The R.A.E. Table of Earth Satellites

1957 ~ 1992

And the extended table

1993 ~ 2016

Compiled at the

Royal Aerospace Establishment / D.G King-Hele, D.M.C. Walker,

Defence Research Agency A.N. Winterbottom, J.A. Pilkington,

Farnborough, England H. Hiller, G.E. Perry

Revised, extended and updated by

L.J.C. Barhorst

Almere, The Netherlands

1.0 Foreword

The RAE Table of Earth Satellites was published by RAE and later by DRA up to 1992. As a yearlong subscriber to the monthly updates I much appreciate the effort that was put in to compile the table. Although the table was continued as the World Wide Satellite Launches by Phillip Clark in a somewhat different layout and with updates to launches in 1957-1992; the need for a big update has become clear from my fellow satellite observers around the world. A digital form is preferred to make further updates easier.

Several updates have been made:

 Conversion of the Greek nomenclature for the years 1957-1962, in dark blue

 Adding the Norad Catalogue numbers, in pink

 Adding and updating Launch vehicle info, in [ ] in red

 Adding Launch site and launch platform, in sky blue

 Renaming pieces of debris to rocket-stages, despin-weights etc.

 Decay dates and lifetimes were added for decayed objects, in red

 Adding recent orbital information, in lime

 Including full details for Space Vehicles from the DRA table of Space Vehicles 1958-1991, in red

 For launches with a lot of fragments details are given in extra pages at the end of the year

1.1 History

## Version 1.0 (2004 May)

In 2000 I've started to scan the RAE Table 1957-1992 and converting it to Word2000 documents, one for each year. The last file was completed in October 2003; although not all years have been updated with recent orbital information for the objects still in orbit.

*Version 1.01 (2004 December 31)*

From October 2003 till the end of December 2004 updates to the tables have been made with respect to new fragments, decay dates and lifetimes, recent orbital information for the objects still in orbit and extra info on the fragmentation of satellites from "History of on-orbit satellite fragmentations", 13th edition, May 2004, Orbital Debris Program Office, Johnson Space Centre, NASA, Houston, TX 77058.

Also the layout was changed with respect to the text colour of the launch site and the recent orbital information.

Making the table complete and the updating will continue. New versions will be published on my homepage. Version 1.01 was started 2004 June 1 and completed 2005 January 2.

*Version 1.02 (May 2005)*

From February till May 2005 the debrispages for the years 1993-2005 were added as an extension of the table.

Also for the years 1957-1964 the extra orbital information for decayed objects was added.

*Version 1.03 (2005), published in January 2006*

For the year 1965 the extra orbital information for decayed objects was added.

Al the years have been updated with newly catalogued objects, decaydates and lifetimes.

In August a start was made with the main pages for the years 1993-present. The pages are combined with the debris-pages for that year.

Page numbering is per year and the page title has the word ‘extended’ in it. The years 1993, 1994, 2000, 2004 and 2005 are ready now.

*Version 1.04 (2006), published in May 2006*

Due to a fire on my houseboat in March 2006 and the following repair I had little time for the table.

However several additions and updates have been made in march and april 2006 and the years 1995-1999 have been added. Also a draft version of 2006.

*Version 1.05 (2007), published in March 2007.*

In the autumn of 2006 work started on the remaining years to be added to the table; 2001-2003 and the rest of 2006. All the launches were added, but not the orbital information except for 2006. So the table is now complete for 1957-2006. Work will continue to add the (recent) orbital information to the years from 1966 onwards.

For the year 2007 a draft version was made with recent launches and a section Launch schedule. Once launched the entry will move to the main table.

*Version 1.06(2007)*

This is an interim version I used in 2007 to update the table. This version was not published on the website.

The launch schedule was removed from the RAE2007 file and is now a separate file.

*Version 1.07 (published January 2008).*

In this version are all the new launches and additions up to 2008 Jan 20. In all the files the recorded changes to the documents were accepted. So these files are ‘clean’ Word2003 documents.

*Version 1.08 (not published)*

*Version 1.09 (published April 2010).*

In march 2008 I moved from Medemblik to Almere. Both 2008 and 2009 were very busy years for me at work, so little could be done to update the tables. In November 2009 I had holiday for some weeks and updated the 2008 file with launches and most of the orbital data. Still working on 2009, which is in draft form up to launch nr 30. In some other year lists info on fragments and decayed objects is added.

*Version 1.10 (not published)*

*Version 1.11 (published January 2012).*

The RAE tables 2010 and 2011 have been compiled. Several RAE tables have been updated with orbital data. Only the years 2001, 2002 and 2003 still have to be updated.

*Version 1.12*

Not published

*Version 1.13 (published partly in 2013, 2014 and complete in January 2015)*

The RAE tables 2012, 2013 and 2014 have been compiled. Updates have been made to the other tables with decays and orbital information.

*Version 1.14 (published in mid 2015)*

The RAE tables 1957-1969 have been updated with orbital information.

The RAE table 2015 (1st part) has been compiled

*Version 1.15 (published 12 July 2016*

The RAE tables 2015 (2nd part) and 2016 (up to launch 2016 44) have been compiled.

1.2 Availability

The most recent version is available on my website at http://www.satlist.nl

Remarks and additions are well appreciated and may be emailed to the address on my website.

1. The Tables

Per year the table is divided in two sections, the main and the fragment section.

The last section was added for the fragments from the launches with a lot of fragments.

* 1. Main section

The main section follows mostly the original table. Added are Noradnumber, launch site and platform, new fragments, new decay dates and lifetimes, recent orbital information. The original page numbering was followed, although in several cases entries were switched to a previous or next page to make room for the entry of Space Vehicles and renaming of fragments to rocket stages, shrouds etc. In this case the original page number is in the footnote.

The heading of the main section has slightly been altered and is explained below.

Year of Launch 1957 RAE Table of Earth Satellites (Revised 2001) Page 1

 Name Cospar ID Launch date Shape and Size Date of Orbital Nodal Semi Perigee Apogee Orbital Argument

 [Launcher] [Norad#] Launchsite Lifetime and descent date weight (kg) (m) orbital Inclination period major axis height height eccentricity of perigee

 Fragment Cospar ID [Norad#] Descent date Lifetime determination (deg) (min) (km) (km) (km) (deg)

Line 1 gives beside the obvious entries also the revision year in red, this is the year in which most of the revision was done.

The next 3 lines are described per column. For column 1-5 line 1 and 2 refer to the main entries of the satellite(s), launcher stages and known parts such as nose caps, shrouds, ullage rockets etc. Line 3 refers to fragments in the main table.

The rest of the columns are the same as in the original table. A full explanation is given in the Introduction.

Additions to the original text are in red. The other colours are explained in chapter 1.0.

The letters to the left of column 1 are the same as in the original tables. However I have omitted the T, as most satellites launched up to the end of 1992 are now well beyond their expected transmitting lifetime, with the exception of several deep space probes and the most recent geostationary communication satellites with an operational lifetime up to 15 years.

The launch sites are given by abbreviations. When a launch pad or –complex is known, it is indicated after a – by LC and the number.

|  |  |  |  |
| --- | --- | --- | --- |
| BAI | Baikonour – USSR/Russia | CC | Cape Canaveral - USA |
| PLE | Plesetsk – USSR/Russia | VDB | Vandenberg - USA |
| KY | Kapustin Yar – USSR/Russia | WLI | Wallops Island - USA |
| SMC | San Marco Indian Ocean Platform - Italy | HAM | Hammaguir - France |
| KAG | Kagoshima - Japan | KOU | Kourou - Europe |
| TAN | Tanegashima – Japan | JIUQ | Jiuquan - China |
| WMR | Woomera – Australia | WUZ or TAI | Wuzhai – China (aka Tai Yuan) |
| PMC | Palmachin - Israel | XI | Xichang - China |
| SRI | Sriharkota - India | ODS | Odyssey Floating Launch Platform |
| VOS | Voschiny - Russia | WSLC | Wenchang - China |

* 1. Fragment section

In this section the fragments from launches with a lot of fragments are listed. This was done to prevent the main section becoming too big. The pages are numbered Extra Page Year – Page number.

Year of Launch 1992 RAE Table of Earth Satellites (Revised 2001) Extra Page 1992 - 5

 Date of Orbital Nodal Semi Perigee Apogee Orbital Argument

 Cospar ID [Norad number] Descent date Lifetime orbital Inclination period major axis height height eccen- of perigee

 determination (deg) (min) (km) (km) (km) tricity (deg)

Text in box is from "History of on-orbit satellite fragmentations", 13th edition, May 2004.

Orbital Debris Program Office, Johnson Space Centre, NASA, Houston, TX 77058.

1. Permission
	1. RAE

To get permission to use the data in the RAE tables I wrote to RAE/DRA the following letter.

*Mr. Alan Winterbottom*

*R14 Building, DRA*

*Farnborough*

*Hampshire*

*GU 14 6 TD*

*United Kingdom*

*Medemblik, March 18, 2001.*

*Dear Mister Winterbottom,*

*I'm writing to you in respect to the RAE Table of Earth Satellites, which was published by RAE up to 1992. As a yearlong subscriber to the monthly updates I much appreciate the effort that was put in to compile the table.*

*Although the table was continued as the World Wide Satellite Launches by Ph. Clark in a somewhat different layout and with updates to launches in 1957-1992; the need for a big update has become clear from my fellow satellite observers around the world.*

*A digital form is preferred to make further updates easier.*

*Last year I've started to scan the RAE Table 1957-1989 and converting it to a Word2000 document.*

*Several updates has been made:*

* *Conversion of the Greek nomenclature*
* *Adding the Norad Catalogue numbers*
* *Renaming pieces of debris to rocket-stages, despin-weights*
* *Decay dates and lifetimes*
* *Adding recent orbital information for objects still in orbit*
* *Including full details for Space Vehicles*
* *For launches with a lot of fragments details are given in extra pages at the end of the year*

*I've included the first 9 pages of the Table (1957-1960) as an example.*

*At the moment I'm updating 1967.*

*I'll make this publication available on the Internet; but before doing so I'm asking permission to use the date from the Table. I'm not sure you're the right person to ask this permission. If not please inform me where to ask for it.*

*I can be reached by email too at: leobarhorst@zonnet.nl*

*Sincerely yours,*

*Leo Barhorst*

*Klinkhamer 5A*

*1671 NH Medemblik*

*The Netherlands*

In response I received this letter.

*Farnborough, March 29, 2001.*

Dear Leo

Thank you for your letter of March 18 and the sample pages of the Table
that you have produced. I am pleased to see that you have the time and
energy to update the Tables, as it is such a large undertaking.

I have talked to Graham Davison, who is the Head of Space Department at
DERA (as we are currently known), and he is happy for you to use the
data from the Satellite Tables as you have planned.

I would be interested to know the Internet address when your publication
is available on the www.

Best regards

Alan Winterbottom
Space Dept.
A8 Building
DERA Farnborough
Hampshire
GU14 0LX
Tel: 1252 394390
Fax: 1252 396330

I also received by email the original layouts for 1990-1992 compiled by Geoffrey Perry. This was much appreciated. It saved me time in not having to scan, OCR and edit these years.

* 1. USSTRATCOM

In September 2005 I received by email approval from USSTRATCOM to use the data from the Spacetrack Website.

Mr. Barhorst,

 Your request to redistribute Bulk TLEs, Satellite Situation Reports and Catalog reports is approved.

 See attached.

Regards,

 JOSEPH E. GUZMAN

MAJ, USA

USSTRATCOM Orbital Data Release Authority

In September 2006 and 2007 the approval was extended for 1 year.

On 2009 July 28 the approval was extended for 1 year.

In December 2011 the approval was renewed:

Van: McKissock, Diana L Civ USAF AFSPC 614 AOC/COD [diana.mckissock@vandenberg.af.mil] namens Vandenberg/Form 1 Requests [form1@vandenberg.af.mil]

Verzonden: dinsdag 13 december 2011 20:06

Aan: Barhorst L.J.C. (Leo)

CC: Dunagan, Erin M Capt USAF AFSPC 614 AOC/CODO; Thao, Theresa L LT USN AFSPC JFCC SPACE/CODS; Puckett, Erin N CTR USSTRATCOM AFSPC JFCC SPACE/J35; Anding, Douglas J CTR USSTRATCOM AFSPC JFCC SPACE/J35; Mcduffie, Adrienne D. (GSFC-595.0)[HONEYWELL TECHNOLOGY SOLUTIONS INC]

Onderwerp: Approved: ODR 11-065

Hello Mr. Barhorst,

Your request to redistribute data from www.space-track.org has been

approved. My apologies for the delay in responding to your ODR. If you have

any questions, please don't hesitate to contact us.

Best regards,

Diana

//SIGNED//

Diana McKissock

Orbital Data Request Coordinator

Joint Space Operations Center / 614 AOC/COD

Vandenberg Air Force Base, California

Comm: 805-606-8259 / DSN: 276-8259

form1@vandenberg.af.mil

Further redistribution renewals were approved 2012, 2013, 2014 Jan 16, 2014 Dec 21 and 2015 Dec 3.Introduction 1957-1989

This is the original introduction from the 1957-1989 Tables issued by RAE in 1990.

THE RAE TABLE OF EARTH SATELLITES

1957-1989

THE RAE TABLE OF EARTH SATELLITES

1957-1989

compiled at

The Royal Aerospace Establishment, Farnborough, Hants, England

by

D.G. Mng-Hele, FRS, D.M.C. Walker, PhD, A.N. Winterbottom,

J.A. Pilkington, B.Sc, H. Hiller, B.Sc and G.E. Perry, MBE

*The Table is a chronological list of the 3196 launches*

*of satellites and space vehicles between 1957 and theend of 1989, giving the name and internationaldesignation of each satellite and its associated*

*rocket(s), with the date of launch, lifetime (actual or*

*estimated), mass, shape, dimensions and at least one*

*set of orbital parameters. Other fragments associated*

*with a launch, and space vehicles that escape from the*

*Earth's influence, are given without details. Including*

*fragments, more than 20000 satellites appear in the*

*1006 pages of the tabulation, and there is a full index*

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Hants, GUI4 6TD.

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Printed at Royal Aerospace Establishment,

Farnborough, Hants, England

INTRODUCTION

**HOW THE TABLE BEGAN AND GREW**

When the first satellite Sputnik 1 was launched on 4 October 1957,scientists at the Royal Aircraft Establishment, Farnborough, had already madeseveral studies of Earth satellites and their orbits, stemming from work earlier

in the 1950s on the ballistic missile Blue Streak and the Skylark research

rocket. Within a few days of its launching, Sputnik 1 was being regularly

tracked by a radio interferometer constructed at the RAE's outstation at Lasham,

Hampshire. The satellite's orbit was determined from these observations, and the

observed decay rate was used to evaluate upper-atmosphere density.

The work was described in an article published in Nature on 9 November 1957

(Volume 180, pages 937-941).

On 3 November 1957, Sputnik 2 was launched, and the need for a regular

prediction service was recognised. Initially the service was provided by the

Royal Greenwich Observatory, Herstmonceux, and was taken over by the RAE in

January 1958. The first US satellite Explorer 1 was launched on 1 February 1958,

to be followed by Vanguard 1 and Explorer 3 during March, and Sputnik 3 in May.

Soon there were numerous requests for a list of satellites, and Doreen Walker,

who was responsible for providing the predictions, compiled the first RAE Table

of satellites - a single sheet - in July 1958. From these small beginnings the

Table has 'just growed', the original format being retained almost unchanged,

apart from conversion to metric units. Very few copies of this 'first edition'

still exist, so a facsimile of the original sheet, slightly reduced in size, is

printed on page ii.

From the beginning it was apparent that there would be little information

available on the sizes, shapes and masses of the many Russian rockets in orbit,

and the decision was taken to make rough estimates of the size and shape from

visual observations, and then to deduce the mass from the observed orbital decay

rate and the (by then) known upper-atmosphere density. This policy has been

pursued ever since, and the estimates have been improved over the years as more

information became available, especially during the past two years.

Since 1957 the RAE has specialised in the analysis of satellite orbits to

determine upper-atmosphere density and winds, and the Earth's gravitational field.

TABLE OF ARTIFTCIAL SATELLITES

 Orbital Orbital Perigee Apogee Orbital Angle from

 Launch date Shape and size Date Incline- Period Height Height Eccen- Apex

 Name and Lifetime Weight tion tricit to perig. (deg.) (min.) (n.m.) (n.m.) (deg.)

Sputnik 1 1957α2 1957 Oct. 4.90 Sphere 23'' dia. 1957 Oct 4.90 65 96.2 122 512 0.052 - 39

instrumented sphere ? 92 days 184 lb. 1957 Oct.25.8 65 95.4

Sputnik 1 1957αl 1957 Oct. 4.90 Cylinder? - 1957 Oct. 4.90 65 96.2 122 512 0.052 - 39

rocket 57.1 days - 1957 Nov.19.00 65 92.0

Sputnik 2 1957 β 1957 Nov. 3.19 - - 1957 Nov. 4.00 65.33 103.760 122 902 0.0987 -31

 161.9 days - 1958 Jan. 4.0O 65.29 100.505 119 739 0.0802 -55

 1958 Feb.21.00 65.26 97.iO5 114 570 0.0605 -76

 1958 Mar.25.00 65.23 93.785 107 402 0.0400 -91

 1958 Apr. 9.00 65.21 90.730 97 253 0.0214 -93

Explorer 1 1958 α 1958 Feb. 1.16 Cylinder 80"long 1958 Feb. 1.16 33.2 1l4.8 199 1371 0.139 31

 4 years 30.8 lb. 6" dia. 1958 July10.05 33.2 113.5 192 1318 0.134 33

Vanguard 1 1958β2 1958 Mar.17.5 Sphere 6.4" dia. 1958 Mar.17.5 34.3 134.1 353 214O 0.191 - instrumented sphere 200 years? 3¼ lb. 1958 June19.52 34.3 134.1 353 2136 0.190 92

Vanguard I 195βl 1958 Mar.17.5 Cylinder 4' long 1958 Mar.17.5 34.3 134.1 353 2140 0.191 -

rocket 50 lb. 20" dia.

Explorer 3 195Bγ 1958 Mar. 26.73 Cylinder 80" long 1958 Mar.26.73 33.3 1l5.7 101 1511 0.166 -

 94 days 31 lb. 6" dia. 1958 Apr. 9.05 33.3 110.4 100 1251 0.140 -

 1958 June 14.13 33.3 96.6 93 565 0.063 -124

Sputnik 3 1958δ2 1958 May 15.3 Cone 12.3' long 1958 May 15.3 65 105.985 122 1013 0.111 -32

instrumented cone 2 years 2926 lb. 68" dia. 1958 June 5.7 65 105.700 122 1000 0.110 -39

 1958 July 9.2 65 105.300 122 979 0.107 -50

Sputnik 3 1958δ1 1958 May 15.3 CyLinder.1 - 1958 May 15.3 65 105.985 122 1013 0.111 -32

rocket 7 months - 1958 June 8.1 65 105.000 124 964 0.106 -40

 1958 July 2.2 65 114.000 121 914 O.100 -48

Notes: Oct. 4.90 means 21 hr. 36 min. G.M.T. on 4 Oct., 1 n.m. = 6080 ft., Perigee and apogee heights for Sputniks are over an earth of

radius 3435 n.m. The values for the Sputniks are from observations and theory. Those for the U.S. satellites have been compiled

from a variety of sources, and there may be inconsistencies.

 Facsimile of the original issue of the Table

 This work depends on choosing satellites for observation, determining the orbits

 from the observations, and then analysing the orbits. In order to choose suit-

 able satellites, a listing like that in the Table is needed, including reasonably

 accurate estimates of the satellite lifetimes. These lifetime estimates are

 vital, because it is no good selecting a satellite for long-term studies of the

 gravitational field, only to find that it decays within two years. Conversely,

 it is no good selecting a satellite for studies of atmospheric winds if no useful

 results can be obtained fox thirty years or more.

 The estimation of lifetime has proved to be the most creative and difficult

 aspect of the Table. The orbits of most satellites are appreciably affected by

 the drag of the upper atmosphere, which makes the orbit contract and eventually

 brings the satellite to a fiery end in a plunge into the lower atmosphere. The

 lifetime is controlled by the upper-atmosphere density: if the density doubles,

 the lifetime will be halved. In fact, the density at a height of 500 km can be

 more than ten times greater at the maximum of the eleven-year sunspot cycle than

 at the minimum; and predictions of the intensity and timing of future sunspot

 maxima are notoriously unreliable. So it is very difficult to make good esti-

 mates for lifetimes greater than 5 years. On a shorter timescale, problems arise

 from the day-to-night variation in density, by a factor of up to 6; from the

 semi-annual- variation, by a factor of up to 3; and from irregular day-to-day

 variations. Also there are some satellites in highly eccentric orbits for which

 the lifetime is governed by the gravitational attraction of the Sun and Moon;

 lengthy computations are then needed, extending over the life of the satellite,

 perhaps 10 or 20 years. Balloon satellites form another unusual group, with

 their lifetime controlled by the radiation pressure of sunlight.

 Though the need for the Table of satellites arose from the work on orbit

 analysis, the Table was so appreciatively received, not only by individuals but

 also in official US and USSR publications, that we decided to continue sending it

 to qualified recipients. By 1980, however, the printing and distribution had

 become expensive and burdensome, and the choice of recipients had become

 difficult. So RAE welcomed the offer of Macmillan Press to publish the Table.

 The first edition, published in 1981, covered the years 1957-1980; the second,

 published in 1983, covered 1957-1982; the third, published in 1987, covered

 1957-1986. Now a fourth edition is called for, covering the years 1957-1989,

 and is published by the RAE.

 As before, the Table has been printed from the original masters, rather

 than being completely reset in type. However, many thousands of amendments have

 been made to the original pages and some pages have been retyped. This method

 suffers some slight inelegance from mismatching of type-faces no longer available,

 but has the great advantages of quicker production and better accuracy.

 The present volume is fully updated to the end of 1989; it supersedes all

 previous issues and will serve as the master copy for future amendment.

 The Table has grown to its present size only after much hard work, and the

 contributions of the compilers and others to the work over the years have been

 as follows. Desmond King-Hele has had general responsibility continuously from

 the outset. The detailed work was done by Doreen Walker between 1958 and 1961,

 and from then until 1968 mainly by Janice Rees, Alan Pilkington and Eileen Quinn.

 Since 1968 the Table has been issued monthly: the task of organizing data on the

 increasing traffic in space and identifying new launches was done by the late

 Harry Hiller from 1968 to 1980 and by Alan Winterbottom thereafter. With the

 aid of this information, the draft of each monthly issue was produced by

 Alan Pilkington from 1968 to 1984, and by.Geoffrey Perry from 1985 to 1989.

 Doreen Walker has been responsible for the lifetime predictions, and has also

 undertaken the exacting editorial and organisational work of updating and

 preparing the volumes for publication.

THE NUMBER OF LAUNCHES

 In 1957 there were two satellite launches, by the USSR; in 1958 there were

 eight, of which seven were by the USA and one by the USSR. From then until 1967

 the total numbers of launchings of satellites and space vehicles increase every

 year except 1963, and the yearly total for 1967 was 127 launches. During the

 next twenty years the world changed greatly, and most activities either strongly

 increased or seriously declined; but the annual numbers of space launchings

 changed surprisingly little. The maximum annual number of launches between 1965

 and 1989 was 129 in 1984 and the minimum was 101 in 1989. The average number of

 launches annually in the years 1965-1989 was 116 (ignoring decimals of a launch,

 which are difficult to visualise). The total number of launches for 1957-1989

 was 3196.

 The diagram opposite shows the yearly numbers of launches of satellites and

 space vehicles in histogram form, with division into launches by the USSR

 (spotted stippling), the USA (dark stippling) and 'others' (light stippling).

 The 'others' include launches by other countries and 'joint' launches, for

 example launches by the USA for international organisations like Intelsat, or by

 the USSR for the Intercosmos consortium. The European launches with the Ariane

 rocket are also counted among the 'others'.

 The diagram shows that the USA had more launches than the USSR in each year

 between 1958 and 1966, but the situation reversed in 1967. During the 1970s the

 preponderance of USSR launches continued, and increased; in the years 1980-1989

 the proportions were: 80% USSR; 12% USA; and 8% others.

 After the USSR and USA, the next country to launch a satellite with a

 home-made rocket was France in 1965. Five years later, Japan became the fourth

 space-launching country, soon followed by China (1970) and the UK (1971). There

 was then another long interval before the appearance of the seventh country,

 India, in 1980, and the eighth, Israel in 1988.

 The 3196 launches are tabulated year by year in 30 categories in the table

 on page vi. The first 8 categories are national launches. Then come 22 'joint'

 categories, with the launching country first. One of these, USA/Shuttle (31

 launches) is treated as 'USA' in the diagram above. The rest are treated as

 'others' in the diagram, and include USA/Intelsat (34 launches), USSR/Intercosmos

 (24) and Europe/Ariane (30).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year of Launch | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | Total |
| Country of origin |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| USSR | 2 | 1 | 3 | 3 | 6 | 20 | 17 | 30 | 48 | 44 | 66 | 74 | 68 | 79 | 81 | 70 | 83 | 79 | 85 | 97 | 96 | 87 | 84 | 89 | 94 | 101 | 98 | 97 | 97 | 91 | 95 | 89 | 73 | 2147 |
| USA |  | 7 | 11 | 16 | 29 | 50 | 38 | 55 | 60 | 72 | 53 | 41 | 33 | 23 | 25 | 24 | 21 | 13 | 23 | 21 | 15 | 25 | 15 | 12 | 13 | 11 | 16 | 13 | 5 | 5 | 7 | 9 | 12 | 773 |
| Japan |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 2 | 1 |  | 1 | 2 | 1 | 2 | 3 | 2 | 2 | 3 | 1 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 38 |
| China |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  |  |  | 3 | 2 |  | 1 |  |  | 1 | 1 | 1 | 3 | 1 | 2 | 2 | 4 |  | 23 |
| France |  |  |  |  |  |  |  |  | 1 | 1 | 2 |  |  | 1 | 1 |  |  |  | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 9 |
| India |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  | 1 |  |  |  |  |  |  | 3 |
| UK |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
| Israel |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  | 1 |
| USA/Intelsat |  |  |  |  |  |  |  |  | 1 | 1 | 3 | 1 | 3 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 2 |  | 1 | 2 | 2 | 1 | 1 | 3 |  |  |  |  | 34 |
| USA/Shuttle |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 2 | 3 | 4 | 5 | 9 | 1 |  | 2 | 5 | 31 |
| Europe/Ariane |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  | 2 |  | 2 | 4 | 3 | 2 | 2 | 7 | 7 | 30 |
| USSR/Intercosmos |  |  |  |  |  |  |  |  |  |  |  |  | 2 | 2 | 1 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 2 |  | 2 |  |  |  | 1 |  |  |  | 1 | 24 |
| USA/UK |  |  |  |  |  | 1 |  | 1 |  |  | 1 |  | 1 | 1 | 1 |  |  | 4 |  |  |  |  | 1 |  | 1 |  |  | 1 |  |  |  |  | 1 | 14 |
| USA/Europe |  |  |  |  |  |  |  |  |  |  |  | 3 | 1 |  |  | 3 |  |  | 1 |  | 3 | 2 |  |  |  |  |  |  |  |  |  |  |  | 13 |
| USA/Canada |  |  |  |  |  | 1 |  |  | 1 |  |  |  | 1 |  | 1 | 1 | 1 |  | 1 | 1 |  | 1 |  |  |  | 1 |  |  |  |  |  |  |  | 10 |
| USA/Italy |  |  |  |  |  |  |  | 1 |  |  | 1 |  |  |  | 1 |  |  | 1 |  |  | 1 |  |  |  |  |  |  |  |  |  |  | 1 |  | 6 |
| USA/NATO |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  | 1 | 1 | 1 |  |  |  |  |  | 1 |  |  |  |  |  | 6 |
| USSR/France |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 | 1 |  | 1 |  | 1 |  |  |  | 1 |  |  |  |  |  |  |  |  | 6 |
| USA/FRG |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  | 2 |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |
| USA/France |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  | 1 |  |  | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 |
| USSR/India |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  | 1 |  | 1 |  |  |  |  |  |  | 1 |  | 4 |
| USA/Indonesia |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 | 1 |  |  |  |  |  |  |  |  |  | 1 |  |  | 3 |
| USA/Japan |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 2 | 1 |  |  |  |  |  |  |  |  |  |  |  | 3 |
| USA/Australia |  |  |  |  |  |  |  |  |  |  | 1 |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 2 |
| France/FRG |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
| USA/India |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  | 1 |
| USA/Netherlands |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
| USA/Spain |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
| USA/FRG/UK |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
| USA/Netherlands/UK |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  | 1 |
| Total | 2 | 8 | 14 | 19 | 35 | 72 | 55 | 87 | 112 | 118 | 127 | 119 | 110 | 114 | 120 | 106 | 109 | 106 | 125 | 128 | 124 | 124 | 106 | 105 | 123 | 121 | 127 | 129 | 121 | 103 | 110 | 116 | 101 | 3196 |

 THE PURPOSE OF THE LAUNCHINGS

 Launching a satellite is an expensive exercise, and, on the assumption that

 human affairs still retain some relics of rationality, it is reasonable to ask

 what was the purpose of the launchings. The difficult task of assigning the

 launches to particular categories was undertaken by Dr Charles Sheldon (iii

 "United States and Soviet Progress in Space", US Congressional Research Service

 Report 81-27, 1981). The figures following are based on his findings.

 He divides the launches into two main groups, military and civil. About

 60% of the launchings have been primarily military, the proportion being greater

 for the USSR than for the USA. In this military group, more than half have been

 photographic-reconnaissance satellites, about 10% have been for communications,

 rather less than 10% for navigation, and the remainder for a variety of purposes,

 such as early warning of missile attack, ocean surveillance, electronic 'listen-

 ing in', and tests of satellite interception.

 In the civil group of launchings, about 40% have had scientific research as

 their aim: most of these satellites were designed to examine the Earth and its

 environment; other targets for research have been the planets, the Sun, the Moon

 or the stars. Nearly 20% of the civil group have been communications satellites,

 more than 10% weather satellites, and rather less than 10% manned satellites.

 Among the others have been many development satellites, for testing new

 instruments or engineering techniques, and a few satellites for the mapping of

 Earth resources.

 NAMES AND DESIGNATIONS

 Each launching organisation likes to give each of its satellites a 'pet

 name' to be used by those working with the data from it. Many of these national

 names are familiar - Apollo, Ariel, Cosmos, Skylab, and so on - but some are

 weird acronyms like Spades (Solar Perturbation of Atmospheric Density Experiments

 Satellite); sometimes two agencies use the same name (Geos is an example); and

 some satellites remain nameless.

 To bring all space launches into a single system', the International Commit-

 tee on Space Research (known as COSPAR) has given all satellites and fragments an

 international designation based on the year of launch and the number of success-

 full launches during the year. Thus the British satellite Prospero is designated

 1971-93A, because it was launch 93 of the year 1971. Usually the letter A is

 given to the instrumented spacecraft, B is given to the rocket and C, D, E,

 to fragments, the letters 1 and 0 being omitted. Thus 1971-93B is the rocket

 that accompanied Prospero into orbit and 1971-93C is a fragment - an aerial that

 was knocked off during injection into orbit. If several spacecraft are sent into

 orbit in one launch, they are usually given the letters, A, B, C, thus in

 the many eight-satellite launches by the USSR, the satellites are designated A-H

 and the rocket is J . When there are more than 24 pieces from one launch, as can

 happen after an explosion, the sequence continues after Z with AA, AB,

 AC, ... AZ, and then BA, BB, BC, ... BZ, and so on. The greatest number of

 fragments so far catalogued from one launch is 489, resulting from the explosion of

 the Ariane third stage, 1986-19C.

 Besides reducing confusion, the international designation is useful because

 it gives not only the year but also the approximate month of launch. Since 1965

 there have been approximately 10 launches per month, so the month of launch can

 be approximately estimated from the designation. Thus Prospero (1971-93A) would

 be assigned to approximately the 10th month of 1971, and it was in fact launched

 on 28 October 1971. Obviously there may be an error of one or two months because

 of the variation in the annual numbers of launches.

 In the years 1957-1962 a different system was used, in terms of the 24

 Greek letters. Thus the first launch of 1960 was 1960 alpha (1960 (α), the second

 1960 beta (1960 β), and so on. After 24 launches, double letters were used with

 αα, ββ, ... for launches 25, 26, The names of the Greek letters are

 listed on page xviii.

 In the Table (pages 1-1006) the national names are given first, followed by

 the international designations. The listing is chronological.

 The index (pages 1007-1056) gives the national names, listed alphabeti-

 cally, with the corresponding international designations and the appropriate page

 numbers. The full names of all satellites known by acronyms also appear in the

 index.

 SATELLITE ORBITS

 Readers who are unfamiliar with orbits may welcome an explanation of the

 terms used on each page of the Table to specify the size, shape and orientation

 of the orbits.

 A satellite succeeds in entering orbit if its launching rocket can take it

 above the dense atmosphere and propel it nearly horizontally at a high enough

 speed. If the orbit is near-circular, 150 km may be regarded as the minimum

 height for avoiding rapid attrition of the orbit by air drag, and at this height

 the minimum velocity for attaining orbit is 7.8 km per second. If the launcher

 injects the satellite into

 orbit horizontally (at a high

 Perigee P enough speed), the satellite

 will fly out to a greater

 height at the opposite side of

 ... the Earth, and will enter an

 th elliptic orbit, as shown in

 the diagram. The point P on

 OC the ellipse where the satel

 lite comes closest to the

 Earth is called the perigee

 and the point of maximum

 height is the apogee, A

 The height of a satel-

 lite's orbit is specified by

 its average distance from the

 Apogee A Earth's centre, that is, half

 the sum of the apogee and

 perigee distances. This average distance, usually denoted by the symbol a , is

 called the semi major axis, the major axis being the distance AP between

 apogee and perigee, the longer diameter of the ellipse. For a circular orbit the

 semi major axis is of course the radius of the orbit.

 The distance of perigee and apogee from the Earth's centre are not very

 useful quantities to tabulate: what we need to know is the height of perigee

 and apogee above the Earth's surface, and the Table gives perigee and apogee

 heights above a spherical Earth of radius 6378 km (the equatorial radius). In

 practice both the perigee distance and the Earth's radius vary with latitude, so

 the simple definition above is not exact, but it usually gives heights within

 20 km of the instantaneous perigee and apogee heights and therefore provides a

 good general guide to the height of a satellite at perigee and apogee.

 The shape of a satellite orbit is specified by its eccentricity, defined

 as the apogee height minus the perigee height, divided by the major axis. Thus a

 satellite with semi major axis 7500 km, perigee height 300 km and apogee height

 1944 km, would have an eccentricity of 1644/15000 = 0.110. If the orbit is

 circular, the perigee and apogee heights are equal, and the eccentricity is zero.

 In practice, nearly circular orbits are convenient for many purposes, and a large

 proportion of actual orbits will be found to have eccentricities less than 0.01.

 The major axis of a satellite's orbit also decides its orbital period,

 the time it takes to go once round the Earth. The orbital period can be as low

 as 88 minutes if the average height is 200 km; the orbital period is about 90

 minutes when the average height is 300 km; it is about 92 minutes when the height

 is 400 km; and so on, with periods of 100 and 120 minutes corresponding to aver-

 age heights of about 800 km and 1700 km respectively. If we go out further, an

 orbital period of 12 hours occurs when the average height is 20000 km; and the

 period is 24 hours when the average height is 36000 km. Since the Earth rotates

 once, relative to the stars, every 23 hours 56 minutes (1436 minutes), a satel-

 lite in an eastbound equatorial orbit with a period of 1436 minutes keeps pace

 with the Earth's rotation and appears stationary as seen from the Earth. This is

 the synchronous orbit much favoured for communication satellites, and many near-

 synchronous orbits will be found in the Table.

 There are several possible definitions of orbital period, and that used in

 the Table is the nodal period, defined as the time between successive northward

 crossings of the Earth's equator by the satellite. (Another possible definition,

 not used here, is the time from one perigee to the next, the anomalistic period.)

 As well as the size and shape of an orbit, we need to know whether it goes

 over the poles or stays near the equator. This is specified by the inclination

 of the orbit to the equator, that is, the angle i between the orbital plane and

 the plane of the Earth's equator as shown in the diagram opposite, where the

 track is assumed to be over a spherical 'Earth'. The point N , where the orbit

 crosses the equator going north, is called the ascending node, whence the name

 'nodal period' previously defined.

 The orbital inclination, given for each satellite in the Table, tells us

 the maximum latitude attained by a satellite as it travels round the world: the

 maximum latitude is equal to the orbital inclination, if we ignore small pertur-

 bations. Thus an inclination of 90' implies an orbit passing directly over the

 north and south poles on each revolution; an orbit of inclination 50' passes

 over all latitudes between

 50'N and 50'S; while an orbit

 of inclination 100 is confined

 to latitudes less than 100.

 The next orbital para-

 meter is the argument of

 perigee, which specifies the

 position of the perigee P

 ecilator relative to the equatorial

 plane. The argument of

 perigee is defined as the

 angular distance round the

 orbit between the ascending

 0 node N and the perigee P

 and it is given by the angle

 NCP in the diagram, where C

 is the Earth's centre. The

 interpretation of the argument of perigee is fairly obvious from the diagrami but

 is listed below for reference.

 Argument of perigee Corresponding geographical position of perigee

 0 0 At equator going north (N in the diagram)

 0 0 - 9 0 0 In northern hemisphere with satellite going north

 900 At maximum latitude north

 9 0 0- 1 8 0 0 In northern hemisphere with satellite going south

 1800 At equator going south

 1800-2700 In southern hemisphere with satellite going south

 2 7 0 0 At maximum latitude south

 2700-3600 In southern hemisphere with satellite going north

 One further orbital parameter, not given in the Table, is the longitude of

 the node; this is of less significance, though orbital specialists would have

 welcomed its inclusion.

 GUIDE TO THE TABLE

 The data given in the main Table, for all satellites other than fragments,

 are as follows.

 Column 1 gives the name of the satellite and its international designation.

 If the name is unknown, the launching vehicle is indicated in square

 brackets. Doubtful entries are distinguished by question marks.

 Letters to the left of Column 1 have the following meanings:

 B denotes unmanned satellites which carried live biological specimens.

 D denotes satellites no longer in orbit on 1 January 1990. (For frag-

 ments, D indicates that all have decayed; ld indicates that one

 has decayed; 2d indicates that two have decayed, and so on.)

 L denotes satellites with retroreflectors for laser tracking.

 M denotes manned satellites; 2m indicates a crew of two at launch;

 etc.

 p indicates that pieces were picked up on Earth after re-entry.

 R denotes satellites which returned to Earth and were recovered intact.

 R denotes satellites carrying capsules which were successfully

 recovered.

 T denotes satellites still transmitting radio signals on 1 January 1990.

 Column 2 gives the launch date, lifetime (actual or estimated), and descent

 date (if appropriate). The dates are given in days and decimals of a

 day UT. Thus 1979 May 18.70 means 1116h 48m UT (or GMT) on 18 May

 1979". Actual lifetimes are given in days (and decimals of a day, if

 known). Estimated lifetimes are given in years, with decimals or

 fractions of a year as appropriate. Manoeuvrable satellites still in

 orbit on 1 January 1990 have 'manoeuvrable' in place of an estimated

 lifetime.

 Column 3 gives the basic shape of the satellite and its mass in kilograms

 (1 kg = 2.205 lb). Sometimes the shape defies description in a few

 words and the description given is only approximate.

 Column 4 gives the basic dimensions of the satellite in metres. Aerials,

 paddles carrying solar cells, and other components projecting from the

 main body are not normally taken into account when giving the size and

 shape (1 m = 3.281 ft).

 Column 5 gives the date for the orbital information in Columns 6-12.

 Column 6 gives the inclination of the orbit to the equator, in degrees.

 Column 7 gives the nodal period of revolution the time interval, in minutes,

 between successive northward equatorial crossings by the satellite.

 Columns 8-11 specify the size and shape of the orbit. The quantities tabulated

 are the semi major axis a , in kilometres; the eccentricity e ;

 and the perigee and apogee heights, {a(l - e) - R} and {a(l + e) - R}

 respectively, where R is the Earth's equatorial radius, 6378.1 km.

 (1 km = 0.6214 statute miles 3281 ft = 0.5396 nautical miles.)

 Column 12 gives the argument of perigee the angle, measured round the

 orbit, from the northward equatorial crossing to the perigee.

 The names of space vehicles (which have escaped from the dominance of the

 Earth's gravitational field) are given below the table, on the appropriate pages.

 The index (pages 1007-1056) gives the names of the satellites in alphabeti-

 cal order, with the international designation of each and the page on whi6h

 details may be found. Satellites which are not Russian or American may be found

 in the index by referring to the appropriate country.

 METHODS USED TO COMPILE THE TABLE

 Our chief difficulty has been the lack of accurate information about the

 size, shape and weight of most of the satellites. The majority of launchings are

 military, and little information is released about these satellites or their

 final-stage rockets; we have to rely largely on deductions from their Visual

 appearance in the night sky and on identifying previous launches of similar

 character. In contrast, we have full details of most international satellites.

 Names and designations of satellites

 The names given by the launching authorities are indicated when known. For

 unnamed United States Air Force satellites, the launch vehicle is given -in square

 brackets: the lists issued by the United Nations have been useful in identifying

 the launch vehicles and orbits for these satellites. Since June 1984, US mili-

 tary payloads have had 'coverall' names, USA 1, USA 2, etc.

 When a name is abbreviated to initials only, the meaning of the acronym is

 given as a footnote for the first satellite of that name. The full names are

 included in the index.

 The international designation of each satellite launching is allocated by

 the World Warning Agency on behalf of COSPAR. But the identification of parti-

 cular components in a multiple launch has often depended on visual observations,

 since an experienced visual observer can usually distinguish between a satellite

 and its rocket, and may be able to recognise the species of rocket or satellite

 being observed. Inevitably, however, there is a possibility of confusion in

 identifying components in a multiple launch.

 The techniques of visual observing are described in Observing Earth

 Satellites by D. King-Hele (Macmillan London, 1983).

 'Fragments' may be defined loosely as 'non-functional components', or, more

 precisely, as any components left over after accounting for the instrumented

 satellite, the various rocket stages and any other major mechanical component

 (such as Molniya 'launchers'). Fragments thus include cast-off heat shields, de-

 spin weights and inter-stage structures, as well as debris from explosions - the

 most prolific source of fragments.

 Life times

 The orbits of most satellites contract slowly under the action of air drag,

 and the severity of the drag determines their lifetimes, which can be estimated

 from the orbital decay rates (unless the satellites are later swept up as space

 rubbish, or suffer other major perturbations). The decay rate depends on air

 density, and the density depends critically on solar activity, which cannot be

 accurately predicted. So most lifetime estimates are likely to be in error by

 10% or more, and lifetime estimates of over 5 years may have much greater errors:

 if solar activity in future cycles should decline to the low levels prevalent in

 the late 17th century, lifetimes of 20-50 years given here would be seriously

 underestimated.

 For most satellites in high-eccentricity orbits, such as the Molniya

 satellites and rockets, the lifetimes depend primarily on lunisolar perturbations

 rather than air drag, and have been estimated by numerical integration.

 Methods for predicting lifetime are described in ESA SP-246, pages 29-37

 (1986) and, in more detail, in RAE Technical Report 87030 (1987). The underlying

 theory is given in Satellite Orbits in an Atmosphere by D. King-Hele (Blackie, 1987).

 Weights and dimensions

 The weights and dimensions of the satellites come from Spacewarn launch

 telegrams, NASA Press Releases, and press and radio reports. Some indication of

 the accuracy is given by the number of significant figures. Often it is diffi-

 cult to define the 'length' or 'diameter' when components of irregular size and

 shape are joined together, and dimensions are therefore sometimes approximate.

 For satellites of unknown mass and size, the average cross-sectional area

 S can be approximately determined from the average brightness when observed

 visually; the mass/area ratio m/S can be obtained from the rate of change of

 orbital period and the known air density at heights near perigee, to give a value

 for the mass m . Many of our values for the dimensions of Russian rockets rely

 on the detailed studies by Dr Charles Sheldon, in Soviet Space Programs 1971-75

 (US Government Printing Office, Washington, 1976).

 We hope that most of the weights and dimensions given with question marks

 are accurate to within a factor of 1.5, i.e. that the real values are between 2/3

 and 3/2 times the value given. It seemed better to give some indication of the

 weights and sizes, even if approximate, rather than to leave blanks.

 orbital accuracy

 Orbital information has come from many sources. Most of the orbits are

 based on the elements issued by the North American Aerospace Defence Command

 (NORAD),and the remainder come mainly from NASA and RAE orbits.

 The accuracy of the orbits varies greatly between one satellite and

 another, and no detailed guide can be given. Most orbits,, however, are believed

 to have an error (sd) of about 0.02° in orbital inclination, 0.02 min in period,

 2 km in semi major axis, 5 km in perigee and apogee heights (when the apogee

 height is less than 2000 km), 0.001 in eccentricity e , and perhaps 3° in

 argument of perigee (if e > 0.02). Some orbits are much more accurate than this,

 and some, particularly those with eccentricity exceeding 0.3 or with very short

 lifetimes, may be much less accurate.

Radio transmissions

 A satellite is given the symbol T if it transmits radio signals during

 its first days in orbit. The cessation of radio signals is rarely publicised, so

 the removal of the T is often based on the estimate that the average active

 life for radio transmission is about 21/2years for Soviet satellites and 7 to

 8 years for US satellites. The transmitting status of Soviet satellites is

 largely based on monitoring by the Kettering Group. The most complete list of

 radio frequencies of satellites is in Telecommunication Journal, Volume 44, No.2

 (1977), updated in subsequent monthly issues of Telecommunication Journal.

 Locations of geosynchronous satellites are not given, because they are

 subject to drift. Current locations are available in a list issued regularly by

 NASA Goddard Space Flight Center.

 LAUNCH SITES

 Launch sites are not indicated in the main Table, but the numbers of

 launches from each site, with the geographical location of the site, are given in

 the table below.

 Country Launch site Latitude Longitude Number of

 launches

 USSR Tyuratam (Baikonur) 45.6°N 63.4°E 847

 Kapustin Yar 48.4°N 45.8°E 83

 Plesetsk 62.8°N 40.1°E 1251

 USA Cape Canaveral (ETR) 28.5°N 81.O°W 396

 Vandenberg AFB (WTR) 34.7°N 120.6°W 484

 Wallops Island 37.9°N 75.4°W 1

 France Hammaguir 31.O°N 8.0°w 4

 USA/Italy Indian Ocean Platform 2.9°S 40.3°E 9

 (San Marco)

 Australia/UK Woomera 31.1°S 136.8°E 2

 Japan Uchinoura (Kagoshima) 31.2°N 131.1°E 18

 Tanegashima 30.4°N 131.O°E 20

 France/EurOPE Kourou 5.2°N 52.8°W 36

 China Shuang Cheng-tzu (Jiquan) 40.6°N 99.8E 17

 Xichang 28.1°N 102.3°E 5

 Wuzhai (Tlai Yuan) 37.8°N 111.5°E 1

 India Sriharikota 13.9°N 80.4°E 3

 Israel Palmachim 31.9°N 34.7°E 1

 ACKNOWLEDGMENTS

 In compiling the Table, our deepest debt is to the North American Aerospace

 Defence Command: for more than 25 years NORAD has (via NASA) supplied orbital

 elements on all satellites to the scientific community. We offer our grateful

 thanks to NORAD for this service, without which not only the Table but also much

 scientific work on orbit analysis would have been impracticable. Nearer home it

 is a pleasure to thank the Kettering Group for supplying exact recovery times for

 hundreds of Cosmos satellites; Leeds University for providing information on

 Cosmos 'Glonass' satellites; and the Commanding Officer and staff of RAF,

 Fylingdales for their essential assistance in making available orbital elements.

 We are also most grateful to a number of skilled visual observers who have been

 able to identify components in multiple launches. At RAE our debts are too

 numerous to specify individually: we particularly thank those who have for many

 years accurately filed the data on the 20000 satellites, and the many typists who

 have not only typed the Table skilfully and accurately but have also cheerfully

 tackled the far worse problem of making thousands of amendments to the masters.

GREEK LETTERS

 The Greek alphabet used in the designations of the satellites of 1957-1962

 is as follows:

 α alpha η eta ν nu τ tau

 β beta θ theta ξ xi υ upsilon

 γ gamma ι iota ο omicron φ phi

 δ delta κ kappa π pi χ chi

 ε epsilon λ lambda ρ rho ψ psi

 ζ zeta μ mu σ sigma ω omega

In the tables this has been converted to the nomenclature in use from 1963 onwards.

α becomes 01, β becomes 02 and so on till ω becomes 24. With more than 24 launches in one year double letters were used: αα = 25, αβ = 26, βα = 49 ect.

1. Introduction 1990-1992

This is the original introduction to the 1990-1992 tables.

DEFENCE RESEARCH AG

Farnborough

Hants

THE R.A.E. TABLE OF EARTH SATELLITES 1990-1992

SUMMARY

The R.A.E. Table of Earth Satellites 1957-1989 was published by the Royal

Aerospace Establishment, Farnborough in 1990, and included all launches to

the end of 1989. The present publication gives details of the 299

successful launches during 1990, 1991 and 1992, listed chronologically

with an alphabetical index. The name and international designation of

each instrumented satellite and its associated rocket(s) are given, with

the date of launch, lifetime (actual or estimated), mass, shape,

dimensions and at least one set of orbital parameters. Other fragments

associated with a launch are listed without details. Catalogue numbers

and the site of each launch are given for the first time.

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INTRODUCTION

A Table of artificial satellites, giving launch dates, lifetimes, masses, sizes and orbits, has been issued by the Royal Aerospace Establishment since 1958, with yearly revisions and monthly supplements.

Now that the data for 1957-1989 have been published as The R.A.E Table of Earth Satellites 1957-1989, no further copies of the Table for these years will be issued.

NUMBERS OF LAUNCHES BY COUNTRY OF ORIGIN

Country 1957-1989 1990 1991 1992 1957-1992

USSR 2147 75 57 54 2333

USA 773 13 9 17 812

Japan 38 3 2 1 44

China 23 3 1 1 28

France 9 0 0 0 9

India 3 0 0 1 4

Israel 1 1 0 0 2

UK I 0 0 0 1

USA/Shuttle 31 6 6 8 51

Europe/Ariane 30 5 8 7 50

USA/Intelsat 34 2 0 1 37

USSR/Intercosmos 24 0 1 0 25

USA/UK 14 1 0 0 15

USA/Europe 13 0 1 0 14

USA/Canada 10 0 0 0 10

USA/NATO 6 0 1 0 7

USA/Germany or FRG 5 1 0 1 7

USA/Italy 6 0 0 0 6

USSR/France 6 0 0 0 6

USSR/India 4 0 1 0 5

USA/Indonesia 3 1 0 1 5

USA/France 4 0 0 0 4

USA/Japan 3 0 0 0 3

USA/Australia 2 0 0 0 2

USA/India 1 1 0 0 2

USA/Inmarsat 0 1 1 0 2

China/Australia 0 0 0 2 2

China/AsiaSat 0 1 0 0 1

China/Pakistan 0 1 0 0 1

France/FRG 1 0 0 0 1

USA/Netherlands 1 0 0 0 1

USA/Spain 1 0 0 0 1

USA/FRG/UK 1 0 0 0 1

USA/Japan/UK 0 1 0 0 1

USA/Netherlands/UK 1 0 0 0 1

China/Sweden 0 0 0 1 1

Total launches 3196 116 88 95 3495

The present publication covers the 299 successful launches during the years 1990 to 1992 with the pages numbered 1007-1113 in continuation of previous years. The table on the previous page gives a census by country, but with Shuttle (STS) and Ariane launches under single headings, 'USA/Shuttle' and 'Europe/Ariane'.

2 GUIDE TO THE TABLE

The data given in the main Table, for all satellites other than fragments, are as follows.

Column 1

gives the name of the satellite, its international designation and catalogue number. Some launch vehicles are indicated in square brackets. Doubtful entries are distinguished by question marks. Letters to the left of Column 1 have the following meanings:

B denotes unmanned satellites that carried live biological specimens.

D denotes satellites no longer in orbit on I January 1993.

 (For fragments, D indicates that all have decayed; Id indicates that

 one has decayed; 2d indicates that two have decayed, and so on.)

L denotes satellites with retro reflectors for laser tracking.

M denotes manned satellites; 2M indicate a crew of two at launch, etc.

p indicates that pieces were picked up on Earth after re-entry.

R denotes satellites that returned to Earth and were recovered intact.

R denotes satellites carrying capsules that were successfully recovered.

T denotes satellites believed to be transmitting radio signals on 1 January 1993.

Column 2

gives the launch date, lifetime (actual or estimated), and descent date (if appropriate). The dates are given in days and decimals of a day UT. Thus 1990 May 18.70 means 16h 48m UT (or GMT) on 18 May 1990. Actual lifetimes are given in days (and decimals of a day, if known). Estimated lifetimes are given in months or years, with decimals or fractions as appropriate.

Manoeuvrable satellites still in orbit on 1 January 1993 have 'manoeuvrable' in place of an estimated lifetime.

Column 3

gives the basic shape of the satellite and its mass in kilograms (1 kg = 2.205 lb). Sometimes the shape defies description in a few words and the description given is only approximate.

Column 4

gives the basic dimensions of the satellite in metres. Aerials, paddles carrying solar cells, and other components projecting from the main body are not normally taken into account when giving the size and shape (1 m = 3.281 ft).

Column 5

gives the date for the orbital information in Columns 6-12.

Column 6

gives the inclination of the orbit to the equator, in degrees.

Column 7

gives the nodal period of revolution the time interval, in minutes, between successive northward equatorial crossings by the satellite.

Columns 8-11

specify the size and shape of the orbit. The quantities tabulated are the semi major axis a, in kilometres; the eccentricity e; and the perigee and apogee heights, (a(l-e)-R) and (a(l+e)-R) respectively, where R is the Earth's equatorial radius, 6378.1 km. (1 km = 0.6214 statute miles = 3281 ft = 0.5396 nautical miles.)

Column 12

gives the argument of perigee the angle, measured round the orbit, from the northward equatorial crossing to the perigee.

The index gives the names of the satellites in alphabetical order, with the international designation of each satellite and the page on which details may be found. Satellites which are not Russian or American may be found in the index by referring to the appropriate country.

3 METHODS USED TO COMPILE THE TABLE

Our chief difficulty has been the lack of accurate information about the size, shape and mass of many of the satellites. The majority of launchings are military, and little information is released about these satellites or their final-stage rockets; we have to rely on deductions from their visual appearance in the night sky and on identifying previous launches of similar character. In contrast, we have full details of most international and non-military satellites.

3.1 Names and designations of satellites

The names given by the launching authorities are indicated when known. Since June 1984, US military payloads have had coverall names, USA 1, USA 2, etc. When a name is abbreviated to initials only, the meaning of the abbreviation or acronym is given as a footnote for the first satellite of that name.

The international designation of each satellite launching is allocated by the World Warning Agency on behalf of COSPAR. The identification of particular components in a launch is based on the

satellite catalogue of the United States Space Command, initially provided by RAF Fylingdales, and supplemented by visual and radio observations.

'Fragments' may be defined loosely as 'non-functional components', or, more precisely, as any components left over after accounting for the instrumented satellite, the various rocket stages and any other major mechanical component. Fragments thus include sensor covers, passive calibration payloads and inter-Btage structures, as well as debris from explosions - the most prolific source of fragments.

3.2 Lifetimes

The orbits of most satellites contract slowly under the action of air drag, and the severity of the drag determines their lifetimes, which are estimated from the orbital decay rates. The decay rate depends on air density, and the density depends critically on solar activity, which

cannot be accurately predicted. So most lifetime estimates are likely to be in error by 10% or more, and lifetime estimates of over 5 years may have much greater errors: if solar activity in future cycles should decline to the low levels prevalent in the late 17th century, lifetimes of

20-50 years given here would be seriously underestimated.

For most satellites in high-eccentricity orbits the lifetimes depend primarily on lunisolar perturbations rather than air drag, and have been estimated by numerical integration of these perturbations.

The methods for predicting lifetimes are described in Satellite orbits in an Atmosphere (Blackie, 1987), chapter 12.

3.3 Masses and dimensions

The masses and dimensions of the satellites come from launch agency press releases and authoritative media reports. The number of significant figures gives some indication of the accuracy. Often it is difficult to define the 'length' or 'diameter' when components of irregular size and shape are joined together, and dimensions are therefore sometimes approximate.

For satellites of unknown mass and size, the average cross-sectional area S can be approximately determined from the average brightness when observed visually; the mass/area ratio m/S can be obtained from the rate of change of orbital period and the known air density at heights near perigee, to give a value for the mass m. Values for the dimensions of Russian rockets originally relied on the detailed studies by the late Dr Charles Sheldon, in Soviet Space Programs 1971-75 (US Government Printing office, Washington, 1976), but in recent years the Soviet Union has provided data as some of their launch services have become commercially available.

We hope that most of the weights and dimensions given with question marks are accurate to within a factor of 1.5, i.e. that the real values are between 0.67 and 1.5 times the value given. It seemed better to give some indication of the weights and sizes, even if approximate, rather than to leave blanks.

3.4 Orbital accuracy

Orbital information has come from many sources. Most of the orbits are based on the elements issued by the United States Space Command and the remainder come mainly from the United Nations, NASA and independent visual observers.

The accuracy of the orbits varies greatly between one satellite and another, and no detailed guide can be given. Most orbits, however, are believed to have an error (sd) of about 0.02º in orbital inclination, 0.02 min in period, 2 km in semi major axis, 5 km in perigee and apogee heights (when the apogee height is less than 2000 km ), 0.001 in eccentricity e , and perhaps 3º in argument of perigee (if e > 0.02). Some orbits are much more accurate than this, and some, particularly those

with eccentricity exceeding 0.3 or with very short lifetimes, may be much less accurate.

3.5 Radio transmissions

A satellite is given the symbol T if it transmits or is capable of transmitting radio signals. The cessation of radio signals is rarely publicized, so the removal of the T is often based on the estimate that the average active life for radio transmission is about 2.5 years for Soviet satellites and 7 to 8 years for US satellites. The transmitting status of most Soviet satellites is largely based on monitoring by the Kettering Group; information on the status of Cosmos 'Glonass' satellites is provided by Leeds University. Listings of radio frequencies of satellites are given in Telecommunication Journal, published by the International Telecommunications Union (ITU).

Locations of geosynchronous satellites are not given, because they are subject to drift. Current locations are available in a list issued regularly by NASA Goddard Space Flight Center.

4 LAUNCH SITES

The numbers of launches from each site, with the geographical location of the site, are given in the table on page 7. The origins of launches in 1990, 1991 and 1992, by launch site, are given on page 8.

5 LAUNCH VEHICLES

The names of the launch vehicles employed by the Commonwealth of Independent States are given in square parentheses beneath the names of each payload. In 1968, in the absence of Soviet information on launch vehicles, the late Dr Charles S Sheldon II, of the Congressional Research

Service of the US Library of Congress devised a classification system that was widely adopted by western analysts. With the lifting of secrecy, the US Department of Defense's SL-system has come to be used.

The Soviet names and designations in both systems are given below.

Soviet name DOD Sheldon

Cosmos SL-8 C-1

Molniya SL-6 A-2e

Proton with fourth stage SL-12 D-le

Proton without fourth stage SL-13 D-1

Soyuz SL-4 A-2

Tsiklon SL-14 F-2

Unnamed SL-11 F-1

Vostok SL-3 A-1

Zenit SL-16 i-1

NUMBER OF LAUNCHES BY SITE, 1957-1989, 1990, 1991, 1992 AND 1957-1992

Country Launch site Latitude Longitude 1957-1989 1990 1991 1992 1957-1992

USSR Tyuratam(Baikonur) 45.60N 63.40E 847 27 22 21 917

 Kapustin Yar 48.40N 45.80E 83 0 0 0 83

 Plesetsk 62.80N 40.1OE 1251 48 37 33 1369

USA Cape Canaveral (ETR) 28.50N 81.OOW 396 23 12 24 455

 Vandenberg AFB (WTR) 34.70N 120.60W 484 4\* 6\* 4 498

 Wallops Island 37.90N 75.40W 19 0 0 0 19

France Hammaguir 31.OON 8.OOW 4 0 0 0 4

USA/Italy Indian Ocean Platform 2.90S 40.30E 9 0 0 0 9

(San Marco)

Australia/UK Woomera 31.10S 136.80E 2 0 0 0 2

Japan Uchinoura (Kagoshima) 31.20N 131.10E 18 1 1 0 20

 Tanegashima 30.40N 131.OOE 20 2 1 1 24

France/Europe Kourou 5.20N 52.80W 36 5 8 7 56

China Shuang Cheng-tsu (Jiuquan) 41.1ON\*\* 100.30E\*\* 17 1 0 2 20

 Xichang 28.10N 102.30E 5 3 1 2 11

 Wuzhai (T'ai Yuan) 38.80N 111.50E 1 1 0 0 2

India Sriharikota 13.90N 80.4E 3 0 0 1 4

Israel Palmachim 31.90N 34.70E 1 1 0 0 2

Total launches 3196 116 88 95 3495

\*Includes one air-launch \*\*Revised values since last issue

ORIGIN OF LAUNCHES BY LAUNCH SITE

Tyuratam (Baikonur)

1990: 14, 16, 20, 22, 33, 41, 44-46, 48, 54, 58, 61, 67, 72, 75, 85, 87, 94, 96, 102, 107, 108, 110, 112, 113 and 116

1991: 2, 5, 10, 11, 14, 20, 24, 25, 34, 38, 46, 49, 57, 61, 64, 69, 71, 73, 74, 79, 85 and 87

1992: 4, 5, 14, 17, 18, 22, 25, 35, 43, 46, 47, 55, 59, 71, 74, 76, 82, 87, 88, 91 and 93

Plesetsk

1990: 3, 4, 6, 9, 10, 12, 17, 18, 23, 24, 26, 29, 32, 35, 36, 38-40, 42, 47, 52, 53, 55, 57, 60, 62, 64, 66, 69-71, 73, 76, 78, 80, 82-84, 86, 92, 98, 99, 101, 104, 109, 111, 114 and 115

1991: 4, 6-9, 12, 13, 16, 19, 21-23, 29, 30, 33, 35, 41-44, 48, 52, 53, 56, 58, 59, 65, 66, 68, 70, 72, 77, 78, 81 and 86

1992: 1, 3, 8, 11, 12, 16, 20, 24, 29, 30, 33, 36, 40, 42, 45, 48, 50, 53, 56, 62, 65, 67-69, 73, 75, 77, 80, 81, 85, 92, 94 and 95

Cape Canaveral

1990: 1, 2, 8, 15, 19, 21, 25, 34, 37, 49-51, 56, 65, 68, 74, 88, 90, 93, 95, 97, 103 and 106

1991: 1, 18, 27, 28, 31, 37, 40, 47, 54, 63, 80 and 83

1992: 2, 6, 9, 13, 15, 19, 26, 27, 31, 32, 34, 37, 39, 44, 49, 57, 58, 61, 63, 66, 70, 79, 86 and 89

Vandenberg AFB

1990: 28 (air launched), 31, 43 and 105

1991: 17, 32, 45, 51 (air launched), 76 and 82

1992: 23, 38, 78 and 83

Uchinoura (Kagoshima)

1990: 7 1991: 62

Tanegashima

1990: 13 and 77 1991:60 1992: 7

Kourou

1990: 5, 63, 79, 91 and 100

1991: 3, 15, 26, 50, 55, 67, 75 and 84

1992: 10, 21, 41, 52, 60, 72 and 84

Shuang Cheng-tsu (Jiuquan)

1990: 89 1992: 51 and 64

Xichang

1990: 11, 30 and 59 1991: 88 1992: 54 and 89

Wuzhai (T'ai Yuan)

1990: 81

Sriharikota

1992: 28

Palmachim

1990: 27

ACKNOWLEDGEMENTS

This is the final issue of The RAE Table of Earth Satellites. Work on the Table, which has been produced continually since July 1958, at Farnborough will cease at the end of March, 1993.

In closing we wish to pay tribute to Dr Doreen Walker, Dr Desmond King-Hele, Mr Alan Pilkington and the late Mr Harry Hiller, who started and continued the Table before we appeared on the scene. We wish to acknowledge our indebtedness to the various sources mentioned for information about the satellites, especially to the United States Space Command, NASA's Goddard Space Flight Center and RAF Fylingdales for comprehensive orbital information, and to all those other individuals who have provided, over the years, data from which the Table has been compiled.

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1. Work to be done on the tables
* Orbital information for fragments and decayed objects from historical TLE’s (Done for 1957-1969)
* Update information such as launch vehicle, launch site and complex, satellite shape, dimensions and weight
* Update the tables with new entries, such as new fragments, decay dates and life times. This will be an ongoing process.
* Recent orbital information for objects still in orbit

From time to time updates will be published on my website at http://www.satlist.nl

Leo Barhorst

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2016 July 12