Air and Space this Week

Item of the Week

THE SURVEYOR PROGRAM

Originally appeared May 27, 2024

KEY WORDS: Surveyor Lunar Orbiter Ranger Arthur C. Clarke Tommy Gold

The launch of Sputnik 1 *by the USSR on October 4, 1957, shocked Americans, and the launch of* Sputnik *2, a satellite large enough to carry a nuke, a month later really scared us. We responded by making massive changes in our military posture, and in our STEM educational programming, as related in a previous Item. Space would become a symbolic battlefield in the already-raging Cold War, especially with the election of JFK and his Space-oriented VP, Lyndon Johnson, who would chair the newly-created National Space Council.*

Public perception of the inferior position of the United States was exacerbated greatly by Yuri Gagarin's orbital flight on April 12, 1961. Alan Shepard's sub-orbital flight on May 5, 1961, only underscored how far we were behind.

President Kennedy's response to the situation was his famous charge to the Nation at a Joint Session of Congress (5/26/1961) to "…commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth." NASA rolled up its collective sleeves and began planning to accomplish that task.

PRE-APOLLO RECONNAISSANCE

NASA planners worked up a number of scenarios to send a person to the Moon and return them safely. But that planning depended critically on the actual nature of the lunar surface and the development of the technology to accomplish the goal. Three separate programs were developed: Ranger, Lunar Orbiter, and Surveyor.

PROJECT RANGER

… was the first. Rocketry was still very primitive, and we had little concrete understanding of the nature of the lunar surface and the processes that affect it. The first goal was to be able to just send a spacecraft to the Moon accurately enough to hit it. Having a camera and other instruments aboard to show the Moon "up close" would come later in the program. The program would have nine attempts to hit the Moon; *Ranger 1* was launched just less than three months after JFK's speech. The Project Ranger series would run from August 23, 1961 to March 21, 1965.

The first six Ranger spacecraft failed miserably. The first three, like so many early lunar/planetary probes, were done in by problems with the launch vehicle. The next two

suffered internal problems. Improvements in both rocketry and the Ranger spacecraft in general allowed *Ranger 6* hit the Moon as planned, but its imaging system failed prior to impact.

The final three Rangers functioned as planned. The 15,000+ images they returned showed that impact craters were the dominant surface feature, not just at scales seen by Earth-based telescopes, but down to a scale of feet. Their success showed how much NASA had learned the hard way about building a functional spacecraft and getting it to the position desired.

However, much more information about the surface as a whole and in detail was necessary to plan for the Apollo landings. Two additional NASA programs were needed, one to provide broader-scale imaging of the surface from orbit (Lunar Orbiter Program) and one to actually return data about the surface from the surface (Surveyor Program). Both were planned while Project Ranger was running, and both would start in 1966.

Project Ranger is covered in more detail in a previous Item of the Week.

LUNAR ORBITER

Five spacecraft were sent to perform a detailed reconnaissance of the lunar surface during the period of August, 1966 to January, 1968. All Lunar Orbiters functioned as planned and their specific objectives were met fully. The first three were placed in a low-inclination orbit around the Moon with the goal of providing detailed photography of potential landing sites, both for landing safety and scientific potential. The remaining two were placed in inclined orbits, which provided data to address broader scientific objectives.

The cameras on the Lunar Orbiters were ingenious for the day. They used photographic film that was developed on board, and then scanned to produce an analog TV image that was transmitted back to Earth.

Lunar Orbiter images allowed scientists to prepare planning maps and hazard analysis for the Apollo landing site selection process. The orbiters also carried devices to measure radiation intensity and micrometeoroid impacts to allow the risks to astronauts from both to be assessed.

Before moving on to the Surveyor Program, I must digress to set the stage a bit.

ARTHUR C. CLARKE

The idea of Space exploration was not new to the American public. The idea was broached a century or so ago by Flash Gordon movies and Edgar Rice Burroughs in entertainment media, and by Percival Lowell's (pseudo) science books. The Cold War era was replete with the idea, too, from the public engagement work by Wernher von Braun, Willy Ley, Chesley Bonestell, and other proponents, amplified by Walt Disney and others, along with movies and TV shows like *Men Into Space* that premiered 18 months before Gagarin's flight.

Another book of that era (1961) that may have affected our thinking about actually exploring and exploiting the Moon was Arthur C. Clark's *A Fall of Moondust*. It garnered a nomination for the Hugo Award for Best Novel for 1961, and was the first science fiction novel selected to become a *Reader's Digest* Condensed Book. Clarke was building a reputation for scientifically-plausible fiction, and the central setting for *A Fall of Moon*dust was that there were places on the Moon covered with a thick fine-dust deposit, material that, in the lunar environment, acted like quicksand. Tourists could take a cruise across such material in a dust-cruiser, like a speedboat over water. Only this time, one of the dust-cruiser sank out of sight into a deep dust pit. The action of the novel revolves around their eventual rescue, using a variety of clever techniques to save the passengers and crew, facing a series of pitfalls along the way.

[I could not help but think of similar-but-real situations earlier from WWII and before, especially in submarines, notably the story of the *USS Squalus*, detailed in the Coda section of this Item. A failure of the plumbing used to submerge the sub flooded its aft section, and after many trials and tribulations, the remaining crew was rescued via the novel use of a diving bell, similar to what saved the dust-cruiser folks.]

Clarke's idea of the lunar surface and its dust cover being dangerous was in the back of a lot of people's minds. Including…

TOMMY GOLD

Thomas Gold was born in Austria on **May 22, 1920, 104 years ago last week**. His father ran one of Austria's largest mining and metal fabrication companies, but those industries crashed when Tommy was a boy, and with the rise of Hitlerism, they had to flee to Switzerland, and then to England when Germany invaded Austria. Initially, he was considered an "enemy alien" and interred, where he met another budding scientist by the name of Hermann Bondi, and then in Canada.

Gold returned to England after the War began, receiving a degree in Physics. He ended up on a project to study radar ground clutter in the fall of 1942, along with Bondi and another scientist, Fred Hoyle. These three were amazing theoreticians, and routinely discussed cutting-edge topics in cosmology, math, and astrophysics. But the War came first, and Gold took a leadership role in the construction of radar systems, devised a plan where landing craft could use radar to navigate during the D-Day invasion, and discovered that the Germans had developed the submarine schnorkel, enabling them to use diesel engines while submerged.

Hoyle and Bondi returned to Cambridge after the War, but Gold stayed with military technology, heling to develop and construct the largest magnetron yet built. He also developed somewhat of an ego, but could back it with a brilliant understanding of basic physics.

The three physicists stayed in touch with one another, and ended up publishing an alternative to the Big Bang model of the Universe. Gold and Bondi accepted the red shift data that showed the Universe was expanding, but did not like the notion that the Universe has a beginning but no end. They, like many, believed that the Universe was homogeneous and isotropic (alike in

all places), and the only way they saw that to be possible, and have the Universe be eternal, was for there to be spontaneous creation of matter to fill the void left by expansion. Their paper, and one by Hoyle, laid out the "Steady-State" model of the Universe. The S-S model fell out of favor when the 3K background radiation pervading Space was discovered and S-S couldn't explain it. But their thinking showed that the three were willing to buck scientific orthodoxy with challenging new ideas.

Gold left Cambridge in 1952 to become the chief assistant to the Astronomer Royal, Harold Spencer-Jones, then moved to Harvard in 1956, when HSJ retired. He moved to Cornell in 1959, jumping at their offer to Chair their Astronomy Department and to set up an interdisciplinary unit within it dedicated to radio-physics and Space research. Problem was, there was only one other faculty member there at time. No problem. Gold hired Carl Sagan and Frank Drake, among others, and oversaw the construction of the Arecibo radio telescope in Puerto Rico!

Tommy Gold's love of the oddball theory continued. He came up with the notion that natural gas and even oil was not the byproduct of the decay of buried biological material but was rather the outgassing of material incorporated into the Earth during its formation. When pulsars were first discovered, he postulated that they were radio signals beaming from a rapidly-rotating neutron star, an idea initially ridiculed but now accepted fact.

He also started consulting with NASA when he went to Cornell. He had another of his idiosyncratic insights about the nature of the lunar surface. He figured that eons of bombardment by objects large and small would have pulverized the lunar surface into a deep layer of micro-fine debris, much like that envisioned by Arthur C. Clarke earlier for Mars. His initial idea was that any astronaut or landing craft on the Moon would likely sink out of sight, but modified that stance after looking more closely at impact craters and the action of material in an electrostatic field.

Managerial thinking affected by the notion of an unstable lunar surface was one of the prime motivations behind the Surveyor Program!

For more about this interesting physicist, see next week's Item. I will flesh out this section, complete with my personal recollection of Dr. Gold.

Dust or no dust, the USSR and USA were heading for the Moon. Who would be first to actually land a spacecraft on the Moon?

They were. They were first to hit the Moon, with *Luna 2*, launched on September 12, 1959. They were also first to land on the surface, with *Luna 9*, launched on January 31, 1966.

But the Americans were not far behind!

SURVEYOR 1

NASA planners chose to fly seven Surveyor robotic lander missions to the Moon, with the following collective objectives: "…support the coming crewed Apollo landings by: (1) developing and validating the technology for landing softly on the Moon; (2) providing data on the

compatibility of the Apollo design with conditions encountered on the lunar surface; and (3) adding to the scientific knowledge of the Moon" (source). Each lander carried a TV imaging system; some carried other scientific tools and instruments.

The Surveyor program got off to a great start.

Surveyor 1 launched on May 30, 1966, atop an Atlas-Centaur rocket using a direct trajectory to the Moon (no parking orbit). The launch went so closely to plan that only one small mid-course correction was necessary. The landing sequence worked perfectly, and *Surveyor 1* set down on the Ocean of Storms on June 2.

And did not sink into a thick layer of dust.

Surveyor 1 deployed its solar panels and began returning images of the lunar surface, and made measurements of the temperatures and radar reflectivity of the surface. Particular interest was paid to images of the pad on the landing leg near the camera. An estimate of the bearing strength of the surface could be made from seeing how far the pad indented the surface.

The news coverage of the landing was played live on national TV, a measure of the interest the public had in our going to the Moon and how worried everyone was over the first landing attempt, given the initial difficulties in the Ranger series.

THE REST OF THE SURVEYOR PROGRAM

The ***Surveyor 2*** spacecraft and mission profile were similar to those of *Surveyor 1*, but alas, the outcome was not. Launched on September 20, 1966, the Atlas and Centaur stages of its launch vehicle worked as planned, however, one of the thrusters used for a mid-course correction failed to start, and the off-centered thrust of the other two caused the spacecraft to tumble out of control. Mission failure.

Surveyor 3 did much better. Before and after the mission. It was launched on April 17, 1967, but this time it was placed in a parking orbit around Earth before its Centaur stage was ignited again to push it on to the Moon. The spacecraft itself was similar to its two predecessors, but it also had a mechanical arm and scoop that could assess surface material properties much better than just imaging the landing footpad. It made a safe landing in a small crater on the Ocean of Storms. Photos and other data starting coming in an hour later.

Surveyor 3's claim to fame is that it was used for a landing target by the Apollo 12 mission. NASA had to be able to demonstrate that it could land a crew on the Moon exactly where they had trained for. But navigating to some landmark could pose difficulties, due to the lack of navigational aids or confirming features. But we knew where the Surveyors were, so one of them was used as the landmark to confirm the success of being able to land where planned. Even better, the *Apollo 12* astronauts were able to cut off pieces of *Surveyor 3* and bring them back to Earth for analysis of how well various materials withstood the harsh lunar conditions.

The camera is now in the collection of the National Air and Space Museum. Some of the pieces from it sparked a short-lived bit of publicity because bacterial spores were found within. Could they have survived on the Moon? Nah, they were just contaminated in the lab.

Surveyor 4 was launched on July 14, 1967. Its flight from Earth, trans-lunar injection, and coast to the Moon worked exactly as planned. However, contact with the spacecraft was lost during the terminal descent stage of the flight and never recovered. The cause of the loss was never determined.

Surveyor 5 was launched on September 9, 1967, targeted for the Sea of Tranquility. Its instruments included an alpha-particle scattering instrument that could determine the gross chemistry of the lunar regolith. An additional test was run to determine the stability of the surface, with the landing rockets were "burped" to produce half a second of thrust, then surface beneath them was imaged to determine any changes. The changes were there, but very minor. Sorry, Tommy!

[At this point, the Surveyor Program seemed to be working out like the first set of *Star Trek* movies that would come, but in an opposite sense, with the *odd*-numbered ones being good and the *even*-numbered ones stinking.]

Surveyor 6 broke the pattern by succeeding, too. It was virtually identical to *Surveyor 5*, but sent to a slightly different location, Sinus Medii. The spacecraft may have been similar to its immediate predecessor, but how its handlers used it on the surface was more aggressive. Instead of a very-short burst from the landing rockets as before, *Surveyor 6* fired them for 2.5 seconds, enough to lift it from the surface about 10 feet and move it about 7 feet laterally from its original landing spot. The stronger burst gave a better look at the mechanical properties of the surface, and the lateral move allowed the camera system to generate 3-D pairs of the area surrounding the landing site, a boon to understanding its surface. [The quest for "firsts" with the Soviets was never stronger; NASA claimed that *Surveyor 6* made the first lift-off from another planet/moon!]

The Surveyors (that worked) pretty much addressed the concerns about surface strength that had arisen earlier. With the basic program goals met fully, planners could be more aggressive about the landing site for the seventh and final lander of the series. Lunar scientists had a pretty good idea of the nature and physical properties of the lunar mare material from two different locations, but no Surveyor had landed in the lunar highlands (yet).

One of the other surface features that was proving to be increasingly important was the material that was ejected from impact craters. Impact ejecta came from a depth much deeper than the Surveyors (or Apollo astronauts) could sample, and may reflect important differences than the uppermost layers. Ejected material was also important because it helped scientists work out the sequence of events that shaped the surface of the Moon, since anything it draped over had to be older than the impact event and anything that altered the ejected material had to be younger than the age of the impact event.

So ***Surveyor 7*** was targeted for the ejecta material (rays) of Crater Tycho, the most prominently-rayed crater on the near side of the Moon, in the highlands. It launched on January 7, 1968, carrying a sample arm/scoop and the alpha-particle device to see if the composition of the ejected ray material was similar/different to samples from mare material. Its other instruments were similar to, but updated versions of, those carried on previous Surveyors.

The Surveyor program met every one of its objectives fully, in spite of having two failures out of seven missions. The information from the program showed that Apollo landings were feasible with the equipment being developed, both from a rocket/spacecraft and lunar surface perspective.

CODA

The submarines *USS Sculpin* (SS-191) and *USS Squalus* (SS-192) were advanced by early 1930s standards but were much more primitive than the subs the US had in WWII. Both were Salmon-class, with only two watertight compartments rather than the eight or so that would soon come, and worse, a main valve on the water line that allowed them to submerge that sometimes didn't close properly.

May 13, 1939, dawned fair. The *Squalus*, commanded by Oliver Naquin, set off from its base at Portsmouth, New Hampshire, for training. As they passed the Isles of Shoals, Naquin ordered a routine dive, but the main induction valve did not close. The inrush of water was so powerful that it couldn't be stopped, filing the aft end of the sub and drowning all 23 within. Herculean effort allowed the hatch between compartments to be closed in time, saving the 33 up forward. But the sub lay on the bottom. Sea water or martian dust – just as fatal.

However, there was hope. Subs of the day were fitted with a buoy with a telephone in it that could be released from a sunken sub. Naquin did so, while the *Sculpin* nearby realized that something was wrong. A search soon revealed the buoy, and word got out about the accident. But how could the men trapped below be rescued?

A new version of an old device presently under development was the answer – a diving bell. The bell was open to the sea on the bottom, but the air trapped inside the bell had no way of escaping unless the bell tipped. It would compress with depth, but if it could be landed over the *Squalus*' forward torpedo room hatch, the hatch could be opened and the men could transfer to the bell and safety. It took several trips, but all that survived the sinking were saved. [Spoiler Alert: that's similar to how the folks suffering from *A Fall of Moondust* were saved, too!]

The *Squalus* was raised in an amazing feat of nautical engineering a few months later. The sub was cleaned out, refurbished, and returned to service, renamed *USS Sailfish*. Sailors tend to be a suspicious lot, but one doesn't need to be superstitious about serving in a vehicle in which others have drowned, and a disciplinarian was made captain. The men got to calling their sub the "Squailfish," but it the captain heard it – bad news.

Later in the War, the US Navy was starting its strike across the central Pacific toward Japan. Operation Galvanic was the invasion of the Gilbert Islands, and Admiral Lockwood, head of the submarine fleet in the central Pacific was planning to use a "wolfpack" system favored by the Germans, where subs hunted in coordinated groups with a senior officer in command of the pack. In this case, the senior officer was Captain John Cromwell, embarked in *Sculpin*, commanded by Fred Connaway. Cromwell was familiar with plans for Galvanic, including the disposition of submarines for it, and worse, he was familiar with the success of our codebreakers in reading the Japanese naval communications. Allowing him in a combat zone was one of the few mistakes made by Admiral Lockwood in the War.

The first-string Japanese anti-submarine forces were on the field, and had already sunk the *USS Corvina*. *Sculpin* encountered a supply convoy, and Connaway moved to attack it, but was sighted. Connaway had to go deep as the convoy defenders moved toward him. The convoy commander was clever, and had left a destroyer behind, waiting for the sub they'd seen to surface. Connaway surfaced, intending to move around to attack the convoy, but the "sleeper" destroyer attacked. *Sculpin* dived, and withstood a couple of depth charge barrages, after which things were quiet again. Several hours later, Connaway ordered his sub to periscope depth for a look-around. The depth gauge stuck on the way up, and the rookie diving officer didn't notice the problem in time to prevent the sub from accidentally surfacing. The destroyer was nearby, and opened fire immediately, causing severe damage. Connaway decided he had no choice but to fight it out on the surface (a decision that others criticized after the fact, but they weren't there). Sub vs. destroyer on the surface was an uneven duel. The destroyer quickly scored hits on the conning tower, killing Connaway, his XO, his gunnery officer, and others. The senior surviving officer (Cromwell was not in the sub's chain of command) ordered "Abandon Ship." Twenty-one men went over the side, to be taken prisoner by the destroyer crew. Cromwell decided to go down with the sub, out of concern for revealing what he knew under torture. The diving officer, awash in guilt for his error, opted for the same fate.

Seven Medals-of-Honor were awarded to member of the U.S. Submarine Service in WWII. John Cromwell got his when the story got back about his sacrificial action this day. ***It's devotion to duty such as this that merits our praise and thanks, especially on Memorial Day!***

The Japanese decided to send the *Sculpin* POWs to Japan. The split the group into two groups, of 10 and 11, and loaded them on light carriers bound for Japan. The one with 11 was found *en route* by one of our subs, which sank it. Only one of the 11 lived to tell the tale. George Rocek would actually survive the War after having two ships sunk out from under him, one of ours and one of theirs.

And the sub that sank the carrier that had the *Sculpin* crewmen aboard? It was none other than the *USS Sailfish*, whose crewmen *Sculpin* helped rescue four years before!

How's that for a Memorial Day story!?

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Last Edited on 27 May 2024