“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 $E = 1.5 \text{ MJ/kg}$ (1.1 to 2.1 for different launches).

An orbiting satellite at the same altitude needs $E=31.6 \text{ MJ/kg}$. 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
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
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.
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
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
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.).

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.).

<table>
<thead>
<tr>
<th>Extruded 5th Stage</th>
<th>Spherical 6th Stage</th>
<th>Hotroc 2nd and 3rd Stage</th>
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<tr>
<td>LENGTH _______ 18.6 IN.</td>
<td>LENGTH _______ 5.5 IN.</td>
<td>LENGTH _______ 71. IN.</td>
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<td>DIAMETER _______ 3.0 IN.</td>
<td>DIAMETER _______ 116.5 IN.</td>
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<tr>
<td>TOTAL WEIGHT _______ 329 LB</td>
<td>TOTAL WEIGHT _______ 1.25 LB</td>
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<td>OPERATING PRESSURE _______ 500 PSI</td>
<td>OPERATING PRESSURE _______ 1.500 PSI</td>
<td>OPERATING PRESSURE _______ 900 PSI</td>
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<tr>
<td>BURNING TIME _______ 5.7 SEC</td>
<td>BURNING TIME _______ 1.0 SEC</td>
<td>BURNING TIME _______ 4.86 SEC</td>
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<tr>
<td>THRUST _______ 1155 LB</td>
<td>THRUST _______ 172 LB</td>
<td>THRUST _______ 14,200 LB</td>
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<tr>
<td>TOTAL IMPULSE _______ 6590 LB-SEC</td>
<td>TOTAL IMPULSE _______ 172 LB-SEC</td>
<td>TOTAL IMPULSE _______ 69,000 LB-SEC</td>
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<td>MOTOR PERFORMANCE INDEX _______ 138</td>
<td>MOTOR PERFORMANCE INDEX _______ 192</td>
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</tbody>
</table>

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