THE DAWN OF THE SPACE AGE

Jonathan McDowell
Harvard-Smithsonian Center for Astrophysics
jcm@cfa.harvard.edu http://www.planet4589.org

“In this decade...”

May 25, 1961: JFK starts the Moon race.

But the Space Age was already in full flow

Now the story can be told: US and Russia have declassified their early programs.

Here is the history of space travel from 1957 to 1961

Plan of talk

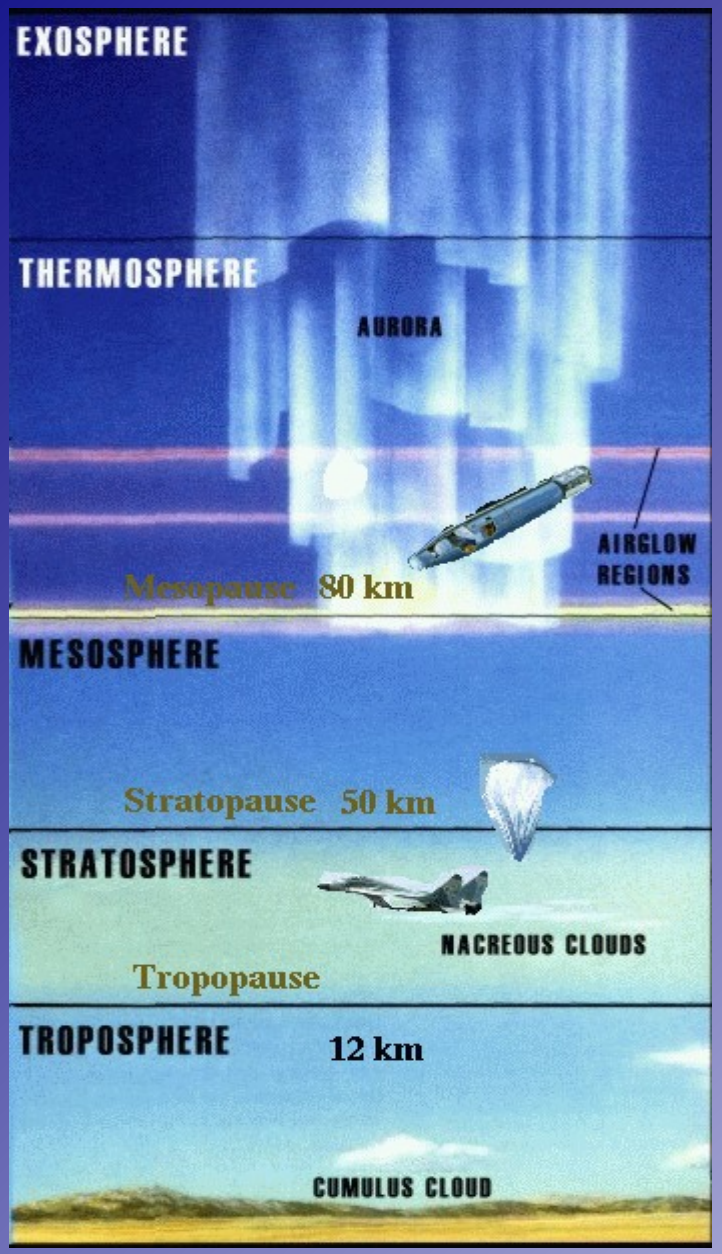
Statistics of the early space age

The Soviet space program 1957-1961

The US space program 1957-1961

Later developments 1961-1963 (if time)

THE EDGE OF SPACE



Highest airplanes 38 km

Highest balloons 51 km

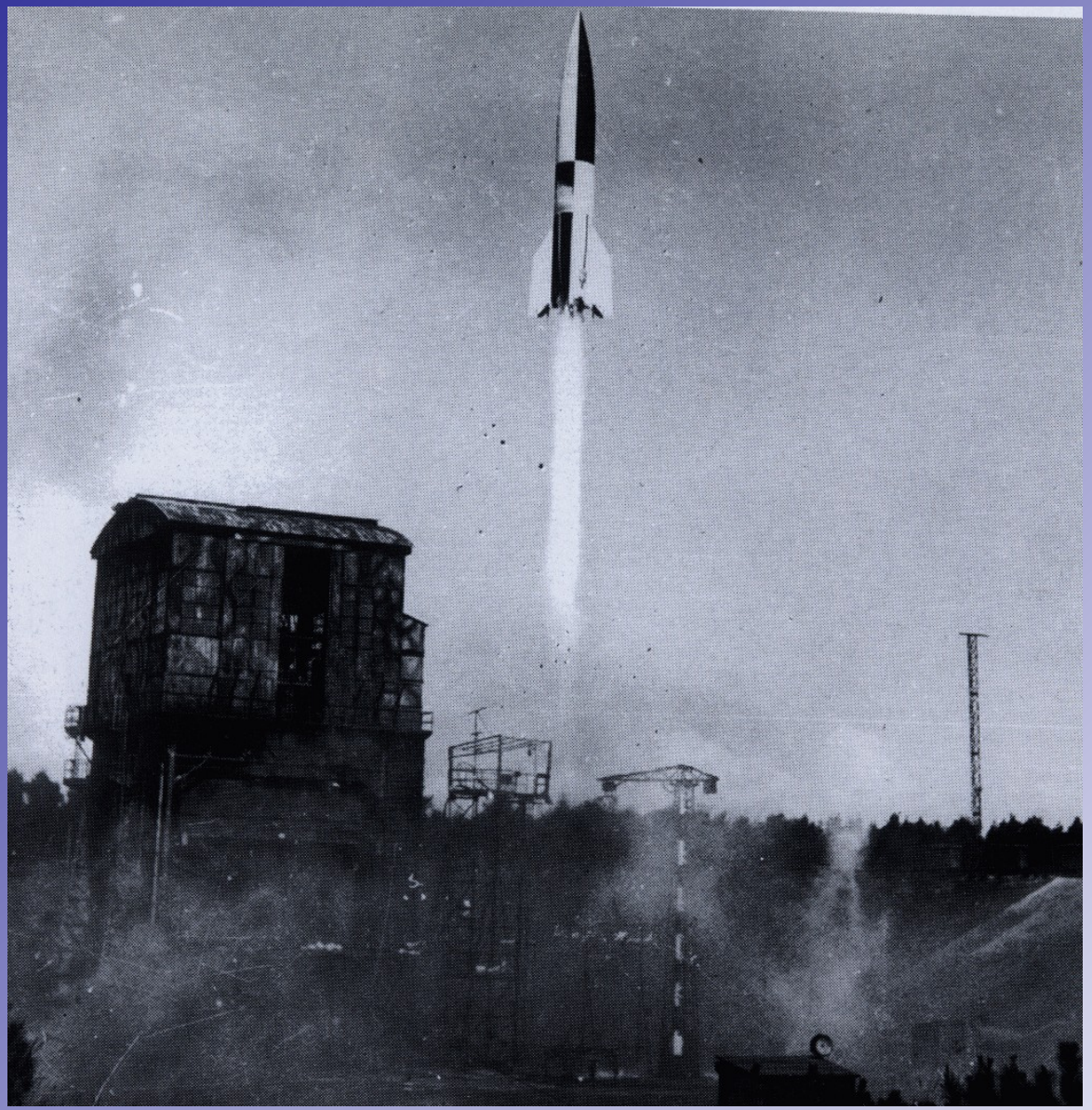
Lowest satellite perigees 90 km (high apogee or freq. reboost)

Physics: highest transition layer is mesopause at nominal 80 km

Tradition: USAF gave astronaut wings at 50 mi.=80 km

I adopt 80 km as a natural boundary

October 1942: First into space



Getting to orbit

Consider the “specific energy” (energy per unit mass, KE + PE) of an object in space relative to an inertial point on the Earth's surface

The V-2, moving slowly at the edge of space, had E = 1.5 MJ/kg (1.1 to 2.1 for different launches)

An orbiting satellite at the same altitude needs E=31.6 MJ/kg. Getting to orbit is MUCH harder! It took 15 more years...

Early space launches (suborbital)

Germany (Peenemunde): 1942 Oct 3 (or 1943 Mar 18?), V-2

USA (White Sands): 1946 May 10, V-2

USSR (Kapustin Yar): 1947 Oct 18, V-2

France (Hammaguir): 1954 Feb 21 , Veronique

UK (Woomera): 1957 Jul 23, Skylark

Japan (Akita): 1960 Jul 11, Kappa-8

Canada (Churchill): 1960 Oct 12, Black Brant 2

China (Jiuquan): 1960 Nov, R-2 (V-2 derivative)

Italy (Sardinia): 1961 Jan 12 with US Nike Cajun

India (TERLS): 1963 Nov 21 with US Nike Apache

India (SHAR): 1971 Oct 9 with RH-300 (?)

Space launches Oct 1957- May 1961

Total orbital attempts 109

USSR attempts 14 out of 25 successful (+1 failed in parking orbit) which is 56 percent (or 60 percent)

US attempts 41 of 84 successful, or 49 percent

Marginal case: USSR Apr 1960 moon launch counted, had 200000 km apogee, better than Pioneer 1 and 3

If these probes are excluded rates are 52 percent to 46 percent

Within root-n Poisson standard deviation, both countries had 50 percent success rate

Note the small number of early USSR launches despite large number of “firsts”

Space launches Oct 1957- May 1961

Von Braun's Jupiter/Juno: 50 percent (16 launches)

Douglas Thor: 65 percent (40 launches)

NASA-Langley Scout: 50 percent (2 launches)

Convair Atlas: 33 percent (9 launches)

Rosen's Vanguard: 27 percent (11 launches)

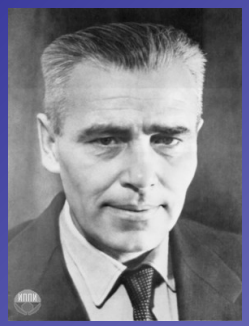
NOTS: 0 percent (6 launches)

Yet within 5 years success rates rose to 92-97 percent

Similar improvement for USSR rockets

The Soviet players

Sergey Pavlovich Korolev, head of OKB-1 (now RKK Energiya) - Designed Sputnik, Luna, Vostok, Soyuz, etc.

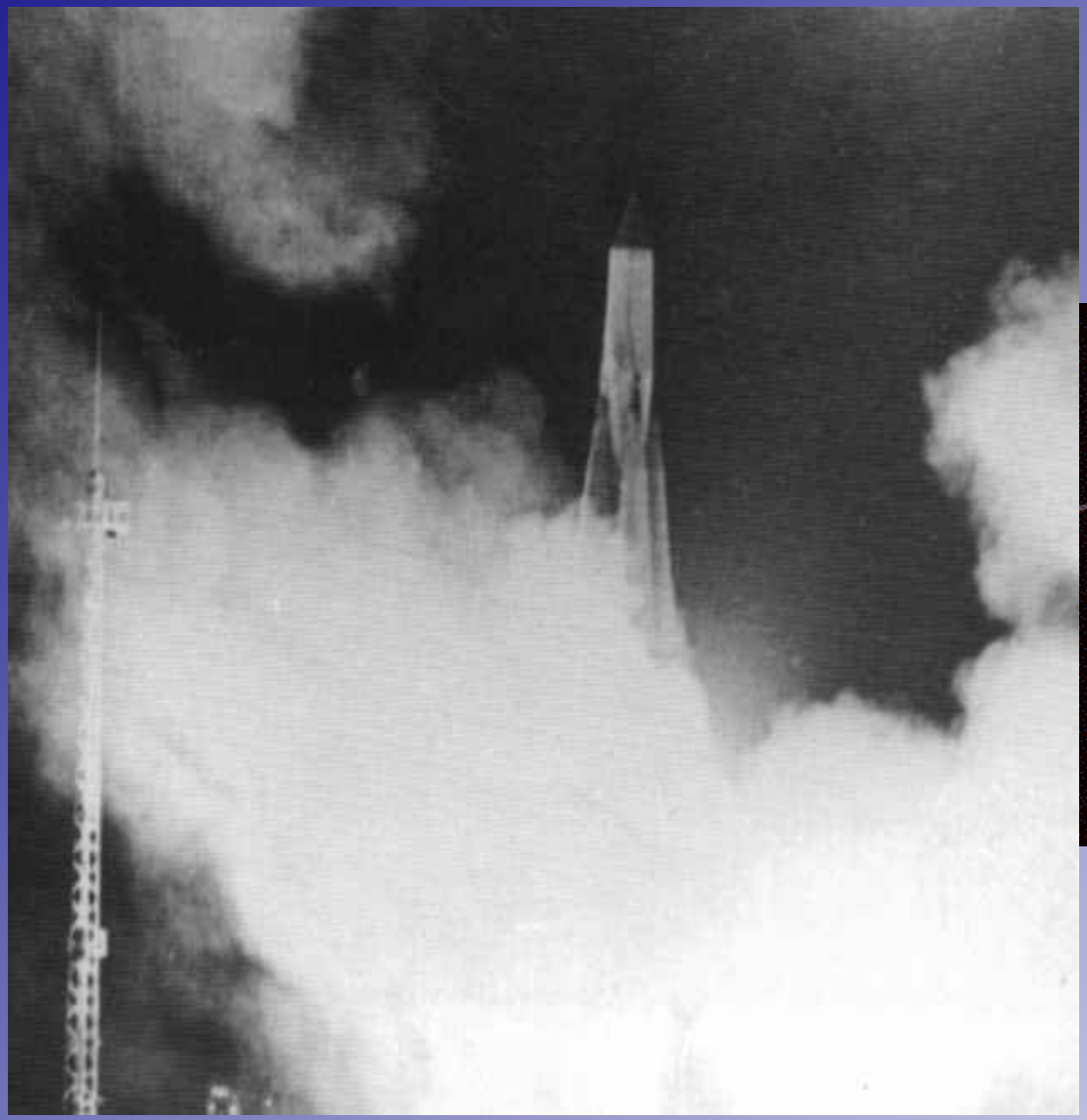


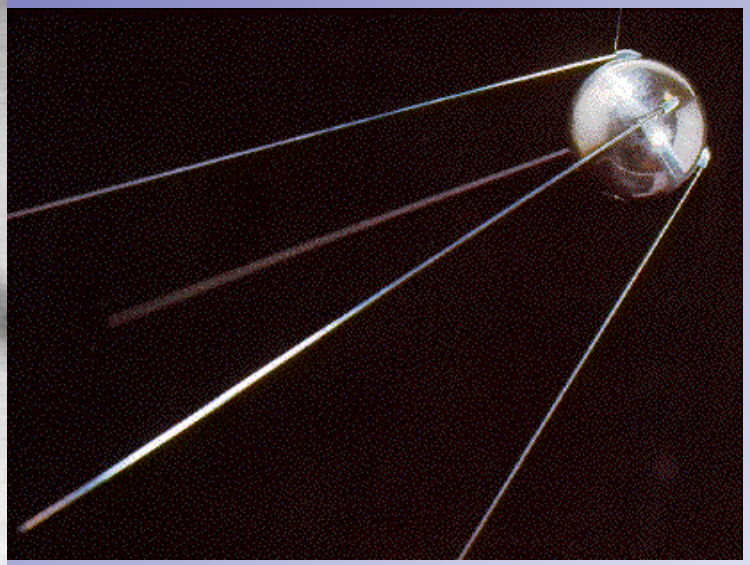
Mikhail Kuzmich Yangel', head of OKB-586 (now KB Yuzhnoe) in Dnepropetrovsk, Ukraine - designed R-12 (Cuban missile crisis)

Vladimir Nikolaevich Chelomey, head of OKB-52 (now Krunichev) - ASAT, UR-100, Proton, Almaz

operated like three independent space agencies

October 1957: Sputnik





The first orbital launch

Korolev (OKB-1) R-7 missile, product 8K71

May 1957 launch failure, Aug 1957 first ICBM

Plan to uprate engines: the 8A91 rocket for orbital launches, slipped to 1958 (Sputnik 3), related to 8K74 operational ICBM

Quick and dirty version to preempt Vanguard: the 8K71PS, minimal mods to prototype ICBM version

PS-1 (Oct 1957) “Simplest satellite”

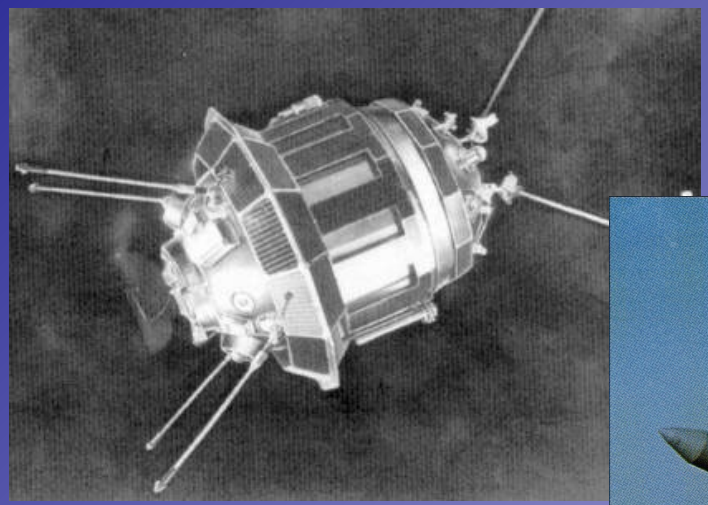
PS-2 (Nov 1957) carried dog Laika

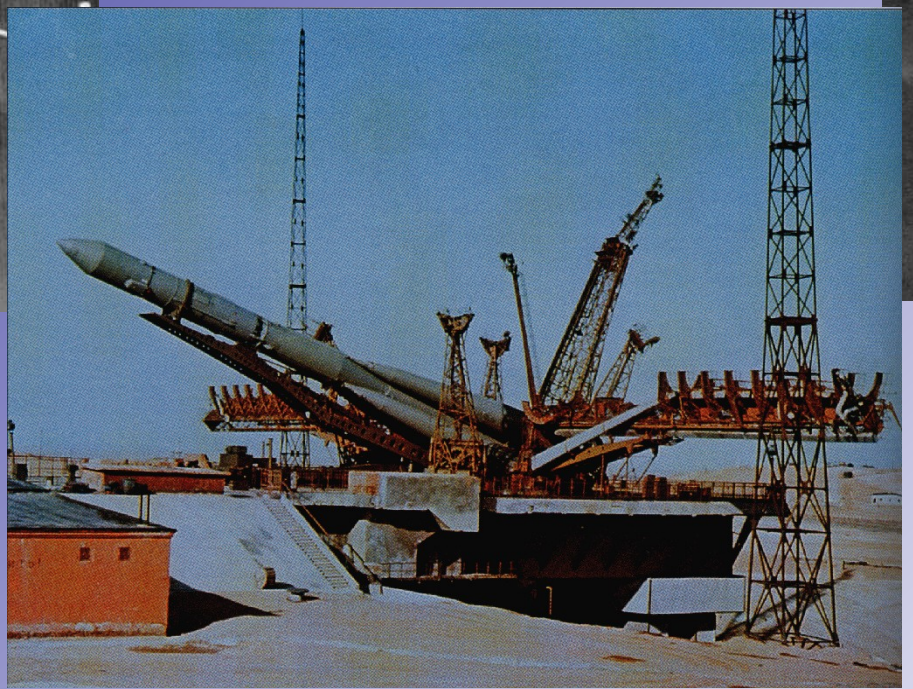
The early Soviet program

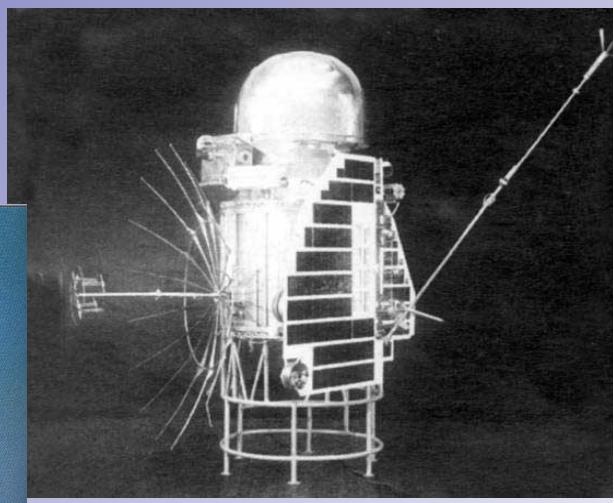
- Object D, 1958 - 2 launches, 1 success (Sputnik-3)
  - 8A91 uprated rocket
- Object E-1, 1958-1959 - 6 launches, 2 successes
  - 8K72 rocket, which was Sputnik with upper stage
  - E-1 No. 4 (Luna-1) first probe to solar orbit
  - E-1A No. 7 (Luna-2) first probe to hit Moon

E-2/E-3 (Luna), Mars, Venera

Object E-2A, 1959 - Luna 3 farside photos
Object E-3, 1960: 2 launches, both failed
1M to Mars, 1960 and 1V to Venus 1961: 4 failed

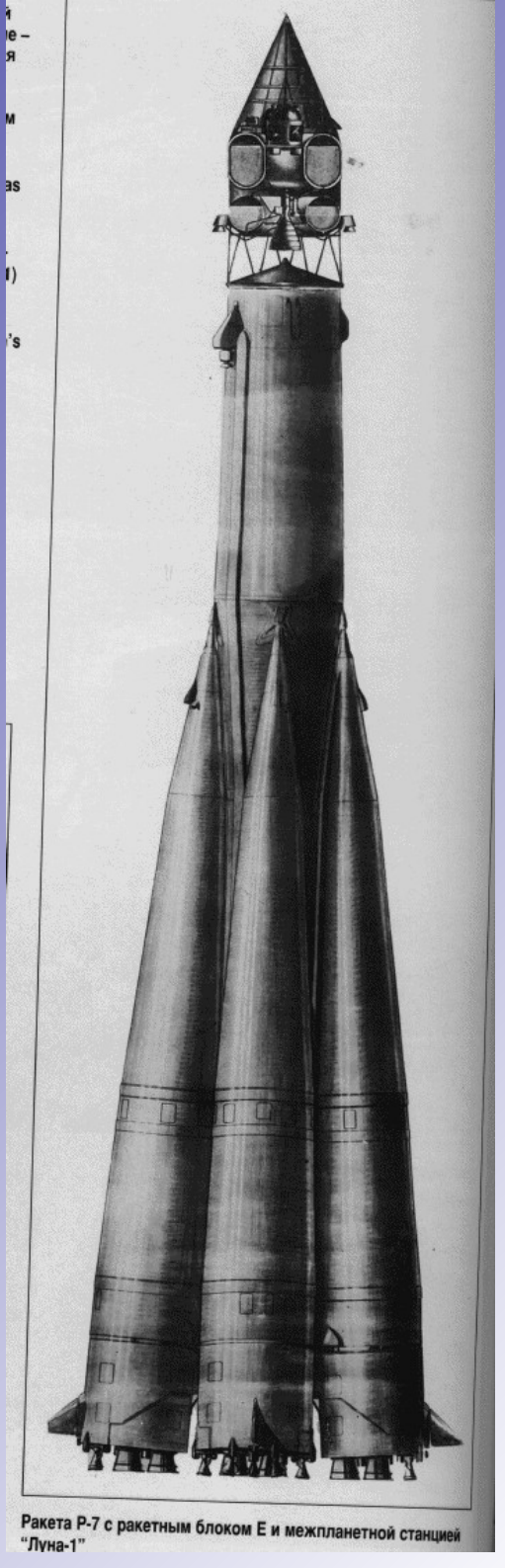






The Luna program: new info

- Long-rumoured 1958 launch attempts confirmed: first try in Sep 1958, a month after first Pioneer launch failure
- Previously unsuspected Apr 1960 launch attempts were “E-3” Luna-3 circumlunar photo follow-ons
- E-3 No. 1 reached 200000 km apogee but was not tracked by USA
- Next series was E-6 landers, starting in 1963



Ракета Р-7 с ракетным блоком Е и межпланетной станцией “Луна-1”

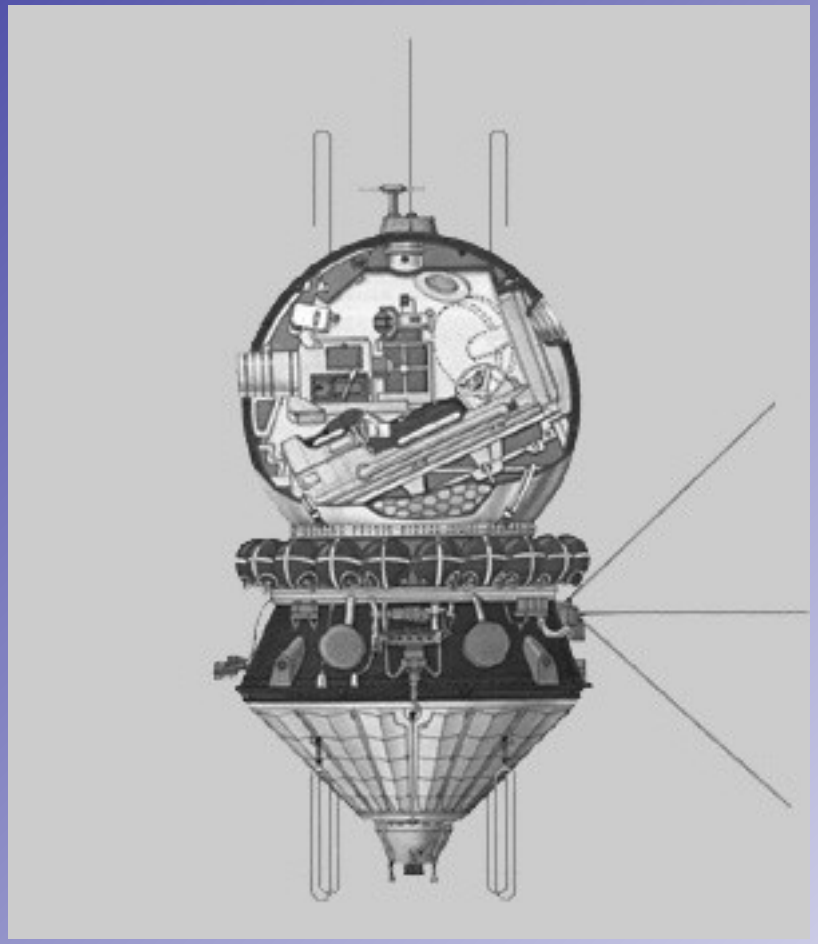
Vostok

Apr 12, 1961: Yuriy Gagarin becomes the first astronaut aboard “Vostok 3KA No. 3”

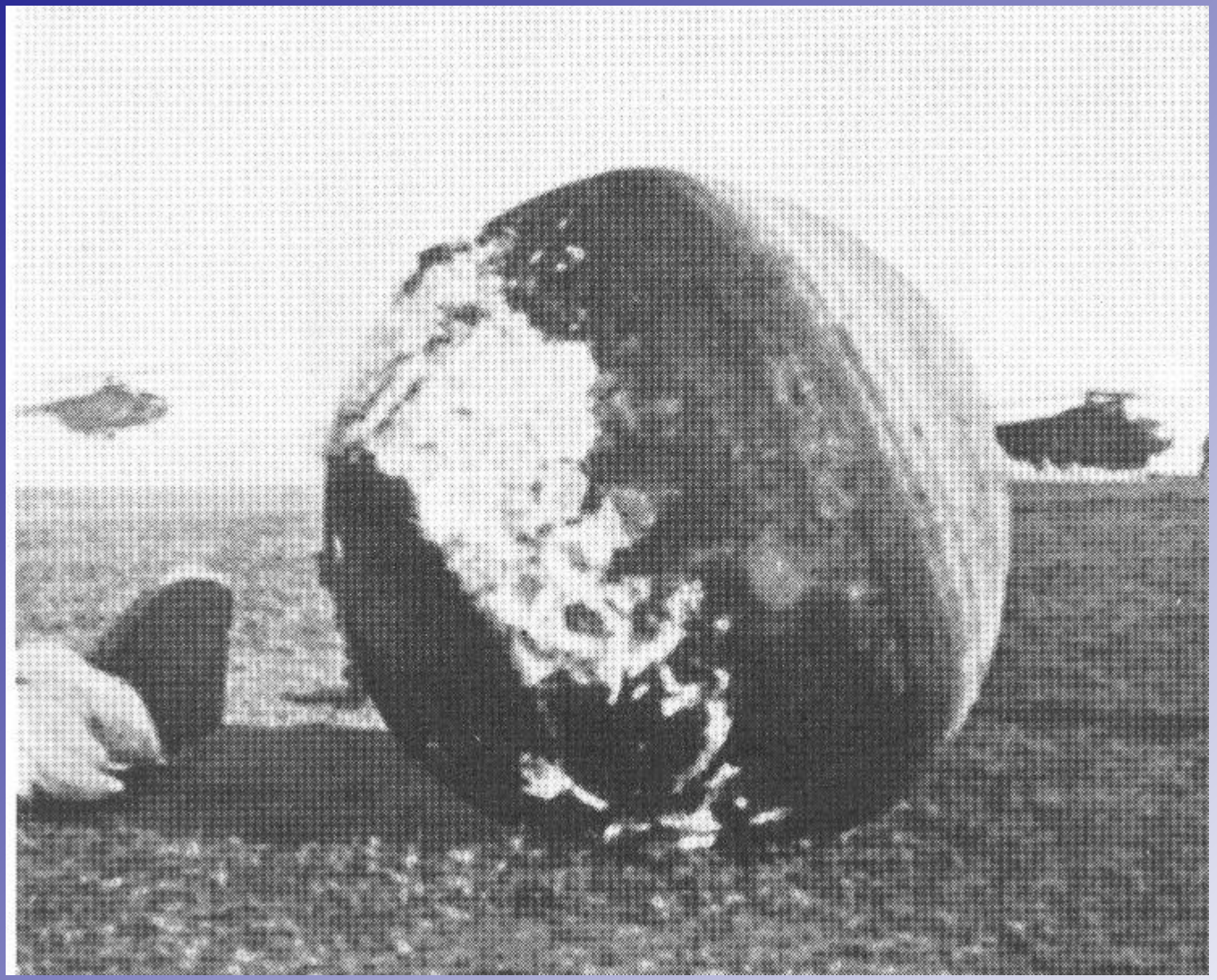
Vostok in orbit

Spherical cabin

Double-cone instrument module with liquid retrorocket



Vostok landing



The Vostok program (1)

- Vostok used the 8K72K rocket, which was a Sputnik with the Blok E upper stage like that used for the “E” lunar missions
- The first launches, without astronauts, were announced as “Korabl'-Sputnik” (Spaceship-Satellite)
- The 1K prototype was followed by the 3KA human-rated version and later the 3KV/3KD multiseater (Voskhod)

The Vostok program (2)

May 1960 test launch - retro fired in wrong direction

July 1960 1K No. 1 crashed near launch site

Aug 1960 1K No. 2 - dogs Belka and Strelka first living things recovered from orbit

Dec 1960 1K No. 3 - destroyed in reentry

Dec 1960 1K No. 4 - launch failure crashed in Siberia

Mar 1961 3KA No. 1 - dog recovered safely after 1 orbit

Mar 1961 3KA No. 2 - dog recovered safely after 1 orbit

Apr 1961 3KA No. 3 - Yuri Gagarin's flight

Aug 1961 - Jun 1963: Titov, Nikolaev, Popovich, Bykovsky, Tereshkova all fly successfully

Other Soviet programs

All these programs (PS, D, E/Luna, Mars, Venera, Vostok) were run by Korolev and used his R-7 (8K71) rocket and its derivatives

Vostok was modified as a spy satellite in 1962; derivatives still fly for science missions

The Yangel program, with “DS” (Dnepropetrovskiy Sputnik) satellites and the R-12 booster got going in late 1961, with first success in 1962 under the Kosmos-1 cover name

The first Chelomei product, an antisatellite development test, flew in 1963.

America in orbit 1957-1961

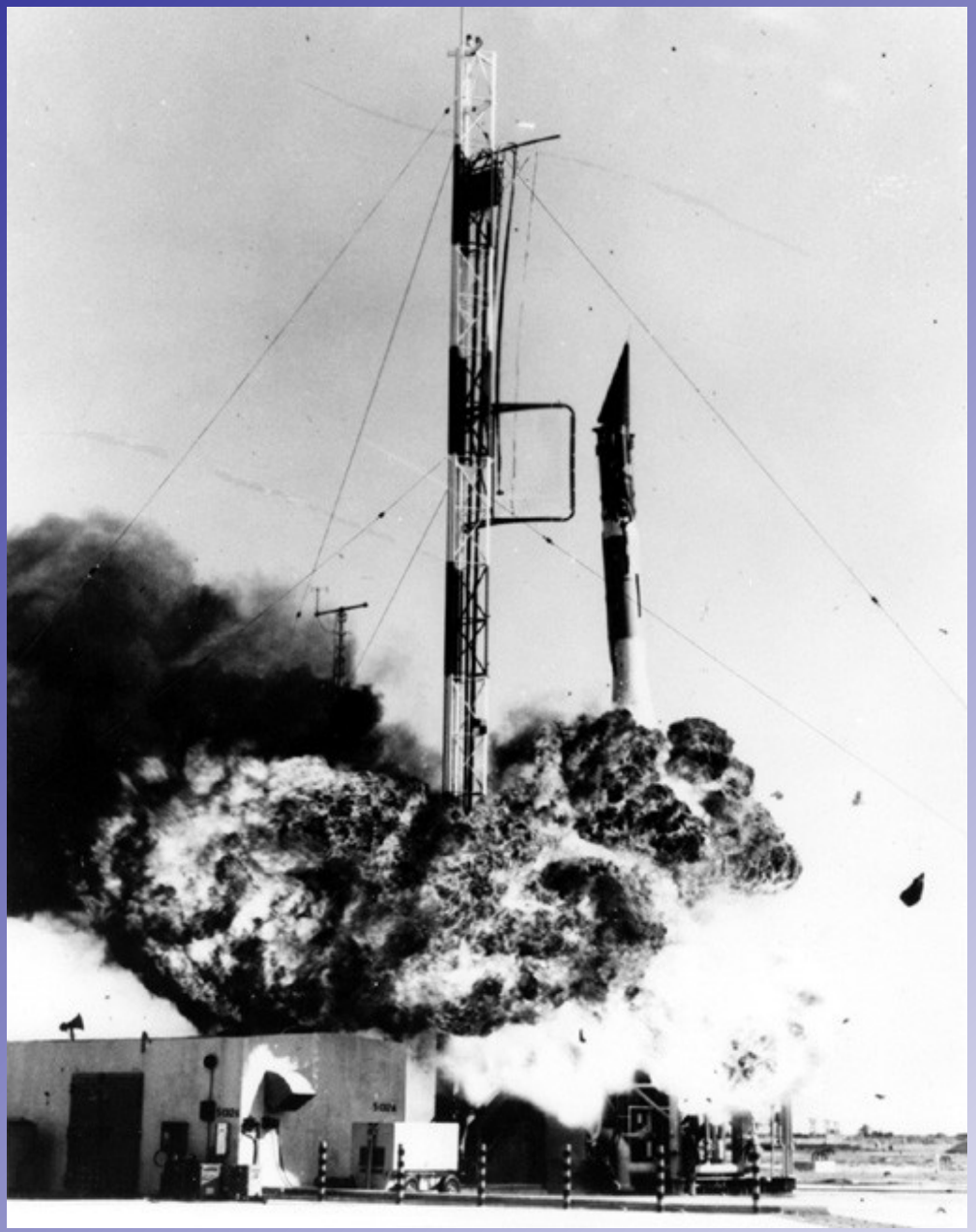
Early program run by military and CIA:

- US Army (ABMA/Huntsville): Explorer, Pioneer (with JPL)
- US Navy (NRL/Washington): Vanguard
- US Navy (NOTS/China Lake): “NOTSNIK”
- US Air Force (WDD/Los Angeles): Able, Samos, Midas
- CIA (Langley): CORONA (Discoverer)

NASA formed 1958 for civilian space programs

NRO formed 1961 for reconnaissance programs

NRL's Vanguard



NRL's Vanguard

Bad rep - but stage 2 and 3 used for Delta with success

Early launches used 2 kg test satellite - success on 3rd try

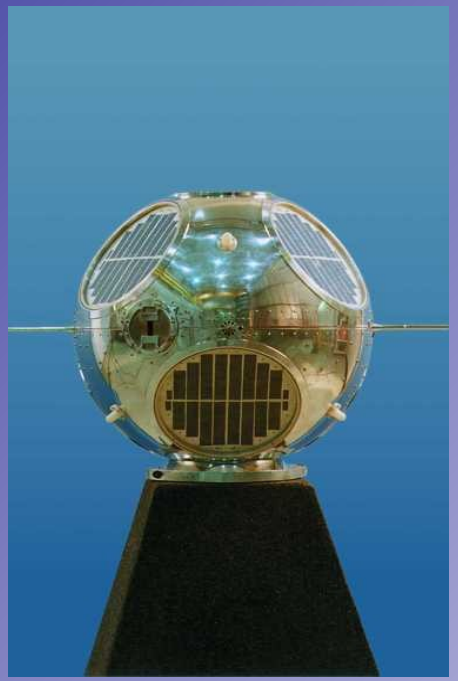
Standard “Vanguard sphere” was 51cm - 2 of 8 made orbit

Some of the Vanguard team went to Goddard to do science satellites, but some stayed at NRL

Now we know: the Vanguard 51-cm sphere satellite had a later, secret history

Secret Vanguard: GRAB

- 51-cm spheres used
- "SOLRAD" solar physics cover story
- First signals intelligence sat, studied Soviet radars



THE WASHINGTON POST Thursday, June 23, 1960

Piggy-Back Satellites Hailed As Big Space Gain for U. S.

By Charles Corddry
United Press International

Two new American satellites circuited the earth today after a spectacular "double-header" launching with a single rocket. Officials hailed their success as proof that America is "moving into space for real."

The moonlets, launched piggy-back fashion from Cape Canaveral, Fla., at 1:54 a. m. EDT Tuesday, were sent aloft to provide the world a precise all-weather navigation system, to improve the accuracy of its clocks and to measure the sun's radiation.

The larger satellite also carried a space experiment for Canada—a receiver to study background radio noises from the galaxies.

America now has 11 satellites in orbit around the earth, compared with Russia's two.

New Space First

The feat of putting up a pair of sattellites simultaneously with a single booster was a new space "first" for the United States. This has not been attempted, so far as is known, by Russia.

A two-stage, Thor-able-star, an Air Force rocket, accomplished the feat.

The Transit II-A sattellite, the navigational aide and time-measuring sphere, soared into a near-circular orbit that will carry it over all of the earth's land masses—including Russia—except certain arctic and antarctic points.

As soon as orbit was achieved, this 223-pound aluminum space probe gave birth to the smaller basketball-sized satellite, which checks on solar radiation. It was ejected by spring action.

Payloads Function

Rear Adm. T. F. Connolly, chief of the Navy Bureau of weapons, told a news conference here that the payloads of the two satellites were functioning properly.

"There are no problems," he said.

Cmdr. R. F. Freitag of the Weapons Bureau said Navy officials are confident now that a system of four Transit satellites, to be in operation by 1962, will be able to fix positions on land and sea within one-tenth of a mile.

The first Transit, launched last April, is giving fixes within a quarter of a mile, they said, and the one launched yesterday will do better.

When all four Transits are in orbit, ships at sea can interrogate them by radio at any time regardless of weather and the satellites will give them "fixes" in code that will tell them where they are.

Moving for Real

Connolly said the launching of a pair of satellites with a single rocket showed that space operations are becoming "something we can count on."

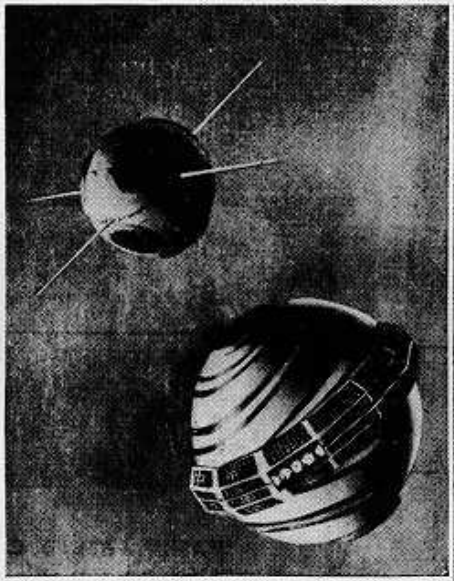
"We are rapidly moving into space for real," he said.

R. B. Kershner of the Johns Hopkins Applied Physics Laboratory said the navigation satellite's orbit was taking it to a maximum of 563 miles from earth and bringing it to within 460 miles.

Its orbiting time is 101.5 minutes. The orbit is inclined 65 degrees to the equator.

The smaller, 42-pound solar radiation sphere probably has fallen behind Transit II-A, Kershner said. It will settle into a somewhat larger orbit and circuit the earth more slowly.

The II-A, in addition to the Canadian experiment, carries a new feature not on the first Transit satellite—an electronic or "digital" clock which the Navy said could "lead to a new global time system."



Associated Press

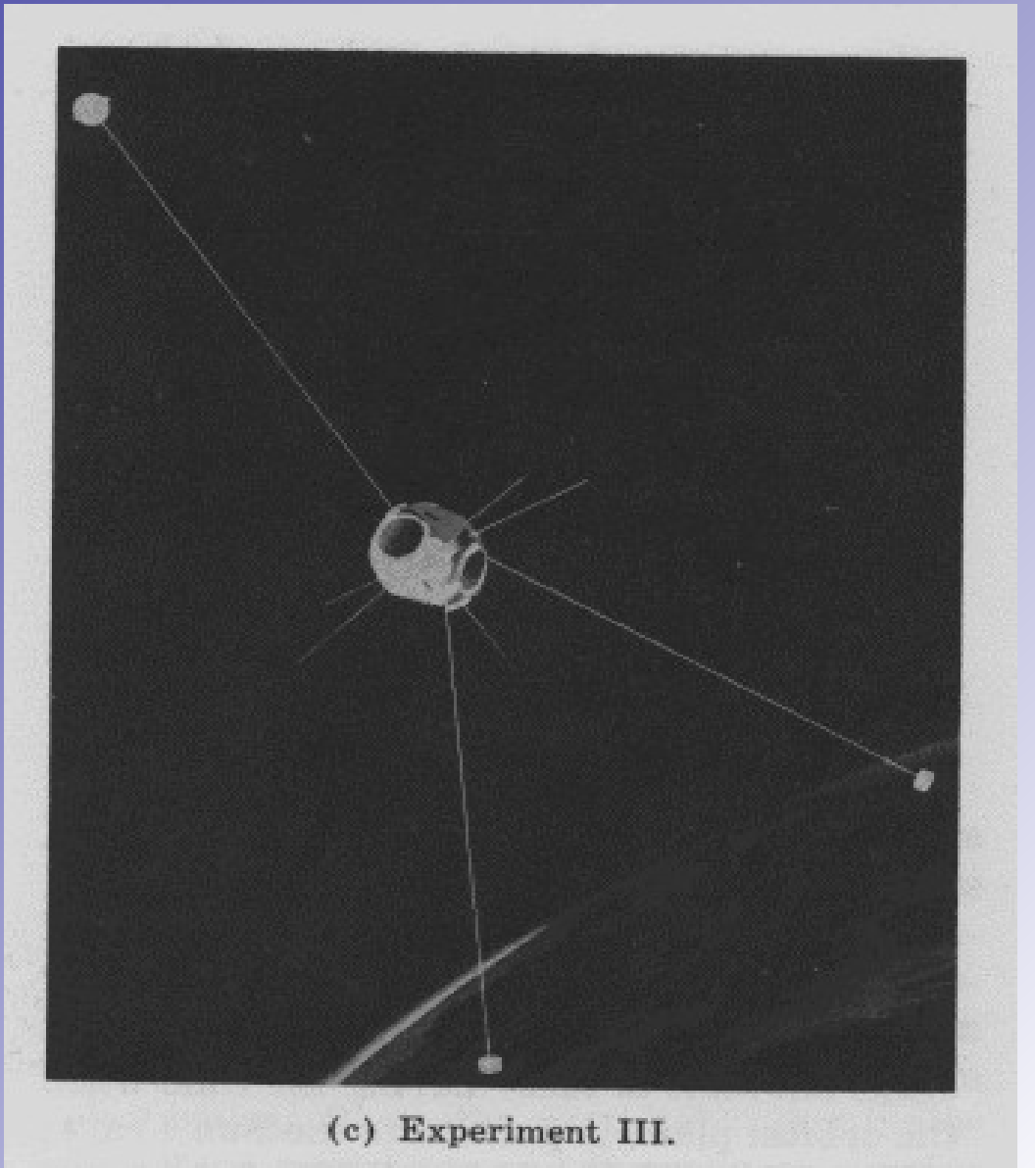
The drawing above shows how the Transit II-A satellite and its "piggyback" package, a solar radiation measurement satellite, appeared just after separation in outer space yesterday. The larger satellite was developed by the Applied Physics Laboratory of Johns Hopkins University at Silver Spring and the smaller vehicle by the Naval Research Laboratory here. At right: the double-header satellite rocket takes off at Cape Canaveral.

UPI Telephoto

DIAGRAM SHOWS ORBIT
. . . of "mother and daughter" satellites

Secret Vanguard: GGSE

- Early gravity gradient experiments
- Also used for formation flight tests which led to radio interferometer surveillance satellites
- Last 51-cm Vanguard sphere launched in 1967? Last derivative 61-cm sphere launched in 1971. Vanguard legacy much longer than usually reported.



(c) Experiment III.

ABMA/JPL Explorer

- Werner von Braun's stretched V-2 with spinning upper stages from JPL and tiny 4 kg payload
- Redstone reached apogee, spinning stages fired horizontally to get orbital velocity

XII. DESCRIPTION OF THE LAUNCHING VEHICLES

A. General Description of Explorer I

The *Juno I* configuration (Fig. 50) is similar to that of the *Jupiter-C*, but with the addition of a fourth stage and a payload. Other changes included a different shroud, over the stage 2 motor domeheads, and a new high-performance fuel—unsymmetrical dimethylhydrazine (UDMH) and dietylene triamine (DETA) in the booster.

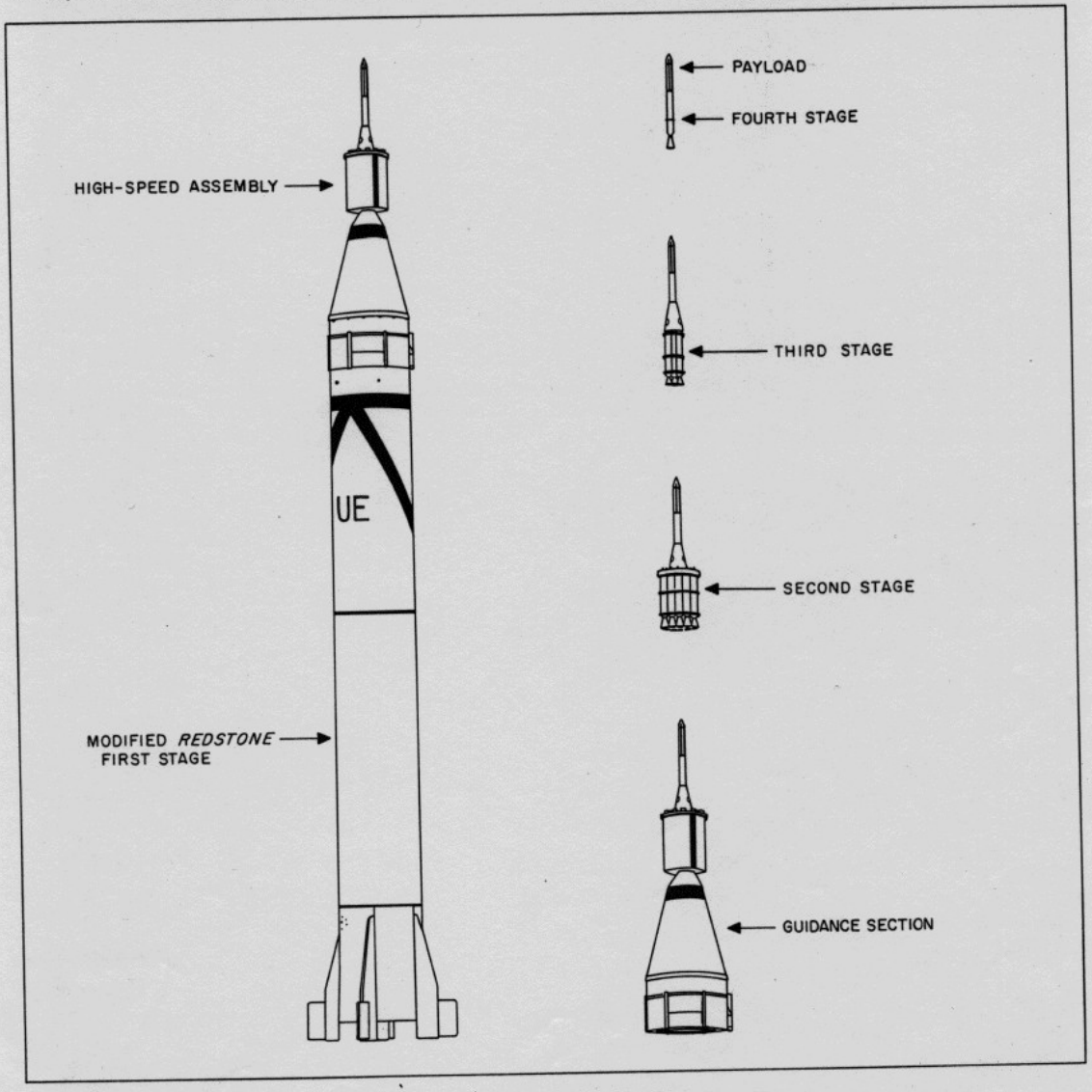
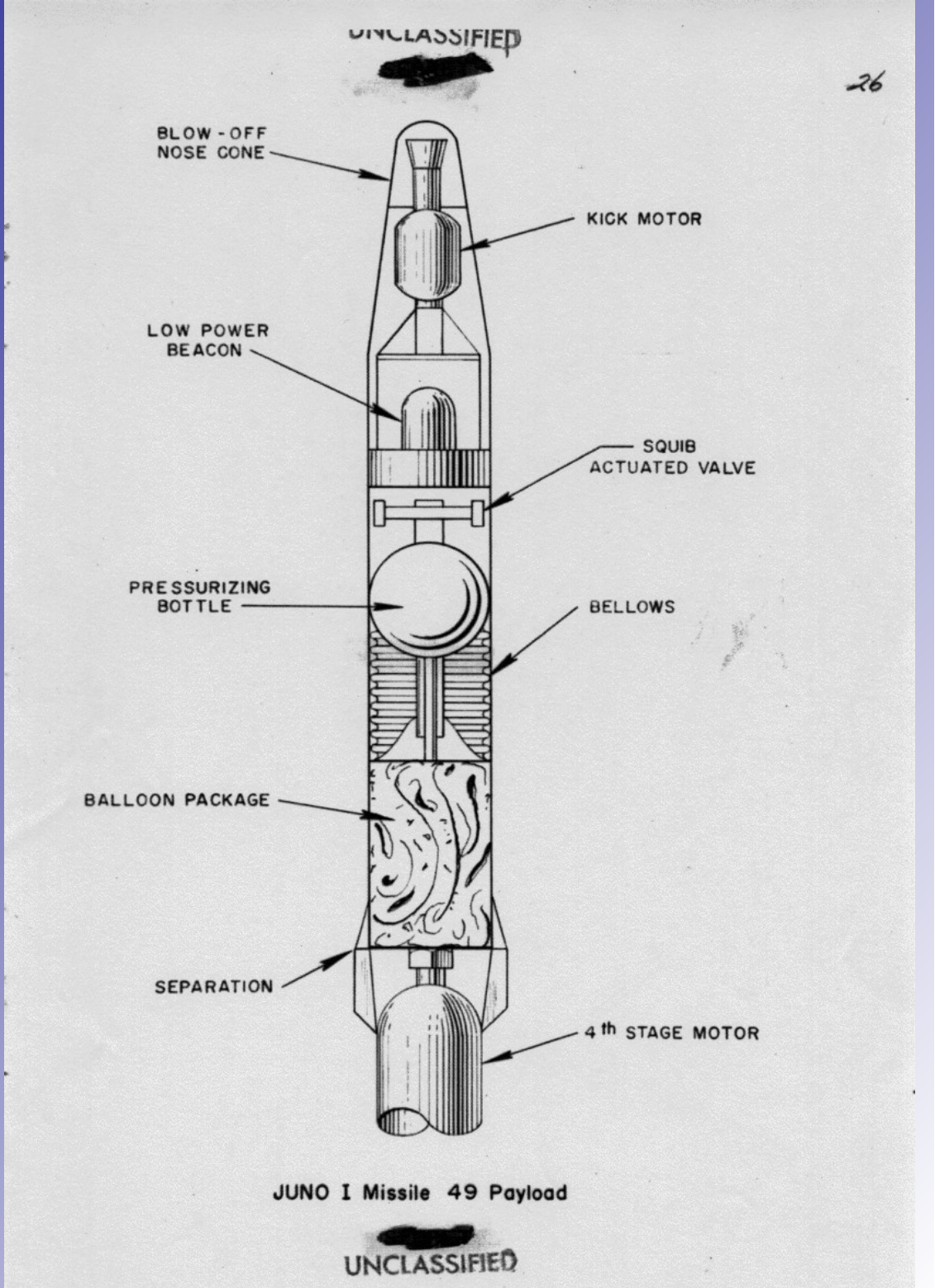


Figure 50. The *Jupiter-C*


UE

A Kick In the Apogee

- First ever apogee motor (1 kg mass)
- Alas, fell in ocean; first full success not till Syncom 2 in 1963
- Pickering (JPL) coined "kick in the apogee" - hence, "Apogee kick motor"
- Independent invention by USN NOTS team

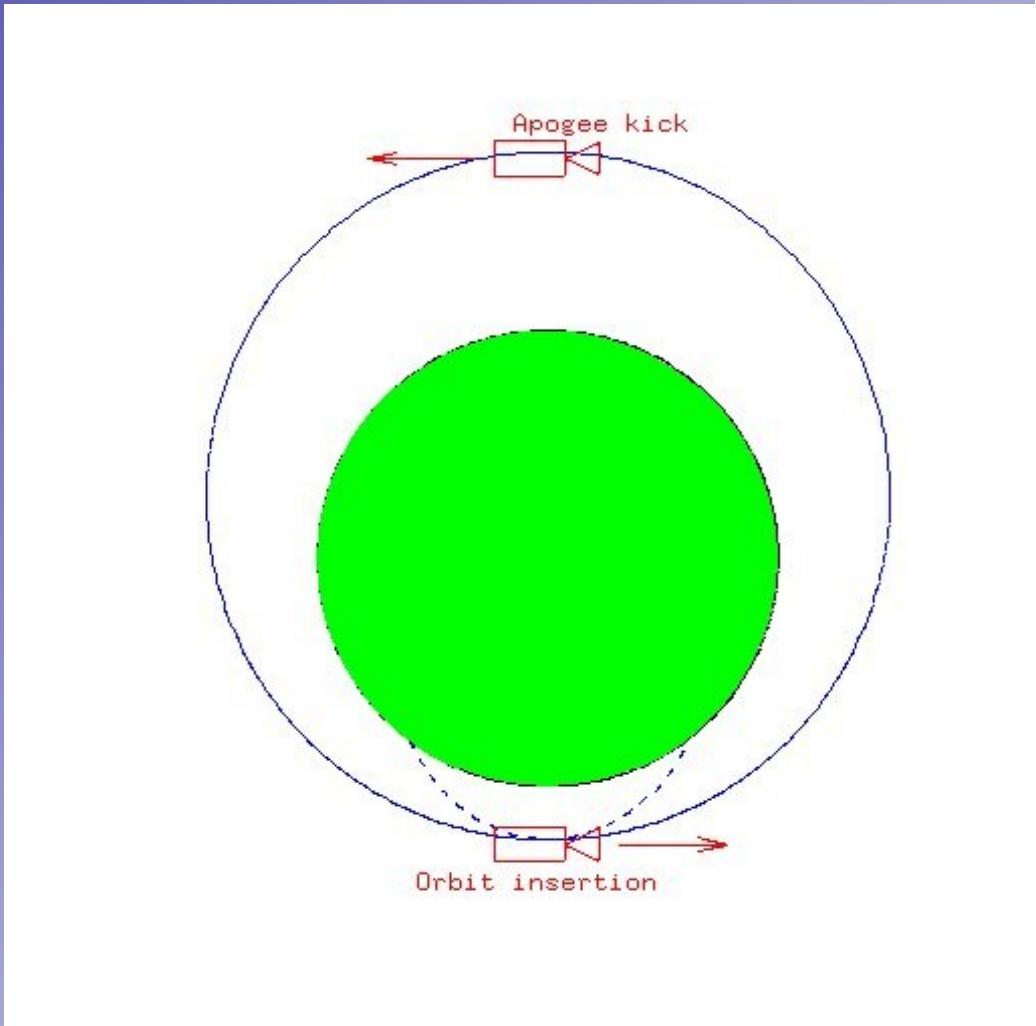


Apogee kicks

Early launches all had upper stages coast to apogee then burn for orbit insertion. Resulting orbits have low perigee, short lifetime.

Add an extra stage to fire after 1/2 orbit, raise perigee to match apogee - circular orbit with long lifetime

Launch motor upside down, rely on spin and timer for correct orientation 1/2 orbit later



NOTSnik - Jul/Aug 1958

NOTS project

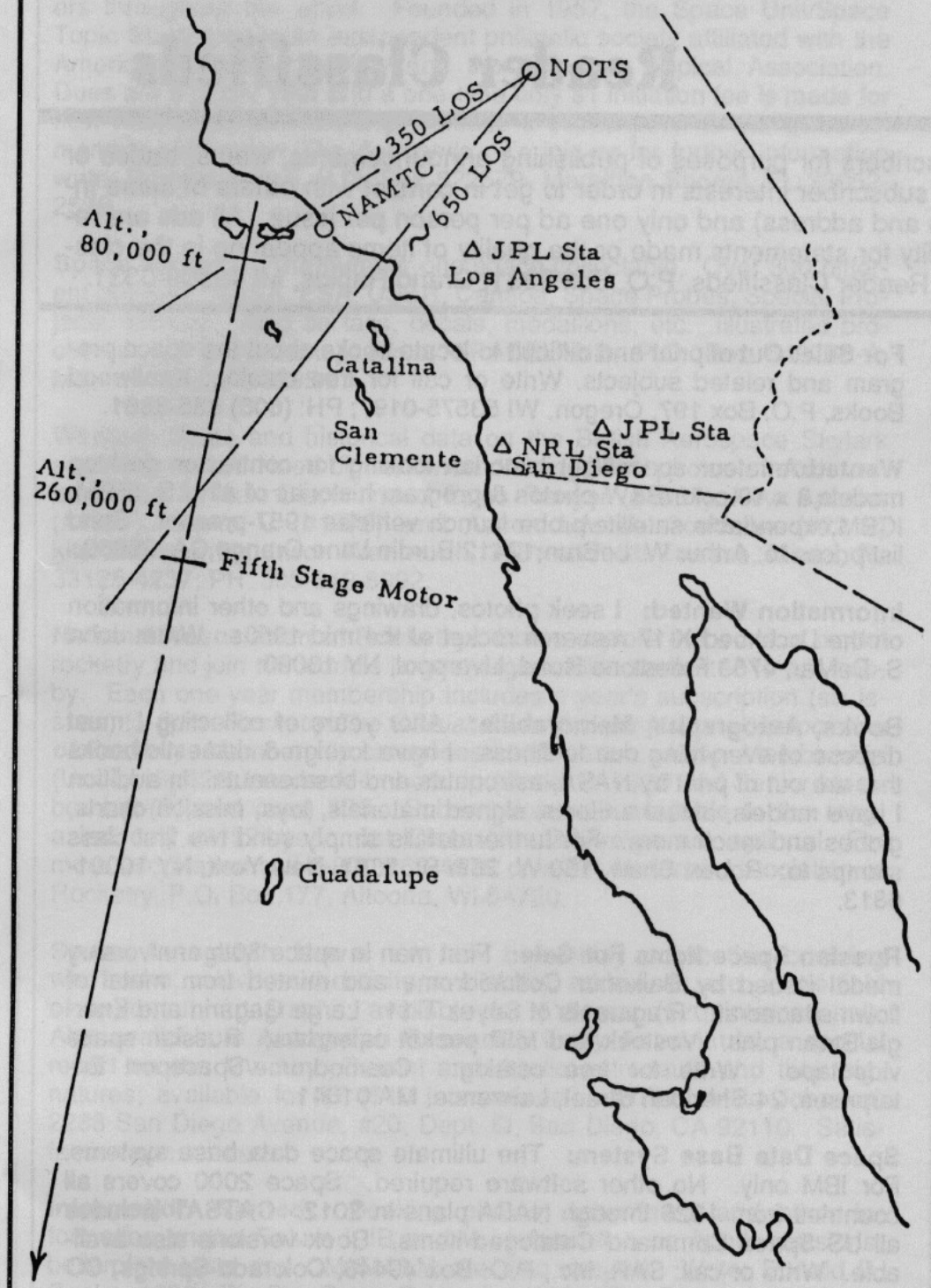
First air-launched satellite attempt, off California coast

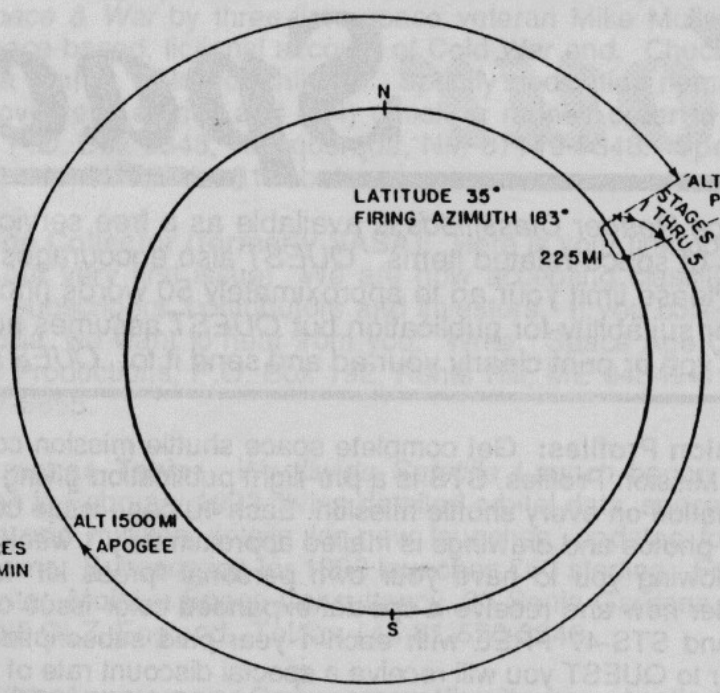
Six tries, no confirmed successes

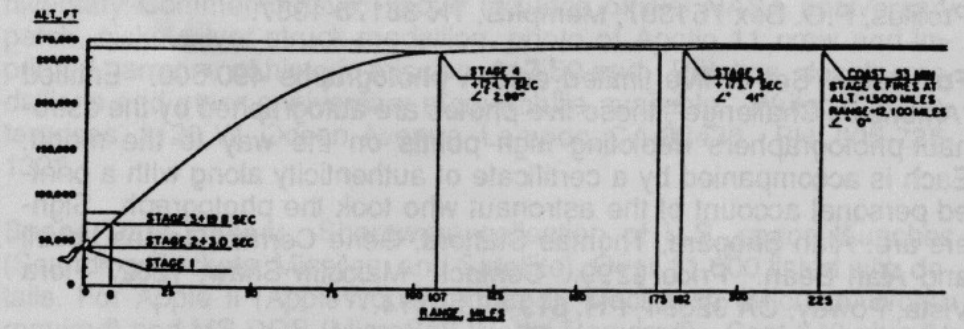
2 types of payload: radiation diagnostics for Argus artificial radiation belts, and infrared scanner instrument. 1 kg satellite!

Five stage vehicle very unreliable

Details did not emerge until 1990s

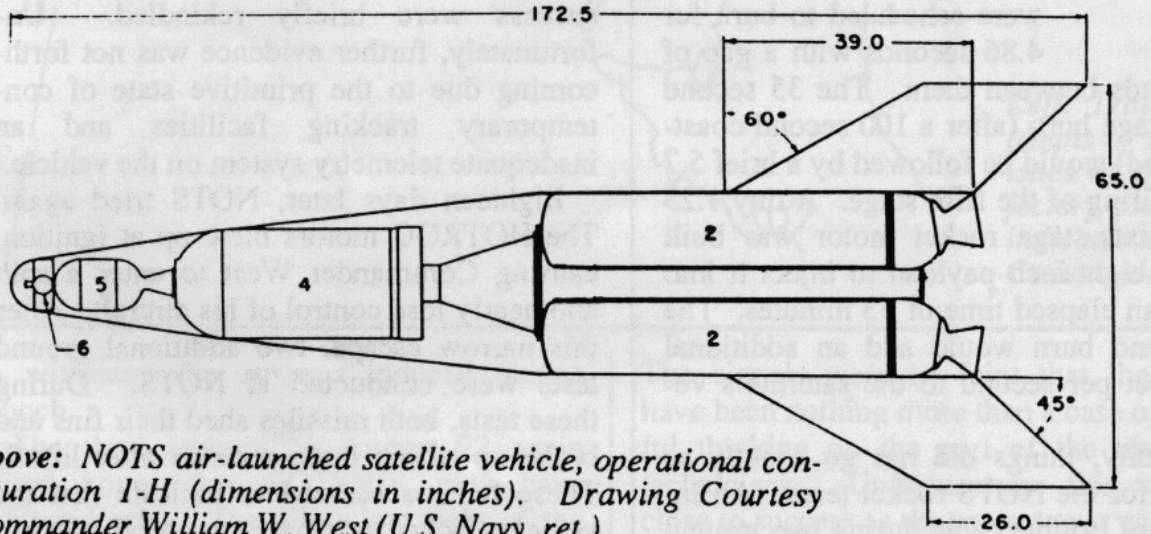






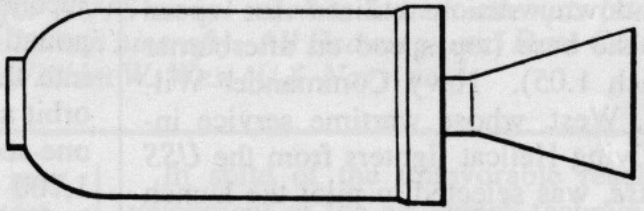
EVENT	TIME, SEC.	∠°	ALTITUDE THOUS. FT	RANGE, MI.	VEL. FT/SEC
EJECT FROM AIRCRAFT	0	30.0	41.0		578
FIRE STAGE 2	3.0	44.9	42.6		3,232
BEGIN COAST	7.9	40.9	48.8		2,434
FIRE STAGE 3	19.9	34.6	69.3		6,838
BEGIN COAST	24.7	32.8	80.8		5,034
FIRE STAGE 4	124.7	2.99	260.7	10°	18,802
BEGIN COAST	160.7	.34	262.5	175	16,729
FIRE STAGE 5	163.7	.41	263.0	182	27,701
BEGIN COAST	173.7	1.26	266.4		20,289
FIRE STAGE 6	3200.0	0	7,930.0	12,100	21,940

Left: Trajectory map of the NOTS air-launched satellite attempts of 1958. Top: Planned trajectory and orbit characteristics of the NOTS satellites. Above: Optimized ascent trajectory plot for NOTS aerial satellite launch attempts (stage 1 indicates the launch aircraft). All Drawings and Data Courtesy Commander William W. West (U.S. Navy, ret.).



Above: NOTS air-launched satellite vehicle, operational configuration 1-H (dimensions in inches). Drawing Courtesy Commander William W. West (U.S. Navy, ret.).

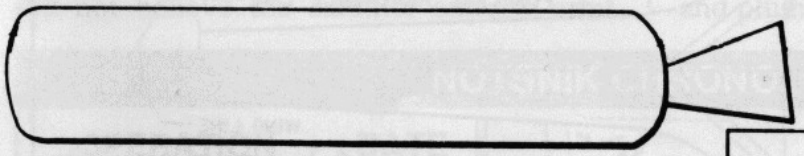
Top: Live NOTS rocket positioned beneath left wing of Skyray launch aircraft at NOTS airstrip in Inyokern, California.



ABL X241 - 4TH STAGE

LENGTH	58.2	
DIAMETER	18.0	IN(NOM)
TOTAL WEIGHT	432	LB
PROPELLANT WEIGHT	376	LB
OPERATING PRESSURE	200	PSI
BURNING TIME	36	SEC
THRUST	2720	LB
SPECIFIC IMPULSE	260.1	LB-SEC/LB
TOTAL IMPULSE	97,930	LB-SEC
MOTOR PERFORMANCE INDEX	225	

Below: Specifications of the five solid propellant stages employed in the NOTS air-launched rocket (stage 1 is the launch aircraft). Data Courtesy Commander William W. West (U.S. Navy, ret.)



HOTROC

2nd and 3rd Stage

LENGTH	71.	IN.
DIAMETER	11.65	IN.
TOTAL WEIGHT	360	LB
PROPELLANT WEIGHT	300	LB
OPERATING PRESSURE	900	PSI
BURNING TIME	4.86	SEC
THRUST	14,200	LB
SPECIFIC IMPULSE	230	LB-SEC/LB
TOTAL IMPULSE	69,000	LB-SEC
MOTOR PERFORMANCE INDEX	192	

SPHERICAL 6th STAGE

LENGTH	5.5	IN.
DIAMETER	3.0	IN.
TOTAL WEIGHT	1.25	LB
PROPELLANT WEIGHT	0.7	LB
OPERATING PRESSURE	1,500	PSI
BURNING TIME	1.0	SEC
THRUST	172	LB
SPECIFIC IMPULSE	245	LB-SEC/LB
TOTAL IMPULSE	172	LB SEC
MOTOR PERFORMANCE INDEX	138	

EXTRUDED 5th STAGE

LENGTH	18.6	IN.
DIAMETER	8.0	IN.
TOTAL WEIGHT	329	LB
PROPELLANT WEIGHT	269	LB
OPERATING PRESSURE	500.	LB
BURNING TIME	5.7	SEC
THRUST	1155	LB
SPECIFIC IMPULSE	245	LB-SEC/LB
TOTAL IMPULSE	6590	LB-SEC
MOTOR PERFORMANCE INDEX	200	

CORONA/Discoverer

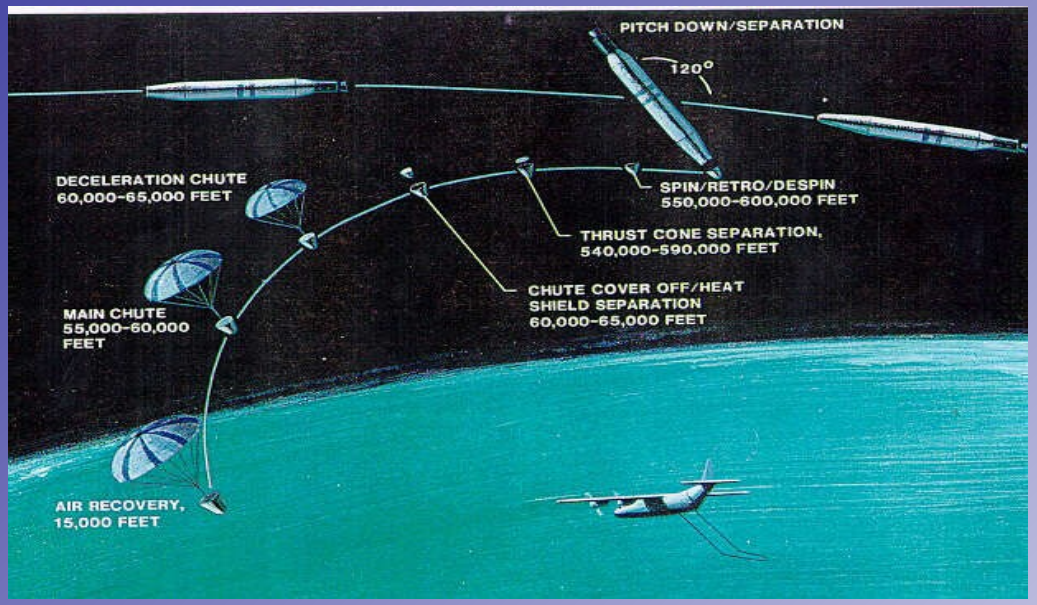
First polar orbiter (D-1, Feb 59 (?))

First 3-axis stabilized satellite (D-2, Apr 59)

First recoverable satellite (D-13, Aug 1960)

First spy satellite images (D-14, Sep 1960)

NRO formed 1961



CORONA

Discoverer 2 capsule down 1/2 orbit off - Spitzbergen (see “Ice Station Zebra”!)

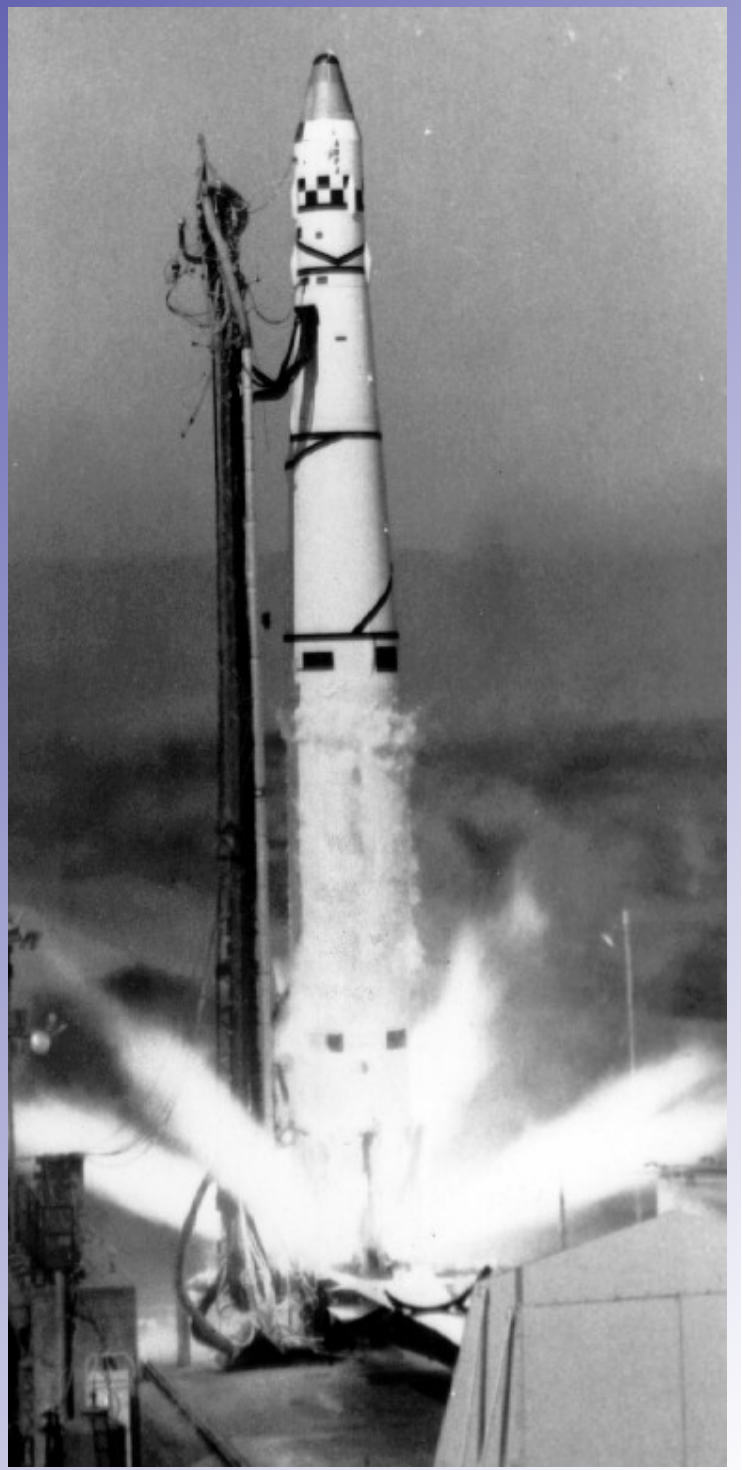
Discoverer 4 was first to carry camera - but perigee was 2 km :-(

Discoverer 5 fired retro wrong way, high orbit

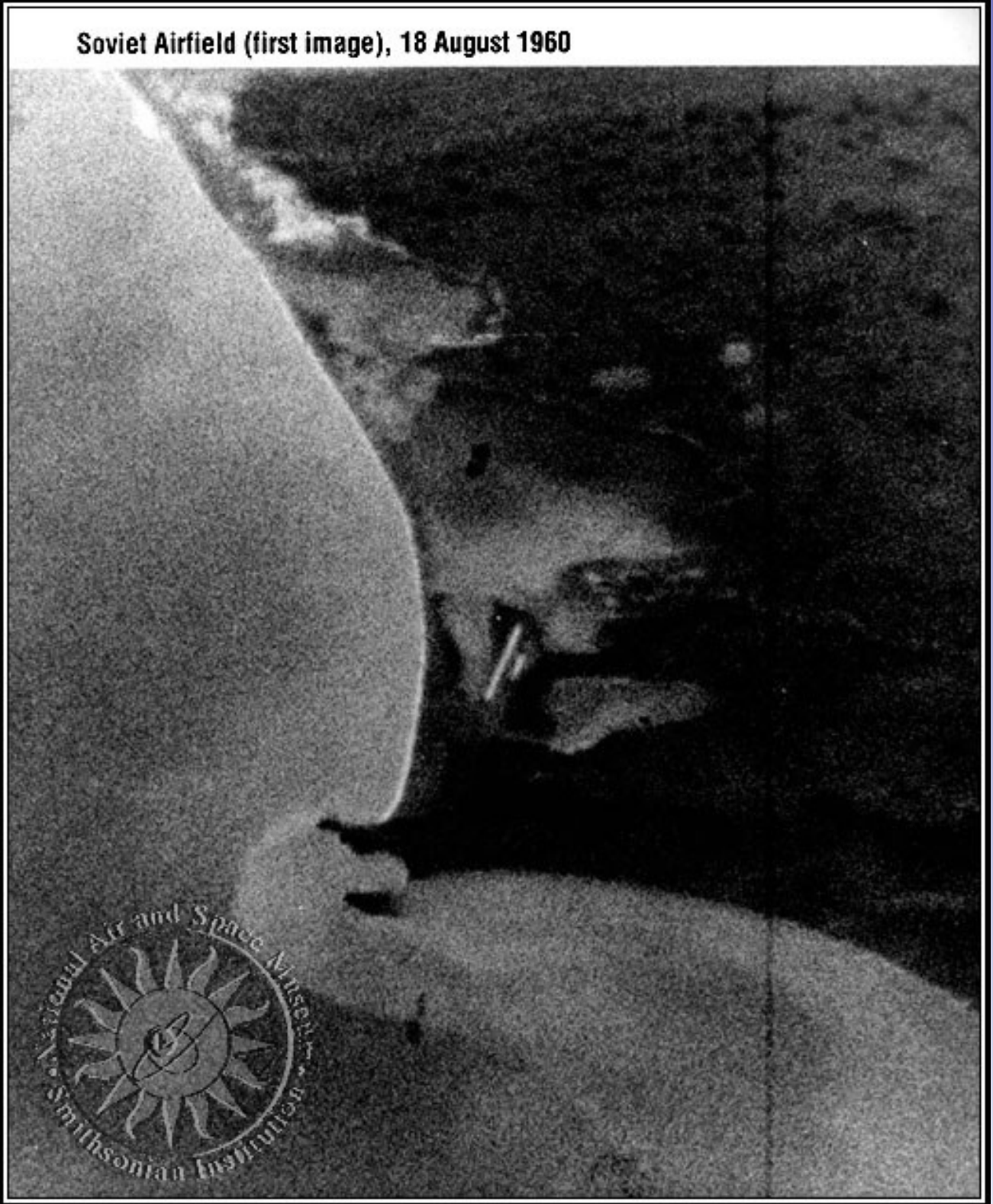
Exploding spin rockets, failing power supply, parachute failure, launch failures...

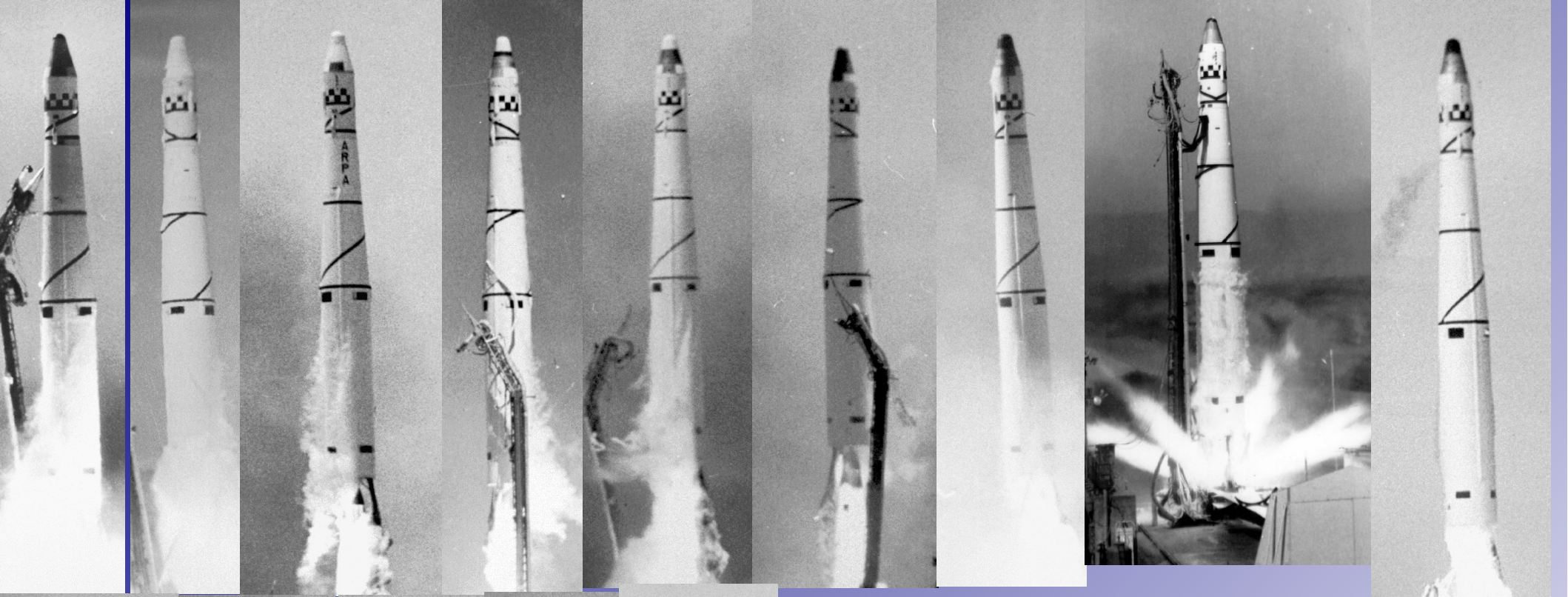
Discoverer 13 (no camera payload) recovered from sea

Discoverer 14 mid-air catch, pictures of USSR airbases



Soviet Airfield (first image), 18 August 1960





14 launches in only 18 months until 1st full success

The benefits of priority funding and failure-tolerant political support!

NASA is formed

NACA Langley lab (Virginia) - Balloon satellites, Scout, Mercury, and aeronautical research

NACA Ames lab (San Francisco) - aeronautical research

NACA Lewis lab (Cleveland) - engines

NRL Vanguard group -moves to new "Beltsville Space Center", later called Goddard

Army ABMA group (Huntsville) - becomes NASA-Marshall in 1960

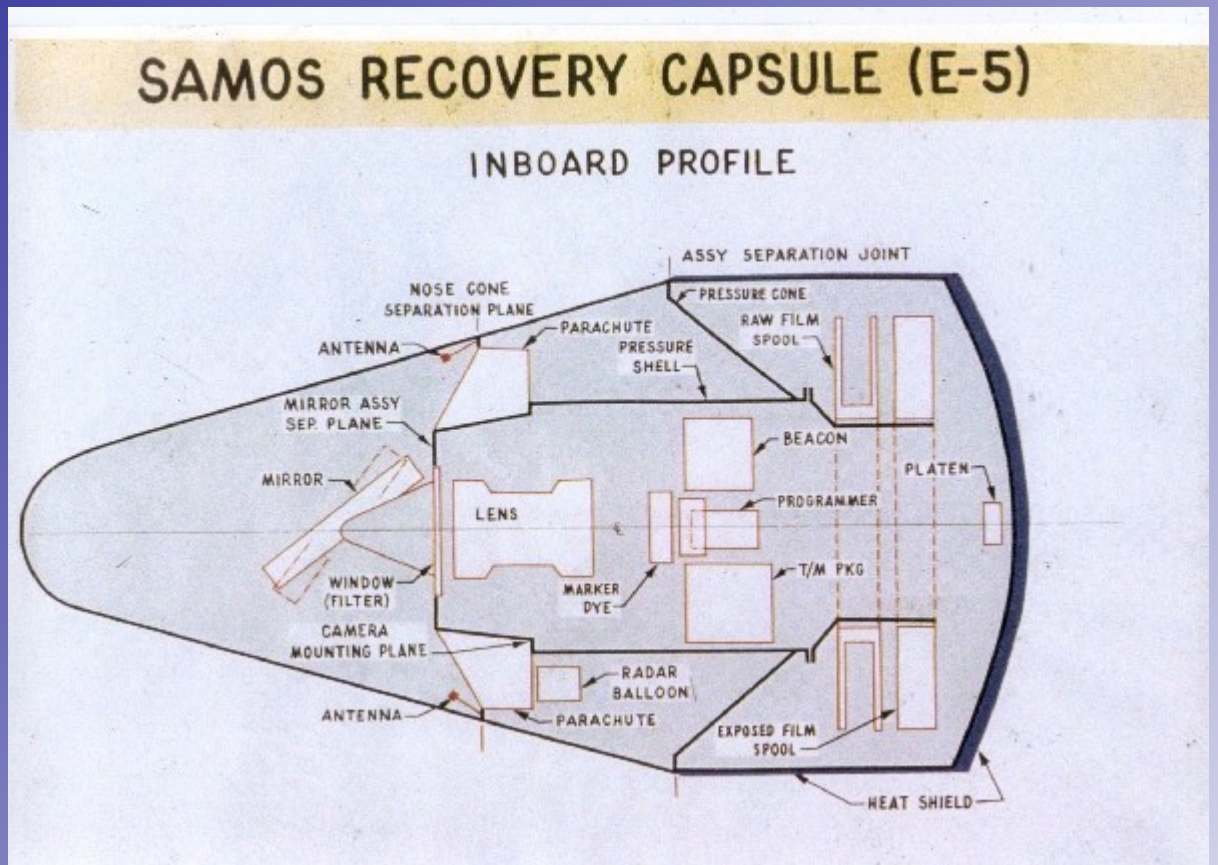
Army contract with JPL goes to NASA

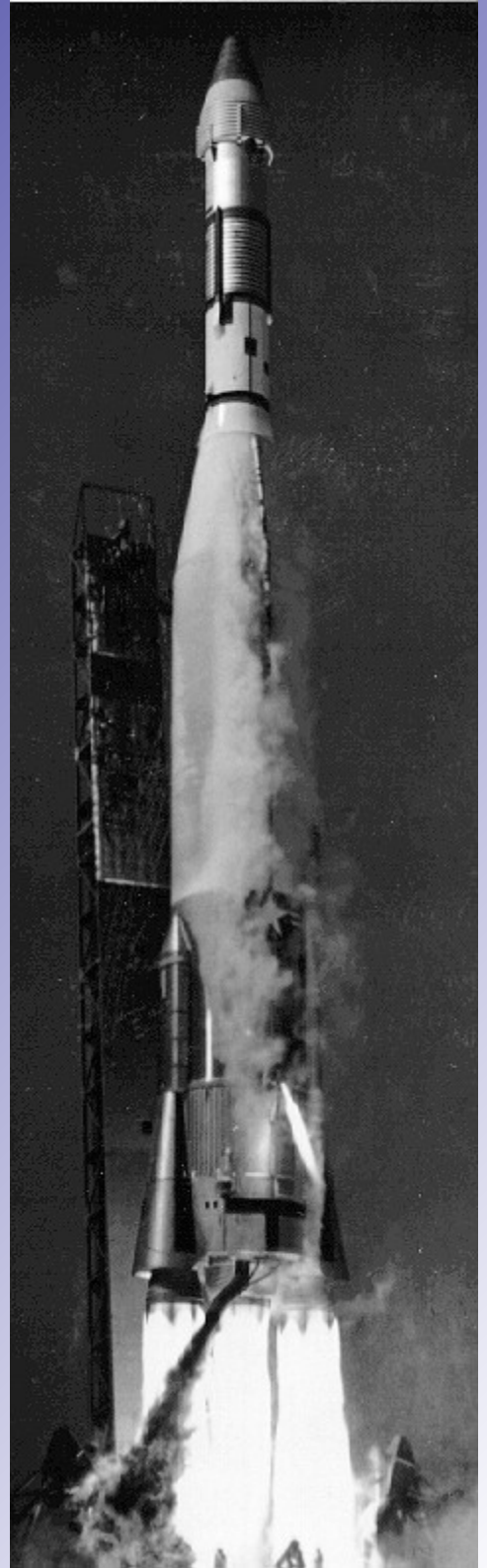
Small group at Canaveral later becomes KSC; Houston develops in mid-1960s

New horizons 1961-1962

SAMOS E-5: the pressurized spy satellite boondoggle

Somewhere under the Yukon snows...

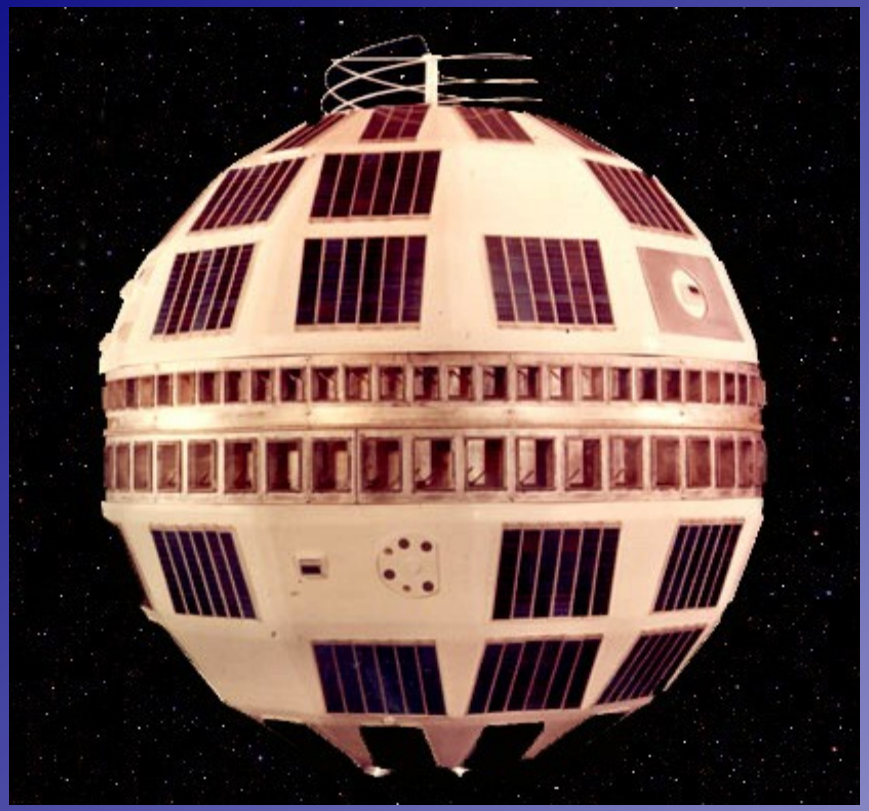




New horizons 1961-1962

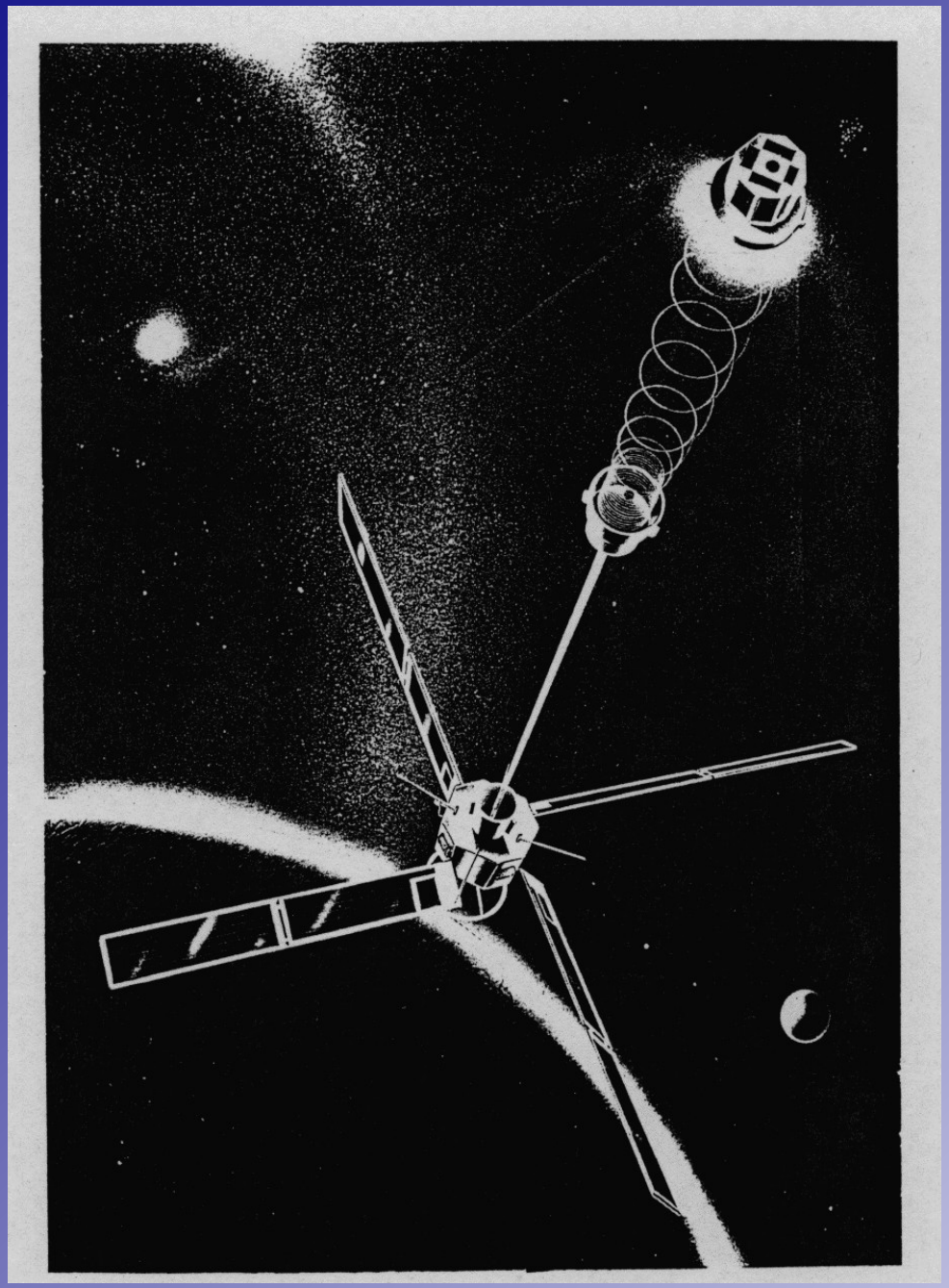
- P35, the NRO's weather satellite
- Launched by Scout rockets
- Parallel to NASA Tiros weather program
- Cloud cover monitor for CORONA
- Later supported Vietnam ops, led to modern DMSP Air Force weather sats

New horizons 1961-1962



- Telstar - first true (real-time, active) communications satellite (1962, medium height orbit)
- First GEO satellite was Syncom 3 in Aug 1964, followed by Early Bird and ATS-1 in 1965-66

New horizons 1963



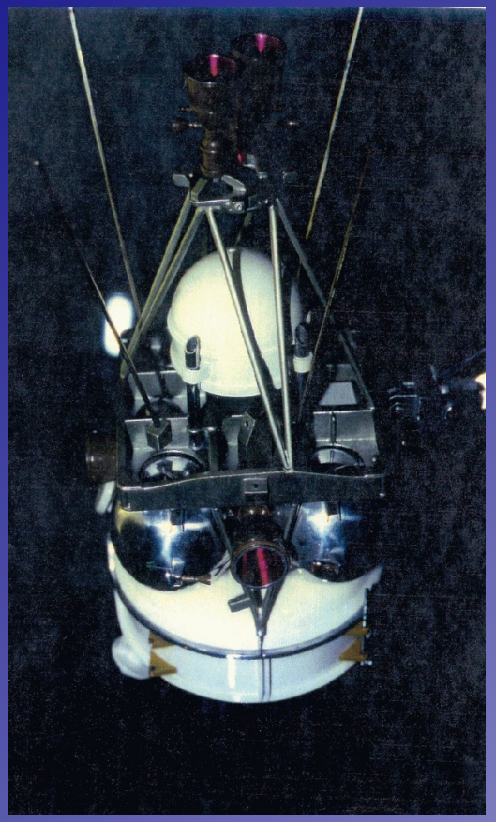
Transit 5A-3: first gravity gradient satellite, June 1963 (5A-1 failed in Dec 1962)

Prototype for Doppler navigation system

Applied Physics Lab (Maryland) for US Navy

30-meter boom

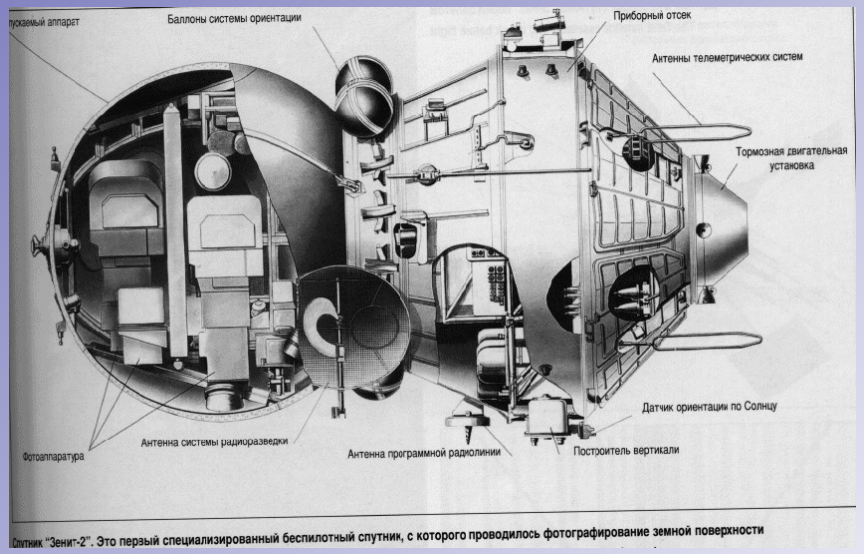
New horizons 1962-3



Chelomei antisatellite weapon prototype Polyot-1, Nov 1963

Claimed as first maneuvering satellite (arguable)

Zenit-2 spy satellite (Dec 61 launch failure, Apr 62 success)



Спутник "Зенит-2". Это первый специализированный беспилотный спутник, с которого проводилось фотографирование земной поверхности

New horizons 1962

Ariel (UK owned, UK-built instruments, US-built satellite)

Alouette (Canadian built and owned, US launched)

The satellite age begins to reach beyond the superpowers