BAB VI
KESIMPULAN

Dari hasil analisa yang telah dilakukan, didapat kesimpulan sebagai berikut :

1. Pada perubahan sudut lintang di lintasan satelit orbit rendah, didapat bahwa semakin besar sudut inklinasi maka semakin besar perubahan sudut lintangnya.
2. Pada perubahan sudut bujur di lintasan satelit orbit rendah, didapat bahwa perubahan sudut bujur adalah relatif tetap.
3. Untuk periode satelit yang berada pada berbagai/semua orbit, didapat bahwa semakin tinggi posisi satelit maka periodenya semakin panjang/lama.
4. Untuk satelit yang mengorbit mengelilingi bumi, maka semakin rendah posisi satelit, kecepatannya semakin besar.

Aplikasi dari sistem komunikasi satelit orbit rendah, antara lain adalah :

1. Telekomunikasi.

   Digunakan pada sistem komunikasi telepon mobil selular. Satelit ini digunakan untuk menghubungkan unit-unit pelanggan, gate way (pintu gerbang) dan sistem peralatan kontrol pada bumi.

   Contoh: satelit IRIDIUM

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Conversion Factors and Constants

NVERSION FACTORS

following values have been established by international agree-
it and are exact as shown. There is *no* roundoff or truncation
r.

foot = 0.3048 meters
statute mile = 1609.344 meters
nautical mile = 1852 meters

e additional conversion factors:

ength 1.000° of arc at surface of earth
= 111.2 km
= 69.10 statute miles
= 60.00 nautical miles

ass 1.000 kg = 6.852 × 10^{-2} slugs

rce 1.000 N = 0.2248 pounds
1.000 kg (force) = 2.205 pounds
(at surface of earth)

ECTED CONVERSION PROCEDURES (to four significant s unless indicated otherwise)

To convert from statute miles to kilometers, multiply by 1.609
To convert from kilometers to statute miles, multiply by 0.6214
To convert from inches to meters, multiply by 0.0254 (exact)
To convert from meters to inches, multiply by 39.37

NSTANTS

s of earth
= 5.98 × 10^{24} kg = 4.10 × 10^{23} slugs

n Earth-Sun distance
AU = 1.49 × 10^{11} m = 92.6 × 10^{6} statute miles

n equatorial radius of earth
R_{eq} = 6.378 × 10^{6} m = 3963 statute miles

Mean radius of earth
$\bar{R}$ = 6.371 × 10^{6} m = 3959 statute miles

Sidereal day = 1436.07 minutes

Solar constant
$P_{\odot}$ = 1.39 kW/m²

Solar day = 1440 minutes (exact)

Speed of light in vacuum
c = 2.9979 × 10^{8} m/s

Stefan-Boltzmann constant

$$\sigma = 5.67 \times 10^{-8} \frac{\text{joules}}{K^4 m^2 s}$$

Gravitational Constant

$$G = 6.67 \times 10^{-11} \frac{m^3}{kg \cdot s^2}$$

$$= 3.44 \times 10^{-8} \frac{ft^3}{slug \cdot s^2}$$

$$GM = 3.986 \times 10^{14} \frac{m^3}{s^2} = 1.408 \times 10^{16} \frac{ft^3}{s^2}$$

Abbreviations
K = kelvin
kg = kilogram
m = meter
N = Newton
s = second

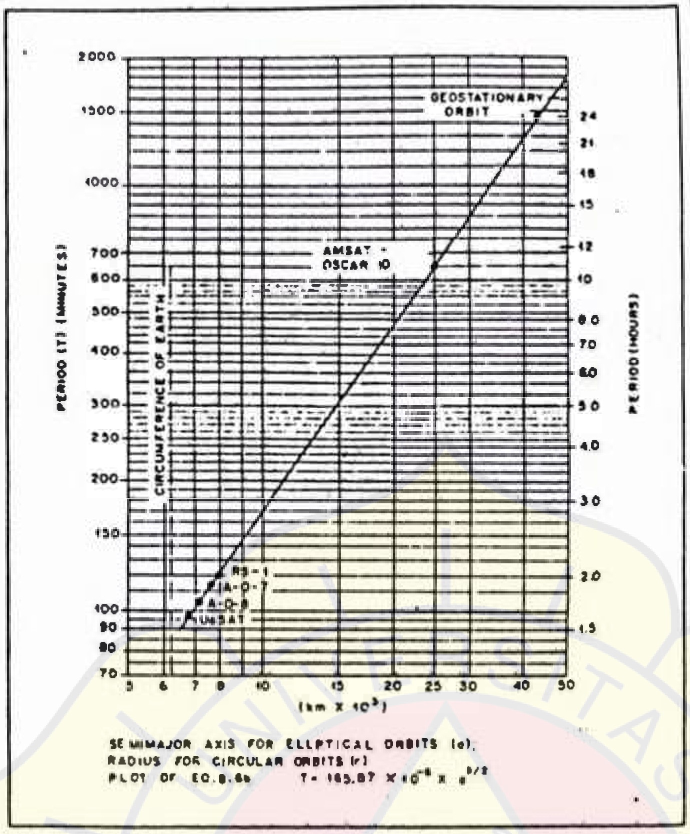


Table 3-3

A Brief History of Radio Amateur Satellites

Satellite; Launch Date	Operating Life	Number of Transponders	Transponder Bandwidth (kHz)	Peak Transmitter Power	Highest Frequency	Number of Beacons	Apogee
OSCAR I Dec. 12, 1961	21 days	0	—	0.1 W	144 MHz	1	290 mi. 471 km
OSCAR II June 2, 1962	19 days	0	—	0.1 W	144 MHz	1	240 mi. 391 km
OSCAR III March 9, 1965	transponder, 18 days; beacon, several months	1	50	1.0 W	145 MHz	2	590 mi. 941 km
OSCAR IV Dec. 21, 1965	85 days	1	10	3.0 W	432 MHz	1	21,000 mi. 33,600 km
Australis-OSCAR 5 Jan. 23, 1970	52 days	0	—	0.2 W	144 MHz	2	925 mi. 1480 km
AMSAT-OSCAR 6 Oct. 15, 1972	4.5 years	1	100	1.5 W	435 MHz	2	910 mi. 1460 km
AMSAT-OSCAR 7 Nov. 15, 1974	6.5 years	2	100/50	8.0 W	2304 MHz	4	910 mi. 1460 km
AMSAT-OSCAR 8 March 5, 1978	5.3 years	2	100/100	1.5 W	435 MHz	2	570 mi. 912 km
RS-1/RS-2 Oct. 26, 1978	several months	1/1	40 kHz each	1.5 W	146 MHz	1/1	1065 mi. 1706 km
AMSAT-Phase III-A May 23, 1980	*2	2	180/180	50 W	435 MHz	2	22,400 mi 35,800 km
UoSAT-OSCAR 9 Oct. 6, 1981	*1	0	—	0.8 W	10.47 GHz	8	338 mi. 544 km
RS-3 — RS-8 Dec. 17, 1981	*1	4 + 2Robots	40 kHz each	1.5 W	146 MHz	2 each	1050 mi. 1690 km
Iskra 2 May 17, 1982	53 days	1	40	1.0 W	29 MHz	1	210 mi. 335 km
Iskra 3 Nov. 18, 1982	37 days	1	40	1.0 W	29 MHz	1	210 mi. 335 km
AMSAT-OSCAR 10 June 16, 1983	*1	2	180/800	50 W	1269 MHz	2	22,060 mi 35,500 km
UoSAT-OSCAR 11 March 1, 1984	*1	0	—	0.8 W	2.4 GHz	3	431 mi 693 km

Notes:
*1 — Operational as this book went to press.
*2 — Launch vehicle malfunction, satellite did not attain orbit.
OSCAR I — First satellite built by radio amateurs.
OSCAR III — First transponder on amateur satellite.
OSCAR IV — Partial launch vehicle malfunction. Satellite did not attain desired orbit. First fully solar-powered amateur spacecraft.
OSCAR 5 — First amateur satellite which could be controlled from the ground.
RS-1/RS-2 — First Soviet radio amateur satellites.

Table 11.5

Some Radio Transmissions Observed in the 136- to 138-MHz Band Between 1978 and 1984

All identifications are tentative. The table is based on articles by G. Roberts in *Orbit* and *OSCAR NEWS* (see Table 11.6 for full references), "Satellite Situation Report" (NASA) and several other sources.

International designation	*Satellite name*	*Period (minutes)*	*Inclination*	*Apogee km*	*Perigee km*	*Frequencies*	*Comments*
62A Alpha 1	Tiros 5	100.1	58.1°	939	588	136.230, 136.920	Continuous tone but periodic pulsing, occasional hiccoughs
62B Alpha 1	Alouette 1	105.3	80.5°	1026	993	136.980	
62 Upsilon 1	Relay 1	185.1	47.5°	7436	1323	136.140, 136.620	
64 03A	Relay 2	194.7	46.4°	7476	2025	136.140, 136.620	Continuous tone
64 83D	Transit 5B-5	106.2	89.8°	1083	1018	136.650	Musical sequence, fm
65 32A	Explorer 27	107.7.	41.1°	1313	933	136.740	
65 51A	Tiros 10	100.5	98.3°	824	735	136.230, 136.920	Continuous tone but slow frequency variations apart from Doppler
65 98A	Alouette 2	120.3	79.8°	2888	502	136.980	
66 77B	EGRS 7 (Secor 7)	167.5	89.9°	3698	3673	136.800	Typical EGRS multi-tone sequence, fm
66 77C	ERS 15	167.6	89.9°	3698	3681	136.440	Modulated fm
66 89B	EGRS 8 (Secor 8)	167.6	90.3°	3694	3688	136.830	
66 110A	ATS-1[1]	1436.2	9.7°	35,792	35,786	136.470, 137.350	See note 1.
67 40D	ERS 20 (OV5 3)	2840	32.9°	111,529	8619	136.260	Modulated signal having period of 4.56 seconds
67 65A	EGRS 9 (Secor 9)	172.1	89.8°	3937	3801	136.840	
67 100A	OSO4	94.3	33.0°	493	472	136.710	
67 111A	ATS-3[1]	1436.1	8.3°	35,856	35,719	136.470, 137.350	See note 1.
69 09A	ISIS 1	128.2	88.4°	3514	577	136.410, 136.080, 136.590	Continuous tone
69 37B	EGRS 13 (Secor 13)	107.2	99.5°	1128	1068	136.800	Standard EGRS fm signal
69 46B	OV5-6	3114.8	32.9°	113,084	15,460	136.380	
69 82B	Timation 2	103.3	70.0°	931	900	137.380	Musical tones, fm
69 82E	—	103.4	70.0°	934	902	137.410	Continuous tone
70 09A	Sert 2	106.1	99.1°	1047	1039	136.920, 136.230, 136.928	Rapid periodic pecking, fm
70 25A	Nimbus 4	107.1	99.6°	1102	1091	136.500, 136.797	Operating illuminated passes only?
70 25B	TOPO 1	106.9	99.7°	1086	1082	136.840	
71 24A	ISIS 2	113.6	88.1°	1426	1360	136.410, 136.080, 136.590	.410-continuous tone .590 occasionally fm
71 30A	Tournesol	96.2	46.4°	697	457	136.630	
71 71A	Eole 1	100.5	50.2°	891	672	136.350	
71 80A	Shinsei	113.2	32.1°	1869	873	136.694	Continuous tone
71 96A	Explorer 45	326.8	3.5°	18,315	362	136.830	
71 110A	—	104.8	69.9°	969	984	136.800	
71 110C	—	104.8	70.0°	992	982	137.080	
71 110D	—	104.8	70.0°	992	982	136.320	
71 110E	—	104.8	70.0°	991	982	137.050	
72 65A	Copernicus	99.5	35.0°	742	731	136.260, 136.440	Modulated fm carrier
72 97A	Nimbus 5	107.2	99.8°	1105	1092	136.500	Operating illuminated passes only?
73 78A	Explorer 50	17,462	51.1°	230,086	203,072	137.980, 136.800	
74 33A	SMS 1	1437.2	4.4°	35,822	35,795	136.380	
74 39A	ATS-6	1435.8	2.2°	35,796	35,767	136.230, 136.112	
74 101A	Symphonie-1	1436.1	1.1°	35,801	35,775	137.020	Modulated fm carrier

Satellite name	*Period (minutes)*	*Inclination*	*Apogee (km)*	*Perigee (km)*	*Frequencies*	*Comments*
Landsat 2	103.2	99.1°	919	904	137.860	Modulated fm carrier
SMS 2	1436.0	0.4°	35,810	[35,763]	136.380	
GEOS 3	101.7	114.9°	863	821	136.320	Strong modulated fm carrier
Aryabhata	96.1	50.7°	591	553	137.440	Strong modulated rasping fm carrier
SRET 2	736.4	64.0°	40,504	763	137.530	Broad modulated fm carrier (see note 2)
Nimbus 6	107.4	99.9°	1116	1105	136.500	
COS B	2202.5	96.5°	89,407	9985	136.950	Modulated fm carrier
Symphonie-2	1436.1	1.6°	35,840	35.734	136.600	Modulated fm carrier
GOES 1	1425.5	0.0°	35,591	35.566	136.380	
Explorer 55	93.6	19.6°	449	447	137.230	
Solrad 11B	7333.8	28.0°	119,817	117.505	136.530	
GOES 2	1436.2	0.7°	35,809	35,770	136.380	
Sirio	1437.6	1.6°	37,049	34,582	136.140	Strong, fm modulation
Meteosat 1	1436.2	0.2°	35.803	35.774	137.080	Strong, fm modulation
Meteor 2-3	102.3	81.2°	887	850	137.300	Soviet APT
IUE	1435.4	28.3°	45,691	25.856	136.860	Modulated carrier, fm
Landsat 3	103.1	99.0°	917	898	137.860	Modulated carrier, fm
HCMM	—	97.7°	—	—	137.170	Continuous tone, cw
OTS 2	1436.1	0.0°	35,796	35.779	137.050	Strong fm modulation
GOES 3	1436.0	0.0°	35.795	35,776	136.380	
ESA GOES	1436.0	0.4°	35,814	35.757	137.200	Modulated carrier, fm
Jiki'ken	473.4	31.1°	27,215	268	136.695	
Tiros-N	102.0	99.0°	876	839	137.620 (APT), 137.770, 136.770	
Intercosmos 18	94.6	82.9°	618	375	137.850	Strong wide fm, slow tone sequence, about 1 min/frame
Magion	94.9	82.9°	648	382	137.150	Pulses (about 1 sec)
Corsa-B	95.5	29.9	554	527	136.725	Strong carrier
Meteor 2-4	102.2	81.2	891	833	[137.300]	Soviet APT
UK 6	97.0	55.0°	651	585	136.560, 137.560	Strong, fm modulation
Bhaskar	95.0	50.7°	529	509	137.230	Strong, fm modulation
NOAA-6	101.2	98.7°	824	807	137.500 (APT), 136.770	
Meteor 2-5	102.5	81.2°	894	874	137.300	Soviet APT
Tansei 4	95.9	38.7°	606	520	137.725	Continuous carrier
Meteor 30	97.5	97°	640	—	137.150, 137.130	Soviet APT (Experimental?)
Meteor 2-6	102.3	81.2°	899	851	137.400	Soviet APT
Kiku 3	563.7	28.2°	32.128	322	136.112	
Astro 1	96.1	31.3°	598	546	136.725	
Meteor 2-7	102.4	81.3°	899	859	137.400	Soviet APT
Meteosat 2	1436.2	0.0°	35.792	35,787	137.080	
Ariane LO3	627.	10. °	35,838	202	136.610	(see note 3)
NOAA-7	101.9	99.0°	856	836	137.620 (APT) 136.770	
Meteor 31	97.8	97.8°	670	630	137.130	Soviet APT
Bhaskara 2	94.9	50.6°	524	502	137.260	
Marecs A	1436.1	0.6°	35,805	35.722	137.170	
Meteor 2-8	104.0	82.5°	958	936	137.850	Soviet APT
Meteor 2-9	102.3	81.2°	910	850	137.300	Soviet APT
NOAA-8	101.2	98.7°	828	802	136.770	
Rohini 3	95.9	46.6°	829	388	137.400	
Meteor 2-10	101.2	81.2°	885	749	137.400	Soviet APT
Meteor 2-11	104.1	82.5°	962	945	137.300	Soviet APT
ECS-2	1436	0°	35.800	35,800	137.140	

CRAFT NAME: AMSAT-OSCAR 8

AMSAT-OSCAR 8 ceased operating in mid 1983, it is the most n the Phase-II series of active communications satellites built AT. As much of the design and telemetry approach typifies 's Phase-II work and may indeed be used in future spacecraft, e included this reference section on A-O 8.)

AL

ntification

national designation: 78-026B

aunch designation: AMSAT-OSCAR D

unch

: 5 March 1978

cle: Two-stage Delta 2910

ncy: U.S. National Aeronautics and Space Administration

: NASA Western Test Range, Lompoc, California (Vandenberg ir Force Base)

bital Parameters

eral designation: low-altitude, sun-synchronous

od: 103.2 minutes

gee altitude: 916 km

gee altitude: 904 km

entricity: 0.0008 (nominally circular)

ination: 98.9° (near polar)

gitude increment: 25.8° West/orbit

ximum access distance: 3250 km

ound Track Data: See Appendix B

perations

rdinating Group: American Radio Relay League

edule (subject to change): see *QST* and *Orbit*

unday-Monday-Tuesday (UTC): Mode A and 29.402 MHz Beacon

hursdy-Friday-Saturday: Mode J and 435.095 MHz Beacon

Vednesday (UTC): Transponder reserved for special experiments arranged in advance with ARRL.

Monday (UTC): Transponder users requested to observe 10-watt EIRP limit (QRP day).

esign/Construction Credits

ject Management: Jan King, W3GEY, AMSAT-USA

acecraft subsystems: Contributed by groups in Canada, Japan, United States, West Germany

rimary Reference: P. Klein and J. Kasser, "The AMSAT-OSCAR D acecraft," *AMSAT NEWSLETTER*, Vol. IX, no. 4, Dec. 1977, pp. 4-10.

ECRAFT DESCRIPTION

hysical Structure

ape: Rectangular solid as shown in Fig. 1(A-O-8), approximately 33 cm (height) by 38 cm by 38 cm.

ss: 25.8 kg

ubsystem Organization

ock diagram: See Fig. 2(A-O-8)

SYSTEM DESCRIPTION

Beacons

	Frequency	Power Output	Max. Doppler
e A Beacon (Beacon)	29.402 MHz	110 mW	0.7 kHz
e-J Beacon (hl Beacon)	435.095 MHz	100 mW	10.1 kHz

Telemetry

ormats available: Morse code, special features

orse code telemetry

frame: A frame contains six channels (six lines by one column). Parameters are sent in a fixed serial format.

channel: A channel consists of a three digit number. The first digit is a line identifier. Because of the single column format, the first digit uniquely identifies the parameter being measured. The last two digits in a channel are the value of "N" and encode the data as per Table 1(A-O-8).

speed: The telemetry is sent at 20 words per minute. A complete frame requires about 20 seconds.

sample data: See Table 2(A-O-8).

pecial features

command enable: When the command system has been enabled and is ready to accept a command, the Morse code telemetry is interrupted and an unmodulated carrier is transmitted on the beacon frequency.

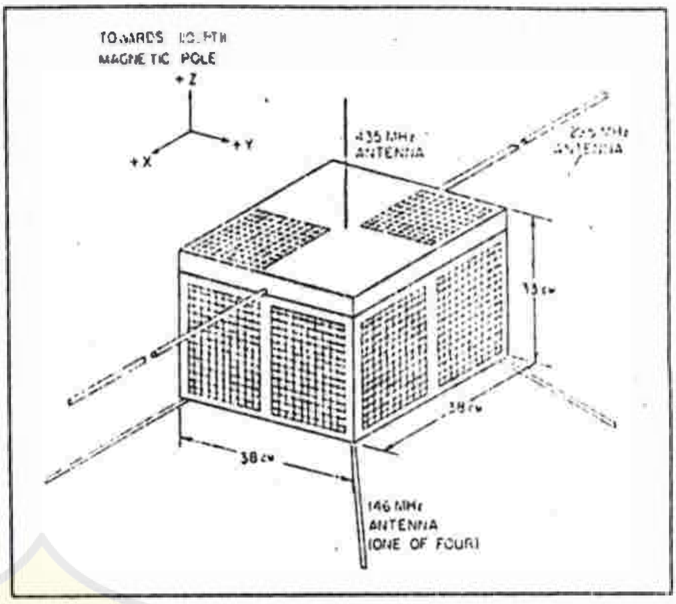


Fig. 1(A-O-8) — AMSAT-OSCAR 8.

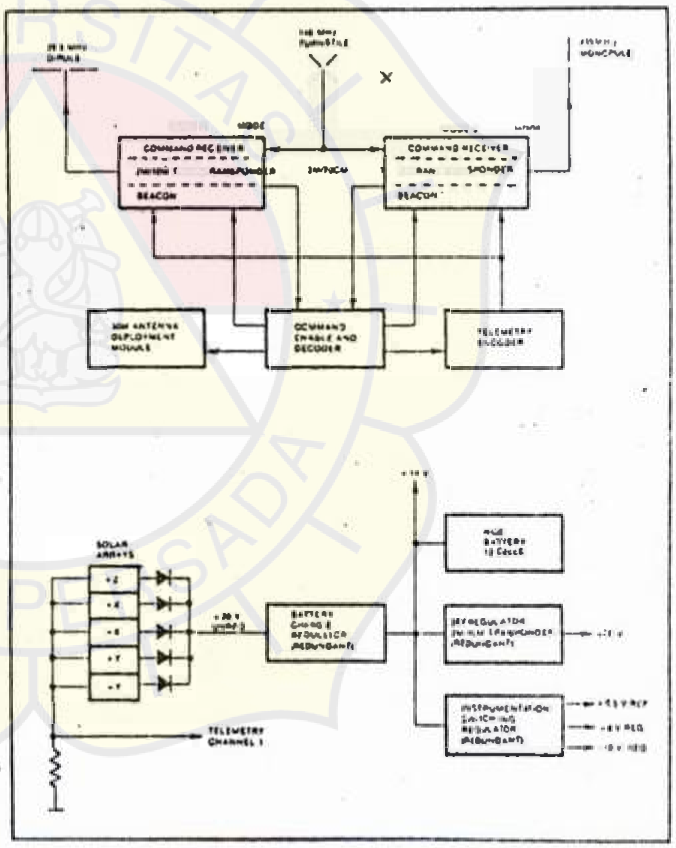


Fig. 2(A-O-8) — AMSAT-OSCAR 8 satellite functional block diagram.

10-m antenna status: When the 10-m antenna deployment command is received at the satellite the beacon transmits a series of pulses. The pulse rate is a function of tip-to-tip antenna length. See 3.6: 29.5-MHz antenna.

AMSAT-OSCAR 8

ble 1(A-O-8)

ISAT-OSCAR 8 Morse Code Telemetry-Decoding Information

annel 1: Total Solar Array Current	I = 7.15 (101 − N) mA[1]
annel 2: Battery Charge-Discharge Current	I = 57 (N − 50) mA[2]
annel 3: Battery Voltage	V = (0.1N + 8.25) volts
annel 4: Baseplate Temperature	T = (95.8 − 1.48N) °C
annel 5: Battery Temperature	T = (95.8 − 1.48N) °C
annel 6: 435-MHz Transmitter Power Output	P = 23 N mW[3]

enever N is less than 10 assume that an overrange condition has occurred. For xample, as the satellite enters the earth's shadow a reading of 101 is transmitted. his refers to channel 1, N = 01. Since N is less than 10 we assume that overanging has occurred and the actual N is 101, which corresponds to zero urrent.

ere is a 2-second integration time associated with the current telemetered on his channel.

ere is a 2.5-second integration time associated with the power telemetered on his channel.

ble 2(A-O-8)

ISAT-OSCAR 8 Telemetry Copied on the 29.402-MHz Beacon March 1978. Courtesy of Richard Zwirko, K1HTV.

BIT #61

1N	*2N*	*3N*	*4N*	*5N*	*6N*
01	47	82	50	48.	01
01	47	82	51	48	01
01	46	82	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—
01	46	—	—	—	—
01	46	81	51	47	01
01	46	81	51	47	01
mmm	continuous	tone		mmmm	
01	41	81	51	47	12
01	42	81	—	48	18
01	41	81	61	—	15
01	41	81	52	47	17
01	—	82	51	46	17
01	41	79	51	47	18
01	44	79	51	47	18
01	41	79	51	47	11
01	41	79	51	48	19
01	41	79	51	48	22
01	41	79	51	46	17
01	41	79	51	46	17
01	41	79	51	48	23
01	41	78	51	46	23
01	41	78	51	48	19
01	41	79	51	48	23
01	41	78	52	48	21
01	41	78	52	48	25
01	41	78	52	46	24
01	41	78	52	46	26
01	41	78	52	48	23
01	43	78	52	47	22
98	43	79	52	48	22
61	48	81	52	47	26
51	48	81	52	47	17
48	47	81	52	48	23
51	46	81	52	48	23
66	51	81	52	48	26
53	49	81	52	47	19
46	49	80	52	47	20
58	49	80	52	47	18
—	49	80	52	47	21
64	48	80	52	48	22
63	49	80	52	48	07
63	49	80	52	48	13
52	49	80	52	47	18
51	49	80	52	48	—

BIT #62

1N	*2N*	*3N*	*4N*	*5N*	*6N*
01	42	76	50	47	17
01	41	77	50	47	17
01	41	77	50	47	17
01	41	78	50	47	—
01	41	78	60	47	21
01	40	78	50	46	21
01	41	78	51	47	17
01	41	76	51	47	14
01	41	78	51	47	20
01	41	78	51	48	mm
mmm	continuous	tone		mmmm	
01	46	77	51	47	01
01	46	77	51	47	01
01	45	77	51	47	01

uisition of orbit #61 at 02:12:28 UTC, 10 Mar. 1978 (ascending node 02:09:20 UTC, .9° W).
mmand station accessing satellite.
de J turned on (see channel 6); Mode A remains on (telemetry being copied on .402 MHz).
ellite crossing terminator into daylight (see channels 1 and 2).
e of orbit #61 at 02:28:25 UTC.
uisition of orbit #62 at 03:59:25 UTC, 10 Mar. 1978 (ascending node 03:52:32 UTC, .7° W).
de J turned off; Mode A remains on.

Table 3(A-O-8)

AMSAT-OSCAR 8 Commands

Command	*Spacecraft Status*
Mode-A Select	2m/10m transponder and 29.402-MHz beacon ON
Mode-J Select	2m/70cm transponder and 435.095-MHz beacon ON
Mode-D Select	Recharge mode. Both transponders and beacons OFF
10-m Antenna Deployment	Activates 10-m antenna deployment mechanism and switches telemetry to pulse format encoding tip-to-tip length of antenna
10-m Antenna Reset	Stops deployment of 10-m antenna (deployment cannot be reversed). Switches telemetry back to Morse code.

3.3 Telecommand System

The command system recognizes five commands as per Table 3(A-O-8).

3.4 Transponders

Transponder I: Mode A (2m/10m)

- type: linear, noninverting
- uplink passband: 145.850-145.950 MHz
- downlink passband: 29.400-29.500 MHz
- translation equation:
  downlink freq. (MHz) = uplink freq. (MHz) − 116.458 MHz ± Doppler
- output power: 1-2 watts PEP
- uplink eirp: a maximum of 80 watts is recommended
- bandwidth: 100 kHz
- maximum Doppler: 4.1 kHz
- comments: The same basic Mode-A transponder has been used on AMSAT-OSCARs 6, 7 and 8. A block diagram is shown in Fig. 3(A-O-8).

Transponder II: Mode J (2m/70cm)

- type: linear, inverting
- uplink passband: 145.900-146.000 MHz
- downlink passband: 435.100-435.200 MHz
- translation equation:
  downlink freq. (MHz) = 581.100 − uplink freq. (MHz) ± Doppler
- output power: 1 to 2 watts PEP. Telemetry channel six measures the output power using a 2.5-second integration time.
- uplink eirp: a maximum of 10 watts is recommended. Under certain conditions of spacecraft temperature and battery voltage, the transponder sensitivity may decrease and 80 watts may be needed.
- bandwidth: 100 kHz
- maximum Doppler: 6.7 kHz
- comments: This transponder was constructed by the Japan AMSAT Association of Tokyo to test the effectiveness of this link for low-altitude spacecraft.

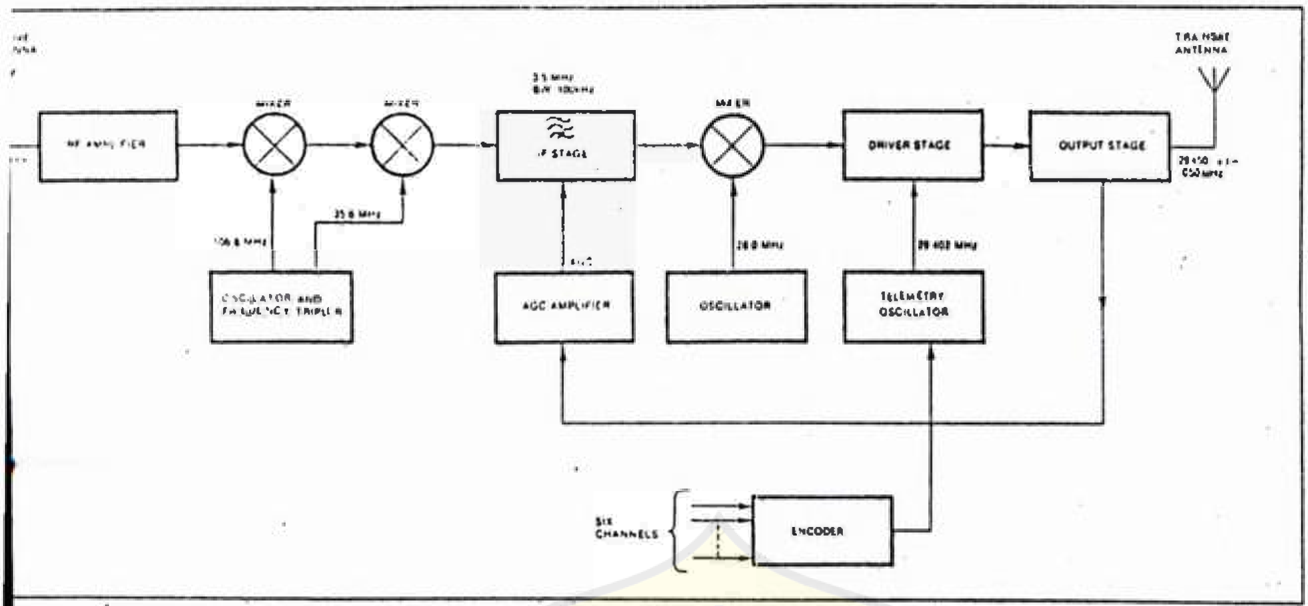
3.5 Attitude Stabilization

Primary control: Four Alnico-5 bar magnets, each approximately 15 cm long and with a square cross-section of about 0.6 cm by 0.6 cm are mounted parallel to the Z-axis of the spacecraft. The resultant far field is similar to that produced by a single 30,000 pole-cm magnet. As the satellite moves along its orbit the Z-axis of the spacecraft constantly changes its direction in inertial space to remain aligned parallel to the local direction of the earth's magnetic field. The +Z-axis (top) of the satellite points in the direction of the earth's north magnetic pole.

Damping: Allegheny Ludlum type 4750 permalloy hysteresis damping rods (0.32-cm diameter) are mounted behind, and parallel to, the +X, −X, +Y and −Y solar panels (perpendicular to the Z-axis) to damp out rotational motion about the Z-axis.

3.6 Antennas (See Fig. 1(A-O-8))

29.5 MHz: The 29.5-MHz transmitting antenna is a half wavelength dipole (about 4.9 m) mounted perpendicular to the Z axis. It is composed of tubular extendable members which are deployed by small motors activated by ground command after launch when the satellite spin rate has decreased below 2 rpm. The non-reversible deployment process takes about 15 seconds. When the satellite receives the 10-m-Antenna Deployment command, the telemetry system transmits a series of pulses, the rate of which is a function of tip-to-tip antenna length. In the fully retracted



)) — Block diagram of AMSAT-OSCAR 8 Mode A transponder.

on (launch state) the rate is about 15 pulses/sec. When tenna is fully deployed the rate is 1.8 pulses/sec.

: The 146-MHz receiving antenna for both transponders nted turnstile. It consists of two "inverted V" shaped s mounted at right angles on the base (−Z face) of the craft. Each dipole consists of two 48-cm spokes (1/4 wave-) constructed from a material similar to 1-cm wide ter's rule. The turnstile is fed by a hybrid ring and matching rk. It produces an elliptically polarized radiation field arly polarized along −Z axis) over a large solid angle. ain approaches 5 dB along the −Z axis; there's some wing along the +Z axis.

: The 435MHz transmit antenna is a 1/4-wavelength pole mounted on the top (+Z face) of the spacecraft. nal polarizations of the spacecraft antennas are summarized le 4(A-O-8).

O-8)

SCAR 8 Antenna Polarizations

	Spacecraft Polarization
nsponder uplink)	left-hand circular'
nsponder downlink Hz beacon	linear
ansponder uplink)	right-hand circular'
ansponder downlink MHz beacon	linear

sense referenced to +Z-axis of spacecraft. Ground stations off the ll observe elliptical polarization. Stations north of the magnetic n Fig. 3-6) will generally find that the circular component is as n the table. Stations in the southern hemisphere will generally find component reversed.

3.7 Energy-Supply and Power Conditioning

The main components of the AMSAT-OSCAR 8 energy-supply and power conditioning subsystem are shown in Fig. 2(A-O-8).

Solar Cell Characteristics

- type: n on p silicon
- size: 1 cm × 2 cm
- total number: 1920
- total surface area: 4005 cm^2
- protective cover: 0.015-cm glass cover slide
- efficiency: 8% (before launch)
- peak array output: 15 w (optimal sun orientation)

Solar Cell Configuration

- basic module: 80 cells in series
- total number of modules: 24
- location: + X, − X, + Y, − Y facets have 5 modules each; + Z facet has 4 modules.

Storage Battery

- type of cell: Nickel-Cadmium
- voltage/cell: 1.45 V (fully charged)
- capacity/cell: 6 Ampere-hours (Ah)
- configuration: 12 cells in series
- battery (100% charged): 17.4 V, 6 Ah
- battery (50% charged): 14.5 V, 3 Ah

Switching regulators

- battery charge regulator: Converts 28- to 30-volt solar array bus to 14- to 16-volt main spacecraft power bus. Tapers charge rate to prevent overcharging at a battery voltage of 17.4. Fully redundant and autoswitching if regulator senses open or short.
- instrumentation switching regulator: Provides well regulated +10 V, −6 V and precision reference of +0.5 V for all spacecraft systems. Fully redundant.
- transponder regulator: Converts 14-16-volt unregulated spacecraft bus to 24-28 volts for use by the 2m/10m transponder power amplifier and driver. Fully redundant.

,PACECRAFT NAMES:

Radio 3	Radio 5	Radio 7
Radio 4	Radio 6	Radio 8

NOTE: These six Soviet Amateur Radio satellites were launched together on a single launch vehicle. All six are profiled in this section.

;ENERAL

.1 Identification

Satellite	International designation	Telemetry identification
Radio 3	81-120A	RS-3
Radio 4	81-120D	RS-4
Radio 5	81-120C	RS-5
Radio 6	81-120F	RS-6
Radio 7	81-120E	RS-7
Radio 8	81-120B	RS-8

.2Launch

Date: 17 December 1981

Site: Pletsetsk, USSR

.3 Orbital Parameters

General designation: low-altitude

Inclination: 82.95° ± 0.05° (near polar)

Maximum access distance: 4200 km

Satellite	Period (minutes)	Apogee Altitude (km)	Perigee Altitude (km)	Eccentricity	Longitude Increment (°W/orbit)
Radio 3	118.46	1688	1577	0.007	29.76
Radio 4	119.34	1692	1641	0.003	29.98
Radio 5	119.50	1690	1653	0.002	30.02
Radio 6	118.66	1691	1593	0.006	29.81
Radio 7	119.14	1689	1634	0.003	29.93
Radio 8	119.71	1693	1657	0.002	30.07

.4 Ground Track Data: See Appendix B

.5 Operations

Coordinating Group: Radio Amateur Satellite Committee
Radio Sport Federation
Box 88
Moscow, USSR

Schedule: Wednesday (UTC): Transponder and autotransponder (ROBOT) reserved for special experiments arranged in advance with USSR Radio Amateur Satellite Committee.

.7 Primary References

Radio 1 and Radio 2 received extensive coverage in *Radio*, a Soviet magazine for radio-electronics experimenters. It's expected that similar coverage will be provided for Radio 3 through Radio 8. Because of the time lag involved in the initial publication, the translation from Russian to English and republication, however, formal information on these spacecraft was not available as this is written. As a result, most of the following technical information must be regarded as tentative. For background information on the Russian amateur satellite program see:

L. Labutin (UA3CR), "The USSR *Radio* Satellites," *Telecommunication Journal*, Vol. 46, no. X, Oct. 1979, pp. 638-639. This report (in English), based on an article published in *Radio*, May 1979, pp. 7-8, summarizes the results of the USSR's first two amateur s/c, Radio 1 and Radio 2.

PACECRAFT DESCRIPTION

.1 Physical Structure: Information not available at presstime.

.2 System Description

General: Each s/c contains two general purpose beacons plus additional equipment.

Radio 3 & Radio 4: These spacecraft are experimental in nature. They do *not* contain either transponders or autotransponders. Details of the experiments will be published in *Radio* at some future date.

Radio 5 & Radio 7: Each spacecraft contains one transponder and one autotransponder.

Radio 6 & Radio 8: Each spacecraft contains one transponder. These s/c do *not* contain autotransponders.

UBSYSTEM DESCRIPTION

.1 Beacons

General: Each spacecraft contains two beacons. Usually, only one is operated at any given time but, at least with Radio 5 and Radio 7, both can operate concurrently. Frequencies are as follows:

Table 1(RS)

Sample RS Morse Code Telemetry

RS6	K33	D78	O84	G00	U21	S18	W16
RS6	IK30	ID00	IO38	IG09	IU15	IS00	IW00
RS6	AK24	AD89	AO75	AG90	AU75	AS90	AW75
RS6	MK36	MD00	MO00	MG80	MU08	MS00	MW09

Satellite: RS6 — transponder: on
date: 12 Jan. 1982 — speed: about 25 wpm
time: 03:16 UTC — source: K2UBC
frequency: 29.453 MHz — ground station QTH: Baltimore, MD

Table 2(RS)

RS Telemetry

Channel	Parameter	Equation
K or EK	transponder output power	0.2 × N^2(mW)
D or ED	battery voltage	0.2 × N(Volts)
O or EO	battery charge current	20 × (100 − N) (mA)
G or EG	telemetry calibration marker	
U or EU	?	
S or ES	temperature of main power regulator	T = N (°C)
W or EW	temperature of 10m tx cooling fins	T = N (°C)
IK or SK	transponder output power	0.2 × N^2(mW)
ID or SD	telemetry zero level	
IO or SO	beacon output power	0.2 × N^2(mW)
IG or SG	transponder sensitivity	
IU or SU	transponder 'S' meter	0.1 × (N − 10) ('S' units)
IS or SS	Robot 'S' meter	0.1 × (N − 10) ('S' units)
IW or SW	command receiver 'S' meter	0.1 × (N − 10) ('S' units)
NK or RK	transponder output power	0.2 × N^2 (mW)
ND or RD	solar panel current	50 × N (mA)
NO or RO	temperature of solar panel 1	2.7 × (N − 26) (°C)
NG or RG	temperature of solar panel 2	2.7 × (N − 26) (°C)
NU or RU	temperature of solar panel 3	2.7 × (N − 26) (°C)
NS or RS	temperature of structure	0.8 × (N − 5) (°C)
NW or RW	temperature of hermetically sealed casing	0.8 × (N − 5) (°C)
AK or UK	transponder output power	0.2 × N^2(mW)
AD or UD	9 V transponder line	0.1 × N (Volts)
AO or UO	7.5 V transponder line	0.1 × N (Volts)
AG or UG	9 V regulator #1	0.1 × N (Volts)
AU or UU	7.5 V regulator #1	0.1 × N (Volts)
AS or US	9 V regulator #2	0.1 × N (Volts)
AW or UW	7.5V regulator #2	0.1 × N (Volts)
MK or WK	transponder output power	0.2 × N^2(mW)
MD or WD	autotransponder log	N = number of QSOs ±1
MO or WO	thermal control system heater	0.1 × N (watts)
MG or WG	input power (Robot or transponder?)	20 × N (mW)
MU or WU	command unit power	20 × N (mW)
MS or WS	input attenuator (Robot)	N (dB)
MW or WW	input attenuator (transponder rx)	N (dB)

This table is based on unofficial prelaunch information and must be regarded as highly tentative. It's likely that there will be minor differences between the six spacecraft. *N* is the two-digit number contained in channel.

Serious experimenters may wish to refer to an article by UA3CR on the Radio 1 and Radio 2 telemetry systems: L. Labutin, *Radio*, March 1979, pp. 18-19. The presence of the extra "dit" in the prefix (changing I to S, A to U, etc.) indicates that the command channel is active.

Satellite	Frequency (MHz) Beacon #1 (0.5-1.5 W)	Frequency (MHz) Beacon #2 (0.1-0.3 W)
Radio 3	29.321	29.401
Radio 4	29.360	29.403
Radio 5	29.331	29.452
Radio 6	29.411	29.453
Radio 7	29.341	29.501
Radio 8	29.461	29.502

Notes

1) Either beacon may be used for Morse code telemetry
2) Either beacon may be used for autotransponder if one is contained on the spacecraft.
3) When a transponder is active the upper frequency (lower power) beacon is generally in operation. The presence of the upper frequency beacon does *not* necessarily imply that the transponder is on.

ne following information on the RS telemetry system must
ced as highly tentative. The spacecraft telemetry systems
employ Morse code.
ame usually consists of 28 channels (4 lines by 7
) sent in a fixed serial format. Each line begins with
ere 'n' identifies the spacecraft. Sometimes the s/c dwells
gle line.
ta: See Table 1(RS)
ach channel consists of a two-letter prefix followed
digits. The first letter (which is sometimes a blank)
s channel row (see note 1); the second letter indicates
column; and the two digits encode the measured
er.
information: See Table 2(RS)

ider the first prefix letter. Two alternate sets are used:
, I, A, M] or [E, S, U, W]. The first set can be trans-
d into the second set by inserting a "dit" in front of
lorse code character representing each letter. The signifi-
of the two sets is not known at this time.
ider the Morse code character representing the second
letter. All characters contain three units. Substituting
0, or True and False, for the "dahs" and "dits" yields
ary sequence that's probably familiar to most amateurs
e worked with digital logic.

K	-.-	101
D	-..	100
O	---	111
G	--.	110
U	..-	001
S	...	000
W	.--	011
missing	010	

(first digit) varies most slowly; (second digit) varies second most rapidly; (third digit) varies most rapidly

mand System
bservations of the RS satellites' operation and published
ion about their telemetry systems we infer that these
aft have a flexible telecommand system whose capabilities

ning major systems (transponder, autotransponder, other)

ing attenuators in the inputs of the transponders and
ansponders;
onnecting each beacon with various internal systems
ing transponder, autotransponder, autotransponder
mory, codestore, memory dump and so on.

ders
ations Transponders

uplink passband (MHz)	*downlink passband (MHz)*
145.910-145.950	29.410-29.450
145.910-145.950	29.410-29.450
145.960-146.000	29.460-29.500
145.960-146.000	29.460-29.500

type: Mode A (2m/10m), linear, non-inverting
translation equation:
downlink freq. (MHz) = uplink freq. (MHz) − 116.495 ± Doppler
output power: 1-2 watts PEP
uplink eirp: 20 watts suggested (do *not* exceed 80 watts.)
bandwidth: 40 kHz
maximum Doppler: 3.6 kHz

Autotransponders

The autotransponders (also known as Robots) aboard Radio 5 and Radio 7 are devices which enable you to "contact" the satellite. If you call the spacecraft using the correct protocol, an onboard computer will (1) acknowledge your call, (2) assign you a serial contact number, and (3) store your call letters and contact number for later downlinking when queried by a command station.

Link frequencies follow:

Satellite	*uplink (MHz) ± Doppler*	*primary downlink (MHz)*	*secondary downlink (MHz)*
Radio 5	145.826	29.331	29.452
Radio 7	145.835	29.341	29.501

The uplink window is only 2 to 3 kHz wide centered on the frequency indicated. Be sure to take Doppler into account by transmitting ≈2kHz low when s/c is rapidly approaching you and ≈ 2 kHz high when s/c is rapidly receding.

The following procedure should be used for contacting the Robot. When it is active (calling CQ) send a few dits on the uplink frequency (*only* a few!). If you hear your dits regenerated on the downlink you're in the capture window. Call the satellite (10 to 30 wpm) as follows:

RS5 DE KA1GD AR

If you're successful Radio 5 will respond

KA1GD DE RS5 QSO NR IJK OP ROBOT TU FR QSO 73 SK

The letters IJK represent a 3-digit QSO number that is incremented after each contact.

Please do *not* hold your key down on the Robot input frequency as this will simply cause the downlink to generate a continuous tone. Each Robot calls CQ about once per minute when active. If only a partial message is received by the Robot you may hear a response of QRZ, QRM or RPT. In this case just try again. If the Robot wants you to send faster or slower it will respond QRQ or QRS. Clean, high-speed cw usually works best, probably because interference is less likely to be a problem.

A memory dump of Radio 7 listed the first 10 autotransponder QSOs:

00 UK3ACM	05 G3IOR
01 UV3FL	06 G4HUV
02 RS3A	07 G3IOR
03 UA3XBU	08 UK1BI
04 UI8BF	09 KA1GD

RIWAYAT HIDUP

N a m a	:	Basuki Witjaksono
Jenis Kelamin	:	Laki-laki
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A g a m a	:	Islam
A l a m a t	:	Bukitduri Rt 002/07 No 30 Tebet Jakarta Selatan 12840
Pendidikan	:	- S D Negeri 03 Pagi Bukitduri Tamat tahun 1982 - S M P Negeri 3 Jakarta Tamat tahun 1985 - S M A Negeri 37 Jakarta Tamat tahun 1988 - Universitas Darma Persada Jakarta mahasiswa tingkat Akhir

Jakarta, September 1993

Basuki Witjaksono

2. Pengamatan bumi.

Satelit dapat dimanfaatkan sebagai pengindera bumi dengan menggunakan kamera. Hal-hal yang diamati adalah seperti cuaca, sumber daya bumi, kehutanan dan metereologi serta kelautan.

Contoh : satelit TIROS-NOAA, LANDSAT, EARTH RADIATION BUDGET SATELLITE (ERBS) dan SEASAT.

3. Riset ruang angkasa.

Satelit orbit rendah juga dapat digunakan sebagai sarana untuk melakukan pengujian terhadap kinerja suatu sistem/sub sistem serta pengujian terhadap karakteristik suatu material dalam lingkungan luar angkasa. Hal lain yang bisa dilakukan dalam riset adalah meneliti sifat-sifat radiasi atau sel partikel terhadap atmosfir, temperatur dan komunikasi dalam batasan orbit rendah.

Contoh : satelit NIMBUS, ATMOSPHERE EXPLORER MISSION (misi B : STRATOSPHERIC AEROSOL and GAS EXPERIMENT/SAGE), UPPER ATMOSPHERE RESEARCH SATELLITE (UARS).