Air and Space this Week

Item of the Week

LANDSAT

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The late 1950's was a time before cell phones, the Internet, and GPS. But then access to low-Earth orbit allowed our society to make great strides forward in meteorology, communications, and astronomy. The new technology and access were a boon for military reconnaissance, too. It was also the time of Silent Spring*, and a growing interest and understanding of the only environment in which we live.*

A view from the high ground is always a good way to get the "Big Picture" of an area. A satellite in low-Earth orbit (LEO) occupies the highest (of usable) ground. This is the story of the satellite series NASA has created since then to provide all sorts of usable data about the Earth's surface environment. The satellites were called "Landsat." ***The launch of the first satellite in what would become the Landsat program occurred 50 years ago this week, on July 23.***

FIRST ADOPTERS

The first American satellites launched were to use Space as a proving ground for new technology, study the LEO environment, and little else. But the ones that immediately followed (within two years) were a big jump forward in their respective fields.

Meteorology: Seeing cloud patterns on a regional scale from above, and watching them move and change with time, was a boon to the science of meteorology as well as the art of weather forecasting. One development that helped was the ability to image temperatures (thermal infrared). The first of the Thermal InfraRed Observation Satellite (TIROS) series was launched in 1960, and the American public soon became accustomed to seeing satellite weather pictures on the evening news or in their newspapers. NASM has the backup *TIROS I* spacecraft in its collection.

Communications: Progress was made on using LEO for communications, first with putting up big balloons off which radio signals could be bounced over the horizon (e.g. *Echo 1*), then by putting up more capable relay stations (e.g. *Telstar*) by mid-1962. Once our rocketry was powerful enough and accurate enough to put a communications relay in geostationary orbit, a global communications network became possible. OK, geosync is a lot higher than LEO, but its value was known a decade before LEO was attainable, so it was a goal to work for.

Astronomy: Getting a telescope above the Earth's atmosphere was desirable for two reasons. The first was that our air blocks a significant portion of the electromagnetic radiation hitting Earth. That's good in some cases, but there is a lot of astronomical information in the blocked wavelengths. The other reason is that atmospheric turbulence adversely affects viewing. Modern techniques can reduce, but not eliminate, that problem. Putting telescopes operating in different wavelength ranges, a long-time astronomer's dream, was now possible. More. And, of course, we'll be seeing a lot of really impressive IR data from the *James Webb Space Telescope* in the coming years!

Military: Reconnaissance of military activities in the Soviet Union were a very high priority in the late 1950s. One plan was to take a page from the Japanese balloon bombs and to put cameras and a microphone (to detect the blast of nuclear tests) on a high-altitude balloon, launch it in Europe, have the jet stream take it over the USSR, and recover it over the Pacific. One of the test balloons from that program crashed outside of Roswell, New Mexico, spawning a UFO industry for the gullible that continues to this day. Another, better, idea was to build a spy plane, the U-2, that could fly over the USSR at very high altitudes and take pictures and other data. That worked well, until May 1, 1960, when the Russians used a new anti-aircraft missile to shoot down one with Francis Gary Powers aboard. Since we now could reach NEO, the next step was a spy camera on a satellite, the CORONA program. This was before digital imaging was possible; CORONA used film, developed on board the satellite, ejected in a capsule, and snagged out of the air by a plane trailing a hook, all over deep water should the catch not be made. We didn't want the folks we were photographing to know what we were seeing!

LOOKING AT EARTH FROM ABOVE

Meteorology, communications, science, and military reconnaissance were important users of access to NEO, but there was one other important are not yet mentioned. Being able to see the Earth from above would have many important applications, such as geological exploration, land-use planning, and more. Little was done about "looking at Earth" during the heyday of the manned spacecraft programs of the 60s, but with the famed Apollo 8 "Earthrise" photo, and the resulting push for the first Earth Day (1970) and greater environmental awareness, NASA realized the value of using LEO as the location of spacecraft dedicated to looking at Earth's resources.

Meteorological satellites had progressed much since the days of *Tiros 1*, and NASA used the *Nimbus 4* satellite design as the base for the *Earth Resources Technology Satellite* (*ERTS*), which was launched on **July 23, 1972**. *ERTS* was primitive by today's standards, but was sophisticated for its time, carrying a three-gun color camera system with near-IR capability, a four-channel multispectral scanner, and a tape recorder that would allow data collection when *ERTS* was out of receiver coverage. The spacecraft infrastructure allowed for accurate pointing of the instruments and other spacecraft operations. *ERTS* lasted almost six years on orbit, and was so successful, and the data it produced were so valuable, that NASA decided to rename it "Landsat 1" and make it the first satellite in a long-running series that still continues to this day.

BENEFITS

Overestimating the returned value of the investment in the Landsat program is almost impossible. Data current in 2012 show that the geospatial industry, which Landsat spawned and supports, was a $73 billion annual business, and that geospatial services companies drove $1.6 trillion in revenue and $1.4 trillion on cost savings throughout the U.S. economy. The geospatial industry employed at least 500,000 Americans in 2012, and the data produced by *Landsat 1*'s successors had a value of over $690 million.

An early cost-benefit evaluation, done in 1976, gives additional perspective. The evaluation considered how the early Landsats benefitted agriculture, oil/mineral exploration, land use, water resources management, forestry, and soil management, and found that the overall return-on-investment was a factor of between 6 and 13. An investment that returned 10 to 1 in its first few years? Sign me up! And the analysis only included tangible dollar return, not semi-intangible benefits such as tech spin-offs and facilitating advances in other fields, and intangible benefits such as educational inspirations.

A later analysis (https://www.sciencedirect.com/science/article/pii/S0034425719300707) emphasizes an additional point about the value of the Landsat program. Its 50-year stream of data now provides scientists and planners with a longer baseline of data continuity, using similar instrumentation. Now decades-long trends can be assessed with high accuracy, and extrapolations of trends have a longer database to support them.

Landsat was there at the beginning and it is there now. But as satellite instrumentation became better, and the number of Earth reconnaissance satellites grew, managing all of the incoming data became a serious problem. Storing, indexing, cataloging, and serving that much data out required big advances in computing technology; the satellites and their data management system became known as the Earth Observing System, a "coordinated series of polar-orbiting and low inclination satellites for long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans. As a major component of the Earth Science Division of NASA's Science Mission Directorate, EOS enables an improved understanding of the Earth as an integrated system. The EOS Project Science Office (EOSPSO) is committed to bringing program information and resources to the Earth science research community and the general public alike." (https://eospso.nasa.gov).

Earth Sciences became one of the four divisions of NASA's Science Mission Directorate. For a list of Earth Sciences Division featured missions and projects, see here.

As only NASA, supported by its partner Agencies, can!

REFERENCES

Picture of the *ERTS* on its booster:
https://www.nasa.gov/directorates/heo/scan/images/history/July1972.html

NASA's Landsat Science site: https://landsat.gsfc.nasa.gov

Landsat 1 History from NASA Landsat Science: https://landsat.gsfc.nasa.gov/satellites/landsat-1

National Archives YouTube: https://www.youtube.com/watch?v=6isYzkXlTHc&ab_channel=USNationalArchives

Landsat 1 Multispectral Scanner: https://landsat.gsfc.nasa.gov/multispectral-scanner-system

Memory of the World: https://www.usgs.gov/landsat-missions/landsat-adds-world-memory

NSSDCA: https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1972-058A

ERTS Flight Profile: https://landsat.gsfc.nasa.gov/about/erts-flight-profile

A Landsat Data Users Handbook was issued after the ERTS mission, and it was updated after each Landsat mission. The September 2, 1976 version, NASA TM-74722, covering the first three Landsat satellites, is here: https://ntrs.nasa.gov/api/citations/19770079550/downloads/19770079550.pdf

The *Landsat 9* Data Users Handbook is here: https://www.usgs.gov/media/files/landsat-9-data-users-handbook

Landsat Summery through *Landsat 7*: https://pubs.usgs.gov/fs/2003/0023/report.pdf

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https://www.nga.mil/defining-moments/Landsat_Program.html

https://appliedsciences.nasa.gov/our-impact/news/landsat-9-extending-nearly-50-year-legacy-observing-our-home

Landsat 9 is still operational; *Landsat Next* **is** next. Here's a comparison of their instrumentation: https://landsat.gsfc.nasa.gov/satellites/landsat-next

Benefits: https://landsat.gsfc.nasa.gov/benefits

Benefits: https://www.usgs.gov/media/images/economic-impact-landsat \

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Earth Observing System: https://eospso.nasa.gov

NASA's Earth Sciences Division: https://science.gsfc.nasa.gov/sed/index.cfm?fuseaction=projects.featured&navOrgCode=610&navTab=nav_about_us

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