a class of maneuverable spacecraft flown to rendezvous within four hours with another Cosmos satellite. In 9 of 20 such missions, orbital debris clouds were created by the active spacecraft, and in one case a passive (target) spacecraft also spawned a few fragments. Fragmentations occurred either in the vicinity of the passive satellite or a few hours after the rendezvous. In the case of Cosmos 249, the spacecraft was launched on a two-revolution rendezvous with Cosmos 248. After a close approach, Cosmos 249 continued on before its warhead was intentionally fired. The elements above are the first available for the final orbit.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 2): Soviet Anti-Satellite Program", N.L. Johnson, Journal of the British Interplanetary Society, August 1983, pp. 357-362.



Cosmos 249 cataloged debris cloud of 43 fragments four months after the event as reconstructed from U.S. Space Surveillance Center database. Cross-tagging with Cosmos 252 debris is evident.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	1.02 Nov 1968
DRY MASS (KG):	1000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 2 m (?)
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	1 Nov 1968	LOCATION:	58N, 34E (asc)
TIME:	0402 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	535 km		

POST-EVENT ELEMENTS

EPOCH:	68306.70122094	MEAN ANOMALY:	297.5777
RIGHT ASCENSION:	76.5565	MEAN MOTION:	12.81276799
INCLINATION:	62.3351	MEAN MOTION DOT/2:	.00811969
ECCENTRICITY:	.1040368	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	73.6953	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

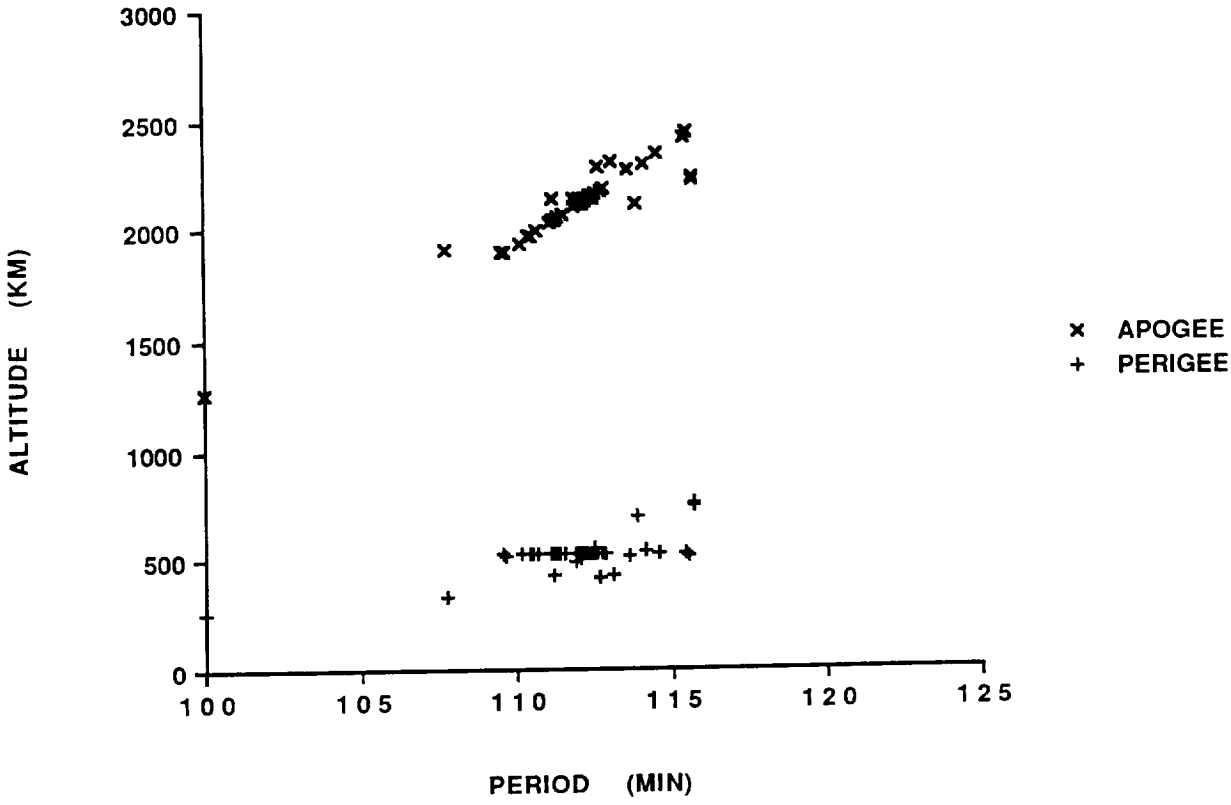
DEBRIS CATALOGED:	140	MAXIMUM ΔP:	8.7 min
DEBRIS IN ORBIT:	53	MAXIMUM ΔI:	0.5 deg

COMMENTS

Cosmos 252 was launched on a two-revolution rendezvous with Cosmos 248. The fragmentation occurred in the vicinity of Cosmos 248. Cosmos 252 was part of the test series begun with Cosmos 249. Elements above are for the orbit of the spacecraft after final maneuver, which took place immediately before fragmentation.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 2): Soviet Anti-Satellite Program", N.L. Johnson, Journal of the British Interplanetary Society, August 1983, pp. 357-362.



Cosmos 252 cataloged debris cloud of 43 fragments four months after the event as reconstructed from U.S. Space Surveillance Center database. Cross-tagging with the Cosmos 249 cloud is evident.

SATELLITE DATA

TYPE:	SL-3 Final Stage
OWNER:	USSR
LAUNCH DATE:	26.52 Mar 1969
DRY MASS (KG):	2100
MAIN BODY:	Cylinder; 2.6 m by 3.1 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	28 Mar 1969	LOCATION:	59N, 91E (dsc)
TIME:	1845 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	555 km		

PRE-EVENT ELEMENTS

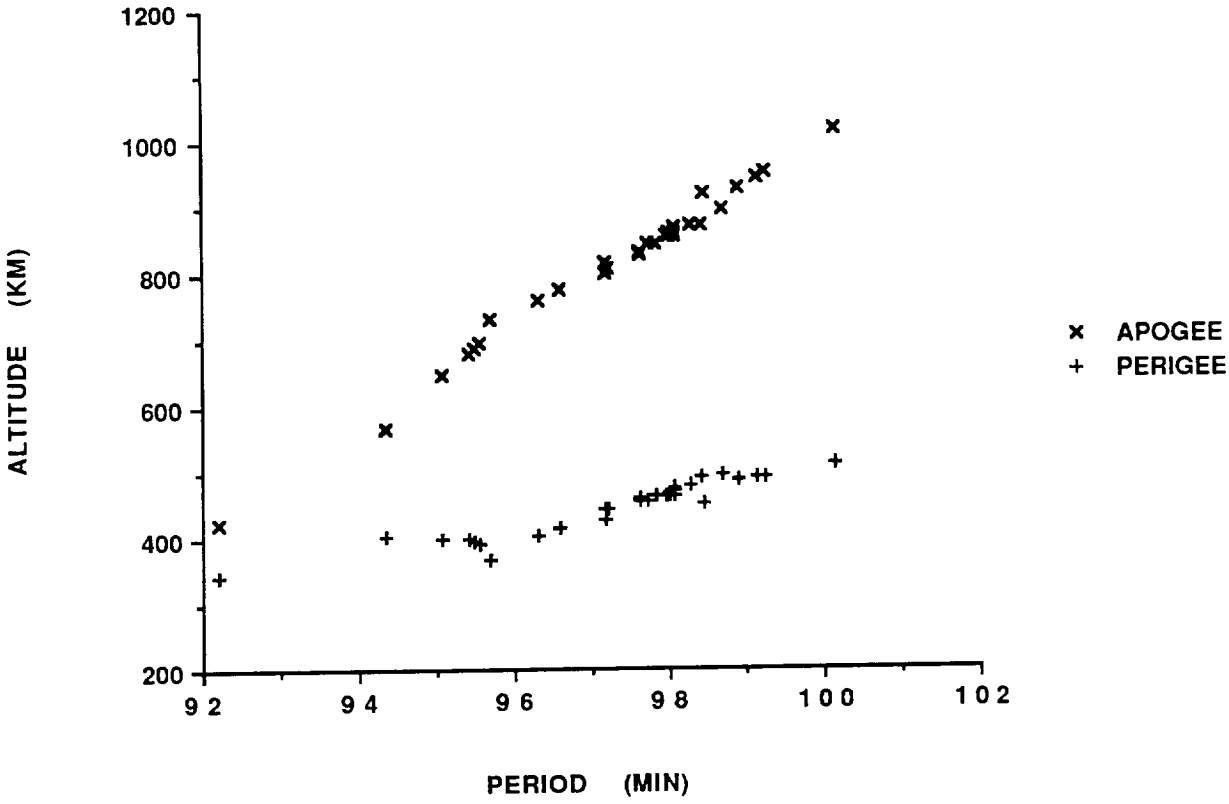
EPOCH:	69087.21308063	MEAN ANOMALY:	175.1148
RIGHT ASCENSION:	33.3926	MEAN MOTION:	14.71400174
INCLINATION:	81.1687	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.0276787	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	184.7318	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	37	MAXIMUM ΔP:	2.4 min
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.5 deg

COMMENTS

The vehicle successfully deployed the Meteor 1-1 payload into the desired orbit. An object believed to be the rocket body was found on 27 March in an orbit (1) of 565 km by 755 km, similar to earlier missions of the SL-3. Early on 28 March an object was found in an orbit (2) of 460 km by 850 km with elements as indicated above. Analysis indicates that a transition from orbit (1) to orbit (2) was possible during the latter part of 27 March. Debris anlysis clearly indicates that the orbit of the parent sattellite had to be similar to orbit (2). Radar cross-section data supports the belief that the post-event object in the center of the debris cloud is the rocket body. No object was found in orbit (1) after the event.



Meteor 1-1 R/B debris cloud of 31 fragments two months after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	TE 364-4
OWNER:	US
LAUNCH DATE:	26.09 Jul 1969
DRY MASS (KG):	1100 (70 without solid propellants)
MAIN BODY:	Sphere-Nozzle; 1.0 m by 1.8 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	26 Jul 1969	LOCATION:	0N, 333E (dsc)
TIME:	0228 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	270 km		

POST-EVENT ELEMENTS

EPOCH:	69208.17261261	MEAN ANOMALY:	166.4542
RIGHT ASCENSION:	130.0186	MEAN MOTION:	9.78100102
INCLINATION:	30.3692	MEAN MOTION DOT/2:	.00000270
ECCENTRICITY:	.2800849	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	187.9970	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

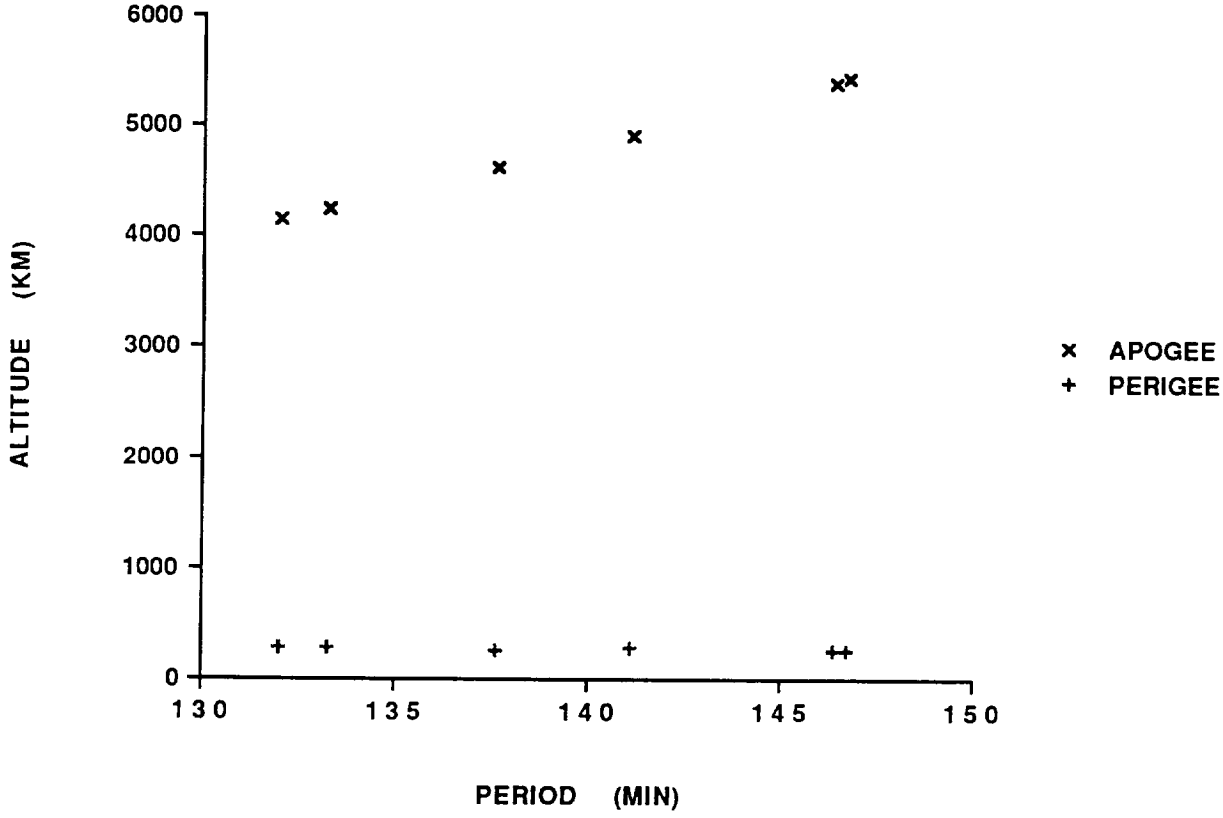
DEBRIS CATALOGED:	26	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	1	MAXIMUM ΔI:	1.2 deg

COMMENTS

This solid-propellant upper stage failed soon after ignition, following a normal launch. The cause of the failure is assessed to be a possible rupture of the motor casing or nozzle. See similar failures of two PAM-D upper stages in 1984. Elements above are first developed for the rocket body about one day after the event. Rocket body may later have been cross-tagged with satellite 4053. Validity of debris identification and cataloging after 1969 is suspect.

REFERENCE DOCUMENTS

TRW Space Log, Winter 1969-70 edition, Vol. 9, No. 4, W.A. Donop, ed., TRW Systems Group, Redondo Beach, pp. 34-36.



Intelsat 3 F-5 R/B debris cloud of six fragments ten days after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Agena D Stage
OWNER:	US
LAUNCH DATE:	30.57 Sep 1969
DRY MASS (KG):	600
MAIN BODY:	Cylinder; 1.5 m by 7.1 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	4 Oct 1969	LOCATION:	54N, 178E (dsc)
TIME:	1553 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	920 km		

POST-EVENT ELEMENTS

EPOCH:	69295.54249482	MEAN ANOMALY:	274.0514
RIGHT ASCENSION:	243.5157	MEAN MOTION:	13.68701087
INCLINATION:	69.9611	MEAN MOTION DOT/2:	.00000064
ECCENTRICITY:	.0117819	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	87.4011	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

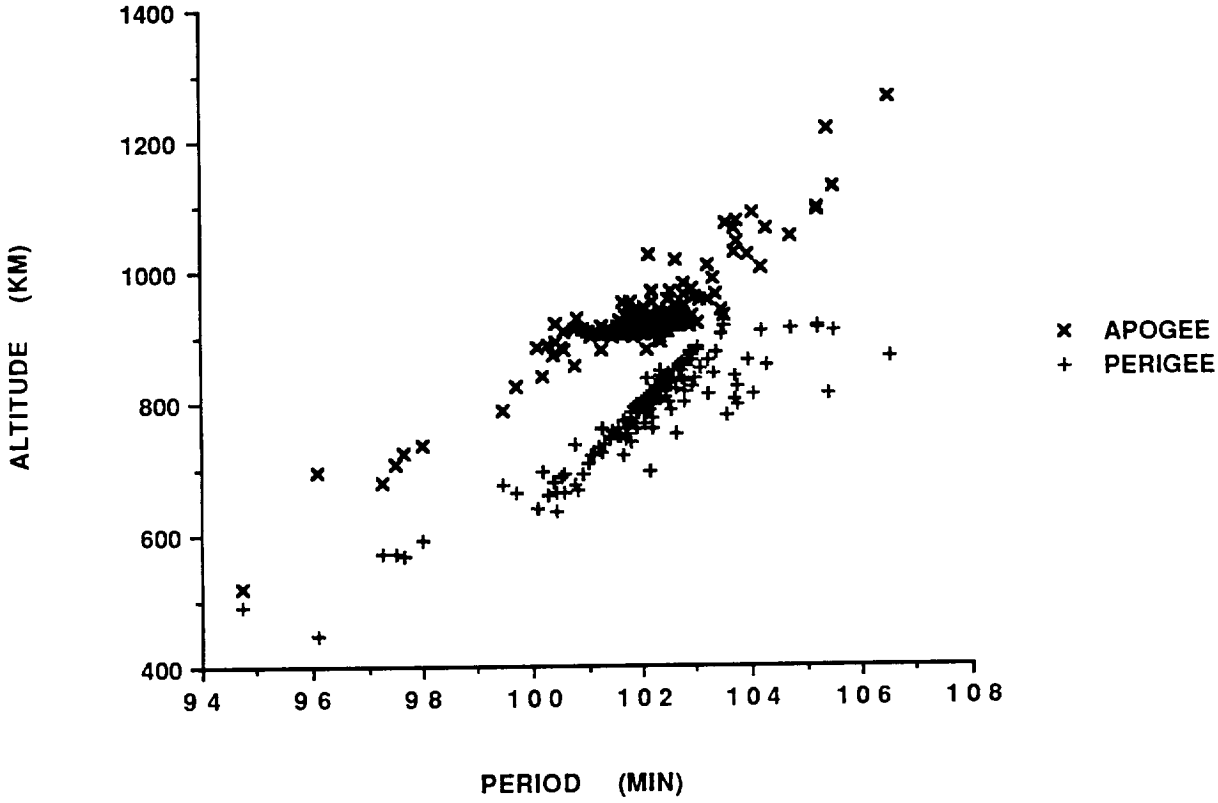
DEBRIS CATALOGED:	260	MAXIMUM ΔP:	3.1 min
DEBRIS IN ORBIT:	107	MAXIMUM ΔI:	1.0 deg

COMMENTS

This was the first of two Agena D stages to fragment in a span of only 12 months. The vehicle delivered ten payloads to an orbit of about 905 km by 940 km. Four days later, before the rocket body had been cataloged, a large fragmentation occurred. What appeared to be the largest piece of the rocket body was found in the orbit described by the elements above almost three weeks after the event. See 1967-53 as a reference to an earlier mission of this type. Both missions were sponsored by DOD and public information is limited.

REFERENCE DOCUMENTS

"Fragmentations of Asteroids and Artificial Satellites in Orbit", W. Wiesel, Icarus, Vol. 34, 1978, pp. 99-116.



OPS 7613 R/B debris cloud (excluding 10 payloads) of 152 fragments eight months after the event. The largest fragment was found in an eccentric orbit with an orbital period of more than 105 min and is presumed to be the rocket body remnant.

SATELLITE DATA

TYPE:	Agena D Stage
OWNER:	US
LAUNCH DATE:	8.35 Apr 1970
DRY MASS (KG):	600
MAIN BODY:	Cylinder; 1.5 m by 7.1 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	17 Oct 1970	LOCATION:	50S, 142E (asc)
TIME:	0317 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	1075 km		

PRE-EVENT ELEMENTS

EPOCH:	70289.33183878	MEAN ANOMALY:	141.3434
RIGHT ASCENSION:	203.5235	MEAN MOTION:	13.49254887
INCLINATION:	99.8780	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.0016616	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	218.6463	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

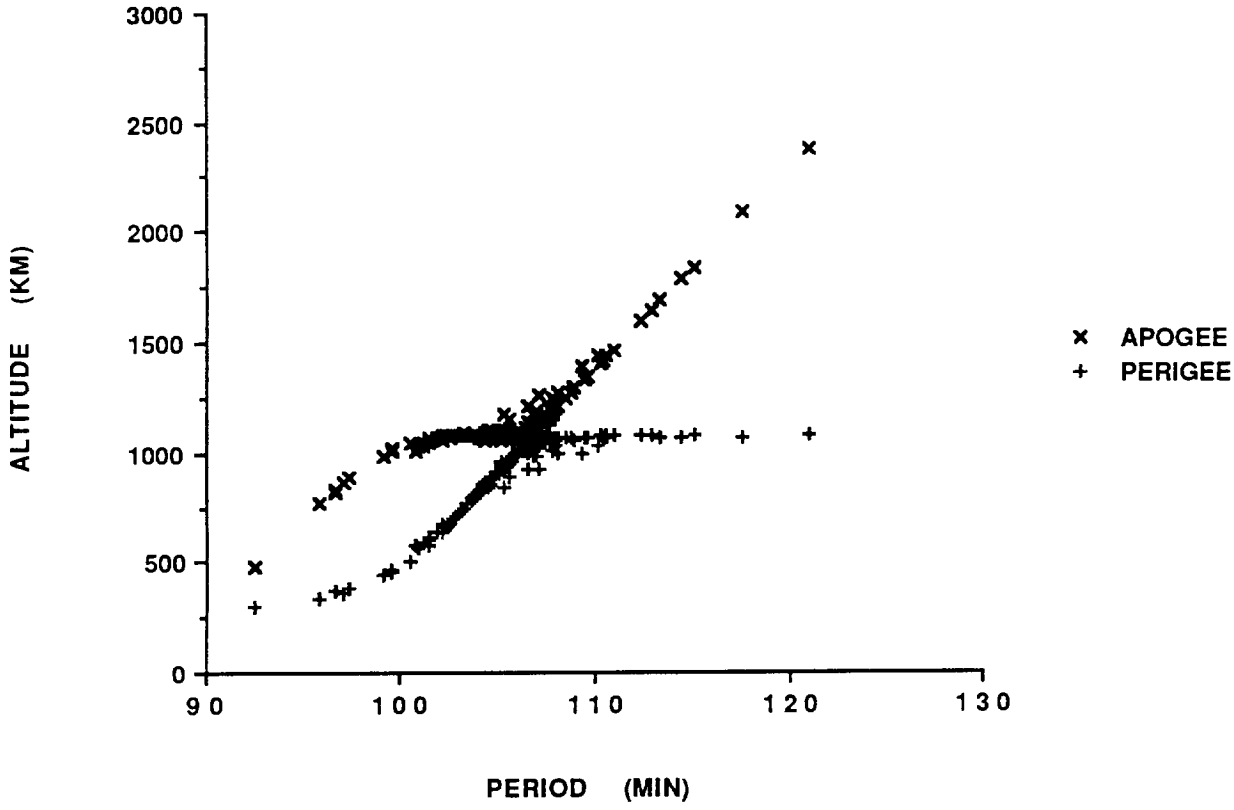
DEBRIS CATALOGED:	370	MAXIMUM ΔP:	14.2 min
DEBRIS IN ORBIT:	276	MAXIMUM ΔI:	0.8 deg

COMMENTS

This was the second Agena D stage to fragment in a span of only 12 months. The event occurred six months after the successful deployment of the Nimbus 4 payload. Twice in 1985, again in 1986, and once in 1991, Nimbus 4 R/B debris spawned a few additional fragments, accounting for an additional 12 new debris objects between the 4 sub-events.

REFERENCE DOCUMENTS

"Fragmentations of Asteroids and Artificial Satellites in Orbit", W. Wiesel, Icarus, Vol. 34, 1978, pp. 99-116.



Nimbus 4 R/B debris cloud of 246 fragments eight months after the event as reconstructed from U.S. Space Surveillance Center database. Some lower period fragments already exhibit the effects of natural decay.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	23.18 Oct 1970
DRY MASS (KG):	1000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 2 m (?)
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	23 Oct 1970	LOCATION:	22S, 217E (asc)
TIME:	1513 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	1195 km		

PRE-EVENT ELEMENTS

EPOCH:	70296.40542099	MEAN ANOMALY:	309.5623
RIGHT ASCENSION:	129.1049	MEAN MOTION:	12.82808179
INCLINATION:	62.9380	MEAN MOTION DOT/2:	.00019973
ECCENTRICITY:	.1039489	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	60.4933	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

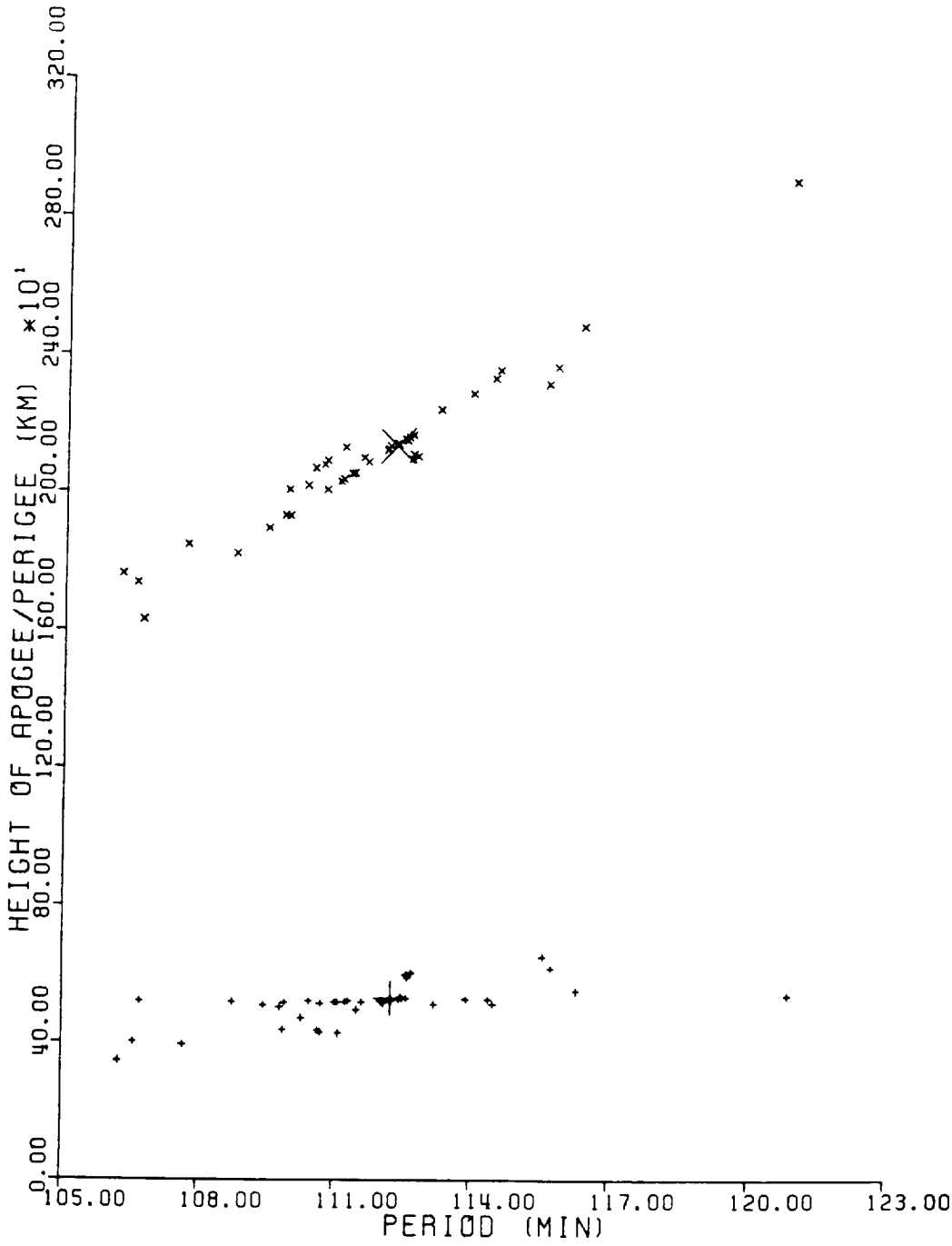
DEBRIS CATALOGED:	103	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	39	MAXIMUM ΔI:	Unknown

COMMENTS

Cosmos 374 was launched on a two-revolution rendezvous with Cosmos 373. After a close approach, Cosmos 374 continued on before its warhead was intentionally fired. Cosmos 374 was part of test series begun with Cosmos 249. Considerable cross-cataloging of Cosmos 374 and Cosmos 375 debris; therefore, ΔP and ΔI are not calculated.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 2): Soviet Anti-Satellite Program", N.L. Johnson, Journal of the British Interplanetary Society, August 1983, pp. 357-362.



Cosmos 374 official debris cloud of 43 fragments five months after the event as reconstructed from U.S. Space Surveillance Center database. All fragments were cataloged after the Cosmos 375 fragmentation, and some contamination exists.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	30.09 Oct 1970
DRY MASS (KG):	1000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 2 m (?)
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	30 Oct 1970	LOCATION:	54N, 23E (asc)
TIME:	0600 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	535 km		

POST-EVENT ELEMENTS

EPOCH:	70306.81102869	MEAN ANOMALY:	313.3102
RIGHT ASCENSION:	96.4080	MEAN MOTION:	12.87482205
INCLINATION:	62.8057	MEAN MOTION DOT/2:	.00009999
ECCENTRICITY:	.1022289	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	56.0864	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

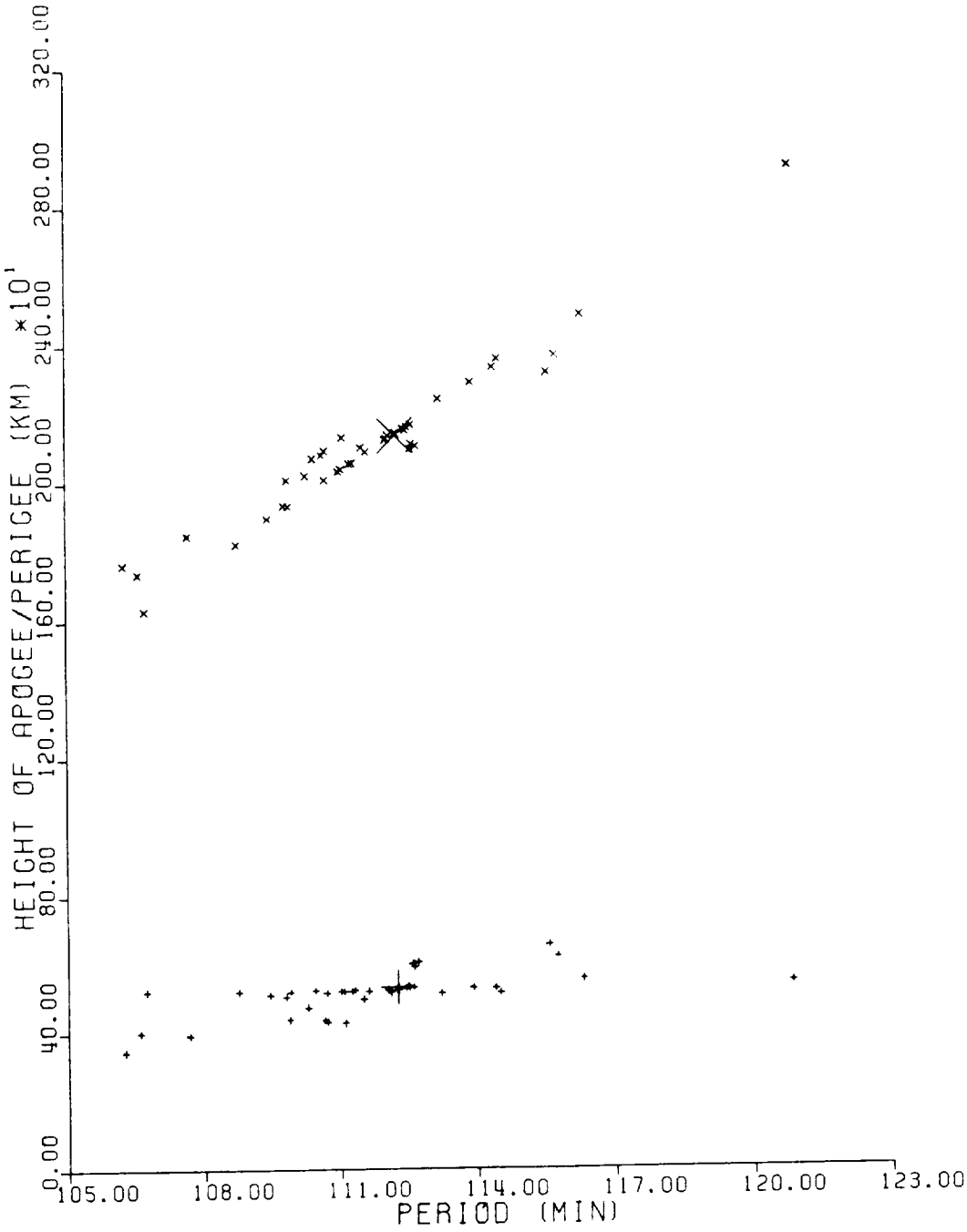
DEBRIS CATALOGED:	47	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	27	MAXIMUM ΔI:	Unknown

COMMENTS

Cosmos 375 was launched on a two-revolution rendezvous with Cosmos 373. The fragmentation occurred in the vicinity of Cosmos 373. Cosmos 375 was part of test series begun with Cosmos 249. Elements above are first reliable ones for orbit after final maneuver which took place immediately before fragmentation. Considerable cross-cataloging of Cosmos 374 and Cosmos 375 debris; therefore, ΔP and ΔI are not calculated.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 2): Soviet Anti-Satellite Program", N.L. Johnson, Journal of the British Interplanetary Society, August 1983, pp. 357-362.



Cosmos 374 official debris cloud of 43 fragments five months after the event as reconstructed from U.S. Space Surveillance Center database. All fragments were cataloged after the Cosmos 375 fragmentation, and some contamination exists.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	25.47 Feb 1971
DRY MASS (KG):	1000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 2 m (?)
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	25 Feb 1971	LOCATION:	54N, 21E (asc)
TIME:	1431 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	585 km		

POST-EVENT ELEMENTS

EPOCH:	71057.77590281	MEAN ANOMALY:	318.5528
RIGHT ASCENSION:	352.8670	MEAN MOTION:	12.68709606
INCLINATION:	65.7618	MEAN MOTION DOT/2:	.00013192
ECCENTRICITY:	.1046189	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	50.3064	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

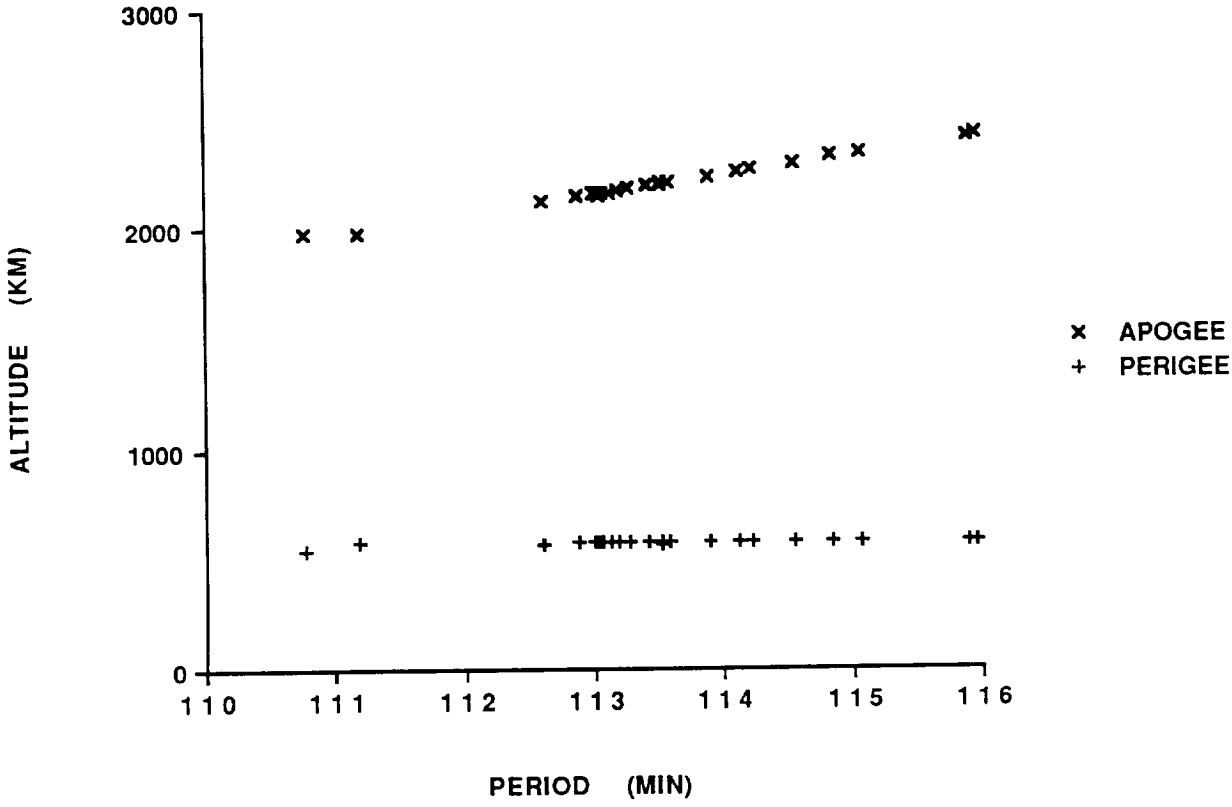
DEBRIS CATALOGED:	116	MAXIMUM ΔP:	2.8 min
DEBRIS IN ORBIT:	63	MAXIMUM ΔI:	1.2 deg

COMMENTS

Cosmos 397 was launched on a two-revolution rendezvous with Cosmos 394. The fragmentation occurred in the vicinity of Cosmos 394. Cosmos 397 was part of the test series begun with Cosmos 249. Elements above are first available for orbit after final maneuver which took place immediately before fragmentation.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 2): Soviet Anti-Satellite Program", N.L. Johnson, Journal of the British Interplanetary Society, August 1983, pp. 357-362.



Cosmos 397 cataloged debris cloud of 26 fragments about seven weeks after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	3.55 Dec 1971
DRY MASS (KG):	1000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 2 m (?)
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	3 Dec 1971	LOCATION:	51N, 7E (asc)
TIME:	1651 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	230 km		

POST-EVENT ELEMENTS

EPOCH:	71339.01001769	MEAN ANOMALY:	316.0762
RIGHT ASCENSION:	294.0999	MEAN MOTION:	13.65823046
INCLINATION:	65.7483	MEAN MOTION DOT/2:	.00001349
ECCENTRICITY:	.1062360	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	53.3215	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

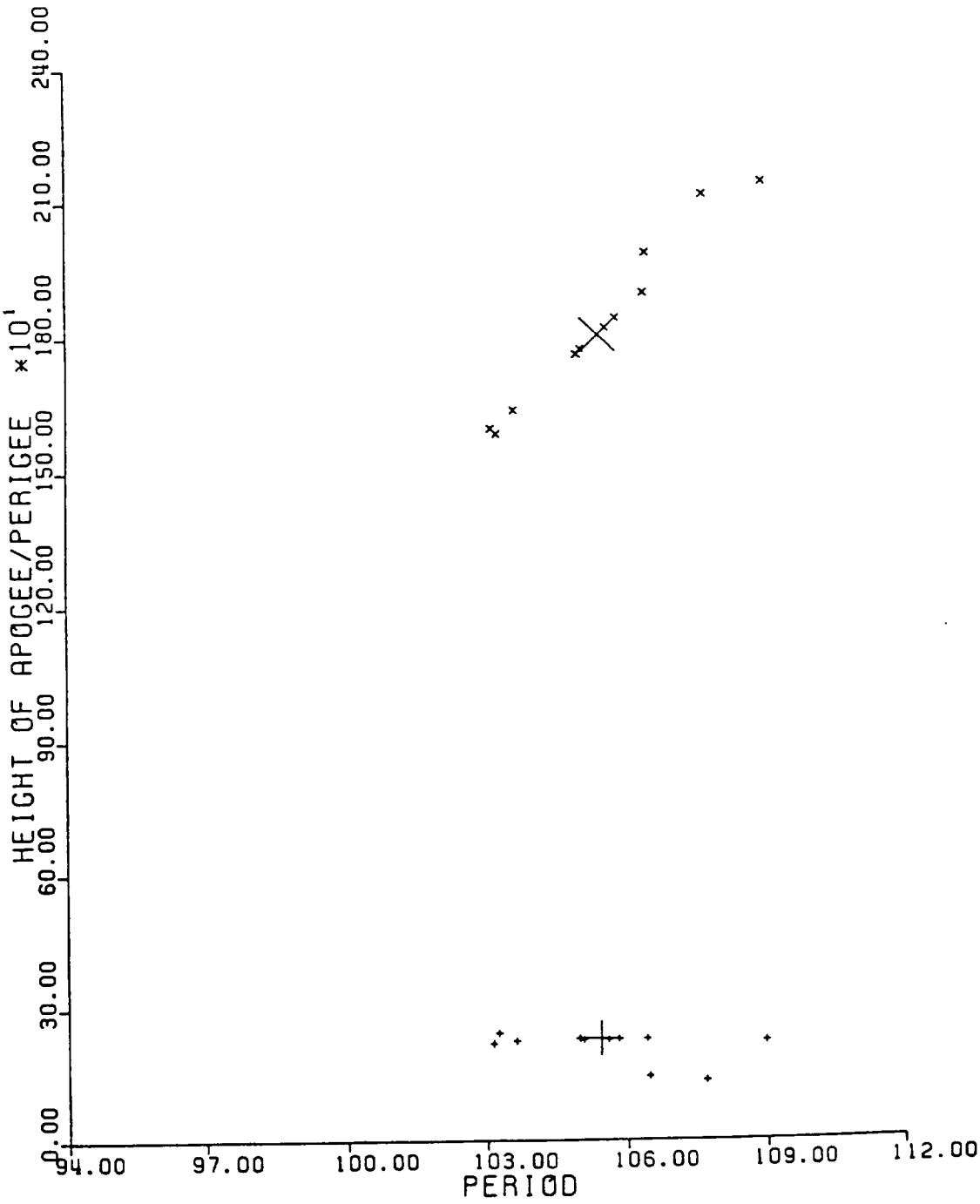
DEBRIS CATALOGED:	25	MAXIMUM ΔP:	3.6 min
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.7 deg

COMMENTS

Cosmos 462 was launched on a two-revolution rendezvous with Cosmos 459. The fragmentation occurred in the vicinity of Cosmos 459. Cosmos 462 was part of test series begun with Cosmos 249. Elements above are first available for orbit after final maneuver which took place immediately before fragmentation.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 2): Soviet Anti-Satellite Program", N.L. Johnson, Journal of the British Interplanetary Society, August 1983, pp. 357-362.



Cosmos 462 debris cloud of 13 cataloged fragments within one week of the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Delta Second Stage (900)
OWNER:	US
LAUNCH DATE:	23.75 Jul 1972
DRY MASS (KG):	800 (?)
MAIN BODY:	Cylinder-Nozzle; 1.4 m by 6.3 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	On-board propellants, range safety device

EVENT DATA

DATE:	22 May 1975	LOCATION:	34S, 46E (asc)
TIME:	1827 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	730 km		

PRE-EVENT ELEMENTS

EPOCH:	75142.56642671	MEAN ANOMALY:	323.2981
RIGHT ASCENSION:	196.3353	MEAN MOTION:	14.36209995
INCLINATION:	98.3439	MEAN MOTION DOT/2:	.00000060
ECCENTRICITY:	.0193108	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	38.1650	BSTAR:	.000027579

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	226	MAXIMUM ΔP:	9.3 min
DEBRIS IN ORBIT:	55	MAXIMUM ΔI:	1.0 deg

COMMENTS

This was the second Delta Second Stage to experience a severe fragmentation. The event occurred 34 months after the successful deployment of the Landsat 1 payload. Cause of the explosion is assessed to be related to the nearly 150 kg of residual propellants and characteristics of the sun-synchronous orbit.

REFERENCE DOCUMENTS

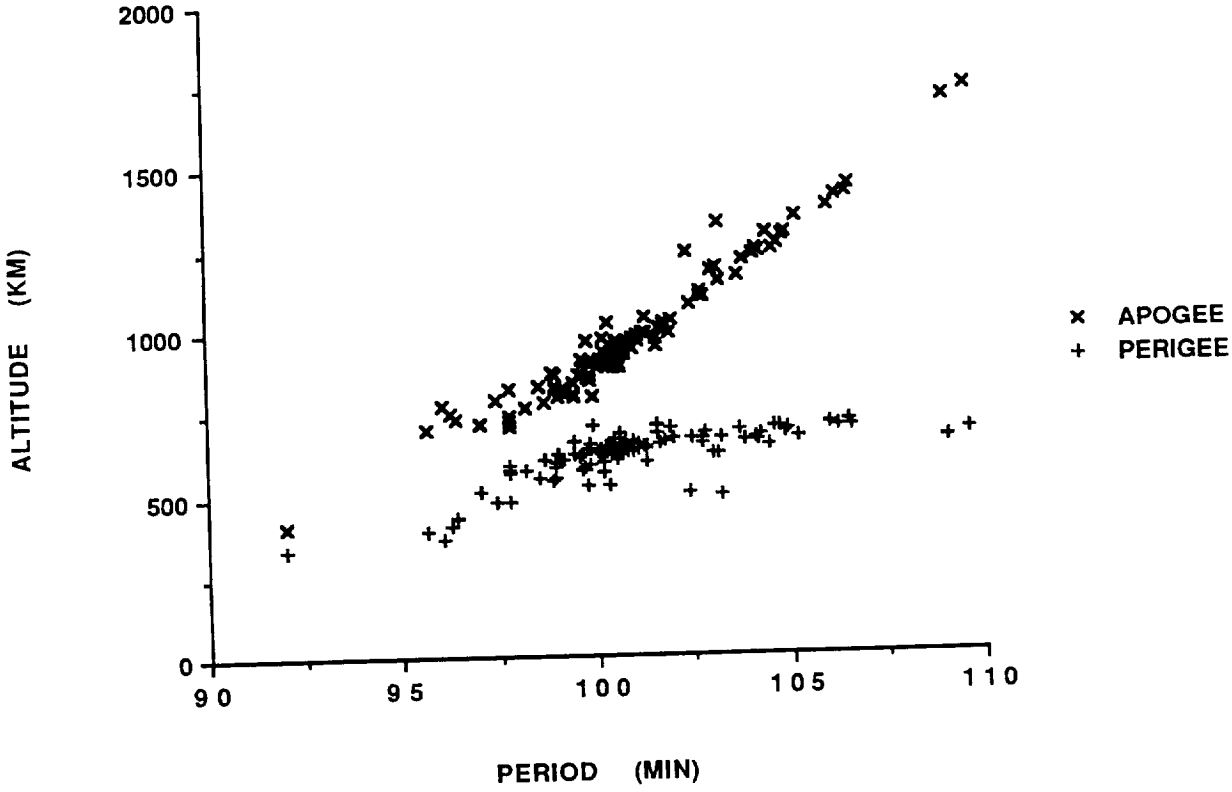
Dynamics of Satellite Disintegration, R. Dasenbrock, B. Kaufman, and W. Heard, NRL Report 7954, Naval Research Laboratory, Washington, 30 January 1976.

"Fragmentations of Asteroids and Artificial Satellites in Orbit", W. Wiesel, Icarus, Vol. 34, 1978, pp. 99-116.

Explosion of Satellite 10704 and other Delta Second Stage Rockets, J.R. Gabbard, Technical Memorandum 81-5, DCS Plans, Hdqtrs NORAD/ADCOM, Colorado Springs, May 1981.

Investigation of Delta Second Stage On-Orbit Explosions, C.S. Gumpel, Report MDC-H0047, McDonnell Douglas Astronautics Company - West, Huntington Beach, April 1982.

A Later Look at Delta Second Stage On-Orbit Explosions, J.R. Gabbard, Technical Report CS85-BMDSC-00-24, Teledyne Brown Engineering, Colorado Springs, March 1985.



Landsat 1 R/B debris cloud of 133 fragments fours months after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	SL-13 Final Stage
OWNER:	USSR
LAUNCH DATE:	3.38 Apr 1973
DRY MASS (KG):	5600 (approx.)
MAIN BODY:	Cylinder-nozzle; 4.2 m by 6.8 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	3 Apr 1973	LOCATION:	45N, 290E (dsc)
TIME:	2236 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	225 km		

PRE-EVENT ELEMENTS

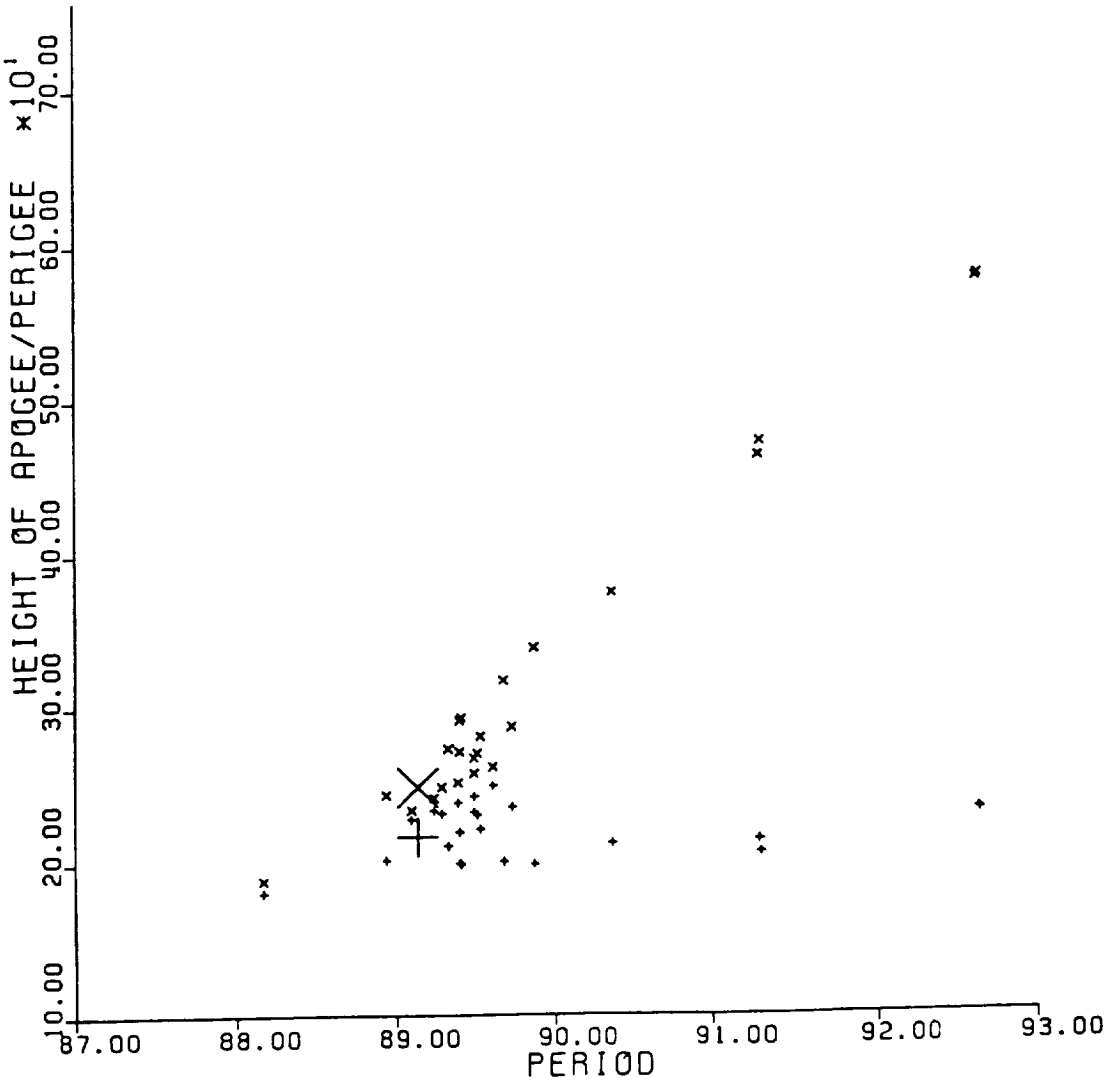
EPOCH:	73093.61404736	MEAN ANOMALY:	357.9254
RIGHT ASCENSION:	334.5652	MEAN MOTION:	16.20127597
INCLINATION:	51.4798	MEAN MOTION DOT/2:	.00508885
ECCENTRICITY:	.0037670	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	2.1878	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	25	MAXIMUM ΔP:	3.8 min
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.5 deg

COMMENTS

This is the only known fragmentation of the SL-13 final stage. Event occurred less than 14 hours after reaching orbit. The event was apparently unrelated to the later payload malfunction. NAVSPASUR counted at least 95 objects shortly after the event. Most reentered before being officially cataloged.



Salyut 2 R/B debris cloud of 25 fragments as reconstructed from U.S. Space Surveillance Center database. Most elements were developed within two days of the event.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	19.38 Apr 1973
DRY MASS (KG):	6000 (approx.)
MAIN BODY:	Sphere-Cylinder-Cone; 2.4 m by 6.5 m (?)
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	6 May 1973	LOCATION:	71S, 215E (asc)
TIME:	0724 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	310 km		

PRE-EVENT ELEMENTS

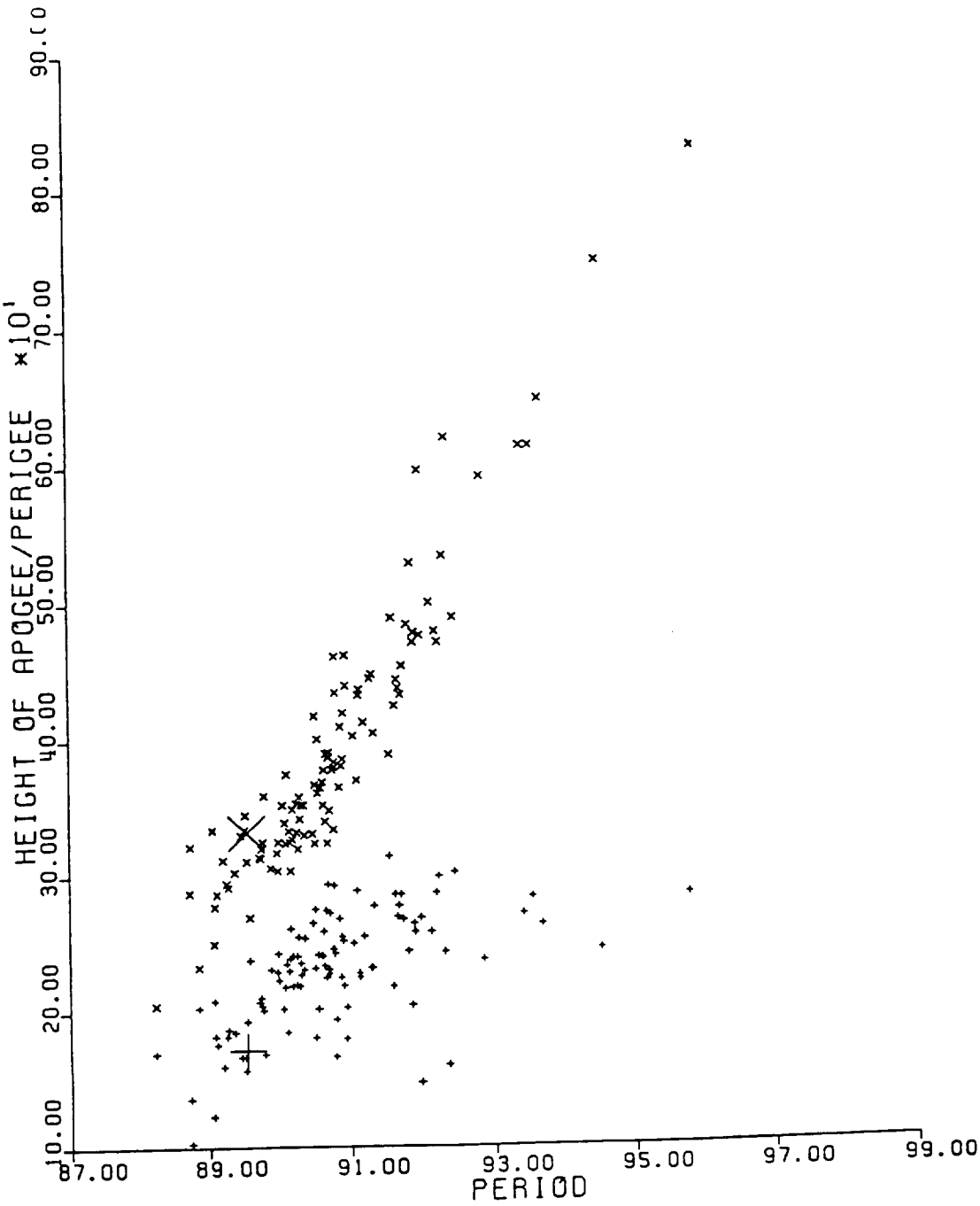
EPOCH:	73125.63953480	MEAN ANOMALY:	337.7411
RIGHT ASCENSION:	305.5573	MEAN MOTION:	16.05578988
INCLINATION:	72.8514	MEAN MOTION DOT/2:	.00433078
ECCENTRICITY:	.0137599	MEAN MOTION DOT DOT/6:	.00010923
ARG. OF PERIGEE:	22.9846	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	195	MAXIMUM ΔP:	6.0 min
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	1.3 deg

COMMENTS

Spacecraft was apparently destroyed after a malfunction prevented controlled reentry and landing in the Soviet Union. Second incident of this type. A total of 88 fragments were cataloged without elements.



Cosmos 554 debris cloud of 107 fragments using initial elements as developed over several weeks. Some decay effects are present. Source is U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Delta Second Stage (300)
OWNER:	US
LAUNCH DATE:	6.71 Nov 1973
DRY MASS (KG):	800 (?)
MAIN BODY:	Cylinder-Nozzle; 1.4 m by 6.3 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	On-board propellants, range safety device

EVENT DATA

DATE:	28 Dec 1973	LOCATION:	37S, 181E (asc)
TIME:	0904 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	1515 km		

PRE-EVENT ELEMENTS

EPOCH:	73359.56303028	MEAN ANOMALY:	202.2816
RIGHT ASCENSION:	41.7242	MEAN MOTION:	12.40088347
INCLINATION:	102.0500	MEAN MOTION DOT/2:	.00000577
ECCENTRICITY:	.0005689	MEAN MOTION DOT DOT/6:	.000000056523
ARG. OF PERIGEE:	157.8450	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	197	MAXIMUM ΔP:	10.4 min
DEBRIS IN ORBIT:	180	MAXIMUM ΔI:	1.4 deg

COMMENTS

This was the first of seven Delta Second Stages to experience severe fragmentations between 1973 and 1981. Six of the seven stages were left in mid-morning, sun-synchronous orbits with residual propellants. Fragmentations occurred from 2-35 months after launch. The seventh stage exploded within hours of launch on a geosynchronous mission. The assessed cause in all cases is a propellant-induced explosion. Depletion burns to remove residual propellants were initiated in 1981, and no Delta Second Stages have fragmented since. In the case of the NOAA 3 R/B, fragmentation took place nearly two months after successful deployment of the NOAA 3 payload. Approximately 130 kg of propellants were left on board.

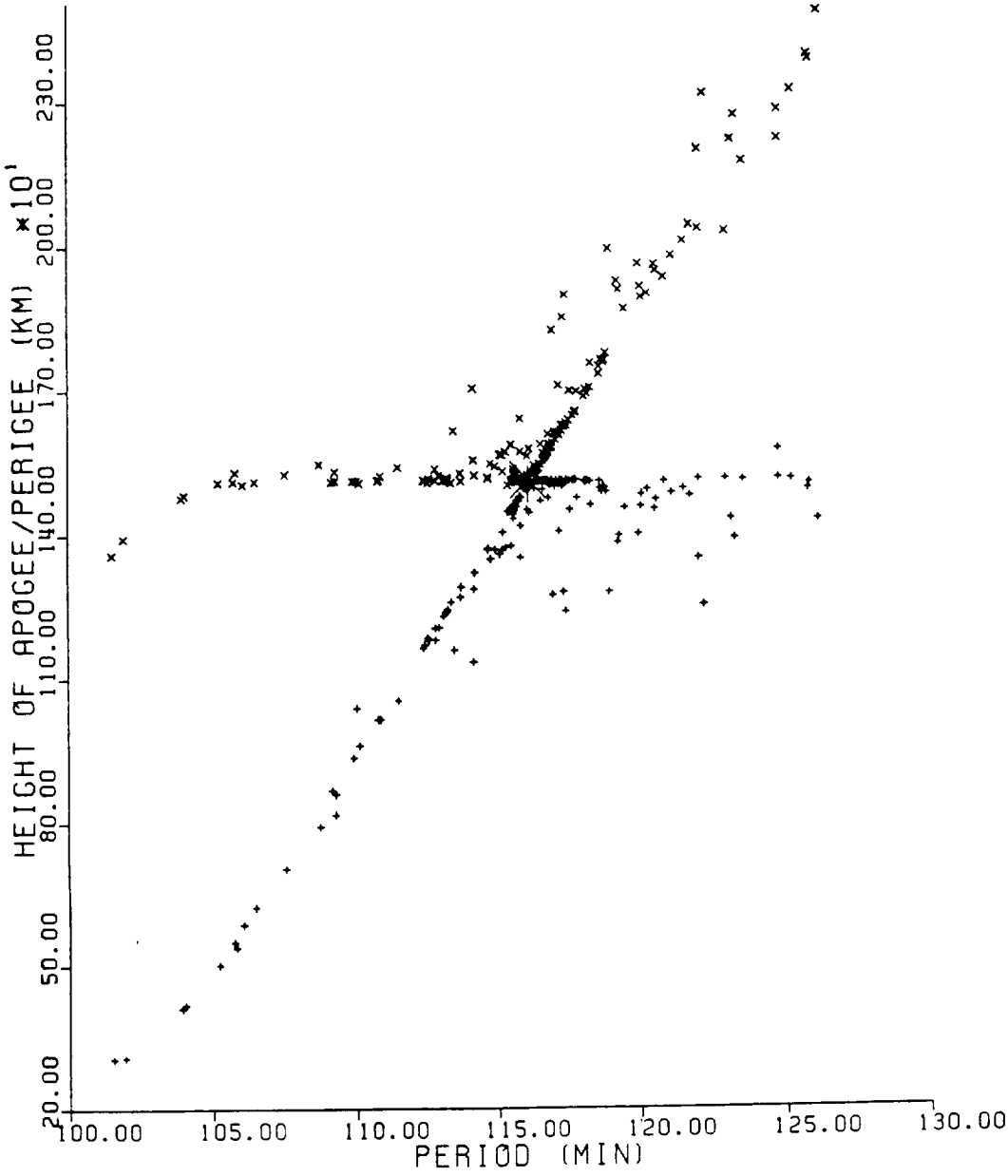
REFERENCE DOCUMENTS

Dynamics of Satellite Disintegration, R. Dasenbrock, B. Kaufman, and W. Heard, NRL Report 7954, Naval Research Laboratory, Washington, 30 January 1976.

Explosion of Satellite 10704 and other Delta Second Stage Rockets, J.R. Gabbard, Technical Memorandum 81-5, DCS Plans, Hdqtrs NORAD/ADCOM, Colorado Springs, May 1981.

Investigation of Delta Second Stage On-Orbit Explosions, C.S. Gumpel, Report MDC-H0047, McDonnell Douglas Astronautics Company - West, Huntington Beach, April 1982.

A Later Look at Delta Second Stage On-Orbit Explosions, J.R. Gabbard, Technical Report CS85-BMDSC-00-24, Teledyne Brown Engineering, Colorado Springs, March 1985.



NOAA 3 R/B debris cloud of 160 fragments four months after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Delta Second Stage (2310)
OWNER:	US
LAUNCH DATE:	15.72 Nov 1974
DRY MASS (KG):	900 (approx.)
MAIN BODY:	Cylinder-Nozzle; 1.4 m by 5.8 m
MAJOR APPENDAGES:	Mini-skirt; 2.4m by 0.3 m
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	On-board propellants, range safety device

EVENT DATA

DATE:	20 Aug 1975	LOCATION:	52S, 278E (dsc)
TIME:	1307 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	1465 km		

PRE-EVENT ELEMENTS

EPOCH:	75231.53619619	MEAN ANOMALY:	309.0001
RIGHT ASCENSION:	277.2201	MEAN MOTION:	12.52826370
INCLINATION:	101.6940	MEAN MOTION DOT/2:	.00000083
ECCENTRICITY:	.0009694	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	51.1891	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	147	MAXIMUM ΔP:	15.7 min
DEBRIS IN ORBIT:	129	MAXIMUM ΔI:	1.8 deg

COMMENTS

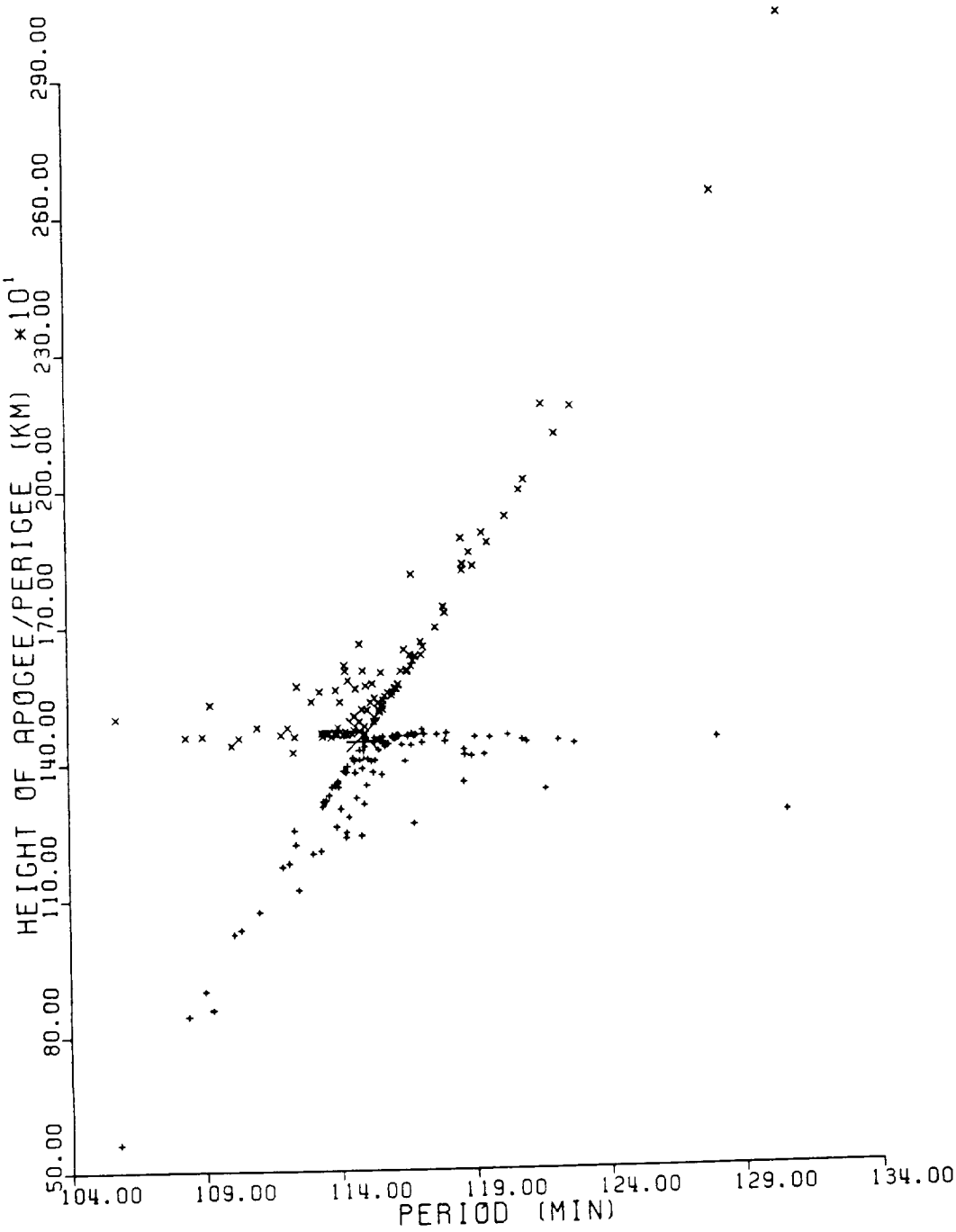
This was the third Delta Second Stage to experience a severe fragmentation. The event occurred 9 months after the successful deployment of the NOAA 4 payload. Cause of the explosion is assessed to be related to the estimated more than 200 kg of residual propellants and characteristics of the sun-synchronous orbit. A fragment from this event (satellite number 8138) may have generated six or more additional pieces in September 1981.

REFERENCE DOCUMENTS

Explosion of Satellite 10704 and other Delta Second Stage Rockets, J.R. Gabbard, Technical Memorandum 81-5, DCS Plans, Hdqtrs NORAD/ADCOM, Colorado Springs, May 1981.

Investigation of Delta Second Stage On-Orbit Explosions, C.S. Gumpel, Report MDC-H0047, McDonnell Douglas Astronautics Company - West, Huntington Beach, April 1982.

A Later Look at Delta Second Stage On-Orbit Explosions, J.R. Gabbard, Technical Report CS85-BMDSC-00-24, Teledyne Brown Engineering, Colorado Springs, March 1985.



NOAA 4 R/B debris cloud of 101 fragments six months after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	24.46 Dec 1974
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA (1)

DATE:	17 Apr 1975	LOCATION:	01N, 278E (dsc)
TIME:	2148 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	437 km		

PRE-EVENT ELEMENTS (1)

EPOCH:	75107.81173798	MEAN ANOMALY:	71.8460
RIGHT ASCENSION:	271.0743	MEAN MOTION:	15.44155646
INCLINATION:	65.0355	MEAN MOTION DOT/2:	.00007106
ECCENTRICITY:	.0014224	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	288.1084	BSTAR:	.0

EVENT DATA (2)

DATE:	2 Aug 1975	LOCATION:	02S, 258E (dsc)
TIME:	1623 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	433 km		

PRE-EVENT ELEMENTS (2)

EPOCH:	75214.45597981	MEAN ANOMALY:	68.4232
RIGHT ASCENSION:	274.3453	MEAN MOTION:	15.46205523
INCLINATION:	65.0458	MEAN MOTION DOT/2:	.00001715
ECCENTRICITY:	.0020980	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	291.4623	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	50	MAXIMUM ΔP:	3.5 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.9 deg*

*Based on NRL analysis

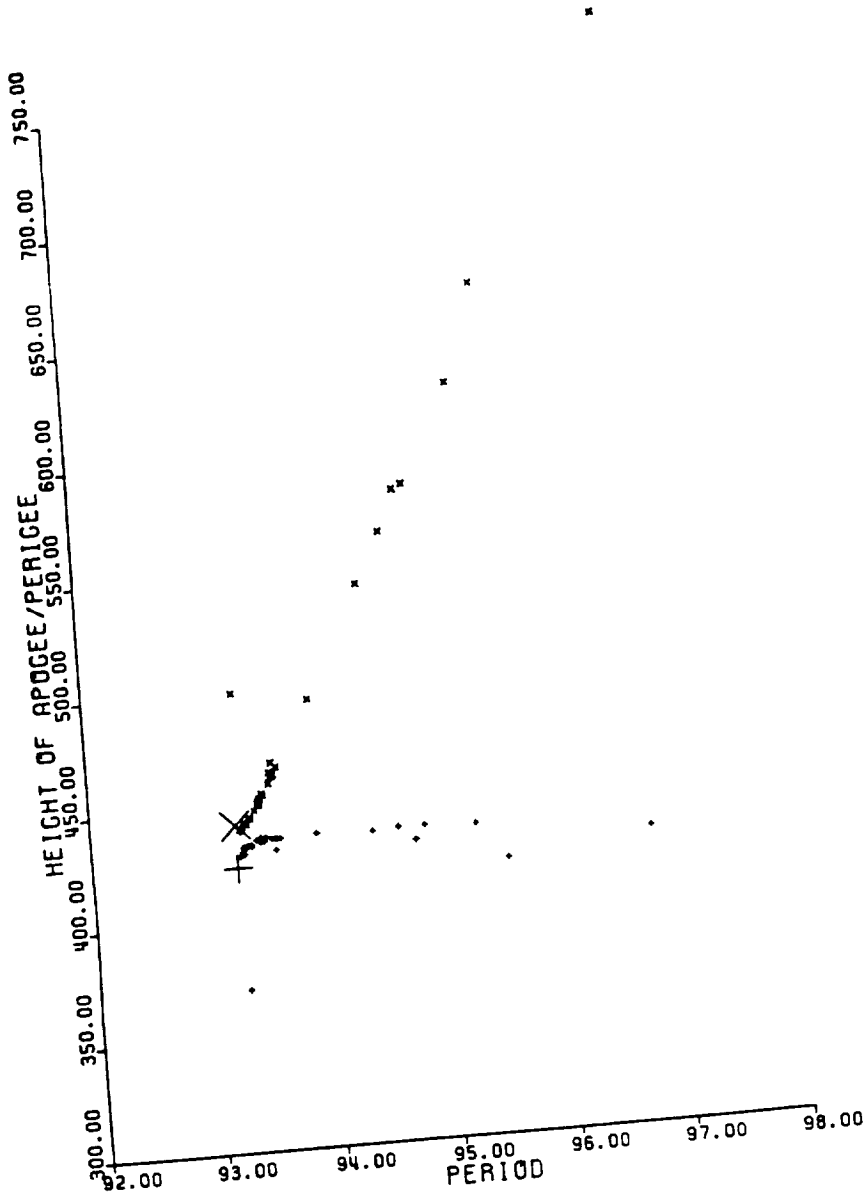
COMMENTS

Cosmos 699 was the first of a new type spacecraft. To date 16 members of this class have experienced breakups. The last fragmentation occurred in 1987. Beginning in 1988 old spacecraft have been commanded to lower perigee at end of life, resulting in an accelerated natural decay with no fragmentations. For several spacecraft, two distinct events have been detected and observational data suggest that the spacecraft remain essentially intact after each event. In all but one case, breakups occur after spacecraft has ceased orbit maintenance and entered natural decay. Debris are sometimes highly unidirectional. In the case of Cosmos 699, the spacecraft had been in a regime of natural decay for one month at the time of the event.

REFERENCE DOCUMENTS

An Analysis of the Breakup of Satellite 1974-103A (Cosmos 699), W. B. Heard, NRL Report 7991, Naval Research Laboratory, Washington, 23 April 1976.

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.



Cosmos 699 debris cloud as reconstructed from radar observations following the first breakup event. This diagram is derived from data found in NRL Report 7991 as cited above.

LANDSAT 2 R/B

1975-04B

7616

SATELLITE DATA

TYPE:	Delta Second Stage (2910)
OWNER:	US
LAUNCH DATE:	22.75 Jan 1975
DRY MASS (KG):	900 (approx.)
MAIN BODY:	Cylinder-Nozzle; 1.4 m by 5.8 m
MAJOR APPENDAGES:	Mini-skirt; 2.4 m by 0.2 m
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	On-board propellants, range safety device

EVENT DATA (1)

DATE:	9 Feb 1976		
TIME:	Unknown	LOCATION:	Unknown
ALTITUDE:	Unknown	ASSESSED CAUSE:	Unknown

PRE-EVENT ELEMENTS (1)

EPOCH:	76040.08509016		
RIGHT ASCENSION:	60.2329	MEAN ANOMALY:	189.3492
INCLINATION:	97.7751	MEAN MOTION:	14.19373945
ECCENTRICITY:	.0120730	MEAN MOTION DOT/2:	.0
ARG. OF PERIGEE:	170.9843	MEAN MOTION DOT DOT/6:	.0
		BSTAR:	.0

EVENT DATA (2)

DATE:	19 Jun 1976		
TIME:	0659 GMT	LOCATION:	7N, 344E (dsc)
ALTITUDE:	750 km	ASSESSED CAUSE:	Propulsion-related

PRE-EVENT ELEMENTS (2)

EPOCH:	76170.97576375		
RIGHT ASCENSION:	175.3897	MEAN ANOMALY:	217.2433
INCLINATION:	97.7497	MEAN MOTION:	14.19574919
ECCENTRICITY:	.0115288	MEAN MOTION DOT/2:	.0
ARG. OF PERIGEE:	143.6594	MEAN MOTION DOT DOT/6:	.0
		BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	207		
DEBRIS IN ORBIT:	43	MAXIMUM ΔP:	5.6 min
		MAXIMUM ΔI:	2.3 deg

COMMENTS

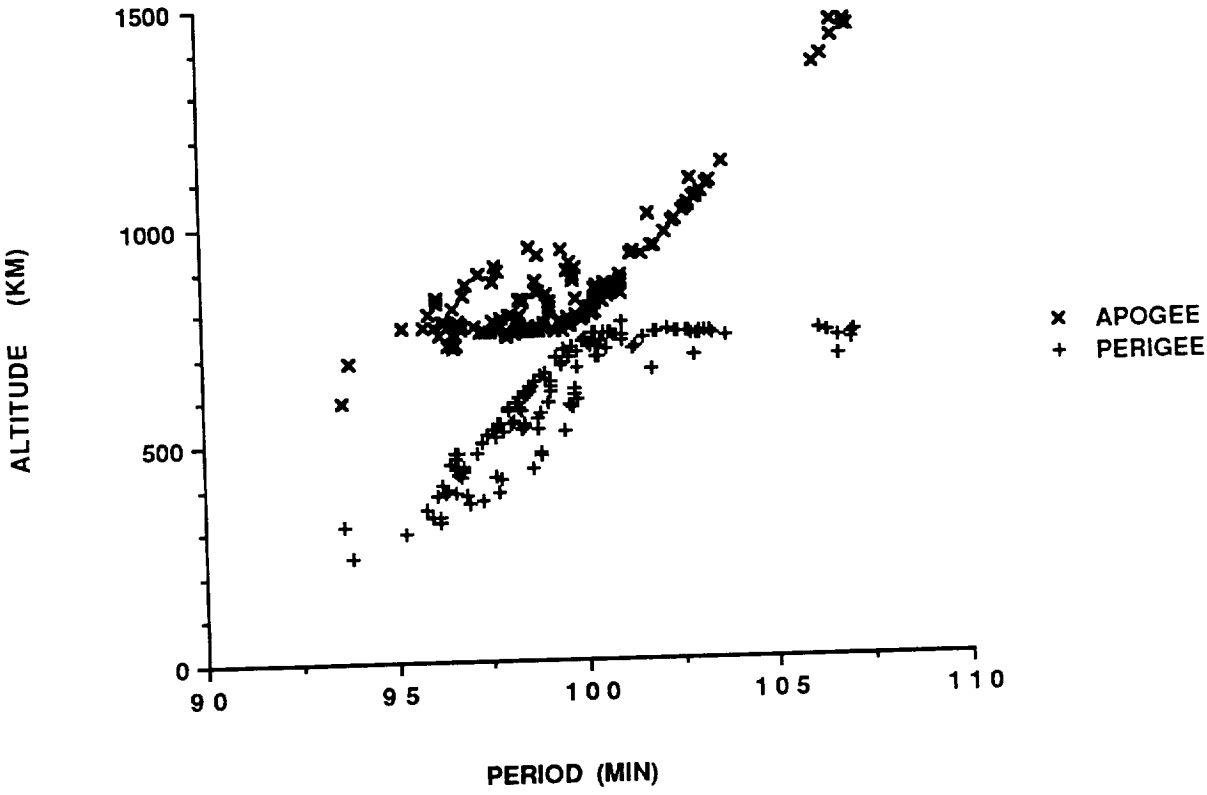
This was the fourth Delta Second Stage to experience a severe fragmentation. The first event occurred almost 13 months after the successful deployment of the Landsat 2 payload. Only 14 fragments were cataloged after the first event and all possessed orbital period changes of less than 0.6 min. Four months later a much larger fragmentation occurred. The cause of the second event is assessed to be related to the estimated 150 kg of residual propellants on board and characteristics of the sun-synchronous orbit.

REFERENCE DOCUMENTS

Explosion of Satellite 10704 and other Delta Second Stage Rockets, J.R. Gabbard, Technical Memorandum 81-5, DCS Plans, Hdqtrs NORAD/ADCOM, Colorado Springs, May 1981.

Investigation of Delta Second Stage On-Orbit Explosions, C.S. Gumpel, Report MDC-H0047, McDonnell Douglas Astronautics Company - West, Huntington Beach, April 1982.

A Later Look at Delta Second Stage On-Orbit Explosions, J.R. Gabbard, Technical Report CS85-BMDSC-00-24, Teledyne Brown Engineering, Colorado Springs, March 1985.



Landsat 2 R/B debris cloud of 147 fragments about six weeks after the second event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Delta Second Stage (2910)
OWNER:	US
LAUNCH DATE:	12.34 Jun 1975
DRY MASS (KG):	900 (approx.)
MAIN BODY:	Cylinder-Nozzle; 1.4 m by 5.8 m
MAJOR APPENDAGES:	Mini-skirt; 2.4 m by 0.3 m
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	On-board propellants, range safety device

EVENT DATA

DATE:	1 May 1991	LOCATION:	66N, 322E (dsc)
TIME:	0856 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	1090 km		

PRE-EVENT ELEMENTS

EPOCH:	91112.56709963	MEAN ANOMALY:	211.7525
RIGHT ASCENSION:	329.2109	MEAN MOTION:	13.43007146
INCLINATION:	99.5801	MEAN MOTION DOT/2:	.00000050
ECCENTRICITY:	.0006217	MEAN MOTION DOT DOT/6:	0.0
ARG. OF PERIGEE:	148.3989	BSTAR:	.0055458

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	233	MAXIMUM ΔP:	27.4 min*
DEBRIS IN ORBIT:	191	MAXIMUM ΔI:	2.4 min*

*Based on uncataloged debris data

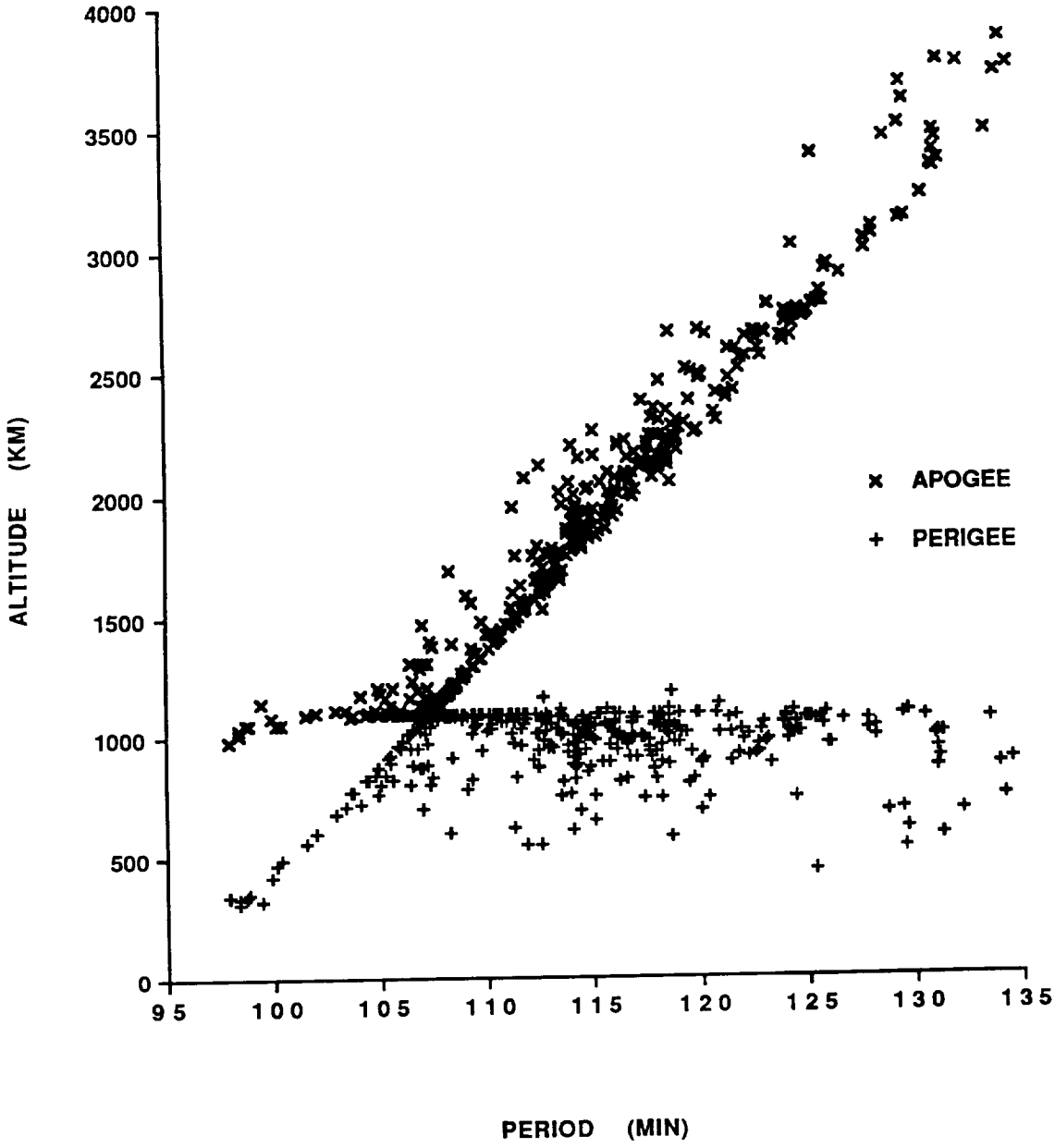
COMMENTS

This was the eighth Delta Second Stage to experience a severe fragmentation. The event occurred nearly 191 months after the successful deployment of the Nimbus 6 payload. Cause of the explosion is assessed to be related to the estimated 245 kg of residual propellants on board and characteristics of the sun-synchronous orbit.

REFERENCE DOCUMENTS

The Fragmentation of the Nimbus 6 Rocket Body, D. J. Nauer and N. L. Johnson, Technical Report CS91-TR-JSC-017, Teledyne Brown Engineering, Colorado Springs, Colorado, November 1991.

Nimbus 6 Delta Upper Stage Rocket Body Breakup Report, E. L. Jenkins and H. V. Reynolds, Naval Space Surveillance Center, Dahlgren, Virginia, 1991.



Nimbus 6 R/B debris cloud of 386 identified fragments within one week of the event as reconstructed from a Naval Space Surveillance System database. This diagram is taken from the first cited reference.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	5.62 Sep 1975
DRY MASS (KG):	6000 (approx.)
MAIN BODY:	Cone-cylinder; 2.4 m by 7 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	6 Sep 1975	LOCATION:	32N, 293E (asc)
TIME:	1906 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	185 km		

PRE-EVENT ELEMENTS

EPOCH:	75249.72782895	MEAN ANOMALY:	294.2107
RIGHT ASCENSION:	189.2795	MEAN MOTION:	16.09422927
INCLINATION:	67.1445	MEAN MOTION DOT/2:	.00430774
ECCENTRICITY:	.0113994	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	67.1020	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	76	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	Unknown

COMMENTS

Spacecraft was apparently destroyed after a malfunction prevented controlled reentry and landing in the Soviet Union. Third incident of this type. Most debris reentered before being officially cataloged. All but three official fragments were cataloged without elements.

Insufficient data to construct a Gabbard diagram.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	29.46 Oct 1975
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA

DATE:	25 Jan 1976		
TIME:	1400 GMT	LOCATION:	53N, 7E (asc)
ALTITUDE:	440 km	ASSESSED CAUSE:	Deliberate Action

PRE-EVENT ELEMENTS

EPOCH:	76025.37753295	MEAN ANOMALY:	88.9272
RIGHT ASCENSION:	303.6319	MEAN MOTION:	15.43461781
INCLINATION:	65.0177	MEAN MOTION DOT/2:	.00000373
ECCENTRICITY:	.0009065	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	271.0782	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

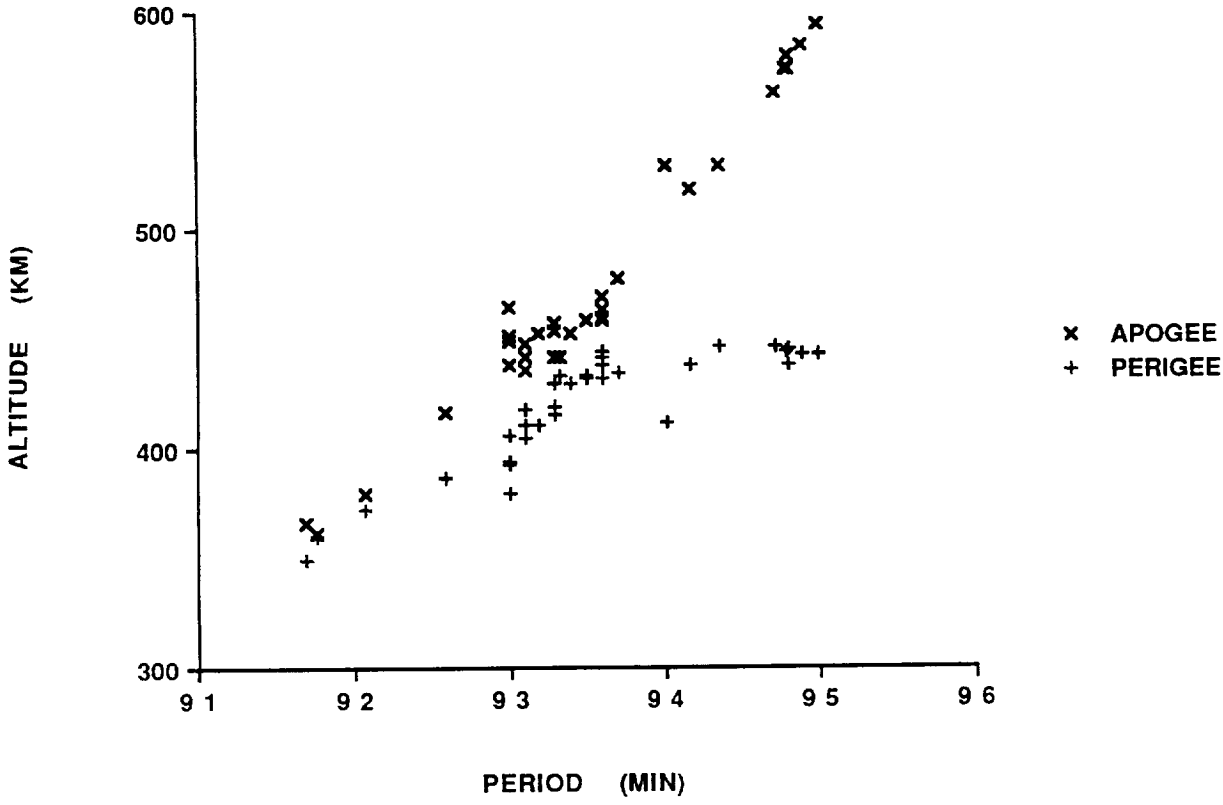
DEBRIS CATALOGED:	62		
DEBRIS IN ORBIT:	0	MAXIMUM ΔP:	1.6 min
		MAXIMUM ΔI:	0.4 deg

COMMENTS

Cosmos 777 was the second spacecraft of the Cosmos 699-type to experience a fragmentation. It is the only one to breakup before terminating its precise orbit maintenance pattern and entering a regime of natural decay. A second event may have occurred about 90 minutes after the event cited above.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.



Cosmos 777 debris cloud of 35 fragments about 10 days after the event as reconstructed from U.S. Space Surveillance Center database. Some drag effects are already evident.

C-2

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	2.44 Jul 1976
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA

DATE:	17 May 1977	LOCATION:	9S, 284E (dsc)
TIME:	1018 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	430 km		

PRE-EVENT ELEMENTS

EPOCH:	77136.94211102	MEAN ANOMALY:	73.5502
RIGHT ASCENSION:	131.3837	MEAN MOTION:	15.45822335
INCLINATION:	65.0556	MEAN MOTION DOT/2:	.00007521
ECCENTRICITY:	.0021270	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	286.3253	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	40	MAXIMUM ΔP:	8.0 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	1.1 deg*

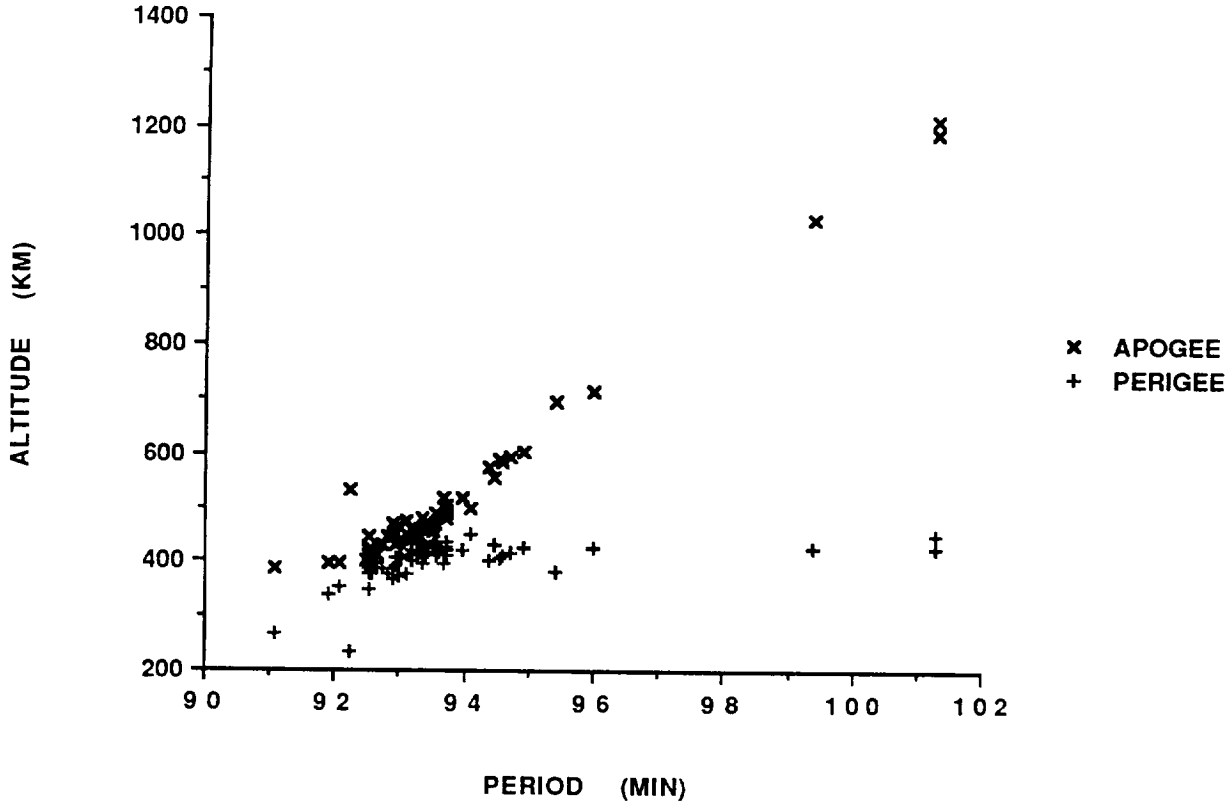
*Based on uncataloged debris data

COMMENTS

Cosmos 838 was the third spacecraft of the Cosmos 699-type to experience a fragmentation. Spacecraft had been in a regime of natural decay for six months prior to the event. Many debris reentered before being officially cataloged.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.



Cosmos 838 debris cloud of 59 fragments about one week after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	8.88 Jul 1976
DRY MASS (KG):	800 (approx.)
MAIN BODY:	Cylinder; 2 m by 2 m (?)
MAJOR APPENDAGES:	Solar panels, gravity-gradient boom (?)
ATTITUDE CONTROL:	Gravity gradient (?)
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	29 Sep 1977	LOCATION:	33S, 162E (dsc)
TIME:	0717 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	1910 km		

PRE-EVENT ELEMENTS

EPOCH:	77270.46732078	MEAN ANOMALY:	7.6996
RIGHT ASCENSION:	85.9347	MEAN MOTION:	12.32137908
INCLINATION:	65.8538	MEAN MOTION DOT/2:	.00000367
ECCENTRICITY:	.0706585	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	351.1444	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

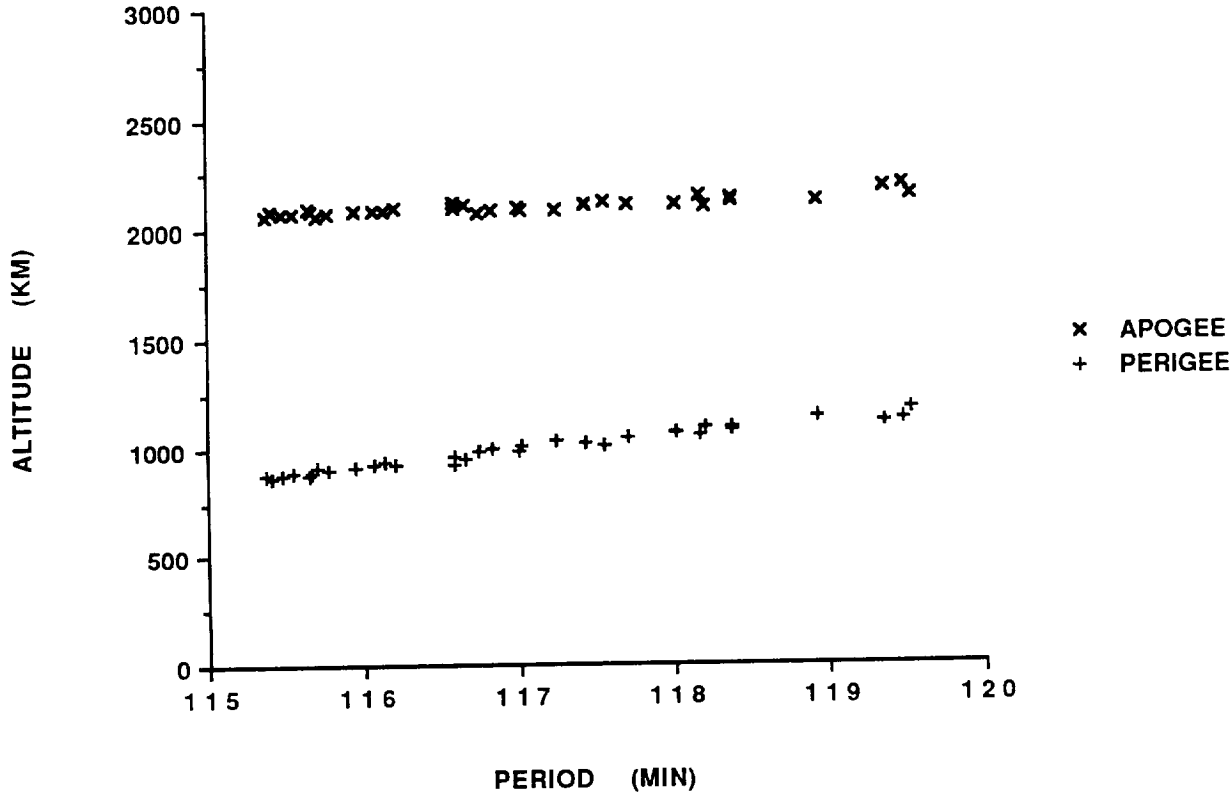
DEBRIS CATALOGED:	69	MAXIMUM ΔP:	2.7 min
DEBRIS IN ORBIT:	66	MAXIMUM ΔI:	0.3 deg

COMMENTS

Cosmos 839 was the first of three satellites of the same class to experience unexplained fragmentations. These satellites are used in conjunction with the Cosmos 249-type spacecraft which are deliberately fragmented; but the cause of the Cosmos 839-type events appears to be unrelated since they occur more than one year after tests with Cosmos 249-type spacecraft. In the case of Cosmos 839, 14 months elapsed between its test with a Cosmos 249-type spacecraft and its fragmentation.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 2): Soviet Anti-Satellite Program", N.L. Johnson, Journal of the British Interplanetary Society, August 1983, pp. 357-362.



Cosmos 839 debris cloud of 33 fragments about five weeks after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	22.66 Jul 1976
DRY MASS (KG):	6000 (approx.)
MAIN BODY:	Cone-Cylinder; 2.4 m by 7 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA

DATE:	25 Jul 1976	LOCATION:	49N, 100E (dsc)
TIME:	1718 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	210 km		

PRE-EVENT ELEMENTS

EPOCH:	76207.45032150	MEAN ANOMALY:	291.2246
RIGHT ASCENSION:	152.6930	MEAN MOTION:	16.04433196
INCLINATION:	67.1467	MEAN MOTION DOT/2:	.00313532
ECCENTRICITY:	.0136374	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	70.3553	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	248	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	Unknown

COMMENTS

Spacecraft was apparently destroyed after a malfunction prevented controlled reentry and landing in the Soviet Union. Fourth incident of this type. No elements were cataloged on any of the official debris. Most fragments reentered rapidly.

Insufficient data to construct a Gabbard diagram.

SATELLITE DATA

TYPE:	Delta Second Stage (2310)
OWNER:	US
LAUNCH DATE:	29.71 Jul 1976
DRY MASS (KG):	900 (approx.)
MAIN BODY:	Cylinder-Nozzle; 1.4 m by 5.8 m
MAJOR APPENDAGES:	Mini-skirt; 2.4 m by 0.3 m
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	On-board propellants, range safety device

EVENT DATA

DATE:	24 Dec 1977	LOCATION:	40S, 146E (asc)
TIME:	1133 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	1510 km		

PRE-EVENT ELEMENTS

EPOCH:	77354.53228225	MEAN ANOMALY:	330.8663
RIGHT ASCENSION:	38.5560	MEAN MOTION:	12.38394892
INCLINATION:	102.0192	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.0010085	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	29.2920	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	159	MAXIMUM ΔP:	12.5 min
DEBRIS IN ORBIT:	155	MAXIMUM ΔI:	3.0 deg

COMMENTS

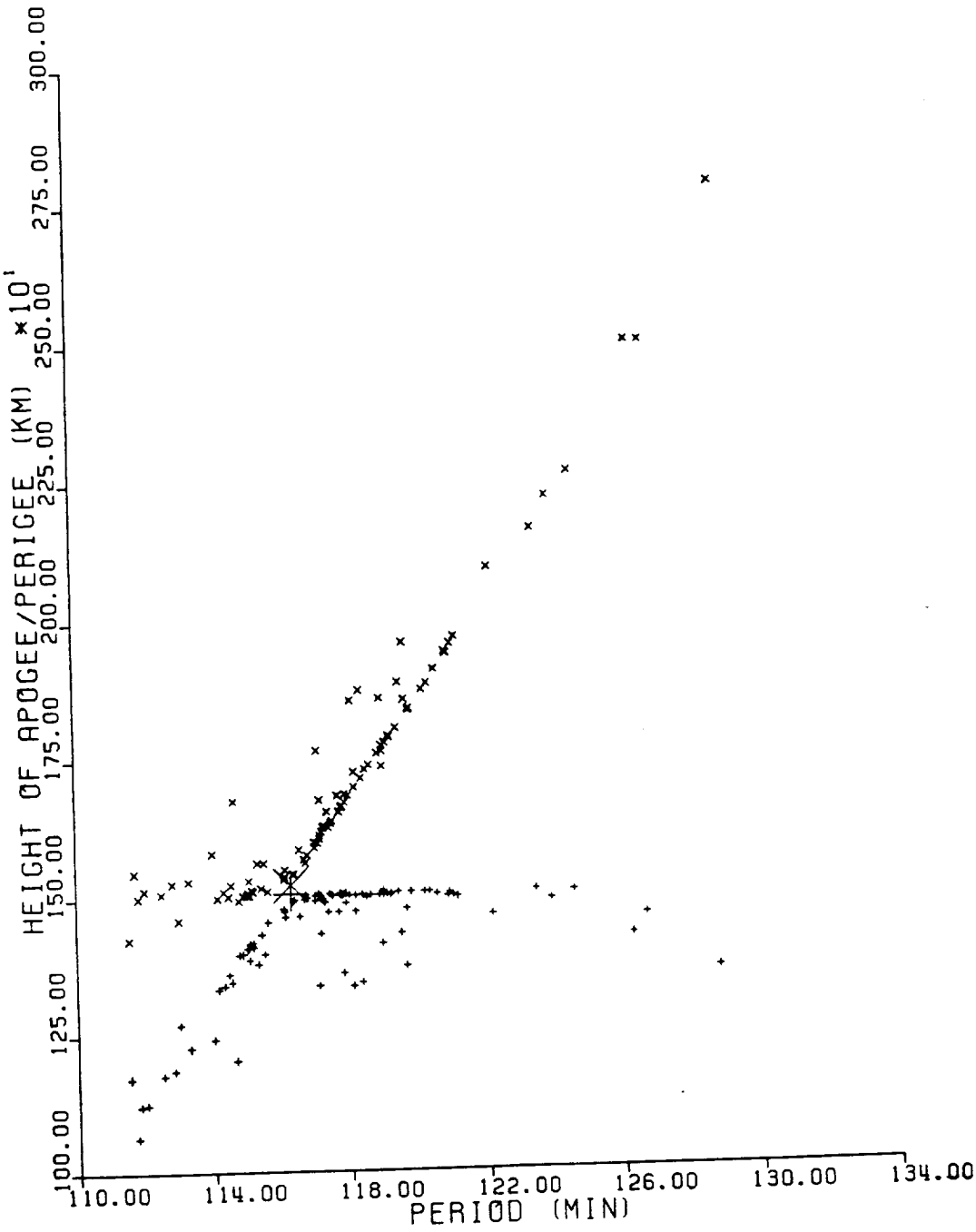
This was the sixth Delta Second Stage to experience a severe fragmentation. The event occurred 17 months after the successful deployment of the NOAA 5 payload. Cause of the explosion is assessed to be related to the estimated 250 kg of residual propellants on board and characteristics of the sun-synchronous orbit.

REFERENCE DOCUMENTS

Explosion of Satellite 10704 and other Delta Second Stage Rockets, J.R. Gabbard, Technical Memorandum 81-5, DCS Plans, Hdqtrs NORAD/ADCOM, Colorado Springs, May 1981.

Investigation of Delta Second Stage On-Orbit Explosions, C.S. Gumpel, Report MDC-H0047, McDonnell Douglas Astronautics Company - West, Huntington Beach, April 1982.

A Later Look at Delta Second Stage On-Orbit Explosions, J.R. Gabbard, Technical Report CS85-BMDSC-00-24, Teledyne Brown Engineering, Colorado Springs, March 1985.



NOAA 5 R/B debris cloud of 98 fragments about four months after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	22.38 Oct 1976
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 1.6 m by 3.4 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	15 Mar 1977	LOCATION:	39N, 114E (asc)
TIME:	1256 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	5375 km		

PRE-EVENT ELEMENTS

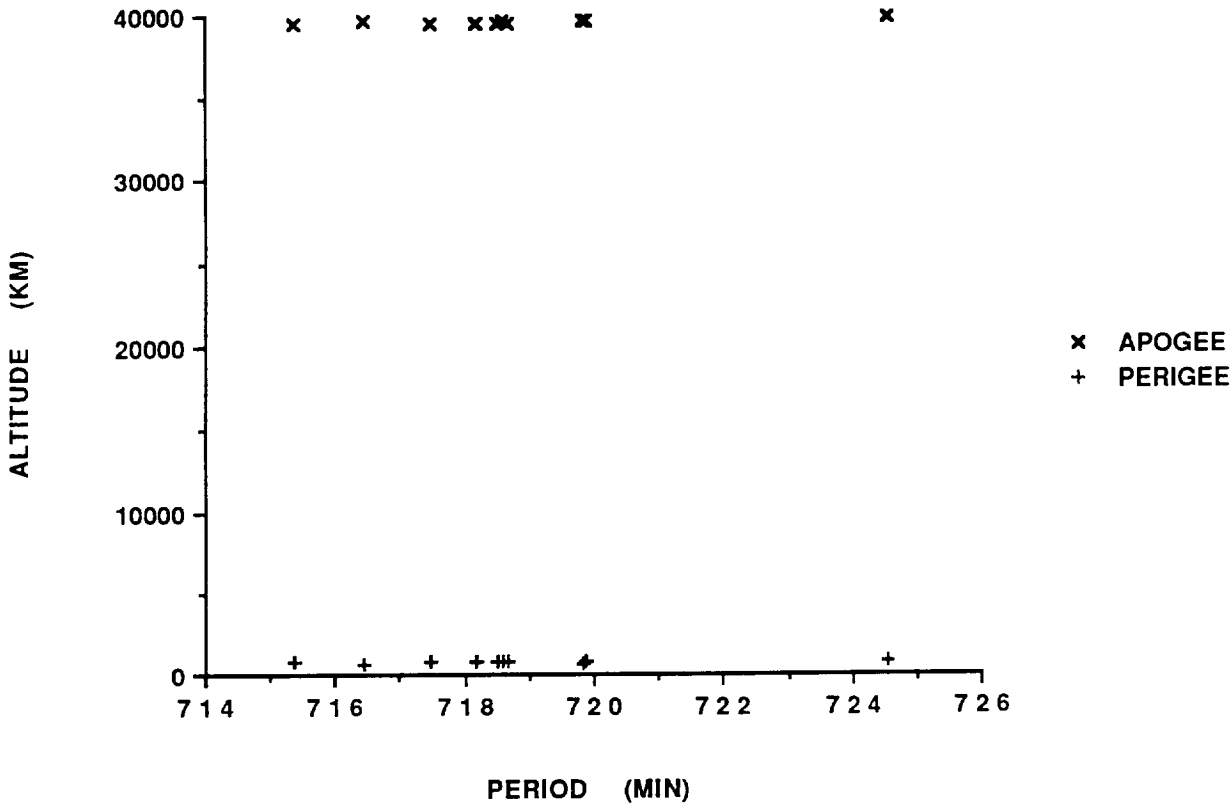
EPOCH:	77066.03986408	MEAN ANOMALY:	4.4196
RIGHT ASCENSION:	98.8078	MEAN MOTION:	2.00311741
INCLINATION:	63.1553	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.7312859	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	318.6653	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	11	MAXIMUM ΔP:	5.7 min
DEBRIS IN ORBIT:	11	MAXIMUM ΔI:	0.4 deg

COMMENTS

Cosmos 862 was the first of a new class of operational satellites in highly elliptical, semi-synchronous orbits which experienced a total of 15 fragmentations during the period 1977-1986. A constellation of 8-9 spacecraft is still maintained, but the fragmentations appear to have ceased. By careful examination of all members of this class which have fragmented, an assessed cause of propulsion-related breakup is determined. Due to the nature of these orbits, which result in high altitudes over the Northern Hemisphere where most surveillance sensors are located, debris detection and tracking is extremely difficult. Only the largest fragments can be seen. Cosmos 862 maneuvered into a pre-operational orbit about 1 November 1976. A station-keeping maneuver was anticipated at about the time of the event to synchronize the spacecraft's groundtrack as demonstrated by earlier test satellites.



Cosmos 862 debris cloud of 10 cataloged fragments two weeks after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	9.84 Dec 1976
DRY MASS (KG):	800 (est.)
MAIN BODY:	Cylinder; 2 m by 2 m (?)
MAJOR APPENDAGES:	Solar panels, gravity-gradient boom (?)
ATTITUDE CONTROL:	Gravity gradient (?)
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	27 Nov 1978	LOCATION:	65S, 306E (dsc)
TIME:	1703 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	560 km		

PRE-EVENT ELEMENTS

EPOCH:	78331.59395829	MEAN ANOMALY:	55.5772
RIGHT ASCENSION:	11.0317	MEAN MOTION:	14.93841919
INCLINATION:	65.8440	MEAN MOTION DOT/2:	.00000004
ECCENTRICITY:	.0050108	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	304.0553	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	49	MAXIMUM ΔP:	1.3 min*
DEBRIS IN ORBIT:	2	MAXIMUM ΔI:	0.0 deg*

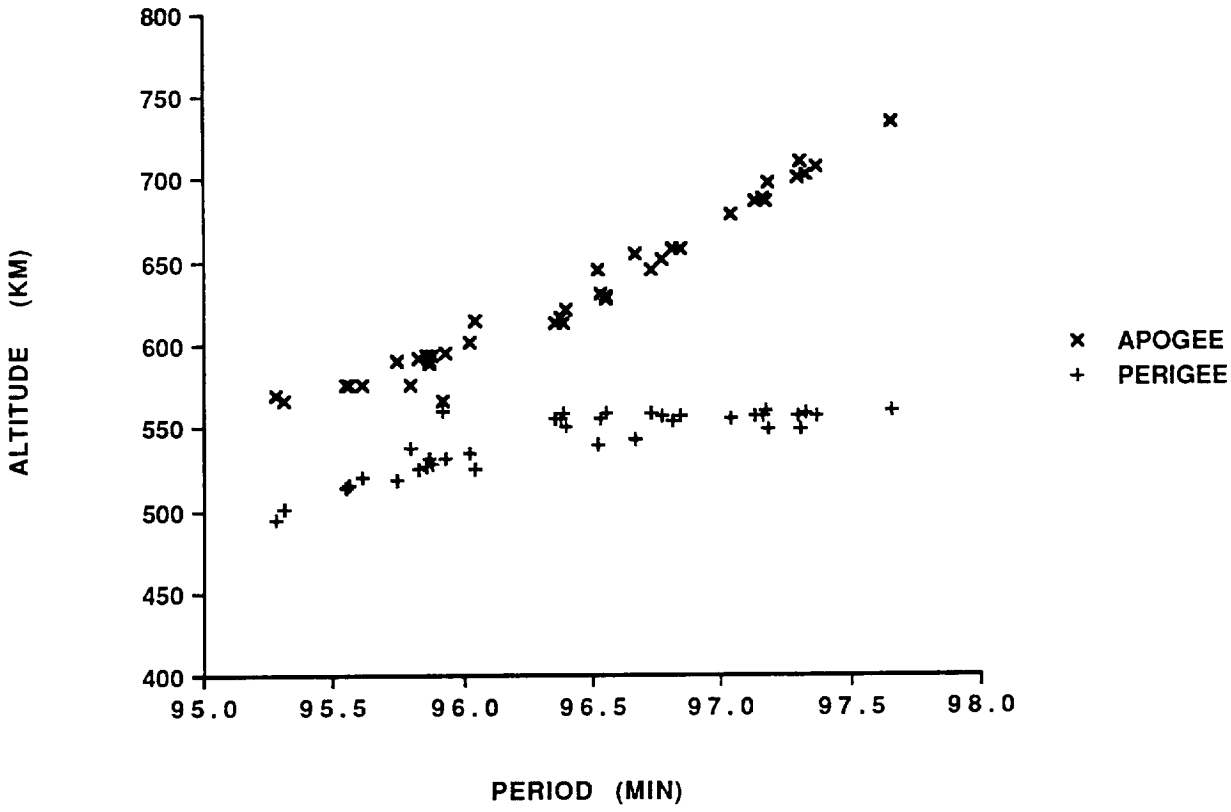
*Based on uncataloged debris data

COMMENTS

Cosmos 880 was the second spacecraft of the Cosmos 839-type to experience a fragmentation. Although these satellites are used in conjunction with the Cosmos 249-type spacecraft which are deliberately fragmented, the cause of the Cosmos 839-type events appears to be unrelated. In the case of Cosmos 880, 23 months elapsed since its test with a Cosmos 249-type spacecraft.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 2): Soviet Anti-Satellite Program", N.L. Johnson, Journal of the British Interplanetary Society, August 1983, pp. 357-362.



Cosmos 880 debris cloud of 40 fragments two days after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	27.53 Dec 1976
DRY MASS (KG):	1000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 2 m (?)
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	27 Dec 1976	LOCATION:	65S, 210E (asc)
TIME:	1840 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	2090 km		

POST-EVENT ELEMENTS

EPOCH:	77362.79720829	MEAN ANOMALY:	313.0540
RIGHT ASCENSION:	306.5669	MEAN MOTION:	12.54457816
INCLINATION:	65.8434	MEAN MOTION DOT/2:	.00004000
ECCENTRICITY:	.1087102	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	57.0236	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

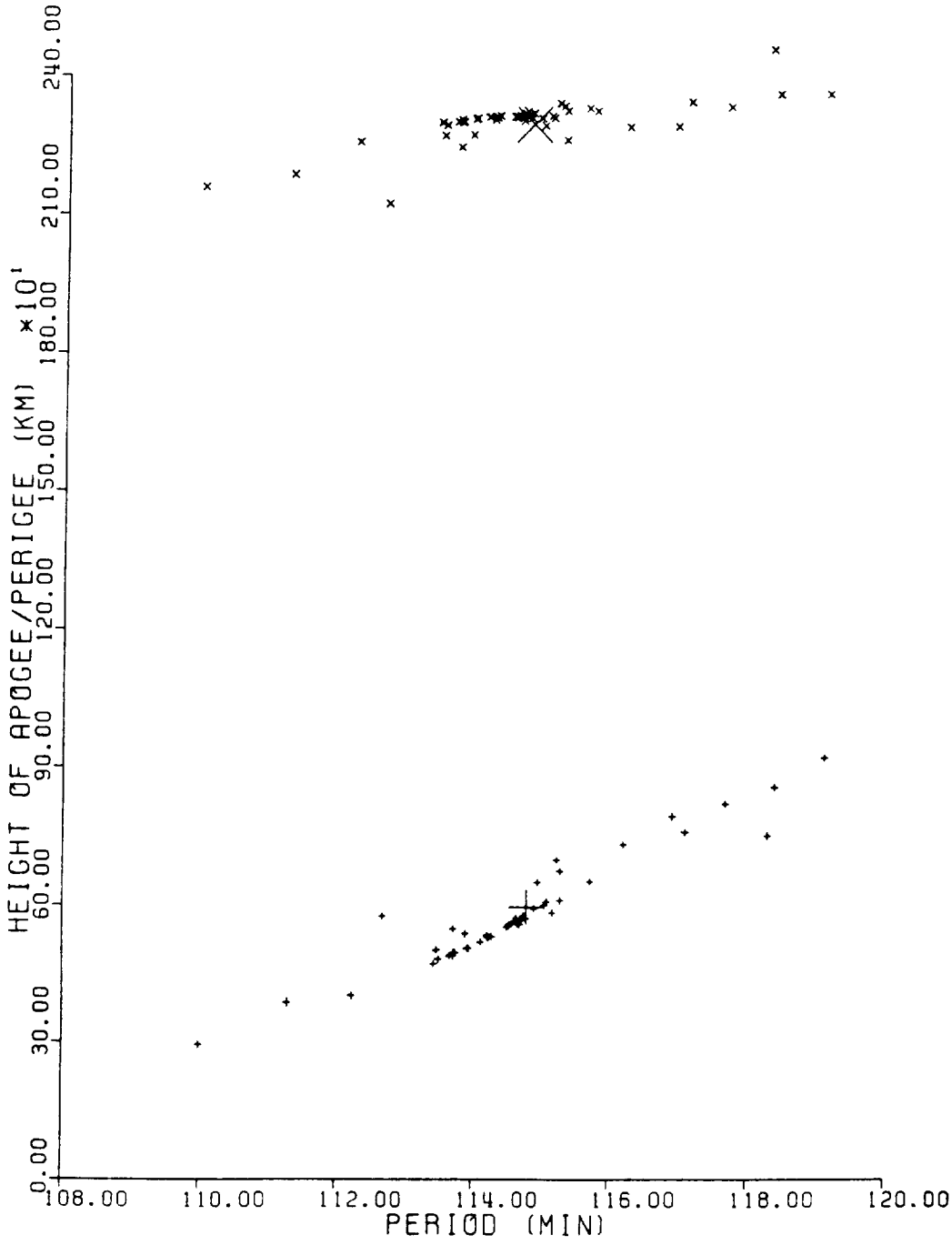
DEBRIS CATALOGED:	76	MAXIMUM ΔP:	4.3 min
DEBRIS IN ORBIT:	63	MAXIMUM ΔI:	0.2 deg

COMMENTS

Cosmos 886 was launched on a two-revolution rendezvous with Cosmos 880. After a close approach, Cosmos 886 continued on before its warhead was intentionally fired. Cosmos 886 was part of test series begun with Cosmos 249. The elements above are the first available after the final maneuver of Cosmos 886 but represent the revolution immediately after the event.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 2): Soviet Anti-Satellite Program", N.L. Johnson, Journal of the British Interplanetary Society, August 1983, pp. 357-362.



Cosmos 886 debris cloud of 53 fragments five months after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	11.07 Apr 1977
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 1.6 m by 3.4 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	8 Jun 1978	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS

EPOCH:	78156.86414074	MEAN ANOMALY:	5.0496
RIGHT ASCENSION:	115.5660	MEAN MOTION:	2.00599850
INCLINATION:	63.1514	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.7100107	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	319.7397	BSTAR:	.0

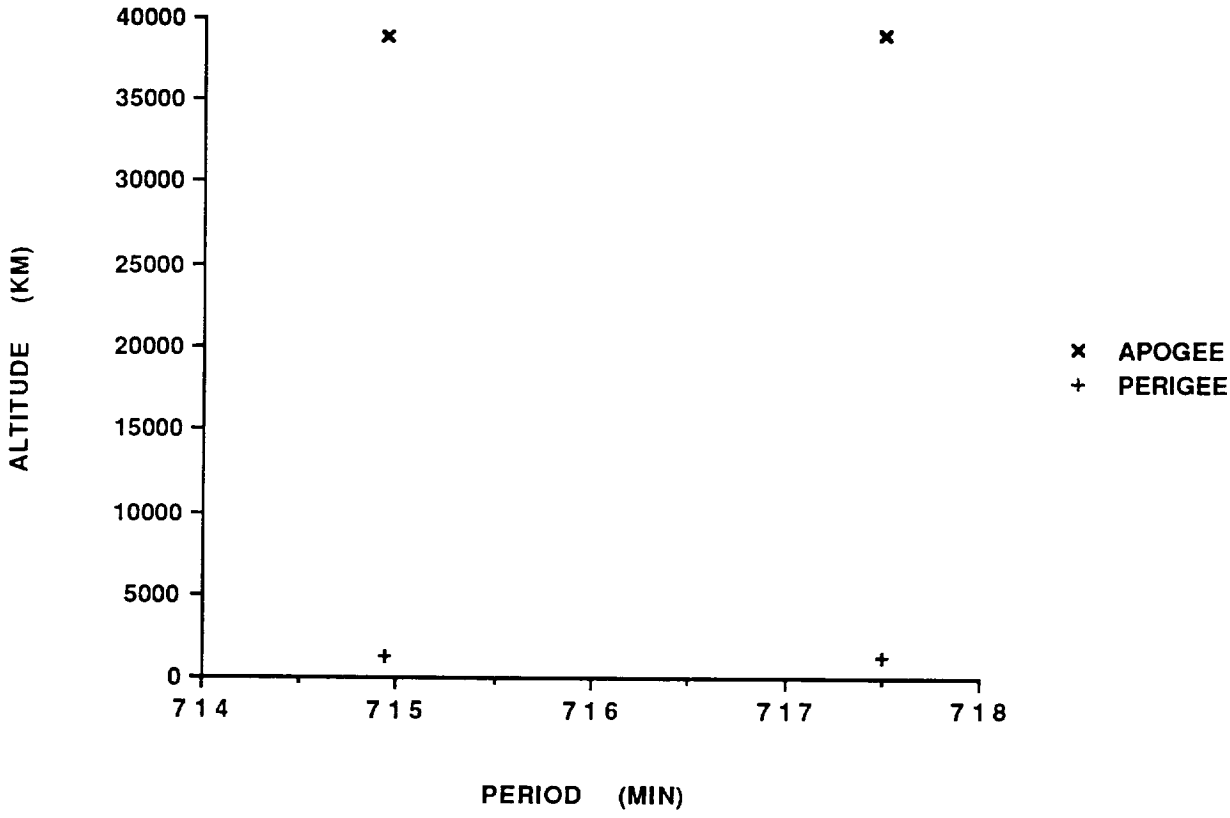
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	2	MAXIMUM ΔP:	2.6 min*
DEBRIS IN ORBIT:	2	MAXIMUM ΔI:	0.5 deg*

*See Comments

COMMENTS

Cosmos 903 was the third spacecraft of the Cosmos 862-type to experience a fragmentation. The last station-keeping maneuver prior to the event occurred about 26 April 1978. Another station-keeping maneuver was required sometime in June to maintain the established groundtrack pattern. After the event Cosmos 903 was found in a lower period orbit consistent with a successful maneuver, but the spacecraft never maneuvered again and drifted off station. One new fragment was cataloged within a week of the event. The ΔP and ΔI values above are based on the lower period (717.5 min) orbit of Cosmos 903 after the event.



Cosmos 903 and a single piece of debris three weeks after the event as reconstructed from U. S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	16.08 Jun 1977
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 1.6 m by 3.4 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	30 March 1979	LOCATION:	63S, 0E (dsc)
TIME:	1545 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	3280 km		

PRE-EVENT ELEMENTS

EPOCH:	79089.17562851	MEAN ANOMALY:	5.2297
RIGHT ASCENSION:	156.1576	MEAN MOTION:	2.00553521
INCLINATION:	62.9498	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.6980052	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	322.3289	BSTAR:	.0

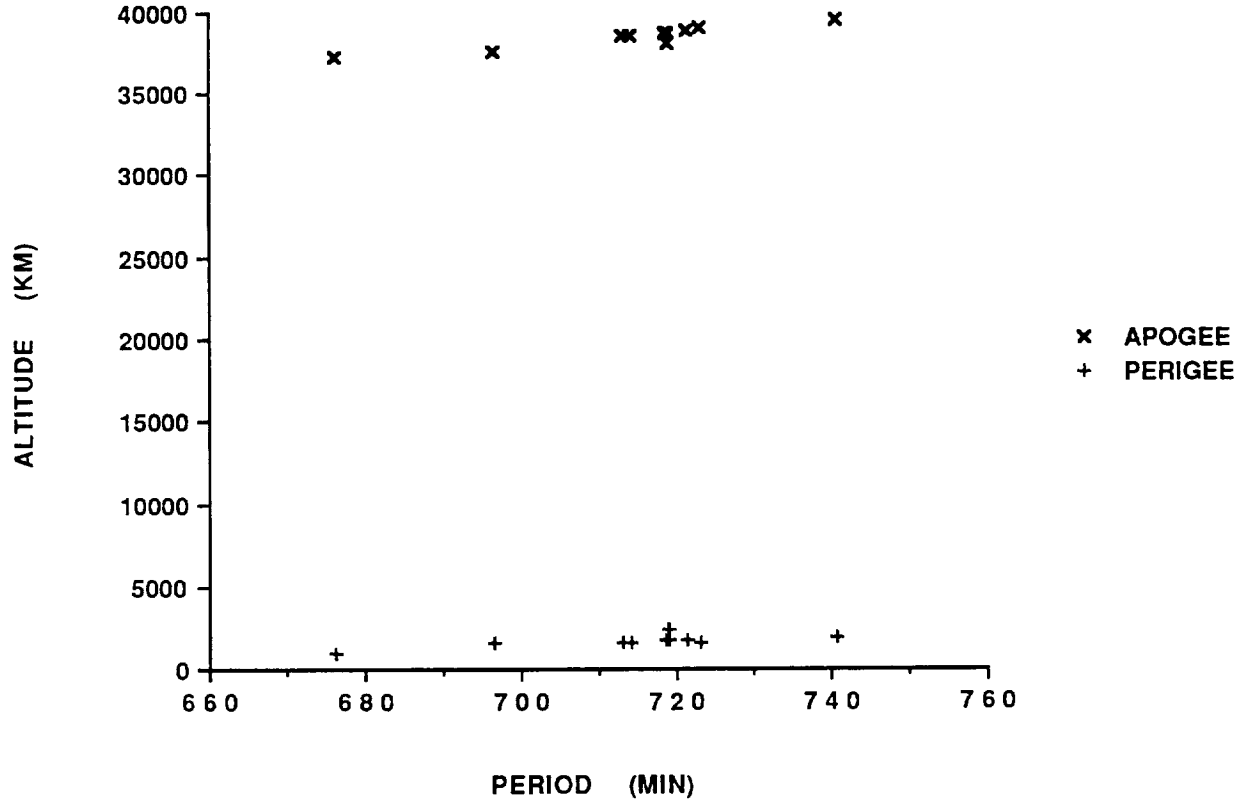
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	1	MAXIMUM ΔP:	22.6 min*
DEBRIS IN ORBIT:	1	MAXIMUM ΔI:	0.6 deg*

*Based on uncataloged debris data

COMMENTS

Cosmos 917 was the fifth spacecraft of the Cosmos 862-type to experience a fragmentation. The last station-keeping maneuver prior to the event occurred about 27 December 1978. By the end of March 1979, another maneuver was required to maintain the established groundtrack pattern. After the event the spacecraft was found in a higher period orbit rather than the necessary lower period orbit. The spacecraft then drifted off station.



Cosmos 917 debris cloud of 12 fragments about three weeks after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Delta Second Stage (2914)
OWNER:	US
LAUNCH DATE:	14.44 Jul 1977
DRY MASS (KG):	900 (approx.)
MAIN BODY:	Cylinder-Nozzle; 1.4 m by 5.8 m
MAJOR APPENDAGES:	Mini-skirt; 2.4 m by 0.3 m
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	On-board propellants, range safety device

EVENT DATA

DATE:	14 Jul 1977	LOCATION:	14N, 249E (dsc)
TIME:	1612 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	1450 km		

POST-EVENT ELEMENTS

EPOCH:	77197.57445278	MEAN ANOMALY:	303.2693
RIGHT ASCENSION:	262.0317	MEAN MOTION:	12.95114397
INCLINATION:	29.0493	MEAN MOTION DOT/2:	.00007335
ECCENTRICITY:	.0973469	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	66.7255	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	169	MAXIMUM ΔP:	9.7 min*
DEBRIS IN ORBIT:	82	MAXIMUM ΔI:	3.0 deg*

*Based on uncataloged debris data

COMMENTS

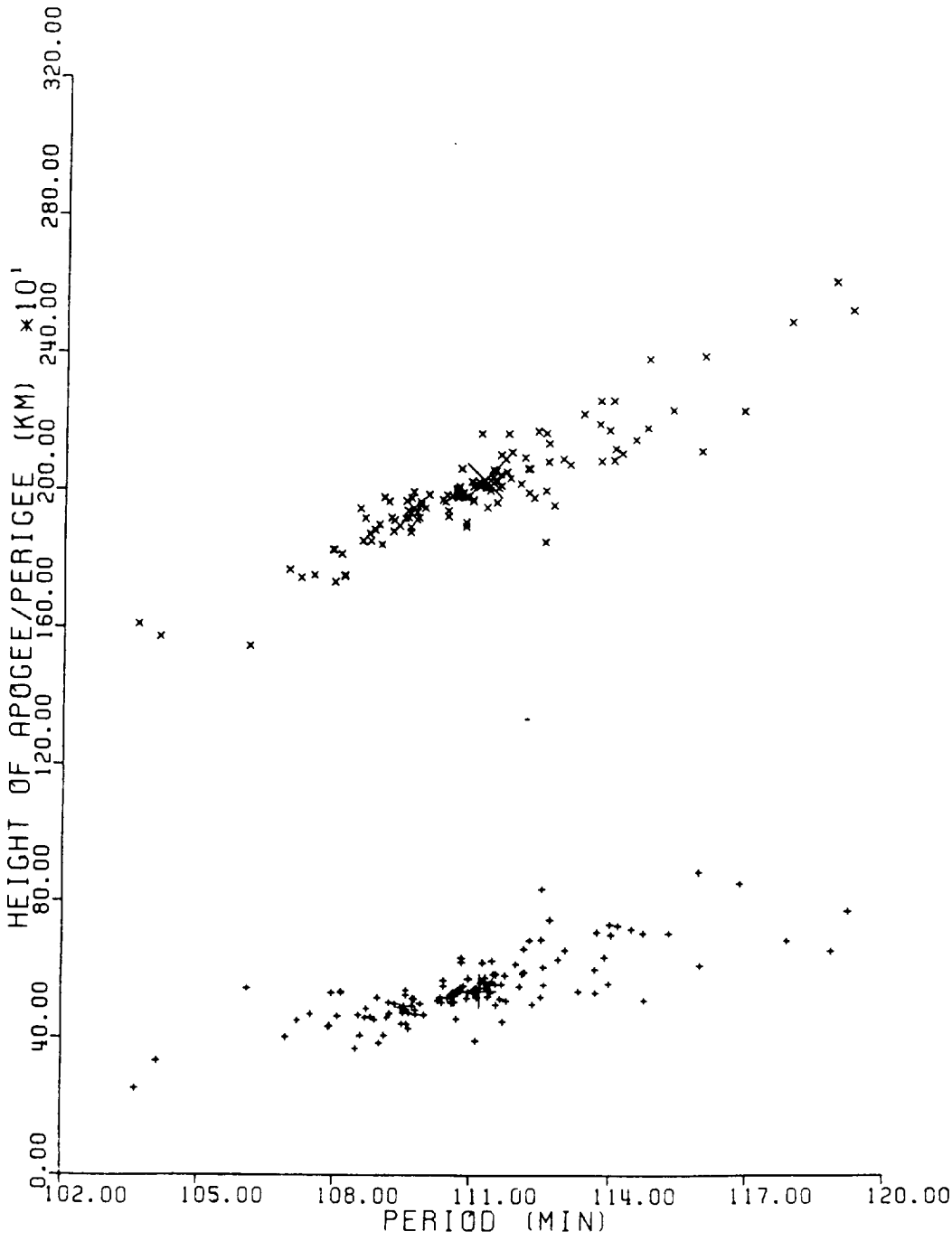
This was the fifth Delta Second Stage to experience a severe fragmentation. It is also the only one which was not in a sun-synchronous orbit, which had performed a depletion burn, and which fragmented on the day of launch. This rocket body did perform its mission successfully, carrying the third stage and the payload into a low Earth orbit. The energy for the breakup is assessed to have been the 40 kg of propellants (mainly oxidizer) remaining after the depletion burn. The elements above are the first available after the depletion burn although also after the event.

REFERENCE DOCUMENTS

Explosion of Satellite 10704 and other Delta Second Stage Rockets, J.R. Gabbard, Technical Memorandum 81-5, DCS Plans, Hdqtrs NORAD/ADCOM, Colorado Springs, May 1981.

Investigation of Delta Second Stage On-Orbit Explosions, C.S. Gumpel, Report MDC-H0047, McDonnell Douglas Astronautics Company - West, Huntington Beach, April 1982.

A Later Look at Delta Second Stage On-Orbit Explosions, J.R. Gabbard, Technical Report CS85-BMDSC-00-24, Teledyne Brown Engineering, Colorado Springs, March 1985.



Himawari 1 R/B debris cloud of 134 fragments about five months after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	20.20 Jul 1977
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 1.6 m by 3.4 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	24 Oct 1977	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS

EPOCH:	77289.02131186	MEAN ANOMALY:	4.2624
RIGHT ASCENSION:	305.6648	MEAN MOTION:	2.00651833
INCLINATION:	62.9440	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.7341055	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	318.8771	BSTAR:	.0

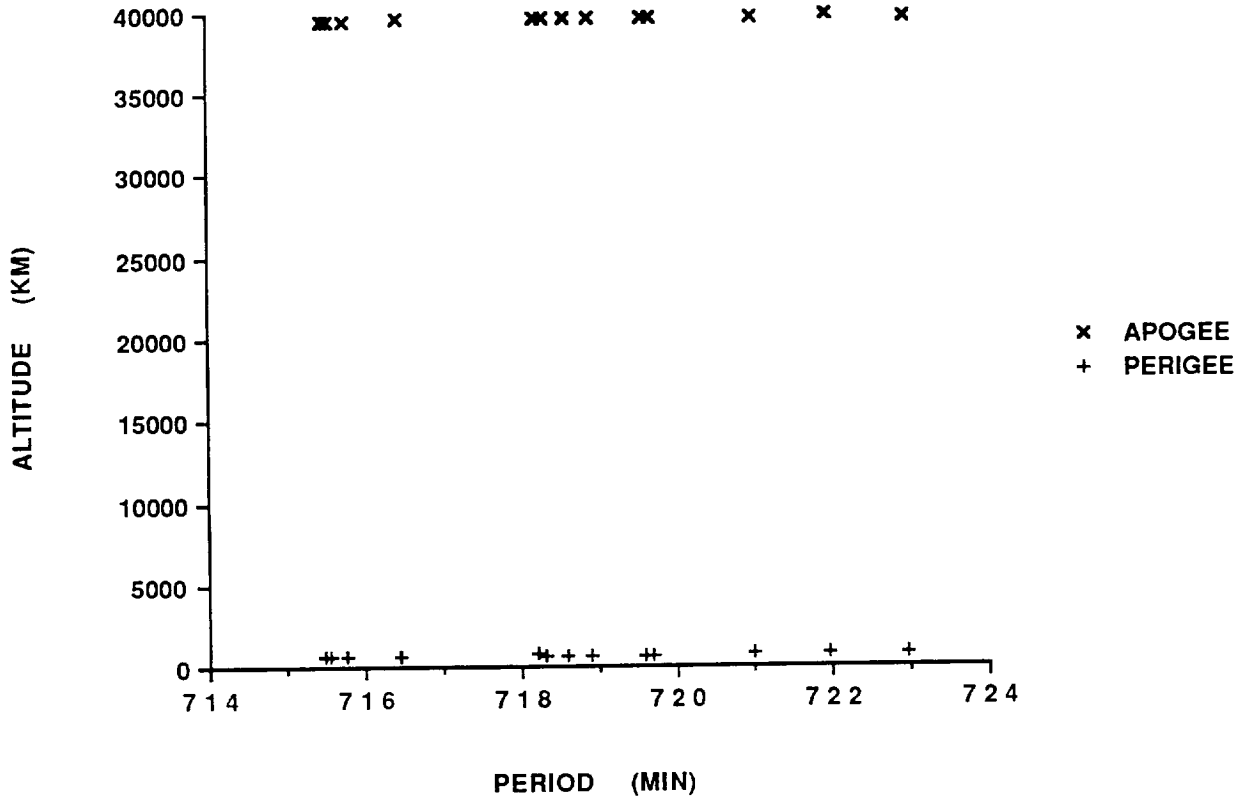
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	6	MAXIMUM ΔP:	5.3 min*
DEBRIS IN ORBIT:	5	MAXIMUM ΔI:	0.7 deg*

*Based on uncataloged debris data

COMMENTS

Cosmos 931 was the second spacecraft of the Cosmos 862-type to experience a fragmentation. The last station-keeping maneuver prior to the event was about 18 September. At the time of the event Cosmos 931 was at the extreme eastern edge of its groundtrack corridor. However, a maneuver at this time was not necessary since natural perturbations were beginning to shift Cosmos 931's groundtrack westward again. Debris were not officially cataloged until four years after the event.



Cosmos 931 debris cloud of 13 fragments two weeks after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	20.73 Sept 1977
DRY MASS (KG):	2,000 (approx.)
MAIN BODY:	Cylinder and plate
MAJOR APPENDAGES:	Plate + 2 Solar Panels
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, Battery

EVENT DATA

DATE:	23 Jun 1978	LOCATION:	0.0N, 98.7E
TIME:	Unknown	ASSESSED CAUSE:	Electrical (NiH_2 Battery Failure
ALTITUDE:	35790 km		

PRE-EVENT ELEMENTS

EPOCH:	88166.03647595	MEAN ANOMALY:	78.3897
RIGHT ASCENSION:	78.3897	MEAN MOTION:	1.00252588
INCLINATION:	0.1137	MEAN MOTION DOT/2:	.0
ECCENTRICITY	.0001436	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	325.2771	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	1	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	1	MAXIMUM ΔI:	Unknown

COMMENTS

This event was revealed by the Commonwealth of Independent States (CIS) in a meeting in early 1992. The event was not detected by the Space Surveillance Network and was not suspected until the CIS revelation. This is the first known geostationary orbit fragmentation and was not detected by the Space Surveillance Network (SSN). No tracked orbital debris in the geostationary belt could be discerned from the analyst satellite historical archives.

Insufficient data to construct a Gabbard diagram.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	21.44 Dec 1977
DRY MASS (KG):	1000 (est.)
MAIN BODY:	Cylinder; 1.3 m by 2 m (?)
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	21 Dec 1977	LOCATION:	38S, 274E (asc)
TIME:	1710 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	1135 km		

PRE-EVENT ELEMENTS

EPOCH:	77355.65049149	MEAN ANOMALY:	245.5638
RIGHT ASCENSION:	282.1792	MEAN MOTION:	13.58084598
INCLINATION:	65.8467	MEAN MOTION DOT/2:	.00023007
ECCENTRICITY:	.0129854	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	116.3098	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

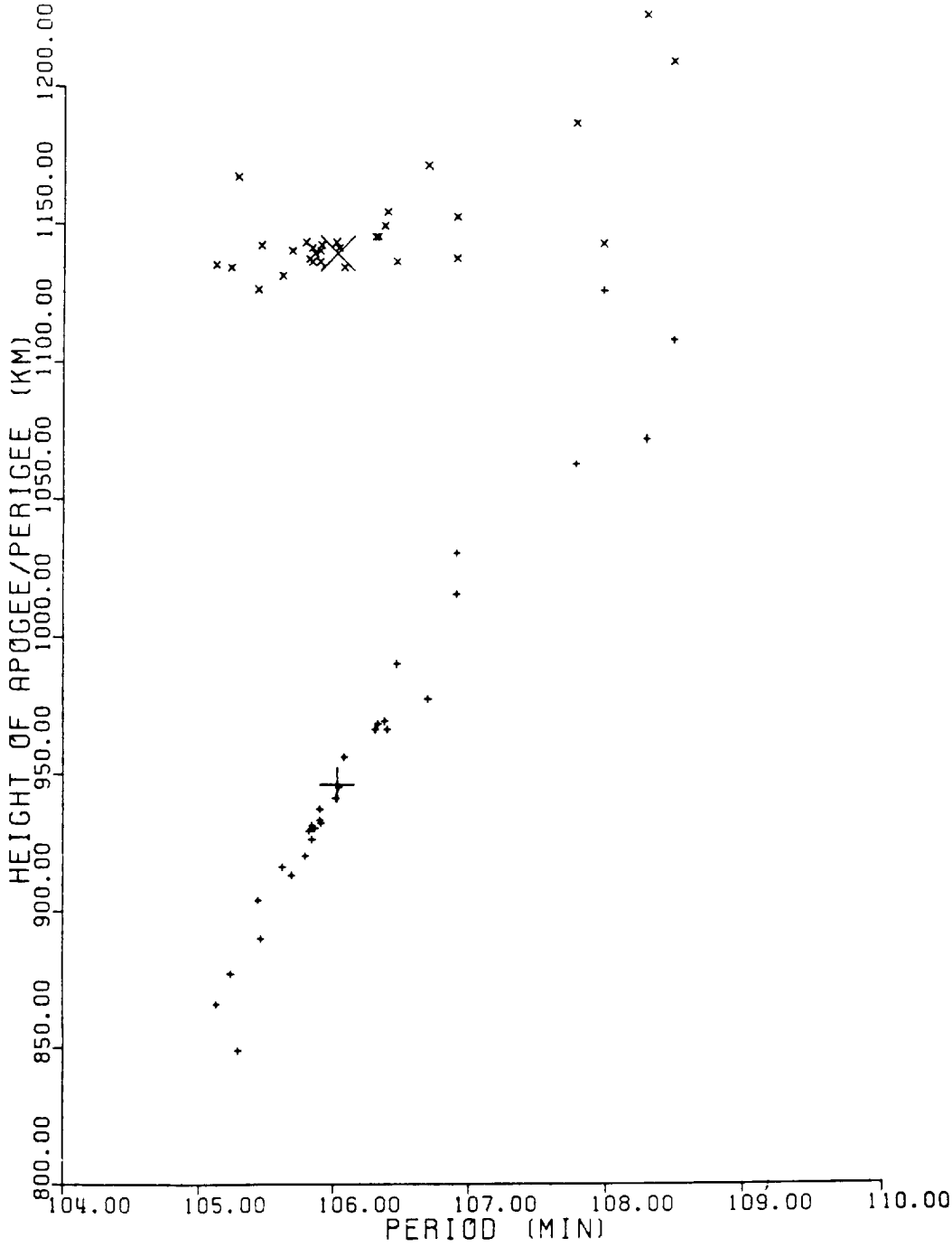
DEBRIS CATALOGED:	70	MAXIMUM ΔP:	4.7 min
DEBRIS IN ORBIT:	68	MAXIMUM ΔI:	1.1 deg

COMMENTS

Cosmos 970 was launched on a two-revolution rendezvous with Cosmos 967. After a close approach, Cosmos 970 continued on before its warhead was intentionally fired. Cosmos 970 was part of test series begun with Cosmos 249.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 2): Soviet Anti-Satellite Program", N.L. Johnson, Journal of the British Interplanetary Society, August 1983, pp. 357-362.



Cosmos 970 debris cloud of 32 fragments about five months after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Delta Second Stage (2910)
OWNER:	US
LAUNCH DATE:	5.75 Mar 1978
DRY MASS (KG):	900 (approx.)
MAIN BODY:	Cylinder-Nozzle; 1.4 m by 5.8 m
MAJOR APPENDAGES:	Mini-skirt; 2.4 m by 0.3 m
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	On-board propellants, range safety device

EVENT DATA

DATE:	27 Jan 1981	LOCATION:	80S, 301E (dsc)
TIME:	0432 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	910 km		

PRE-EVENT ELEMENTS

EPOCH:	81026.99107090	MEAN ANOMALY:	147.0549
RIGHT ASCENSION:	68.7927	MEAN MOTION:	13.96108433
INCLINATION:	98.8485	MEAN MOTION DOT/2:	.00000434
ECCENTRICITY:	.0006255	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	212.9842	BSTAR:	.00032708

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	208	MAXIMUM ΔP:	9.1 min
DEBRIS IN ORBIT:	149	MAXIMUM ΔI:	0.5 deg

COMMENTS

This was the seventh Delta Second Stage to experience a severe fragmentation. The event occurred nearly 35 months after the successful deployment of the Landsat 3 payload. Cause of the explosion is assessed to be related to the estimated 100 kg of residual propellants on board and characteristics of the sun-synchronous orbit.

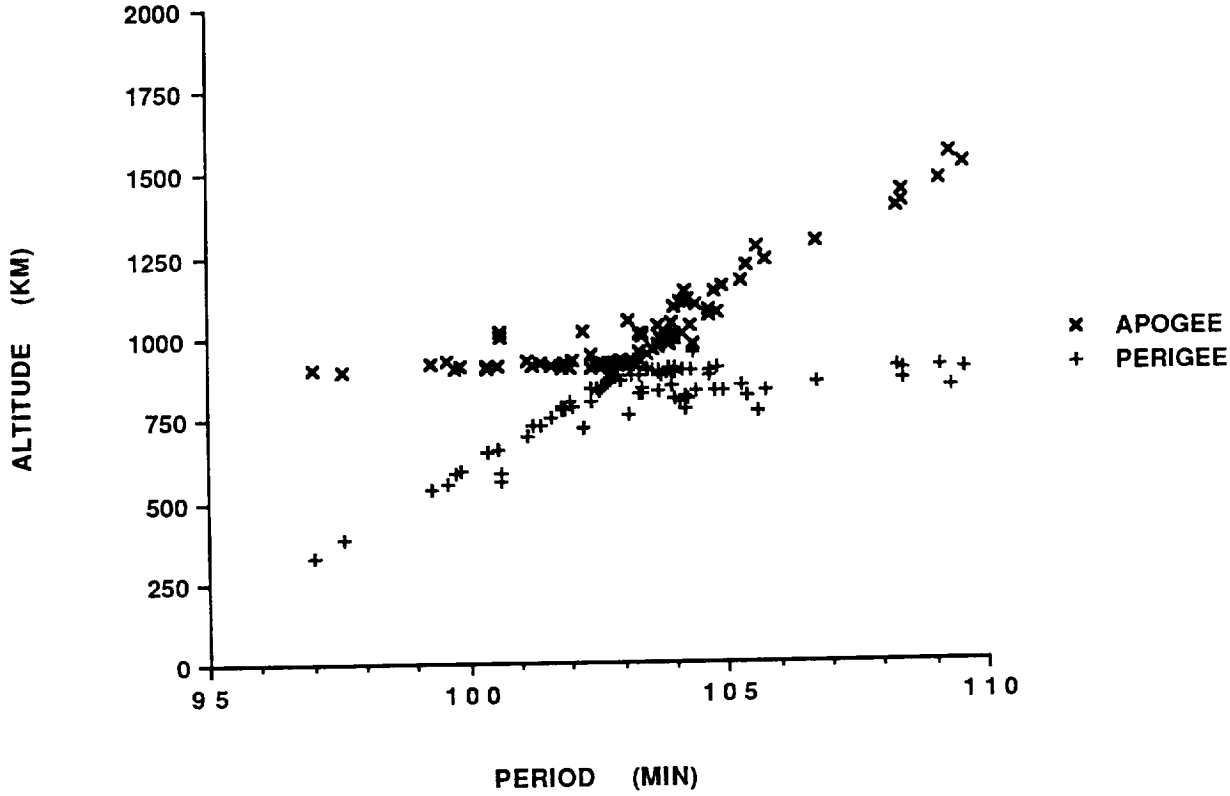
REFERENCE DOCUMENTS

Explosion of Satellite 10704 and other Delta Second Stage Rockets, J.R. Gabbard, Technical Memorandum 81-5, DCS Plans, Hdqtrs NORAD/ADCOM, Colorado Springs, May 1981.

Analysis of PARCS Recorded Data on the Breakup of Satellite 10704 on 27 January 1981, S.F. Hoffman and P.P. Shinkunas, Technical Report MSB82-ADC-0138, Teledyne Brown Engineering, Huntsville, February 1982.

Investigation of Delta Second Stage On-Orbit Explosions, C.S. Gumpel, Report MDC-H0047, McDonnell Douglas Astronautics Company - West, Huntington Beach, April 1982.

A Later Look at Delta Second Stage On-Orbit Explosions, J.R. Gabbard, Technical Report CS85-BMDSC-00-24, Teledyne Brown Engineering, Colorado Springs, March 1985.



Landsat 3 R/B debris cloud of 90 identified fragments four days after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	6.13 Sep 1978
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 1.6 m by 3.4 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	10 Oct 1978	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS

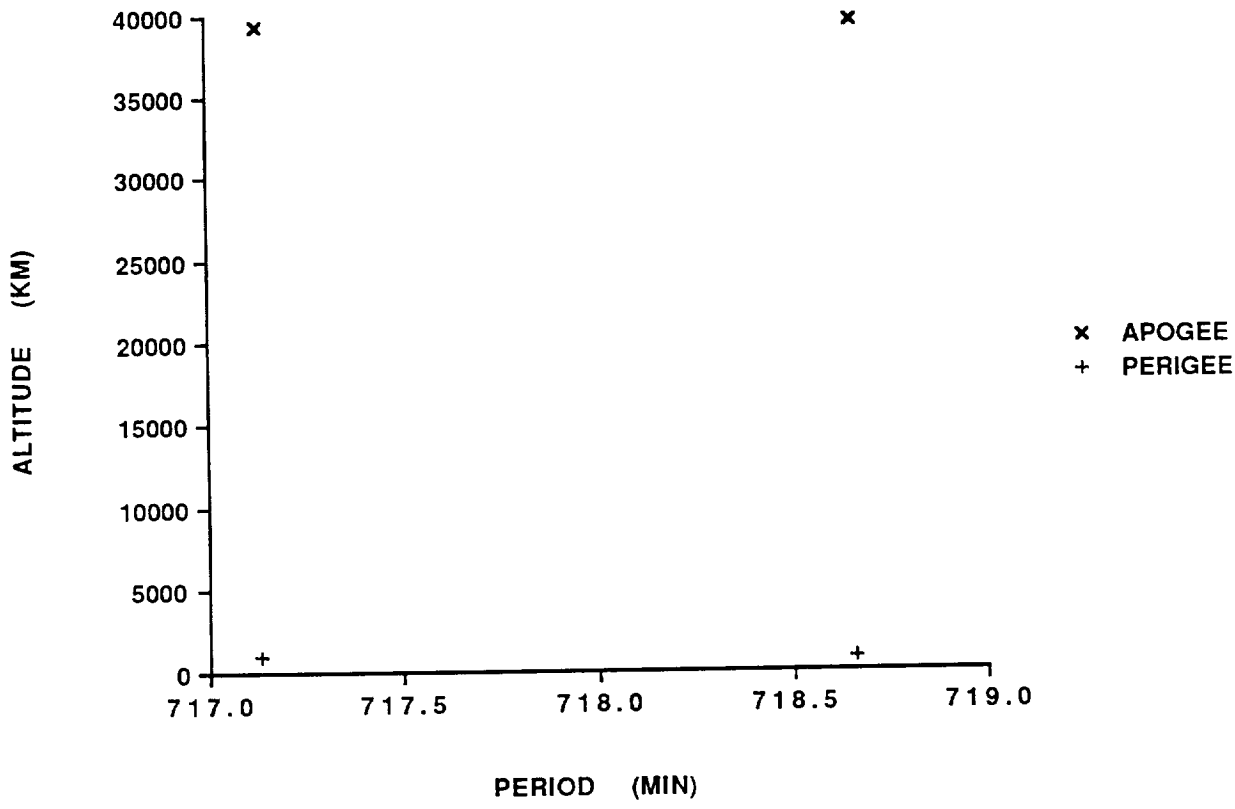
EPOCH:	78277.19859350	MEAN ANOMALY:	4.9827
RIGHT ASCENSION:	336.7676	MEAN MOTION:	2.00213289
INCLINATION:	62.8388	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.7350882	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	318.4262	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	4	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	4	MAXIMUM ΔI:	Unknown

COMMENTS

Cosmos 1030 was the fourth spacecraft of the Cosmos 862-type to experience a fragmentation. After entering a Molniya-type transfer orbit on 6 September, Cosmos 1030 maneuvered about 14 September to enter an operational orbit. However, the maneuver was less than that needed to maintain the anticipated groundtrack. Another maneuver on about 18 September increased the orbital period instead of lowering its as required to correct its groundtrack. No other maneuvers were observed prior to the event on 10 October. Elements on the first identifiable fragment did not appear until a year after the event. Official cataloging of debris did not begin until three years after the event.



Cosmos 1030 and a single debris fragment one year after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Delta Second Stage (2910)
OWNER:	US
LAUNCH DATE:	24.34 Oct 1978
DRY MASS (KG):	900 (approx.)
MAIN BODY:	Cylinder-Nozzle; 2.4 m by 8 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	On-board propellants, range safety device

EVENT DATA

DATE:	26 Dec 1981	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Unknown
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS

EPOCH:	81360.19972720	MEAN ANOMALY:	311.8261
RIGHT ASCENSION:	277.7553	MEAN MOTION:	13.85390161
INCLINATION:	99.3003	MEAN MOTION DOT/2:	.000000425
ECCENTRICITY:	.0010821	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	48.3801	BSTAR:	.00004426123

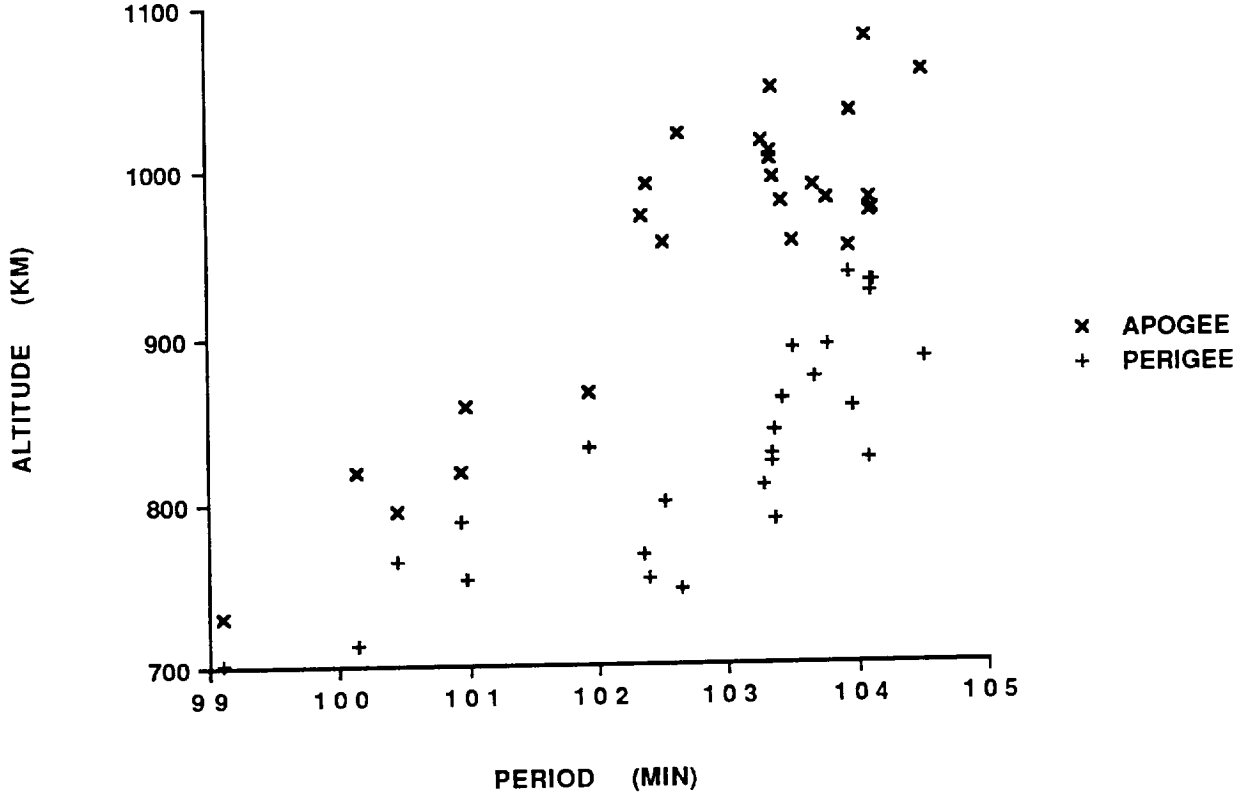
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	1	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	1	MAXIMUM ΔI:	0.6 deg*

*Based on uncataloged debris data

COMMENTS

Nimbus 7 R/B is designated Cameo in U.S. Space Command Satellite Catalog in reference to scientific piggy-back payload attached to the Delta second stage. This satellite experienced an anomalous event prior to and after the event cited above (See Section 3). Most fragments decayed very rapidly, preventing an accurate assessment of the event and its resulting debris cloud. No new objects were cataloged as a result of this event. The event apparently occurred prior to 0700 GMT.



The Nimbus 7 R/B debris cloud remnant of 27 fragments a few days after the event as reconstructed from U.S. Space Surveillance Center database. Most fragments have already experienced considerable drag effects.

SATELLITE DATA

TYPE:	SL-14 Final Stage
OWNER:	USSR
LAUNCH DATE:	26.29 Oct 1978
DRY MASS (KG):	1400
MAIN BODY:	Cone-Cylinder; 2.1 m by 3.3 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	9 May 1988	LOCATION:	29S, 126E (dsc)
TIME:	1218 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	1705 km		

PRE-EVENT ELEMENTS

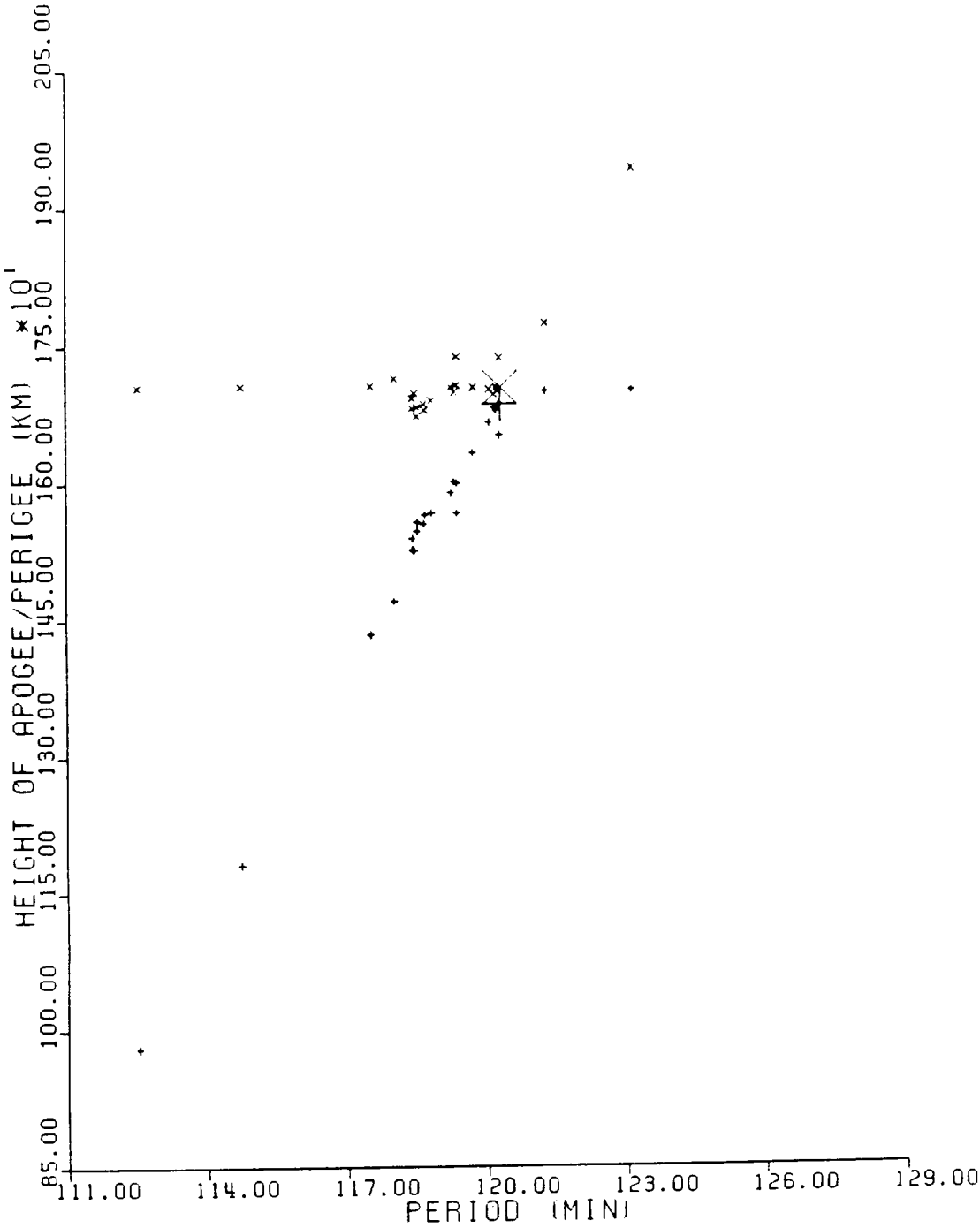
EPOCH:	88121.02005933	MEAN ANOMALY:	279.0818
RIGHT ASCENSION:	359.3059	MEAN MOTION:	11.97080974
INCLINATION:	82.5543	MEAN MOTION DOT/2:	.000000208
ECCENTRICITY:	.0011463	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	81.1553	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	42	MAXIMUM ΔP:	7.8 min
DEBRIS IN ORBIT:	42	MAXIMUM ΔI:	0.9 deg

COMMENTS

This flight, which successfully carried three separate payloads, was the fifth orbital mission of the SL-14 final stage. Propellants used were N_2O_4 and UDMH. Nearly 10 years elapsed from launch to breakup. No other SL-14 final stage has broken-up.



Cosmos 1045 R/B debris cloud as determined one week after the event with 25 fragments. Element source is U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	US
LAUNCH DATE:	24.35 Feb 1979
DRY MASS (KG):	850
MAIN BODY:	Cylinder; 2.1 m by 1.3 m
MAJOR APPENDAGES:	1 solar panel
ATTITUDE CONTROL:	Spin-stabilized
ENERGY SOURCES:	None

EVENT DATA

DATE:	13 Sep 1985	LOCATION:	35N, 234E (asc)
TIME:	2043 GMT	ASSESSED CAUSE:	Deliberate Test
ALTITUDE:	525 km		

PRE-EVENT ELEMENTS

EPOCH:	85256.72413718	MEAN ANOMALY:	260.9644
RIGHT ASCENSION:	182.5017	MEAN MOTION:	15.11755304
INCLINATION:	97.6346	MEAN MOTION DOT/2:	.00000616
ECCENTRICITY:	.0022038	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	99.4081	BSTAR:	.000037918

CATALOGED DEBRIS CLOUD DATA

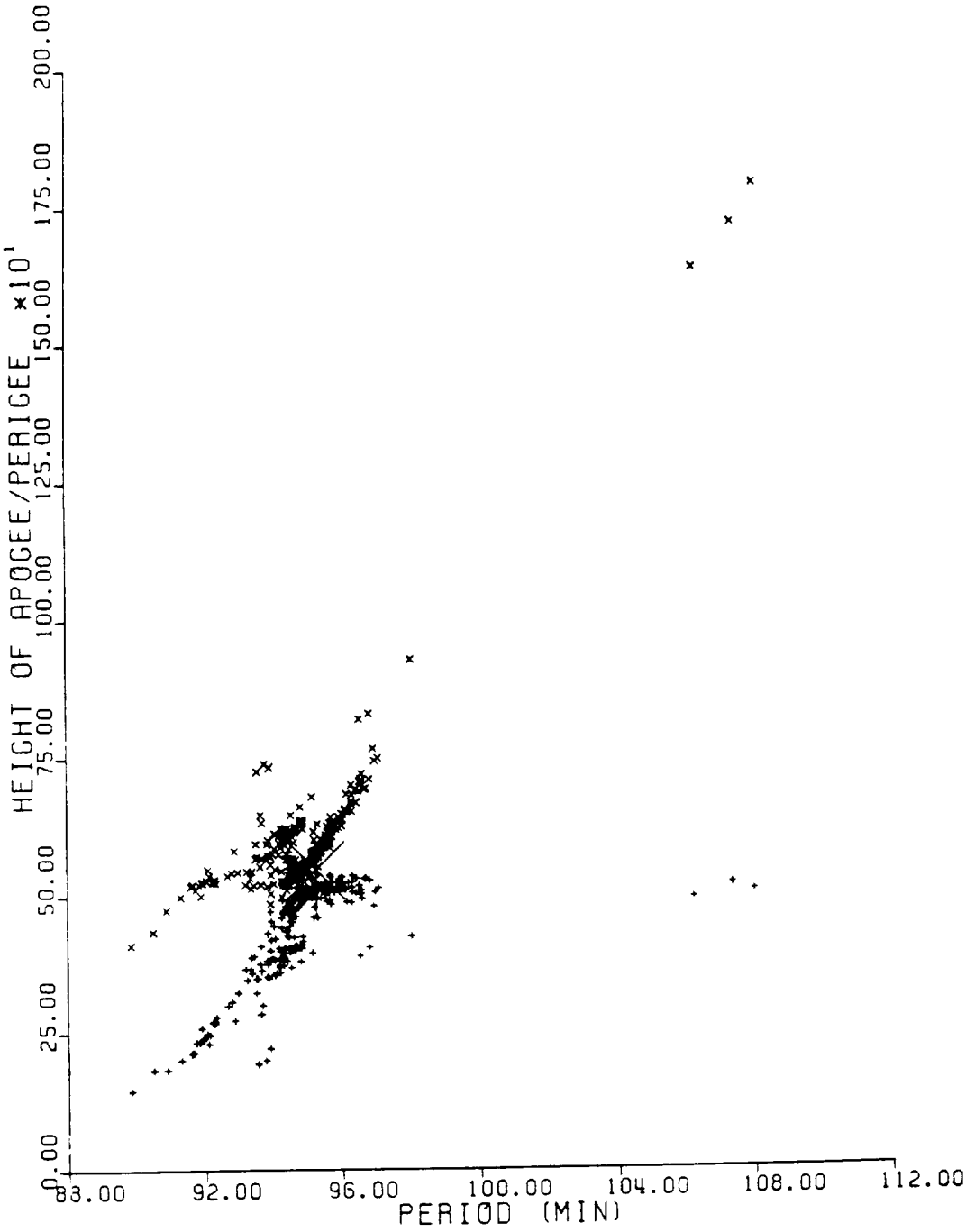
DEBRIS CATALOGED:	285	MAXIMUM ΔP:	12.7 min
DEBRIS IN ORBIT:	12	MAXIMUM ΔI:	1.4 deg

COMMENTS

P-78 was impacted by a sub-orbital object at high velocity as part of a planned test.

REFERENCE DOCUMENTS

Postmortem of a Hypervelocity Impact: Summary, R. L. Kling, Technical Report CS86-LKD-001, Teledyne Brown Engineering, Colorado Springs, September 1986.



P-78 debris cloud remnant of 267 fragments seen 11 hours after the event by the U.S. Space Surveillance Network PARCS radar.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	18.50 Apr 1979
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA

DATE:	17 Sep 1979	LOCATION:	53S, 336E (dsc)
TIME:	1039 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	385 km		

PRE-EVENT ELEMENTS

EPOCH:	79260.33615661	MEAN ANOMALY:	61.9566
RIGHT ASCENSION:	271.8638	MEAN MOTION:	15.58096051
INCLINATION:	65.0398	MEAN MOTION DOT/2:	.00102640
ECCENTRICITY:	.0016936	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	297.9871	BSTAR:	.0013492

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	1	MAXIMUM ΔP:	7.1 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.3 deg*

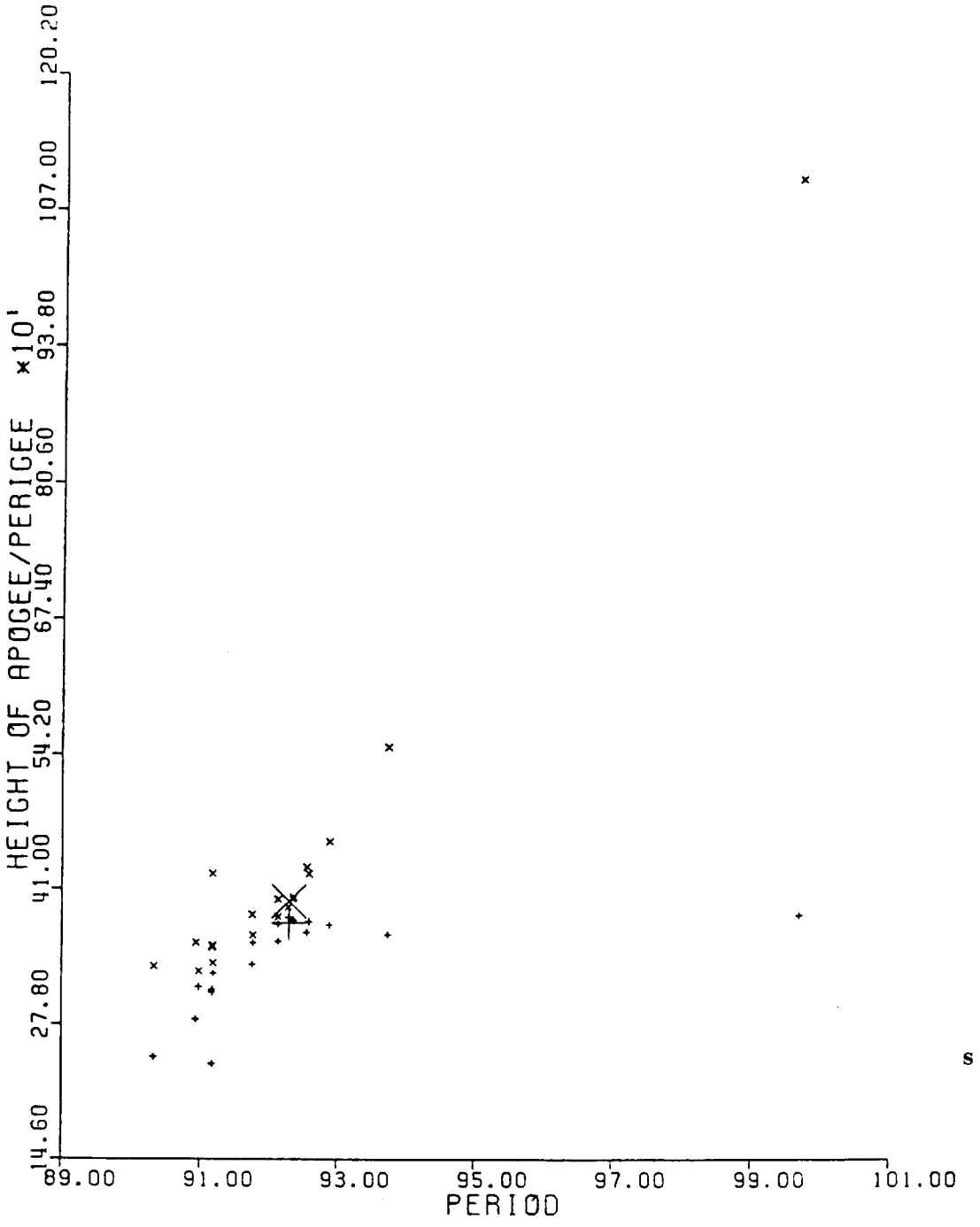
*Based on uncataloged debris data

COMMENTS

Cosmos 1094 was the fourth spacecraft of the Cosmos 699-type to experience a fragmentation. Spacecraft had been in a regime of natural decay for four months prior to the event. All new debris decayed before being officially cataloged.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.



Cosmos 1094 debris cloud of 20 fragments within one week of the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	27.76 Jun 1979
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 1.6 m by 3.4 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	Mid-Feb 1980	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS

EPOCH:	80048.26161234	MEAN ANOMALY:	5.0375
RIGHT ASCENSION:	104.4713	MEAN MOTION:	2.00453352
INCLINATION:	63.3495	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.7238911	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	318.4445	BSTAR:	.0

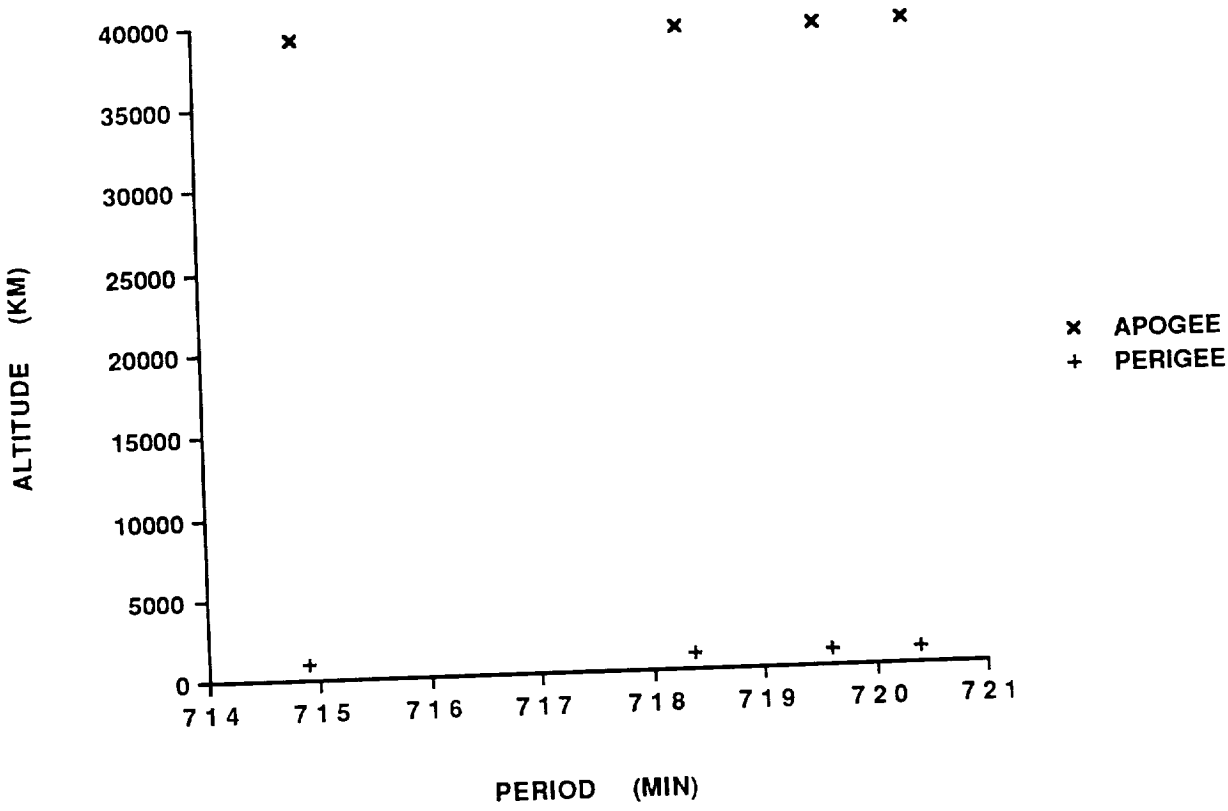
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	6	MAXIMUM ΔP:	3.5 min*
DEBRIS IN ORBIT:	6	MAXIMUM ΔI:	0.2 deg*

*Based on uncataloged debris data

COMMENTS

Cosmos 1109 was the seventh spacecraft of the Cosmos 862-type to experience a fragmentation. Cosmos 1109 maneuvered into an operational orbit about 19 July. A station-keeping maneuver was required in the second half of September to maintain groundtrack synchronization, but none was conducted. After five more months in the non-synchronized orbit, Cosmos 1109 fragmented. The payload was "lost" after 17 February 1980 and three pieces of debris were soon found which could be traced back to that period.



Cosmos 1109 and three fragments in February 1980 as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	28.01 Aug 1979
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 1.6 m by 3.4 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	9 Sep 1979	LOCATION:	52N, 304E (asc)
TIME:	0230 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	8375 km		

PRE-EVENT ELEMENTS

EPOCH:	79249.09448656	MEAN ANOMALY:	3.7678
RIGHT ASCENSION:	288.1742	MEAN MOTION:	2.00548359
INCLINATION:	63.0212	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.7383335	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	318.3799	BSTAR:	.0

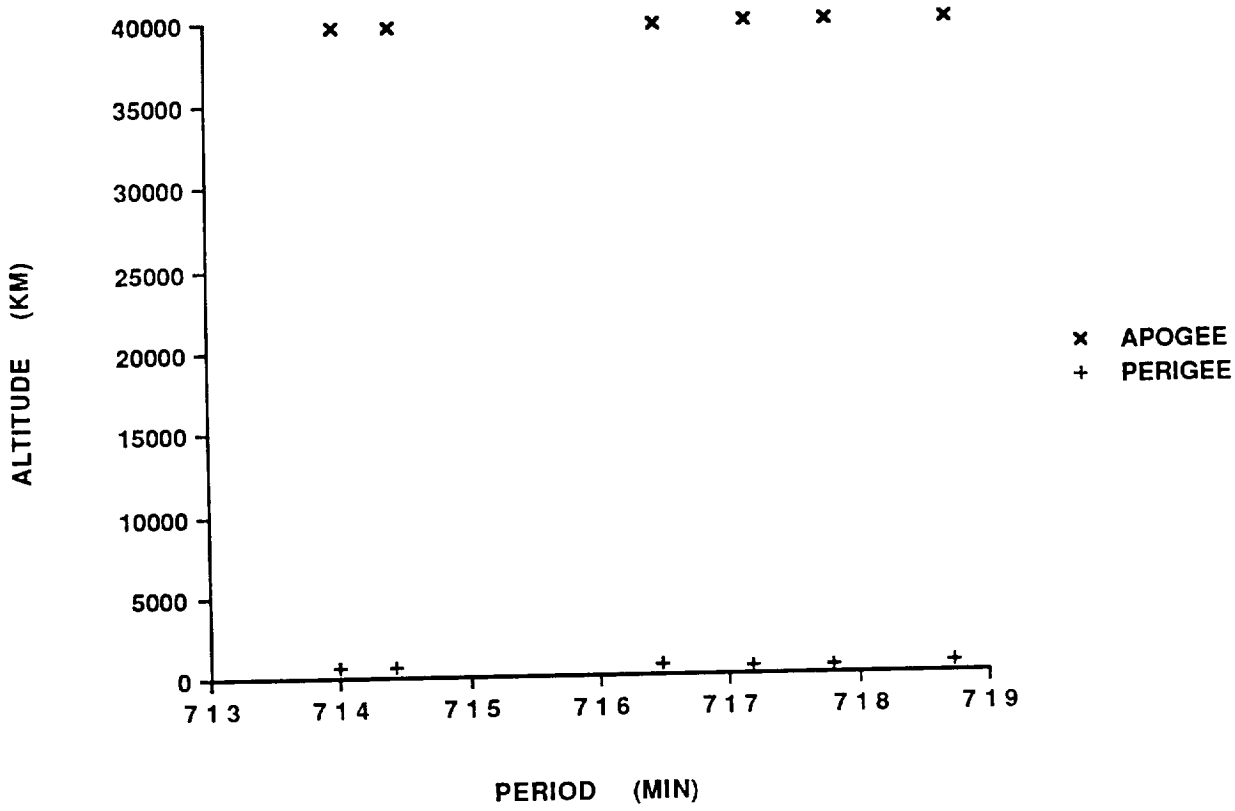
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	5	MAXIMUM ΔP:	4.0 min*
DEBRIS IN ORBIT:	5	MAXIMUM ΔI:	0.1 deg*

*Based on uncataloged debris data

COMMENTS

Cosmos 1124 was the sixth spacecraft of the Cosmos 862-type to experience a fragmentation. After insertion into a Molniya-type transfer orbit on 28 August, Cosmos 1124's ascending node was allowed to drift until 3 September when a maneuver placed the spacecraft into an operational, semi-synchronous orbit. The fragmentation occurred six days later. The spacecraft never maneuvered again and soon drifted off station.



Cosmos 1124 debris cloud of six fragments about one week after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Ariane 1 Final Stage
OWNER:	ESA
LAUNCH DATE:	24.72 Dec 1979
DRY MASS (KG):	1400
MAIN BODY:	Cylinder; 2.6 m by 10.3 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	On-board propellants, range safety device

EVENT DATA

DATE:	Apr 1980	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Unknown
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS

EPOCH:	80088.55565320	MEAN ANOMALY:	17.6019
RIGHT ASCENSION:	101.5521	MEAN MOTION:	2.48253031
INCLINATION:	17.9092	MEAN MOTION DOT/2:	.001764977
ECCENTRICITY:	.7152375	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	264.7858	BSTAR:	.001078542

CATALOGED DEBRIS CLOUD DATA

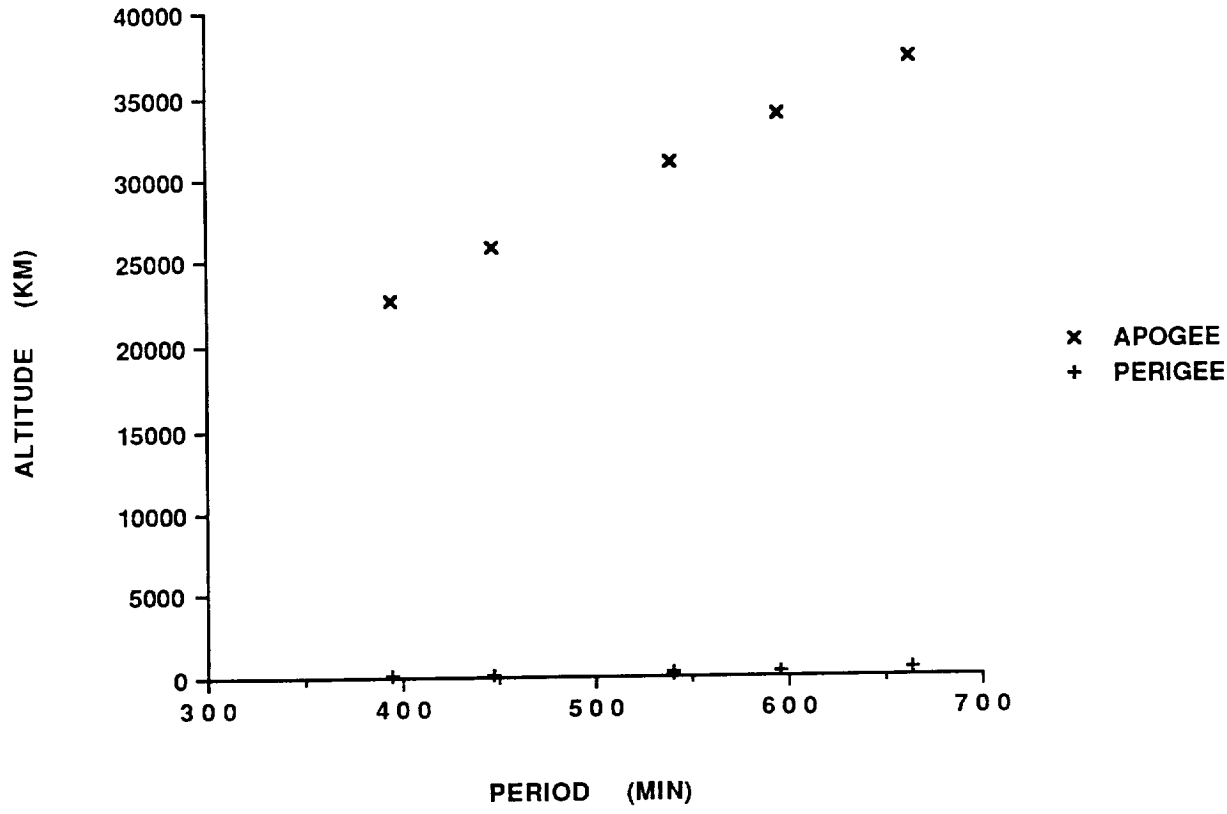
DEBRIS CATALOGED:	1	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	Unknown

COMMENTS

This mission was the inaugural flight of the Ariane 1 launch vehicle. Payload and R/B were apparently cross-tagged until mid-January 1980. Detection and tracking of debris has always been extremely difficult in part due to low inclination and highly elliptical orbit. Debris data were first developed in the second half of April, and calculations suggest the fragmentation occurred during the first week of April. The magnitude of the event and the total number of pieces created are unknown. Many debris had high decay rates.

REFERENCE DOCUMENTS

A Preliminary Analysis of the Fragmentation of the Spot 1 Ariane Third Stage, N. L. Johnson, Technical Report CS87-LKD-003, Teledyne Brown Engineering, Colorado Springs, March 1987.



CAT R/B debris cloud of seven fragments about eight weeks after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	14.44 Mar 1980
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA

DATE:	15 Jul 1981	LOCATION:	10N, 106E (asc)
TIME:	0921 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	430 km		

PRE-EVENT ELEMENTS

EPOCH:	81196.19449955	MEAN ANOMALY:	110.8351
RIGHT ASCENSION:	174.9184	MEAN MOTION:	15.54665775
INCLINATION:	65.0101	MEAN MOTION DOT/2:	.00025375
ECCENTRICITY:	.0068471	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	248.6139	BSTAR:	.00034595

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	12	MAXIMUM ΔP:	1.0 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.5 deg*

*Based on uncataloged debris data

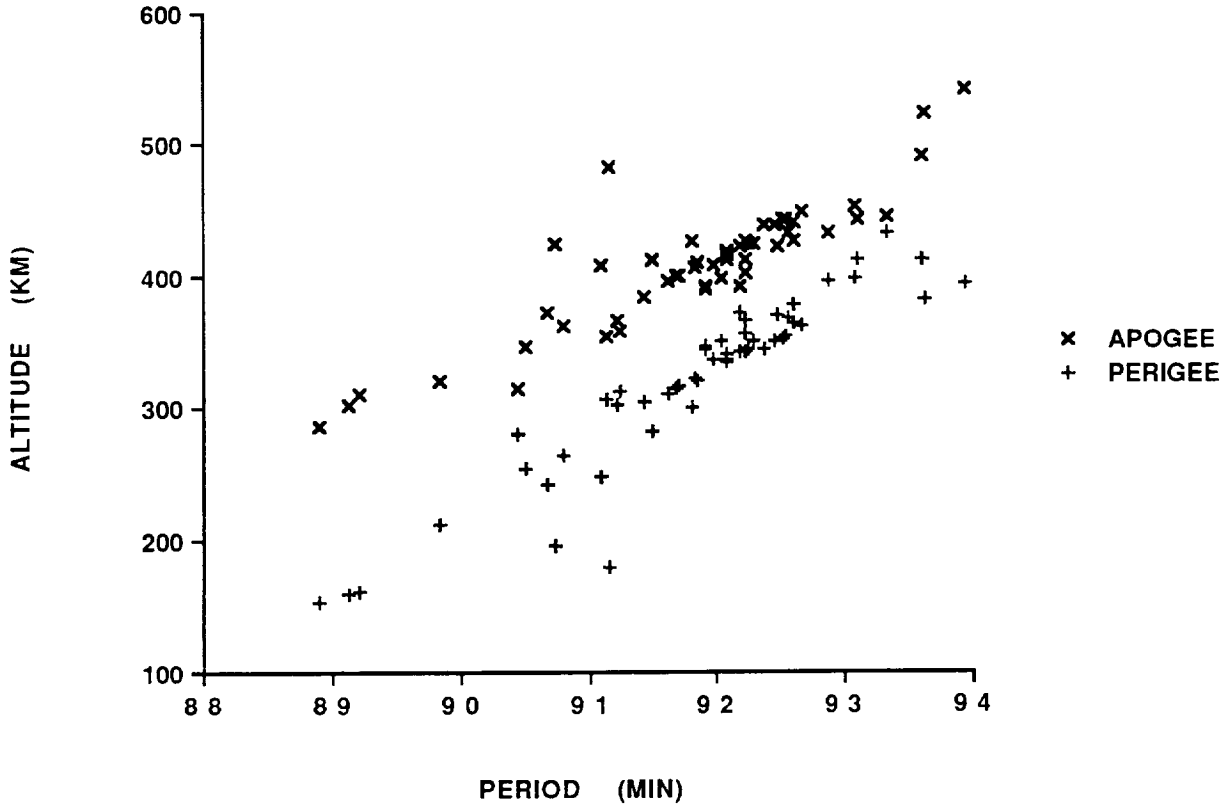
COMMENTS

Cosmos 1167 was the fifth spacecraft of the Cosmos 699-type to experience a fragmentation. The spacecraft had been in a regime of natural decay for three months prior to the event. Most debris reentered before being officially cataloged.

REFERENCE DOCUMENTS

The Fragmentations of USSR Satellites 11729 and 12504 (U), J. R. Gabbard and P. M. Landry, Technical Memorandum 82-S-03, DCS/Plans, Hdqtrs NORAD/ADCOM, Colorado Springs, August 1982 (Secret).

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.



Cosmos 1167 debris cloud remnant of 53 fragments about two weeks after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	18.04 Apr 1980
DRY MASS (KG):	1000 (est.)
MAIN BODY:	Cylinder; 1.3 m by 2 m (?)
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	18 Apr 1980	LOCATION:	47N, 322E (asc)
TIME:	0726 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	1625 km		

POST-EVENT ELEMENTS

EPOCH:	80109.51771250	MEAN ANOMALY:	102.2095
RIGHT ASCENSION:	250.9679	MEAN MOTION:	13.64414319
INCLINATION:	66.1153	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.0865337	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	248.5294	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

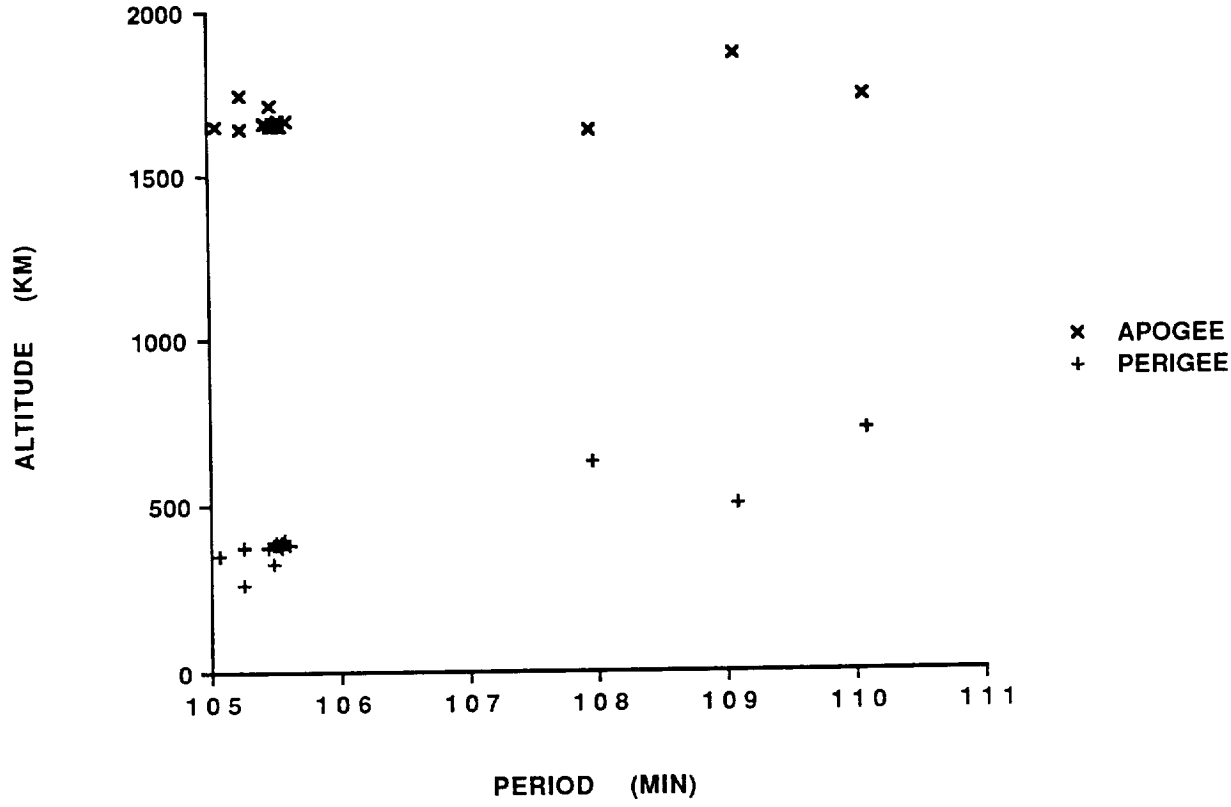
DEBRIS CATALOGED:	46	MAXIMUM ΔP:	5.4 min
DEBRIS IN ORBIT:	11	MAXIMUM ΔI:	0.6 deg

COMMENTS

Cosmos 1174 was launched on a two-revolution rendezvous with Cosmos 1171. After a close approach, Cosmos 1174 performed a final maneuver shortly before its warhead was intentionally fired. Elements above are first data available after the final maneuver but also following the fragmentation. Cosmos 1174 was part of test series begun with Cosmos 249.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 2): Soviet Anti-Satellite Program", N.L. Johnson, Journal of the British Interplanetary Society, August 1983, pp. 357-362.



Cosmos 1174 debris cloud of 18 identified fragments about 10 days after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	2.04 Jul 1980
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 1.6 m by 3.4 m(?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	14 May 1981	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS

EPOCH:	81133.07322634	MEAN ANOMALY:	5.1166
RIGHT ASCENSION:	198.5704	MEAN MOTION:	2.00555560
INCLINATION:	62.6448	MEAN MOTION DOT/2:	.00001257
ECCENTRICITY:	.7180863	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	319.4330	BSTAR:	.0

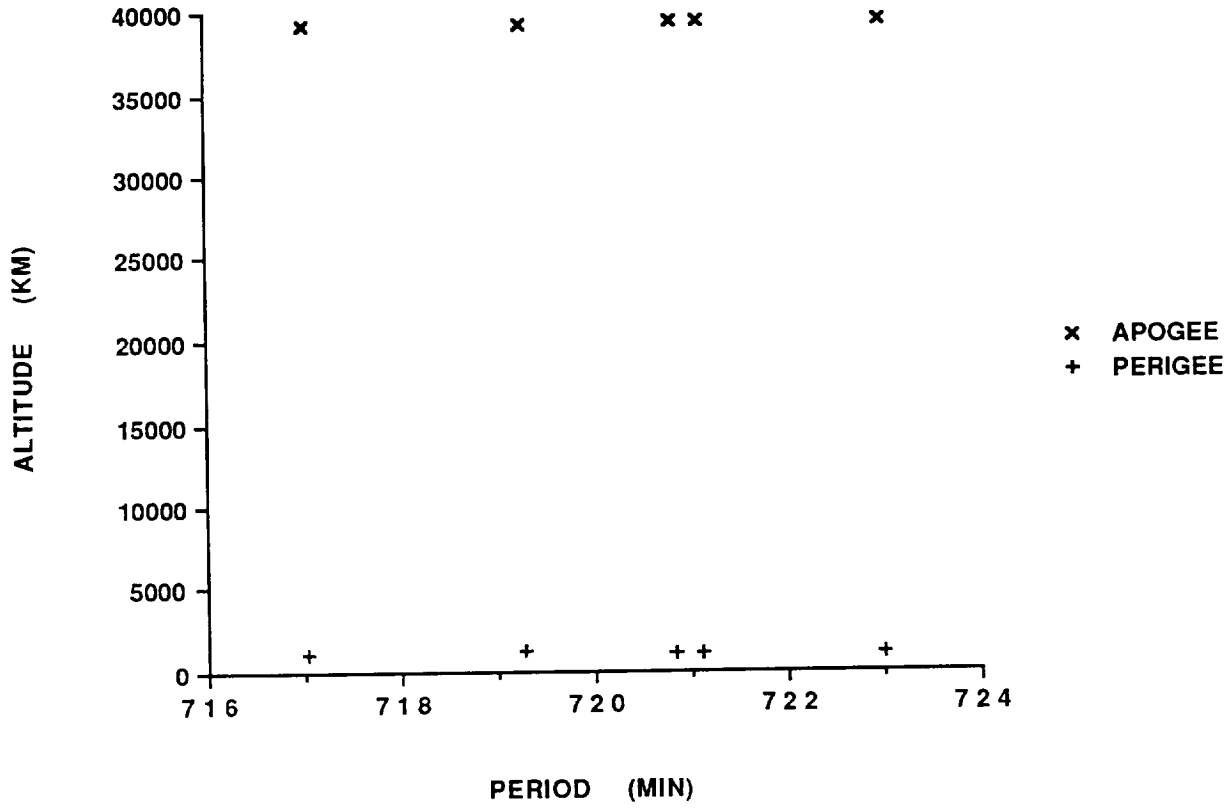
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	2	MAXIMUM ΔP:	6.0 min*
DEBRIS IN ORBIT:	2	MAXIMUM ΔI:	0.1 deg*

*Based on uncataloged debris data

COMMENTS

Cosmos 1191 was the ninth spacecraft of the Cosmos 862-type to experience a fragmentation. The last station-keeping maneuver prior to the event occurred about 7 March 1981. The next station-keeping maneuver was anticipated in mid-May. A maneuver may have been performed 14 May, during or immediately after which debris was generated. The first debris elements were developed for 25 May. The spacecraft began drifting off station immediately after the event and never recovered.



Cosmos 1191 debris cloud of 5 identified fragments one month after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	4.63 Nov 1980
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA (1)

DATE:	20 Jun 1982	LOCATION:	10S, 332E (dsc)
TIME:	1818 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	875 km		

PRE-EVENT ELEMENTS (1)

EPOCH:	82171.72558670	MEAN ANOMALY:	0.2166
RIGHT ASCENSION:	330.3811	MEAN MOTION:	14.49658466
INCLINATION:	65.0033	MEAN MOTION DOT/2:	.00000066
ECCENTRICITY:	.0219432	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	357.8883	BSTAR:	.000025640

EVENT DATA (2)

DATE:	25 Aug 1982	LOCATION:	65S, 238E (dsc)
TIME:	1231 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	665 km		

PRE-EVENT ELEMENTS (2)

EPOCH:	82230.91714195	MEAN ANOMALY:	22.7965
RIGHT ASCENSION:	159.4489	MEAN MOTION:	14.49745561
INCLINATION:	65.0025	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.0225583	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	336.3217	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	78	MAXIMUM ΔP:	3.4 min*
DEBRIS IN ORBIT:	1	MAXIMUM ΔI:	1.8 deg*

*Based on uncataloged debris data

COMMENTS

Cosmos 1220 was the seventh spacecraft of the Cosmos 699-type to experience a fragmentation. The spacecraft had been in a natural decay regime for more than 14 months at the time of the first event. A total of 47 fragments had been officially cataloged by the time of the second event which occurred

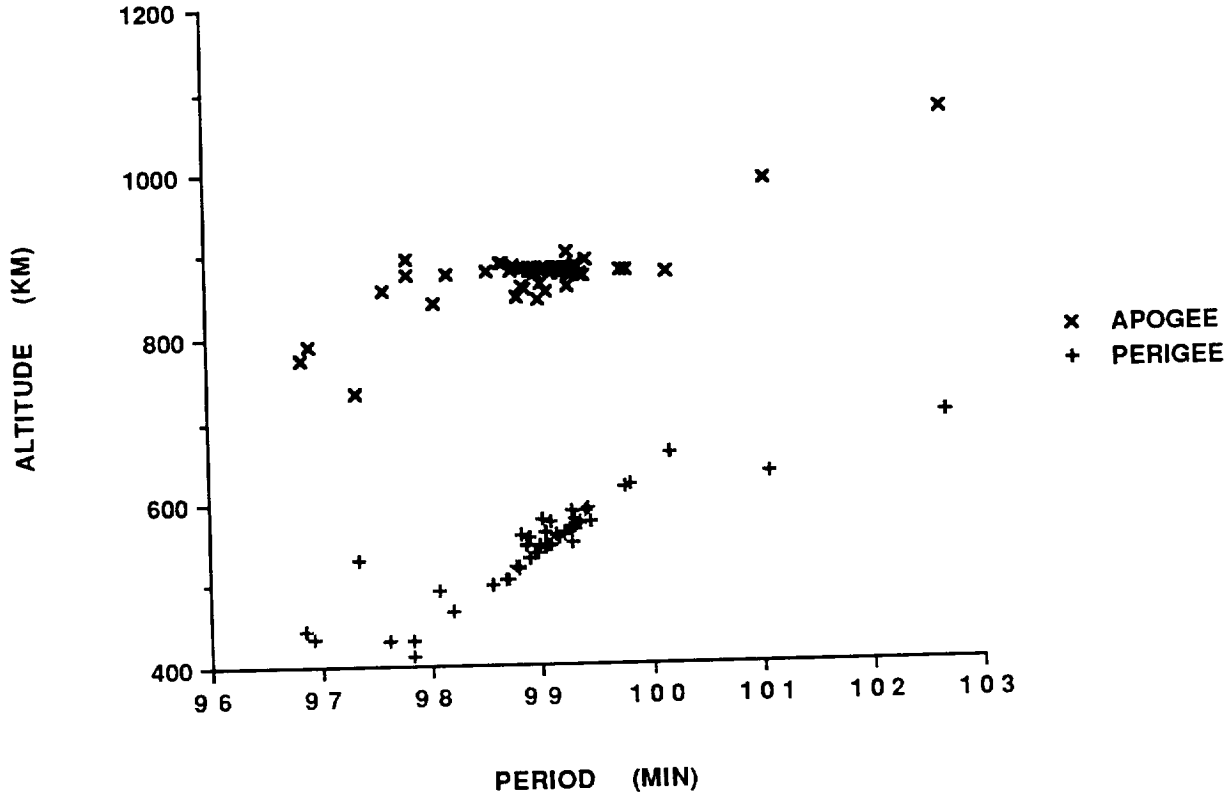
two months later. See similar dual events happening in the summer of 1982 with Cosmos 1306 and Cosmos 1260.

REFERENCE DOCUMENTS

Analysis of PARCS Recorded Data on the Breakup of Satellite 12054, J.W. Rider, Technical Report MSB83-ADC-0162, Teledyne Brown Engineering, Huntsville, January 1983.

Analysis of Cosmos 1220 and Cosmos 1306 Fragments (U), D. Fennessy, Report AH-23, FTD/OLAI, Cheyenne Mountain, Colorado, 12 January 1983 (Secret).

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.



Cosmos 1220 debris cloud of 72 fragments about one week after the first event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	19.41 Feb 1981
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 1.6 m by 3.4 m (?)
MAJOR APPENDAGES:	Solar panels
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	20 Oct 1981	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS

EPOCH:	81293.17083627	MEAN ANOMALY:	5.0298
RIGHT ASCENSION:	214.2278	MEAN MOTION:	2.00570861
INCLINATION:	62.9685	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.7233048	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	318.2473	BSTAR:	.0

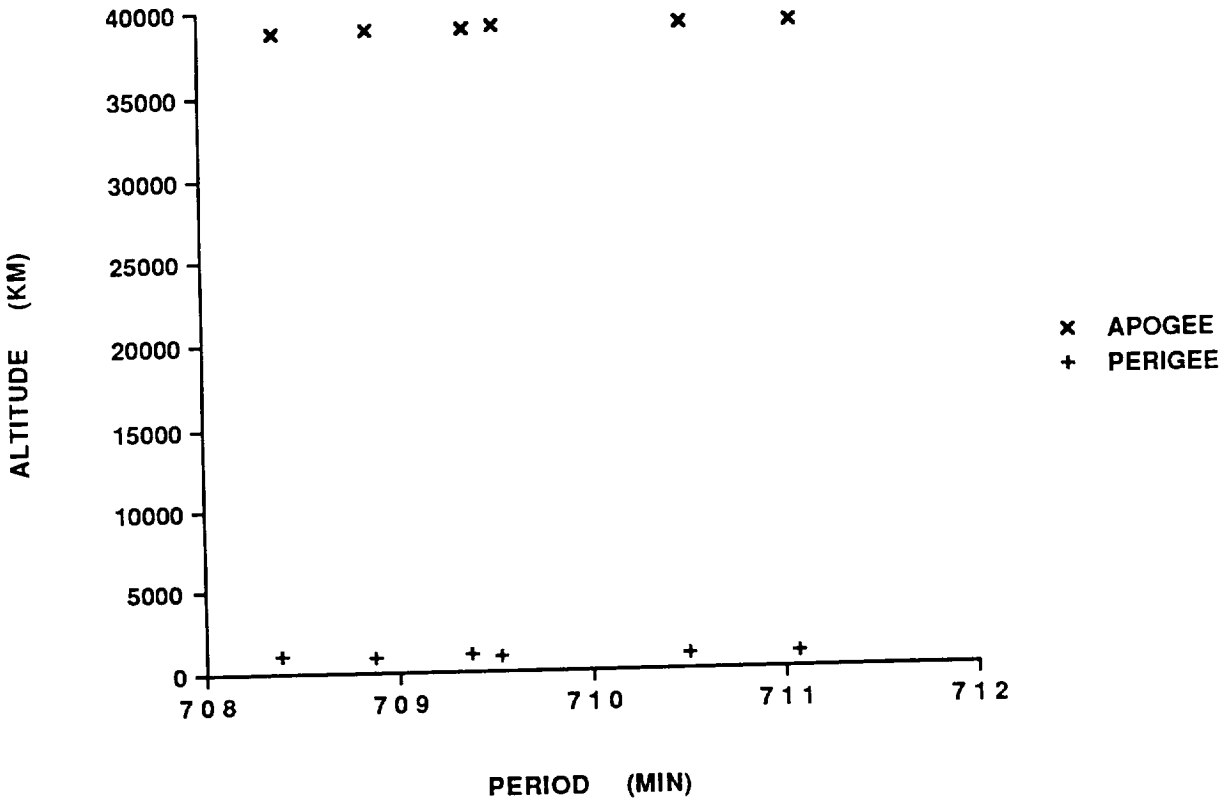
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	4	MAXIMUM ΔP:	2.7 min*
DEBRIS IN ORBIT:	4	MAXIMUM ΔI:	0.4 deg*

*See comments below

COMMENTS

Cosmos 1247 was the tenth spacecraft of the Cosmos 862-type to experience a fragmentation. The last station-keeping maneuver before the event occurred about 23 July 1981. Another station-keeping maneuver was anticipated for the mid-October to mid-November period. Cosmos 1247 appears to have completed the first burn of a 2-phase maneuver sequence on the event date, followed by debris generation. The ΔP and ΔI values above are based on the post-maneuver, 711-minute orbit of 12303 rather than the pre-maneuver, 718-minute orbit cited above. The spacecraft began drifting off station immediately after the event and never recovered.



Cosmos 1247 debris cloud of six fragments about six weeks after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	20.99+ Mar 1981
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA (1)

DATE:	8 May 1982	LOCATION:	40N, 62E (asc)
TIME:	0444 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	555 km		

PRE-EVENT ELEMENTS (1)

EPOCH:	82127.98788154	MEAN ANOMALY:	28.1726
RIGHT ASCENSION:	337.2406	MEAN MOTION:	14.88799005
INCLINATION:	65.0246	MEAN MOTION DOT/2:	.00003980
ECCENTRICITY:	.0214690	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	330.7493	BSTAR:	.00028791

EVENT DATA (2)

DATE:	10 Aug 1982	LOCATION:	51N, 238E (dsc)
TIME:	2335 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	750 km		

PRE-EVENT ELEMENTS (2)

EPOCH:	82222.89259484	MEAN ANOMALY:	62.7628
RIGHT ASCENSION:	45.7388	MEAN MOTION:	14.89366232
INCLINATION:	65.0248	MEAN MOTION DOT/2:	.00004369
ECCENTRICITY:	.0219155	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	295.0884	BSTAR:	.00030390

CATALOGED DEBRIS CLOUD DATA

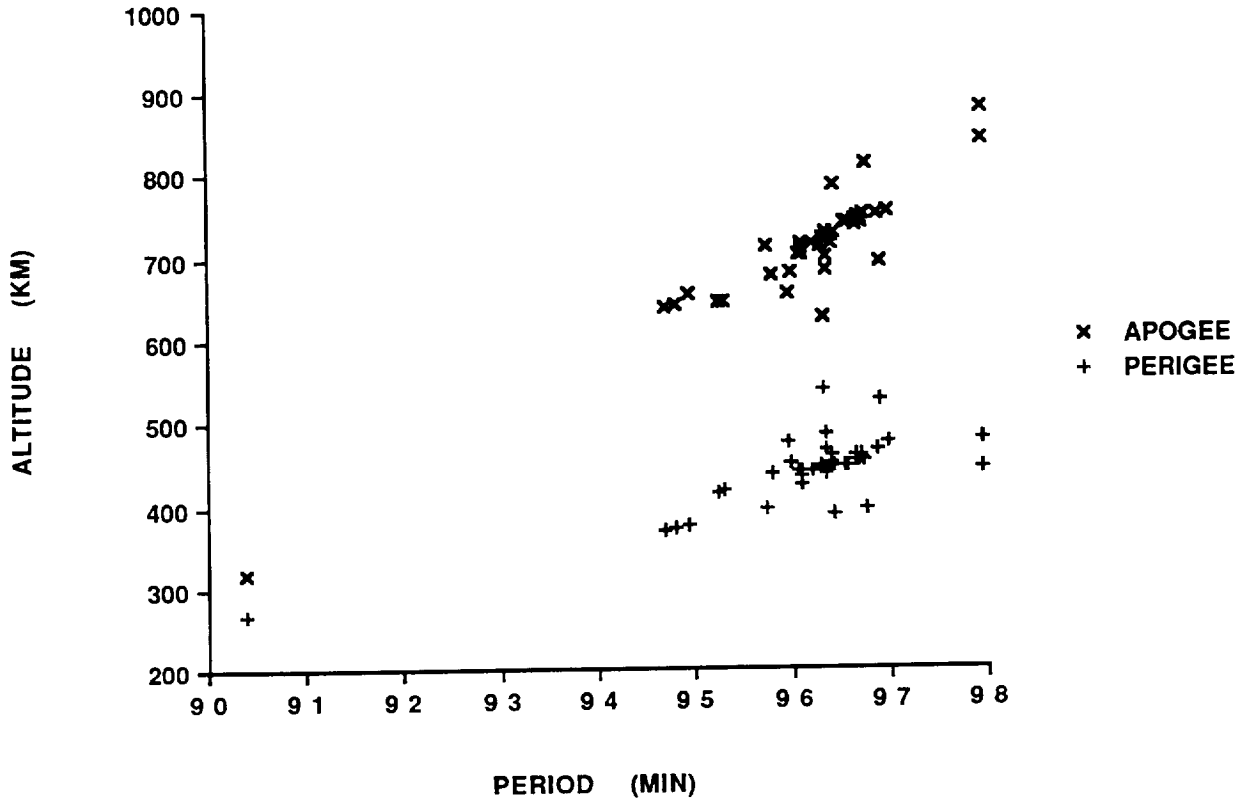
DEBRIS CATALOGED:	68	MAXIMUM ΔP:	5.2 min
DEBRIS IN ORBIT:	1	MAXIMUM ΔI:	1.0 deg

COMMENTS

Cosmos 1260 was the sixth spacecraft of the Cosmos 699-type to experience a fragmentation. The spacecraft had been in a regime of natural decay for eight months before the first event. After the event the main remnant became satellite 13183, which then fragmented three months later. A total of 40 new fragments were officially cataloged prior to the second event. See also Cosmos 1220 and Cosmos 1306 for similar dual fragmentations of Cosmos 699-type spacecraft during this period.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.



Cosmos 1260 debris cloud of 43 fragments three weeks after the first event from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	31.40 Mar 1981
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 1.6 m by 3.4 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	Apr-May 1981	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS

EPOCH:	81095.90157023	MEAN ANOMALY:	4.6715
RIGHT ASCENSION:	282.6240	MEAN MOTION:	2.00494188
INCLINATION:	63.0386	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.7369210	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	316.4347	BSTAR:	.0

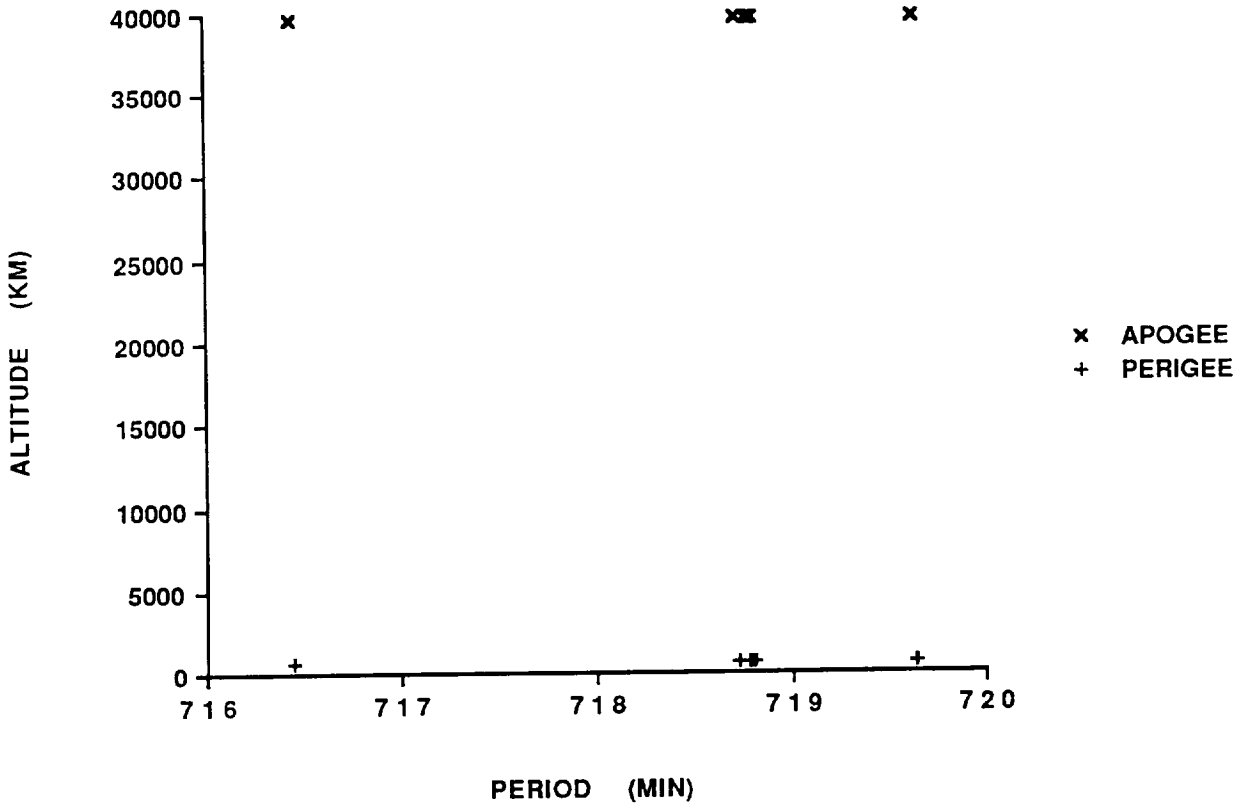
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	4	MAXIMUM ΔP:	2.3 min*
DEBRIS IN ORBIT:	4	MAXIMUM ΔI:	0.3 deg*

*Based on uncataloged debris data

COMMENTS

Cosmos 1261 was the eighth spacecraft of the Cosmos 862-type to experience a fragmentation. The spacecraft attempted to maneuver from its transfer orbit to an operational orbit three days after launch. The maneuver appears to have been unsuccessful, and the spacecraft never became groundtrack-stabilized. Some debris appeared immediately after the maneuver, while additional debris were discovered in mid-May. More than one event may have occurred. The element set above is the first available after the unsuccessful maneuver.



Cosmos 1261 debris cloud of six fragments about eight weeks after (initial) event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	4.66 Jun 1981
DRY MASS (KG):	800
MAIN BODY:	Cylinder; 2.0 m by 2.1 m (?)
MAJOR APPENDAGES:	Gravity-gradient boom
ATTITUDE CONTROL:	Gravity gradient
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	24 Jul 1981	LOCATION:	68N, 197E (asc)
TIME:	2351 GMT	ASSESSED CAUSE:	Probable Unplanned Hypervelocity Impact
ALTITUDE:	980 km		

PRE-EVENT ELEMENTS

EPOCH:	81205.39693092	MEAN ANOMALY:	221.3567
RIGHT ASCENSION:	119.8245	MEAN MOTION:	13.73455672
INCLINATION:	82.9633	MEAN MOTION DOT/2:	.000000580
ECCENTRICITY:	.0036415	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	139.0334	BSTAR:	.00004538900

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	306	MAXIMUM ΔP:	4.9 min
DEBRIS IN ORBIT:	279	MAXIMUM ΔI:	0.4 deg

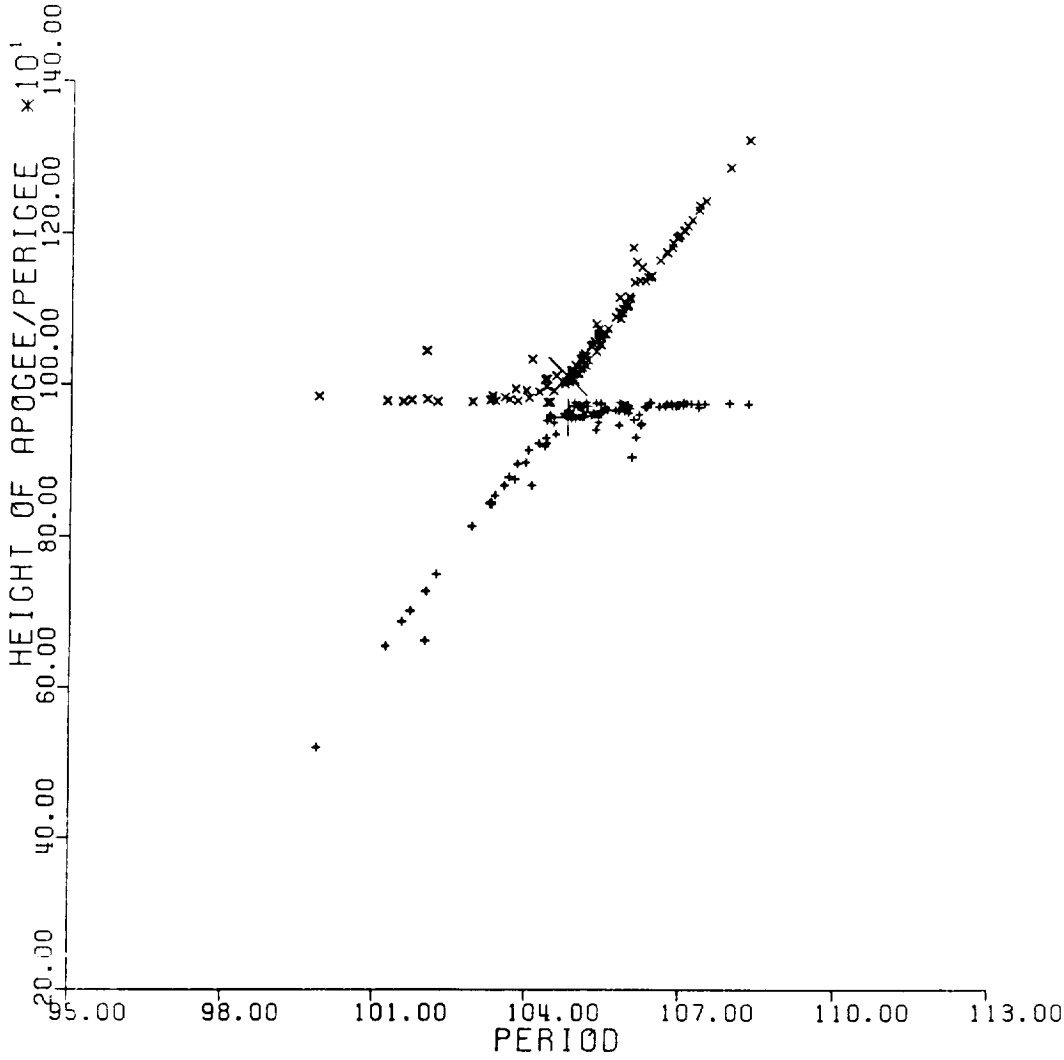
COMMENTS

Cosmos 1275 is the only member of its class to fragment. Satellite was only 50 days old at the time of the event. Probable victim of an accidental collision, no cataloged satellite were in the vicinity at the time of the event. During the February, 1992 Space Debris Converence the Russians indicated that independent analysis favors collision with an unknown object as the most probable fragmentation mechanism. This is the first event to be assessed a probable unplanned collision.

REFERENCE DOCUMENTS

The Fragmentations of USSR Satellites 11729 and 12504 (U), J.R. Gabbard and P.M. Landry, Technical Memorandum 82-S-03, DCS/Plans, Hdqtrs NORAD/ADCOM, Colorado Springs, August 1982 (Secret).

Determining the Cause of a Satellite Breakup: A Case Study of the Kosmos 1275 Breakup, D.S. McKnight, IAA-87-573, 38th Congress of the International Astronautical Federation, Brighton, England, October 1987.



Cosmos 1275 debris cloud of 115 identified fragments one week after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	19.81 Jun 1981
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Unknown
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	Early Dec 1986	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS

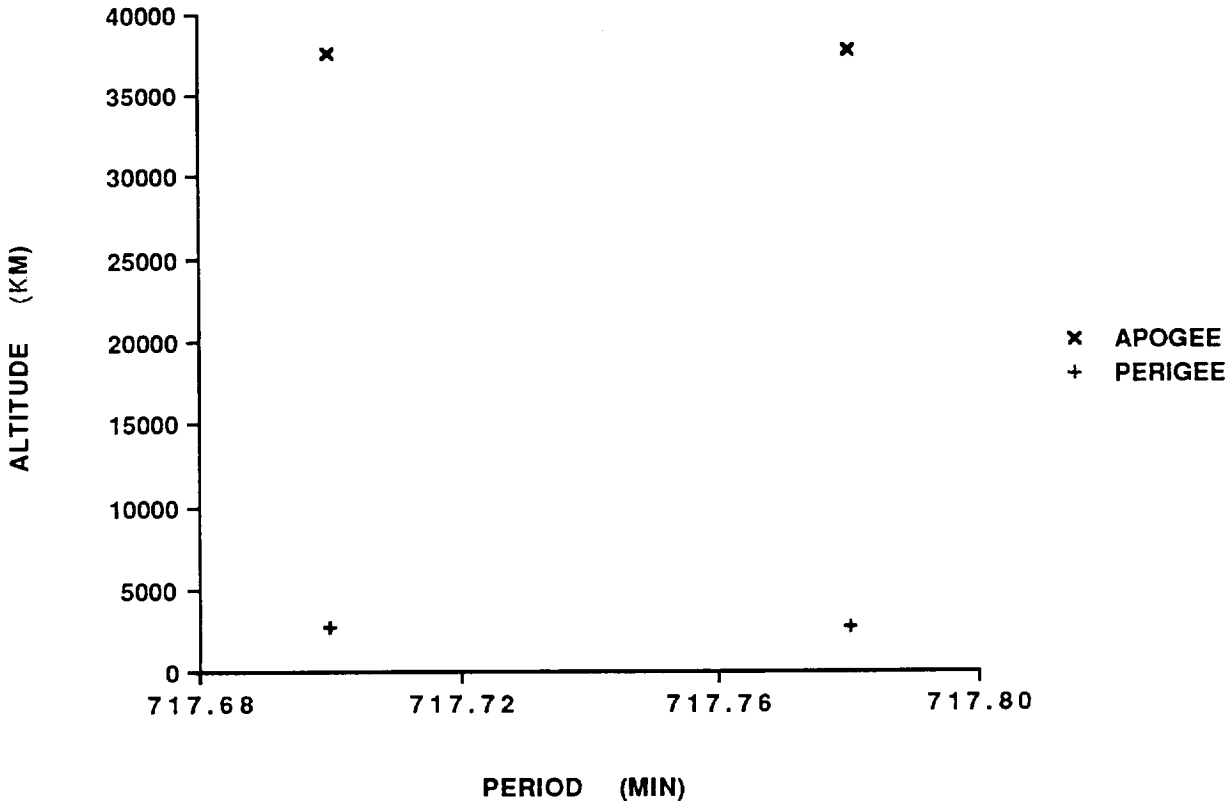
EPOCH:	86334.22199701	MEAN ANOMALY:	12.7886
RIGHT ASCENSION:	288.0814	MEAN MOTION:	2.00618298
INCLINATION:	67.1073	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.6594262	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	291.9890	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	2	MAXIMUM ΔP:	0.1 min
DEBRIS IN ORBIT:	2	MAXIMUM ΔI:	0.0 deg

COMMENTS

Cosmos 1278 was the fifteenth spacecraft of the Cosmos 862-type to experience a fragmentation. Spacecraft had apparently been inactive since early 1984. Additional fragments may exist, but surveillance for small objects in this orbit is difficult.



Cosmos 1278 and additional fragment in mid-December 1986. Elements from U.S. Space Surveillance Center as published by NASA Goddard Space Flight Center.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	4.01 Aug 1981
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 1.6 m by 3.4 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	21 Nov 1981	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS

EPOCH:	81324.16708257	MEAN ANOMALY:	4.8196
RIGHT ASCENSION:	249.5852	MEAN MOTION:	1.98014597
INCLINATION:	63.1086	MEAN MOTION DOT/2:	.00000781
ECCENTRICITY:	.7350717	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	317.0022	BSTAR:	.0

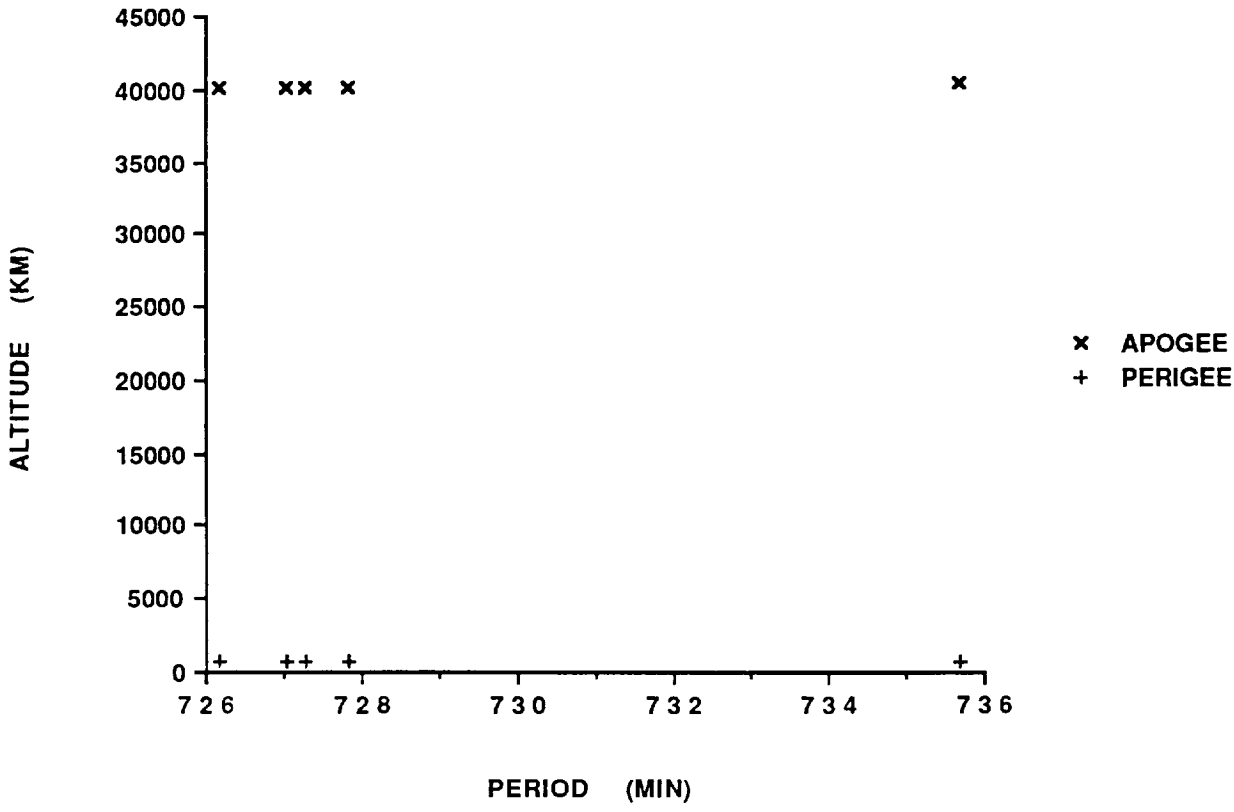
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	3	MAXIMUM ΔP:	8.6 min*
DEBRIS IN ORBIT:	3	MAXIMUM ΔI:	0.2 deg*

*Based on uncataloged debris data

COMMENTS

Cosmos 1285 was the eleventh spacecraft of the Cosmos 862-type to experience a fragmentation. Spacecraft was placed in a temporary transfer orbit on the day of launch by its launch vehicle but never maneuvered to an operational orbit, suggesting an early fatal spacecraft malfunction. Event occurred three and a half months after the launch.



Cosmos 1285 debris cloud of five fragments less than a week after the event as reconstructed from U. S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	4.35 Aug 1981
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA

DATE:	29 Sep 1982	LOCATION:	51N, 80E (asc)
TIME:	0520 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	325 km		

PRE-EVENT ELEMENTS

EPOCH:	82272.21193719	MEAN ANOMALY:	92.4681
RIGHT ASCENSION:	132.9736	MEAN MOTION:	15.86141247
INCLINATION:	65.0071	MEAN MOTION DOT/2:	.00400345
ECCENTRICITY:	.0017215	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	267.4145	BSTAR:	.0015199

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	2	MAXIMUM ΔP:	0.9 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.2 deg*

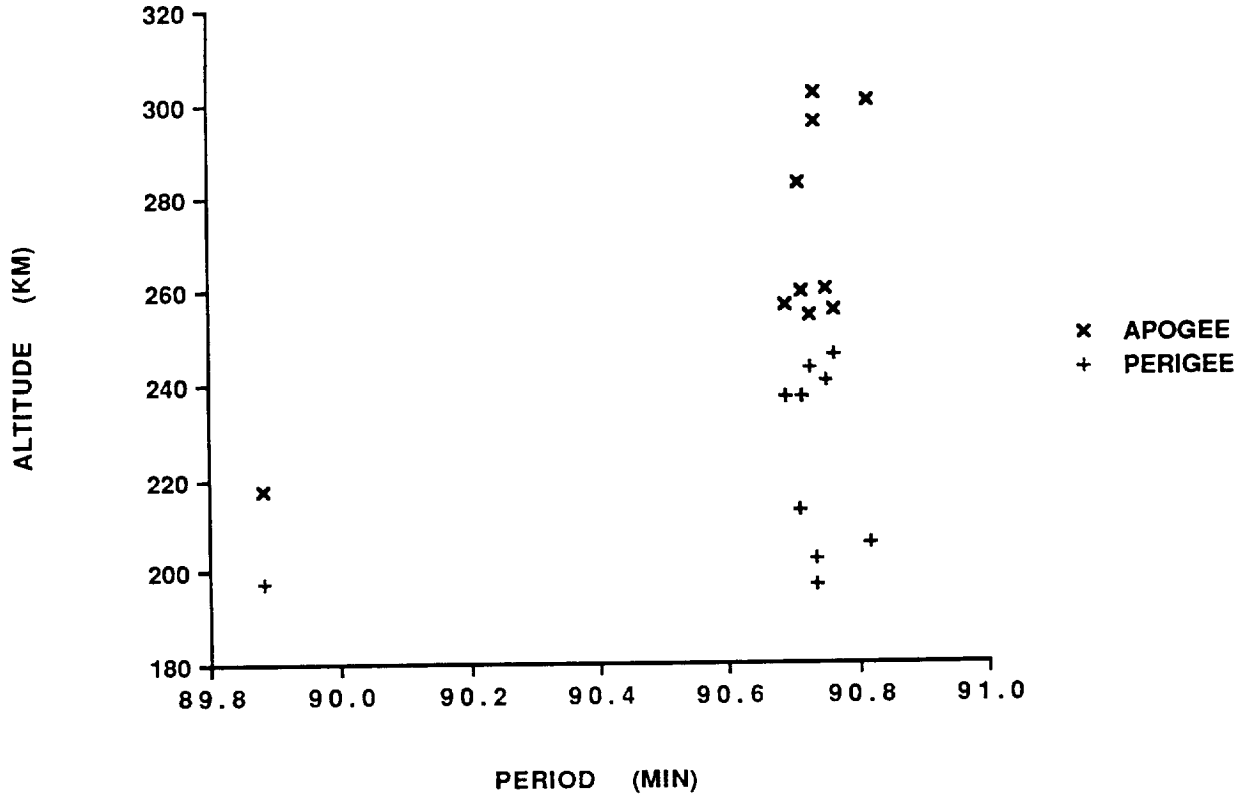
*Based on uncataloged debris data

COMMENTS

Cosmos 1286 was the ninth spacecraft of the Cosmos 699-type to experience a fragmentation. The spacecraft had been in a regime of natural decay for more than six months at the time of the event. The low altitude and high drag conditions made determination of the precise breakup time uncertain. The breakup or a precursor event may have occurred earlier on 29 September 1982. Most fragments decayed before being officially cataloged.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.



Cosmos 1286 debris cloud of 10 fragments one day after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	SL-6 Final Stage
OWNER:	USSR
LAUNCH DATE:	11.36 Sep 1981
DRY MASS (KG):	1000 (approx.)
MAIN BODY:	Cylinder; 2.4 m by 2.2 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	11 Sep 1981	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	Unknown		

POST-EVENT ELEMENTS

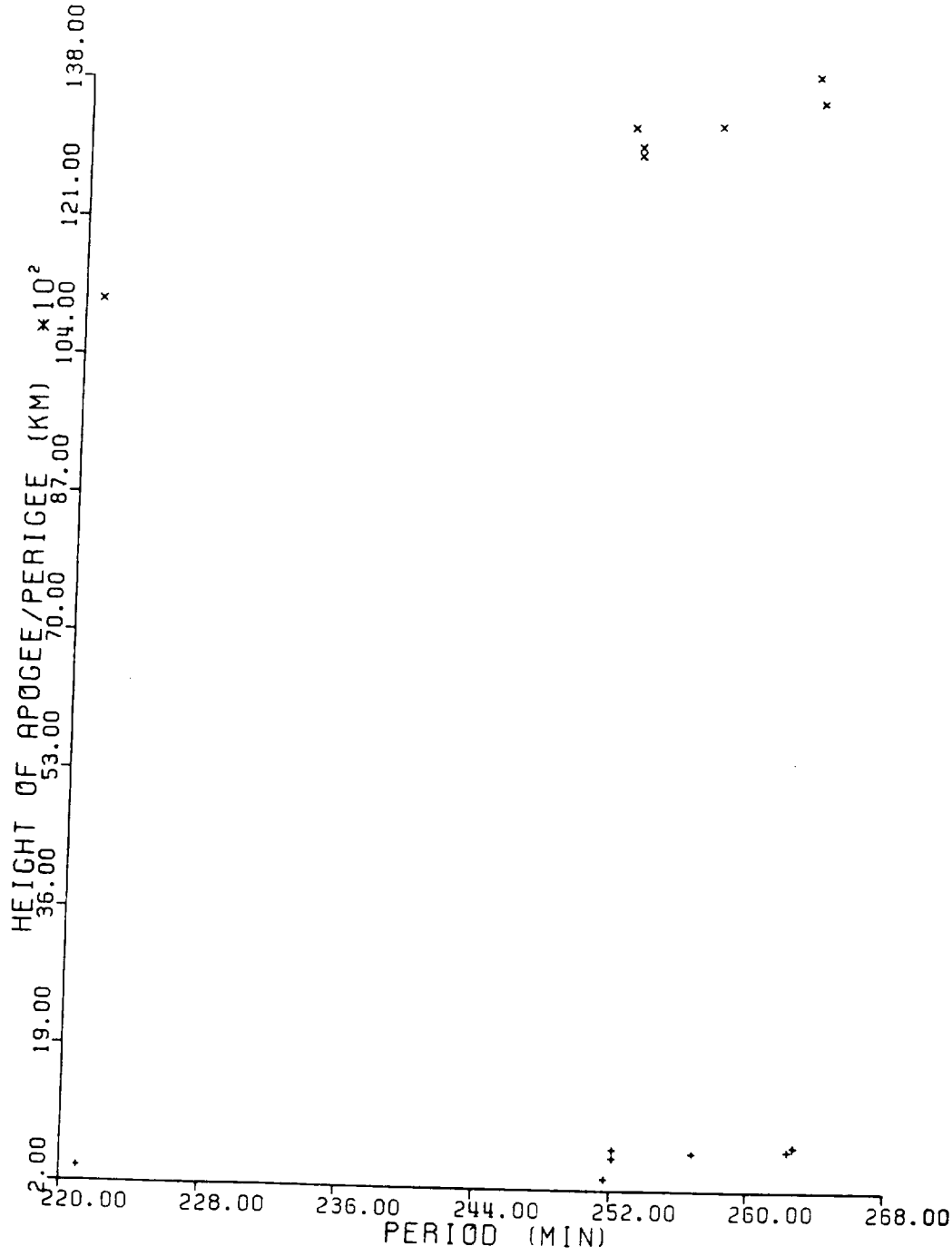
EPOCH:	81258.60717998	MEAN ANOMALY:	26.9249
RIGHT ASCENSION:	68.6245	MEAN MOTION:	5.48678032
INCLINATION:	62.8166	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.4855644	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	286.6972	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	3	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	3	MAXIMUM ΔI:	Unknown

COMMENTS

Cosmos 1305 R/B malfunctioned about 1 hour after launch during a maneuver from a LEO parking orbit to a Molniya-type orbit. The maneuver was initiated at approximately 0937 GMT near 58S, 245E (asc) at an altitude of 600 km. Apogee was raised to less than 14,000 km. Debris tracking after the event was limited, preventing an accurate assessment of magnitude of the event. First debris officially cataloged in June 1983. Debris generation is assumed to have occurred during or immedately after the unsuccessful maneuver. The element set above is for the rocket body after burn termination.



Cosmos 1305 R/B debris cloud of seven fragments about two years after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	14.85 Sep 1981
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA (1)

DATE:	12 Jul 1982	LOCATION:	65S, 40E (asc)
TIME:	2325 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	380 km		

PRE-EVENT ELEMENTS (1)

EPOCH:	82193.22052182	MEAN ANOMALY:	72.7640
RIGHT ASCENSION:	43.8843	MEAN MOTION:	15.58171668
INCLINATION:	64.9399	MEAN MOTION DOT/2:	.00042116
ECCENTRICITY:	.0019953	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	287.2390	BSTAR:	.00055055

EVENT DATA (2)

DATE:	18 Sep 1982	LOCATION:	32N, 293E (asc)
TIME:	1702 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	370 km		

PRE-EVENT ELEMENTS (2)

EPOCH:	82260.17037940	MEAN ANOMALY:	44.8033
RIGHT ASCENSION:	173.7764	MEAN MOTION:	15.65882738
INCLINATION:	64.9408	MEAN MOTION DOT/2:	.00076164
ECCENTRICITY:	.0002181	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	315.2578	BSTAR:	.00073994

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	8	MAXIMUM ΔP:	2.1 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.2 deg

*Based on uncataloged debris data

COMMENTS

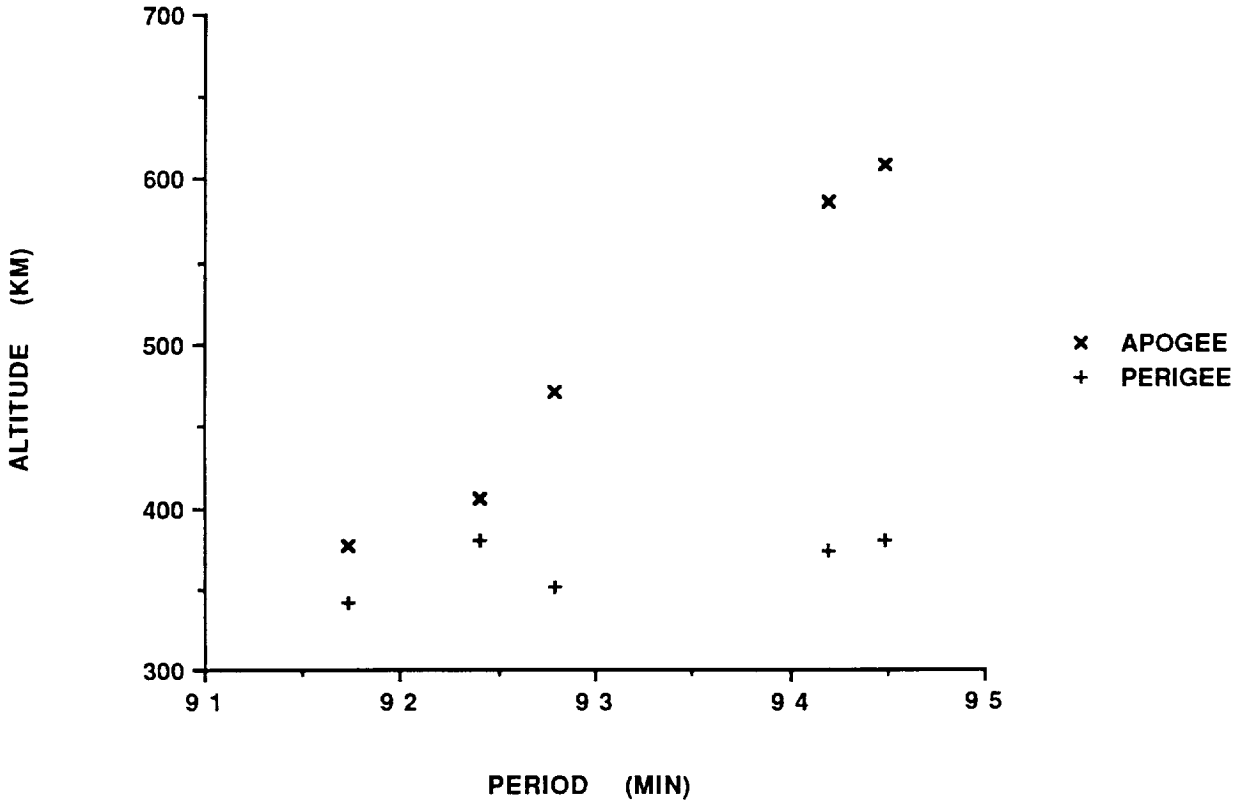
Cosmos 1306 was the eighth spacecraft of the Cosmos 699-type to experience a fragmentation. The first event occurred five months after the spacecraft had entered a regime of natural decay. After the event the main remnant was tagged as satellite 13369, while a piece of debris tagged as 12828 decayed

on 16 July 1982. Only 5 new fragments were officially cataloged prior to the second event when satellite 13369 experienced a fragmentation. Three long-lived fragments cataloged with 1981-89 (13393, 13404, and 14837) were actually part of the breakup of 1980-89, another Cosmos 699-type satellite. Most Cosmos 1306 debris reentered quickly and elements were developed for only a few fragments.

REFERENCE DOCUMENTS

Analysis of Cosmos 1220 and Cosmos 1306 Fragments (U), D. Fennessy, Report AH-23, FTD/OLAI, Cheyenne Mountain, Colorado, 12 January 1983 (Secret)

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.



Cosmos 1306 debris cloud of five identified fragments one day after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	31.95 Oct 1981
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 1.6 m by 3.4 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	25-28 Jan 1984	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS

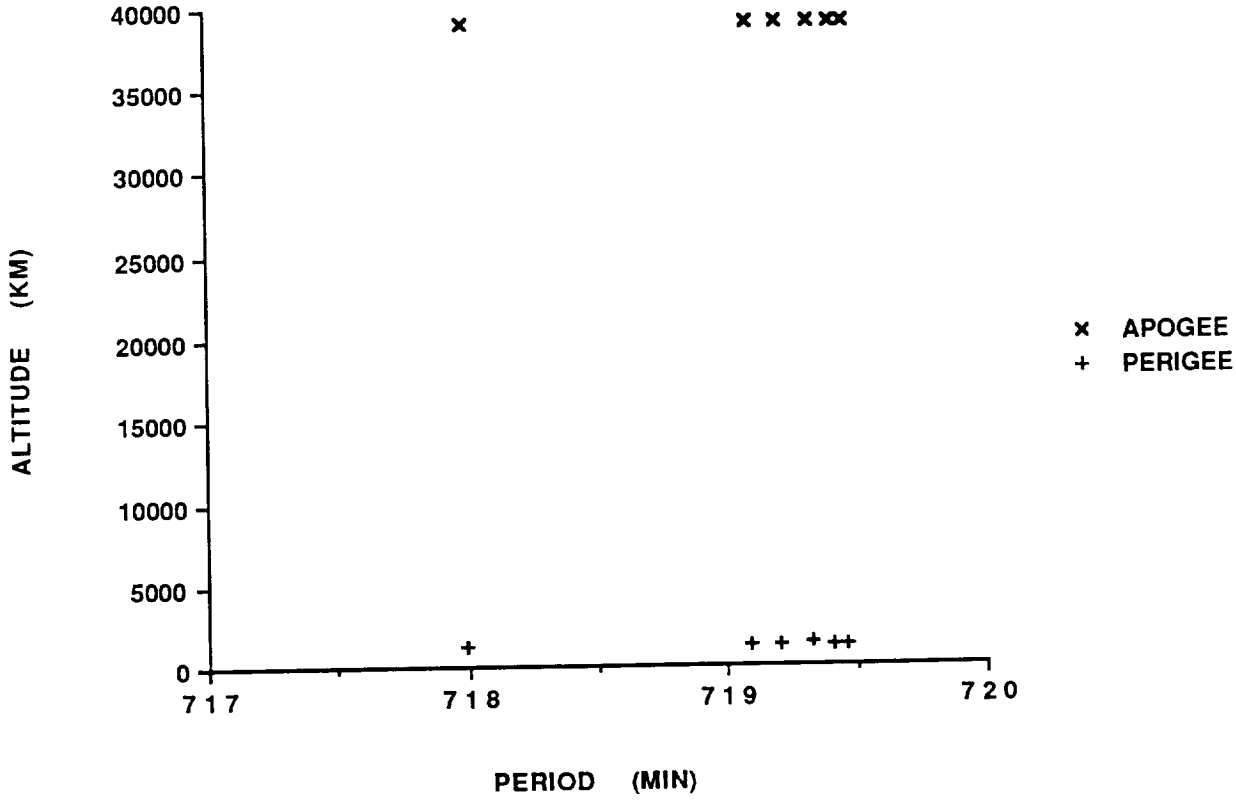
EPOCH:	84024.46309667	MEAN ANOMALY:	4.4900
RIGHT ASCENSION:	219.5352	MEAN MOTION:	2.00535027
INCLINATION:	62.8286	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.7103977	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	324.1891	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	4	MAXIMUM ΔP:	1.8 min
DEBRIS IN ORBIT:	4	MAXIMUM ΔI:	0.3 deg

COMMENTS

Cosmos 1317 was the fourteenth and the last spacecraft of the Cosmos 862-type to experience a fragmentation. The spacecraft may have been active at the time of the event, having last made a station-keeping maneuver on 5 November 1983. Cosmos 1317's orbital parameters immediately prior to the event were consistent with the need for another station-keeping maneuver. The spacecraft began drifting off station immediately after the event and never recovered



Cosmos 1317 debris cloud of seven fragments about two weeks after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	29.41 Apr 1982
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA (1)

DATE:	8 Aug 1983	LOCATION:	32S, 310E (asc)
TIME:	2331 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	365 km		

PRE-EVENT ELEMENTS (1)

EPOCH:	83220.21851552	MEAN ANOMALY:	66.8795
RIGHT ASCENSION:	279.4096	MEAN MOTION:	15.63233551
INCLINATION:	65.0504	MEAN MOTION DOT/2:	.00048258
ECCENTRICITY:	.0024043	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	292.8515	BSTAR:	.00051620

EVENT DATA (2)

DATE:	1 Feb 1984	LOCATION:	4S, 200E (asc)
TIME:	0322 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	320 km		

PRE-EVENT ELEMENTS (2)

EPOCH:	84031.38369465	MEAN ANOMALY:	81.7159
RIGHT ASCENSION:	25.3553	MEAN MOTION:	15.84652631
INCLINATION:	65.0404	MEAN MOTION DOT/2:	.00119378
ECCENTRICITY:	.0017572	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	278.1110	BSTAR:	.00050318

EVENT DATA (3)

DATE:	20 Feb 1984	LOCATION:	Unknown
TIME:	Before 0340 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS (3)

EPOCH:	84050.69015256	MEAN ANOMALY:	105.8772
RIGHT ASCENSION:	316.3115	MEAN MOTION:	15.97914042
INCLINATION:	65.0338	MEAN MOTION DOT/2:	.00430956
ECCENTRICITY:	.0014134	MEAN MOTION DOT DOT/6:	.000083799
ARG. OF PERIGEE:	254.0517	BSTAR:	.00093344

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	29	MAXIMUM ΔP:	36.8 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	2.3 deg*

*Based on uncataloged debris data (Event 1)

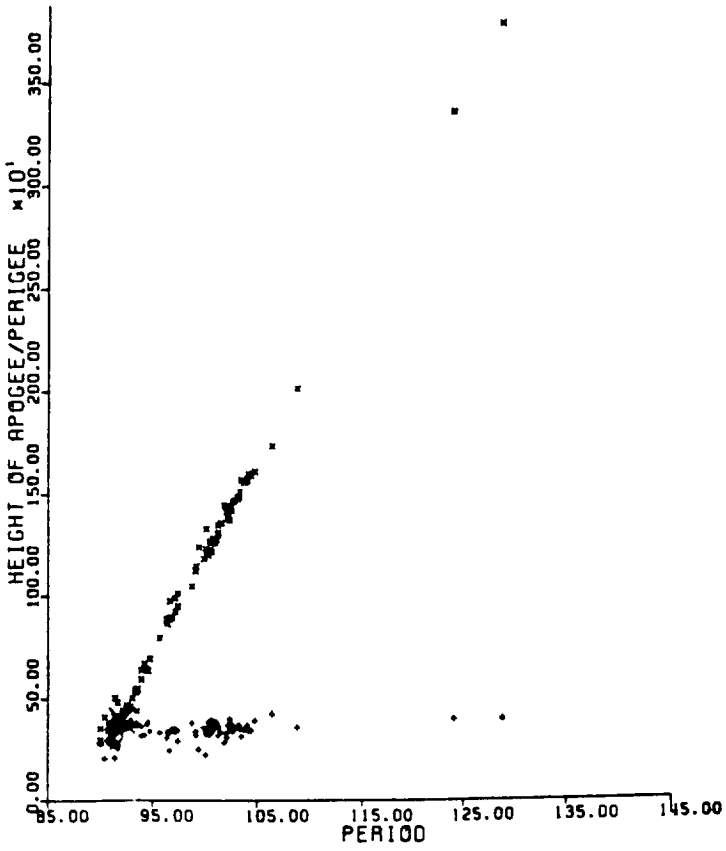
COMMENTS

Cosmos 1355 was the tenth spacecraft of the Cosmos 699-type to experience a fragmentation. The spacecraft had been in a regime of natural decay for six months prior to the first event. Twenty-one fragments were cataloged following the first event, and the main body became satellite 14275. This object spawned at least seven more fragments on 1 February. The parent was then retagged to the original 13150 satellite number. The third event resulted in the development of 13 new fragment element sets, but none were cataloged and the low altitude prevented an estimate of a precise breakup location.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.

Analysis of the Fragmentation of Kosmos 1355, N. L. Johnson, Technical Report CS84-SPACECMD-28, Teledyne Brown Engineering, Colorado Springs, January 1985.



Cosmos 1355 debris cloud of 149 fragments about seven hours after the first event in August 1983 as seen by the U.S. Space Surveillance Network PARCS radar. Figure from the cited reference.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	6.72 Jun 1982
DRY MASS (KG):	800 (est.)
MAIN BODY:	Cylinder; 2 m by 2 m (?)
MAJOR APPENDAGES:	Solar panels, gravity-gradient boom (?)
ATTITUDE CONTROL:	Gravity gradient (?)
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	21 Oct 1985	LOCATION:	66N, 351E (asc)
TIME:	0353 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	995 km		

PRE-EVENT ELEMENTS

EPOCH:	85293.85195210	MEAN ANOMALY:	333.5602
RIGHT ASCENSION:	350.2805	MEAN MOTION:	13.71079597
INCLINATION:	65.8390	MEAN MOTION DOT/2:	.00000158
ECCENTRICITY:	.0005355	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	26.5667	BSTAR:	.00023894

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	58	MAXIMUM ΔP:	2.3 min*
DEBRIS IN ORBIT:	57	MAXIMUM ΔI:	0.1 deg*

*Based on uncataloged debris data

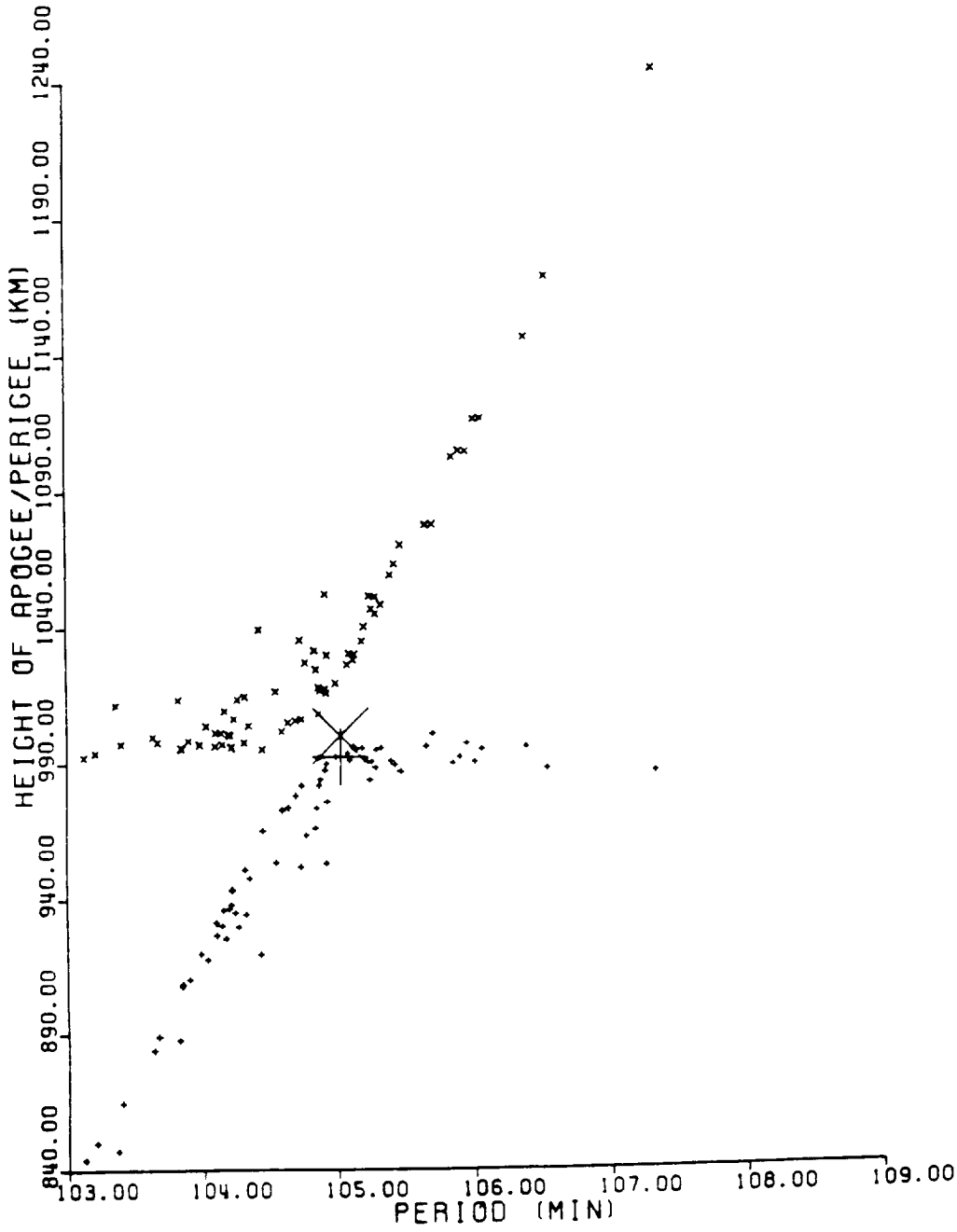
COMMENTS

Cosmos 1375 was the third spacecraft of the Cosmos 839-type to experience a fragmentation. Although these satellites are used in conjunction with the Cosmos 249-type spacecraft which are deliberately fragmented, the cause of Cosmos 839-type events appears to be unrelated. In the case of Cosmos 1375, 40 months elapsed since its test with a Cosmos 249-type spacecraft.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 2): Soviet Anti-Satellite Program", N.L. Johnson, Journal of the British Interplanetary Society, August 1983, pp. 357-362.

Analysis of the Kosmos 1375 Fragmentation, J. M. Koskella and R. L. Kling, Technical Report CS86-USASDC-0006, Teledyne Brown Engineering, Colorado Springs, March 1986.



Cosmos 1375 debris cloud of 68 fragments seen a few hours after the event by the U.S. Space Surveillance Network PARCS radar.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	4.74 Sep 1982
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA

DATE:	20 Dec 1983	LOCATION:	25S, 45E (dsc)
TIME:	1215 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	330 km		

PRE-EVENT ELEMENTS

EPOCH:	83354.22079767	MEAN ANOMALY:	42.0375
RIGHT ASCENSION:	126.1259	MEAN MOTION:	15.81899265
INCLINATION:	65.0055	MEAN MOTION DOT/2:	.00186341
ECCENTRICITY:	.0020774	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	318.0927	BSTAR:	.00088277

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	32	MAXIMUM ΔP:	7.3 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	2.0 deg*

*Based on uncataloged debris data

COMMENTS

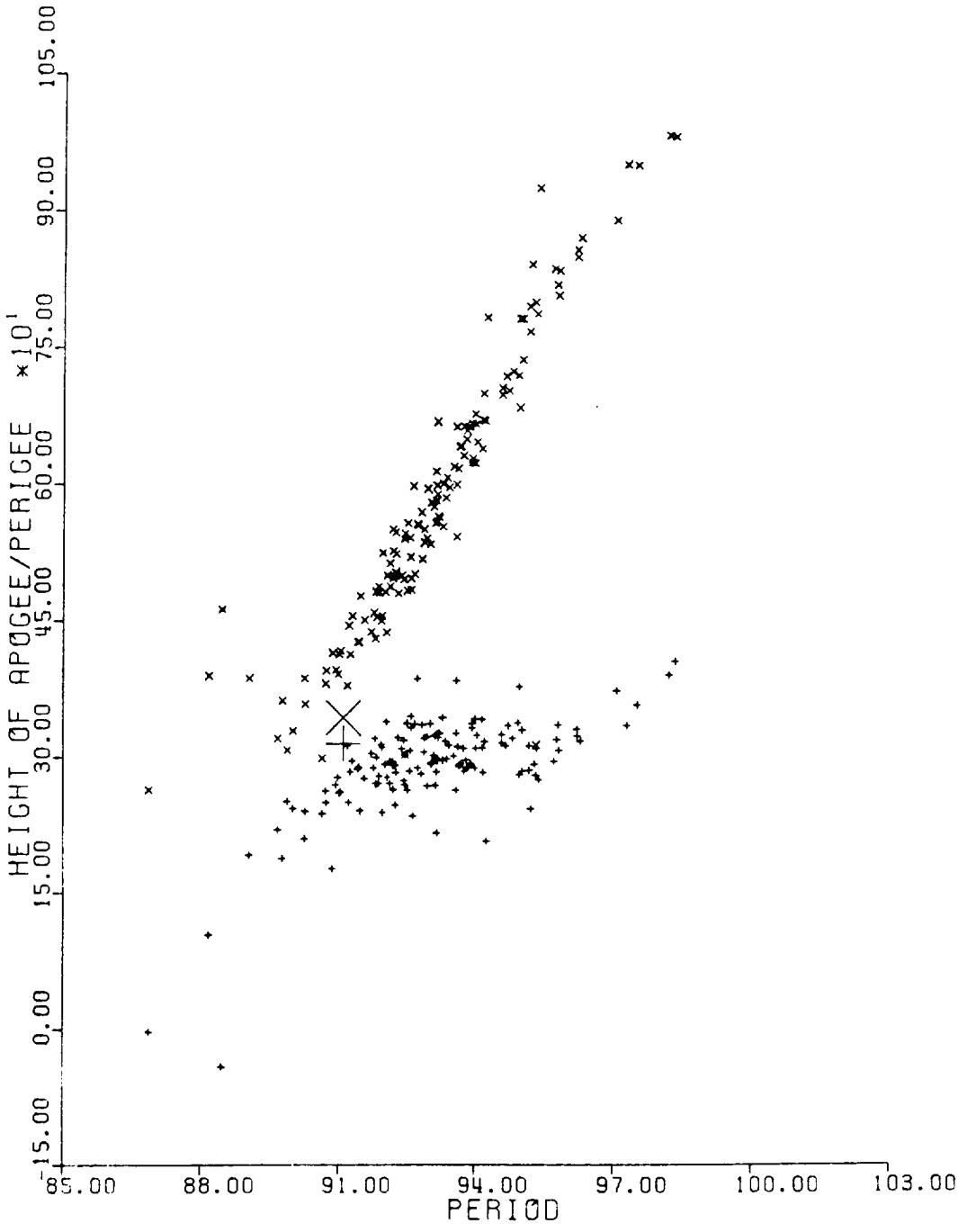
Cosmos 1405 was the eleventh spacecraft of the Cosmos 699-type to experience a fragmentation. Spacecraft had been in natural decay for 12 months prior to the event. Most debris reentered before being officially cataloged.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.

Separation of Objects from Cosmos 1405, F.T. Lipp, NAVSPASUR Technical Note 1-84, Naval Space Surveillance System, Dahlgren, 2 April 1984.

Analysis of the Fragmentation of Kosmos 1405, N.L. Johnson, Technical Report CS84-SPACECMD-10, Teledyne Brown Engineering, Colorado Springs, September 1984.



Cosmos 1405 debris cloud of 142 fragments one hour after the event as seen by the U.S. Space Surveillance Network PARCS radar. Figure from Analysis of the Fragmentation of Kosmos 1405.

SATELLITE DATA

TYPE:	SL-6 Final Stage
OWNER:	USSR
LAUNCH DATE:	8.58 Dec 1982
DRY MASS (KG):	1000 (approx.)
MAIN BODY:	Cylinder; 2.4 m by 2.2 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	8 Dec 1982	LOCATION:	62S, 302E (asc)
TIME:	1448 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	400 km		

PRE-EVENT ELEMENTS

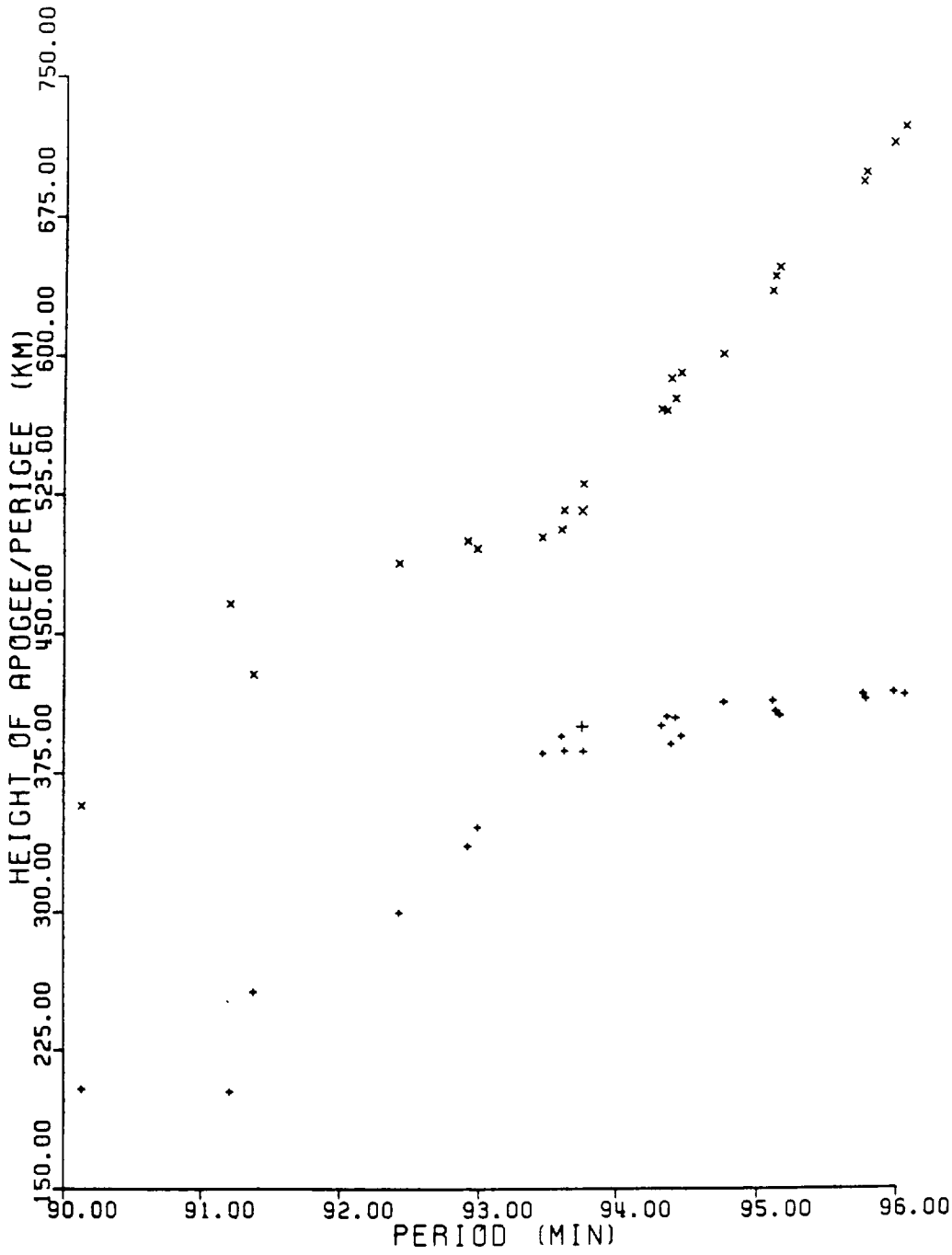
EPOCH:	82342.56790507	MEAN ANOMALY:	305.2204
RIGHT ASCENSION:	316.3789	MEAN MOTION:	15.79849844
INCLINATION:	62.9496	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.0143321	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	56.2493	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	29	MAXIMUM ΔP:	4.9 min
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.2 deg

COMMENTS

Fragmentation occurred at the time the SL-6 final stage was fired to move the payload from a parking orbit to a Molniya-type transfer orbit. Pre-event elements are taken from satellite 13686 for first revolution parking orbit. A second fargmentation may have occurred on 9 December 1982.



Cosmos 1423 R/B debris cloud of 24 fragments soon after the event(s) as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Operational Debris
OWNER:	USSR
LAUNCH DATE:	23.53 Mar 1983
DRY MASS (KG):	Unknown
MAIN BODY:	Unknown
MAJOR APPENDAGES:	Unknown
ATTITUDE CONTROL:	None
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	3 Sep 1984	LOCATION:	12S, 352E (dsc)
TIME:	2023 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	400 km		

PRE-EVENT ELEMENTS

EPOCH:	84247.05150886	MEAN ANOMALY:	106.3279
RIGHT ASCENSION:	94.4099	MEAN MOTION:	14.50264973
INCLINATION:	51.5306	MEAN MOTION DOT/2:	.00079313
ECCENTRICITY:	.0710960	MEAN MOTION DOT DOT/6:	.0000075234
ARG. OF PERIGEE:	246.1573	BSTAR:	.00035531

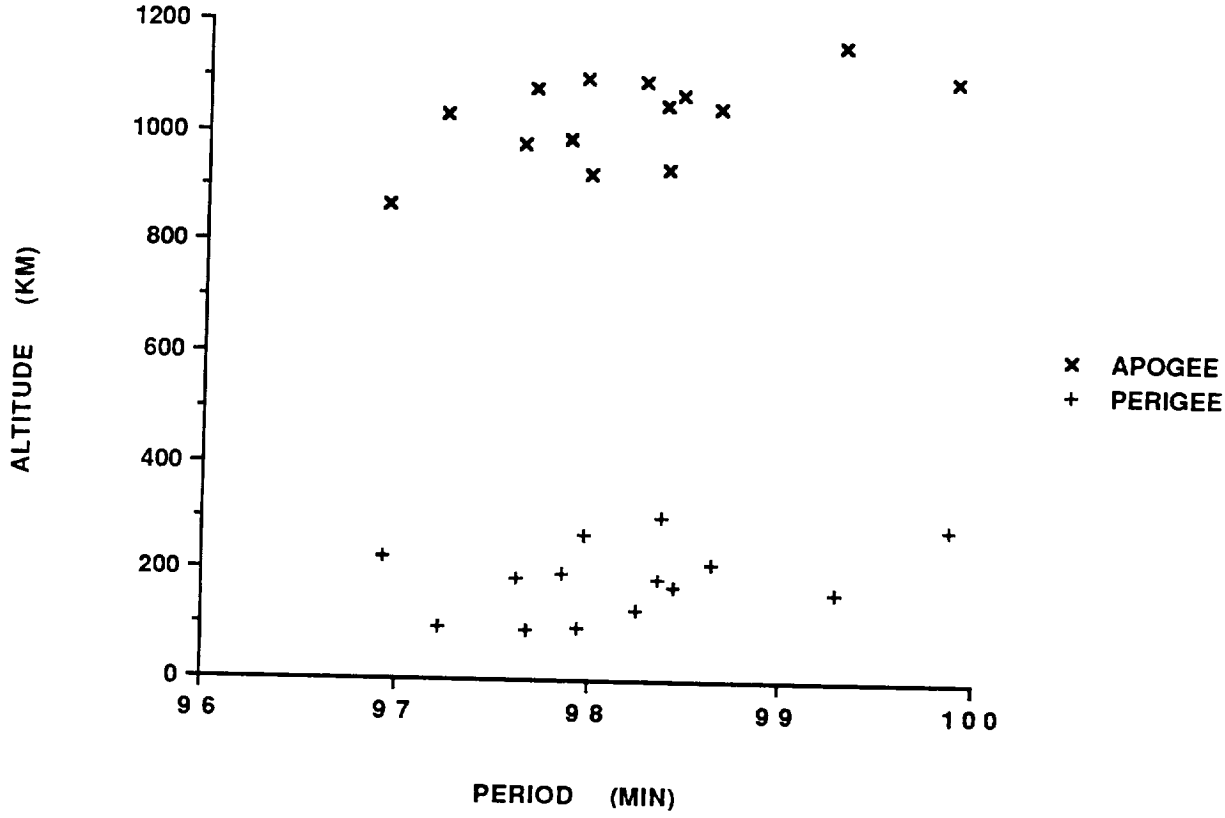
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	1	MAXIMUM ΔP:	2.4 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.3 deg*

*Based on uncataloged debris data

COMMENTS

Parent satellite was apparently one of two operational pieces of debris which are routinely released after the first burn of the SL-12 final stage and is misidentified as a platform in the U.S. Space Command Satellite Catalog. The nature of these objects is unknown. Element sets on 16 fragments were developed. None were officially cataloged. A second event with as many as five debris may have occurred on 9 September 1984. Possibly related to fragmentation of Cosmos 1656 debris which occurred after 31 months in orbit, Cosmos 1519-1521 debris which occurred after 86 months in orbit, and Cosmos 1710-1712 which occurred after 72 months in orbit.



Fragments from Astron debris as determined within a few days of the first event. Elements from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	US
LAUNCH DATE:	28.66 Mar 1983
DRY MASS (KG):	1000 (approx.)
MAIN BODY:	Cylinder-box; 1.9 m by 7.5 m
MAJOR APPENDAGES:	1 solar panel
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	30 Dec 1985	LOCATION:	68S, 300E (dsc)
TIME:	1005 GMT	ASSESSED CAUSE:	Electricial System Malfunction
ALTITUDE:	825 km		

PRE-EVENT ELEMENTS

EPOCH:	85348.40460348	MEAN ANOMALY:	83.2801
RIGHT ASCENSION:	16.9717	MEAN MOTION:	14.22481975
INCLINATION:	98.6488	MEAN MOTION DOT/2:	.00000037
ECCENTRICITY:	.0015724	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	276.6589	BSTAR:	.000025130

CATALOGED DEBRIS CLOUD DATA

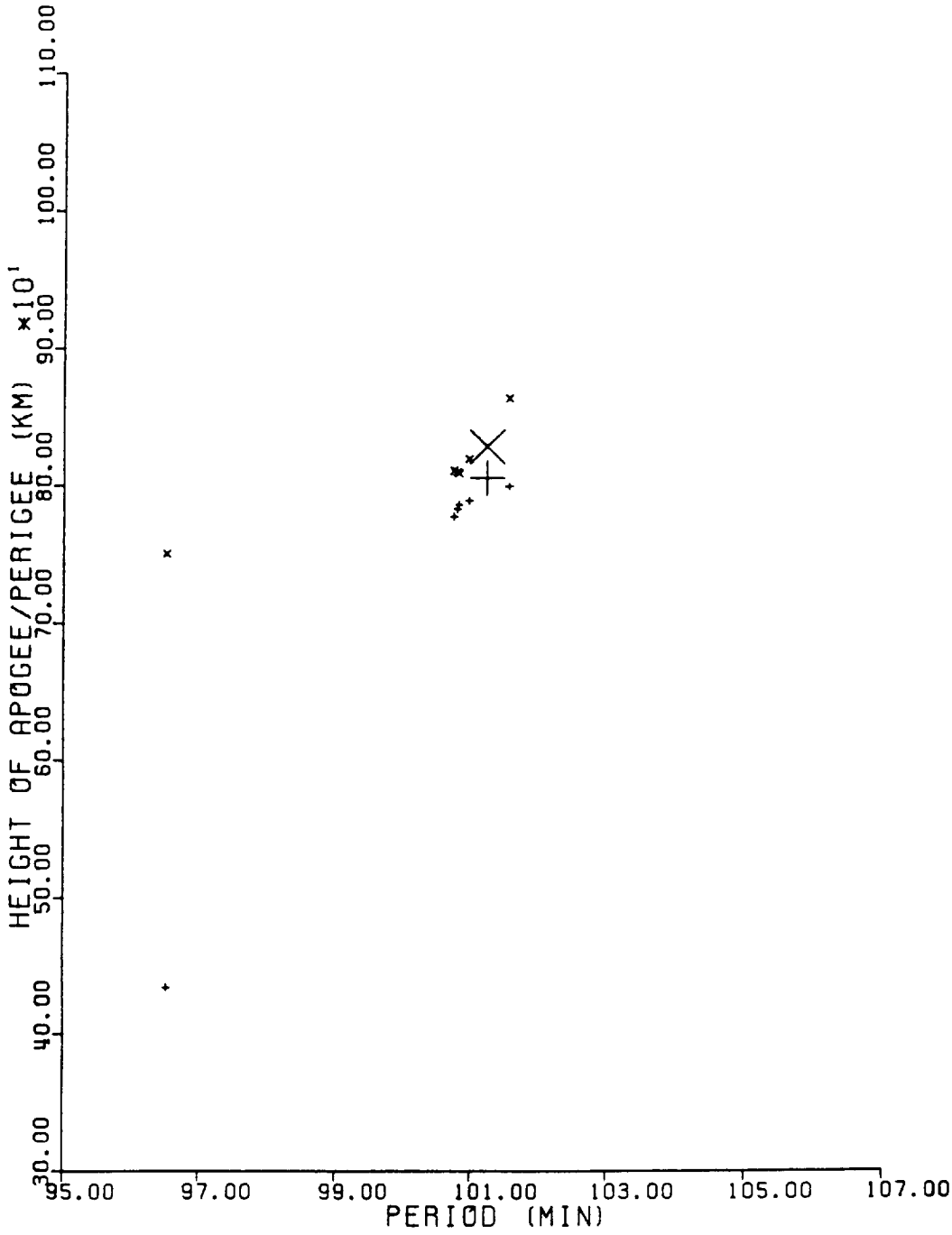
DEBRIS CATALOGED:	7	MAXIMUM ΔP:	4.7 min
DEBRIS IN ORBIT:	1	MAXIMUM ΔI:	0.1 deg

COMMENTS

A malfunction on NOAA 8 caused a battery to overcharge, resulting in a minor explosion of the battery. The spacecraft was operational at the time of the event. Six new fragments were detected and cataloged. All decayed by February 1989, leaving the parent still in orbit.

REFERENCE DOCUMENTS

"NOAA Turns Off Satellite Following Malfunction", Aviation Week and Space Technology, 13 January 1986, p. 21.



NOAA 8 debris cloud of six fragments plus the parent satellite (large symbols) one day after the event as reconstructed from Naval Space Surveillance System database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	25.81 Apr 1983
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 1.6 m by 3.4 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	13 Aug 1983	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS

EPOCH:	83225.00107283	MEAN ANOMALY:	4.5332
RIGHT ASCENSION:	79.8630	MEAN MOTION:	2.00589678
INCLINATION:	63.3076	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.7324437	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	320.0041	BSTAR:	.0068163

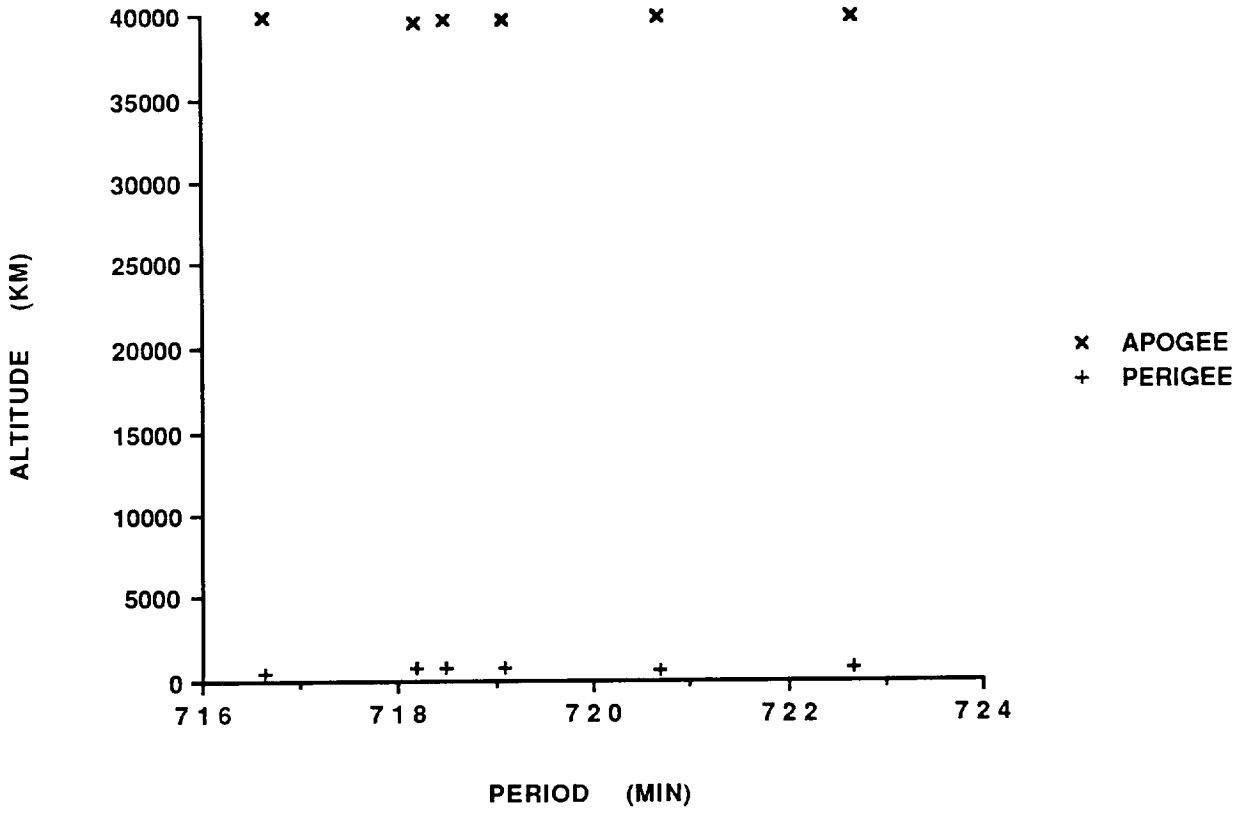
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	4	MAXIMUM ΔP:	4.8 min*
DEBRIS IN ORBIT:	4	MAXIMUM ΔI:	0.4 deg*

*Based on uncataloged debris data

COMMENTS

Cosmos 1456 was the thirteenth spacecraft of the Cosmos 862-type to experience a fragmentation. The spacecraft may have been active at the time of the event, having last made a station-keeping maneuver on 22 June 1983. The next station-keeping maneuver should have occurred in the second half of August or early September 1983. The spacecraft began drifting off station immediately after the event and never recovered.



Cosmos 1456 debris cloud of six fragments less than three weeks after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	7.44 May 1983
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA (1)

DATE:	11 Mar 1985	LOCATION:	4S, 196E (asc)
TIME:	0940 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	750 km		

PRE-EVENT ELEMENTS (1)

EPOCH:	85068.60956125	MEAN ANOMALY:	101.2285
RIGHT ASCENSION:	157.6403	MEAN MOTION:	14.49322542
INCLINATION:	65.0244	MEAN MOTION DOT/2:	.00000357
ECCENTRICITY:	.0224980	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	256.3703	BSTAR:	.000080310

EVENT DATA (2)

DATE:	13 May 1985	LOCATION:	10N, 82E (asc)
TIME:	0133 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	845 km		

PRE-EVENT ELEMENTS (2)

EPOCH:	85125.54047130	MEAN ANOMALY:	121.1528
RIGHT ASCENSION:	353.4544	MEAN MOTION:	14.49239036
INCLINATION:	65.0248	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.0222492	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	236.8082	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	158	MAXIMUM ΔP:	5.9 min*
DEBRIS IN ORBIT:	3	MAXIMUM ΔI:	1.0 deg*

*Based on uncataloged debris data

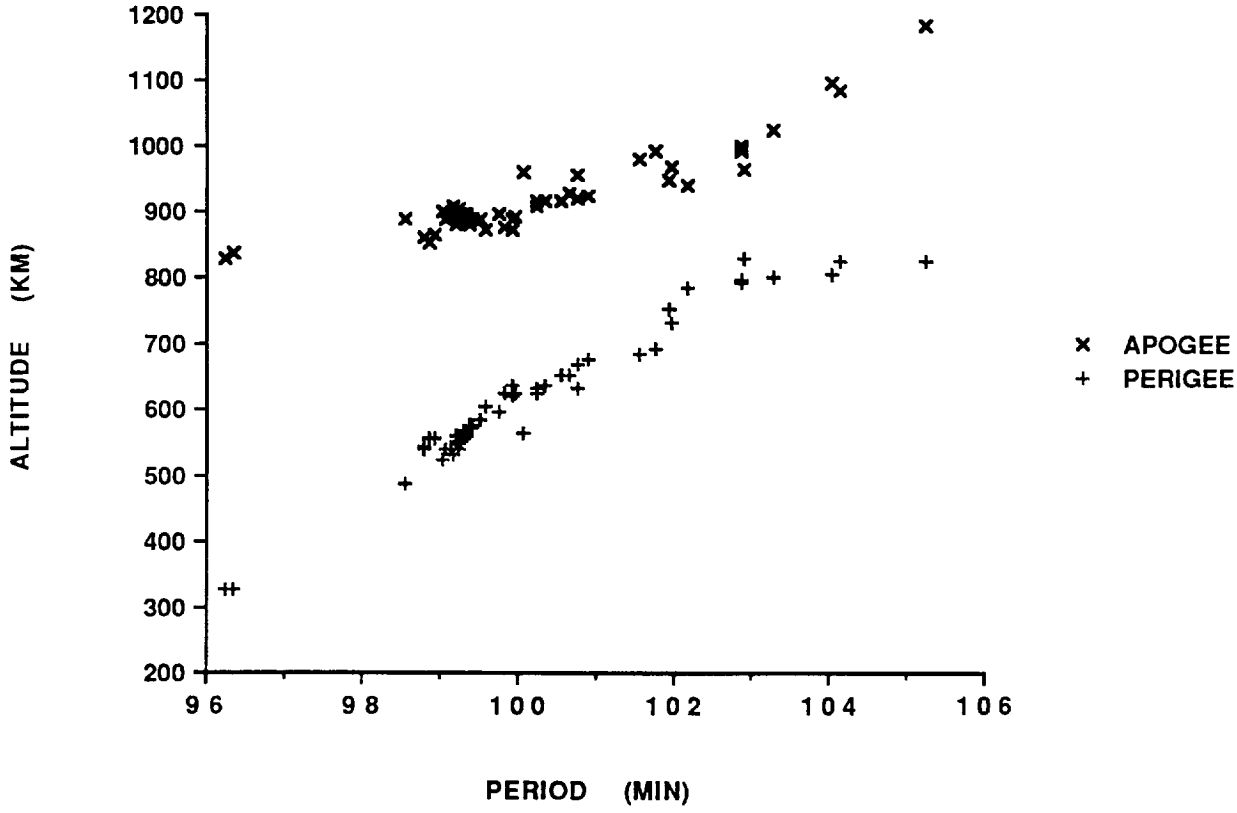
COMMENTS

Cosmos 1461 was the twelfth spacecraft of the Cosmos 699-type to experience a fragmentation. Cosmos 1461 entered a natural decay regime more than 13 months prior to first event. After the first event as many as 20 fragments were detected but only six new objects were cataloged. The second event occurred two months later and produced considerably more debris. These events followed the pattern set by Cosmos 1220 and Cosmos 1260.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.

Analysis of the Fragmentation of Kosmos 1461, G.T. DeVere and N.L. Johnson, Technical Report CS85-BMDSC-0056, Teledyne Brown Engineering, Colorado Springs, September 1985.



Cosmos 1461 debris cloud remnant of 65 fragments four days after the second event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	8.80 Jul 1983
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 1.6 m by 3.4 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	9 Jul 1983	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	Unknown		

PRE-EVENT ELEMENTS

EPOCH:	83189.85702098	MEAN ANOMALY:	4.6462
RIGHT ASCENSION:	166.3194	MEAN MOTION:	2.03523282
INCLINATION:	62.9394	MEAN MOTION DOT/2:	.00000702
ECCENTRICITY:	.7337681	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	317.9301	BSTAR:	.0

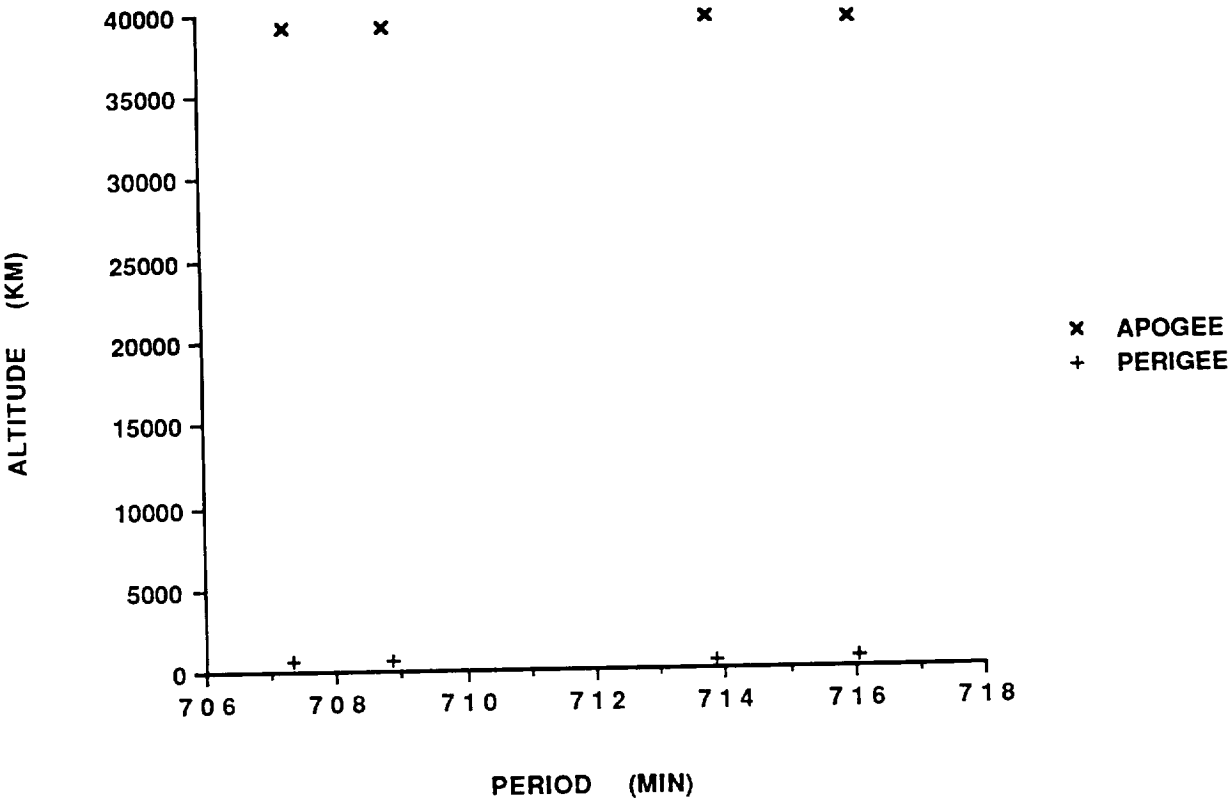
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	3	MAXIMUM ΔP:	8.7 min*
DEBRIS IN ORBIT:	3	MAXIMUM ΔI:	0.8 deg*

*Based on uncataloged debris data

COMMENTS

Cosmos 1481 was the twelfth spacecraft of the Cosmos 862-type to experience a fragmentation. The event apparently occurred within a day of launch. An expected orbital maneuver by Cosmos 1481 to move from its transfer orbit to an operational orbit about 3 days after launch was never performed.



Cosmos 1481 debris cloud of four objects one month after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Operational Debris
OWNER:	USSR
LAUNCH DATE:	20.04 Dec 1983
DRY MASS (KG):	Unknown
MAIN BODY:	Unknown
MAJOR APPENDAGES:	Unknown
ATTITUDE CONTROL:	None
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	4 Feb 1991	LOCATION:	28N, 106E (dsc)
TIME:	0312 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	18550 km		

PRE-EVENT ELEMENTS

EPOCH:	91032.22560633	MEAN ANOMALY:	10.4843
RIGHT ASCENSION:	133.4557	MEAN MOTION:	4.30882556
INCLINATION:	51.9464	MEAN MOTION DOT/2:	.00004140
ECCENTRICITY:	.5787304	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	315.5487	BSTAR:	.0018354

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	4	MAXIMUM ΔP:	Unknown
DEBRIS IN ORBIT:	4	MAXIMUM ΔI:	Unknown

COMMENTS

This piece of operational debris was one of two objects which are routinely released by the SL-12 final stage after the first burn. The nature of these objects is unclear. NAVSPASUR observed at least 12 fragments on the day of the event and approximately three dozen on 7 February. An element set was developed on only one new fragment. This object type has been the subject of three other known fragmentation events [Astron Debris -- 1983-020; Cosmos 1656 Debris -- 1985-042; and Cosmos 1710-1712 Debris -- 1985-118].

Insufficient data to construct a Gabbard diagram.

SATELLITE DATA

TYPE:	PAM-D Upper Stage
OWNER:	US
LAUNCH DATE:	3.54 Feb 1984
DRY MASS (KG):	2230 (205 without solid propellants)
MAIN BODY:	Sphere-Nozzle; 1.2 m by 2.1 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Spin-stabilized
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	6 Feb 1984	LOCATION:	0N, 120E (asc)
TIME:	1600 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	280 km		

PRE-EVENT ELEMENTS

EPOCH:	84037.35377144	MEAN ANOMALY:	82.4657
RIGHT ASCENSION:	138.8370	MEAN MOTION:	15.97451864
INCLINATION:	28.4669	MEAN MOTION DOT/2:	.00197501
ECCENTRICITY:	.0006481	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	277.3659	BSTAR:	.00040999

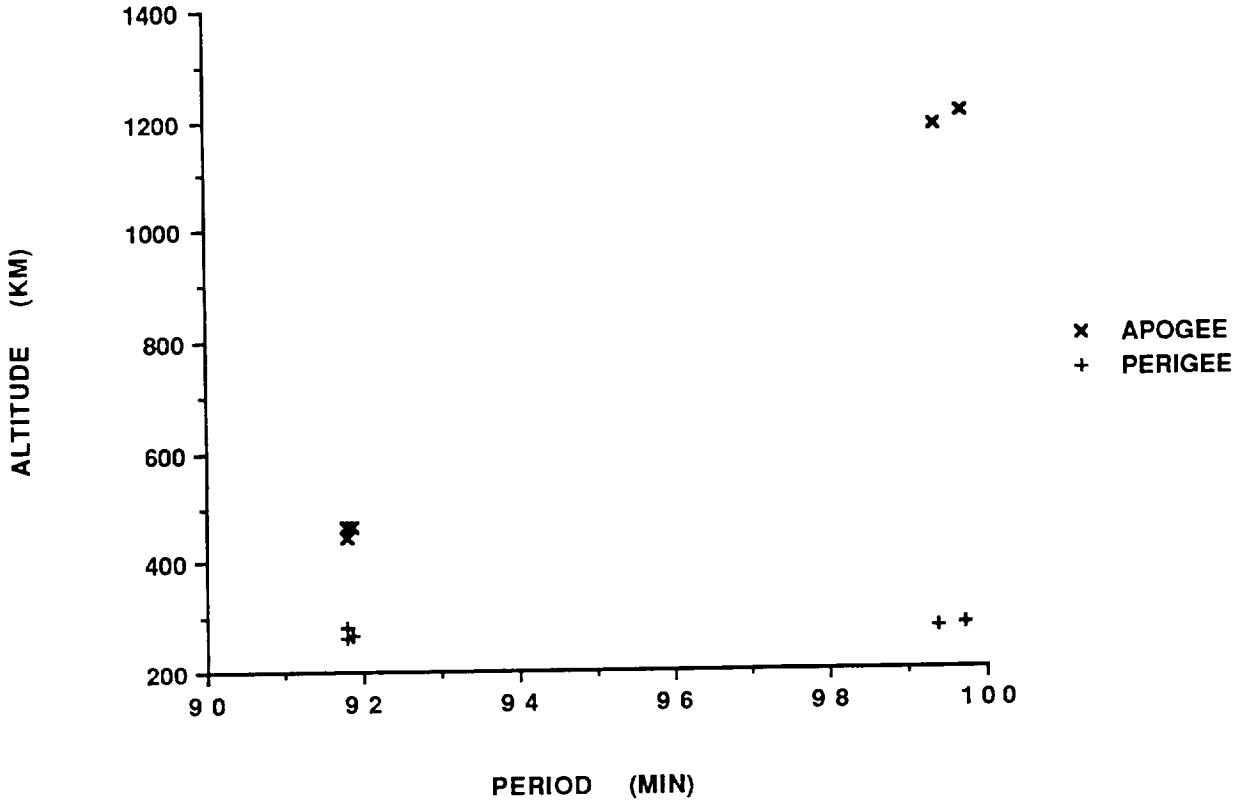
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	3	MAXIMUM ΔP:	9.4 min*
DEBRIS IN ORBIT:	1	MAXIMUM ΔI:	0.3 deg*

*Based on uncataloged debris data

COMMENTS

Palapa B2 and its PAM-D upper stage were deployed from the Space Shuttle Challenger at 1513 GMT, 6 February 1984. Ignition of the upper stage occurred on schedule at 1600 GMT, but the nozzle fragmented within 10 seconds. Without the nozzle the burn could not be sustained and a natural shutdown quickly followed. The PAM-D then separated from Palapa B2. The above elements are for the Shuttle prior to deployment. The Shuttle made a small posigrade evasive maneuver after deployment and before ignition of the the PAM-D. See also Westar 6 R/B fragmentation.



Palapa B2 R/B debris cloud of five fragments about three days after the event as reconstructed from U.S. Space Surveillance Center database. The Palapa B2 R/B is the object with the second highest orbital period.

SATELLITE DATA

TYPE:	PAM-D upper stage
OWNER:	US
LAUNCH DATE:	3.54 Feb 1984
DRY MASS (KG):	2230 (205 without solid propellants)
MAIN BODY:	Sphere-Nozzle; 1.2 m by 2.1 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Spin-stabilized
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	3 Feb 1984	LOCATION:	0N, 56E (asc)
TIME:	2145 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	305 km		

PRE-EVENT ELEMENTS

EPOCH:	84034.84362284	MEAN ANOMALY:	48.7355
RIGHT ASCENSION:	157.5848	MEAN MOTION:	15.88299499
INCLINATION:	28.4660	MEAN MOTION DOT/2:	.00000250
ECCENTRICITY:	.0006644	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	311.2683	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

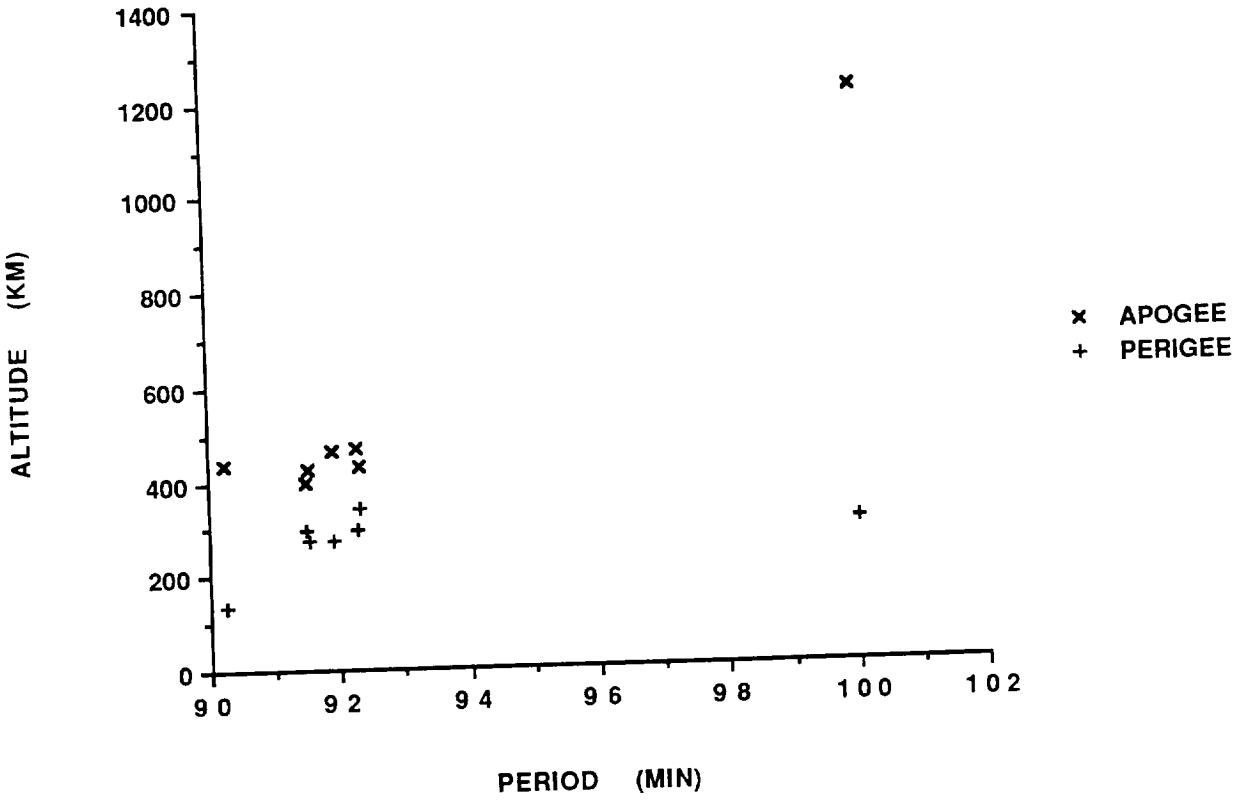
DEBRIS CATALOGED:	14	MAXIMUM ΔP:	9.7 min
DEBRIS IN ORBIT:	1	MAXIMUM ΔI:	0.8 deg

COMMENTS

Westar 6 and its PAM-D upper stage were deployed from the Space Shuttle Challenger at 2100 GMT, 3 February 1984. Ignition of the upper stage occurred on schedule at 2145 GMT but the nozzle fragmented within 10 seconds. Without the nozzle the burn could not be sustained and a natural shutdown quickly followed. The PAM-D then separated from Westar 6. See also Palapa B2 R/B fragmentation.

REFERENCE DOCUMENTS

Westar Failure, Technical Memorandum from N.L. Johnson, Teledyne Brown Engineering, to Preston Landry, NORAD/ADCOM/XPYS, Colorado Springs, 7 February 1984.



Westar 6 R/B debris cloud of seven fragments less than two days after the event as reconstructed from U.S. Space Surveillance Center database. The Westar 6 R/B is the object in the high, 100-min orbit.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	7.95 Aug 1984
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA

DATE:	23 Feb 1986	LOCATION:	29N, 187E (asc)
TIME:	1850 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	430 km		

PRE-EVENT ELEMENTS

EPOCH:	86048.57631415	MEAN ANOMALY:	72.5463
RIGHT ASCENSION:	268.3025	MEAN MOTION:	15.47795866
INCLINATION:	65.0271	MEAN MOTION DOT/2:	.00005888
ECCENTRICITY:	.0022403	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	287.3230	BSTAR:	.00011680

CATALOGED DEBRIS CLOUD DATA

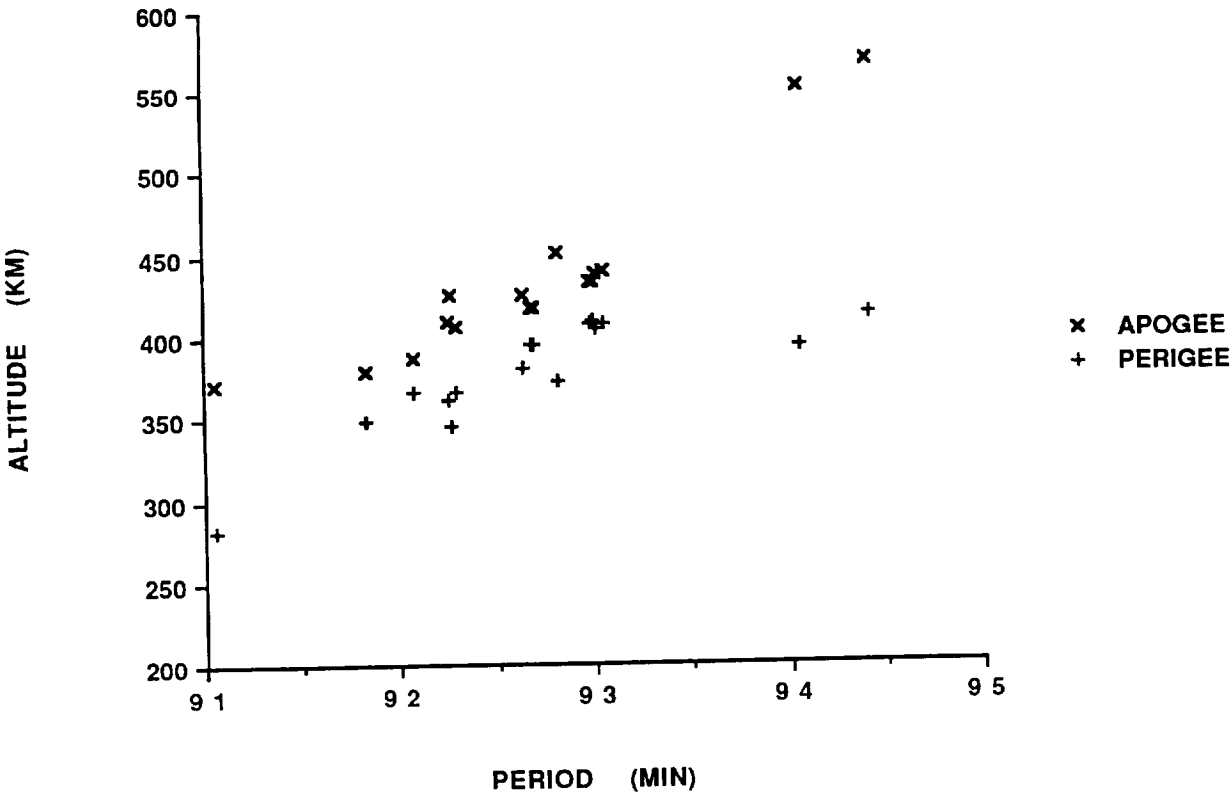
DEBRIS CATALOGED:	45	MAXIMUM ΔP:	2.0 min
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.4 deg

COMMENTS

Cosmos 1588 was the thirteenth spacecraft of the Cosmos 699-type to experience a fragmentation. Spacecraft had been in natural decay for seven months prior to the event.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.



Cosmos 1588 cataloged debris cloud of 16 fragments three weeks after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	18.90 Apr 1985
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA

DATE:	20 Nov 1987	LOCATION:	65N, 300E (dsc)
TIME:	0131 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	410 km		

PRE-EVENT ELEMENTS

EPOCH:	87323.98216942	MEAN ANOMALY:	105.3951
RIGHT ASCENSION:	286.0367	MEAN MOTION:	15.56048984
INCLINATION:	65.0306	MEAN MOTION DOT/2:	.00039428
ECCENTRICITY:	.0018658	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	254.4728	BSTAR:	.00055895

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	24	MAXIMUM ΔP:	5.5 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.2 deg*

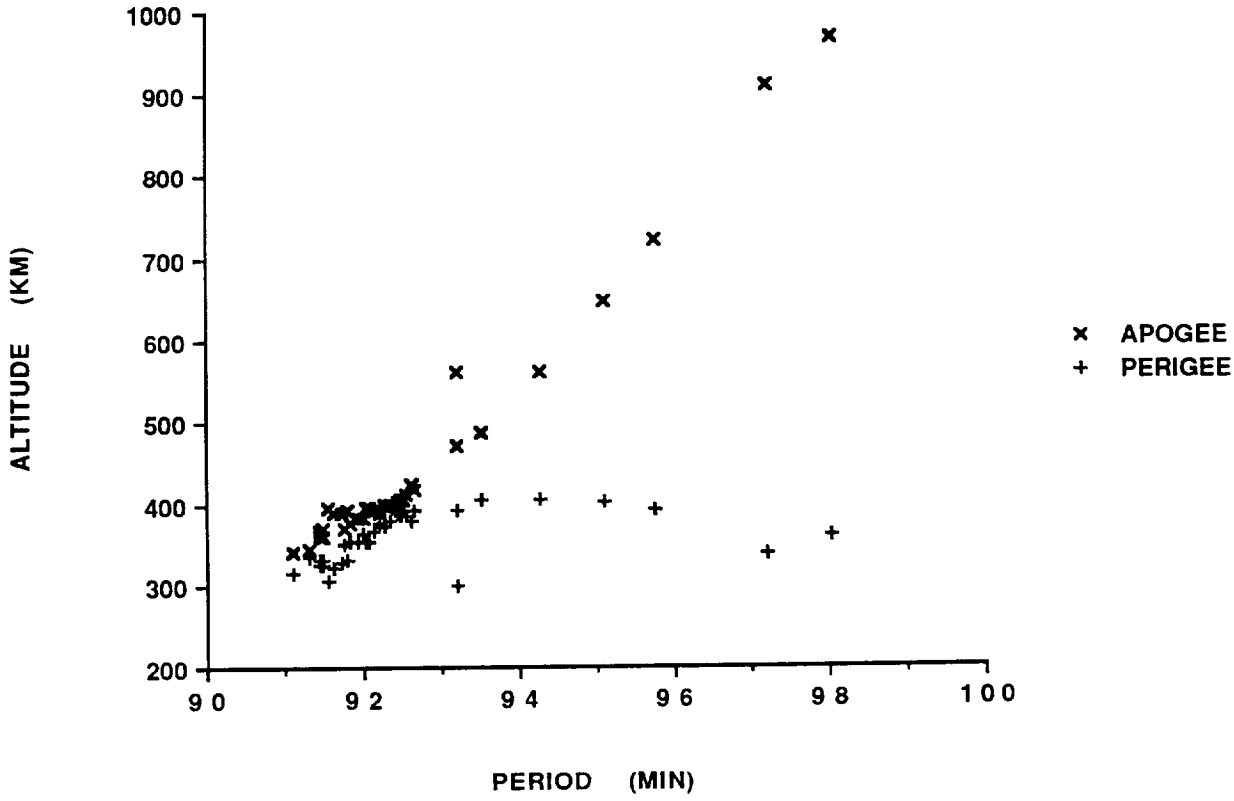
*Based on cataloged and uncataloged debris data

COMMENTS

Cosmos 1646 was the sixteenth and last spacecraft of the Cosmos 699-type to experience a fragmentation. Spacecraft had been in natural decay for nearly 20 months prior to the event. Many debris reentered before being officially cataloged.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.



Cosmos 1646 debris cloud remnant of 38 fragments about 10 days after the event as reconstructed from U.S. Space Surveillance Center database.

C-3

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	23.53 May 1985
DRY MASS (KG):	6000 (approx.)
MAIN BODY:	Cone-cylinder; 2.4 m by 7 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	21 Jun 1985	LOCATION:	8N, 292E (asc)
TIME:	1047 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	200 km		

PRE-EVENT ELEMENTS

EPOCH:	85172.01363851	MEAN ANOMALY:	313.0734
RIGHT ASCENSION:	1.2391	MEAN MOTION:	16.11890623
INCLINATION:	64.8566	MEAN MOTION DOT/2:	.00311214
ECCENTRICITY:	.0086971	MEAN MOTION DOT DOT/6:	.000034493
ARG. OF PERIGEE:	47.8764	BSTAR:	.00015520

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	18	MAXIMUM ΔP:	22.1 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	1.5 deg*

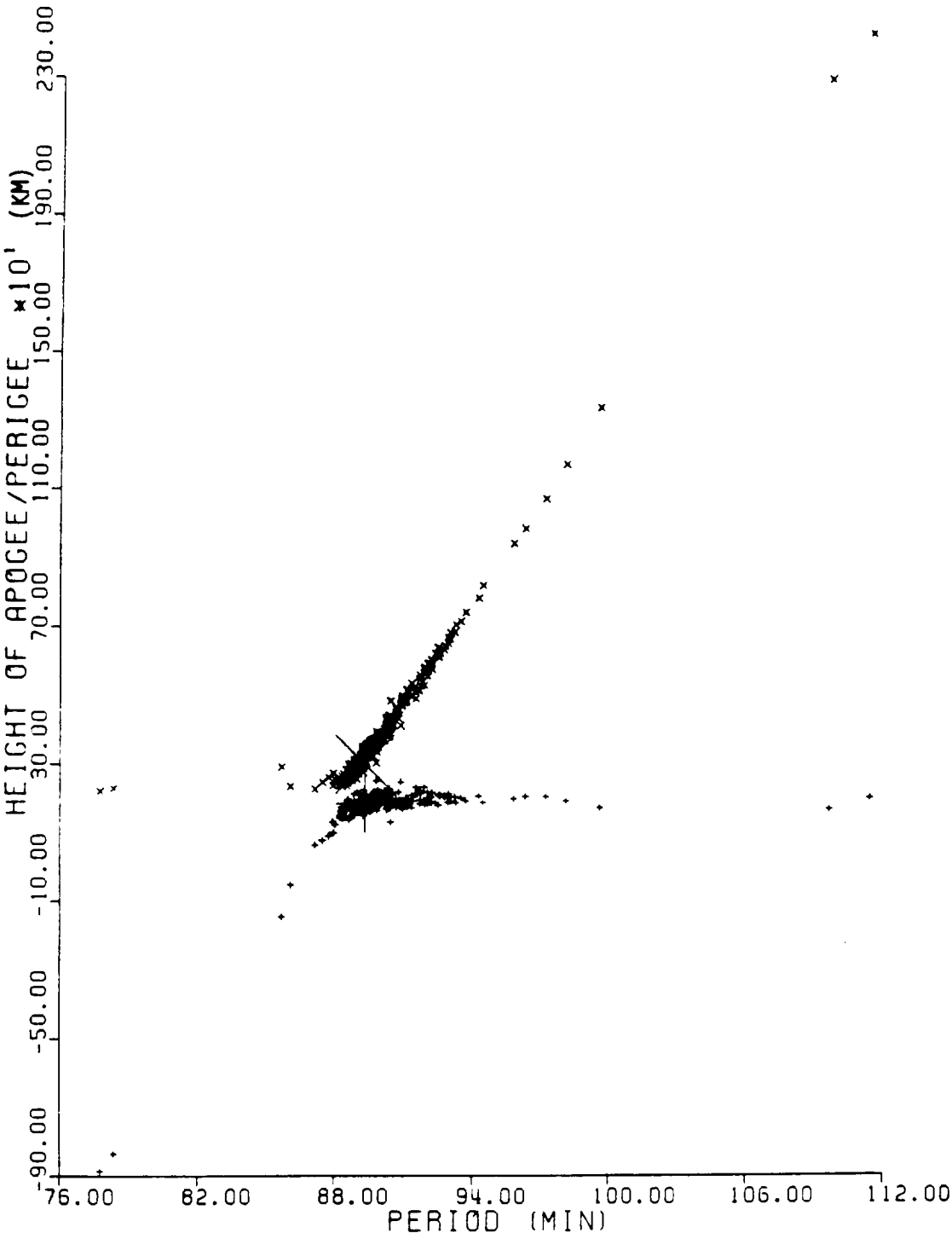
*Based on uncataloged debris data

COMMENTS

Spacecraft was apparently destroyed after a malfunction prevented controlled reentry and landing in the Soviet Union. Fifth incident of this type. Most debris reentered before being officially cataloged.

REFERENCE DOCUMENTS

Analysis of the Fragmentation of Kosmos 1654, G.T. DeVere, Technical Report CS86-BMDSC-0003, Teledyne Brown Engineering, Colorado Springs, October 1985.



Cosmos 1654 debris cloud remnant of 351 fragments seen nine hours after the event by the U.S. Space Surveillance Network PARCS radar.

SATELLITE DATA

TYPE:	Operational Debris
OWNER:	USSR
LAUNCH DATE:	30.62 May 1985
DRY MASS (KG):	Unknown
MAIN BODY:	Unknown
MAJOR APPENDAGES:	Unknown
ATTITUDE CONTROL:	None
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	5 Jan 1988	LOCATION:	66N, 151E (asc)
TIME:	0147 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	860 km		

PRE-EVENT ELEMENTS

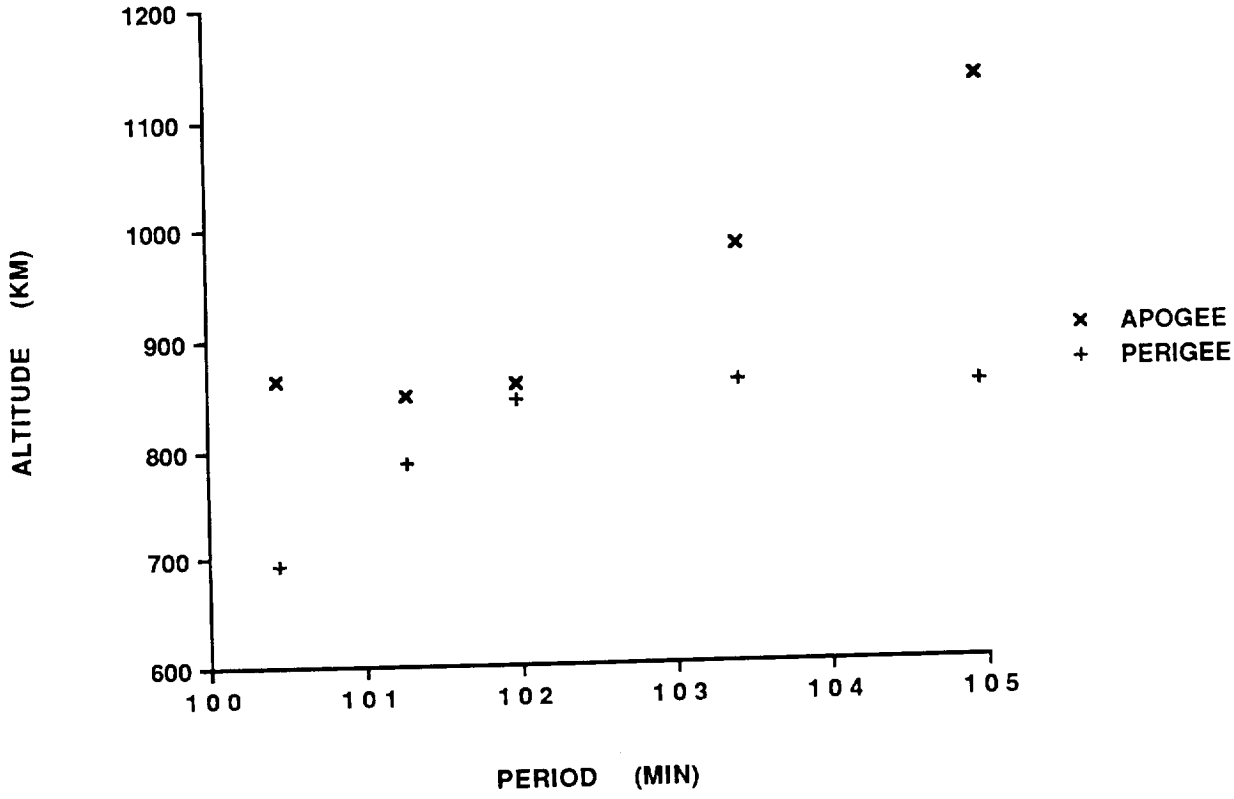
EPOCH:	88002.58690356	MEAN ANOMALY:	91.9605
RIGHT ASCENSION:	205.7335	MEAN MOTION:	14.17143400
INCLINATION:	66.5867	MEAN MOTION DOT/2:	.00000144
ECCENTRICITY:	.0034143	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	267.7562	BSTAR:	.000088961

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	6	MAXIMUM ΔP:	3.3 min
DEBRIS IN ORBIT:	6	MAXIMUM ΔI:	0.0 deg

COMMENTS

This piece of operational debris was one of two objects which are routinely released by the SL-12 final stage after the first burn. The nature of these objects is unclear. NAVSPASUR observed two additional, uncataloged fragments associated with this event. Similar objects from the Astron mission fragmented in 1984 after 17 months in orbit, the Cosmos 1519-1521 mission after 86 months in orbit, and the Cosmos 1710-1712 mission after 72 months in orbit.



Fragments from Cosmos 1656 debris as determined two weeks after the event. Elements from U.S. Space Surveillance Center as published by NASA Goddard Space Flight Center.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	19.07 Sep 1985
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA

DATE:	18 Dec 1986	LOCATION:	22S, 292 E (asc)
TIME:	2017 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	415 km		

PRE-EVENT ELEMENTS

EPOCH:	86351. 87879723	MEAN ANOMALY:	315.5258
RIGHT ASCENSION:	337.4852	MEAN MOTION:	15.45249396
INCLINATION:	65.0089	MEAN MOTION DOT/2:	.00011076
ECCENTRICITY:	.0068048	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	45.1423	BSTAR:	.00021714

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	23	MAXIMUM ΔP:	2.3 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.7 deg*

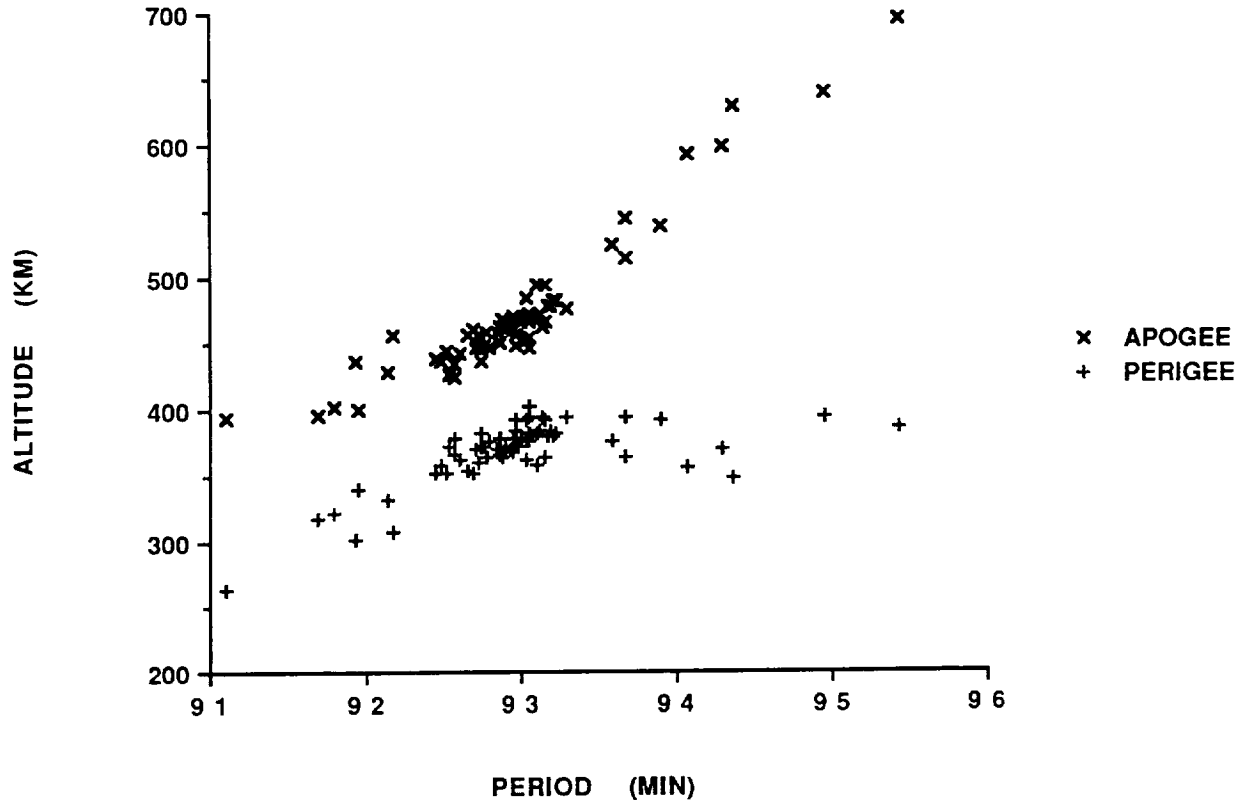
*Based on uncataloged debris data

COMMENTS

Cosmos 1682 was the fourteenth spacecraft of the Cosmos 699-type to experience a fragmentation. Spacecraft had been in natural decay for two months prior to the event. Many debris reentered before being officially cataloged.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.



Cosmos 1682 debris cloud remnant of 66 fragments about one week after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	9.90 Oct 1985
DRY MASS (KG):	200 (est.)
MAIN BODY:	Unknown
MAJOR APPENDAGES:	Unknown
ATTITUDE CONTROL:	Unknown
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	22 Nov 1985	LOCATION:	31N, 326E (dsc)
TIME:	0840 GMT	ASSESSED CAUSE:	Electrical
ALTITUDE:	1415 km		

PRE-EVENT ELEMENTS

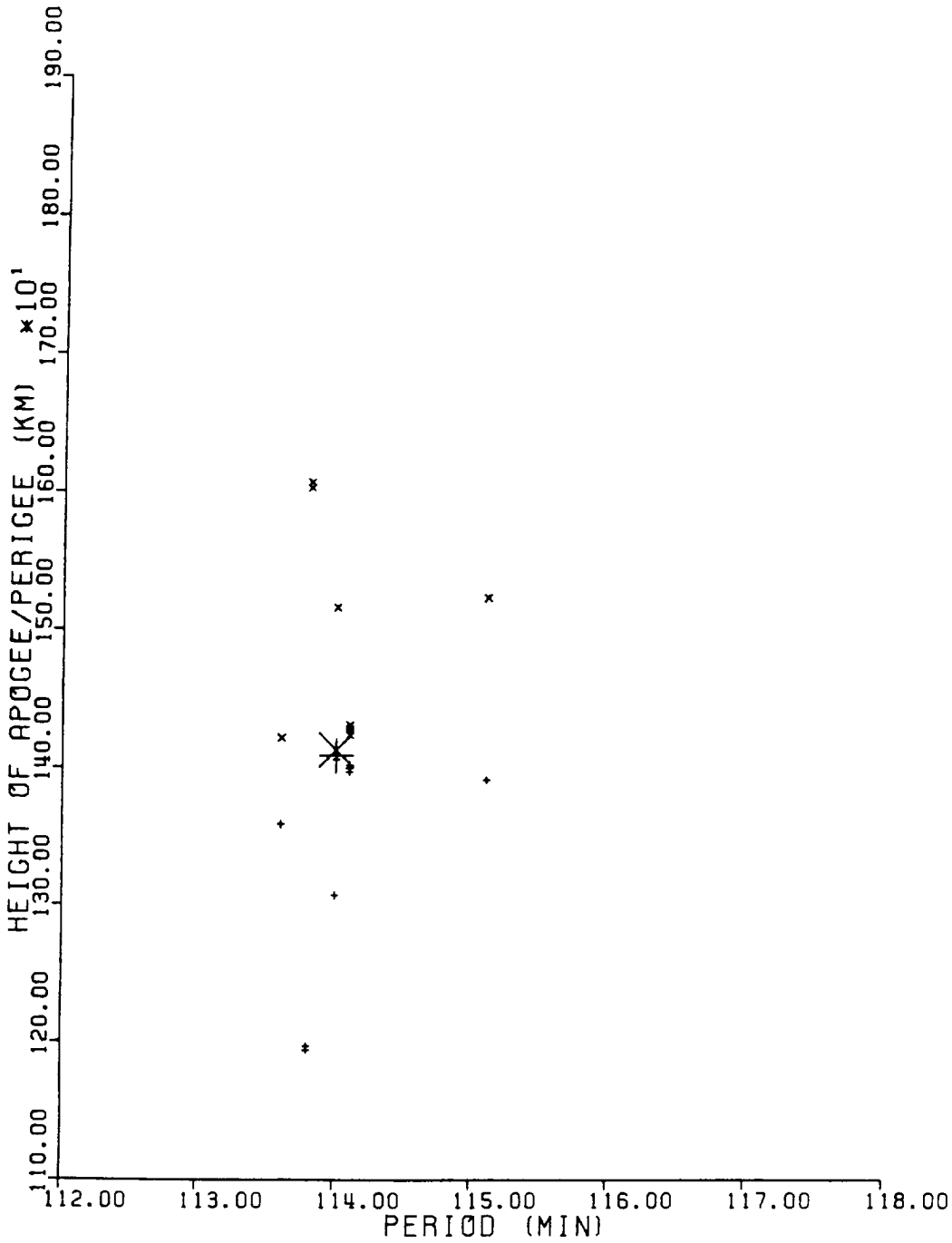
EPOCH:	85320.62059878	MEAN ANOMALY:	91.0897
RIGHT ASCENSION:	345.1807	MEAN MOTION:	12.62038878
INCLINATION:	82.6124	MEAN MOTION DOT/2:	.00000022
ECCENTRICITY:	.0002812	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	268.9870	BSTAR:	.000099999

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	14	MAXIMUM ΔP:	1.0 min
DEBRIS IN ORBIT:	11	MAXIMUM ΔI:	0.1 deg

COMMENTS

Cosmos 1691 was one of six independent payloads on this launch, which was only the second in this program. Cosmos 1691 was the last payload deployed and may be referred to as Cosmos 1695 in the Soviet Union. One fragment was administratively decayed in February, 1989. No other payloads in this program have fragmented. This event is assessed to be the second known NiH_2 battery failure as indicated by Dr. K. M. Suitnshev during the Early 1992 Space Debris Conference.



Cosmos 1691 debris cloud of 10 fragments two days after the event as reconstructed from Naval Space Surveillance System database.

SATELLITE DATA

TYPE:	Operational Debris
OWNER:	USSR
LAUNCH DATE:	24.91 Dec 1985
DRY MASS (KG):	Unknown
MAIN BODY:	Unknown
MAJOR APPENDAGES:	Unknown
ATTITUDE CONTROL:	None
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	29 Dec 1991	LOCATION:	25.3N, 331.9E
TIME:	0903 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	4728 km		

PRE-EVENT ELEMENTS

EPOCH:	91333.40579226	MEAN ANOMALY:	46.8976
RIGHT ASCENSION:	48.0333	MEAN MOTION:	4.23089679
INCLINATION:	65.2547	MEAN MOTION DOT/2:	.00000167
ECCENTRICITY:	.5645362	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	245.7447	BSTAR:	.0012603

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	1	MAXIMUM ΔP:	5.7 min *
DEBRIS IN ORBIT:	1	MAXIMUM ΔI:	0.8 deg *

* based upon uncataloed debris data

COMMENTS

There were 26 objects associated with this event on 30 December per a phonecon with NAVSPASUR (Edna Jenkins). Only 2 analyst satellites were generated and insufficient data was available for a Gabbard diagram. This event is likely related to three other events involving SL-12 launch related debris [Astron Debris (83-20), Cosmos 1656 Debris (85-42), and Cosmos 1519-1521 Debris (83-127)].

Insufficient data to construct a Gabbard diagram.

SATELLITE DATA

TYPE:	Ariane 1 Final Stage
OWNER:	ESA
LAUNCH DATE:	22.07 Feb 1986
DRY MASS (KG):	1400
MAIN BODY:	Cylinder; 2.6 m by 10.3 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None at time of the event
ENERGY SOURCES:	On-board propellants, range safety package

EVENT DATA

DATE:	13 Nov 1986	LOCATION:	7N, 42E (asc)
TIME:	1940 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	805 km		

PRE-EVENT ELEMENTS

EPOCH:	86305.08337689	MEAN ANOMALY:	300.1947
RIGHT ASCENSION:	18.0087	MEAN MOTION:	14.22163662
INCLINATION:	98.6973	MEAN MOTION DOT/2:	.00000203
ECCENTRICITY:	.0021203	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	60.1312	BSTAR:	.000099999

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	489	MAXIMUM ΔP:	6.2 min
DEBRIS IN ORBIT:	59	MAXIMUM ΔI:	1.2 deg

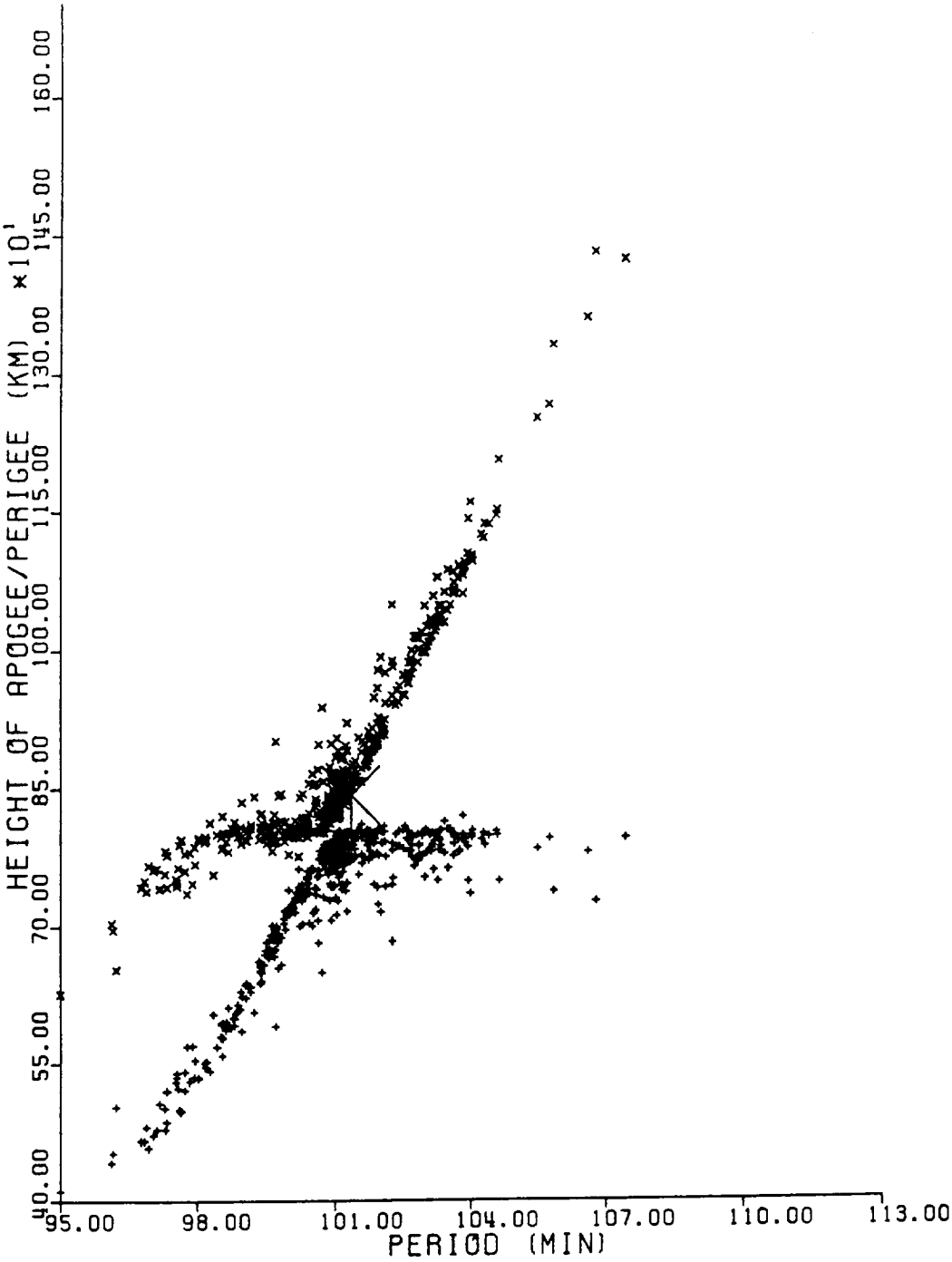
COMMENTS

Event occurred approximately nine months after the rocket body had successfully deployed the Spot 1 and Viking payloads. First use of Ariane launch vehicle for low Earth orbit. May be related to other Ariane fragmentations.

REFERENCE DOCUMENTS

A Preliminary Analysis of the Fragmentation of the Spot 1 Ariane Third Stage, N. L. Johnson, Technical Report CS87-LKD-003, Teledyne Brown Engineering, Colorado Springs, March 1987.

Orbital Debris from Upper Stage Breakup, J.P. Loftus, Jr., ed., Vol. 121, Progress in Astronautics and Aeronautics, AIAA, 1989.



Spot 1 R/B debris cloud of 465 fragments three months after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	4.21 Aug 1986
DRY MASS (KG):	3000 (approx.)
MAIN BODY:	Cylinder; 1.3 m by 10 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA

DATE:	21 Sep 1987	LOCATION:	60S, 174E (dsc)
TIME:	1205 GMT	ASSESSED CAUSE:	Deliberate Action
ALTITUDE:	320 km		

PRE-EVENT ELEMENTS

EPOCH:	87263.81808697	MEAN ANOMALY:	70.4851
RIGHT ASCENSION:	122.5376	MEAN MOTION:	15.63167584
INCLINATION:	65.0147	MEAN MOTION DOT/2:	.00078200
ECCENTRICITY:	.0099296	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	288.4915	BSTAR:	.00065556

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	4	MAXIMUM ΔP:	1.9 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.0 deg*

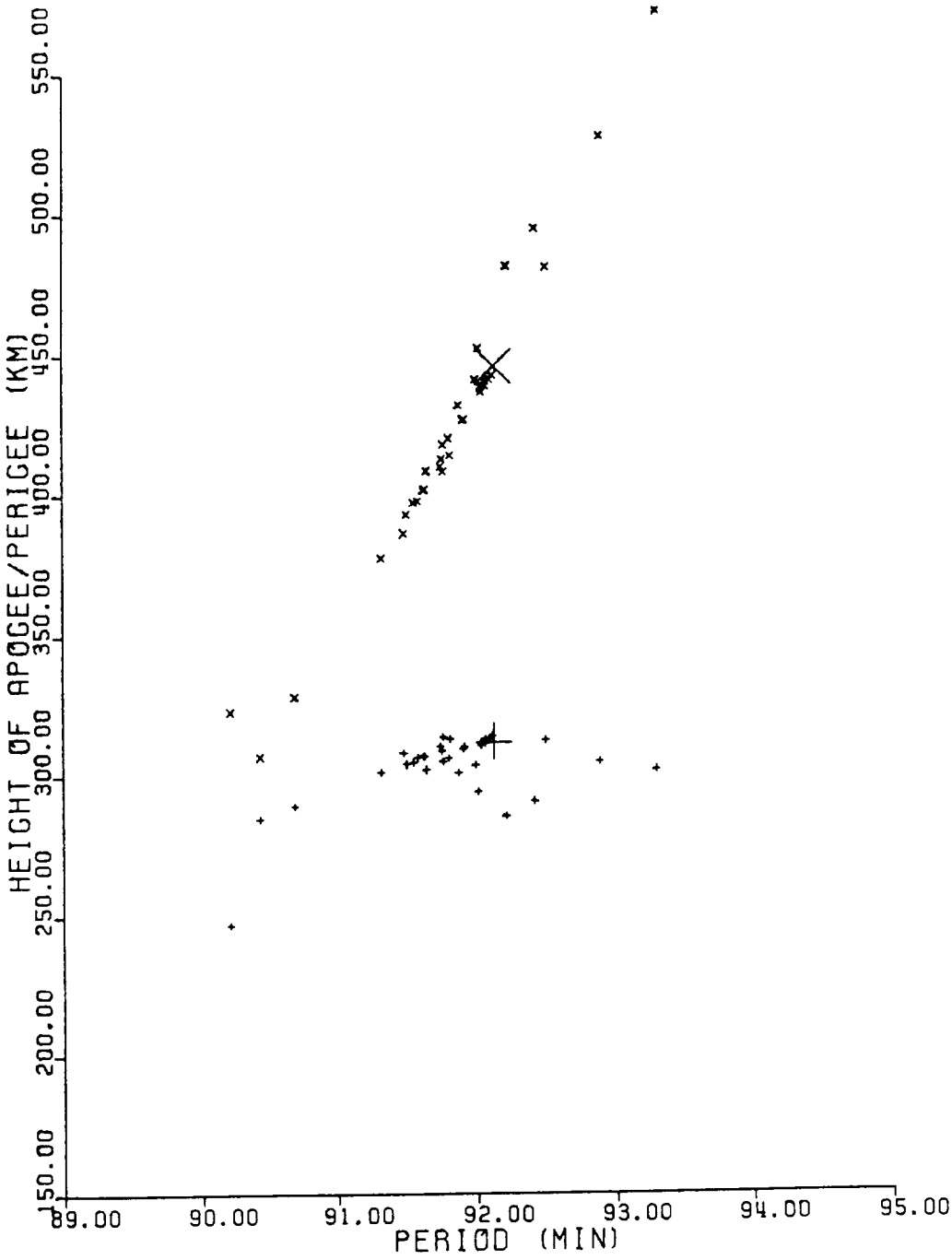
*Based on uncataloged debris data

COMMENTS

Cosmos 1769 was the fifteenth spacecraft of the Cosmos 699-type to experience a fragmentation. Spacecraft was regularly maneuvered until 17 Sep 1987 when the vehicle began to decay naturally. Most debris reentered before being officially cataloged.

REFERENCE DOCUMENTS

"Artificial Satellite Break-Ups (Part 1): Soviet Ocean Surveillance Satellites", N. L. Johnson, Journal of the British Interplanetary Society, February 1983, pp. 51-58.



Cosmos 1769 debris cloud remnant of 34 fragments 3 days after the event as reconstructed from Naval Space Surveillance System database.

SATELLITE DATA

TYPE:	Payload
OWNER:	US
LAUNCH DATE:	5.63 Sep 1986
DRY MASS (KG):	930
MAIN BODY:	Cylinder-Cone; 1.2 m by 4.6 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge (?)

EVENT DATA

DATE:	5 Sep 1986	LOCATION:	15N, 166E (asc)
TIME:	1752 GMT	ASSESSED CAUSE:	Deliberate Test
ALTITUDE:	220 km		

POST-EVENT ELEMENTS

EPOCH:	86250.63774662	MEAN ANOMALY:	335.3264
RIGHT ASCENSION:	28.1524	MEAN MOTION:	15.28976390
INCLINATION:	39.0665	MEAN MOTION DOT/2:	.01159823
ECCENTRICITY:	.0390567	MEAN MOTION DOT DOT/6:	.0000050922
ARG. OF PERIGEE:	26.7075	BSTAR:	.0028192

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	13	MAXIMUM ΔP:	424.1 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	4.4 deg*

*Based on uncataloged debris data

COMMENTS

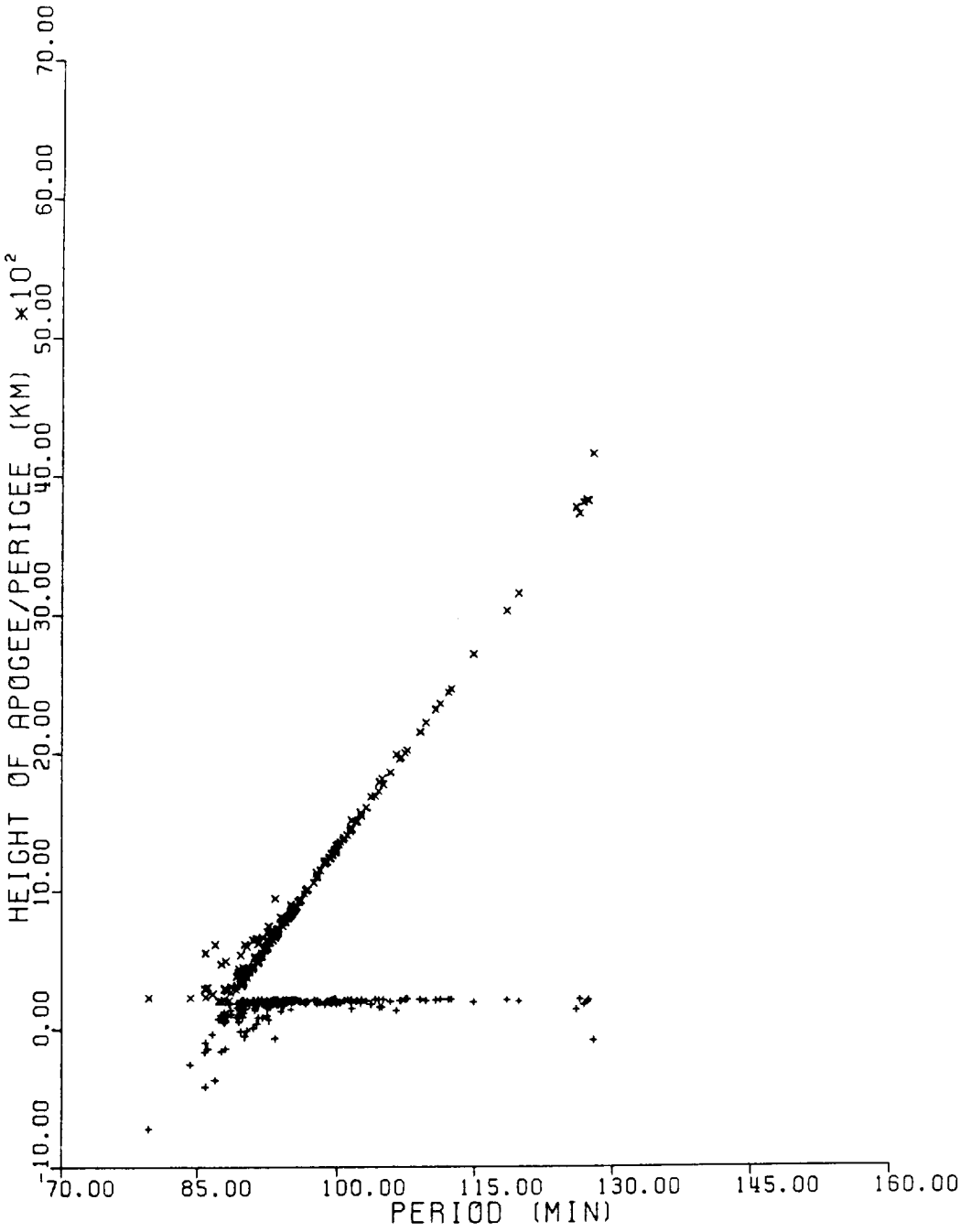
USA 19 deliberately collided with USA 19 R/B at high relative velocity. Both satellites were thrusting at the time of impact. Element set above is post-event and is best estimate of orbit at time of the event. Most debris reentered before being officially cataloged.

REFERENCE DOCUMENTS

The Collision of Satellites 16937 and 16938: A Preliminary Report, N. L. Johnson, Technical Report CS87-LKD-002, Teledyne Brown Enigneering, Colorado Springs, 3 December 1986.

The Collision of Satellites 16937 and 16938: Debris Characterization, R. L. Kling, Technical Report CS87-LKD-005, Teledyne Brown Engineering, Colorado Springs, 15 May 1987.

Hazard Analysis of the Breakup of Satellites 16937 and 16938, Technical Report JSC 22471(U), NASA Lyndon B. Johnson Space Center, Houston, 27 February 1987.



USA 19 debris cloud remnant of 191 fragments one day after the event as seen by the U.S. Space Surveillance radar FPS-85 at Eglin AFB, Florida.

SATELLITE DATA

TYPE:	Delta Second Stage (3920) with auzillary payload
OWNER:	US
LAUNCH DATE:	5.63 Sep 1986
DRY MASS (KG):	1455
MAIN BODY:	Cylinder-Nozzle; 1.4 m by 4.8 m
MAJOR APPENDAGES:	Mini-skirt; 2.4 m by 0.3 m
ATTITUDE CONTROL:	Active
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	5 Sep 1986	LOCATION:	15N, 166E (asc)
TIME:	1752 GMT	ASSESSED CAUSE:	Deliberate Test
ALTITUDE:	220 km		

POST-EVENT ELEMENTS

EPOCH:	86249.96053354	MEAN ANOMALY:	307.9381
RIGHT ASCENSION:	10.4654	MEAN MOTION:	15.50608380
INCLINATION:	22.7830	MEAN MOTION DOT/2:	.00138611
ECCENTRICITY:	.0288474	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	54.7772	BSTAR:	.00033298

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	5	MAXIMUM ΔP:	53.6 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	2.5 deg*

*Based on uncataloged debris data

COMMENTS

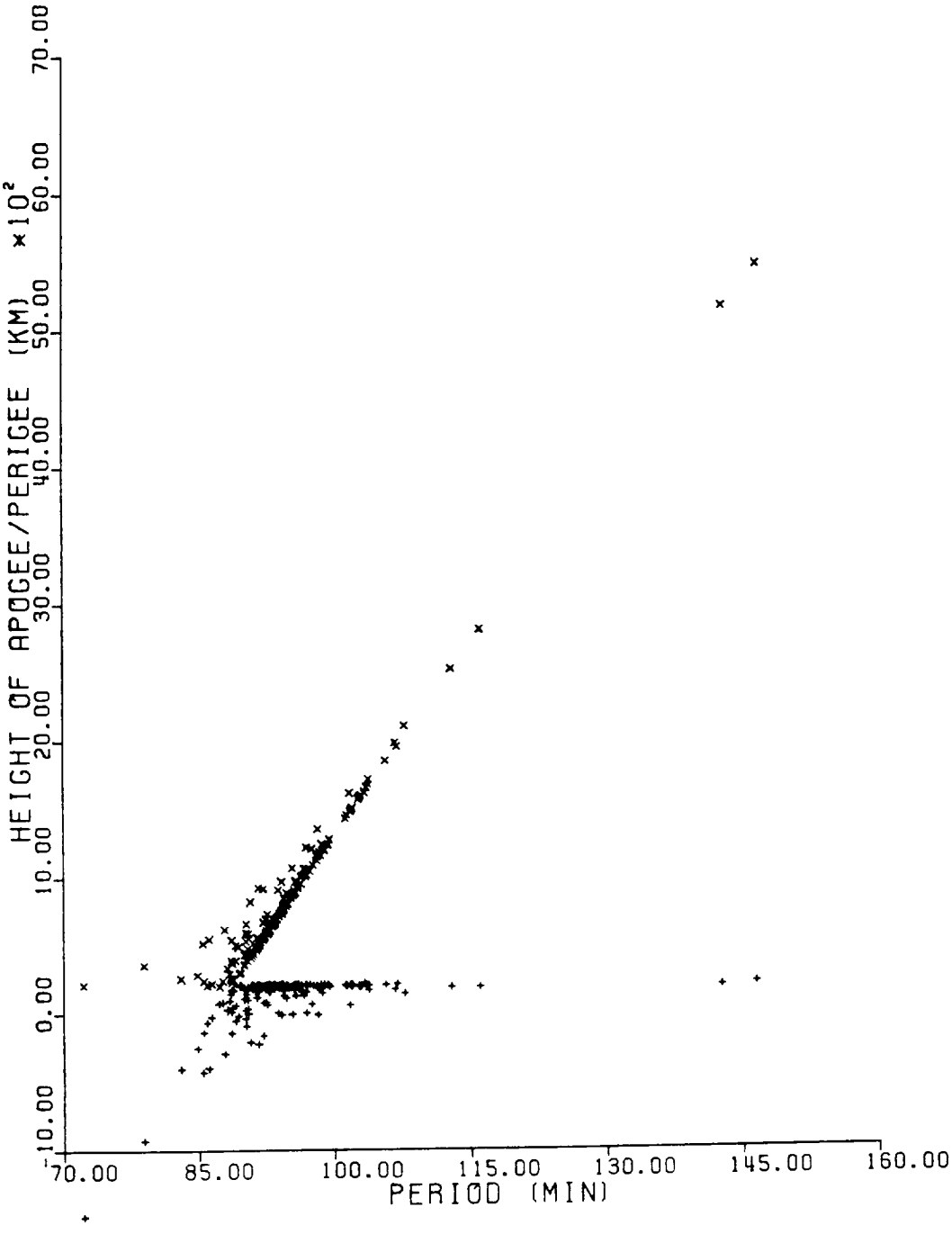
USA 19 R/B was deliberately struck by USA 19 at high relative velocity. Both satellites were thrusting at the time of impact. Element set above is post-event and is best estimate of orbit at time of the event. Most debris reentered before being officially cataloged.

REFERENCE DOCUMENTS

The Collision of Satellites 16937 and 16938: A Preliminary Report, N. L. Johnson, Technical Report CS87-LKD-002, Teledyne Brown Enigneering, Colorado Springs, 3 December 1986.

The Collision of Satellites 16937 and 16938: Debris Characterization, R. L. Kling, Technical Report CS87-LKD-005, Teledyne Brown Engineering, Colorado Springs, 15 May 1987.

Hazard Analysis of the Breakup of Satellites 16937 and 16938, Technical Report JSC 22471(U), NASA Lyndon B. Johnson Space Center, Houston, 27 February 1987.



USA 19 R/B debris cloud remnant of 190 fragments one day after the event as seen by the U.S. Space Surveillance radar FPS-85 at Eglin AFB, Florida.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	15.47 Jan 1987
DRY MASS (KG):	6000 (approx.)
MAIN BODY:	Sphere-Cylinder-Cone, 2.4 m by 6.5 m (?)
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	29 Jan 1987	LOCATION:	73N, 122E (asc)
TIME:	0555 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	390 km		

PRE-EVENT ELEMENTS

EPOCH:	87028.91020168	MEAN ANOMALY:	178.1696
RIGHT ASCENSION:	256.7724	MEAN MOTION:	15.60427146
INCLINATION:	72.8163	MEAN MOTION DOT/2:	.00008569
ECCENTRICITY:	.0043147	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	182.0100	BSTAR:	.000099999

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	194	MAXIMUM ΔP:	9.1 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.1 deg*

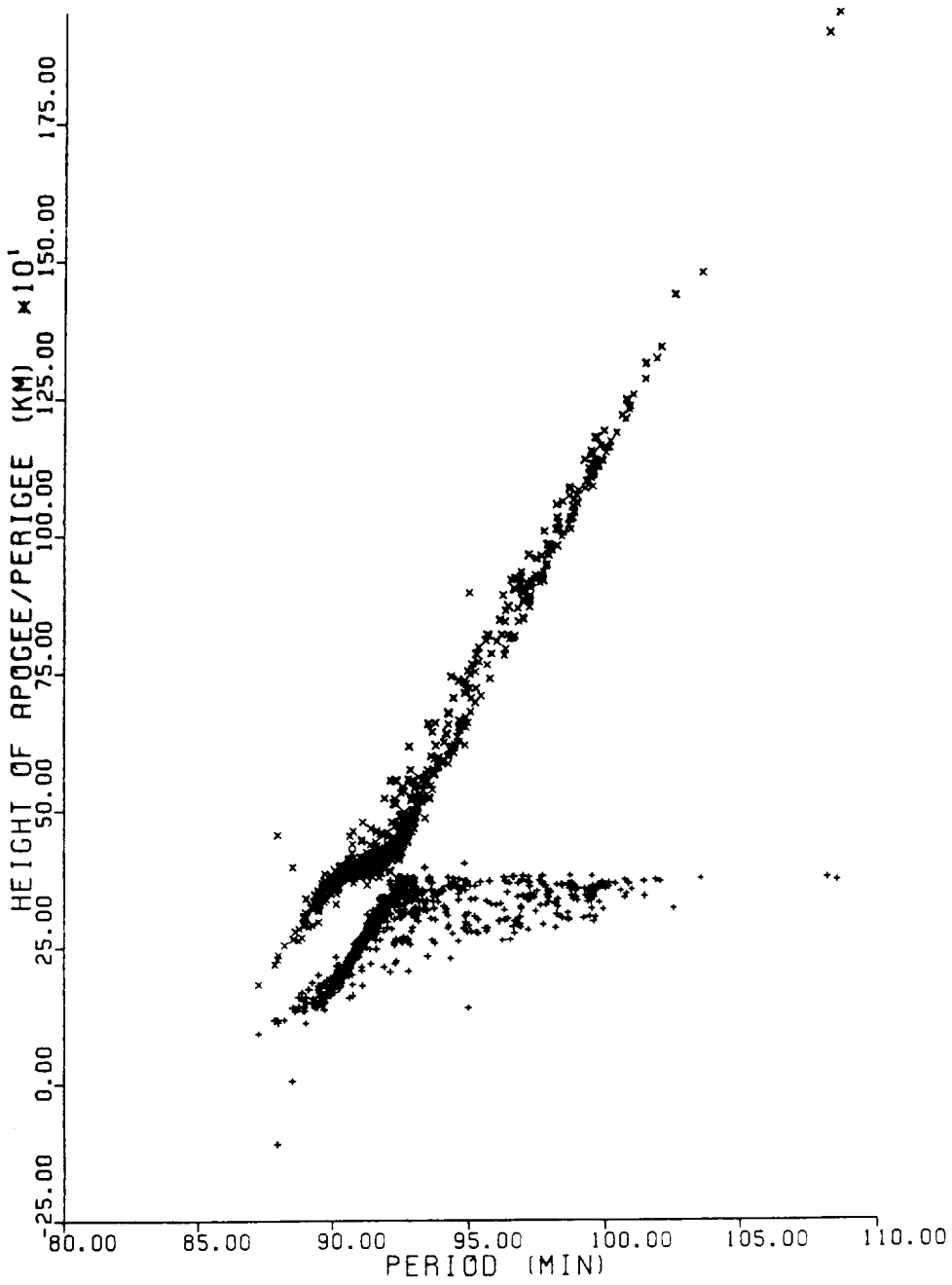
*Based on PARCS observations

COMMENTS

Spacecraft apparently destroyed after a malfunction prevented controlled reentry and landing in the Soviet Union. Sixth incident of this type. A total of 846 separate fragments were observed during one pass over a U. S. Space Surveillance Network radar (PARCS) two days after the event.

REFERENCE DOCUMENTS

The Fragmentation of Kosmos 1813, R. L. Kling and J. S. Dowdy, Technical Report CS87-LKD-004, Teledyne Brown Engineering, Colorado Springs, 8 May 1987.



Cosmos 1813 debris cloud as reconstructed from PARCS radar observations taken about 10 hours after the breakup. A total of 801 fragments were identified with Cosmos 1813. This diagram is taken from the cited reference document.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	20.20 Feb 1987
DRY MASS (KG):	1500 (est.)
MAIN BODY:	Cylinder; 2.0 m by 2.1 m
MAJOR APPENDAGES:	Gravity-gradient boom; 10 small solar panels
ATTITUDE CONTROL:	Gravity gradient
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	17 Dec 1987	LOCATION:	15S, 18E (dsc)
TIME:	1739 GMT	ASSESSED CAUSE:	Electrical
ALTITUDE:	1485 km		

PRE-EVENT ELEMENTS

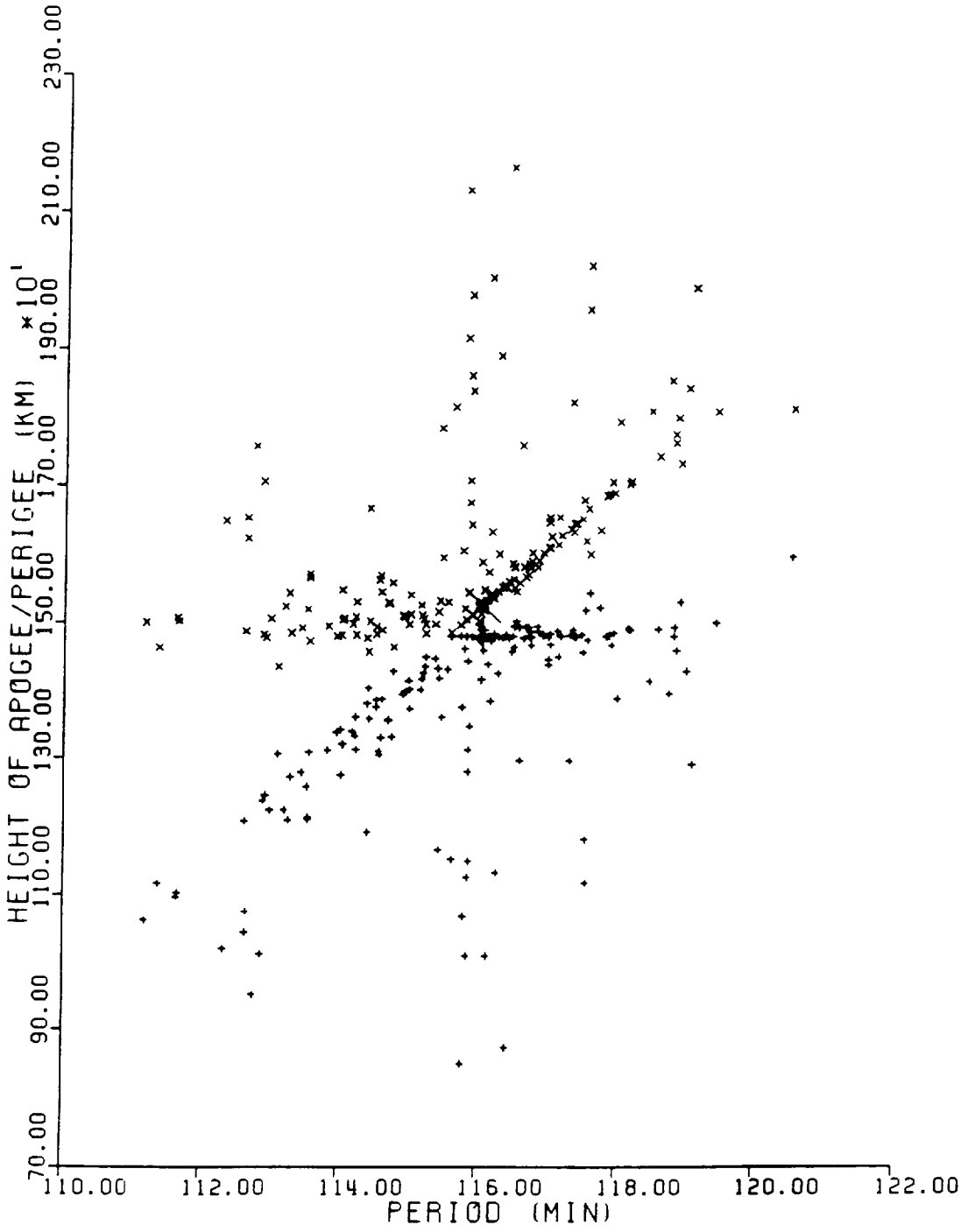
EPOCH:	87351.61079422	MEAN ANOMALY:	147.6712
RIGHT ASCENSION:	184.5746	MEAN MOTION:	12.40947361
INCLINATION:	73.6064	MEAN MOTION DOT/2:	.0
ECCENTRICITY:	.0028819	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	212.2988	BSTAR:	.0

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	110	MAXIMUM ΔP:	4.9 min
DEBRIS IN ORBIT:	49	MAXIMUM ΔI:	1.4 deg

COMMENTS

Cosmos 1823 has been acknowledged by the Soviet Union as a geodetic spacecraft, the eighth in a series which debuted in 1981. The spacecraft is known to have been operating three months before the event. USSR acknowledged mission termination as of 19 December 1987. Unusually strong radial velocity components are evident in cloud analyses over a period of many months. This event has been confirmed to be the third known failure of the NiH_2 battery as reported by Dr. K. M. Suitashev at the February, 1992 Space Debris Conference held in Moscow.



Cosmos 1823 debris cloud of 165 fragments two weeks after the event as reconstructed from Naval Space Surveillance System database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	9.67 Jul 1987
DRY MASS (KG):	6000 (approx.)
MAIN BODY:	Cone-Cylinder; 2.4 m by 7 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	26 Jul 1987	LOCATION:	57S, 239E (asc)
TIME:	1539 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	245 km		

PRE-EVENT ELEMENTS

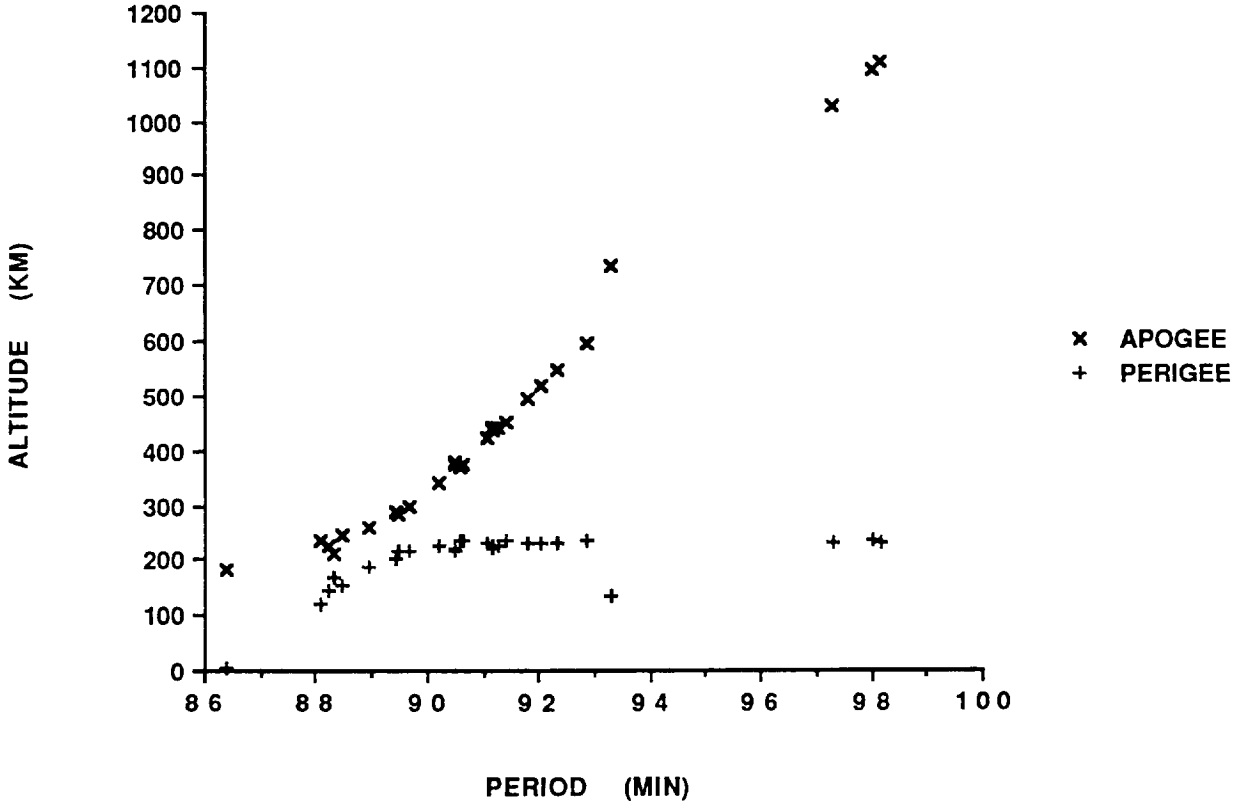
EPOCH:	87207.60199851	MEAN ANOMALY:	300.9577
RIGHT ASCENSION:	98.7735	MEAN MOTION:	16.25421506
INCLINATION:	67.1494	MEAN MOTION DOT/2:	.01099941
ECCENTRICITY:	.0073576	MEAN MOTION DOT DOT/6:	.000028662
ARG. OF PERIGEE:	61.7654	BSTAR:	.00016423

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	9	MAXIMUM ΔP:	17.3 min
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.5 deg

COMMENTS

Spacecraft was apparently destroyed after a malfunction prevented controlled reentry and landing in the Soviet Union. Seventh incident of this type. Hundreds of fragments were detected but most reentered before being officially cataloged.



Cosmos 1866 debris cloud remnant of 27 fragments 1-2 days after the event as reconstructed from U.S. Space Surveillance Center database. Two fragments with orbital periods greater than 103 minutes were cataloged in mid-August 1987.

SATELLITE DATA

TYPE:	Ariane 3 Final Stage
OWNER:	ESA
LAUNCH DATE:	16.03 Sep 1987
DRY MASS (KG):	1200
MAIN BODY:	Cylinder; 2.6 m by 9.9 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	16-19 Sep 1987	LOCATION:	Unknown
TIME:	Unknown	ASSESSED CAUSE:	Unknown
ALTITUDE:	Unknown		

POST-EVENT ELEMENTS

EPOCH:	87264.18031994	MEAN ANOMALY:	170.9704
RIGHT ASCENSION:	176.7680	MEAN MOTION:	2.22860839
INCLINATION:	6.8720	MEAN MOTION DOT/2:	.00014489
ECCENTRICITY:	.7324768	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	182.0665	BSTAR:	.0038829

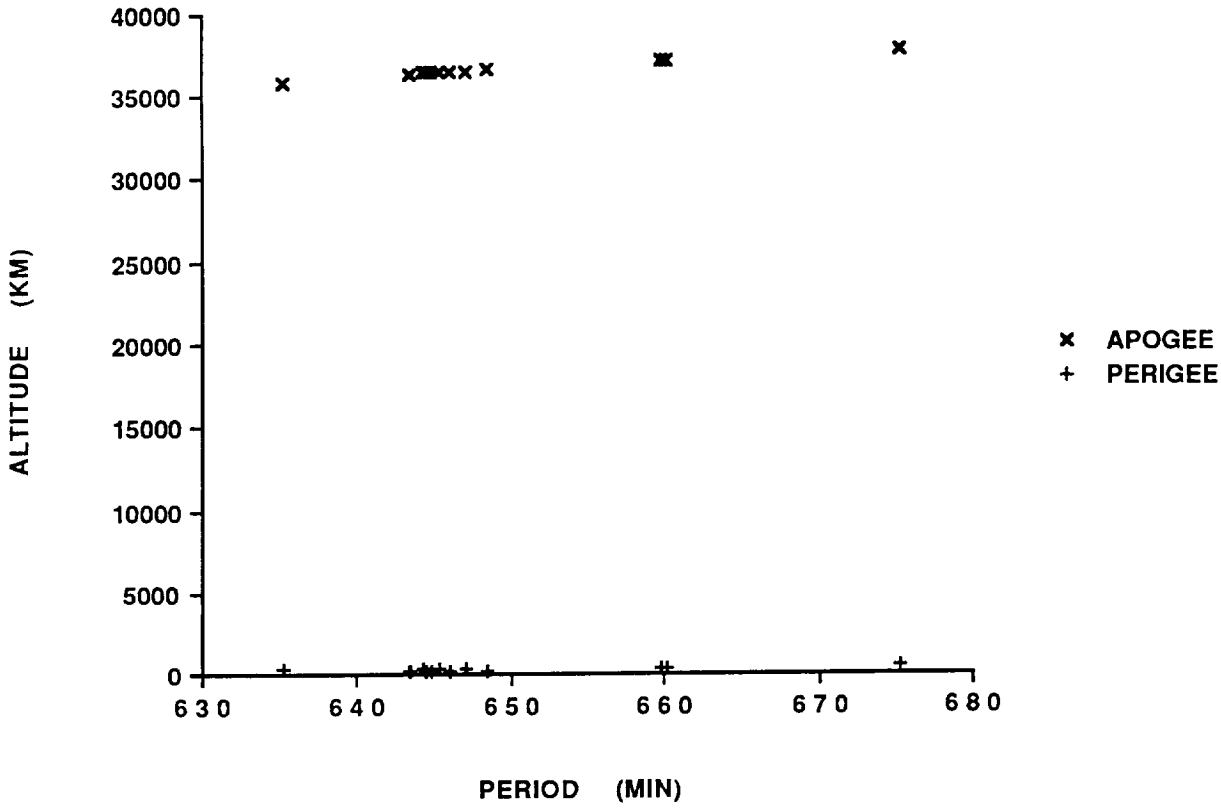
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	2	MAXIMUM ΔP:	29.1 min*
DEBRIS IN ORBIT:	2	MAXIMUM ΔI:	0.9 deg*

*Based on uncataloged debris data

COMMENTS

Above elements are initial published values for the rocket body but are after the event. Third suspected fragmentation of Ariane final stage. Debris may be operational in nature.



AUSSAT/ECS R/B debris cloud of 12 fragments about four days after launch as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	26.48 Dec 1987
DRY MASS (KG):	6000 (approx.)
MAIN BODY:	Sphere-Cylinder-Cone; 2.4 m by 6.5 m (?)
MAJOR APPENDAGES:	2 small solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	31 Jan 1988	LOCATION:	11S, 138E (dsc)
TIME:	1109 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	250 km		

PRE-EVENT ELEMENTS

EPOCH:	88030.87152193	MEAN ANOMALY:	208.0352
RIGHT ASCENSION:	254.6565	MEAN MOTION:	16.07089398
INCLINATION:	82.5872	MEAN MOTION DOT/2:	.00174892
ECCENTRICITY:	.0015551	MEAN MOTION DOT DOT/6:	.000012805
ARG. OF PERIGEE:	152.1926	BSTAR:	.00022253

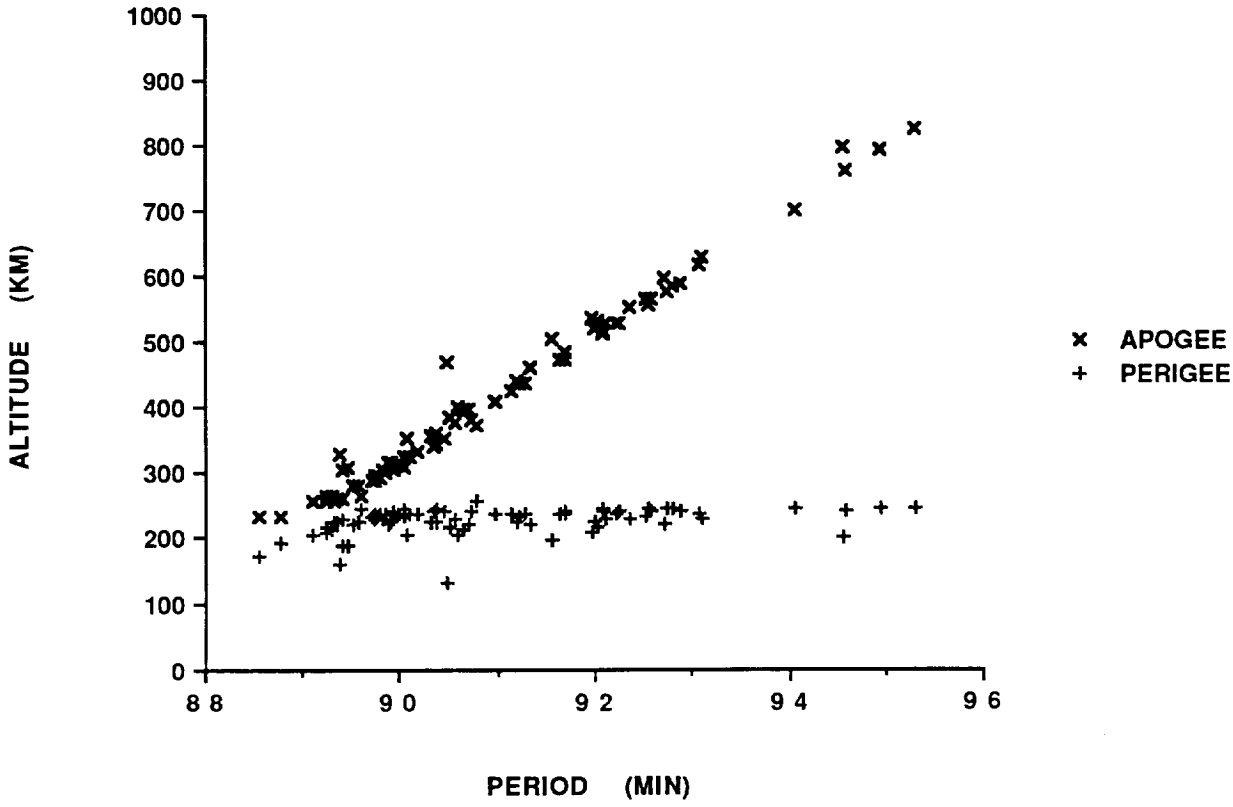
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	37	MAXIMUM ΔP:	5.7 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	1.7 deg*

*Based on cataloged and uncataloged debris data

COMMENTS

Spacecraft apparently destroyed after a malfunction prevented controlled reentry and landing in the Soviet Union. Eighth incident of this type. Elements for 83 objects remaining in orbit about 10 days after the event were developed. Other debris reentered before being officially cataloged. This may have been the first or second flight of a new spacecraft modification.



Cosmos 1906 debris cloud remnant of 83 objects 10 days after the event as reconstructed from Naval Space Surveillance System database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	3.15 Feb 1988
DRY MASS (KG):	6000 (approx.)
MAIN BODY:	Cone-Cylinder; 2.4 m by 7 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	27 Feb 1988	LOCATION:	62N, 98E (asc)
TIME:	0444 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	155 km		

PRE-EVENT ELEMENTS

EPOCH:	88058.12322153	MEAN ANOMALY:	309.0154
RIGHT ASCENSION:	264.6529	MEAN MOTION:	16.30989909
INCLINATION:	64.8359	MEAN MOTION DOT/2:	.03233928
ECCENTRICITY:	.0060041	MEAN MOTION DOT DOT/6:	.00003669
ARG. OF PERIGEE:	51.6410	BSTAR:	.00025587

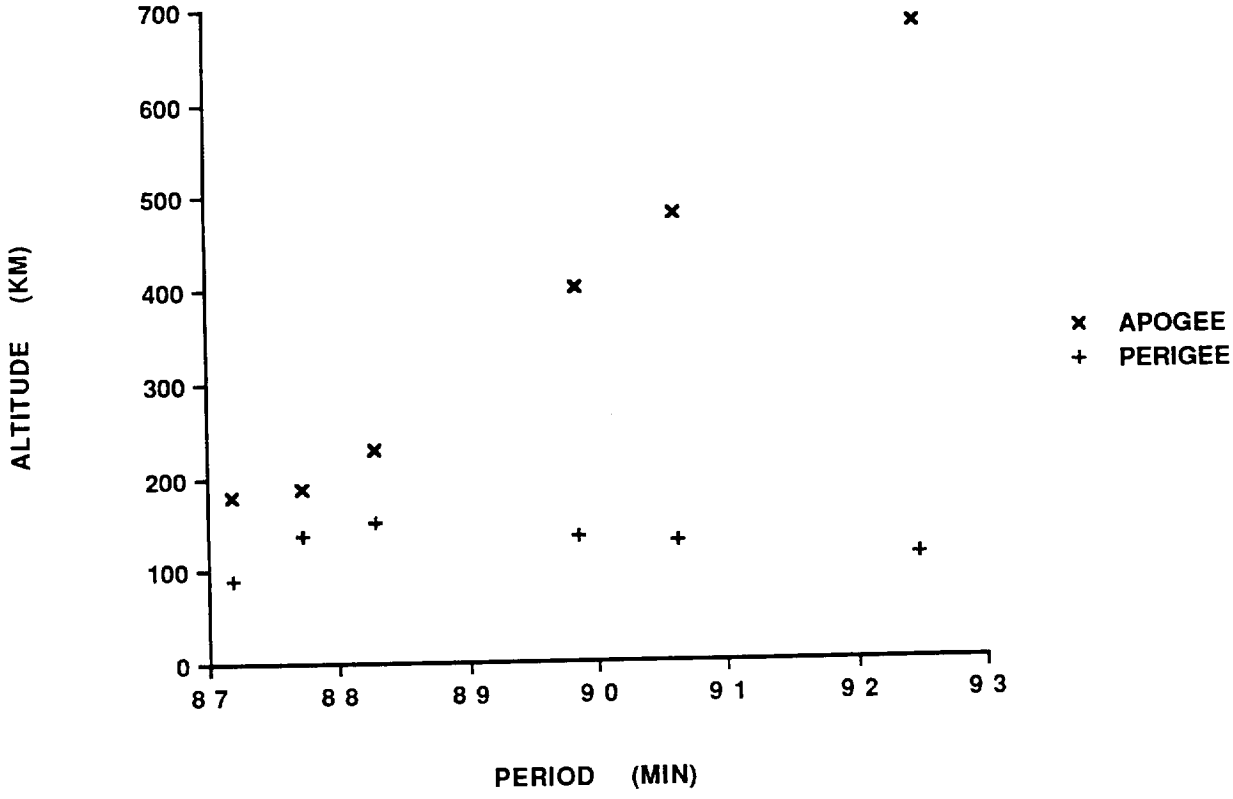
CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	1	MAXIMUM ΔP:	4.2 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	1.1 deg*

*Based on uncataloged debris data

COMMENTS

Spacecraft apparently destroyed after a malfunction prevented controlled reentry and landing in the Soviet Union. Ninth incident of this type. Early elements on only 6 objects available. All debris reentered before being officially cataloged.



Cosmos 1916 debris cloud remnant of six objects within one day of the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	12.63 Jul 1989
DRY MASS (KG):	6000 (approx.)
MAIN BODY:	Cone-Cylinder; 2.4 m by 7 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	28 Jul 1989	LOCATION:	35-65N, 95-140E (asc)
TIME:	0410-0420 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	150 km		

PRE-EVENT ELEMENTS

EPOCH:	89208.98384568	MEAN ANOMALY:	302.7810
RIGHT ASCENSION:	89.7470	MEAN MOTION:	16.33519268
INCLINATION:	67.1441	MEAN MOTION DOT/2:	.03079561
ECCENTRICITY:	.0048139	MEAN MOTION DOT DOT/6:	.000029506
ARG. OF PERIGEE:	57.9032	BSTAR:	.00023479

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	1	MAXIMUM ΔP:	7.1 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	1.3 deg*

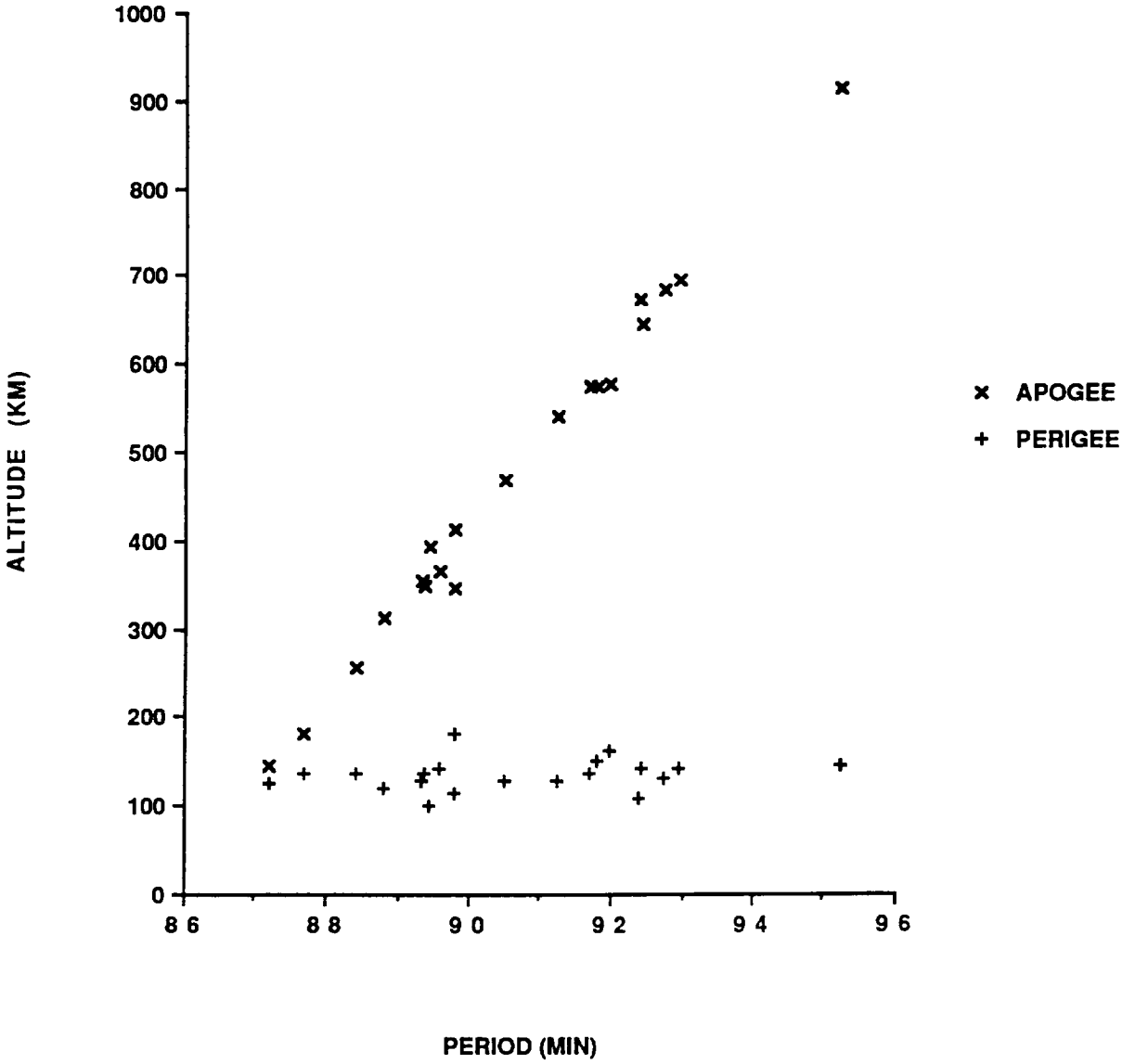
*Based on uncataloged debris data

COMMENTS

Spacecraft was apparently destroyed after a malfunction prevented controlled reentry and landing in the Soviet Union. Tenth incident of this type. Early element sets on only 20 objects available. Rapid decay of objects made calculation of breakup time and location difficult.

REFERENCE DOCUMENTS

The Fragmentation of Kosmos 2030, N. L. Johnson, Technical Report CS89-TR-JSC-002, Teledyne Brown Engineering, Colorado Springs, Colorado, September 1989.



Cosmos 2030 debris cloud remnant of 20 objects 2-3 days after the event as reconstructed from U.S. Space Surveillance Center database. This diagram is taken from the cited reference.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	18.51 Jul 1989
DRY MASS (KG):	6000 (approx.)
MAIN BODY:	Cone-Cylinder; 2.4 m by 7 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, exposive charge

EVENT DATA

DATE:	31 Aug 1989	LOCATION:	43N, 111E (dsc)
TIME:	1851 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	270 km		

PRE-EVENT ELEMENTS

EPOCH:	89243.76468690	MEAN ANOMALY:	305.4386
RIGHT ASCENSION:	242.9132	MEAN MOTION:	15.89273241
INCLINATION:	50.5464	MEAN MOTION DOT/2:	.00196451
ECCENTRICITY:	.0093577	MEAN MOTION DOT DOT/6:	.00002154
ARG. OF PERIGEE:	55.5300	BSTAR:	.00045172

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	9	MAXIMUM ΔP:	7.4 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.9 deg*

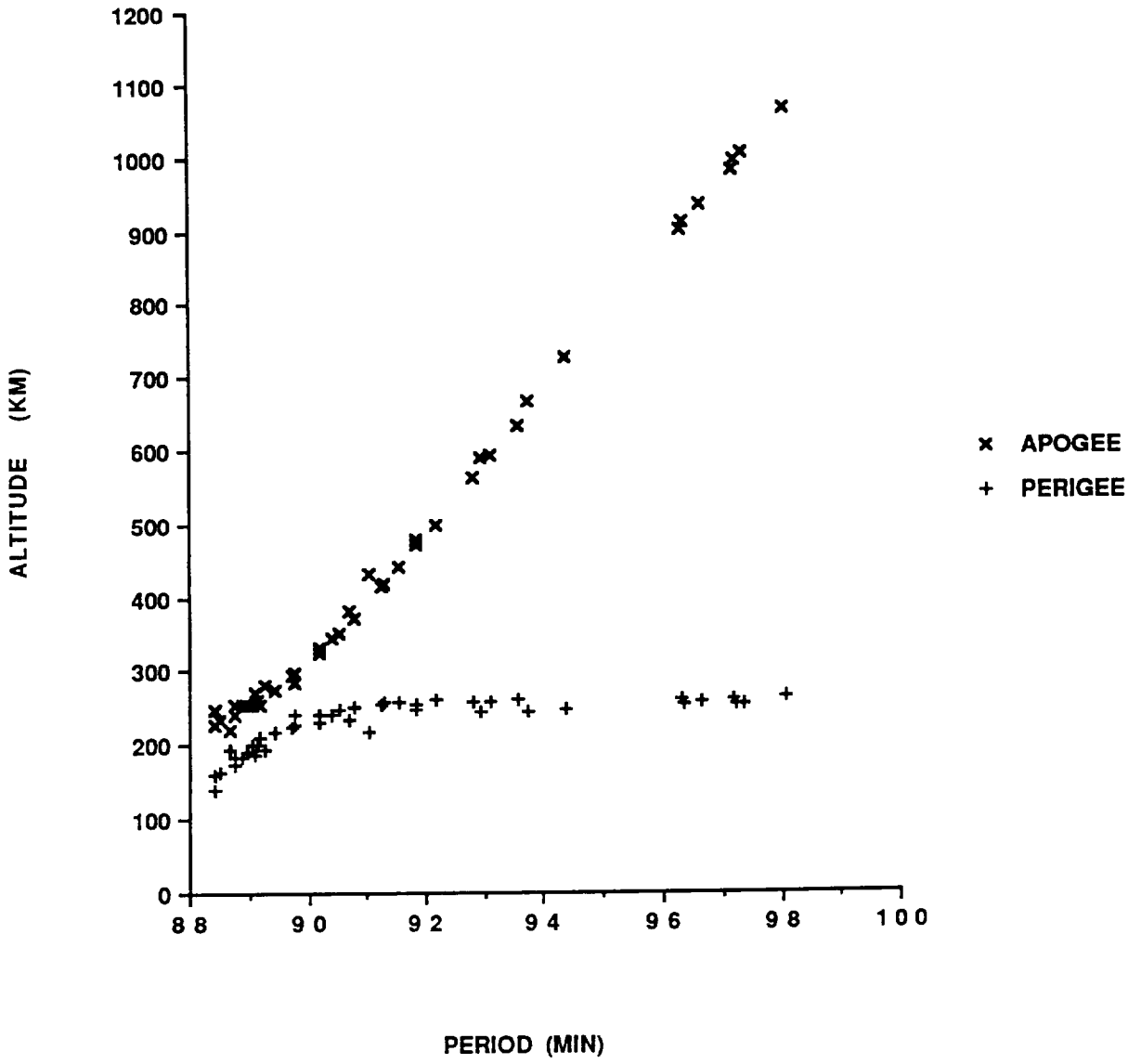
*Based on uncataloged debris data

COMMENTS

Spacecraft was apparently destroyed after a malfunction prevented controlled reentry and landing in the Soviet Union. Eleventh incident of this type. Early elements on 43 objects available. Most debris reentered before being officially cataloged.

REFERENCE DOCUMENTS

The Fragmentation of Kosmos 2031, N. L. Johnson, Technical Report CS89-TR-JSC-003, Teledyne Brown Engineering, Colorado Springs, Colorado, September 1989.



Cosmos 2031 debris cloud remnant of 43 objects 2-3 days after the event as reconstructed from Naval Space Surveillance System database. This diagram is taken from the cited reference.

SATELLITE DATA

TYPE:	CZ-4A Final Stage (L-14)
OWNER:	PRC
LAUNCH DATE:	3.04 Sep 1990
DRY MASS (KG):	1000 (approx.)
MAIN BODY:	Cylinder-Nozzle; 2.9 m by ~5m
MAJOR APPENDAGES:	none
ATTITUDE CONTROL:	none
ENERGY SOURCES:	On-board propellants (?)

EVENT DATA

DATE:	4 Oct 1990	LOCATION:	81S, 68E (asc)
TIME:	2014 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	895 km		

PRE-EVENT ELEMENTS

EPOCH:	90276.6451544	MEAN ANOMALY:	162.6773
RIGHT ASCENSION:	310.6975	MEAN MOTION:	14.01192890
INCLINATION:	98.9340	MEAN MOTION DOT/2:	.000003118
ECCENTRICITY:	.0010179	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	197.4122	BSTAR:	.0002183343

CATALOGED DEBRIS CLOUD DATA

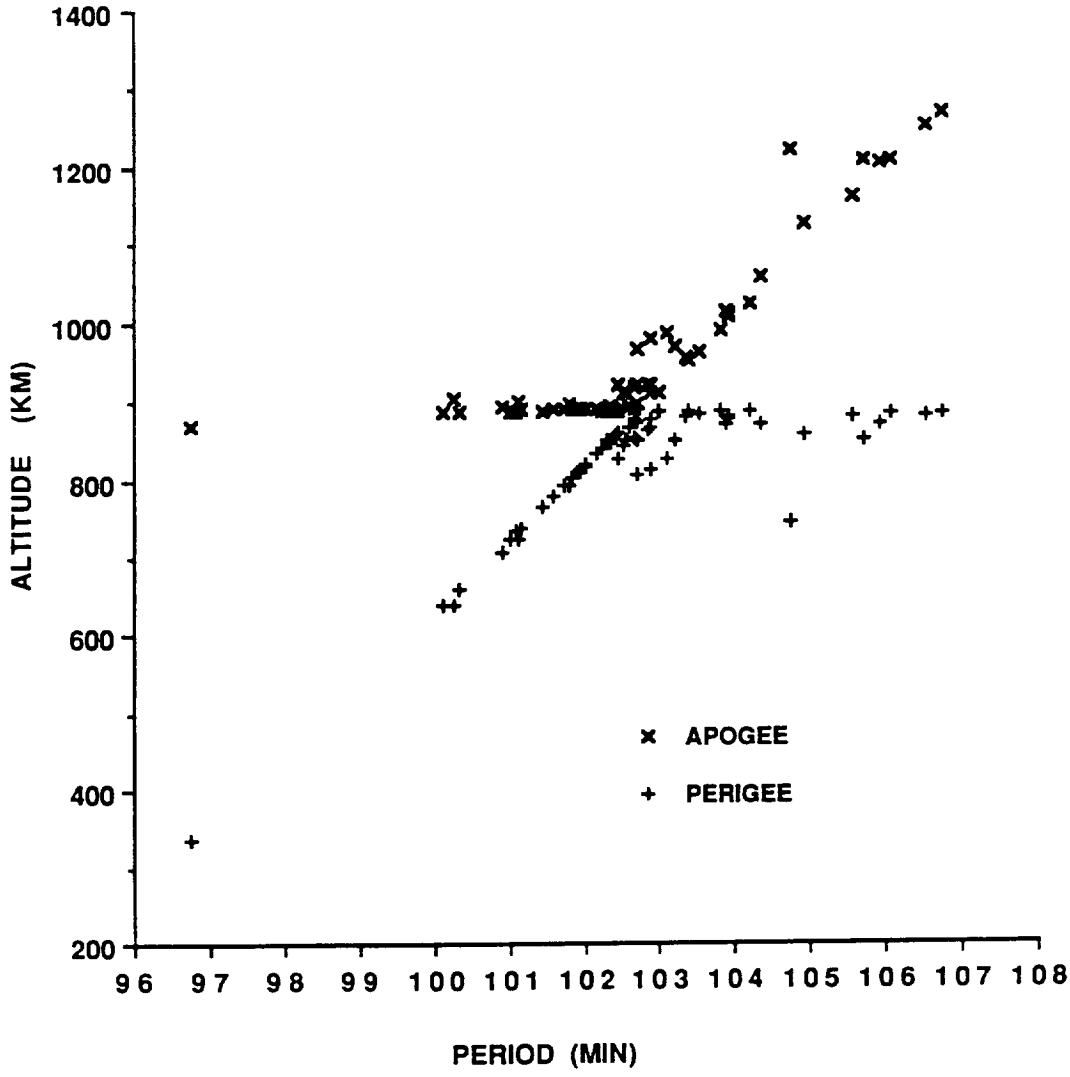
DEBRIS CATALOGED:	73	MAXIMUM ΔP:	5.8 min
DEBRIS IN ORBIT:	70	MAXIMUM ΔI:	0.1 deg

COMMENTS

This second flight of the CZ-4 final stage successfully deployed three payloads (one weather satellite and two inflated balloons) into a sun-synchronous orbit. Propellants used were N_2O_4 and UDMH. An estimated 70-75 fragments were detected soon after the event.

REFERENCE DOCUMENTS

The Fragmentation of Fengyun 1-2 R/B, N. L. Johnson, Technical Report CS90-TR-JSC-013, Teledyne Brown Engineering, Colorado Springs, Colorado, November 1990.



Fengyun 1-2 R/B debris cloud remnant of 62 objects 5 days after the event as reconstructed from Naval Space Surveillance System database. This diagram is taken from the cited reference.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	1.46 Oct 1990
DRY MASS (KG):	6000 (approx.)
MAIN BODY:	Cone-Cylinder; 2.4 m by 7 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	30 Nov 1990	LOCATION:	54N, 157E (dsc)
TIME:	1720 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	210 km		

PRE-EVENT ELEMENTS

EPOCH:	90334.45391019	MEAN ANOMALY:	205.3252
RIGHT ASCENSION:	347.9431	MEAN MOTION:	16.12811753
INCLINATION:	64.7547	MEAN MOTION DOT/2:	.00671617
ECCENTRICITY:	.0065418	MEAN MOTION DOT DOT/6:	.000035339
ARG. OF PERIGEE:	155.2258	BSTAR:	.00040815

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	4	MAXIMUM ΔP:	>7.3 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.3 deg*

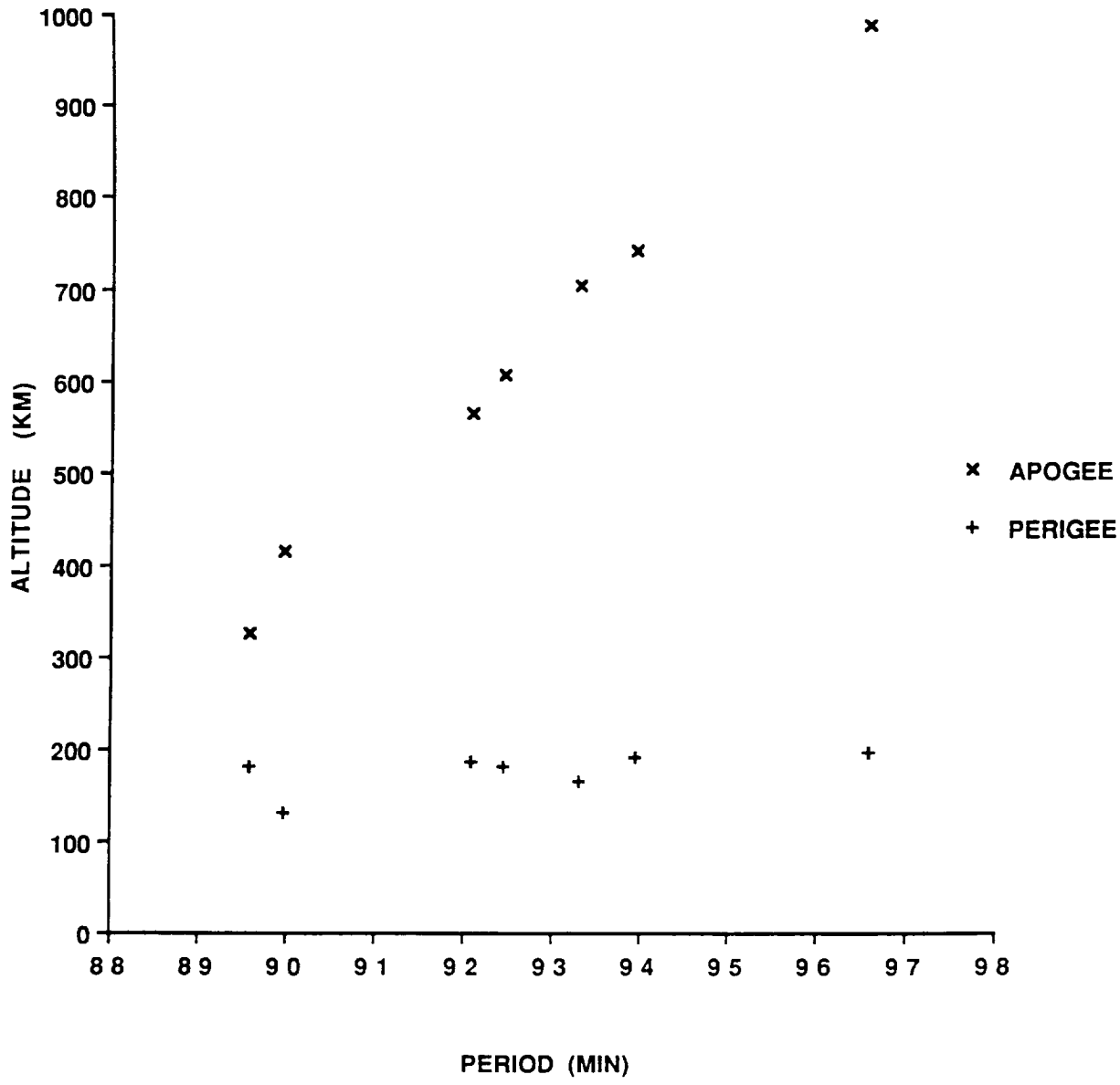
*Based on uncataloged debris data

COMMENTS

Spacecraft was apparently destroyed after a malfunction prevented controlled reentry and landing in the Soviet Union. Twelfth incident of this type. Early elements on only 7 objects available. Most debris reentered before being officially cataloged.

REFERENCE DOCUMENTS

The Fragmentation of Kosmos 2101, N. L. Johnson, Technical Report CS91-TR-JSC-002, Teledyne Brown Engineering, Colorado Springs, Colorado, January 1991.



Cosmos 2101 debris cloud remnant of 7 objects 3 days after the event as reconstructed from Naval Space Surveillance System database. This diagram is taken from the cited reference.

SATELLITE DATA

TYPE:	Payload
OWNER:	US
LAUNCH DATE:	1.66 Dec 1990
DRY MASS (KG):	856 kg
MAIN BODY:	Cylinder; 1.1 m by 3.7 m
MAJOR APPENDAGES:	1 solar panel
ATTITUDE CONTROL:	Active, 3 axis
ENERGY SOURCES:	On-board propellants

EVENT DATA

DATE:	1 Dec 1990	LOCATION:	6N, 232E (dsc)
TIME:	1610 GMT	ASSESSED CAUSE:	Propulsion-related
ALTITUDE:	850 km		

POST-EVENT ELEMENTS

EPOCH:	90335.71008487	MEAN ANOMALY:	0.9090
RIGHT ASCENSION:	4.0350	MEAN MOTION:	14.29892145
INCLINATION:	98.8600	MEAN MOTION DOT/2:	-.00000049
ECCENTRICITY:	.0080986	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	359.1948	BSTAR:	-0.000010171

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	29	MAXIMUM ΔP:	>2.0 min*
DEBRIS IN ORBIT:	6	MAXIMUM ΔI:	1.0 deg*

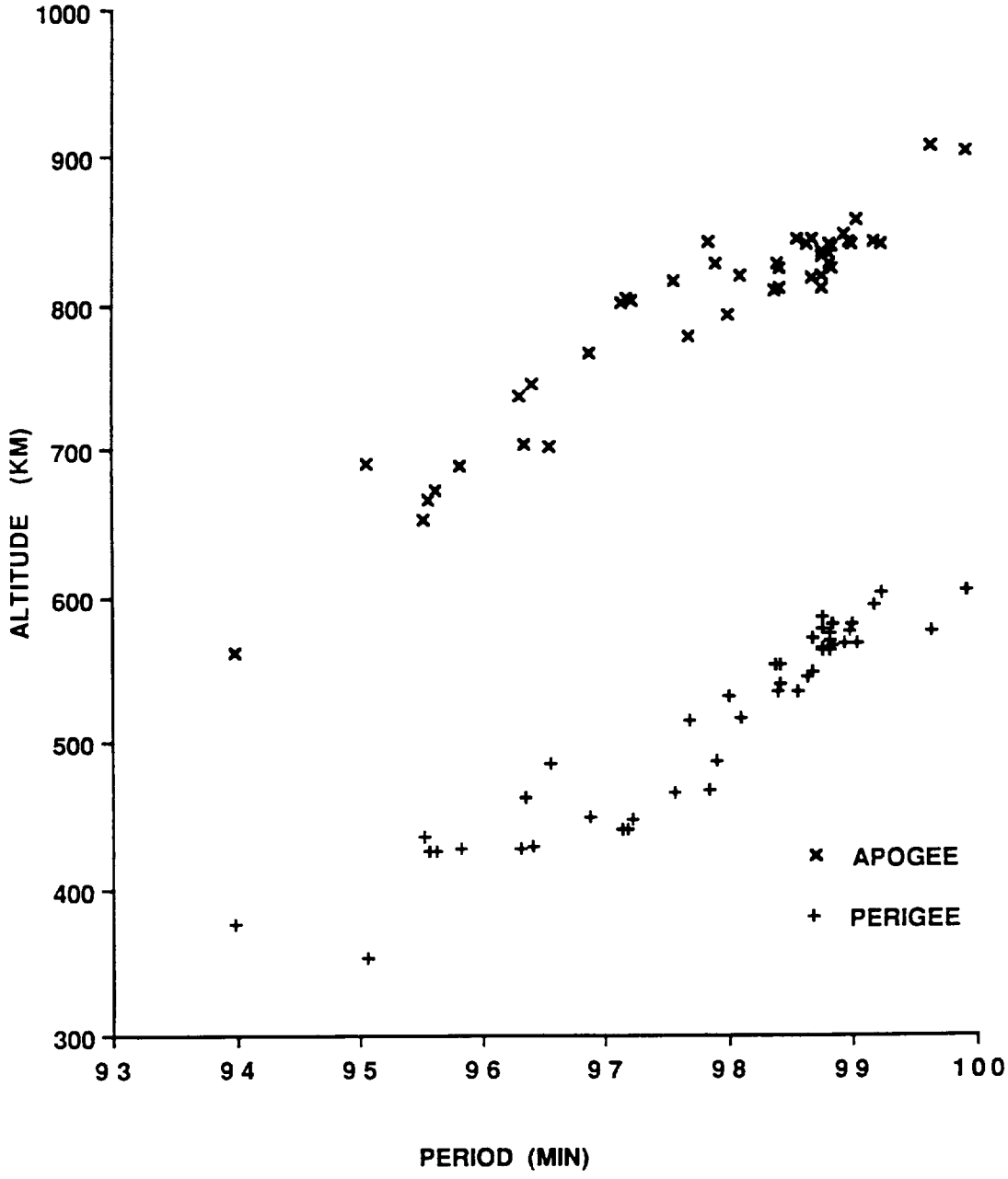
*Based on uncataloged debris data

COMMENTS

During the burn of USA 68's solid-fuel apogee kick motor (STAR-37S, TE-M-364-15), the 20 kg nozzle came apart, terminating thrust. At shutdown USA 68 was in an orbit of 610 km by 850 km. Immediately, a hydrazine orbit make-up system was activated, providing an additional 32.3 m/s ΔV. More than 40 pieces of non-operational debris were observed within a day of the event. The observed debris may include components of the USA 68 sun shield and AKM nozzle shield (total mass 2 kg). Most debris decayed very rapidly. The payload remained operational.

REFERENCE DOCUMENTS

The Fragmentation of USA 68, N.L. Johnson, Technical Report CS91-TR-JSC-005, Teledyne Brown Engineering, Colorado Springs, Colorado, March 1991.



USA 68 debris cloud remnant of 46 fragments 12 days after the event as reconstructed from U.S. Space Surveillance Center database.

SATELLITE DATA

TYPE:	SL-8 Final Stage
OWNER:	USSR
LAUNCH DATE:	12.12 Feb 1991
DRY MASS (KG):	1500 (approx.)
MAIN BODY:	Cylinder; 2.4 m by 5 m
MAJOR APPENDAGES:	Payload deployment mechanism
ATTITUDE CONTROL:	None at the time of event
ENERGY SOURCES:	Unknown

EVENT DATA

DATE:	5 Mar 1991	LOCATION:	43S, 140E (asc)
TIME:	1345 GMT	ASSESSED CAUSE:	Unknown
ALTITUDE:	1560 km		

PRE-EVENT ELEMENTS

EPOCH:	91062.94236834	MEAN ANOMALY:	112.8991
RIGHT ASCENSION:	166.0317	MEAN MOTION:	12.19552620
INCLINATION:	74.0386	MEAN MOTION DOT/2:	.00000005
ECCENTRICITY:	.0166507	MEAN MOTION DOT DOT/6:	.0
ARG. OF PERIGEE:	245.0348	BSTAR:	.000099999

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	70	MAXIMUM ΔP:	4.3 min*
DEBRIS IN ORBIT:	70	MAXIMUM ΔI:	0.3 deg*

*Based on uncataloged debris data

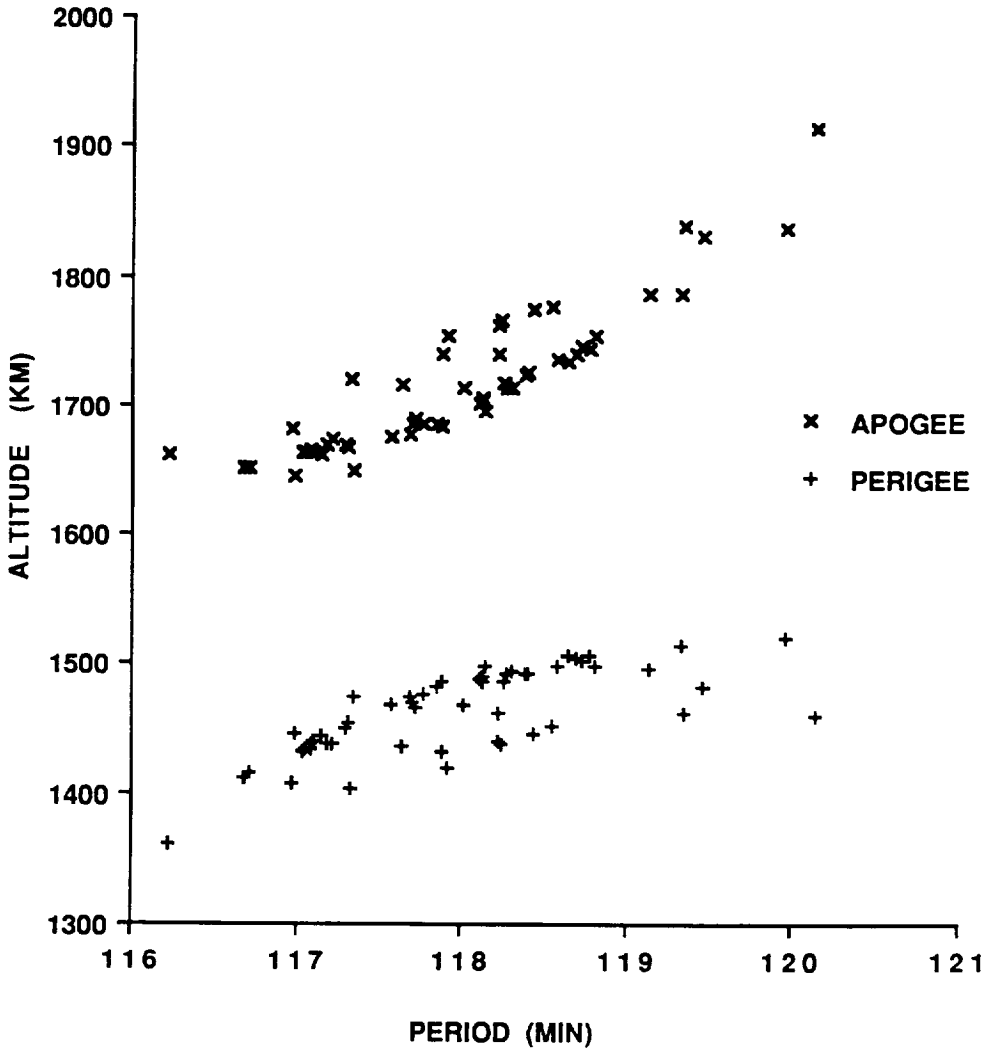
COMMENTS

This is the second known fragmentation of the SL-8 final stage and the first in more than 25 years and 370 missions. Like the earlier event (Cosmos 61-63 R/B), this rocket body successfully completed its multiple payload delivery before breakup. NAVSPASUR has determined that several minor separations occurred both prior to and after the main breakup cited above (see NAVSPASUR report referenced below).

REFERENCE DOCUMENTS

Cosmos 2125-2132 Rocket Body (U), Fragmentation and Breakup Report (U), E.L. Jenkins and R.E. Farmer, Naval Space Surveillance Center, Dahlgren, Virginia, April, 1991.

A Preliminary Analysis of the Fragmentations of the Kosmos 2125-2132 Rocket Body, N.L. Johnson, Technical Report CS91-TR-JSC-007, Teledyne Brown Engineering, Colorado Springs, Colorado, April 1991.



Cosmos 2125-2132 R/B debris cloud of 54 objects 5 days after the major breakup event as reconstructed from a Naval Space Surveillance System database. This diagram is taken from the reference cited at the top of this page.

SATELLITE DATA

TYPE:	Payload
OWNER:	USSR
LAUNCH DATE:	9.55 October 1991
DRY MASS (KG):	6000 (approx.)
MAIN BODY:	Cone-Cylinder; 2.4 m by 7 m (?)
MAJOR APPENDAGES:	Solar panels (?)
ATTITUDE CONTROL:	Active, 3-axis
ENERGY SOURCES:	On-board propellants, explosive charge

EVENT DATA

DATE:	6 December 1991	LOCATION:	55N, 154E (dsc)
TIME:	2021 GMT	ASSESSED CAUSE:	Deliberate Detonation
ALTITUDE:	210 km		

PRE-EVENT ELEMENTS

EPOCH:	91340.51933896	MEAN ANOMALY:	213.3470
RIGHT ASCENSION:	37.7884	MEAN MOTION:	16.18797546
INCLINATION:	64.7678	MEAN MOTION DOT/2:	.00862876
ECCENTRICITY:	.0054670	MEAN MOTION DOT DOT/6:	.000035685
ARG. OF PERIGEE:	147.5032	BSTAR:	.00035926

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	1	MAXIMUM ΔP:	>9.8 min*
DEBRIS IN ORBIT:	0	MAXIMUM ΔI:	0.2 deg*

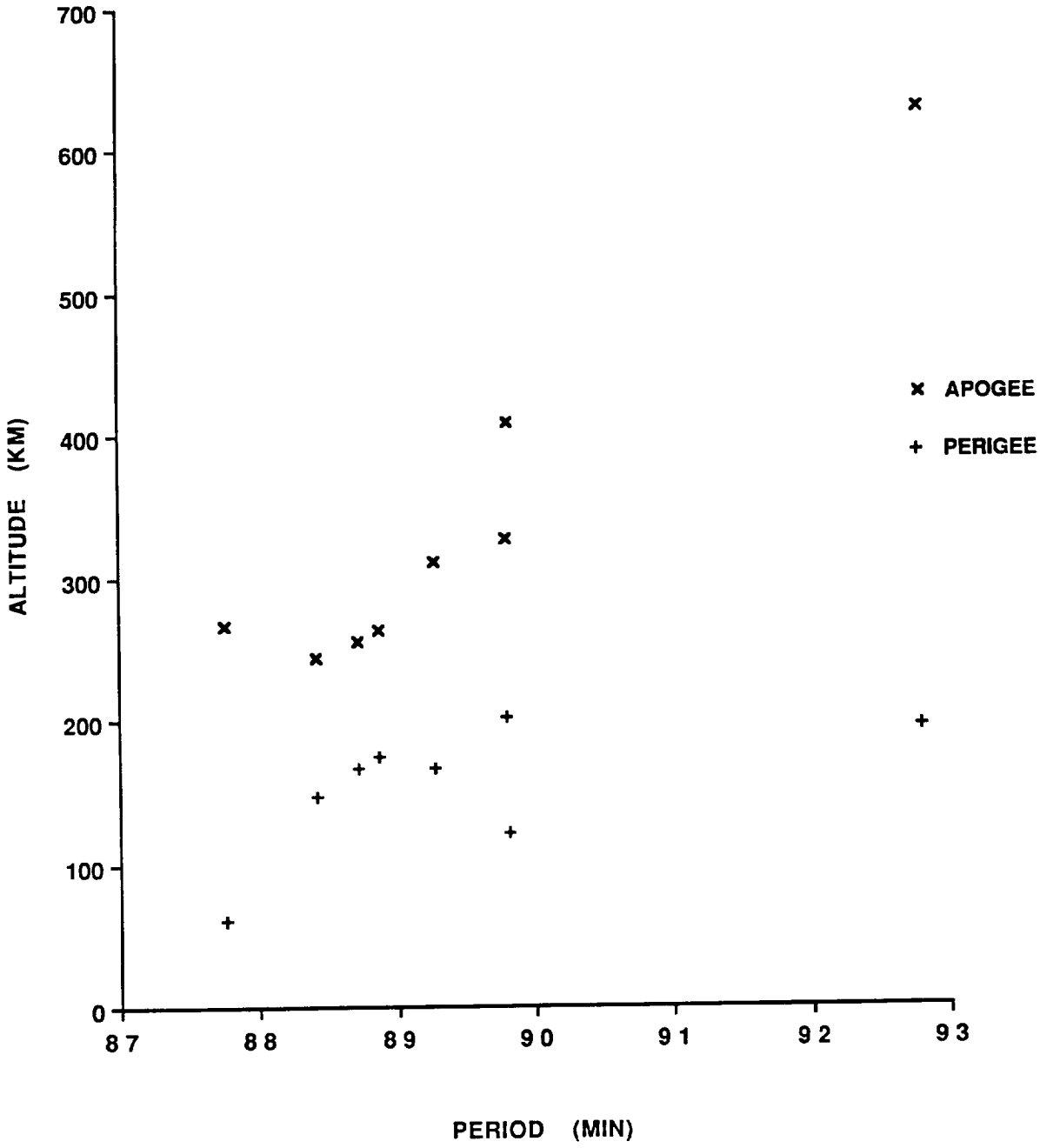
*Based on uncataloged debris data

COMMENTS

Spacecraft was apparently destroyed after a malfunction prevented controlled reentry and landing in the Soviet Union. Thirteenth incident of this type. Early elements on only 8 objects available. All debris reentered before being officially cataloged.

REFERENCE DOCUMENTS

The Fragmentation of Kosmos 2163, Technical Report CS92-TR-JSC-002, Teldyne Brown Engineering, Colorado Springs, Colorado, January 1992.



Cosmos 2163 debris cloud remnant of 8 objects one day after the event as reconstructed from U.S. Space Surveillance Center database. This diagram is taken from the cited reference.

3.0 SATELLITE ANOMALOUS EVENTS

This section describes the identified anomalous events compiled by TBE throughout the years of Satellite Catalog and orbital debris analysis associated with this volume. No exhaustive search for anomalous events has yet been conducted, although the following compilation should represent the most significant events noted thus far.

3.1 Background and Status

As defined in the introduction of this volume, an **anomalous event** is the unplanned separation, usually at low velocity, of one or more detectable objects from a satellite which remains essentially intact. The assessment that the configuration of the parent satellite has not changed significantly is to a degree subjective and is often based on indirect parameters and not on detailed imagery.

Anomalous events can be caused by material deterioration of items such as thermal blankets, protective shields, or solar panels and by impacts of small debris, either natural or man-made. The fact that about half of the satellites noted in this section experienced multiple anomalous events suggests that the former factor may be more prevalent. Other satellite deteriorations, e.g., paint debonding, are known to take place, but are undetectable with the sensors of the U.S. SSN. Interestingly, 10 of the 16 satellites in this section are U.S. payloads, whereas the remaining six are rocket bodies (2 U.S., 4 U.S.S.R.). Four of the last five objects to be the subject of anomalous events have been Soviet SL-3 upper stages in orbit for 16-26 years. These events are summarized in Tables 3.1 and 3.2.

Due to the usually low velocity of debris ejection and the potential delay in detecting debris liberated in small numbers, the accuracy of the calculated time of separation is often degraded. Hence, only the month and year of each event are provided, although in some cases the time of the event has been narrowed to a shorter interval. As in the previous section, orbital altitudes are cited to the nearest 5 km based on a mean Earth radius and on the last element set prior to the assessed event date.

Anomalous event debris often exhibit unusually high decay rates which are indicative of high area-to-mass ratios. This feature, coupled with the normal small size of the debris, hinders official tracking and cataloging. Consequently, some debris are observed but are lost or decay before being assigned a permanent catalog number. The numbers of cataloged debris listed in this section are only from the anomalous events and do not include normal operational debris identified with the particular launch nor the parent itself.

Historically, anomalous events have often been confused with satellite breakups and have not been the subject of separate, extensive analyses. The list of events in this section is known to be incomplete. Several other satellites have been tentatively tagged as sources of anomalous events. Moreover, preliminary satellite catalog surveys suggest that additional anomalous events have occurred but remain unrecognized as such. Table 3.2 suggests a potential correlation of anomalous events with high solar activity. This section will be updated as future studies warrant.

TABLE 3.1 HISTORY OF SATELLITE ANOMALOUS EVENTS BY LAUNCH DATE (As of 1 April 1992)

NAME	INTERNATIONAL DESIGNATOR	CATALOG NUMBER	LAUNCH DATE	FIRST EVENT DATE	KNOWN EVENTS	CATALOGED DEBRIS	IN-ORBIT DEBRIS	APOGEE (KM)	PERIGEE (KM)	INCLINATION (DEG)
OPS 4412 (TRANSIT 9)	1964-26A	801	4-Jun-64	Dec-80	2	2	0	930	845	90.5
COSMOS 44 R/B	1964-53B	877	28-Aug-64	Nov-90	1	1	1	775	655	65.1
OPS 4988 (GREB 6)	1965-16A	1271	9-Mar-65	Nov-80	1	1	1	935	900	70.1
OPS 4682 (SNAPSHOT)	1965-27A	1314	3-Apr-65	Nov-79	7	47	45	1320	1270	90.3
OPS 8480 (TRANSIT 5B-6)	1965-48A	1420	24-Jun-65	Aug-80	3	6	0	1135	1025	89.9
OPS 1593 (TRANSIT 11)	1966-05A	1952	28-Jan-66	Apr-80	3	5	1	1205	855	89.8
OPS 1117 (TRANSIT 12)	1966-24A	2119	26-Mar-66	Jul-81	1	1	0	1115	890	89.9
OPS 4947 (TRANSIT 17)	1967-92A	2965	25-Sep-67	Apr-81	2	5	0	1110	1035	89.3
COSMOS 206 R/B	1968-19B	3151	14-Mar-68	Nov-90	1	0	0	515	450	81.2
METEOR 1-7 R/B	1971-03B	4850	20-Jan-71	Jun-87	1	1	1	665	535	81.2
METEOR 1-12 R/B	1972-49B	6080	30-Jun-72	Sep-89	1	1	1	935	860	81.2
GEOS 3 R/B	1975-27B	7735	9-Apr-75	Mar-78	1	3	2	845	835	115.0
SEASAT	1978-64A	10967	27-Jun-78	Jul-83	2	5	0	780	780	108.0
TIROS N	1978-96A	11060	13-Oct-78	Sep-87	1	2	0	855	835	99.0
NIMBUS 7 R/B	1978-98B	11081	24-Oct-78	May-81	2	1	0	955	935	99.3
OSCAR 24 / 30	1985-66	15935/6	3-Aug-85	Feb-92	1	1	1	1253	1000	89.9
					TOTAL	82	53			

TABLE 3.2 HISTORY OF SATELLITE ANOMALOUS EVENTS BY EVENT DATE (As of 1 April 1992)

NAME	INTERNATIONAL DESIGNATOR	CATALOG NUMBER	LAUNCH DATE	FIRST EVENT DATE	KNOWN EVENTS	CATALOGED DEBRIS	IN-ORBIT DEBRIS	APOGEE (KM)	PERIGEE (KM)	INCLINATION (DEG)
GEOS 3 R/B	1975-27B	7735	9-Apr-75	Mar-78	1	3	2	845	835	115.0
OPS 4682 (SNAPSHOT)	1965-27A	1314	3-Apr-65	Nov-79	7	47	45	1320	1270	90.3
OPS 1593 (TRANSIT 11)	1966-05A	1952	28-Jan-66	Apr-80	3	5	1	1205	855	89.8
OPS 8480 (TRANSIT 5B-6)	1965-48A	1420	24-Jun-65	Aug-80	3	6	0	1135	1025	89.9
OPS 4988 (GREB 6)	1965-16A	1271	9-Mar-65	Nov-80	1	1	1	935	900	70.1
OPS 4412 (TRANSIT 9)	1964-26A	801	4-Jun-64	Dec-80	2	2	0	930	845	90.5
OPS 4947 (TRANSIT 17)	1967-92A	2965	25-Sep-67	Apr-81	2	5	0	1110	1035	89.3
NIMBUS 7 R/B	1978-98B	11081	24-Oct-78	May-81	2	1	0	955	935	99.3
OPS 1117 (TRANSIT 12)	1966-24A	2119	26-Mar-66	Jul-81	1	1	0	1115	890	89.9
SEASAT	1978-64A	10967	27-Jun-78	Jul-83	2	5	0	780	780	108.0
METEOR 1-7 R/B	1971-03B	4850	20-Jan-71	Jun-87	1	1	1	665	535	81.2
TIROS N	1978-96A	11060	13-Oct-78	Sep-87	1	2	0	855	835	99.0
METEOR 1-12 R/B	1972-49B	6080	30-Jun-72	Sep-89	1	1	1	935	860	81.2
COSMOS 44 R/B	1964-53B	877	28-Aug-64	Nov-90	1	1	1	775	655	65.1
COSMOS 206 R/B	1968-19B	3151	14-Mar-68	Nov-90	1	0	0	515	450	81.2
OSCAR 24 / 30	1985-66	15935/6	3-Aug-85	Feb-92	1	1	1	1253	1000	89.9
					TOTAL	82	53			

3.2 IDENTIFIED SATELLITE ANOMALOUS EVENTS

SATELLITE DATA

TYPE:	Payload
OWNER:	US
LAUNCH DATE:	4 June 1964
DRY MASS (KG):	60
MAIN BODY:	Octagonal cylinder; 0.5 m by 0.4 m
MAJOR APPENDAGES:	4 solar panels; gravity-gradient boom
ATTITUDE CONTROL:	Gravity-gradient boom

EVENT DATA

KNOWN EVENTS: 2

FIRST DATE: December 1980

APOGEE	PERIGEE	PERIOD	INCLINATION
930 km	845 km	102.7 min	90.5 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED: 2

DEBRIS IN ORBIT: 0

COMMENTS

Second event observed Jul 1982. First fragment decayed rapidly; the second decayed more slowly. One of five known Transits involved in anomalous events.

SATELLITE DATA

TYPE: SL-3 Upper Stage

OWNER: USSR

LAUNCH DATE: 28 August 1964

DRY MASS (KG): 2100

MAIN BODY: Cylinder; 2.6 m by 3.1 m

MAJOR APPENDAGES: None

ATTITUDE CONTROL: None

EVENT DATA

KNOWN EVENTS: 1

FIRST DATE: Late-1990

APOGEE	PERIGEE	PERIOD	INCLINATION
775 km	655 km	99.1 min	65.1 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED: 1

DEBRIS IN ORBIT: 1

COMMENTS

Cosmos 44 was the first prototype spacecraft of the Meteor 1 program. This is one of four SL-3 rocket bodies associated with this old program to shed a piece of debris since 1987. The age of the rocket bodies at the time of the anomalous event has been 16-26 years.

SATELLITE DATA

TYPE:	Payload
OWNER:	US
LAUNCH DATE:	9 March 1965
DRY MASS (KG):	40
MAIN BODY:	Sphere
MAJOR APPENDAGES:	Unknown
ATTITUDE CONTROL:	Unknown

EVENT DATA

KNOWN EVENTS:	1
FIRST DATE:	November 1980

APOGEE	PERIGEE	PERIOD	INCLINATION
935 km	900 km	103.4 min	70.1 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	1
DEBRIS IN ORBIT:	1

COMMENTS

No other events observed.

SATELLITE DATA

TYPE: Payload (attached to Agena D upper stage)

OWNER: US

LAUNCH DATE: 3 April 1965

DRY MASS (KG): 2500 (approx.)

MAIN BODY: Cylinder-Cone; 1.5 m by 11.6 m

MAJOR APPENDAGES: None

ATTITUDE CONTROL: None at time of event

EVENT DATA

KNOWN EVENTS: 7

FIRST DATE: November 1979

APOGEE	PERIGEE	PERIOD	INCLINATION
1320 km	1270 km	111.5 min	90.3 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED: 47

DEBRIS IN ORBIT: 45

COMMENTS

Six additional events observed: Dec 1980, Aug 1981, Mar 1983, Aug 1983, Nov 1983, and Jan 1985. Debris include five very large pieces (18-38 m^2). Decay rates of all debris are nominal for this altitude. One debris was administratively decayed in February, 1989.

REFERENCE DOCUMENT

Investigation of Certain Anomalies Associated with Object 1314, A US Nuclear Powered Satellite, G. T. DeVere, Technical Memorandum 85-S-001, Headquarters NORAD/ADCOM, DCS/Plans, March 1985 (Appendix TM-85-001A, Secret).

SATELLITE DATA

TYPE:	Payload
OWNER:	US
LAUNCH DATE:	24 June 1965
DRY MASS (KG):	60
MAIN BODY:	Octagonal cylinder; 0.5 m by 0.4 m
MAJOR APPENDAGES:	4 solar panels; gravity-gradient boom
ATTITUDE CONTROL:	Gravity-gradient

EVENT DATA

KNOWN EVENTS:	3
FIRST DATE:	August 1980

APOGEE	PERIGEE	PERIOD	INCLINATION
1135 km	1025 km	106.8 min	89.9 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	6
DEBRIS IN ORBIT:	0

COMMENTS

Two additional events observed: one two days after the initial event and the last in Jun 1981. All debris appear very small. One of five known Transits involved in anomalous events.

SATELLITE DATA

TYPE:	Payload
OWNER:	US
LAUNCH DATE:	28 January 1966
DRY MASS (KG):	60
MAIN BODY:	Octagonal cylinder; 0.5 m by 0.4 m
MAJOR APPENDAGES:	4 solar panels; gravity-gradient boom
ATTITUDE CONTROL:	Gravity-gradient

EVENT DATA

KNOWN EVENTS: 3

FIRST DATE: April 1980

APOGEE	PERIGEE	PERIOD	INCLINATION
1205 km	855 km	105.8 min	89.8 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED: 5

DEBRIS IN ORBIT: 1

COMMENTS

Two additional events observed: Sep 1980 and Jul 1983. Last event may have originated with a piece of debris from earlier event. One of five known Transits involved in anomalous events.

SATELLITE DATA

TYPE:	Payload
OWNER:	US
LAUNCH DATE:	26 March 1966
DRY MASS (KG):	60
MAIN BODY:	Octagonal cylinder; 0.5 m by 0.4 m
MAJOR APPENDAGES:	4 solar panels; gravity-gradient boom
ATTITUDE CONTROL:	Gravity-gradient

EVENT DATA

KNOWN EVENTS: 1

FIRST DATE: July 1981

APOGEE	PERIGEE	PERIOD	INCLINATION
1115 km	890 km	105.1 min	89.9 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED: 1

DEBRIS IN ORBIT: 0

COMMENTS

No other events observed. One of five known Transits involved in anomalous events.

SATELLITE DATA

TYPE:	Payload
OWNER:	US
LAUNCH DATE:	25 September 1967
DRY MASS (KG):	60
MAIN BODY:	Octagonal cylinder; 0.5 m by 0.4 m
MAJOR APPENDAGES:	4 solar panels; gravity-gradient boom
ATTITUDE CONTROL:	Gravity-gradient

EVENT DATA

KNOWN EVENTS: 2

FIRST DATE: April 1981

APOGEE	PERIGEE	PERIOD	INCLINATION
1110 km	1035 km	106.7 min	89.3 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED: 5

DEBRIS IN ORBIT: 0

COMMENTS

Second event observed in Aug 1986. One of five known Transits involved in anomalous events.

SATELLITE DATA

TYPE: SL-3 Upper Stage

OWNER: USSR

LAUNCH DATE: 14 March 1968

DRY MASS (KG): 2100

MAIN BODY: Cylinder; 2.6 m by 3.1 m

MAJOR APPENDAGES: None

ATTITUDE CONTROL: None

EVENT DATA

KNOWN EVENTS: 1

FIRST DATE: Late-1990

APOGEE	PERIGEE	PERIOD	INCLINATION
515 km	450 km	94.3 min	81.2 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED: 0

DEBRIS IN ORBIT: 0

COMMENTS

Cosmos 206 was a prototype spacecraft of the Meteor 1 program. This is one of four SL-3 rocket bodies associated with this old program to shed a piece of debris since 1987. The age of the rocket bodies at the time of the anomalous event has been 16-26 years. One piece of debris was released and was still in orbit, although not officially cataloged, by 1 April 1991.

SATELLITE DATA

TYPE:	SL-3 Upper Stage
OWNER:	USSR
LAUNCH DATE:	20 January 1971
DRY MASS (KG):	2100
MAIN BODY:	Cylinder; 2.6 m by 3.1 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None

EVENT DATA

KNOWN EVENTS:	1
FIRST DATE:	June 1987

APOGEE	PERIGEE	PERIOD	INCLINATION
665 km	535 km	96.7 min	81.2 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	1
DEBRIS IN ORBIT:	1

COMMENTS

No other events observed.

SATELLITE DATA

TYPE: SL-3 Upper Stage

OWNER: USSR

LAUNCH DATE: 30 June 1972

DRY MASS (KG): 2100

MAIN BODY: Cylinder; 2.6 m by 3.1 m

MAJOR APPENDAGES: None

ATTITUDE CONTROL: None

EVENT DATA

KNOWN EVENTS: 1

FIRST DATE: September 1989

APOGEE	PERIGEE	PERIOD	INCLINATION
935 km	860 km	102.9 min	81.2 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED: 1

DEBRIS IN ORBIT: 1

COMMENTS

No other events observed.

SATELLITE DATA

TYPE:	Delta Second Stage (2410)
OWNER:	US
LAUNCH DATE:	9 April 1975
DRY MASS (KG):	900 (approx.)
MAIN BODY:	Cylinder-Nozzle; 2.4 m by 8 m
MAJOR APPENDAGES:	None
ATTITUDE CONTROL:	None

EVENT DATA

KNOWN EVENTS:	1
FIRST DATE:	March 1978

APOGEE	PERIGEE	PERIOD	INCLINATION
845 km	835 km	101.7 min	115.0 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	3
DEBRIS IN ORBIT:	2

COMMENTS

Only one event noted with three fragments cataloged 12 March 1978. Repeated mistaging during 1978 among rocket body and debris. One fragment lost in 1978 and administratively decayed in 1983. This event may be related to series of major Delta Second Stage breakups.

SATELLITE DATA

TYPE: Payload (attached to Agena R/B)

OWNER: US

LAUNCH DATE: 27 June 1978

DRY MASS (KG): 2300

MAIN BODY: Cylinder; 1.5 m by 21 m

MAJOR APPENDAGES: 2 solar panels; 1 antenna panel; miscellaneous booms

ATTITUDE CONTROL: Unknown at time of event

EVENT DATA

DATE: July 1983

APOGEE	PERIGEE	PERIOD	INCLINATION
780 km	780 km	100.5 min	108.0 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED: 5

DEBRIS IN ORBIT: 0

COMMENTS

Second event observed Feb 1985. Later events possible. Most debris experience very rapid decay for this altitude.

SATELLITE DATA

TYPE:	Payload
OWNER:	US
LAUNCH DATE:	13 October 1978
DRY MASS (KG):	725
MAIN BODY:	Cylinder; 1.9 m by 3.7 m
MAJOR APPENDAGES:	1 solar panel
ATTITUDE CONTROL:	Unknown at time of event

EVENT DATA

KNOWN EVENTS:	1
FIRST DATE:	September 1987

APOGEE	PERIGEE	PERIOD	INCLINATION
855 km	835 km	101.9 min	99.0 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED:	2
DEBRIS IN ORBIT:	0

COMMENTS

Both fragments decayed rapidly during winter of 1988-89.

SATELLITE DATA

TYPE: Delta Second Stage (2910)

OWNER: US

LAUNCH DATE: 24 October 1978

DRY MASS (KG): 900 (approx.)

MAIN BODY: Cylinder-Nozzle; 2.4 m by 8 m

MAJOR APPENDAGES: None

ATTITUDE CONTROL: None

EVENT DATA

KNOWN EVENTS: 2

FIRST DATE: May 1981

APOGEE	PERIGEE	PERIOD	INCLINATION
955 km	935 km	104.0 min	99.3 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED: 1

DEBRIS IN ORBIT: 0

COMMENTS

Second anomalous event apparently occurred about Jan 1987. A more prolific event in Dec 1981 is tentatively categorized as a satellite breakup (see Section 2). The cataloged debris section above refers only to the new fragment observed after the second anomalous event and does not include the Delta second stage which is accounted for in the tables of Section 2. These events may be related to the series of major Delta Second Stage breakups.

SATELLITE DATA

TYPE:	Payload
OWNER:	US
LAUNCH DATE:	3 August 1985
DRY MASS (KG):	60
MAIN BODY:	Octagonal Cylinder; 0.5 m by 0.4 m
MAJOR APPENDAGES:	4 solar panels; gravity-gradient boom
ATTITUDE CONTROL:	Gravity-gradient boom

EVENT DATA

KNOWN EVENTS: 1

FIRST DATE: February 1992

APOGEE	PERIGEE	PERIOD	INCLINATION
1253 km	1000 km	107.8 min	89.9 deg

CATALOGED DEBRIS CLOUD DATA

DEBRIS CATALOGED: 1

DEBRIS IN ORBIT: 1

COMMENTS

Other debris pieces are associated with this dual payload launch. The most recent event identified (SCC 21878) apparently originated from one of the two payloads. Reports indicated that the object originated from Oscar 24, but element set analysis indicates the event most likely occurred between 92030-92034 off 15935 (Oscar 30). One object which may be an additional anamolous event (not accounted for in the totals above) is SSC number 17164 which was cataloged in November/December 1986, 15 months after launch.

4.0 OTHER SATELLITES ASSOCIATED WITH FRAGMENTATIONS

Satellite fragmentation lists compiled by other organizations, in particular by the National Security Council and NAVSPASUR, were carefully reviewed during the preparation of the fourth edition of the History of On-Orbit Satellite Fragmentations. However, due to the frequent exchange of information within the small orbital debris and space operations community and the long period during which satellite fragmentation lists have been maintained, no current list is completely independent from all others. For this reason, every known and suspected satellite fragmentation was re-examined and re-validated. Since its publication, new analyses of one historical "breakup", that of the Cosmos 95 rocket body, indicated that in fact no breakup occurred; therefore, this entry no longer appears in the present edition.

These reviews also revealed the need to define better the terms "satellite breakup" and "anomalous event" as discussed in Section 1. Many "breakup" lists have historically included entries related to normal launch and mission activities which resulted in numbers of debris in excess of the handful usually observed on these occasions. Some researchers have been misled by tracking difficulties and cataloging procedures which may cause late cataloging or misidentification of debris, superficially giving the appearance of fragmentations. A higher than average number of debris alone is not sufficient to assume a satellite fragmentation. Such pitfalls can generally be avoided by conducting analyses with complete satellite element set data rather than the limited orbital data available in the U.S. Satellite Catalog.

The following space missions, listed by international designator, have been examined in detail and have failed to qualify as either satellite breakup or anomalous event as set forth in Section 1. The source of debris associated with nearly all of these flights is of an operational nature.

1965-73	1973-27	1984-08
1965-88	1973-75	1984-106
1965-112	1974-74	1985-21
1967-01	1976-12	1985-75
1967-11	1976-124	1985-97
1967-24	1977-42	1985-121
1967-86	1978-43	1986-24
1968-117	1979-08	1986-30
1969-21	1979-63	1986-52
1970-05	1980-83	1986-101
1970-33	1981-93	1988-19
1970-65	1982-06	1988-67
1971-41	1982-07	1989-100
1972-78		

5.0 SATELLITES NOT ASSOCIATED WITH FRAGMENTATIONS

Previous editions of the History of On-Orbit Satellite Fragmentations have listed the SSC numbers of satellites which are not associated with a given fragmentation and were not included in the object counts. The table below identifies specific SSC numbers of objects which are not associated with the indicated event. For example, 61-OMI was a fragmentation of the Ablestar Stage Rocket Body. The mission deployed two objects (Transit 4A and Solrad 3/Injun 1) which were not associated with the rocket body explosion. Those two objects are not counted in the 61-OMI totals (296 cataloged at the cut-off date for this edition), although they definitely are associated with the 61-Omicron international designator.

Occasionally it is not obvious whether an object should be included in a fragmentation event. In those cases historical research and historical Satellite Catalogs usually reveal whether an object should be included in the count. The list below represents the best summary of excluded objects.

Int'l Designator	Excluded Satellites
61-OMI	116,117
64-70	920
65-12	1095
65-20	1267, 2168, 1269
65-82	1624
66-12	2012, 2014
66-46	2186, 2189, 2190
66-56	2255, 2256, 2511
66-59	2291
68-25	3170
68-81	3428, 3429, 3430, 3431, 5999
68-91	3505
69-29	3835
69-64	4051
69-82	4111, 4132, 4166, 4168, 4237, 4247, 4256, 4257, 4259, 4295
70-25	4362,4363
70-89	4897
71-15	4965
71-106	5650, 5664, 5665, 5672
72-58	6126
73-17	6398
73-21	6434, 6436
73-86	6920
74-89	7529, 7530, 7531
74-103	7588

Int'l Designator	Excluded Satellites
75-04	7615
75-52	7924, 7965
75-80	8192
75-102	8417
76-63	8933
76-67	9013, 9016
76-72	9048
76-77	9057
76-105	9496, 9497, 9506
76-120	9604, 9605
76-126	9643, 9644, 9645
77-27	9912, 9913, 9921
77-47	10060, 10066, 10089
77-65	10143, 10145, 10156
77-68	10151, 10152, 10167
77-121	10532
78-26	10702, 10703
78-83	11016, 11017, 11076
78-98	11080, 18605
78-100	11084, 11085, 11086, 11177
79-17	11279, 11291, 11322
79-33	11334, 11367
79-58	11418, 11423, 11555
79-77	11512, 11513, 11550
79-104	11645
80-21	11730
80-30	11766
80-57	11872, 11873, 11888
80-89	12055
81-16	12304, 12305, 12306, 12311
81-24	12388
81-28	12365
81-31	12377, 12378, 12384
81-53	12508
81-58	12548, 12549, 12561
81-71	12629, 12630, 12680
81-72	12632
81-88	12818, 12819, 12820, 12821, 12822
81-89	12829
81-108	12934, 12935, 12940
82-38	13151
82-55	13260, 13261
82-88	13509
82-115	13685, 13686, 13692, 13693

Int'l Designator	Excluded Satellites
83-20	13901, 13903, 20413
83-22	13924, 14477
83-38	14036, 14037, 14038, 14041, 14042, 14043
83-44	14065
83-70	14183, 14184, 14191
83-127	14590, 14591, 14592, 14593, 14594, 14595, 14607
84-11	14681, 14688, 14689, 14692, 14695, 14696
84-83	15168
85-30	15654
85-39	15735
85-42	15770, 15771, 15772, 15773, 15774
85-82	16055
85-94	16138, 16140, 16141, 16142, 16143, 16144
85-118	16396, 16397, 16398, 16399, 16403, 16404, 16405, 16406, 16407, 16445
86-19	16613, 16614, 16616
86-59	16896
87-04	17298
87-20	17536
87-59	18185, 18186
87-78	18350, 18351, 18353
87-108	18714
88-07	18824
89-54	20125
89-56	20137, 20138
90-81	20788, 20789, 20790, 20792, 20793, 20797, 20798
90-87	20829
91-09	21100, 21101, 21102, 21103, 21104, 21105, 21106, 21107
91-71	21742