Identification of UI Objects in
Classification of Geosynchronous Objects Issue 11

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Abstract

Sixty-seven (67) objects reported as unidentified in Classification of Geosynchronous Objects, Issue 11, have been newly correlated with launches, and identified as a specific piece from their launch. Corrections of 5 previous independent identifications are proposed. This increases the total number of identified objects to 140, out of 152 originally reported as unidentified.

1. Introduction

The European Space Agency's European Space Operations Centre reports annually on the status of objects in geosynchronous orbit, via the Classification of Geosynchronous Objects (COGO) series, produced by the Space Debris Office of the Ground Systems Engineering Department.

COGO Issue 11, Section 4.7, reports 152 objects tracked by the International Scientific Optical Network (ISON), classified as unidentified, because they could not initially be correlated with a specific launch. They receive permanent IDs of the form UI.nnn, in which UI denotes unidentified, and nnn is a serial number. Objects that are eventually correlated to launches retain their UI designation, but are also listed in Section 4.7 with their COSPAR designation.

The launches expected to account for most of the 152 UI objects are the 77 which placed a total of 153 officially catalogued objects into geosynchronous orbit, for which orbital elements are not available from official sources. COGO Issue 11, identifies 40 objects that had been correlated with their launches, and independent researchers have correlated an additional 33 objects. All belong to the 77 known launches.

The present study originates within the small community of hobbyists who observe objects in orbits for which official orbital elements are not available, and analyze their orbits, optical characteristics and radio transmissions. During the 1980s and early 1990s, the group concentrated almost exclusively on low Earth orbit. In the mid-1990s, several members began to report on a few of the brighter geosynchronous objects, and discovered a small number in unpublished orbits, which were then tracked periodically.

By the middle of the present decade, several members employed telescopic cameras to regularly observe geosynchronous objects, in both published and unpublished orbits. The addition of the UI objects and their elements to the COGO reports in 2005, provided new targets for study, and the hobbyists continued to improve their equipment and methods in order to observe them.

By late 2009, the hobbyists had observed most of the UI objects, and reported nearly 7,000 observations of optical characteristics, mainly visual magnitude, which could be used to assist in classifying and identifying them. Since the number of UI objects in the COGO reports had grown to roughly match the number known to have been launched into unpublished orbits, it seemed a propitious time to make the final push to identify as many of them as possible. A puzzle is most readily solved when all or most of the pieces are at hand.

2. Methods and Sources

The UI objects were correlated with their launches using a variety of methods and sources. Generally, all applicable methods were applied to each object. Agreement among multiple methods reinforced confidence in the findings; conflicts prompted additional analysis until they could be resolved.

The two main techniques to correlate with launches were correlation with historical TLEs (two-line orbital elements), and correlation with the initial inclination and right-ascension of ascending node. Mean motion and standard visual magnitude were used to identify specific pieces from each launch.

2.1 Correlation With Historical TLEs

Since the beginning of the Space Age, the U.S. government has been the only public source of regularly updated orbital elements of artificial satellites. Prior to June 1983, the U.S. published the TLEs of nearly all objects which could be tracked. In June 1983, publication of the TLEs of the majority of its military satellites ceased, and their historical elements were withdrawn from distribution. In 1999, the embargo was expanded to include nearly all military satellites.

Researchers have discovered in their personal archives, many historical TLEs issued pre-embargo, and made them public. As a result, official two-line orbital elements of 30 of the 77 possible source launches were available for use in the correlations.

The correlations were accomplished by propagating elements using the int3 numerical integrator. In most cases, it was sufficient to propagate the historical elements forward to the epoch of the UI elements, which often resulted in matches of inclination and right-ascension of ascending node to within a few tenths of a degree, and argument of perigee to within several degrees.

In the case of payloads that had manoeuvred during their operational years to maintain east-west and/or north-south station-keeping, propagating current UI elements back to the epoch of the historical elements sometimes produced more reliable correlations. This was especially true for old objects, for which the UI elements are most representative of the orbit during the intervening years.

2.2 Correlation With Initial Inclination and Ascending Node

The initial geosynchronous inclination of many of the launches in question was reported to the U.N., as required by treaty, typically to a precision of 0.1 deg. The right-ascension of ascending node of the low-Earth orbit parking orbit was readily estimated to an accuracy of several degrees, as a function of the published location of the launch site and the date and time of the launch.

In many cases, the UI elements could be propagated to within a small fraction of a degree of the initial inclination, and within several degrees of the estimated initial right-ascension of ascending node, even over spans of four decades.

The correlations were accomplished by propagating the UI elements with the int3 numerical integrator, backward to the date of launch of all 77 possible source launches, and then extracting the inclination, right-ascension of ascending node and argument of perigee on each launch date. The data was displayed for analysis in a spreadsheet, organized so that scrolling vertically moved backward and forward through the launches, and scrolling horizontally, moved between UI objects. The tables containing this data are available from the author by request.

2.3 Other Methods to Correlate With Launches

Correlations were also made on the basis that the propagated elements of payloads and their upper stage rockets typically converge on or near their launch date.

Certain payloads and their rockets entered almost precisely equatorial initial orbits, e.g. early DSP satellites, and the DSCS satellites, which aided greatly in spotting the correlations.

Standard visual magnitude was used mainly to identify specific pieces from a launch, but it also added confidence to certain correlations with launches, e.g. the Rhyolite satellites, which were among the brighter satellites of the 1970s.

2.4 Identification of Individual Pieces

In the case of launches that orbited multiple objects, it was necessary to distinguish among them, in order to correctly identify the individual pieces. Orbital data – mainly the mean motion, and/or optical characteristics were most useful.

Objects that manoeuvre to maintain east-west and/or north-south station-keeping, are readily discernible as operational payloads. Objects in librating orbits, typically are payloads that were not re-orbited at the end of their useful life, or their debris.

Objects with mean motion between about 0.98 and 0.99 rev/d commonly are payloads that have been re-orbited at the end of their useful life. Objects with mean motion between about 1.005 and 1.02 rev/d commonly are rocket bodies. There is considerable overlap, so these cannot be considered as rules, but they are useful guidelines.

Optical behaviour - mainly the standard visual magnitude - often can help distinguish between payloads and their rockets. Payloads tend to be brighter, for example, Vortex are about 2 magnitudes brighter than their Transtage rockets. There are exceptions, e.g. Canyon satellites are a bit less bright than their Agena D stages.

Bright flare-ups from antenna or solar arrays are another visual clue of a payload. Operational DSP satellites rotate, which give them a distinctive optical signature.

3. Findings

The results of the study are summarized in the table in the Appendix. The main findings and remaining problems are discussed below.

3.1 Canyon and Vortex Related

The analysis began with the Canyon and Vortex payloads and their rocket bodies, which are readily discernible from all other objects, due to their ~0.1 eccentricity. The Vortex payloads had previously been identified, and this analysis is in complete agreement.

Several of the Canyon and Vortex launches were sufficiently close in date and plane to make the ID challenging - until the key initial conditions of argument of perigee were determined:

Approximate Initial Argument of Perigee, deg

Type	Payload	Rocket
Canyon	130	180
Vortex	100	170

3.1.1 Objects Not Found

No match was found for Canyon 3 (1970-069A); therefore, it was concluded that as of COGO 11, it remained to be discovered in orbit.

Two rocket bodies have been officially catalogued for Canyon 7 (1977-038A); however, this study found only one matching UI object, UI.082, which has been assigned as the Agena D (1977-038B), in accordance with other Canyon launches.

It was concluded that as of COGO 11, the second rocket remained to be discovered in orbit. In the official catalogue, it is 1977-038C; however, none of the other Canyon launches employed 2 upper stages, and the orbital data provided to the U.N. is inconsistent with a Canyon orbit (and with the laws of physics!) which raises considerable doubt about its identity. One possible explanation is that it is debris from Canyon 7 or its Agena D, and the orbital data provided to the U.N. was garbled.

3.1.2 Past Cross-tagging

Another new finding – at least to the author - is that for nearly 10 years, official TLEs of Canyon 1 (1968-063A, UI.102) were issued erroneously as object 1978-062D, which entered the public catalogue in September 1990. The data is found in Jonathan McDowell's archive:

http://www.planet4589.org/space/elements/20800/S20801

The single late 1971 TLE and those with epoch between 1976 May 06 and 2000 Jan 01 correspond to Canyon 1. Apparently, the object had been tracked for nearly 15 years, perhaps as an uncorrelated target, before its assignment to 1978-062D in 1990, at which time the earlier TLEs were all issued with the new designation. That its orbital history predated the year of launch implied by the COSPAR designation somehow was overlooked. The error was corrected in January 2000. The orbits have similar inclination, right-ascension of ascending node, and mean motion, but differ greatly in eccentricity.

3.2 DSP Related

All of the DSP satellites had previously been identified, either in COGO, or by independent researchers, including hobbyists. This study confirmed all but four of the independent identifications, which were found to be erroneous.

DSP F2 (1971-039A) had been incorrectly matched to UI.035, which has been identified in this study as Rhyolite 1 (1970-046A). Correlation with pre-embargo TLEs revealed that UI.042 is DSP F2. Also, Rhyolite are significantly brighter than the early DSP.

DSP F3 (1972-010A) had been incorrectly matched to UI.043, which has been identified in this study as Rhyolite 2 (1973-013A). Correlation with pre-embargo TLEs revealed that UI.144 is DSP F3. Also, Rhyolite are significantly brighter than the early DSP.

The UI objects previously identified as DSP F5 (1975-118A) and DSP F6 (1976-059A) need to be swapped. 1975-118A is UI.052, and 1976-059A is UI.056.

UI.143 correlates closely with DSP F15 (1990-095A), and its IUS 2nd stage (1990-095D), which suggests that it may be the DSP's aperture cover, which has not been officially catalogued.

Of the various DSP upper stages, only the Delta IV 5 meter 2nd stage of DSP F23 had previously been identified. This study indentified all but one of the remaining 21 Transtages and IUS 2nd stages used to orbit DSPs, for which official TLEs are not published. No match was found for the Transtage of DSP F7 (1977-007C); therefore, it was concluded that as of COGO 11, it remained to be discovered in orbit.

3.2.1 Past Cross-tagging

Six pre-embargo TLEs of the rocket of DSP F2 (1971-039B) are available, with epochs between 1980 Sep 18 and 1983 Jan 01; however, they were found to have been of a different object: TacSat (1969-013A), so they were of no use in identifying 1971-039B among the UI objects. UI.093 has been matched to 1971-039B, primarily on the basis of propagation of its right-ascension of ascending node and inclination to the date of launch, which are in reasonable agreement with those of its payload on the same date.

3.3 Titan Centaur

Ten (10) Titan Centaur rocket stages are in geosynchronous orbit. The three launched during 2002-2003 had previously been identified among the UI objects. This study identified the remaining 7, launched during 1994-2001. They are among the brightest objects in orbit, which helped to distinguish them as a class (most had long been suspected by hobbyists to be Titan Centaurs, for this reason). Comparison with inclination and right-ascension of ascending node of their payloads on the date of launch was the most useful means of correlation.

3.4 DSCS Related

Most of the DSCS had previously been identified; five remained to be matched with UI objects. Since the DSCS performed north-south station-keeping during their operational years, int3 cannot reliably propagate UI objects back to their date of launch. Instead, it was used to estimate the date when candidate UI objects ended their north-south station-keeping, which was assumed to occur in the chronological order of launch. Given the closeness in time of some of the launches, and the variability of satellite useful life, that assumption may not always prove valid.

DSCS have been orbited using several different upper stages, which inserted them into nearly exact equatorial orbits. In this study, all of the IUS 2nd stages, Transtages and IABS related to DSCS have been correlated to their launches, and matched to the specific piece.

3.5 Rhyolite

All four Rhyolite satellites have been identified among the UI objects by this study. Two had been identified incorrectly by independent analysts as DSP satellites, as discussed in Section 3.2.

3.6 Uncertain IDs

The following may be considered as tentative IDs; they are not yet proposed for adoption.

UI.005 correlates closely with DSP F20 (2000-024A), and its IUS 2nd stage (2000-024D), which suggests that it may be the DSP's aperture cover, 2000-024E.

UI.100 correlates closely with DSP F7 (1977-007A), and its Transtage (1977-007C), which suggests that it may be the DSP's aperture cover, 1977-007D.

UI.137 correlates closely with 1979-087C, the AKM of Ekran 4. With a standard magnitude of 6, it is one of the faintest UI objects observed by hobbyists, which suggests that it may be an uncatalogued piece of debris.

UI.139 has been known to hobbyists as 90007 / 00653A, since it was discovered by Ed Cannon in June 2000. It is notable for its bright periodic flashes. Its inclination nearly matches that of SDS 2-2 (1990-097B) on its launch date, but they were fairly far apart in plane, which needs to be explained before the identification can be confirmed. SDS 2-2 is known to be UI.092, so if the correlation is confirmed, UI.139 would be 1990-097D, which is officially listed as a rocket body, but which some researchers believe to be a payload.

3.7 UI Objects Remaining to be Matched

At the time of this report, seven UI objects remained to be matched by this study:

Object	Propagated Minimum Inclination		Epoch 2009 Jan 01 Orbit				
			i	e	n	Perigee	Apogee
	deg	Date	deg	-	rev/d	km	km
UI.031	0.85	1969 Oct	8.3	0.0220	1.0190	34417	36253
UI.041	0.38	1983 Apr	14.0	0.0047	1.0030	35578	35978
UI.044	0.11	1983 Mar	14.3	0.0052	1.0027	35568	36007
UI.058	0.01	1981 Mar	17.0	0.0037	0.9433	37374	37703
UI.089	1.50	1970-71	9.3	0.0186	1.0071	34881	36445
UI.094	3.51	1984 Oct	13.1	0.0701	0.9370	34642	40828
UI.153	1.61	2007 Sep	2.2	0.0256	0.9512	36179	38411

The date of the propagated minimum inclination may be a clue as to the approximate date of launch, or end of north-south station-keeping.

The long-term orbits of UI.041, UI.044 and Sirio (1977-080A) are similar. COGO 11 reports that for a time, official TLEs of UI.041 were "erroneously associated with" 1977-080A. The possibility of a relationship between UI.044 and 1977-080A requires further study.

The apogee of UI.094 catches the eye due to its similarity to the Canyon and Vortex orbits. Propagation reveals a rough apparent relationship with Canyon 7 (1977-038A); on the date of launch. UI.094 would have been 1.6 deg lower in inclination and within 1 deg of right-ascension of ascending node, but the difference in inclination is fairly large, and the perigee seems too high to be related to this launch. Could UI.094 be the unusual second rocket body that was catalogued from this launch (perhaps erroneously) as 1977-038C?

3.8 Catalogued Objects Remaining to be Matched

At the time of this report, ten officially catalogued objects for which official TLEs are unavailable, had yet to be tentatively or conclusively matched to a UI object by this study, as tabulated.

SSN	COSPAR	Name	Type	Comment
3430	1968-081C	ERS 21	ERS 21	Not yet observed
4510	1970-069A	Canyon 3	Canyon	Not yet observed
8517	1975-118D	DSP F5 cover	DSP Aperture Cover	
8919	1976-059D	DSP F6 cover	DSP Aperture Cover	
9855	1977-007C	DSP F7 r2	Transtage	Not yet observed
15422	1977-038C	Canyon 7 r2?	Canyon 7 r2?	Not yet observed
20364	1979-053D	DSP F8 cover	DSP Aperture Cover	
20319	1989-046E	DSP F14 cover	DSP Aperture Cover	
27680	1997-008E	DSP F18 cover	DSP Aperture Cover	
26887	2001-033E	DSP F21 cover	DSP Aperture Cover	

4. Acknowledgements

The author thanks all fellow hobbyists who have contributed visual and radio observations of geosynchronous objects. Most notable, are Scott Campbell, Greg Roberts and Peter Wakelin, who in recent years have specialized in this activity, and reported many thousands of precise observations of satellite positions and optical characteristics, which were essential to this study.

Mike McCants is a long time observer and analyst of satellites in distant orbits, but his greatest contribution to the hobby has been to help all of us stay on track, by rapidly and reliably updating orbital elements of nearly 300 objects, correcting errors, and identifying unknowns. He also maintains data on optical characteristics, and writes useful software, including the wonderfully accurate int3 propagator, which was essential to performing this study.

Jonathan McDowell is a professional astrophysicist, who in his spare time, documents the technical history of spaceflight. For more than two decades, he has produced Jonathan's Space Report, a regular e-mail report on new launches. He has built a unique public archive of the technical details of orbital and sub-orbital rocket launches. His record of launch dates and times, satellite catalogue, archive of historical TLEs, and compilation of orbital data from U.N. filings, were indispensible to this study.

Mike Waterman has been an active observer since the late 1950s. Six years ago, he undertook the huge task of searching his paper archives for decades-old officially released TLEs of objects, that had since been embargoed and withdrawn from official databases, or been lost. Mike recovered and meticulously re-typed at least 1,500 element sets, which he shared with researchers. Sixteen identifications in this study relied primarily on this data, eleven of which are new, or corrections of earlier efforts.

Appendix

The results of the study are summarized on the following pages. Objects are listed in order of launch, and identified using their official and common designations and descriptions; the ID numbers of the matching UI objects are in the column with red coloured font. The key column headings are defined in the footnotes.

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Object									Orientation of Orbit at Launch								Basis of Launch Identification
									Listed Object			Matching UI Object					
									Est	Reported		Propagated			UI		
SSN	COSPAR	USA	Name	Type	Std Mv	T	n0	e0	Ω	i	Ω	i	Ω	ω	#	E	
3334	1968-063A		Canyon 1	Canyon	5.2	D1	0.9924	0.0918	307.7	9.9		10.0	304.6	191	102	N	i, Ω, ω
27785	1968-063B		Canyon 1 r	Agena D	4.5	D1	1.0177	0.1081	307.7	9.9		10.0	304.7	193	055	N	i, Ω, ω
3430	1968-081C		ERS 21	ERS 21	NA				305.1	3.0	300.0	Match not found					Not yet observed
3889	1969-036A		Canyon 2	Canyon	5.2	D1	1.0038	0.0982	64.3	10.2		10.2	60.3	158	070	N	i, Ω, ω
27786	1969-036B		Canyon 2 r	Agena D	4.5	D1	1.0385	0.0986	64.3	10.2		10.2	60.7	181	012	N	i, Ω, ω
4376	1970-032A		Intelsat 3F7	Intelsat 3	4.8	L1	1.0028	0.0005	236.8	0.2	227.5	0.3	230.8	60	036	U	i, Ω
4418	1970-046A		Rhyolite 1	Rhyolite	3.5	L1	1.0026	0.0006	267.2	0.1		0.1	292.7	174	035	R	i, Ω, mag
4510	1970-069A		Canyon 3	Canyon	5.2				180.5	10.3	178.0	Match not found					Not yet observed
27787	1970-069B		Canyon 3 r	Agena D	4.5	D1	1.0170	0.1245	180.5	10.3	178.0	10.3	175.2	184	145	N	i, Ω, ω
5204	1971-039A		DSP F2	DSP Block 1	4.3	D1	0.9816	0.0018	164.0	0.9		0.5	334.5	332	042	N	pre-embargo TLE, i, Ω
5205	1971-039B		DSP F2 r	Transtage	4.9	D1	1.0040	0.0037	164.0	0.9		0.2	341.6	43	093	N	i, Ω
5851	1972-010A		DSP F3	DSP Block 1	4.3	D1	0.9976	0.0010	129.6	0.2		0.3	317.6	331	144	N	pre-embargo TLE, i
5854	1972-010B		DSP F3 r	Transtage	4.9	D1	1.0068	0.0065	129.6	0.2		0.3	316.4	108	038	N	pre-embargo TLE, i
6317	1972-101A		Canyon 5	Canyon	5.2	L1	1.0037	0.1324	250.3	9.7		9.6	247.9	136	138	N	i, Ω, ω
6318	1972-101B		Canyon 5 r	Agena D	4.5	D1	1.0231	0.1287	250.3	9.7		9.7	248.4	182	059	N	i, Ω, ω
6380	1973-013A		Rhyolite 2	Rhyolite	3.5	L1	1.0027	0.0019	132.1	0.2	115.0	0.3	325.3	232	043	R	i, Ω, mag
6691	1973-040A		DSP F4	DSP Block 1	4.3	D1	0.9982	0.0007	194.7	0.3		0.2	196.5	116	048	U	pre-embargo TLE, i, Ω
11940	1973-040B		DSP F4 r	Transtage	4.9	D1	0.9956	0.0032	194.7	0.3		0.2	204.2	133	049	N	pre-embargo TLE, i, Ω
7963	1975-055A		Canyon 6	Canyon	5.2	L1	1.0028	0.1298	241.7	9.0		8.7	235.3	132	060	N	i, Ω, ω
7964	1975-055B		Canyon 6 r	Agena D	4.5	D1	1.0209	0.1323	241.7	8.0		8.8	236.0	184	103	N	i, Ω, ω
8482	1975-118A		DSP F5	DSP Block 2	4.9	D1	1.0049	0.0028	346.7	0.3		0.1	1.8	314	052	R	pre-embargo TLE, i, Ω
8516	1975-118C		DSP F5 r2	Transtage	4.9	D1	1.0055	0.0012	346.7	0.1		0.1	346.6	139	050	N	pre-embargo TLE, i, Ω
8517	1975-118D		DSP F5 cover	DSP Aperture Cover	NA				346.7	0.1		Match not found					
8916	1976-059A		DSP F6	DSP Block 2	4.9	D1	0.9948	0.0004	145.0	0.0		0.1	335.9	142	056	R	pre-embargo TLE, i, Ω
8918	1976-059C		DSP F6 r2	Transtage	4.9	D1	1.0054	0.0009	145.0	0.1		0.1	317.2	228	054	N	pre-embargo TLE, i, Ω
8919	1976-059D		DSP F6 cover	DSP Aperture Cover	NA				145.0	0.1		Match not found					
9803	1977-007A		DSP F7	DSP Block 2	4.9	D1	0.9753	0.0081	51.9	0.1		0.6	1.5	14	057	U	pre-embargo TLE, i, Ω
9855	1977-007C		DSP F7 r2	Transtage	4.9				51.9	0.1		Match not found					Not yet observed
9856	1977-007D		DSP F7 cover	DSP Aperture Cover	NA				51.9	0.1		Match uncertain					May be UI.100

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Object									Orientation of Orbit at Launch								Basis of Launch Identification
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									Est	Reported		Propagated			UI		
SSN	COSPAR	USA	Name	Type	Std Mv	T	n0	e0	Ω	i	Ω	i	Ω	ω	#	E	
10016	1977-038A		Canyon 7	Canyon	5.2	L1	1.0026	0.1223	340.2			7.6	334.7	144	086	N	i, Ω, ω
10017	1977-038B		Canyon 7 r	Agena D	4.5	D1	1.0233	0.1456	340.2			7.5	335.2	183	082	N	i, Ω, ω
15422	1977-038C		Canyon 7 r2?	Canyon 7 r2?	NA				340.2			Match not found					Not yet observed
10508	1977-114A		Rhyolite 3	Rhyolite	3.5	L2	1.0025	0.0018	247.5			5.7	239.8	138	146	N	Ω, mag
10669	1978-016A		FleetSatCom F1	FleetSatCom	5.3	D1	0.9900	0.0004	284.5	2.7	272.4	2.7	280.4	69	101	U	pre-embargo TLE, i, Ω
10787	1978-038A		Rhyolite 4	Rhyolite	3.5	D1	1.0048	0.0015	31.9			3.5	358.8	297	091	N	i, mag
10941	1978-058A		Vortex 1	Vortex	2.7	D1	1.0012	0.1443	11.5	12.0		12.3	8.4	99	009	U	i, Ω, ω
10942	1978-058B		Vortex 1 r	Transtage	4.9	D1	0.9962	0.1435	11.5	12.0		12.1	9.4	170	010	N	i, Ω, ω
11397	1979-053A		DSP F8	DSP Block 3	3.8	D1	0.9874	0.0005	286.5	1.9	286.6	2.1	291.1	343	053	U	pre-embargo TLE, i, Ω
11436	1979-053C		DSP F8 r2	Transtage	4.9	D1	0.9944	0.0057	286.5	1.9	286.6	2.0	288.2	360	051	N	pre-embargo TLE, i, Ω
20364	1979-053D		DSP F8 cover	DSP Aperture Cover	NA							Match not found					
11558	1979-086A		Vortex 2	Vortex	2.7	D1	1.0016	0.1239	5.8	7.5		7.8	8.1	115	023	U	i, Ω, ω
11560	1979-086C		Vortex 2 r2	Transtage	4.9	D1	0.9968	0.1274	5.8			7.6	8.3	167	024	N	i, Ω, ω
Not Catalogued			79087C debris?	Debris	6.0	D1	1.0033	0.0015	Long-term comparison of elements						137	U	Orbit similar to 79087C
11890	1980-060A		Ekran 5	Ekran	NA	L3	1.0023	0.0015		0.4	281.0	Not propagated			098	U	Currently accepted
12046	1980-087A		FleetSatCom F4	FleetSatCom	5.3	D1	0.9896	0.0006	283.8	2.5	282.4	2.4	293.8	191	096	U	pre-embargo TLE, i, Ω
12339	1981-025A		DSP F9	DSP Block 3	3.8	D1	0.9882	0.0014	291.0			2.1	293.4	355	045	U	pre-embargo TLE, i, Ω
12371	1981-025C		DSP F9 r2	Transtage	4.9	D1	1.0133	0.0052	291.0	2.0		2.0	290.8	24	040	N	pre-embargo TLE, i, Ω
12930	1981-107A		Vortex 3	Vortex	2.7	L2	1.0017	0.0947	5.8			7.4	359.8	78	129	U	i, Ω, ω
12932	1981-107C		Vortex 3 r2	Transtage	4.9	D1	0.9960	0.0954	5.8			7.0	7.5	171	076	N	i, Ω, ω
13086	1982-019A		DSP F10	DSP Block 3	3.8	D1	0.9819	0.0003	281.1	2.0		2.2	284.0	15	046	U	pre-embargo TLE, i, Ω
13089	1982-019B		DSP F10 r	Transtage	4.9	D1	1.0125	0.0013	281.1	2.0		2.1	280.5	238	039	N	pre-embargo TLE, i, Ω
13637	1982-106B		DSCS 3-1	DSCS 3	4.0	D1	0.9782	0.0014	285.1	2.5	277.4	6.9	300.8	318	135	U	pre-embargo TLE, i, Ω
14675	1984-009A		Vortex 4	Vortex	2.7	C2	1.0027	0.1085	2.2			6.7	4.0	105	026	U	i, Ω, ω
14677	1984-009C		Vortex 4 r2	Transtage	4.9	D1	0.9944	0.0973	2.2			6.8	1.5	173	025	N	i, Ω, ω
14930	1984-037A		DSP F11	DSP Block 3	3.8	D1	0.9868	0.0003	281.7	1.3		2.1	276.0	38	037	U	i, Ω
14931	1984-037B		DSP F11 r	Transtage	4.9	D1	1.0116	0.0030	281.7	1.3		2.0	276.1	78	095	N	i, Ω
15453	1984-129A	7	DSP F12	DSP Block 4	4.2	D1	0.9886	0.0003	276.9	3.4		3.1	270.8	121	034	U	i, Ω
15454	1984-129B		DSP F12 r	Transtage	4.9	D1	1.0116	0.0001	276.9	3.4		3.1	268.5	23	032	N	i, Ω

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SSN	COSPAR	USA	Name	Type	Std Mv	T	n0	e0	Ω	i	Ω	i	Ω	ω	#	E	
15543	1985-010B	8	Magnum 1	Magnum	3.5	C2	1.0027	0.0048	247.2			4.1	239.5	229	097	U	i, Ω
15545	1985-010D		Magnum 1 r2	IUS 2nd stage	4.9	D1	1.0081	0.0024	247.2			4.6	241.4	104	047	N	i, Ω
16116	1985-092B	11	DSCS 3-2	DSCS 3	4.0	D1	0.9898	0.0006	66.8	0.3		Not propagated			079	N	End of N/S stn-keeping
16117	1985-092C	12	DSCS 3-3	DSCS 3	4.0	D1	0.9932	0.0003	66.8	0.3		Not propagated			077	N	End of N/S stn-keeping
16119	1985-092E		DSCS 3-2 r2	IUS 2nd stage	4.9	D1	1.0108	0.0056	66.8	2.1		2.0	256.6	332	033	N	i
17181	1986-096A	20	FleetSatCom F7	FleetSatCom	5.3	C2	1.0028	0.0025	296.8	5.3	288.9	5.3	289.8	9	134	N	i, Ω, pre-embargo TLE
18583	1987-097A	28	DSP F13	DSP Block 4	4.2	D1	0.9838	0.0021	305.0	2.9		3.2	298.4	75	030	U	i, Ω
18584	1987-097B		DSP F13 r	Transtage	4.9	D1	1.0124	0.0005	305.0	2.9		3.1	296.6	63	029	N	i, Ω
19976	1989-035A	37	Vortex 6	Vortex	2.7	C2	1.0028	0.0960	351.0			7.4	350.8	100	018	U	i, Ω, ω
19983	1989-035C		Vortex 6 r2	Transtage	4.9	D1	0.9943	0.1048	351.0			7.2	351.9	172	020	N	i, Ω, ω
20066	1989-046A	39	DSP F14	DSP Block 5	3.5	C2	1.0027	0.0001	288.0	3.1		3.2	285.7	56	150	U	i, Ω
20069	1989-046D		DSP F14 r3	IUS 2nd stage	4.9	D1	1.0130	0.0048	288.0	3.1		3.2	285.8	179	080	N	i, Ω
20319	1989-046E		DSP F14 cover	DSP Aperture Cover	NA				288.0			Match not found					
20202	1989-069A	43	DSCS 2-15	DSCS 2	4.0	D1	0.9861	0.0011	257.5	6.1		Not propagated			087	N	End of N/S stn-keeping
20203	1989-069B	44	DSCS 3-4	DSCS 3	4.0	D1	0.9903	0.0008	257.5	5.0		Not propagated			127	N	End of N/S stn-keeping
20205	1989-069D		DSCS 2-15 r2	Transtage	4.9	D1	1.0125	0.0069	257.5	4.4		0.6	268.4	164	088	N	i, Ω
20253	1989-077A	46	FleetSatCom F8	FleetSatCom	5.3	C2	1.0027	0.0006	323.8	5.1	305.2	5.1	305.4	259	130	U	pre-embargo TLE, i, Ω
20355	1989-090B	48	Magnum 2	Magnum	3.5	C2	1.0027	0.0264	253.5			6.3	250.9	326	136	U	i, Ω
20357	1989-090D		Magnum 2 r	IUS 2nd stage	4.9	D1	0.9952	0.0316	253.5			6.3	251.0	326	090	N	i, Ω
20929	1990-095A	65	DSP F15	DSP Block 5	3.5	D1	0.9840	0.0009	246.8	3.1		2.6	278.8	295	083	U	i, Ω
20932	1990-095D		DSP F15 r3	IUS 2nd stage	4.9	D1	0.9926	0.0010	246.8	3.1		2.5	272.3	266	084	N	i, Ω
Not Catalogued			DSP F15 cover	DSP Aperture Cover	NA	D1	0.9929	0.0037	246.8	3.1		2.5	271.1	159	143	U	i, Ω
20963	1990-097B	67	SDS 2-2	SDS 2	4.7	C2	1.0027	0.0125	237.5		233.3	1.7	213.4	202	092	U	i, Ω
20965	1990-097D		SDS 2-2 r2?	SDS 2-2 r2?	NA				237.5		233.3	Match uncertain					May be UI.139
21805	1991-080B	75	DSP F16	DSP Block 5	3.5	C2	1.0028	0.0001	245.1	2.5		2.6	272.0	28	133	U	i, Ω
21807	1991-080D		DSP F16 r	IUS 2nd stage	4.9	D1	1.0127	0.0024	245.1	2.5		2.6	271.8	198	078	N	i, Ω
21873	1992-006A	78	DSCS 3-5	DSCS 3	4.0	D1	0.9950	0.0023	336.3	0.9		Not propagated			071	N	End of N/S stn-keeping
21877	1992-006C		DSCS 3-5 r2	IABS	4.5	D1	1.1078	0.0660	336.3	0.3		0.9	328.5	183	132	N	i, Ω, e0
22009	1992-037A	82	DSCS 3-6	DSCS 3	4.0	C2	1.0027	0.0004	75.4	0.2		Not propagated			123	U	Currently accepted
22011	1992-037C		DSCS 3-6 r2	IABS	4.5	D1	1.0164	0.0026	75.4	0.3		0.2	50.0	142	085	N	i, Ω

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SSN	COSPAR	USA	Name	Type	Std Mv	T	n0	e0	Ω	i	Ω	i	Ω	ω	#	E	
22719	1993-046A	93	DSCS 3-7	DSCS 3	4.0	D2	0.9908	0.0005	94.4			Not propagated			120	U	Currently accepted
22738	1993-046C		DSCS 3-7 r2	IABS	4.5	D1	1.0212	0.0083	94.4			0.0	35.7	217	028	N	i
22787	1993-056A	95	UFO 2	UFO	4.6	C2	1.0028	0.0003	337.5	5.1	322.7	5.4	322.4	72	069	U	pre-embargo TLE, i, Ω
22915	1993-074A	97	DSCS 3-8	DSCS 3	4.0	C2	1.0027	0.0001	248.5		243.9	Not propagated			066	U	Currently accepted
22916	1993-074B		DSCS 3-8 r	IABS	4.5	D1	0.9992	0.0073	248.5			0.2	252.7	335	081	N	i, Ω
22988	1994-009A	99	Milstar 1	Milstar 1	2.9	C2	1.0027	0.0002	290.2	12.0		12.1	295.4	86	142	U	i, Ω
22989	1994-009B		Milstar 1 r	Titan Centaur	2.1	D1	1.0060	0.0010	290.2	12.0		10.7	294.9	120	014	N	i, Ω
23132	1994-035A	104	UFO 3	UFO	4.6	L2	1.0036	0.0002	305.7	5.1	316.6	5.4	317.2	91	068	U	pre-embargo TLE, i, Ω
23223	1994-054A	105	Mercury 1	Mercury	2.4	C2	1.0027	0.0048	295.5			6.3	307.5	224	008	U	Ω
23247	1994-054B		Mercury 1 r	Titan Centaur	2.1	D1	0.9958	0.0124	295.5			3.0	332.5	162	017	N	Ω
23435	1994-084A	107	DSP F17	DSP Block 5	3.5	C2	1.0027	0.0028	251.7			2.5	280.9	141	131	U	i, Ω
23438	1994-084D		DSP F17 r3	IUS 2nd stage	4.9	D1	1.0118	0.0003	251.7			2.5	280.6	56	019	N	i, Ω
23467	1995-003A	108	UFO 4	UFO	4.6	C2	1.0028	0.0007	334.8	5.1	322.5	6.2	324.2	168	121	U	pre-embargo TLE, i, Ω
23567	1995-022A	110	Mentor 1	Mentor	1.0	C3	1.0028	0.0133	263.8			6.1	275.0	68	128	U	i, Ω, mag
23568	1995-022B		Mentor 1 r	Titan Centaur	2.1	D1	1.0056	0.0013	263.8			6.8	257.6	272	021	N	i, Ω
23589	1995-027A	111	UFO 5	UFO	4.6	C2	1.0027	0.0001	306.1	5.1	322.5	5.7	323.1	96	122	U	pre-embargo TLE, i, Ω
23628	1995-038A	113	DSCS 3-9	DSCS 3	4.0	C2	1.0027	0.0001	127.3			Not propagated			115	U	Currently accepted
23648	1995-038C		DSCS 3-9 r2	IABS	4.5	D1	1.0127	0.0016	127.3			0.1	268.0	193	022	N	i, Ω
23696	1995-057A	114	UFO 6	UFO	4.6	C2	1.0027	0.0004	336.0	5.1	322.4	6.4	323.8	126	119	U	pre-embargo TLE, i, Ω
23712	1995-060A	115	Milstar 2	Milstar 1	2.9	C2	1.0027	0.0003	309.4			4.1	295.5	83	124	U	i, Ω
23713	1995-060B		Milstar 2 r	Titan Centaur	2.1	D1	1.0060	0.0032	309.4			3.0	285.0	101	016	N	i, Ω
23855	1996-026A	118	Mercury 2	Mercury	2.4	C2	1.0027	0.0515	33.2			6.4	5.3	97	073	U	i, Ω
25349	1996-026B		Mercury 2 r	Titan Centaur	2.1	D1	0.9956	0.0478	33.2			7.8	10.7	171	075	N	i, Ω
23967	1996-042A	127	UFO 7	UFO	4.6	C2	1.0027	0.0002	319.7	5.1	321.2	6.4	323.2	169	116	U	pre-embargo TLE, i, Ω
24737	1997-008A	130	DSP F18	DSP Block 5	3.5	C2	1.0027	0.0001	284.4		281.7	3.0	287.7	157	125	U	i, Ω
24740	1997-008D		DSP F18 r3	IUS 2nd stage	4.9	D1	0.9912	0.0009	284.4		281.7	2.9	288.3	245	126	N	i, Ω
27680	1997-008E		DSP F18 cover	DSP Aperture Cover	NA				284.4			Match not found					
25019	1997-065A	134	DSCS 3-10	DSCS 3	4.0	C2	1.0027	0.0004	230.6			Not propagated			110	U	Currently accepted
25258	1998-016A	138	UFO 8	UFO	4.6	C2	1.0027	0.0006	322.9	6.1	315.0	6.7	316.7	235	111	U	pre-embargo TLE, i, Ω

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SSN	COSPAR	USA	Name	Type	Std Mv	T	n0	e0	Ω	i	Ω	i	Ω	ω	#	E	
25336	1998-029A	139	Mentor 2	Mentor	1.0	C2	1.0027	0.0053	76.9			7.3	4.9	164	074	U	i, Ω, mag
25337	1998-029B		Mentor 2 r	Titan Centaur	2.1	L1	1.0032	0.0046	76.9			7.3	17.1	308	027	N	i, Ω
25501	1998-058A	140	UFO 9	UFO	4.6	D1	0.9818	0.0016	324.0	6.1	319.8	6.7	319.9	271	113	U	pre-embargo TLE, i, Ω
25967	1999-063A	146	UFO 10	UFO	4.6	C2	1.0027	0.0005	308.9	6.0	313.1	6.5	314.2	287	065	U	pre-embargo TLE, i, Ω
26052	2000-001A	148	DSCS 3-11	DSCS 3	4.0	C1	1.0027	0.0019	321.1			Not propagated			104	U	Currently accepted
26054	2000-001C		DSCS 3-11 r2	IABS	4.5	D1	1.0118	0.0018	321.1			0.1	270.5	321	015	N	i, Ω
26356	2000-024A	149	DSP F20	DSP Block 5	3.5	C2	1.0027	0.0000	292.7	2.9	289.9	3.0	298.6	18	004	U	i, Ω
26359	2000-024D		DSP F20 r3	IUS 2nd stage	4.9	D1	0.9971	0.0005	292.7		289.9	3.0	298.6	47	067	N	i, Ω
28156	2000-024E		DSP F20 cover	DSP Aperture Cover	NA				292.7			Match uncertain					May be UI.005
26575	2000-065A	153	DSCS 3-12	DSCS 3	4.0	C1	1.0027	0.0002	224.5			Not propagated			105	U	Currently accepted
26577	2000-065C		DSCS 3-12 r2	IABS	4.5	D1	1.0118	0.0053	224.5			0.1	282.9	191	011	N	i, Ω
26635	2000-080A	155	SDS 3-1	SDS 3	3.4	C2	1.0027	0.0005	302.6			5.0	311.6	235	007	U	i, Ω
26715	2001-009A	157	Milstar 4	Milstar 2	2.0	C2	1.0027	0.0002	303.4		301.3	4.5	310.1	344	112	U	i, Ω
26716	2001-009B		Milstar 4 r	Titan Centaur	2.1	D1	1.0048	0.0013	303.4		301.3	2.6	306.2	23	003	N	i, Ω
26770	2001-020A	158	GeoLITE	GeoLITE	NA	C2	1.0027	0.0028	328.4			5.8	317.3	179	114	N	Ω
26880	2001-033A	159	DSP F21	DSP Block 5	3.5	C2	1.0027	0.0001	252.6		249.8	3.0	296.4	26	001	U	i, Ω
26883	2001-033D		DSP F21 r3	IUS 2nd stage	4.9	D1	0.9989	0.0010	252.6		249.8	3.0	296.3	313	061	N	i, Ω
26887	2001-033E		DSP F21 cover	DSP Aperture Cover	NA				252.6			Match not found					
26948	2001-046A	162	SDS 3-2	SDS 3	3.4	C2	1.0027	0.0006	243.4			5.0	274.3	3	151	U	Ω
27168	2002-001A	164	Milstar 5	Milstar 2	2.0	C2	1.0026	0.0001	308.5	4.5	309.9	4.5	309.9	32	063	U	i, Ω
27169	2002-001B		Milstar 5 r	Titan Centaur	2.1	D1	1.0014	0.0047	308.5	6.3	312.0	6.3	312.0	44	013	U	i, Ω
27691	2003-008A	167	DSCS 3-13	DSCS 3	4.0	C1	1.0027	0.0001	8.7			Not propagated			106	U	Currently accepted
27693	2003-008C		DSCS 3-13 r2	IABS	4.5	D1	1.0111	0.0003	8.7			0.1	252.0	244	006	N	i, Ω
27711	2003-012A	169	Milstar 6	Milstar 2	2.0	C2	1.0027	0.0005	227.8	4.4	284.9	4.5	284.8	92	109	U	i, Ω
27712	2003-012B		Milstar 6 r	Titan Centaur	2.1	D1	1.0058	0.0022	227.8	3.7	306.3	3.7	306.2	205	064	U	i, Ω
27875	2003-040A	170	DSCS 3-14	DSCS 3	4.0	C1	1.0027	0.0011	151.7			Not propagated			107	U	Currently accepted
27877	2003-040C		DSCS 3-14 r2	IABS	4.5	D1	1.0074	0.0021	151.7			0.1	278.1	242	002	N	i, Ω
27937	2003-041A	171	Mentor 3	Mentor	1.0	C2	1.0027	0.0047	240.7			5.0	248.4	10	118	U	i, Ω, mag
27938	2003-041B		Mentor 3 r	Titan Centaur	2.1	D1	1.0084	0.0035	240.7			6.5	248.5	118	072	U	i, Ω
28117	2003-057A	174	UFO 11	UFO	4.6	C2	1.0027	0.0005	309.5			5.3	310.9	297	117	U	i, Ω
28158	2004-004A	176	DSP F22	DSP Block 5	3.5	C2	1.0029	0.0000	252.3		250.0	3.0	289.5	144	108	U	i, Ω

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SSN	COSPAR	USA	Name	Type	Std Mv	T	n0	e0	Ω	i	Ω	i	Ω	ω	#	E	
28161	2004-004D		DSP F22 r3	IUS 2nd stage	4.9	D1	0.9981	0.0006	252.3		250.0	3.0	289.0	345	062	N	i, Ω
29240	2006-024A	187	Mitex 1	Mitex OSC	5.5	C4	0.9995	0.0002	69.4			2.2	276.0	24	149	R	i, Ω, mag
29241	2006-024B	188	Mitex 2	Mitex Lockheed	7.5	C4	1.0059	0.0005	69.4			2.3	275.2	173	148	N	i, Ω, mag
29242	2006-024C		Mitex 1 r	NRL Upper Stage	4.9	D1	1.0401	0.0002	69.4			0.3	282.1	255	140	U	i, Ω
32258	2007-046A	195	WGS SV-1	WGS	4.0	C1	1.0027	0.0005	210.4			1.1	265.7	304	152	U	i, Ω
32287	2007-054A	197	DSP F23	DSP Block 5	3.5	L1	1.0031	0.0003	263.0			4.0	272.9	333	141	U	i, Ω
32288	2007-054B		DSP F23 r	D-IV 5m 2nd stg	3.3	D1	0.9587	0.0262	263.0			4.4	271.5	164	147	U	i, Ω

1. SSN is the space surveillance number, aka catalogue number, assigned by the U.S. Strategic Command.
2. The COSPAR designation identifies objects by year of launch, sequence of launch, and piece from launch (A, B, C …).
3. In 1984, the U.S. began to identify most military launches as USA, followed by a serial number.
4. Name and Type are author's preference.
5. Std Mv is standard visual magnitude (1000 km , 90 deg phase angle) of all objects of the listed type, for which hobbyists have reported observations.
6. Column T denotes orbit type, as defined in Classification of Geosynchronous Objects (COGO), Issue 11.
7. n0, e0 are mean motion and eccentricity of elements in COGO Issue 11.
8. Estimated Ω (right-ascension of ascending node) is based on typical LEO parking orbit after launch from Cape Canaveral.
9. Reported i (inclination) is as reported to the U.N., or in official or hobbyist TLEs, when available and determined to be reliable.
10. Reported Ω is from official or hobbyist TLEs.
11. Propagated i, Ω, ω are derived from TLE equivalents of osculating elements in COGO Issue 11, using int3 numerical integrator.
12. UI# is the three digit ID used in COGO Issue 11.
13. Column E denotes effect of the match on hobbyist designations: U=Unchanged, N=New, R=Revised
14. Basis of Launch Identification lists main factors used to match objects to launches; n0, e0 and std mv used extensively to ID objects within launches.