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Chapter 16

Creating Space for Science: From Apollo to Skylab*

Hyoung Joon An†

Abstract

Science is believed to make space humanized, as it has been a constitutive element (an integral part) of space missions since the beginning of space exploration. In this chapter, I will examine the early history of the Skylab, the first US space station, to capture the process of creating space for science at the border between exploration and science. The story will deal with two most significant traits of Skylab related to scientific practice in space. First, I will investigate the unique characteristics of Skylab comparing to traditional concept of laboratory. Historians of science have drawn attention to the locality and spatial situation to understand how scientific knowledge is made and how it achieves credibility. Scientific discoveries should be witnessed by an uninterested party and replicated in a different laboratory, due to the "placeness" of the original laboratory. I will insist that the appearance of Skylab as the start of "overnaturalized" places beyond the modern lab characterized by "placelessness/placeness," in that scientific experiments in Skylab have been justified with the human desire for exotic knowledge, and the efforts for and knowledge of "permanent weightlessness,"

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† Dr., Science and Technology Policy Institute, B509, Sejong National Research Complex 370, Sicheong-daero, Sejong-si, 30147, Republic of Korea. E-mail: hjan@stepi.re.kr.

which is overwhelming the experience [experiments] on Earth. Second, I will analyze how US Air Force and the Space Science Board competed to control the design, timing, and function for the project. In adding that, I will examine the process of selecting the scientist-astronaut for Skylab project and investigate the role of scientist-astronaut in conducting experiments; during totally 171 days in space, nine crews spent 3,036 hours for experimental performance such as solar astronomy and Earth resources experiments, medical studies, and educational experiments. In sum, I will argue that the appearance of hybrid explorer-researcher, as it were, scientist-astronaut led to persuade the value of man in future explorations of space to the people.

Acronyms/Abbreviations

Apollo Applications Program (AAP)
Apollo Extension System (AES)
Conseil Européenne pour la Recherche Nucléaire (CERN)
liquid oxygen (LOX)
National Aeronautics and Space Administration (NASA)
Orbital Workshop (OWS)

I. Introduction: From Exploration to Science

What kind of space is the space (out of the Earth) to human? At least, space is not a sacred "out there" any longer. Many works have shown that space has become a highly secular place filled with politics, business, and militarism. For example, in their book, *Cosmic Society: Towards a Sociology of the Universe,* Dickens and Ormrod argue that space is being humanized, incorporated into today's political economy, in satellite surveillance, space tourism, and space weaponry [1].

Science and technology are believed to make space humanized. Science has been a constitutive element (an integral part) of space missions since the beginning of space development. Yuri Gagarin and Alan Shepard's inaugural human orbit around the Earth in 1961 was based on the great progress of science and technology, and the announcement in the same year of the US decision to go to the Moon by the end of the decade was described to be a great challenge to take the leadership in science and technology in the Cold War era. Was space itself, then, space for pure science at the beginning of space era?

Space was not a “field” for scientists where they could collect data and experiment, rather just a “site” for explorers where they conquer and put a flag. For example, the biggest objective of Apollo project was, put in the simplest terms, to place a man on the Moon and return him safely for people’s innate drive to explore unknown regions and national prestige and security. Of course, Apollo program indeed acquired scientific validity. However, those were rocket science and planet science for placing human on the Moon by scientists on the Earth. In other words, space itself was not a “field” for scientists conducting “science-in-space,” rather, a frontier to explore and conquer with help of scientists researching “science of space.”

In this chapter, I would examine the transition process of space from a “site for exploration” to a “field for science” by tracking the history of Skylab. Skylab was the United States’ first space station in Earth’s orbit from 1973 to 1979 and visited by crews three times in 1973 and 1974. The story will deal with two most significant traits related to scientific practice in space; (1) the appearance of a “rocket-modified-laboratory” and (2) the “scientist-astronaut.” Through the whole story, I will analyze how “science-in-space” went beyond “science-of-space” in terms of the two transitional traits.

	Explore	**Skylab**	**Science**
Hardware	Spacecraft	**Rocket-Modified-Lab**	Laboratory
Human	Pilot	**Scientist-Astronaut**	Scientist

II. Space Laboratory as a Scientific Instrument

Who was the first man who thought of the possibility to build a laboratory in orbit around the earth? It was Edward E. Hale’s fictional story in *Atlantic Monthly* during 1869-1870 that mentioned the idea of space station for prolonged stays in space first [2]. However, the origin of Skylab as the first space laboratory goes ahead to 1940s. Dr. Wernher von Braun, who had worked on the V2 missile program in Germany during World War II, had been relocated to the USA and joined the American missile program. He was mainly concerned with some projects to research adaptation of military missiles for space exploration, however, he also had dreamed of the day when scientists could stay and conduct scientific research in space station for extended periods of time.

Dr. von Braun's earliest concept and design of space laboratory, which might be prototype of Skylab in the future, is portrayed in his book *Space Frontier,* published in 1967, in considerable detail. Above all, he pointed out a significant value of building a laboratory in space: "a space station is the ideal place for research on the effects of a number of conditions impossible to simulate on earth: prolonged weightlessness, space radiation of various types, near-perfect vacuum of unlimited size" [3]. To him, space was the special place that provides unique spatial conditions never acquired on the Earth with scientist unlimitedly.

For making an ideal laboratory for conducting scientific research, he proposed several architectural characteristics to be kept in building; it will be highly desirable to "modularize" the design of the future space laboratory. For example, biological zero-gravity experiments involving small animals such as mice, guinea, and pigs might be accompanied by the unavoidable "zoo smell," so that the bio-laboratory should be kept away from the living quarters. Also, some scientific instruments to need precise measurement such as astronomical observations should be a detachable like "astronomy module." Besides, to relieve orbiting scientists from housekeeping functions such as monitoring the station's temperature controls, space laboratory must be separated by an area of centralized facilities for general service.

For those reasons, space laboratory must be, he suggested, "modularized space station consisting of a number of separate but interconnected laboratories and an area of centralized facilities." Another interesting point is that he considered a space laboratory as a "university campus in orbit," where scientists and postgraduate students of many nations gathered and conduct many different science activities. He insisted that space laboratory satisfying all those conditions will be "multi-storied structures built of modules or 'cans' that can be stacked one on the other," to provide a large space base accommodating as many as 50 or 100 people.

The space laboratory that Dr. von Braun suggested as an ideal place for international cooperation of space scientist conjures up the image of CERN, the European Organization for Nuclear Research, is one of the world's largest and most respected center for scientific research established in 1954. CERN's main function is to provide the particle accelerators and other infrastructure needed for high-energy physics research. Accelerators boost beams of particles with high energies under extreme temperature and pressure, which can never exist in nature on the Earth, collide with each other or with stationary targets. Now 2,600 full-time employees, as well as some 7,931 scientists and engineers from eighty countries are conducting numerous experiments by international collaborations [4].

Dr. von Braun's ideal of space laboratory bears a striking resemblance to the image of CERN in the present. To him, space laboratory is identical with a complex scientific instrument generating extreme physical conditions such as "prolonged weightlessness, space radiation of various types, near-perfect vacuum of unlimited size," which do not exist on the Earth. Moreover, the laboratory having the unique instrument must be an ideal place of scientist from all over the world for international cooperation.

III. A Rocket Acquiring a Name of "LAB"

Could Dr. von Braun's ideal of space laboratory come true through Skylab project in reality? Speaking at the conclusion, it is no. Skylab was not a modularized space station consisting of a number of separate but interconnected laboratories, as well as not an ideal place of scientist from all over the world for international cooperation either. It must be mainly related to technical problem, but I suggest that it be fundamentally because of transitional trait of Skylab as a hybrid of an expedition ship for exploration and a laboratory for experiment. In other words, Skylab project had fundamental limitation to have its identity as a laboratory for scientific object.

The identity of Skylab as a laboratory was not established for a long time as shown the course of naming it. Despite of its name after laboratory, Skylab's original object to conduct scientific experiments in space was not clear. NASA wanted to build space station orbiting around the Earth to keep military leadership after accomplishing Apollo mission to land human on the Moon [5]. The key to the planning revolved around making maximum use of Apollo technology.

This main living quarters of Skylab, the Orbital Workshop (OWS), was a reused Saturn IB second stage rocket of Apollo project. The crews would live and work within the liquid hydrogen tank of the stage while the liquid oxygen (LOX) tank would be used for the storage of refuse. A converted Saturn S-IVB stage whose rocket engine has been removed, provided (in the stage's liquid hydrogen tank) a laboratory/crew quarters facility with as much room as a three-bedroom home [6].

What NASA wanted to build after Apollo might have been called a "space station" or derived name by Apollo: Apollo Extended Apollo (Apollo X) by 1962, Apollo Extension System (AES) by 1965, and Apollo Applications Program (AAP) by 1969. While the identity of Skylab project had strayed, opponents used to call the project "Almost A Programs," or "Apples, Apricots, and Pears" [7]. However, the project brought huge dollar signs to the minds of the nation's political leader at a time when the US was pouring massive expenditures

into the Vietnam War. Finally, in 1970, just three years before the launch of the space station, NASA decided to give it a name of laboratory submitted by an Air Force officer [8]. Nevertheless, Skylab had been described "as a house, a classroom, a hotel, attest tube, and an apartment" [9] rather than laboratory.

The image of Skylab had changed more dramatically when it was about to reenter the Earth in 1979. America's top military and civilian space scientists could not predict even roughly where Skylab would fall. When Skylab fell in the early morning hours of July 12, 1979, it was no longer responding to commands from controllers. It was the ultimate random shot. At first, relieved emergency officials in Canberra and elsewhere announced Skylab had fallen into the Indian Ocean off Australia's west coast. The *Time* magazine covered Skylab's reentry on July 16, 1979, describing it "the fiery fall of the largest machine man has ever hurled into space" [10]. Skylab was not a laboratory at all any longer. It was just nothing more than a totally burned out rocket.

IV. Creating "Scientist-Astronaut"

In the preceding pages, I examined the appearance of a "rocket-modified-laboratory," and in the following pages, I would like to discuss the appearance of "scientist-astronaut." The 1960s was the period of an appreciable development in the nation's technological capabilities for space research: more safe rockets were

being rapidly developed, techniques of space craft also had advanced substantially. With the increasing of people's expectation to possibility of using space, the Space Science Summer Study was conducted under the auspices of the Space Science Board of the National Academy of Sciences at the State University of Iowa during the period June 17 to August 10, 1962.

The study was to examine the national program of basic research in space and its future objectives, and NASA's scientific advisory community fist addressed the role of the astronaut in space science at the study. Concerning the Apollo Project, the study recommended "at least one crew member of each Apollo lunar mission to possess the maximum scientific ability and training consistent with his required contribution to spacecraft operation," and they have designated such a man "scientist-astronaut," fully trained both as a scientist and as an astronaut [11].

Though their aim to maximize the scientific return in space exploration was clear, a precise definition of the role of the scientist in space explorations was not easy to develop. Not only the scientific content of the space program, but also the opinion of recruiting process was treated very differently by the different groups of specialists participating in the Summer Study. For instance, biologists thought that scientists will be "very useful primarily for biological studies" [12], while astronomers believe that "a man is not required to operate an orbiting observatory-that, in fact, his presence would be positively detrimental" [13]. There also was big difference of opinions about the education and training of them; training pilots to experiments or teaching a scientist to fly.

Nevertheless, the report recommended the four types of astronaut as scientist for "Earth-Orbiting Manned laboratories" still in the conceptual stage [14].

1. Scientist-astronaut: men who combine the experience and resourcefulness of trained scientist and trained astronaut
2. Scientist-passenger: experienced, mature scientists with adequate training in critical and emergency space craft operations
3. Ground scientist: leading scientists in pertinent fields who collaborates with space craft personnel in the accomplishment of the scientific mission
4. Astronaut-observers: astronauts with varying degrees of special training in making scientific observation.

It was quite generally rational to make multiple identity of scientists in space mission in that many instances a person, not necessarily a 100 percent scientist or a pilot, could contribute substantially to the reliability effectiveness of a scientific mission through the observing and operating, as well as safety of flying through emergency operations. The most interesting aspect of the classification is that, on examining the role of man from a number of aspects, we can put each

type of scientist-astronauts between researcher and explorer based on the proximity to the expertise of pilot and scientist;

Explorer				**Researcher**
Pilot-astronaut	Astronaut-observer	**Scientist-astronaut**	Scientist-passenger	Ground Scientist

The above diagram says that the closer the left (Explorer), the less required the scientific expertise. On the contrary, the closer to the right (Researcher), the less the required pilot expertise. I suggest that the way to define the role of scientist-astronaut should be fully linked to transition process of space from a "site for exploration" to a "field for science." In the early stage of space exploration only pilot-astronaut were needed as explorer, however, the border between explorer and researcher became vague with the appearance of various astronaut types.

V. Scientist's Value in Space

According to the proposal of the study, NASA selected the fourth group of astronauts, "astronaut group 4" (scientist-astronaut) in 1965 [15]. They might symbolize the coming of a new phase in the spaceflight effort, and were believed to eventually lead to a greater capacity for "science in space" beyond "science of space."

In 1971, Skylab project had been suggested that the crews should consist of one pilot-astronauts, preferably a flight experienced astronaut joined by two scientist-astronauts to maximize the scientific output from these flights. However, the plan was changed into two pilot-astronauts and one scientist-astronaut in case something went wrong. The scientist-astronaut for Skylab project was selected in "Astronaut Group 4" who was the fourth group of astronauts selected in 1965. The six members of Group 4 were required to have doctoral degrees in science, while the astronauts of the previous three groups were required to test pilot backgrounds.

The crews of Skylab 2 project consist of Charles Conrad and Paul J. Weitz who were test pilots, and Joseph P. Kerwin selected in Group 4, who had a Doctor of Medicine degree. Even though their backgrounds were different, they obviously had a great teamwork to conduct their repair mission [16] and science experiment mission. However, interestingly, there was a subtle difference in their attitude and evaluation to the scientific practice in space. Now I examine the Sky-

lab 2 crews' different attitude on "scientific performance in space" shown in the testimony from Skylab astronauts [17].

Conrad and Weitz (pilot-astronauts) put a great value in their scientific performance, while Kerwin (scientist-astronaut) showed a pessimistic view on it. For example, Conrad, the commander of Skylab 2, mentioned that their work in space was "very difficult to accomplish any kind of operation" and required "inventiveness on their own." Weitz also said that he "probably won't be able to from the package of experiments on board Skylab," though he "can apply what he has learned from this flight and approach specific problems." And two pilot-astronauts' perspective on the manned spaceflight and space experiments in the future was optimistic, because they believe and trust the role of scientist in space.

> **Mr. Hechler** [18]: Do you have any recommendations for the next Skylab for future experiments that might link up with possible future applications of solar energy?
>
> **Mr. Conrad**: We need to allow anybody access to it, which means the scientist rather than us having to train to be scientists which we in our fields are not, … And then I look to American ingenuity to supply the payload, whether it be scientists who can do the job faster than we can on the solar physics, or whether it is an unmanned satellite you are putting up to make another communications link or something like that [19].
>
> **Mr. Hechler**: What could you do with your Earth resources survey equipment in Skylab that you could not do with an unmanned Earth resources technology satellite?
>
> **Mr. Weitz**: We can be more selective with our data taking. I think we have shown in the past with unmanned satellites that part of the problem is that you have a continuous data flow… you can be selective and you can pick out specific sites, fields or a bend in the river, if you want to study silting [20].

On the other hand, Kerwin's attitude on their performance as a scientist-astronaut was different. He described their scientific performance in space as a job "to be there" and "have the tools," moreover he replied "a piece of a cake" to a question about any concern about next Skylab mission. Evaluation on space experiments and vision were also somewhat neutral, rather he looked to take Skylab as a new human habitation not a laboratory.

> **Dr. Kerwin**: I do not believe that at this point it is either demonstrably beneficial medically or cost effective. What I would like to work toward is to make space environment available to normal people of reasonable health in all walks of life so that they can do useful things up in space.

Mr. Hechler: Do you have any recommendations for the next Skylab for future experiments that might link up with possible future applications of solar energy?

Dr. Kerwin: We will be up there for a long time. I think you better put a fifty-first star on the flag [21].

The difference of perspective on the scientific performance in Skylab between two groups (accurately speaking, two pilot-astronauts and a scientist-astronaut) shows a transitional trait of Skylab as a hybrid of an expedition ship for exploration and a laboratory for experiment. Kerwin's evaluation on their scientific works in Skylab and perspective on "science in space" might be based on his recognition of the limitation as a scientist before being an astronaut.

Conrad, the commander of Skylab 2, mentioned about the next Skylab for future at the congress hearing: "We need to allow anybody access to it[space], which means the scientist rather than us having to train to be scientists … So I think the next step is to see that the term astronaut will disappear and that we get over into the operational mode that says we develop a space transportation system and that we provide an operational capability to use it" [22]. In reality, the term "scientist-astronaut" was never used again in selection after Group 4 in 1964 and Group 6 in 1967 for seventeen astronauts. In the present, "Mission Specialist" (MS) is used for a position of general scientist working in space, have nothing to do with pilot working by NASA [23]. This implicates that space as a "field of scientist" should be more definite.

VI. Conclusion

Skylab was visited three times by nine crews (three crews for each project) from 1973 to 1974. They had managed to complete ninety major scientific experiments such as solar astronomy, Earth resources experiments, medical studies, and educational experiments. There were 3,036 hours used for experimental performance in solar astronomy and Earth resources experiments, medical studies, and educational experiments.

The Skylab program, as the first scientific mission conducted in space, was successful in aiding the expansion of scientific knowledge, but it also offered the long-range benefit of demonstrating the importance of the continuance of the human component in the American space program [24]. However, the Skylab project was somewhat unsuccessful, because the mission planners in particular seemed unable to learn from the experiences of previous crews; Skylab's experiment program was created operational difficulties, crowded the training schedule, and occasionally led crewmen into errors [25]. I insist that these opposed

evaluations of the Skylab's scientific mission are partly due to the transition traits of space from a "site for exploration" to a "field for science"; in particular, the appearance of a "rocket-modified-laboratory" and the "scientist-astronaut."

Sorrenson (1996) insisted that a ship conducted a voyage of scientific discovery in the eighteenth century was never merely a vehicle, but rather a scientific instrument be operated by skilled observers in the field. In contrary to a ship in eighteenth century, Skylab had an inherent limitation to be a laboratory of purely scientific object, which could lead some operational difficulties in conducting experiments. Skylab, as a rocket-modified-laboratory, could not be a scientific instrument such as CERN, but rather was still an expedition ship for explorer.

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[16] Skylab's meteorite-and-sun shield and one of its solar arrays had torn loose during launch. Baker (2007), p. 30.

[17] Committee on Aeronautical and Space Sciences (1973), *Testimony from Skylab Astronauts,* US Government Printing Office Washington, DC.

[18] He casted some critical questions on the Skylab project during the hearing. When the shuttle program was introduced in 1970, Hechler opposed the project. At the center of the debate was the question of whether manned or unmanned missions were more cost effective and scientifically productive.

[19] *Testimony from Skylab Astronauts,* p. 15.

[20] *Testimony from Skylab Astronauts,* p. 16.

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