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crusize mailbox
VAR/MAIL

KB - Baikonur
WTR - Vandenberg.

ISSR	137	1965-94A	Cosmos 96	A/AC 105/INF. 118 030
US	422	1965-102A		A/AC 105/INF. 125 030.
		Thor Agena		
		Decay Dec 31 65		

sci. space history

Stan Gordon.

- article on Cosmos 96 angle of Russian reaction
- seeing what you get on FOIA angle - Cosmos 96.
- at least 8 objects
- reports of radiation

Archives for 1968 Satellite agreement.

FAA for reports on Kichsburg.

Briefing Hoover Jan 31, 89

"even the possibility of life" Science News, 22 July 1967.
Air Force document on Keokburg - no physical evidence

Mrs. Arnold Kelp & two children



UNITED STATES SPACE COMMAND

PETERSON AIR FORCE BASE, COLORADO 80914-5001

11 DEC 1989

Dr Henry Azadehdel
24 Prestwood Dv.
Aspley Park
Nottingham NG8 3LY
England

Dear Dr Azadehdel

This responds to your October 21, 1989, Freedom of Information Act (FOIA) request for information regarding any unknown object on the Continent of Southern Africa during the dates of 6th and 7th of May 1989.

The following information is releasable:

On the days of interest (May 6-7, 1989), six objects decayed from orbit, but because these objects had a less than 5 percent chance of surviving re-entry, no impact point was predicted nor recorded. On May 8, 1989; however, one satellite did re-enter and likely impacted within your area of interest. Details are:

International designator	1989-032B (USSR)
Satellite number	19942
Common name	FOTON 2 (rocket body)
Launch date	April 26, 1989
Impact time (plus/minus 1 min)	0119Z May 8, 1989
Impact location	Lat - 18.0 degrees (S) Long - 41.1 degrees (E) Inclination - 62.8 degrees
Rev number since launch	181, descending to south-west

Fees for this service are waived.

Sincerely

Jerry W. Felder
JERRY W. FELDER, Colonel
Deputy Chief of Staff

*Dear Grant, This is the letter from USSPLCOM
See the date May 8, 89 - and the name. It never was
a satellite.*

Reverse - The fax I received

Waiting to hear from you.

Henry

Aug. 2, 1990

Smithsonian Institution
 National Museum of Natural History
 Department of Mineral Sciences
 Global Volcanism Program
 FAX 202-357-2476

Telefax Cover Sheet

Sent to Dr. Henry Azadehdel

Telefax number 602 - 784 - 688

Sent by Kevin Kivimaki

Voice contact at 202-357-1511

Date/Time August 1, 1990

Comments Regarding your inquiry about phenomenon over
southern Africa, a check of all back issues of the GVN Bulletin
since May 1989 revealed no meteor sightings reported in that region.

0 pages
to follow

- ☐ Please confirm receipt by voice phone at number listed above.
- ☐ Please respond as soon as possible ...
- ☐ by voice phone at number above.
- ☐ by FAX at 202-357-2476.
- ☒ In response to our earlier conversation.
- ☒ For your information only—no need to respond.

04 June 1990

202 357 2476

TOTAL P.01
P.01

TRANSACTION REPORT

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NOTE

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Artificial satellites—Continued

and rockets world missile/space encyclopedia 1965. *Il Miss & Roc* 17:37-44+ 1 '65
of current space activity. R. N. Watts, *Sky & Tel* 31:28-9 Ja '66
levator proposed to link space to earth; *ect. Skyhook. Sci N L* 87:50 J1 24 '65
vehicle log (cont) *Aviation W* 82:125 15 '65
quiet satellites. *Sci N L* 87:262 Ap '65
Soviet space probes; US lead in space. *New Repub* 152:7 Je 19 '65
anned scientific satellites; future hinges *manned project plans. Il Miss & Roc* 17: 00 N 29 '65
ee also
vehicles

Astronomical applications

telescopes in orbit to study stars in *for one of the orbiting astronomical
ervatories. Sci N L* 87:248 Ap 17 '65
look at NGC 4565. N. G. Roman. *Il
Ed* 1:5-8 O '65
vehicle becomes major scientific prog- *ram; groundwork for expanded solar and
planetary program. D. E. Fink. Il
Aviation W* 82:116-18+ Mr 15 '65
orbits solar observatory. *Aviation W* 82:116-18+ Mr 15 '65
orders three more OSOs. *Aviation W* 82:116-18+ Mr 15 '65
spacecraft are designed to carry whole *observatory units. T. D. Nicholson. Il
ur Hist* 74:28-30 N '65
-B telescope will scan stars mapped by *AOAO; orbiting astronomical observ-
ry. R. D. Hibben. Il Aviation W* 83:74-
J1 19 '65
2 satellite in orbit. R. N. Watts, Jr. *Il
y & Tel* 30:353-4 D '65
s sold for manned observatories. W. S. *iller. Il Miss & Roc* 16:28-30+ My 17 '65
otype telescope for AOAO-C tested. R. D. *Hibben. Il Aviation W* 82:71+ Mr 22 '65
to utilize 750-1,000-ft. antennas; radio *tronomy explorer satellite. D. E. Fink.
Aviation W* 83:106-7+ S 27 '65
nd orbiting solar observatory. R. N. *Watts, Jr. Il Sky & Tel* 29:151-2 Mr '65
nd sun-watching satellite now in orbit; *SO-B2. Il Sci N L* 87:115 F 20 '65
ile space antennas under study. R. Pay. *Miss & Roc* 17:32-3 N 1 '65
ce balloon vehicles seen inflating in orbit. *Sci N L* 89:37 Ja 15 '66
ce observatory successfully launched; *biting geophysical observatory. Sci N L* 89:37 Ja 15 '66
264 O 23 '65
ce science stresses optics, antennas. K. *ansen. Aviation W* 82:34 Ap 6 '65
in-dia, liquid orbiting eye proposed. R. *ay. Il Miss & Roc* 16:43 Je 14 '65

Communication applications

See Communications satellites

Equipment

See Space vehicles—Equipment

Launching

gets two OV's for dual launch. W. E. *Wilks. Miss & Roc* 17:18 D 6 '65
d eight makes 300; eight US satellites *orbit in one launching. Newsweek* 65:51
ly 31 '65
ht satellites at once. R. N. Watts, Jr. *Sky & Tel* 30:87 Ar '65
st industry-built Saturn 1 puts Pegasus- *in precise orbit. Aviation W* 82:21 My 31
65

Mapping applications

chmarks in space can aid mapping; laser *beam to photograph Explorer 22. W. S.
eller. Il Miss & Roc* 16:33+ Ap 12 '65
os-A launched, returns data from orbit *higher than planned. Aviation W* 83:38 N
5 '65
GEOS to help find size and shape of earth; *Passive geodetic earth orbiting satellite.
lcovery) Sci N L* 88:133 Ag 28 '65
COR V upgrading geodetic effort. *Il Miss
& Roc* 17:16 Ag 16 '65

Meteorological applications

Moons and satellites could track weather. *Sci N L* 87:105 F 13 '65
d line chill; lack of cooperation by Soviet *Union. Reporter* 22:14+ Mr 11 '65
OD steps up weather satellite work. D. L. *Zylstra. Miss & Roc* 16:16 My 31 '65
rly bird speeds chart transmission; data *gathered by Tiros IX. Il Miss & Roc* 17:35+
J1 5 '65

GAO charge to spur Nimbus investigation.

Aviation W 82:99+ F 22 '65
Geophysical observations from Nimbus I. W. *Nordberg. bibliog Il Science* 150:559-72 O 29
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Global weather observation system urged; *testing Ghost for global horizontal sounding
technique. with launch of Nimbus B. D. E.
Fink. Aviation W* 83:34 D 6 '65
Hurricane Betsy viewed by TIROS satellites; *photographs. Miss & Roc* 17:18 S 20 '65
John o' Groats to Timbuctoo; photographs *taken by the Nimbus weather satellite. Sci
Digest* 57:inside back cover Mr '65
Latest weather monitor: Tiros 9. R. N. *Watts, Jr. Sky & Tel* 29:151 Mr '65
NASA launches first cartwheel satellite; *TIROS (television infrared observation
satellite) Il (S1) Sci N L* 87:88 F 6 '65
NASA weather satellite plans. *Il Aviation
W* 84:40-2+ Ja 3 '66
Radiation, inc. equipping Nimbus-B satellite. *M. Getler. Miss & Roc* 16:35 Mr 8 '65
Satellite could show temperatures, pressures. *Sci N L* 87:152 Mr 6 '65
Tiros 10 monitors tropical storm belt. *Avia-
tion W* 83:36 J1 12 '65
Weather buoy-satellite link is studied. W. H. *Gregory. Il Aviation W* 82:54-5+ F 8 '65

Military applications

Base where MOL will be born; air force's *Vandenberg. Il Bsns W* p70-2+ N 13 '65
Cosmos 57 believed destroyed by Soviets; *photographic reconnaissance spacecraft.
W. J. Normyle. Aviation W* 82:34 Ap 12 '65
Douglas gets a jump with MOL; manned *space laboratory. Il Bsns W* p50-2 D 25 '65
From Washington: the air force in space and *peacekeeping assessments. H. Margolis. Bul
Atomic Sci* 21:34-7 O '65
Satellite photo station ready soon; Electro- *optical surveillance station. R. Pay. Miss
& Roc* 17:42 J1 19 '65
Schriever reveals MIDAS advances. *Miss &
Roc* 16:12-13 My 24 '65
Soviet article raps DOD space role; summary *of report. M. Golyshev. Miss & Roc* 17:17
N 22 '65

Navigational applications

Satellites to aid in sea studies; nine oceano- *graphic ships planned. H. Taylor. Il Miss &
Roc* 17:41-2+ S 6 '65
Ships and planes navigated by satellites. *W. Von Braun. Il Pop Sci* 186:76-7+ My '65

Power supply

See Space vehicles—Power supply

Tracking

ALOTS advances airborne tracking. R. Pay. *Il Miss & Roc* 17:26-7 N 22 '65
He keeps score for the space race; B. Lovell *and his radiotelescope at Britain's Jodrell
bank. Il Bsns W* p96-8+ O 30 '65
How hams track space shots. R. Gannon. *Il
Pop Sci* 186:99-102 My '65
Satellite photo station ready soon; Electro- *optical surveillance station. R. Pay. Miss
& Roc* 17:42 J1 19 '65
Track man; expert schoolboy. *Newsweek* 65:
69 Mr 15 '65
Western satellite research network. G. A. Mc- *Cue and others. Il Sky & Tel* 30:88-90 Ar
'65
Where do dead satellites go? I. Asimov. Il
Sci Digest 58:86-7 D '65
See also
Communications satellites—Tracking

Use in research

Aerojet demonstrates solid pulse motors. *Avia-
tion W* 82:30 Ap 19 '65
AF drafting own animal satellites; biosatel- *lite program. H. M. David. Miss & Roc* 16:
32 Mr 22 '65
AF gets two OV's for dual launch. W. E. *Wilks. Miss & Roc* 17:18 D 6 '65
Application satellite technology; report will *decide navigation role. Il Miss & Roc* 17:
91-2+ N 29 '65
AE-B to probe higher in atmosphere. W. S. *Beller. Il Miss & Roc* 17:28+ N 15 '65
Benchmarks in space can aid mapping; laser *beam to photograph Explorer 22. W. S.
Beller. Il Miss & Roc* 16:33+ Ap 12 '65
Biosatellite hardware nearly ready. H. M. *David. Il Miss & Roc* 16:33+ F 22 '65
Decision nearing on cislunar MDS; meteoroid *detection satellite. Miss & Roc* 16:14 Ap
26 '65
ESRO II in early test phase; experiments *dealing with solar radiation measurements.
Il Miss & Roc* 17:26-7 J1 5 '65

Artificial satellites—Use in research—C

Explorer 26. R. N. Watts, Jr. *Sky &
Tel* 31:30 Ja '66
Explorer 30. R. N. Watts, Jr. *Sky &
Tel* 31:30 Ja '66
Hope grows for follow-on Pegasus. M. Get- *ler. Il Miss & Roc* 16:14-15 F 22 '65
Improved solar cells planned for IMF *R. D. Hibben. Il Aviation W* 83:53+ J1
'65
Measuring meteoroids; orbiting Pega- *lus launched. Il Time* 55:58 F 26 '65
Meteoroid program may be expanded. *Il
& Roc* 16:17 My 31 '65
Michigan satellite design near completion. *R. D. Hibben. Il Aviation W* 83:75+
22 '65
Micrometeoroid measurements. J. H. Wu *Jr. Il Electr World* 74:42-3+ N '65
NASA plans two optical experiment awa- *D. E. Fink. Aviation W* 83:33 S 13 '65
NASA will pick two contractors for *liminary OTS design work; optical te-
chnology satellite. Aviation W* 83:22 J1 5
OAR to use own vehicles for OV sh *R. Pay. Il Miss & Roc* 18:32-4+ Ja 17
OV-2 will seek to determine extent of *Allen belt threat; orbital vehicle. Il A-
viation W* 83:113+ S 27 '65
Pegasus returning meteoroid flux data *Aviation W* 82:28 F 22 '65
Pegasus satellite flies. R. N. Watts, Jr. *Sky & Tel* 29:210 Ap '65
Pegasus 2 launched; meteoroid-detection *tellite. R. N. Watts, Jr. Il Sky & Tel*
18:19 J1 '65
Pegasus 3; meteoroid-collecting sate- *lite. R. N. Watts, Jr. Il Sky & Tel* 30:215 O
Proposed optical satellite described; opt- *ical technology satellite. M. Getler. Miss
& Roc* 16:30+ Mr 29 '65
Radiation-monitoring satellite awaits T- *111-C launching. S. Butler. Miss & Roc*
15 S 20 '65
Satellites while orbiting could aid agri- *culture. Sci N L* 87:216 Ap 3 '65
Study of advanced meteoroid detection *satellite is planned. Aviation W* 83:34 Ar
UK-3 to probe lightning's RF noise. *Il
& Roc* 16:30+ Je 21 '65

Artificial satellites, British

UK-3 to probe lightning's RF noise. *Il
& Roc* 16:30+ Je 21 '65

Artificial satellites, French

Fr-1 bolsters French civil space ambi- *tion. W. C. Wetmore. Il Aviation W* 84:54
Ja 10 '66
France enters the space race, but— *Il
News* 59:3 D 6 '65
France in orbit; il Newsweek 66:68 D 6
France injects first satellite into orbit. *L.
Doty. Il Aviation W* 83:29 D 6 '65
France's first satellite. R. N. Watts, Jr. *&
Tel* 31:27 Ja '66
France's silent satellite. *Bsns W* p54 D
French FR-1A satellite orbited. *Aviation
W* 83:36 D 13 '65
Pre-election satellite launching sought by *Gaullie government. Aviation W* 83:2
20 '65
Satellite balloon-watch; Project EOLE *measures air currents, pressures and
temperatures. Sci N L* 87:115 F 20
'65

Artificial satellites, Japanese

Japan moves toward launch of home- *made satellite in '68. Il Miss & Roc* 17:29-30
'65

Artificial satellites, Russian

Cosmos 57 believed destroyed by Soy- *uz precursor to manned Soviet flights. W.
Normyle. Aviation W* 82:34 Ap 12 '65
New pictures of Elektron and Cosmo- *mos. Il Miss & Roc* 16:15 My 24 '65
Operational Russian satellites scan
Earth. H. Kottum. Il Aviation W 82:22 F 2
Russians believed deploying Comsat
satellite. J. Klass. Aviation W 83:29 O 11 '65
Russians rap U.S. satellites; Moly *launching. Bsns W* p 126 O 23 '65
Soviet satellite tests space transmiss- *ion. Aviation W* 82:21 My 3 '65
Soviet satellites watching us. R. N. W. *Jr. Il Sky & Tel* 29:359-60 Je '65
Soviets boost recon satellite launch *1965 Cosmos satellites. Il Aviation W*
32 Ar 16 '65

Artificial teeth. See Teeth, Artificial

Artistic ability. See Creation (literary, artistic, etc.)

Artistic cookery. See Cookery, Ornamental

Artistic photography. See Photography, Artistic

Flight—Physiological aspects—Cont.
 4 crucial to manned flight plans, H. M. David, Miss & Roc 16:28+ My 24 '65
 7 will emphasize calcium study, H. M. David, Miss & Roc 17:32-3 S 20 '65
 ting around by voice control; ways to control an astronaut maneuvering unit, Time 85:80 Ap 23 '65
 much can you take? weightless maneuvers around scale-model space capsule, Vaughan, Il Sat Eve Post 238:32-4+ v 22 '65
 double or nothing in space; McDivitt and hite Gemini flight, Il Bsns W p 105-6 19 '65
 ov space activity called strenuous, W. Wetmore, Aviation W 82:25 Je 21 '65
 rest journey; Gemini 7/6 mission, Il Newsweek 66:60 D 13 '65
 is moon-rated, Il Time 86:64-6 S 10 '65
 A gets biolab recommendations; AES, JRL and Apollo-X, H. M. David, Miss Roc 17:36-8 Ar 23 '65
 A's firefly project, Il Life 59:35-6 J 9 '65
 EVA in next three Gemini flights, Miss Roc 17:14 J 12 '65
 for man in space; medical reports on ce flight of Gemini-7, Il Bsns W p54+ 8 '66
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 te biosensors sought for astronauts, ation W 82:36 Ap 19 '65
 movement studied, Il Sci N L 87:262 24 '65
 ing for space; Coriolls acceleration form, Il Time 85:78 Mr 12 '65
 nal manikin to aid MSC, M. Getler, Il s & Roc 16:49+ My 17 '65
 suited for orbit; Gemini 7/6 astronauts, Newsweek 67:45 Ja 10 '66
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 support systems
 medicine
 tlessness

Psychological aspects

1 effects of long space flights toler- Sci N L 88:168 S 11 '65

Social aspects

sity and the exploration of space; ad- s, October 11, 1965, H. L. Dryden, Sci 150:1129-33 N 26 '65
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 nducting further space cabin atmos- e studies in sixty-eight day test, H. David, Il Miss & Roc 17:29-30 O 18 '65
 lots to simulate Apollo flight, H. M. d, Miss & Roc 16:84-5 My 31 '65
 s tests helium as atmosphere, H. M. s, Miss & Roc 16:38-41 Je 28 '65
 much can you take? weightless man- ers around scale-model space capsule, Vaughan, Il Sat Eve Post 238:32-4+ 2 '65
 space simulator designed, C. D. nd, Il Miss & Roc 17:45-6 S 13 '65
 lans first manned chamber tests soon, s & Roc 17:14 N 22 '65
 87:154-5 Mr 6 '65
 rnaround completed day early, G. nder, Il Aviation W 83:32-3 D 13 '65
 saves egg after eleven-story drop; tive padding used in zero-gravity Sci N L 88:345 N 27 '65
 y simulator will employ MHD, D. L. a, Il Miss & Roc 16:24+ Ad 5 '65
 mera to monitor biodynamics, M. , Il Miss & Roc 16:32-3 My 3 '65
 simulates LEM landings, Il Miss & 3:43 My 17 '65
 chambers to check Apollo 011, S. d, Miss & Roc 17:27 D 6 '65
 d lunar gravity simulated by device, 3) Sci N L 87:200 Mr 27 '65
 slows astronaut performance, H. M. il Miss & Roc 17:34+ N 8 '65
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 ght to Jupiter
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 1 manned research; Mars, Venus easible by 1980, Il Miss & Roc 17: N 29 '65
 art on Mars systems urged, H. M. Miss & Roc 17:22 J 12 '65
 at odds over Mars goals, R. Pay, Roc 16:39+ F 22 '65

Soviets see Mars as manned space goal, W. J. Normyle, Aviation W 82:37 My 10 '65
 To Mars or bust, I. Wolfert, Il Read Digest 87:63-8 J 1 '65
 When will we land on Mars? W. Von Braun, Il Pop Sci 186:86-8+ Mr '65

See also

Space probes
 SPACE flight to Mercury

See also

Space probes
 SPACE flight to the moon

Apollo blueprint 1970, J. Eberhart, Il Sci N L 87:378-9+ Je 12 '65
 AES management plan nears completion; Apollo extension system, D. E. Fink, Aviation W 83:16-17 J 19 '65
 AES program definition to begin, Miss & Roc 16:17 Je 7 '65
 Business on the moon; profits to be made from lunar exploration, Il Time 86:89-90 O 29 '65
 Conservative approach dictating lunar sci- entific research plan, W. J. Normyle, Avi- ation W 82:17 Je 7 '65
 Funding boost might cut Apollo cost, Miss & Roc 17:18 O 25 '65
 Funding to start for Apollo lunar science, W. J. Normyle, Aviation W 82:13-19 My 31 '65
 How U.S. plans to conquer the moon; inter- view, G. E. Mueller, Il U S News 59:33-7 D 27 '65
 Kepler's dream, by J. Lear, Review
 Sat R, Il 48:41 Ap 3 '65, W. D. Stahlman
 Lunar mission retains top U.S. priority, W. J. Normyle, Il Aviation W 82:105-8+ Mr 15 '65
 Moon landing possible in 1968? what U.S. proved with four days in space, Il U S News 58:40-1 Je 21 '65
 NASA alerts Congress to plans for major post-Apollo missions, Aviation W 82:23 F 22 '65
 New post-1970 missions investigated, W. E. Wilks, Il Miss & Roc 17:22-3 N 1 '65
 Space race pace quickens, J. Eberhart, Il Sci N L 87:387+ Je 19 '65
 Special report, Apollo at mid-term; symposi- um, Il Aviation W 83:55-7+ N 15 '65
 Special report on Apollo applications, Il Avi- ation W 83:64-5+ O 11 '65
 Three giant steps to the moon, Il Pop Mech 124:90-4+ O 116-20+ N 104-8+ D '65
 Two spacemaps to the moon, G. Bylinsky, Il N Y Times Mag p6-7+ My 30 '65

See also

Lunar probes
 Space flight—Manned flights

Cost

Lunar landing: the big goal, Il U S News 59:54 N 1 '65
 Moon struck, W. J. Coughlin, Miss & Roc 16:46 Ad 12 '65
 NASA's target: keep date with moon, Il Bsns W p28-9 F 6 '65

International aspects

Moon race: is it worth while? statements from National youth conference on the atom, Il Sr Schol 86:20-1 F 4 '65
 Race to moon: can U.S. still catch Russia? Il U S News 58:46-8 Mr 29 '65
 U.S. and Russia in space; the pace quickens, Il U S News 59:25-6 Ag 30 '65

SPACE flight to Venus

Advanced manned research; Mars, Venus trips feasible by 1980, Il Miss & Roc 17: 75-6+ N 29 '65

Manned Venus flyby possible in '75, W. S. Beller, Miss & Roc 17:34 Ag 30 '65

See also

Space probes
 SPACE heaters. See Electric heaters
 SPACE industry. See Aerospace industries
 SPACE law
 International regulation of outer space ac- tivities, D. Galloway, Il Bul Atomic Sci 21: 36-9 F '65
 Laws for space debated, Sci N L 88:197 S 25 '65
 SPACE medicine
 Adaptation of medicine to space conditions seen, Sci N L 88:153 S 4 '65
 AA experiment proposals studied, Il Miss & Roc 17:23 D 6 '65
 Birds aid space study, Sci N L 88:34 J 17 '65
 Drugs studied to aid astronauts, Il Miss & Roc 16:33 Mr 15 '65
 Gagenko discusses Soviet space medicine, O. G. Gagenko, Il Aviation W 82:40-1+ Je 7 '65

SPACE medicine—Continued

Tests show tooth needs. *Sci N L* 88:86 Ag 7 '65

See also

Space flight—Physiological aspects
Weightlessness

SPACE navigation. See Navigation (space flight)

SPACE perception

Stimulus variables determining space perception in infants. T. G. R. Bower. *bibliog* *il Science* 149:88-9 J1 2 '65

SPACE photography

Apollo crater landing seen possible; Ranger IX photos. W. E. Wilks. *Miss & Roc* 16:26+ Mr 29 '65

Can you see the moon in 3-D? L. Mallan. *il Pop Phot* 57:52-5 S '65

Close tracking of Mariner continues. *il Miss & Roc* 17:14-15 J1 19 '65

Complex system produced Mars photos. *il Aviation W* 83:67-8 J1 26 '65

Crew of Gemini 5 vehicle provided detailed storm data. E. J. Bulban. *il Aviation W* 83:68-9+ S 20 '65

Drama from the moon; flight of Ranger IX. *il Time* 85:48 Ap 2 '65

First orbiter to picture moon's far side. *Aviation W* 83:30 O 4 '65

Gemini V experiments on zodiacal light and gegenschein. E. P. Ney and W. F. Huch. *bibliog il Science* 150:53-6, 1629 O 1, D 17 '65

Gemini photos advance AES experiments; with photographs. D. E. Fink. *Aviation W* 83:61-2+ Ag 9 '65

Gemini 7 may take photographs of Gemini 6 re-entry sequence. W. J. Normyle. *Aviation W* 83:23 N 29 '65

Gemini 6 crewmen to photograph Bahamas in storm damage study. W. J. Normyle. *Aviation W* 83:37 S 20 '65

GTC-3 astronaut photographs Africa, Mexico. *il Aviation W* 82:68-9 Ap 12 '65

How they shot the space walk. *il U S Camera* 28:68-9+ S '65

John o' Groats to Timbuctoo; photographs taken by the Nimbus weather satellite. *Sci Digest* 57:inside back cover Mr '65

Looking sharp; Questar telescope for space photography. *il Newsweek* 66:88 S 27 '65

Lunar results from Rangers 7 to 9. G. P. Kuiper. *bibliog il Sky & Tel* 29:293-308 My '65

Mapping the moon; Ranger VIII. *il Time* 85:58-9 F 26 '65

Mariner 4 completes Mars mission. R. N. Watts, jr. *il Sky & Tel* 30:136-8 S '65

Mariner 4 photographs of Mars. *il Sky & Tel* 30:155-61 S '65

Mariner IV photography of Mars: Initial results. R. B. Leighton and others. *il Science* 149:627-30 Ag 6 '65

Mariner 4 photos, data reducing unknowns about Mars. H. D. Watkins. *il Aviation W* 83:16-20 J1 26 '65

Mariner observes Mars. *il Sci N L* 88:51 J1 24 '65

Mariner photographic field determined. *Aviation W* 82:25 F 15 '65

Mars never seen. *il Newsweek* 66:54-6+ J1 26 '65

NASA studies feasibility of color television from lunar surface. *il Aviation W* 84:71+ Ja 17 '66

Photos point to Mars landing difficulty. R. Pay. *il Miss & Roc* 17:13-14+ J1 26 '65

Pictures of success; Gemini 7. *il Time* 86:53 D 31 '65

Portrait of a planet; flight of Mariner IV. *il Time* 86:36-8+ J1 23 '65

Ranger 8 lunar photos appear to confirm Ranger 7 data. *il Aviation W* 82:20-3 Mr 1 '65

Ranger 8 lunar reconnaissance. *il Sky & Tel* 29:205-9 Ap '65

Ranger missions to the moon. H. M. Schurmeier and others. *il Sci Am* 214:52-67 *bibliog* (p 134-5) Ja '66

Ranger 9 data promises basic insights on lunar surface. H. D. Watkins. *il Aviation W* 82:84-9 Ap 5 '65

Ranger IX may shoot Surveyor site; with editorial comment. W. E. Wilks. *il Miss & Roc* 16:18+, 46 Mr 1 '65

Ranger program exceeds expectations. W. E. Wilks. *il Miss & Roc* 16:28+ Ap 5 '65

Rangers confirm moon landing areas. W. E. Wilks. *Miss & Roc* 16:22-3 Ap 12 '65

Ranger's-eye view. *il Sci N L* 87:149 Mr 6 '65

Research in America; Ranger 8 findings. J. Lear. *il Sat R* 48:47-8 Ap 3 '65

So vast, so beautiful, so overpowering; photographs of earth taken from Gemini 6. *Life* 59:30-9 S 24 '65

Surveyor unit permits live TV broadcast from Ranger 9. H. D. Watkins. *il Aviation W* 82:26-7 Mr 29 '65

Techniques tomorrow; cameras being used in space. B. Sherman. *il Mod Phot* 29:40+ D '65

Terrain of neighbor Mars; pictures taken 135 million miles away. *il Life* 59:62A-62C Ag 6 '65

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 NASA readies Pageos satellite for launch into circular orbit. il Aviation W 84:176-7+ Je 20 '66
 Pageos. R. N. Watts, jr. il Sky & Tel 32:87+ Ag '66

Wagman Says Constellation Gemini Shower Expected, Allegheny Head Notes

An orange "fireball" that flashed through Western Pennsylvania skies may have been a meteor from the constellation of Gemini, the director of Allegheny Observatory said today.

Meanwhile, scientists and Army and Air Force officials resumed a search today for a "smoldering object" reported to have fallen in a wooded area near Kecksburg in Westmoreland County.

A shower of Gemini meteors had been expected today, according to Dr. Nicholas Wagman, director of the observatory.

"As a rule, they are numerous but not bright," he said. "A bright one, such as the one sighted yesterday, is generally sporadic."

Mr. Wagman said there were reports of a shock wave in parts of Western Pennsylvania at the time of the sightings.

"The last such shock wave was in 1938, and large pieces of the meteorite were found north of Butler," he said.

Pentagon sources earlier said the flash could have been a meteor.

Possibly Man-Made

Another theory advanced was that the flash could have been made by any one of 200 man-made objects in orbit re-entering the atmosphere.

Western Pennsylvanians weren't the only ones to view the spectacular "fireball" shortly before 5 p. m. yesterday.

Blue Smoke Reported

Mrs. Arnold Kalp, of RD 1 Acme, in the Kecksburg area, said she saw blue smoke rising from the woods about a half mile from her home.

"It seemed like it might have been an ordinary fire but in five minutes the smoke was gone."

She said her son, Nevin, 8,

The orange flash was sighted by airplane pilots and residents in Windsor, Ontario; Michigan; Illinois; Indiana; Northern Ohio; New York, and Northern West Virginia.

A spokesman for the North American Air Defense Command (NORAD) at Colorado Springs, Colo., said its tracking stations did not track the flash of light. NORAD said if it were a meteor it should have shown up on their radar scopes.

The Kecksburg search got under way about 6 p. m. after seven residents of the community of 500 reported seeing a smoldering object crash to the earth.

By Allegheny Observatory Head

Meteor Called 'Fireball' Cause

(Continued from Page One)

told her he saw an object streaking through the sky "like a star on fire."

Several residents in the area reported hearing a "thud" and one man said it shook his garage.

Off Route 982

The search was concentrated in a wooded area off Route 982, about five miles from Route 31.

State Police from Greensburg, Army and Air Force officials, scientists and volunteer firemen from Kecksburg conducted the search in a 75-acre area under a full moon as about 150 on-lookers joked about "little green men" and flying saucers.

Shortly before the search broke off about 2 a. m., eight or nine persons reported they saw a bright, blue light in the woods about 150 feet from where they were standing on a hillside.

A State trooper, who also saw the light, descended the hillside but when he got about half way down, those standing above said the light disappeared.

Reports of debris falling were also made in Midland, it police there said no objects were found.

In Erie, where the fireball was sighted at 4:50 p. m., Eric Johnson, a reporter for an Erie television station, said it flashed across the lake, north-northwest of the Erie airport, leaving a kind of cloud smoke behind it.

A woman in Elyria, Ohio, reported a fireball the size of a "volley ball" fell into a wooded lot across from her home. Lt. Jack Trumble, an Elyria fireman, described

the blaze which followed as "about 10 small fires spread over a one thousand foot area."

Dr. Paul Annear of the Baldwin Wallace Observatory in Ohio said the flash could have been a bolide, a meteor which disintegrates as it falls to earth, or a meteor shower expected to come next week.

He added that the large number of sightings by airplane pilots indicated validity of the reports. "After all, these people should know what they are talking about."

Sighting times of 4:40 p. m. in Indiana, 4:44 p. m. in Oberlin, Ohio, and 4:50 p. m. in Erie indicated a west-to-east line of flight by the object.

Raymond Wallings, a private airplane pilot from

Painesville, Ohio, said he was flying over the lake when he saw the "fireball." He said he kept his eye on it until it plummeted into the lake.

No sightings were made at Allegheny Observatory here because of the daylight hour, a spokesman said, but added the observatory received many calls reporting the fireball.

[The Press had 20 callers report the flash.]

While Pentagon sources indicated they believed the orange flash was a meteor, officials at Wright Patterson Air Force Base at Dayton, Ohio, refused to speculate about what the object might have been.

National Guard and Air Force personnel both denied early reports the flash came from a rocket fired

KECKSBURG

Received: from merak
(gcameron@merak.cc.umanitoba.ca [130.179.18.10]) by
electra.cc.umanitoba.ca (8.7.1/8.7.1) with SMTP id DAA14267
for <gcameron@cc.umanitoba.ca>; Mon, 2 Dec 1996 03:12:14 -0600 (CST)
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Message-ID: <32A29D69.21B9@cc.umanitoba.ca>
Date: Mon, 02 Dec 1996 03:12:09 -0600
X-UIDL: 849518238.001
From: Grant Robert Cameron <gcameron@cc.UManitoba.CA>
Organization: University of Manitoba
X-Mailer: Mozilla 3.0 (X11; I; SunOS 5.4 sun4m)
MIME-Version: 1.0
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<http://www.garlic.com/ufo/txt2/1291.ufo>

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Content-Transfer-Encoding: 7bit
Content-Disposition: inline; filename="1291.ufo"

SUBJECT: MYSTERY OF METEOR ROAD STILL UNSOLVED

FILE: UFO1291

NEWS CLIPPING SERVICE

DATE OF ARTICLE: July 10, 1989
SOURCE OF ARTICLE: Tribune-Review
LOCATION: Greensburg, Pennsylvania
BYLINE: None

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MYSTERY OF METEOR ROAD STILL UNSOLVED

By The Tribune-Review

There's no telling who'll show up in Kecksburg August 13 when the Community Day Parade trumpets the 50th anniversary of the Kecksburg Volunteer Fire Department.

A chance exists that someone will boldly go beyond the inspiring tales of firefighting heroics into another world to debate whether a UFO or meteor landed in a wooded area off Meteor Road -- that's right, METEOR ROAD -- 24 years ago.

Talk threatens to climb beyond the stratosphere ever since

Japanese tel
Township earlier in they year. The footage shot -- no one seems to know what will be highlighted -- will form part of a two-hour special scheduled to air in that country later in the year, possibly September.

Lore about what happened on Dec. 9, 1965, encroaches on the Zone of Beyondo Bizzaro.

~~The Office of Special Investigations at Wright-Patterson Air Force Base in Dayton, Ohio, won't comment on whether its personnel were running around Meteor Road that day.~~

The township supervisors thought enough of what occurred then to christen the byway as Meteor Road. As expected, the road signs disappear as fast as a shooting star, said township Secretary Ray Zimmerman.

"They're a big item," he says.

Kecksburg Fire Department President Jim Mayes was on the road that day, looking down into a field as military personnel, state police and a swarm of authorities converged to do something mysterious and keep area residents from seeing it.

"I remember it like it was yesterday," said Mayes. "We had the four-wheel-drive truck and we took the military down. They kept people there all night. There was a tractor-trailer and a couple other vehicles, and I still say they took something out of there. ~~The big thing about it was the blue blinding lights -- like a timing light.~~"

The field of Jerome and Valeria Miller was tramped through by Boy Scouts a day later, searching for the magnet that would later draw college students from the University of Colorado and the film crew from Japan.

Valeria Miller was not at home at the time of the most famous drop-in since John Martin Keck started the village of Kecksburg in the 1860s.

Stan Gordon, who heads the Pennsylvania Association for the Study of the Unexplained, hasn't completely ruled out that space debris -- and not a UFO -- went down in the area.

But the easier to swallow suggestion has choked one eyewitness who disputed that theory in talking with Gordon.

The eyewitness, identified only as Pete by Gordon, said the object resembled a giant metal acorn and contained writing that "looked like hieroglyphics" on part of its raised surface. The object was supposedly loaded onto a flatbed trailer, covered with a tarp and hauled to an unknown location.

Gordon is in search of more witnesses who might want to come forward on what made the noise heard around the world, and whether, just by chance, anyone might have seen anything leave that area before authorities arrived.

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8/89

* THE U.F.O. BBS - <http://www.ufobbs.com/ufo> *

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KECKSBURG

Received: from merak
(gcameron@merak.cc.umanitoba.ca [130.179.16.10]) by
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Organization: University of Manitoba
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<http://www.garlic.com/ufo/txt3/2483.ufo>

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Content-Transfer-Encoding: 7bit
Content-Disposition: inline; filename="2483.ufo"

SUBJECT: REGARDING KECKSBURG CRASH CONTROVERSIAL

FILE: UFO2483

Regarding Kecksburg:

The descriptions of the object that I have read remind me of one thing: A Soviet SOYUZ-type reentry module. These were designed for a ground landing, the shape is similar, and the Russians flew several variants of the SOYUZ as moonships (called ZOND), biological research satellites (COSMOS, but that's a generic name for almost anything they launch), and more significantly, as spy satellites. The Soviet Union figured out that economy of scale paid off where their space program was concerned and utilized the same basic designs for years. They still launch SOYUZ-class vehicles to rendezvous with MIR.

What I think happened, and this is just a conjecture, a SWAG if you will, is that either the DIA or the NSA figured out the command sequences for a Soviet spy satellite. They commanded the thing to land, it came down in Kecksburg, and the rest is history.

You have to remember that the best pictures from spy satellites are the ones where you have access to the negatives. This implies a recovery vehicle that can withstand re-entry. We had at least two series of spysats that employed re-entry vehicles: Big Bird (launched by Titan from Vandenberg) and the old Discoverers (launched by Atlas boosters). It makes sense to me that the Soviets would want to do the same thing, and that given their habit of recycling spacecraft designs they may have done it with the SOYUZ-type craft.

Why land the thing in Kecksburg instead of the desert? Either someone screwed up or we didn't have reliable orbital data for the thing while it was in orbit (these things happen; remember Skylab?). Maybe it was a rush job.

The coverup was needed to prevent the Soviets from realizing what we had done. Of course, once they couldn't find their satellite I think they would've realized it anyway, but by the it's too late.

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DEPARTMENT OF THE AIR FORCE
WASHINGTON DC 20330-1000

C

OFFICE OF THE SECRETARY

September 23, 1991

MEMORANDUM FOR SAF/AAZ

SUBJECT: Freedom of Information Act Request - Case #91-1128

The attached correspondence is forwarded for your action in accordance with AFR 12-30.

Request you provide us with:

a. Releasable records requested, and if necessary, information in writing on which to base a reply to the requester; or

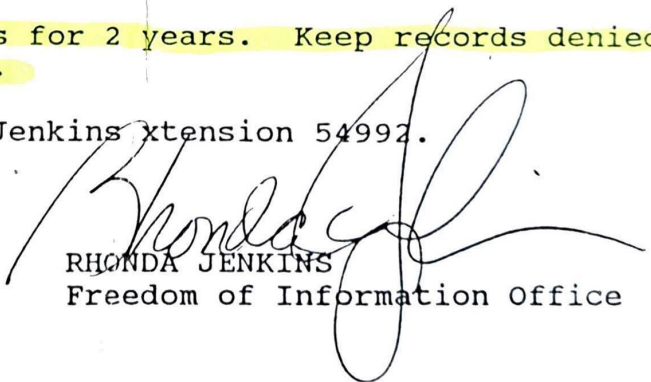
b. If you determine that parts or all of the records should be withheld, prepare a response addressed directly to the requester citing the specific exemption(s) from AFR 12-30. Coordinate your letter with SAF/GC (Mr. Wren, x56552) and this office before signature. Only authorized denial authorities can sign a final reply withholding records.

If you estimate search and duplication costs will exceed \$25.00 or amount requester agreed to pay, which ever is higher, please call us before starting the search.

To meet time limits imposed by law, we need your response by October 1, 1991.

Keep any releasable records for 2 years. Keep records denied or partially denied for 6 years.

Refer questions to Rhonda Jenkins extension 54992.


RHONDA JENKINS
Freedom of Information Office

2 Atch

1. Requester ltr w/atchs
2. DD Form 2086

a leak?!



DEPARTMENT OF THE AIR FORCE
WASHINGTON DC 20330-1000

2

80 SEP 1991

OFFICE OF THE SECRETARY

Dr. Armen Victorian
P.O. Box: 99
West PDO
Nottingham, NG8 3NT
England

Dear Dr. Victorian:

We are responding to your April 11, 1991 letter (DH-391).

Paragraph 3 of your letter was treated as a new request, we are attaching records.

Sincerely,

CAROLYN W. PRICE

Freedom of Information Manager

1 Atch
Responsive records

91-1128

04 OCT 1991

see answer over leaf



DEPARTMENT OF THE AIR FORCE

HEADQUARTERS AIR FORCE SPACE COMMAND
PETERSON AIR FORCE BASE, COLORADO 80914-5001

21 AUG 1990

Dr Armen Victorian
PO Box 99
West PDO
Nottingham NG8 3NT
England

Dear Dr Victorian

This replies to that portion of your July 12, 1990, Freedom of Information Act (FOIA) request pertaining to Information (Scientific) on Ground Based Electro-Optical Deep Space Surveillance System, capable of detecting 23,000 miles or so into space.

Ground-Based Electro-Optical Deep Space Surveillance System, Phase 1 Training Handbook and Fact Sheet are totally releasable and attached. We hope they will be of use to you.

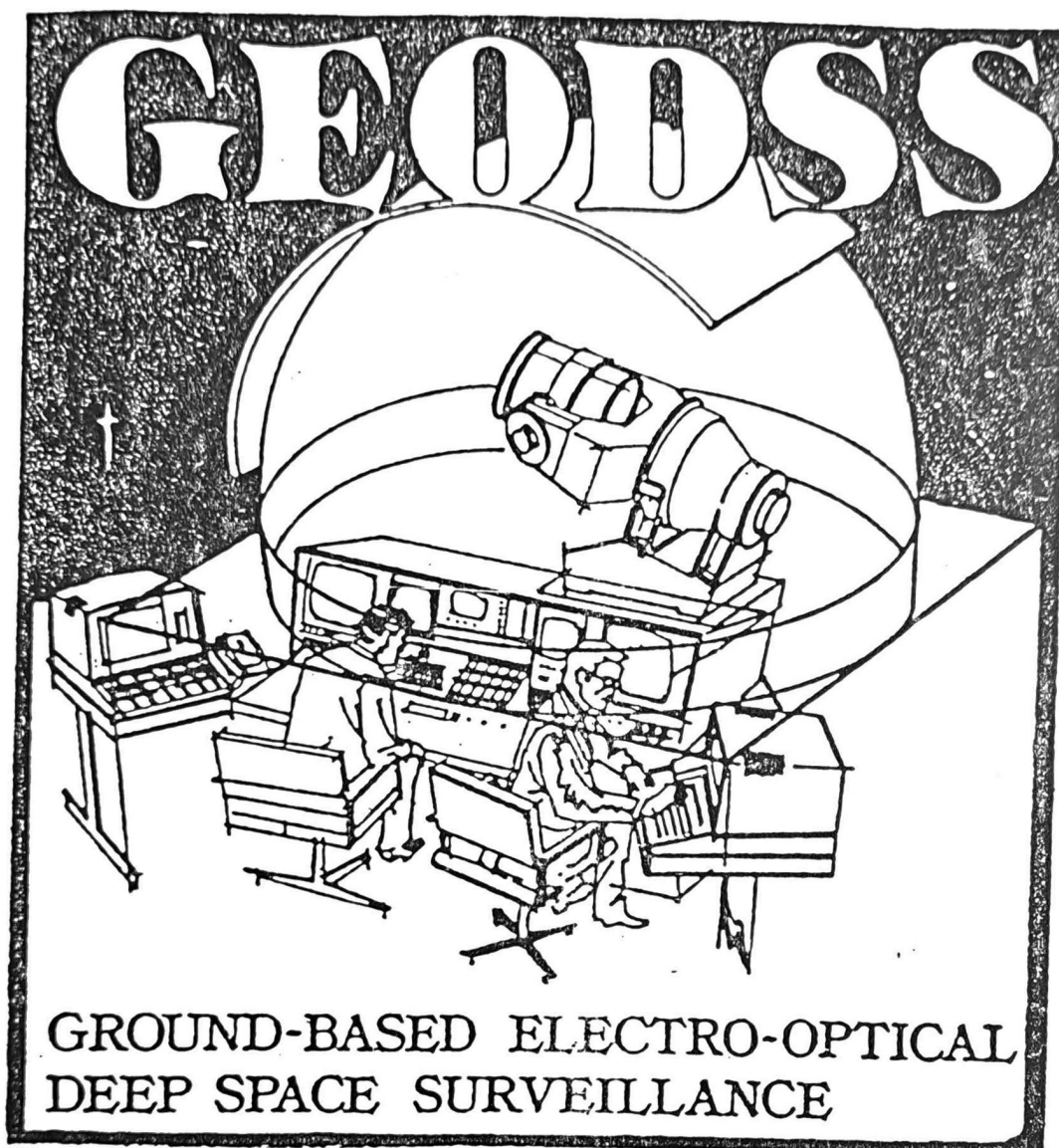
Fees for these records are waived.

Sincerely

A handwritten signature in cursive script, reading "Sharon A. Law", is positioned above the typed name.

SHARON A. LAW
Acting Chief, Records Management Division
Directorate of Information Management

2 Atch
1. Training Handbook
2. Fact Sheet



PHASE I TRAINING HANDBOOK

prc

Planning Research Corporation

PRC

Technical Services Division
2862 South Circle Drive
Suite 240
Colorado Springs, CO 80906

I wrote about missing pages, and talked to Bob Kirk in USSPACECOM. He said those pages are subject to review for releasability?!!

However the information in this pamphlet is fascinating. Science fiction capability at the tip of their fingers.

Henry
30-8-90

1. GEODSS. GEODSS is an acronym for Ground-Based Electro-Optical Deep Space Surveillance. The GEODSS system employs telescopes and computers to distinguish faint objects in the night sky. The reflection of sunlight on a space object makes it visible to the system.

The primary GEODSS mission is to track deep space satellites beyond 2000 nautical miles (nm). In a more limited data gathering capability, the system tracks near earth satellites at a distance of 350 to 2000 nm.

GEODSS site locations are shown in Figure 1. The system is intended to be a worldwide network of tracking stations spaced at approximately equivalent intervals around the globe. All sites are located in the northern hemisphere, with the exception of site 4, located at Diego Garcia.

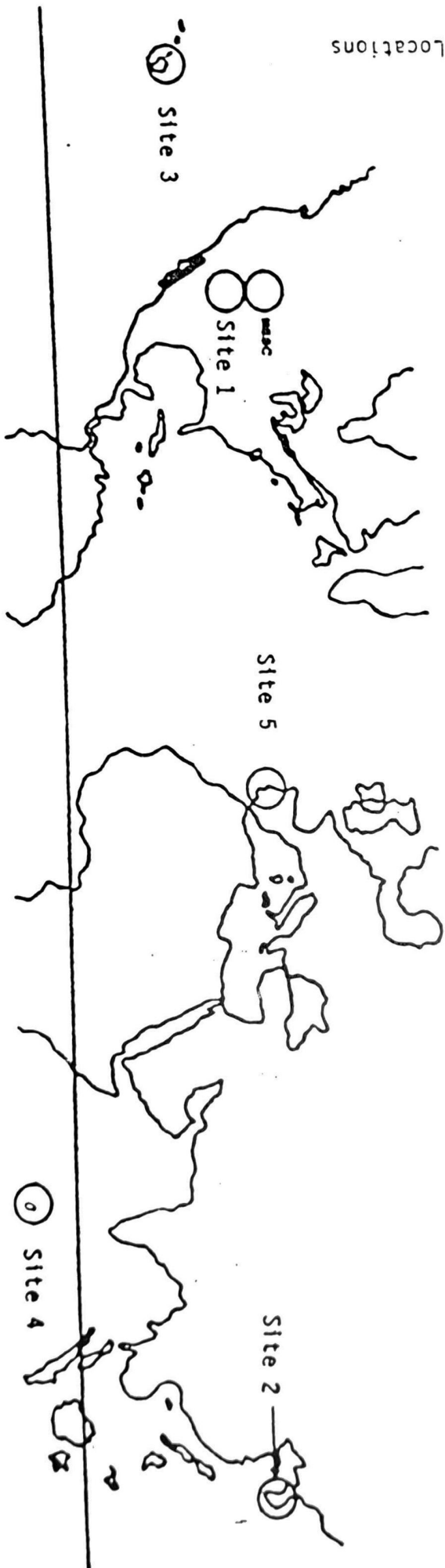
2. THE HISTORY OF GEODSS. Early space observation efforts were directed toward the VANGUARD project. Satellites designed during the VANGUARD project emitted radio signals that could be tracked from ground tracking stations. Before VANGUARD could be implemented, the Soviet Union launched their SPUTNIK I satellite. It transmitted a radio signal using a frequency that the VANGUARD project was unable to receive or detect. Because the satellite had a different signal, U.S. ground tracking stations were unable to track it. This shortcoming led to the development of two major systems, SPACETRACK and Missile Early Warning System (MEWS).

The SPACETRACK system provided a means for detecting, tracking, cataloging, and identifying satellites by using tracking radars. The dual system MEWS organization was developed to provide missile defense of the North American continent. The sea-launched Ballistic Missile (SLBM) system detects missiles fired toward the coast of the North American continent. Ballistic Missile Early Warning System (BMEWS) consists of a sensor network that can provide early warning for all types of ballistic missile attacks against the United States. With the increase of satellite populations, all of the systems were incorporated into SPACETRACK. A second BMEWS mission, BMEWS SPACETRACK, came into existence. Its purpose is to detect, track, and report orbiting objects in space.

GEODSS is an evolution of the Baker-Nunn camera system which, from 1960 to 1982, comprised the primary dedicated deep space tracking system. In the early 1970's it became apparent that the Baker-Nunn system could not continue to provide the projected mission support requirements that were seen for the 1980's and beyond. Trade-off studies conducted during 1973-75 indicated that an electro-optical system provided the most cost effective means of acquiring the needed capability. In May, 1978, TRW was selected by ESD through competitive procurement to be the production contractor, with RCA subcontracted to TRW for the initial O&M effort. Production and integration of the hardware and software were conducted at the TRW Newbury Park, California, facility. Subsystem testing and initial DT&E testing was conducted at this facility throughout 1981. Full system DT&E and IOT&E were performed at the Stallion RCC site during January through May 1982. An initial operational capability (IOC) was declared for the Stallion site on 15 May 1982. The Korean site at Taegu achieved IOC during July 1982 and the Maui site quickly followed suit in achieving IOC during September. The formal declaration of system operational capability was made by CINCNORAD during March of 1983. Since 1 October 1983, the O&M of the system has been competitively bid by Space Command, with PRC Kentron being awarded both the

Figure 1. GEODSS Site Locations

GEODSS SITE LOCATIONS



original and the follow-on contracts. Maintenance of the hardware, software, facilities, and operations of the site are conducted by contract to private industry, with a complement of 6-8 Air Force personnel per site performing overall monitoring of the contractor's performance and providing liaison with other Government agencies.

3. GEODSS SITES. When system installation is complete, there will be five GEODSS sites, with locations in Socorro, NM; Taegu, Republic of Korea; Maui, HI; Diego Garcia; and Portugal. Each site has its own unique characteristics, but an effort has been made to standardize the sites to the greatest extent possible.

The physical GEODSS sites consist of the facilities (Real Property Installed Equipment [RPIE]), Prime Mission Equipment (PME), and Prime Mission Related Equipment (PMRE). Space is provided in the facilities for administrative offices, maintenance shops, secure communications, the Space Surveillance Operations Room (SOC) where mission operations are conducted, the Computer Operations Room (COR), and various storage areas. The floor plan for each of the five sites is similar and a typical layout is illustrated in Figure 2. Additional support facilities, such as power generating plants, motor generator sheds, etc., vary for each site. However, the prime mission equipment and the operator interface is nearly identical at each site, with the minor variances that are present due to site specific requirements resulting from the physical location.

4. SYSTEM OVERVIEW. GEODSS sites consist of the facilities (RPIE), Prime Mission Equipment (PME), and Prime Mission Related Equipment (PMRE). Space is provided in the facilities for administrative offices, maintenance shops, secure communications, the Surveillance Operations Center (SOC) where mission operations are conducted, the Computer Operations Room (COR), and various storage areas.

a. General Characteristics. The GEODSS system detects reflected sunlight from satellites by using specially designed telescopes, high resolution television cameras, and video signal processing electronics. The hardware complement is driven by a sophisticated software system that processes the digitized video signals, performs automatic recognition of the satellite and presents the operator with the necessary displays. In the normal mode of operation, Precision Positional Measurement (PPM), the telescopes are driven at the same rate and direction as the star field, thus the stars appear as point images and the satellite as a streak. In the Space Object Identification (SOI) mode of operations the telescope is driven along the path of the satellite at the computed satellite angular rates. The satellite image is retained in the field of view of the radiometer so that the intensity of reflected sunlight can be measured. The software system provides the operator with full control over each mode of operation. The general specifications for the system are provided in Figures 3a through c. A simplified block diagram of data flow is provided in Figures 4a through d. Referring to Figure 4:

(1) The software system computes the position of the satellite and sends the appropriate commands to the mount control electronics which drives the telescope to the desired position.

(2) Reflected sunlight from the satellite is focused on the television tube face plate and the radiometer if in the SOI mode of operation.

(3) The camera electronics processes video data, which consists of both the satellite image and stars (Threshold Video), and passes the data to the Automatic Moving Target Indicator (AMTI) adaptive signal processors (Link I and Link II). These processors, in conjunction with the AMTI computers, perform the most critical function in the system by subtracting the stars and transient noise from the video frames (Background Rejection), leaving the satellite image (OR-Frame).

(4) Satellite position and rates are computed from the processed frame and compared by the Applications computer software with the predicted position of the satellite. If the measured position is within allowable tolerances, the satellite is considered to be correlated and the satellite number and correlation factor are passed to the graphics channels for display with the satellite image at the operators console. If the position does not fall within allowable tolerances, the satellite is considered to be an uncorrelated track (UCT) and a Candidate UCT (CU) number will be displayed along with the image. At this point the operator has several options available to him that will be discussed during the UCT procedures of this course.

(5) Control of system operations is conducted from two Console Control and Display Groups (CCDG) that are depicted in Figure 4D. Each CCDG is a two position console, thus a total of four positions are available for controlling the three telescopes. In the normal configuration, three positions are designated for telescope operations and one position as the Supervisor and Communications position. Control over any of the three telescopes can be exercised from any console positions and is solely dependent upon how the system is configured during console log-on. Each position is basically comprised of a primary and secondary graphics video monitor that displays satellite and telescope data, an alphanumeric display terminal for communicating with the computer system and a joystick for controlling/selecting menu data from the primary graphics monitor displays. The center of the console contains the necessary equipment for collecting strip chart recordings of intensity data and a telephone for each operator.

(6) The video from any sensor can be displayed at any console position by switch selection, regardless of the sensor assignment. This capability allows two or all of the operators to perform simultaneous tracking of a satellite while having visual access to what is occurring at each position. It also allows the Supervisor to monitor console activities at each sensor from his position.

(7) When detection of the satellite has been completed, the operator is provided the option of transmitting the observed data to the North American Aerospace Defense Command (NORAD) through the GEODSS communications system. A worldwide Automatic Digital Network (AUTODIN) line and a dedicated Advanced Data Communications Control Protocol (ADCCP) line to NORAD are the two primary means of communications. Voice communications are conducted over worldwide Automatic Voice Switching Network (AUTOVON) and commercial lines.

b. Major Modes of Operation. The GEODSS system operates in eight primary modes, including the daytime maintenance configuration. Each of the operational modes can be exercised either under software control or manually by the console operators' function keys.

(1) Non-Mission Mode. In this mode the consoles are generally logged-off and the alphanumeric terminal acts as a normal peripheral terminal to the computers for performing software maintenance tasks. In addition the graphics monitors are inactive. This is the normal mode of operation during the daytime while both hardware and software maintenance activities are being conducted. The remaining modes all pertain to mission operations.

(2) Calibration (CAL). Routines are available for calibrating the mount and the radiometer on a nightly basis and the camera on an as needed basis. Selection of calibration is conducted either under software control or manually by selecting the CALIB function key on the operator's console. The major calibrations routines are:

(a) Full (Global) Calibration. This function is used to calibrate telescope mount pointing and is performed during the period between civil and nautical twilight. Optimum results are obtained when the sky is relatively clear so that stars are selected throughout the hemisphere where the system software automatically points the telescope at a series of stars around the sites hemisphere. The offset of each star from the telescope boresight axis is measured and entered in the global calibration data base. These errors are subsequently used for correcting telescope pointing and observational measurements during mission operations.

(b) Radiometric Calibration (RADCAL). The RADCAL function is used to determine the boresight axis of the radiometer in relation to the telescope axis and to calibrate the radiometer response curve. The function is normally performed just prior to collecting data on the first SOI task, with optimum results obtained under clear, dark sky conditions.

(c) Camera Misalignment Correction (Part 1). This alignment is used to determine the error between the camera axis and the telescope mount, with the measured deviation used to correct the observations collected by the system. This function is normally exercised only when the camera has been removed for maintenance or there is a reason for believing the corrections may no longer be valid.

(d) Camera Tube Misalignment (Part 2). This function is used to determine the alignment errors between the camera tube and the telescope boresight axis. This function must be performed when the camera tube is replaced. As with Part 1, the measured errors are used in correcting the computed position of the observations.

(e) Sky Brightness. The intensity of the sky background may be measured at any time through selection of this function. Typical applications, when called through the CALIB function, are for determining if a bright sky was the reason for failing to detect an object or to determine if the sky is dark enough to perform a task. The Sky Brightness function is also called from the GVM (CALIB box) when performing an SOI track and is used to correct the collected radiometric data.

(f) Atmospheric Extinction. As the name implies, this function is used to measure the absorption of light through the atmosphere. It is also used for determining if atmospheric conditions, clouds, haze, dust, etc., were the reason for a failed detection. The function is also used both pre and post SOI data collection to gather correction measurements applied to radiometric data.

(g) Local Calibration. The Local Calibration function is an option presented to the operator following a successful PPM detection. The function selects a series of stars around the point-of-track to perform a miniature global calibration. The measured errors between the true stellar position and computed telescope pointing are applied to correction of the observation.

(3) Maneuver Query (MQ). The MQ mode serves two functions. Primarily, the mode is meant to quickly measure the current position of a satellite, compare it with the predicted position, and display the results to the console operator in the form a maneuver/non-maneuvered information box. Secondly, the MQ function is executed prior to the first measurement in a PPM task to correct the boresight positioning of the object in order to bring the PPM as close to the boresight axis as possible. Minor errors due to tube non-linearity are thus avoided.

(4) Precision Positional Measurement (PPM). The PPM mode is the normal and most accurate mode for collecting satellite positional data. Positional data is computed from the centroid of the streak data discussed earlier.

(5) AMTI Assist. In this mode of operation the console operator has manual control over the streak recognition process. The automatic PPM mode is bypassed. In the ASSIST mode the satellite streak will continue to build on the screen until the operator ends the process. He then designates each end of the streak with the Graphics Video Monitor (GVM) cursor. Positional data is then computed from the center point of the two streak designation points. This mode of operation is inherently less accurate than the PPM mode for several reasons. Foremost, the positional data is measured from the graphical representation of the streak, rather than the streak data itself. Secondly, it is nearly impossible to precisely position the GVM cursor while designating the beginning and ending points of the streak. The combined errors result in a positional measurement that is 3-4 times less accurate than the PPM mode. However, use of the ASSIST mode is sometimes essential to obtaining positional data when the software system is unable to recognize a severely fragmented streak due to weather or dimness, or the satellite is tumbling/-rotating and the intensity randomly exceeds threshold sensitivity.

(6) Sensitive Track (ST). The ST mode is the most sensitive mode of operations. In this mode over 60 video frames are collected and integrated. It is possible to detect satellites that are very dim and would otherwise be below the threshold sensitivity in the PPM or ASSIST modes. Because of the large number of frames processed, the ST mode is also the most time consuming method and is normally only used when the PPM and ASSIST modes have failed to detect the satellite.

(7) Space Object Identification (SOI). The SOI mode is used for collecting measurements of the satellite's reflected light intensity. In this mode the primary instrument is the telescope radiometer, while a portion of the energy is fed to the camera for operator display and telescope steering. The SOI mode is commonly referred to as a rate tracking mode as the telescope is driven along the satellite's path at the same angular rate the satellite is moving relative to the site.

user provides all of the software, file support, and software/-hardware interfaces for the communications system. The Office Automation System can be reconfigured with the Applications computer providing all communications functions in the event that the Executive computer is unavailable for maintenance or software activities. Under extreme conditions, a Model 40 Teletype (TTY) unit is available at each site and may be configured for message transmission and receipt. However, since messages can not be transferred to the prime GEODSS computers, this configuration is rarely used. Communications support is accessed from the Control Console and Display Group (CCDG) through the Master Menu. The console position that is used for communications must be logged on as a station and be designated as the communications position. The major capabilities of the system include:

- (1) Circuit configuration with either the ADCCP or AUTODIN line acting as the prime circuit, with back-up provided by the other circuit in case of primary line failure.
- (2) Message Preparation and Edit. Upon selecting this function, the operator is permitted to select a blank message format for originating a message or to select a "canned" message format, such as a Status Report, Element Set Request, etc., to be edited and subsequently transmitted. In the Edit mode, the message may be scrolled, lines deleted or inserted, lines printed, or the function may be exited.
- (3) Received message file maintenance. The File Services option of the communications system permits the operator to display or print the message log, and to display or print individual messages from the message log.
- (4) Message transmission/retransmission. When the message generation function is completed, the operator will normally review the contents to ensure it is correct and then exit to the transmit option. The operator is then prompted to enter the classification, priority, sender AUTODIN or data circuit, and routing code file number. Previously generated messages may be retransmitted through the File Services Menu - Data Circuit (or AUTODIN) Transmitted File.
- (5) Primary and Alternate Routing File Maintenance. The GEODSS communications system permits the operator to establish files of predetermined addressees. The files are sequentially numbered and are used by various functions in the system, such as observation and SOI data transmission, to automatically attach the appropriate routing indicators on transmitted messages. The files may also be used when generating and transmitting a message to specify the appropriate addressees. The files are created, edited, and deleted through Communications Services Primary Menu - File Services Menu. Three primary files are maintained

that each contain a set of Route Codes, with the file to be used selected when the communications circuits are enabled and defaults to Routing File #1.

- (6) Flash Message Review. On occasion, a very high precedence message (FLASH) will be received on the AUTODIN circuit. These messages are normally associated with New Foreign Launch element set distribution and notifications of the launch. Receipt of a FLASH message will cause the audio alarm on the CCDG assigned as the communications position to be activated and FLASH will be displayed at the NOTICES QUEUED line on the alphanumeric display terminal. The received message may be viewed at the line printer or on the terminal through the Communications Services Primary Menu - Display Flash Message.
- (7) Classified message maintenance. One of the more important features of the communications system is a timed buffer for classified messages wherein the transmission of the message may be terminated within the first 60 seconds if an improper classification was inadvertently assigned.

b. Communications Initiation and Interface. The communications segment is entered from the system Master Menu - Option #4. The communications services menu is displayed to the operator and provides him with access to all sub-menu items and functions.

8. ORBITAL MECHANICS, PHYSICAL CONSIDERATIONS.

a. Introduction. The basic data necessary to describe the orbit of a satellite so that its position may be determined at any given time is contained in the Orbital Element Set (OES). The GEODSS system has the capability to create a new orbital element set and to refine an existing element set, with both functions using observations collected during the tracking process. These two functions are referred to as Initial Orbit Determination (IOD) and Differential Orbit Correction (DOC), respectively. The operator is a key component in this process, as the decision to accept or reject the results of the computations are the operator's responsibility. This decision is based on observation of the satellite characteristics during the track, evaluation of the positional data record, and evaluation of the computed element set displayed at the GVM.

(1) The ability to visualize where the satellite is in respect to the site, what the probable (or known) type of orbit is, and an appreciation of the orbital characteristics are some of the most valuable assets an operator may have for it allows the operator to make rational decisions on what steps must be taken to maintain track on an object and the reasonableness of computed values in the IOD/DOC process. The value of having this ability is also carried to normal operations in making decisions on steps to take when an object is not acquired.

(2) Visual clues are presented at the GVM in the form of azimuth, elevation, and the actual streak length and direction. By interpreting this

information, the operator may make some valid assumptions as to the type of UCT satellite being tracked. If an existing element set is being used (as is the case for the DOC function), then the range of the satellite and the sun angle are also displayed.

(3) In order to understand what the information being displayed at the GEODSS consoles means, a basic understanding of orbital mechanics is necessary. This section is meant to provide the student with sufficient information to understand the terms that are used in discussing orbital element sets, the basic characteristics of the major types of orbits and the relationship to the IOD/DOC function. It is not meant to make the student an orbital analyst, although, when certified, he or she will have sufficient knowledge to conduct meaningful discussions with the NORAD analysts and to make valid decisions during IOD/DOC operations.

(4) The mathematics of orbital mechanics are minimized in this section. For those students wishing a more detailed study of orbital mechanics, a bibliography of reference material is presented at the end of the text.

b. General. Johannes Kepler and Sir Issac Newton formulated the basic laws of motion over three hundred years ago. These laws are as applicable today as they were then and form the basis for all space exploration, including earth orbiting satellites. This discussion will delve into Keplerian and Newtonian principles primarily as they apply to earth orbiting satellites. In order to maintain the context and clarity of the lesson, these principles have been rephrased to apply to man-made, earth orbiting satellites.

(1) Kepler's Laws of Satellite (Planetary) Motion. Kepler's most detailed studies were of Mars. From these studies, he formulated his first two laws of motion that deal with the type of orbit and the relationship between velocity and distance.

(a) The Law of Ellipses. Kepler's Law of ellipses states that:

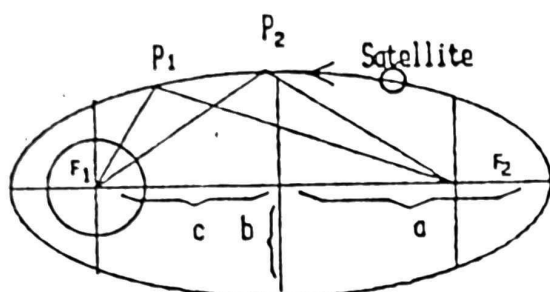
The orbit of each satellite is an ellipse with the earth always located at one foci.

Figure 5A illustrates this principle, with F1 being the earth's center. The ellipse is a closed curve such that the sum of the distances from the foci to a point anywhere on the curve is constant. For example, the sum of the distances from F1P1F2 is equal to the sum of the distances F1P2F2. An ellipse may be drawn by simply connecting a piece of string between two tacks and tracing the curve with a pencil holding the string taut. One should be able to visualize the concept that as the string becomes longer, with the tacks in the same position, the curve that is traced will progressively approach the shape of a circle. We will discuss the properties of the ellipse and its various parameters in the following sections.

(b) The Law of Areas (Equal Area in Equal Time). Kepler's second law states that:

Each satellite revolves around its foci so that the radius vector between the two sweeps out equal areas in equal intervals of time.

Kepler's First Law The Orbit is an Ellipse



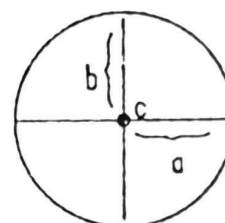
$$\text{eccentricity} = e = c/a$$

For an ellipse:

$$0 < e < 1$$

A

The Circle

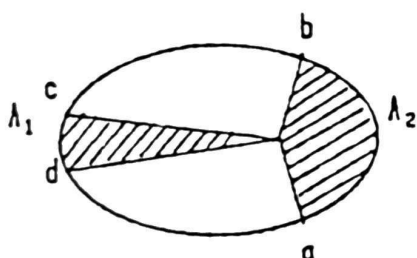


$$\text{circle } c = 0$$

$$\text{eccentricity} = c/a = 0/a = 0$$

C

Kepler's Second Law Equal Area in Equal Time

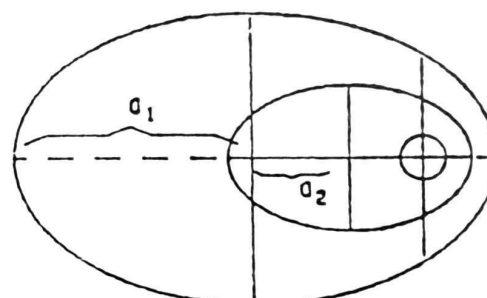


The time to transit from a to b
same as that to transit from c to d.
The areas (A_1 & A_2) are equal.

B

Kepler's Third Law The Law of Harmonics

$$\text{Mean Distance} = \text{Semi-Major Axis} = a_1$$



$$a_1^3/a_2^3 = P_1^2/P_2^2$$

$$a = \text{semi-major axis} \quad P = \text{Period}$$

D

Figure 5. Keplerian Principles

Figure 5B illustrates the law, wherein the area inscribed between a-b will be equal to the area inscribed by c-d, given that the time for the satellite to travel between a-b is equal to the time to travel between c-d. The important concept to understand from this law is that the closer the satellite is to the foci point, the greater its velocity. Conversely, the farther from the foci, the slower its velocity. Thus, if the satellite took 30 minutes to traverse the two segments of the curve in Figure 5B, clearly it must be moving slower when travelling from c to d. This concept is important when evaluating the streak length and direction on the GVM. A short streak indicates a slowly moving object, thus we may presume that it is at a fairly long range. The streak length, along with the streak direction and the pointing position of the telescope, will be shown to provide you with significant information as to the type of satellite being observed.

(c) The Law of Harmonics. The third Keplerian law that we are concerned with, The Law of Harmonics, states that:

The squares of the periods (the time it takes to complete one revolution) of any two satellites are in the same proportion as the cubes of their mean distances from the earth.

This means that the greater the mean distance the satellite is from the earth, the orbital period will increase proportionately. Figure 5D depicts the relationship in Kepler's third law and, when one considers that the satellite remains in orbit because of its inertia as discussed below, it is clear that the larger orbit takes a longer period of time to complete.

(2) Newtonian Principles. Newton was able to mathematically prove to the world Galileo's law of inertia wherein it is stated that: "A body at rest will remain at rest unless acted upon by an unbalanced force, and a body in motion will continue to move with uniform velocity unless acted upon by an unbalanced force." This law is known as Newton's first law of motion and is important in our discussions on orbital geometry as the earth acts as a force on the satellite. The next few paragraphs will deal with some basic Newtonian principles that are important to understanding how and why a satellite remains in orbit (or is drawn back to the earth), why the satellite displays some of the characteristics that it does in the elliptical orbit, and how a satellite is transferred from one orbit to another.

(a) Law of Inertia. Newton's law of inertia is a slight rephrasing of Galileo's wherein Newton states that:

A body at rest will remain at rest and a body in motion will remain in motion unless acted upon by an outside force.

Again, the outside force for an earth orbiting satellite is the earth. We may equate this law to the life cycle of a satellite from the time that it is launched into orbit by either a booster or the shuttle spacecraft, is held in the earth orbit by the balance between its own momentum and the gravitational attraction of the earth, and then eventually succumbs to that attraction and decays into the earth's atmosphere. Several important principles that are associated with the law of inertia include:

(b) Equilibrium. Equilibrium is the state of balance that is produced by the counter action of two forces. In our case, this is the equilibrium that is produced between the momentum of the satellite and the earth's gravitational attraction. If the satellite is given exactly the right amount of velocity when it is launched, then a state of equilibrium will be achieved wherein the orbit described by the satellite is correct for its intended mission. Too much velocity and the satellite will either be in the wrong orbit or could even escape the earth's gravitational attraction and continue into space. Too little velocity and again we could have the wrong orbit, or in the worst case, the satellite would be pulled back to earth. A good example of too little velocity occurred in 1984 during a shuttle launch of the Westar and Palapa satellites. The rocket motors that were supposed to take them out to a 20,000 nm circular orbit failed to provide sufficient velocity and the satellites ended up in elliptical orbits at approximately 650 nm and were useless for their intended communications mission.

(c) Motion. As discussed earlier, we are concerned with how fast the satellite appears to be moving and in what direction on the GVM. The principle terms that we are concerned with are speed, velocity and the velocity vector.

(1) Speed. Linear speed of an object is the rate of motion in a straight line. Angular speed is the change of direction per unit time. Angular speed is the value we will most generally be concerned with as the GEODSS system provides the rate of motion of a satellite in angular rates. The relationship is straight forward wherein:

$$S_{(speed)} = D_{(distance)} / T_{(time)}$$

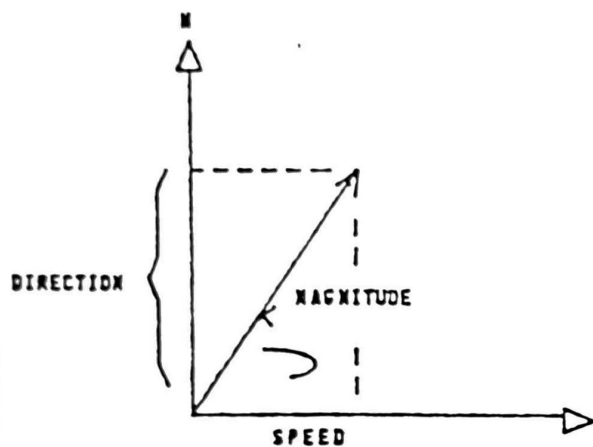
(2) Velocity. Velocity includes direction as well as the speed of an object. Thus when we discuss the velocity of a satellite we are describing its direction as well as speed. For example, we may say that the satellite was observed to be travelling in a northerly direction at 33 arcseconds/second.

(3) Velocity Vectors. The velocity of the satellite may be graphically represented by a line whose length represents the speed and the angle from the y-axis representing the direction of motion. The direction of motion is normally depicted graphically with North being up and the direction of rotation being clockwise from 0 degrees (North) to 360 degrees. Both speed and direction must be present in order for it to be a velocity vector. These components are depicted in Figure 6A.

(4) Acceleration. Acceleration is the rate of change in velocity; any change in the velocity of an object - either to start it, stop it, speed it up, slow it down or to change its direction - is considered acceleration. If the velocity increases, you have positive (+) acceleration. If the velocity decreases, you have negative (-) acceleration (e.g., it decelerates).

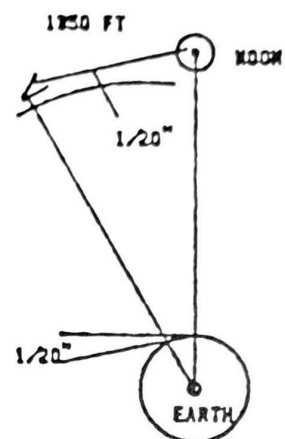
c. Falling Motion. A concept that is somewhat more difficult to understand, but forms the basis for a satellite remaining in orbit, is that of "falling motion". For example, consider the motion of the moon in Figure 62. Presume the moon moves 3350 feet in its orbit and falls (is attracted by the earth's gravitation) 1/20 of an inch towards the earth. However,

THE VELOCITY VECTOR MUST HAVE BOTH SPEED AND DIRECTION



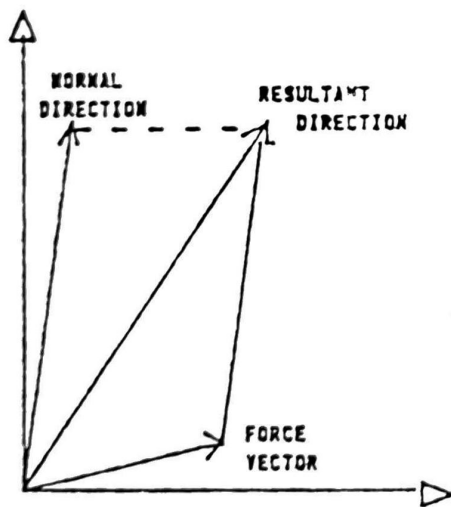
A

THE "FALL" OF THE MOON MATCHES THE EARTH'S CURVATURE



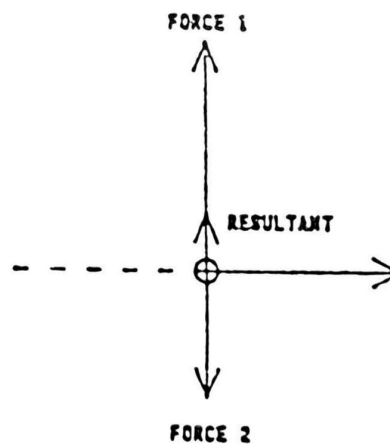
B

THE PATH OF A SATELLITE IS A RESULT OF ITS MOMENTUM AND EXTERNAL FORCES



C

OPPOSITE FORCES COMBINE WITH THE RESULTANT BEING THE ALGEBRAIC SUM OF THE TWO



D

Figure 6. Force Vectors

because of the earth's curvature, the moon remains the same distance from the earth. Thus, even though the moon continually "falls" towards the earth, it never gets closer. The same principle applies to man-made satellites, although it is somewhat more difficult to visualize for elliptical orbits wherein the satellite does come closer to the earth.

d. Law of Force and Momentum. Newton's second law deals with the effect of an outside force acting upon a body. This law states that: "If an outside force acts upon a body, the body will be accelerated. The magnitude of the acceleration will be proportional to the magnitude of the outside force and the direction of acceleration is in the direction of the outside force." Keep in mind that acceleration can be both positive and negative. For example, when we hit a golf ball (object at rest) with a club (outside force) we are exerting a positive acceleration to the ball (hopefully in a straight line). When the ball hits the ground (again an outside force) it receives a negative acceleration and will eventually come to rest again due to rolling friction.

(1) Force. Force is defined as the rate at which it produces a change in the momentum of the body upon which it acts. In our example above, if we hit the ball with a driver as opposed to the putter, we are exerting a greater force upon the ball. In the case of a satellite, the closer to the earth the satellite is, the greater will be the effects (force) of the earth's gravity and the greater the velocity of the satellite (Kepler's second law). The gravitational effect will also change the direction of the satellite's motion. The combined effect is portrayed with vectors in Figure 6C. In the diagram, the "normal direction" and the earth's gravity "force vector" form what is commonly referred to as a parallelogram of forces, with the resultant vector being the revised path of the satellite. In reality this is a constant effect on the satellite, with the earth's gravity exerting a constant "pulling" action on the satellite and is continually changing its direction. This continual change in direction results in the shape of the orbit.

(2) Static Equilibrium. When two forces act upon each other to cancel out, the object does not move. It is said to be in "Static Equilibrium". This situation occurs very momentarily at two points in the satellite's orbit - apogee and perigee. It also occurs for synchronous satellites where the velocity vector closely matches the earth's rotational speed and gravitational attraction. In this case the satellite remains stationary over a point above the earth's equator. These "synchronous" satellites form the basis for all of our major transcontinental and television communications satellites.

(3) Law of Gravitation. The effect of the earth's gravity on a satellite was expressed by Newton as:

"Between any two objects in space there exists a force of attraction that is proportional to the product of their masses and inversely proportional to the square of the distance between them."

A means of visualizing this concept is to think of a weight tied to the end of a string. If you spin the weight around your body, the faster you spin, the greater the force the weight exerts in trying to break loose. If the

weight is heavy enough, or you can spin fast enough, the string will break and the weight will fly off in its own direction. The same is true of satellites. The earth's gravitational attraction acts as the string, while the velocity of the satellite, when combined with its weight, acts as the weight on the string. Given enough velocity, the satellite would break the earth's attraction and fly off into space - which is exactly the concept that was used for the lunar missions.

e. Law of Action and Reaction. Newton's third law of motion states:

Whenever one body exerts a force on another, the second body exerts a force equal in magnitude and opposite in direction on the first body.

For example, when you fire a gun, the explosion exerts a force both on the bullet that is positive and an equal force, in the opposite direction, on the gun itself (the so called kick). This law is used extensively in spacecraft to maintain the attitude of the satellite and to perform adjustments in its orbit.

f. Summary. The basic physical laws that have been presented form the basis for planetary motion, as well as launching and controlling the orbit of all spacecraft. These laws will subsequently be combined with the parameters that define the shape of the orbit to provide you with an understanding of the satellites that you will be routinely observing with the GEODSS system.

9. PROPERTIES OF THE ORBIT

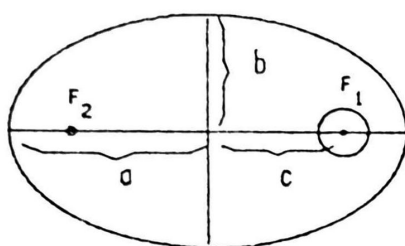
a. Orbital Parameters. As previously mentioned, every earth orbiting satellite has an elliptical orbit. The shape of the orbit (ellipse) is described by twelve classical parameters. Of these, several are used to form the orbital element set that is used by the GEODSS system to determine the position of a satellite at any given time. In this section we will discuss the basic parameters associated with the orbit. It is important that you understand the basic concepts presented, as they will form the basis for the remainder of the discussions in this section, the lesson on UCT concepts and procedures, and for search concepts. The few mathematical formulas that are presented are for the purpose of demonstrating the relationship between the individual components that describe an orbit. It is not the intention of this section to delve deeply into the analytical geometry that is used in actually computing the orbit.

(1) The Parameters of the Orbit (Ellipse). Refer to Figure 7 during the discussion of the parameters that define the ellipse. These parameters will subsequently be used in describing a portion of the format of the NORAD element set and in presenting practical applications for visualizing the orbit while operating the consoles.

(a) The Foci. An orbit has two foci, one of which is at the center of gravitational attraction (the earth for earth orbiting satellites), and the other being an imaginary point within the orbit. The two foci (F1 and F2) are depicted in Figure 7A.

(b) The Major and Semi-Major Axis. The major axis is the longest axis of the ellipse and passes through both foci. Referring to

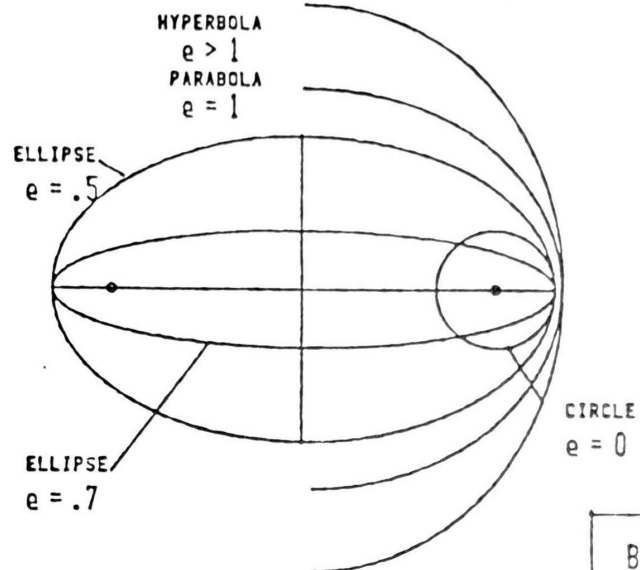
THE SEMI-MAJOR AND SEMI-MINOR AXIS
OF THE ELLIPSE



F = FOCI
a = SEMI-MAJOR AXIS
b = SEMI-MINOR AXIS
 $e = c/a$

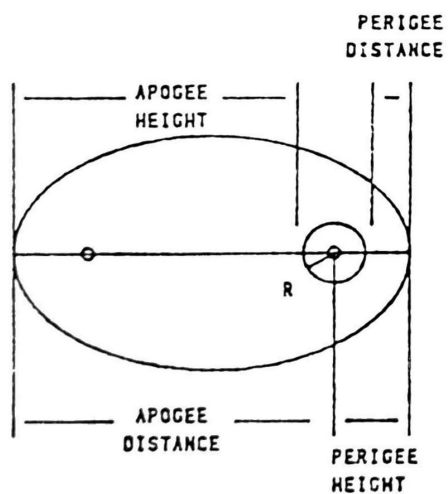
A

THE ORBIT SHAPE IS DEPENDENT UPON ECCENTRICITY



B

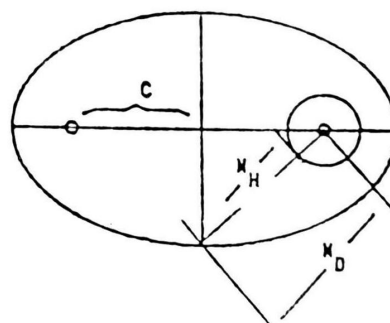
HEIGHT AND DISTANCE DIFFER BY THE
EARTH'S RADIUS



R IS APPROXIMATELY 6378 KM

C

THE MEAN HEIGHT AND DISTANCE
OF THE ORBIT



D

Figure 7. Basic Orbital Parameters

Figure 7A, the major axis is the twice the distance of (a) - the semi-major axis. The major axis is referred to with the symbol (A), while the semi-major axis is denoted by (a). The semi-major axis is normally the distance that is used when computing other orbital parameters such as eccentricity.

(c) The Minor and Semi-Minor Axis. The minor axis is the shortest diameter of the orbit and is twice the distance of (b) - the semi-minor axis. The minor axis is usually denoted with the symbol (B), while the semi-minor axis is denoted by (b). The minor axis is normal (perpendicular) to the major axis.

(d) The c-Distance. The "c" distance is the distance from the center of the orbit to one of the foci. This distance is depicted in Figure 7A. As we will see momentarily, the length of (c) is used in computing the eccentricity of the orbit. The relationship between the c-distance, major axis, and the minor axis describes the shape of the orbit.

(e) Eccentricity. The eccentricity, denoted by "e", is the amount that the orbit deviates from circular. Eccentricity is expressed as the decimal relationship between the c-distance and the distance of the semi-major axis.

$$e = c/a$$

Four major shapes are described by eccentricity:

(1) Circle. If the foci and the center of the orbit are the same point (e.g., only one focal point), the c-distance is zero and the eccentricity will be zero. The orbit is a circle. The circle is sometimes referred to as the special case of the ellipse. ($e = 0$).

(2) Ellipse. As the foci move apart, the c-distance becomes greater than zero, the shape becomes elongated (elliptical), and the eccentricity becomes greater than 0. The greater the elongation of the ellipse, the larger will become the ratio between c and a. The eccentricity of the ellipse will always be greater than zero, but less than one. ($0 < e < 1$).

(3) Parabola. When the eccentricity reaches one ($c = a$), the shape described is that of a parabola. In this case the satellite would no longer be orbiting the earth. ($e = 1$).

(4) Hyperbola. If the eccentricity exceeds one, the shape becomes even more flattened and describes a hyperbola. Both the hyperbola and the parabola may be used for other than earth orbiting satellites, with the deciding factor usually being which plane will require the least energy for the booster and injection rockets. ($e > 1$).

Each of these orbits is depicted in Figure 7B. Some relationships that are interesting to note:

<u>Semi-Major Axis (a)</u>	<u>Semi-Minor Axis (b)</u>	<u>Eccentricity (e)</u>
IF: Increases No Change Increases	AND: Increases Decreases May: Increase Decrease No Change	THEN: No Change Increases Increases

The change in eccentricity is strictly dependent upon the relative lengths of the (c) and (a) axis. The GEODSS system will track satellites whose eccentricity ranges from 0 to .97. Typically these orbits will range from a few hundred kilometers to 100,000 km or more for objects in highly eccentric orbits. A table of the more common satellites that you will be tracking and their basic elements is presented after the discussion of perigee and apogee.

(2) Distance and Height Measurements. Frequently the range to a satellite is expressed in either height or distance. The difference between the two is equal to one earth radius or approximately 6378 kilometers. There are two terms that are associated with these distance measurements that concern the orbital parameters - apogee and perigee. The difference between these measurements is depicted in Figure 7C.

(a) Apogee Distance. Apogee is the distance from the center of the earth (or other primary foci) to the farthest point in the orbit. This is also the point in the orbit that the satellite will normally display its slowest angular rates relative to the observer.

(b) Apogee Height. This is the distance from the surface of the earth to the farthest point in the orbit.

(c) Perigee Distance. Perigee distance is the distance from the center of the earth (or other primary foci) to the closest point in the orbit. A satellite will normally have its greatest angular rates relative to the observer during, or near, its perigee passage.

(d) Perigee Height. Perigee height is the closest point to the surface of the earth in the orbital path.

(e) Range. Range is another term that is often associated with the orbit, but is not to be confused with the orbital parameters. Range is most commonly associated with the distance from the observer, or site, to the satellite. Thus range is a dynamic measurement that varies with the orbital parameters and specific point in the orbit being observed.

(3) Mean Distance and Mean Height. Mean distance and mean height are the average distance and height of the orbit. They can be measured from the point where the minor axis intersects the orbit to the center of gravitational attraction (earth) and are measured to the surface of the earth, respectively. This distance is equal to the length of the semi-major axis. It is also equal to one-half the sum of the apogee and perigee distances. The relationship between these distances is depicted in Figure 7D.

(4) Some Typical Orbits. The following table provides a summary of the major type of orbits that you will be tracking with the GEODSS system. The distances given are approximate and will vary from satellite to satellite. The student should note that as the perigee and apogee heights approach each other the orbit becomes more circular (e approaches 0). In contrast is the case of Prognoz, wherein there is a very large difference in the perigee and apogee heights and the eccentricity is approaching a parabolic orbit.

Common Name	Perigee (km)	Apogee (km)	e	Period (mins)	Type
Molniya P/L	720	39,600	.72	718	Elliptic
Molniya R/B	480	40,600	.74	732	Elliptic
COSMOS	1,000	39,300	.73	718	Elliptic
GPS	20,100	20,100	.00	718	Circular
Synch Sat	39,000	39,000	.00	1436	Circular
Near Earth Circular	210	450	.02	91	Near
Prognoz	980	197,400	.93	5687	Highly -Elliptic

(5) In summary, the physical laws derived by Newton, Galileo, Kepler and others, apply to both the mechanics of launching a satellite in its orbit and determine the shape of the orbit once it has been launched. The major orbit that concerns the GEODSS operations technician is the ellipse. Every earth orbiting satellite is in an elliptical orbit, if one considers the circle as an ellipse with eccentricity of zero. (In reality a perfectly circular orbit is never achieved, thus eccentricity will be greater than 0).

10. THE ORBITAL PARAMETERS.

a. The Orbital Elements. Up to this point we have been discussing the simple geometric properties of the ellipse. Although these parameters adequately describe the shape of the orbit, they do not fully describe its orientation relative to the earth. The next few sections will discuss the parameters that are used to describe the shape of the orbit and its orientation to the earth.

b. General. A unique set of parameters are associated with the orbit of a satellite that allow us to describe its shape, orientation to the earth, and to predict where the satellite will be at any given time. These parameters are contained within what is commonly referred to as the Element Set. The vast majority of the element sets that GEODSS uses are generated by NORAD and reside in the GEODSS Resident Space Object (CXRSOC) and Element Set (CXELEM) files. CXRSOC is a file of the element sets in the NORAD format. CXELEM is a file of the element sets that have been transformed into the format necessary for GEODSS use. The CXELEM file is also the file that will be used for site generated element sets and for storing a site or NORAD element set that you may have refined with the DOC process.

c. The Basic Elements. There are six parameters stored in each file that comprise the basic element set. These parameters are referred to as the

Keplerian orbital elements. Additionally, there are several other parameters stored that are necessary in order to uniquely identify the satellite and to allow prediction of a future position. The six basic elements and their symbols are the:

- (1) Semi-major Axis (a)
- (2) Inclination (i)
- (3) Argument Of Perigee (ω)
- (4) Eccentricity (e)
- (5) Right Ascension of the Ascending Node (Ω)
- (6) Epoch Time (t)

d. Describing the Size and the Shape of the Orbit. As we have seen, the semi-major axis and the eccentricity describe the size and the shape of the orbit. Thus, the longer the distance of the semi-major axis, the larger the orbit. The greater the eccentricity, the more elliptical the orbit.

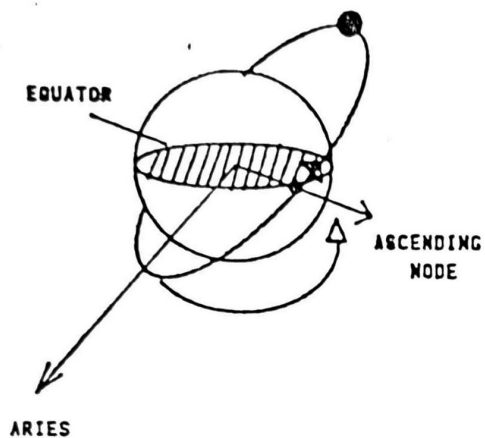
(1) The minimum orbital height is approximately 200 nm. Orbits less than this experience drag from the earth's atmosphere and will soon decay.

(2) The eccentricity and semi-major axis are determined prior to launch. These two parameters, in conjunction with the other terms we will be discussing, must be established so that the orbit of the satellite fulfills its mission requirements. Normally these parameters are established so that the satellite "sees" a specific portion of the earth at a specific time. For instance, the synchronous satellite orbit is set so that it remains over a given longitude. The majority of these satellites support transcontinental or transoceanic communications. Control of the longitudinal position is important so that the users, both the transmitting and receiving parties, sustain constant communications. On the other hand, surveillance satellites may need to be in a highly inclined circular orbit and phased with each other so that they "see" specific regions of the earth that are sunlit.

e. Orientation of the Orbital Plane. The orientation of the orbital plane in space is described by the Right Ascension of the Ascending Node (RA) and the Inclination (i).

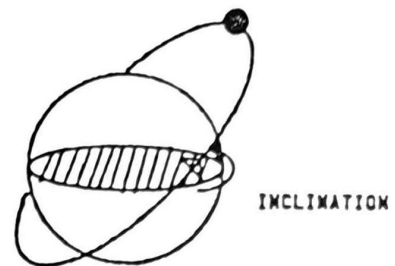
(1) Right Ascension of the Node. If we were to extend the plane of the equator into space as a flat plate, a satellite will intersect the plane at two points. The point at which the satellite intersects the plane when travelling from south to north is referred to as the ascending node. Conversely, the point that the satellite intersects the plane when travelling from north to south is referred to as the descending node. Referring to Figure 8A, the position of the ascending node where it intersects the equatorial plane is one of the elements we use to orient the plane of the satellite. The angle formed between the hour circle of the star Aries and

THE ASCENDING NODE



A

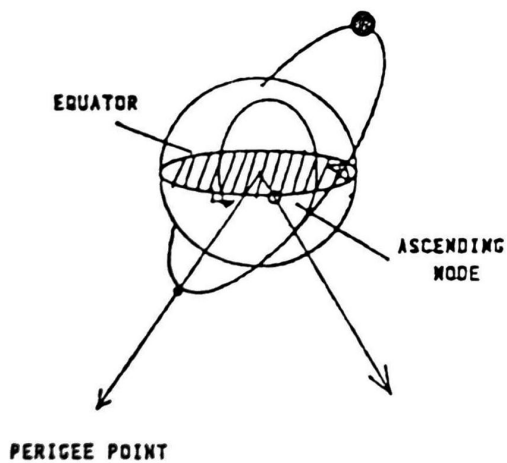
THE ANGLE OF INCLINATION



INCLINATION IS THE ANGLE THE PLANE OF THE SATELLITE MAKES WITH THE EQUATOR.

B

ARGUMENT OF PERIGEE POINT



C

Figure 8. Major Orbital Parameters

the satellite as it crosses the equatorial plane on its ascending node is referred to as the Right Ascension of the Node. The angle is measured eastward from Aries. Given this point, the time that it occurred, and the other orbital parameters, we can predict a future position of the satellite.

(2) Inclination. Inclination is simply the angle that the plane of the satellite makes with the equatorial plane. This angle is depicted in Figure 8B. There are also four types of orbits that are associated with the angle of inclination.

- (a) Prograde - Inclination less than 90 degrees.
- (b) Retrograde - Inclination greater than 90 degrees.
- (c) Polar - Inclination is 90 degrees.
- (d) Equatorial - Inclination is 0 degrees.

f. Orientation of the Orbit within the Orbital Plane. Now that we have the size, shape and orientation of the orbital plane described, the next step is to orient the orbit within the plane. To clarify the orientation of the orbit within the plane, presume the orbit is an ellipse. There must be a means for describing where the apogee and perigee points occur. Consider the perigee point. Does it occur over the US ?; the Soviet Union ?; or maybe even Australia ?. Within the plane of the orbit, any of these points are possible by simply rotating the ellipse around in the plane. The parameter that describes this position is the Argument of Perigee.

(1) Argument of Perigee is the angle formed along the orbital path between the ascending node and the point of perigee (the satellites closest point to the earth). The angle is measured in the direction of motion of the satellite. The Argument of Perigee is depicted in Figure 8C. In this particular case, the angle is measured from the ascending node, counter-clockwise to the point of perigee (roughly 270 degrees). The vast majority of satellites that the GEODSS system tracks have their perigee point in the southern hemisphere.

(2) Apogee is located 180 degrees in the orbital plane from the point of perigee. Thus, if the Argument of Perigee is 100 degrees, apogee occurs at 280 degrees. The mean distances (Figure 8D) occur 90 degrees from these points, or 10 and 190 degrees.

(3) Perigee Shift is an important consideration for determining the inclination of the orbit. Due to the earth being an oblate spheroid, a torque is applied to the orbit that causes the perigee point to shift. The shift is referred to as perigee rate and can be either positive or negative, dependent upon the inclination angle. The effect is a shift of the perigee point in the plane of the orbit, i.e., the ellipse is shifted within its plane. The effect is summarized below. It is also interesting to note that many of the orbits common to GEODSS operations use a 63 degree inclination in order to minimize this effect.

<u>Inclination (Degs)</u>	<u>Perigee Rate</u>
0 - 63.3	Positive
63.4	No Shift
63.5 - 116.5	Negative
116.6	No Shift
116.7 - 180	Positive

g. Locating the Satellite in the Orbit. Now that we have the orbit firmly fixed in space, the final step is to locate the satellite within the orbit. Since the parameters of the orbit - such as eccentricity, inclination and the ascending node - have been defined, we need only determine where the satellite was at some specific time in order to predict a future position. The time parameter is referred to as the Epoch time and is commonly referenced to the time of the ascending node, but can be at any predefined point.

h. Summary. The six Keplerian orbital elements define the shape and position of the orbit and locate the satellite within the orbit. A summary of the meaning of these parameters follows.

(1) Semi-Major Axis and Eccentricity - Define the size and shape of the orbit.

(2) Right Ascension and Inclination - Orient the orbital plane in space.

(3) Argument of Perigee - Orients the orbit within the orbital plane.

(4) Epoch Time - Locates the satellite within the orbit.

11. PRE-OPERATIONAL TASKS. Specific administrative tasks must be accomplished on a daily basis to prepare the system for mission operations and to fulfill contractual obligations. This section will highlight tasks that are accomplished to ensure activities such as producing the necessary reports, saving mission files to tape, and setting up for the coming night's mission are completed. Most of these activities are conducted using the Operations Daily Checklist. This checklist covers a 24-hour period and is used as a guide for all operations personnel to ensure primary or critical mission tasks are accomplished. The checklist is also supplemented by other task specific checklists where necessary, such as the NDL/NFL checklists and worksheets. The following text uses the Daily Operations Checklist as a basis for discussing the 24-hour mission responsibilities of the site. Clarification and amplification of the steps are provided so the student may receive a clear idea of the minimum tasks required to complete the GEODSS mission.

GEODSS ACRONYMS AND ABBREVIATIONS

The following listing is intended to be a comprehensive list of those acronyms and abbreviations applicable to all phases of the GEODSS mission.

A&A	- Allowance and Authorization
AATS	- AMOS Acquisition Telescope System
ACDA	- U.S. Arms Control and Disarmament Agency
ACK	- Acknowledge
ACP	- Allied Communications Publication
ACSI	- Assistant Chief of Staff for Intelligence, DOA
ACU	- Attendant Console Unit
A/D or A-D	- Analog to Digital
ADCCP	- Advanced Data Communications Control Protocol
ADMIN	- Administration
ADP	- Automatic Data Processing
	- Alarm Display Panel
ADPE	- Automatic Data Processing Equipment
ADPM	- Automated Data Processing Machine
ADT	- Alphanumeric Display Terminal
ADTAC	- Air Defense Tactical Air Command
AENA	- Astronomical Ephemeris and Nautical Almanac
AF	- Air Force
A&F	- Accounting and Finance
AFB	- Air Force Base
AFCC	- Air Force Communications Command
AFLC	- Air Force Logistics Command
AFM	- Air Force Manual
AFOSH	- Air Force Occupational Safety and Health
AFP	- Air Force Pamphlet
AFR	- Air Force Regulation
AFRAMS	- Air Force Recoverable - Assembly Management System
AFS	- Air Force Station
AFSC	- Air Force Specialty Code
AFSCF	- Air Force Satellite Control Facility (Sunnyvale, CA)
AFTO	- Air Force Technical Order
AIG	- Address Indicating Group
ALC	- Air Logistics Center
ALCOR	- Advance Research Projects Agency (ARPA) and Lincoln C-Band Observable Radar (Kwajalein)
ALS	- Advanced Logistics System
ALU	- Arithmetic Logic Unit
	- Attendant Line Unit
ALTAIR	- ARPA Long-Range Tracking and Instrumentation Radar
AM	- Administration Manager
AMOS	- Air Force Maui Optical Station
AMTI	- Automatic Moving Target Indicator
A/N	- Alphabetic/Numeric

ANSI	- American National Standards Institute
ANSSC	- Alternate NORAD Space Surveillance Center
A ₀	- Operational Availability
A _p	- Appendix
AP0	- Army Post Office
APPL	- Applications Computer, PDP 11/70 VK
APR	- April
AQAE	- Functional Area Quality Assurance Evaluator
ARFCOS	- Armed Forces Courier Service
ARPA	- Advance Research Projects Agency
ASAP	- As Soon As Possible
ASAT	- Anti-satellite
ASC	- AUTODIN Switching Center
ASCII	- Allowance Source Code
ASD(C)	- American Standard Code for Information Inter- change
A _t	- Assistant Secretary of Defense (Comptroller)
AUG	- Availability Test
AUTODIN	- August
AUTOVON	- Automatic Digital Network
AUX	- Automatic Voice Switching Network
AV	- Auxilliary
AWM	- AUTOVON
AWP	- Awaiting Maintenance
AZ	- Awaiting Parts
BC	- Azimuth
BCD	- Budget Code
BDN	- Binary Coded Decimal
BI	- Besselian Day Number
BITE	- Background Investigation
BIU	- Built In Test Equipment
BL	- Bus Interface Unit
BM	- Bill of Lading
BMEWS	- Business Manager
BOF	- Ballistic Missile Early Warning System
BOI	- Bottom Of File
BPS	- Basis Of Issue
Brd	- Bits Per Second
BT	- Board
BSS	- Break Text
BTOD0	- Base Service Store
BUF	- Base Technical Order Distribution Office
(C)	- Back-up Facility
CA	- CONFIDENTIAL
CAB	- California
CA/CRL	- Civil Aeronautics Board
CAI	- Custody Authorization/Custody Receipt Listing
CAL	- Communications Action Identifier
CAN	- Calibration
CAN-US	- Cancel
CAP	- Canada-United States
	- Communications-Electronics Authorization Program
	- Communications Allowance Program

CAR	- Customer Account Representative
CAT	- Category
CAU	- Crypto Auxiliary Unit
CBL	- Commercial Bill of Lading
CCDG	- Console Control and Display Group
CCG	- Communications, Control Group
CD	- Command Director at Cheyenne Mountain Complex
CDR	- Critical Design Review
CDRL	- Contract Data Requirements List
CDSS	- Canadian Department of Supply and Services
CDU	- Console Display Unit
C-E	- Communications-Electronics
CEFR	- Communications - Electronics Facility Records
CEIP	- C-E Implementation Plan
CEM	- Communications Electronics Maintenance
CEMOI	- C-E Maintenance Operating Instruction
CEMT	- Command Equipment Management Team
CENTO	- Central Treaty Organization
CES	- Communications/Electronics Supervisor
CF	- Centrally Funded
CFE	- Contractor Furnished Equipment
Ch	- Chapter
Chg	- Change
CI	- Configuration Item
	- Critical Item
CIC	- Content Indicator Code
CIG	- Content Indicator Group
CINCNORAD	- Commander in Chief NORAD
CIV	- Civilian
Ckt	- Circuit
CLASSY	- Satellite Catalog Compilations
CM	- Candidate Material
	- Corrective Maintenance
CMC	- Cheyenne Mountain Complex
CMP	- Configuration Management Plan
	- Contrast Mode Photometer
	- DEC Compare Utility
CODEC	- Code/Decode
CO	- Colorado
COI	- Communications Operating Instruction
COMBO	- Combination of Miss Between Orbits
COMINT	- Communications Intelligence
COMM	- Communications
COMSAT	- Communications Satellite
COMSEC	- Communications Security
COND	- Condemned
CONUS	- Continental United States
COR	- Computer Operations Room
COS	- Certificate of Service
	- Chief of Supply
COSMOS	- General Class of Soviet Military Satellites
CP	- Command Post
	- Centrally Procured (through AFLC Manager)
	- Contingency Plan

CPC	- Computer Program Component
CPCI	- Computer Program Configuration Item
CPDP	- Computer Program Development Plan
CPET	- Contractor Performance Evaluation Team
CPR	- Cardiopulmonary Resuscitation
CPT&E	- Computer Program Test and Evaluation
CPU	- Central Processing Unit
CQAE	- Chief Quality Assurance Evaluator
CR	- Carriage Return
CRB	- Configuration Review Board
CRD	- Cumulative Recurring Demands
CRI	- Collective Routing Indicator
CRISP	- Computer Resources Integrated Support Plan
CRT	- Cathode Ray Tube
CRYPTO	- Cryptographic
CS	- Communications Subsystem
	- Computer Science
CSB	- Computer Support Base
CSDB	- Common System Data Base
CSDBM	- Common System Data Base Maintainer
	- Common System Data Base Manager
CSISM	- COMSEC Supplement to the ISM
CSO	- Cognizant Security Office
CSRI	- Called Station Routing Indicator
CSRL	- Code Selected Reconciliation List
CSS	- Communications System Segment
CTA	- Cobra Talon Alert (Ref N/A/S 55-12)
CTK	- Composite Tool Kit
CTRL	- Control
	- Control Key
CTRL/Z	- Control Z Key strokes
CTS	- Clear To Send
CU	- Candidate Uncorrelated Target
CUSR	- Central United States Registry
- CVI	- Colorado Video Integrator
D	- Directive
D/A or D-A	- Digital to Analog
DACS	- Day(s) After Contract Start
DADS	- Digital Automatic Display System
DAR	- Data Automation Requirement
DB	- Data Base
db	- decibel
DCA	- Defense Communications Agency
DCAC	- Defense Communications Agency Circular
DCAS	- Defense Contract Administration Services
DCASR	- Defense Contract Administration Services Region
DCD	- Data Carrier Detect
DCE	- Data Communications Equipment
DCII	- Defense Central Index of Investigations
DCS	- Defense Communication System
	- Deputy Chief of Staff
DCT	- Data Communications Terminal
DD	- Department of Defense (For use with forms)
DDC	- Dedicated Data Circuit

DEC

DEC Writer

DEFCON

DEFSMAC

DET

DG

DGR

DIA

DID

DIFM

DIS

DISCO

DISCR, OGC, OSD

DLA

DLM

DLS

DNACC

DO

D/O

DOC

DOD

DODM

DODR

DOE

DOFD

DOL

DOLD

DOLF

DOLI

DOLT

DOR

DOT

DP

DPDO

DPG

DPS

DR

DSA

DSAL

DSI

DSP

DSP&P

DSR

DSSTRR

DSW

- December
- Declination
- Declination Angle
- Digital Equipment Corporation
- Terminal/Printer
- Defense Readiness Condition
- Defense Special Missile and Astronautics Center
- Detachment
- Dome Group
- Designated Government Representative
- Defense Intelligence Agency
- Data Item Description
- Due-In From Maintenance
- Defense Investigative Service
- Defense Industrial Security Clearance Office
- Director for Industrial Security Clearance Review, Office of the General Council, Office of Secretary of Defense
- Defense Logistics Agency
- Depot-Level Maintenance
- Documentation/Library Specialist
- Defense National Agency Check Center
- Director of Operations
- Due Out (DUO)
- Differential Orbit Correction
- Due Out Cancellation
- Department of Defense
- Department of Defense Manual
- Department of Defense Regulation
- Department Of Energy
- Date of First Demand
- Department Of Labor
- Date of Last Demand
- Date of Last Follow-Up
- Date of Last Inventory
- Date of Last Transaction
- Due Out Release
- Department Of Transportation
- Demand Processing
- Defense Property Disposal Office(r)
- Data Processing Group
- Data Processing Subsystem
- Dead Reckoning
- Defense Radar
- Deficiency Report
- Defense Supply Agency
- Deep Space Attention List
- Defense Security Institute
- Disposal
- Director for Security Plans & Programs, Office of the Deputy Under Secretary of Defense (Policy)
- Data Set Ready
- Deep Space Sensor Tasking Response Report
- Device Status Word

DT&E	- Development Test and Evaluation
DTG	- Date Time Group
DTIC	- Defense Technical Information Center
DTMF	- Dual Tone Multi-Frequency
DTR	- Data Terminal Ready
DUSD	- Deputy Under Secretary of Defense for Policy
DVM	- Digital Voltmeter
E	- Encrypted
EAA	- Emergency Priority
EACC	- Equipment Approval Authority
EAHIST	- Electronic Asset Control Center
EAID	- Evaluate Historical
EAIM	- Equipment Authorization Inventory Data
EAM	- End Article Item Manager
EAR	- Electronic Accounting Machines
EC	- Export Administration Regulation
ECD	- Equipment Custodian
ECO	- Estimated Completion Date
EDD	- Equipment Control Officer
EDLM	- Estimated Delivery Date
EEFI	- Emergency Depot Level Maintenance
EEIC	- Essential Elements of Friendly Information
EEX	- Element of Expense/Investment Code
EFTO	- Excess Exception Code
EIA	- Encrypted For Transmission Only
EIC	- Electronic Industries Association
EIP	- Engineer-In-Charge
EL	- Equipment Inoperative for Parts
ELSET	- Elevation
EM	- Element Set
E&M	- End of Medium
- E Magnitude	- Signaling Leads (used in telephony)
EMC	- Exoatmospheric reference Magnitude
EMI	- Emergency Message Change
EMO	- Electro Magnetic Interference
ENAC	- Equipment Management Office
E.O.	- Expanded National Agency Check
EODET	- Executive Order
EOM	- Early Orbit Determination
EOMI	- End Of Message
EOQ	- Equipment Maintenance Operating Instruction
EOS	- Economic Order Quantity
EOSS	- Electro/Optical Sensor
EOT	- Electro-Optical Sensor Subsystem
EPA	- End Of Transmission
EPABX	- Environmental Protection Agency
EPROM	- Electronic Private Automatic Branch Exchange
ERRC	- Electrically Programmable Read Only Memory
ERRCD	- Expendability, Recoverability, Repairability Category Code
ERU	- Expendability/Recoverability/Repairability/Cost Designator
	- Earth Rate Unit

<ESC>

ESD

ESR

ESV

ETA

ETB

ETRO

ETX

EXEC

EXT

FAA

FAD

FAR

FASW

FAU

FBI

FCA

FCL

FCP

FCU

FD

FDX

FE

FEB

FEMA

FFK

FLP

FMS

FOB

FOCI

FOUO

FOV

FPO

FQT

(FRD)

FRS

FSC

FSN

FSO

FSS

F4P

G

GA

GAO

GBL

GCT

GDPSS

GE

GEODSS

- Escape Key
- Electronic Systems Division
- Equipment Status Report
- Earth Satellite Vehicle; a man-made earth orbiting object
- Estimated Time of Arrival
- End of Transmission Block
- Estimated Time to Return to Operations
- End of Text
- Executive Computer, PDP 11/70 VK
- Extinction
- Extension
- Federal Aviation Administration
- Force/Activity Designator
- Federal Acquisition Regulation
- Functional Applications Software
- Fuse Alarm Unit
- Federal Bureau of Investigation
- Functional Configuration Audit
- Facility (Security) Clearance
- Fuse and Connector Panel
- Flexible Conference Unit
- Federal Document
- Full Duplex
- Facilities Engineering
- February
- Federal Emergency Management Agency
- Fixed Function Keys
- Follow-Up
- Foreign Military Sales
- Found-On-Base
- Foreign Ownership, Control, or Influence
- For Official Use Only
- Field Of View
- Fleet Post Office
- Formal Qualification Test
- Formerly Restricted Data
- Federal Reserve System
- Federal Supply Class
- Federal Stock Number
- Facility Security Officer/Supervisor
- Federal Supply Schedule
- FORTRAN - IV Compiler
- Guidance
- Giga (10⁹)
- Georgia
- General Accounting Office
- Government Bill of Lading
- Greenwich Civil Time (Zulu)
- GEODSS DPS Simulator
- General Engineer
- Ground-Based Electro Optical Deep Space Surveillance System