SPACE AND ATMOSPHERIC RESEARCH IN UTAH: 1949 TO PRESENT

Paul Concidine

Department of History
Utah State University
Logan, UT 84321

Abstract

Space and atmospheric research have been carried out in Utah since Dr. Leon B. Linford and his team of researchers from the University of Utah participated in the launching of V-2 rockets in 1949. This paper describes the work that has been done since that time and situates it in the broader context of space and military technology. Several specific projects are described, including aurora research, the EXCEED missions, CIRRIS missions, SABER, SPIRIT III, and the RAMOS project. Sources of funding and trends in research are also considered. These patterns demonstrate that military and defense needs have "shaped" space and atmospheric research in Utah.

Introduction

On March 21, 1949 a German built V-2 rocket was launched at New Mexico's White Sands Missile Range by a team of researchers and students from the University of Utah. Though this rocket failed, its launch marked the beginning of an extensive and highly successful program of space and atmospheric research in Utah. Since then, over 400 payloads have been designed by scientists from Utah with a success rate exceeding 93%.[1] Nearly all of these projects have military applications and should therefore be seen in the context of cold war space technology.

Several histories have already been written on space research in the state. Some of the most important of these, including "The University, Electrical Engineering and Space Travel,"[2] "The Upper Air Research Laboratory,"[3] and "V-2 Attempts by Utahns to search outer space"[4] were written by Doran J. Baker. These articles provide information on the use of V-2 rockets by researchers in Utah and the establishment of space research at Utah State University in 1970.

Three publications by the Space Dynamics Lab provide more detailed and recent information about SDL. "An Overview of Space and Atmospheric Research at Space Dynamics Laboratory Utah State University"[5] traces the general history of the Lab and details several specific projects. Photographs, diagrams, and graphs are included as well as brief descriptions of several important experiments. The second article, "An Overview of Space Dynamics Laboratories,"[6] contains precise information on aurora research which had important cold war applications. This publication also describes funding and capabilities of the lab, and lists faculty and students involved there. The third publication by the SDL, "Overview of Space Research: Space Dynamics Laboratory Utah State University,"[7] was prepared in 1989 for General Gary Schnelzer of the Space Defense Initiative Organization. This report offers the most detailed and extensive information on research projects of the SDL, including aurora missions and later projects adopted at the end of the cold war. Charts, diagrams and summaries are also included.

Though these articles provide an important base of information, they do not bring to their subject a clear theoretical approach. One theory, dubbed the "social shaping of technology" by Donald MacKenzie[8] holds that technologies develop within and are influenced in important ways by society. Contrary to "technological determinism," proponents of this view seek to demonstrate the roles politics, gender, racism, economics, and the military play in the development of technologies. One important example of the way the military has influenced technology is provide by Janet Abbate In "Cold War and White Heat: The Origins and Meanings of Packet Switching."[9] In this article she examines ARPANET, the military precursor to the internet, and points out that research and development of ARPANET emerged from a desire to create a communications network capable of surviving a nuclear attack. Since ARPANET was a distributed network with out a real center, no single, well-aimed warhead could destroy it. The larger social context thereby dictated the direction of technological change. Because of the military needs presented by the cold war, atmospheric research and technological developments in Utah have also been "socially shaped."

Between March of 1949 and June of 1951 researchers from the University of Utah launched a total of five V-2 rockets intended for ionospheric research. Unfortunately, four of these rockets failed; moreover, the one that made a successful ascent was unable to provide data due to failure of its onboard UHF reference transmitter.[10] On January 30, 1952 scientists began using United States Air Force Aerobee rockets equipped with upward pulse delay and downward pulse delay (UPD and DPD) sensors to gather *in situ* ionospheric data. The first successful experiment occurred about one year later, on January 26, 1953, when good ascent data was collected.[11] These experiments measured delay in HF pulses transmitted between the rocket and sensors on the ground, and were thereby able to obtain data on ionospheric electron densities.

On November 23, 1958 the first Nike-Cajun rocket (a solid fueled, and therefore less expensive rocket than the Aerobee) was launched by researchers from the Upper Air Research Labs (UARL).[12] These rockets were used almost exclusively for falling sphere experiments, in which an instrumented sphere ejected from the rocket was used to measure drag acceleration in order to determine air densities at various altitudes.

Another area of research the lab undertook at this time involved the use of impedance probes. By measuring changes in the impedance of a rocket-borne antenna as it passed through ionized regions of the atmosphere, scientists were able to make local measurements and ascertain electron densities in the ionosphere. UARL researchers performed Impedance experiments during a variety of perturbed atmospheric conditions, including barium cloud releases, solar eclipses, high altitude nuclear explosions, and aurora phenomena. The first of these experiments took place on April 22, 1959, and impedance probes continued to be an important area of research well into the 1990s.[13]

During *Operation Fishbowl*, a series of nuclear tests conducted by the United States in 1962 at the Johnson Islands in the Pacific Ocean, University of Utah researchers performed both falling sphere and impedance probe experiments in conjunction with nuclear blasts. A total of 19 Nike-Cajun and Honest John-Nike rockets were launched during these tests which collected air and electron density data. These were perhaps the most exotic experiments taken on by the Upper Air Research Lab. In the words of Glenn Allred, the author of several brief histories on space research in Utah, "There are many hair-raising stories to be told about this program."[14] These launches are summarized in table 1.

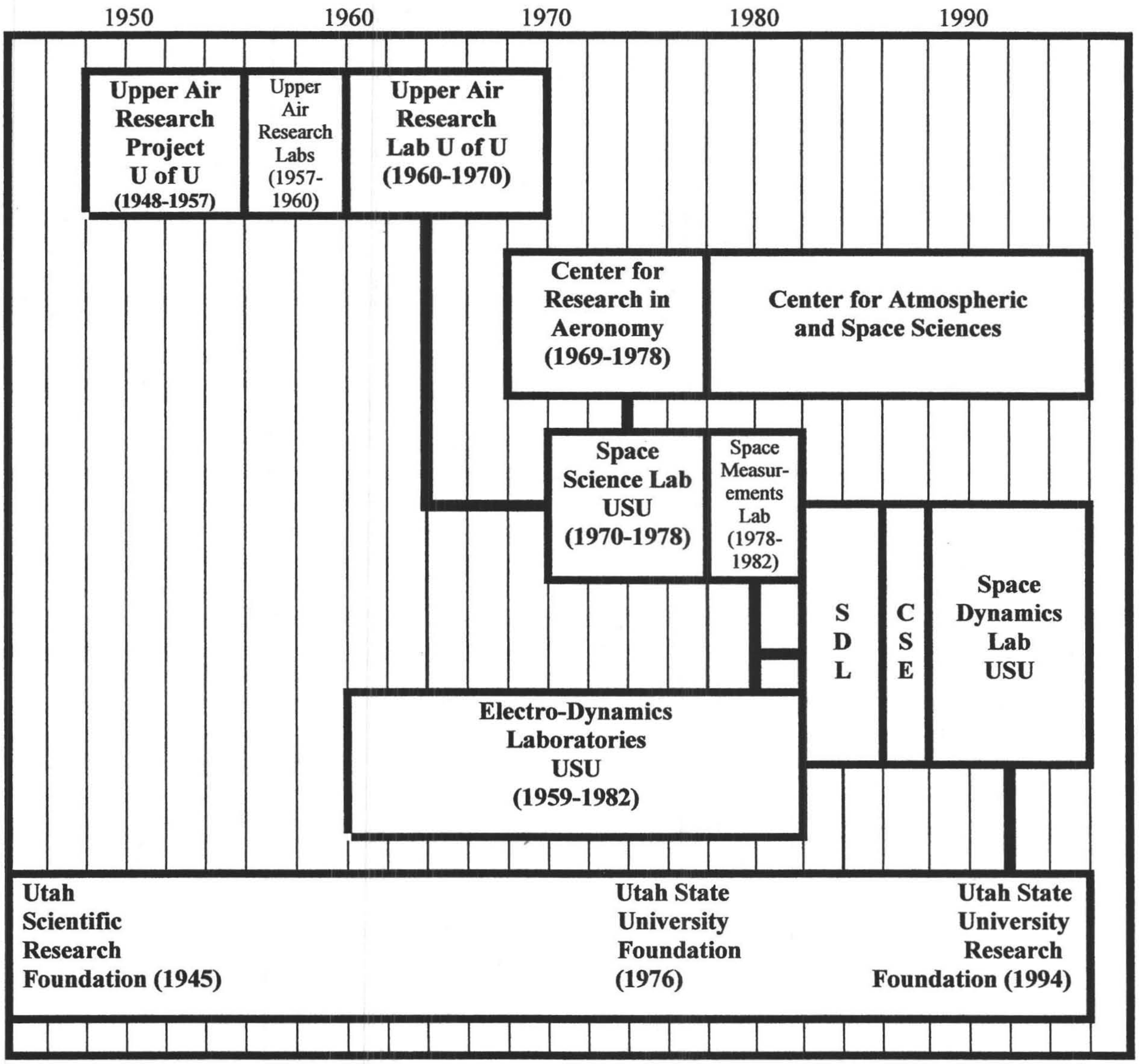
Table 1. Experiments performed during *Operation Fishbowl*[15]

Vehicle Type	Launch Date	Experiment	Data
Nike-C	1 Jun 62	Falling Sphere	Good
Nike-C	19 Jun 62	Falling Sphere	Good
Nike-C	8 Jul 62	Falling Sphere	Good
H. J-N	9 Jul 62	Impedance	No 2nd stage ignition
H. J-N	9 Jul 62	Impedance	Good
Nike-C	19 Jul 62	Falling Sphere	Good
Nike-C	25 Jul 62	Falling Sphere	Good
Nike-C	20 Oct 62	Falling Sphere	Good
H. J-N	25 Oct 62	Impedance	Good
H. J-N	26 Oct 62	Impedance	Good
H. J-N	26 Oct 62	Impedance	Good
Nike-C	26 Oct 62	Falling Sphere	Good
H. J-N	26 Oct 62	Impedance	Good
H. J-N	1 Nov 62	Impedance	Good
H. J-N	1 Nov 62	Impedance	Good
Nike-C	1 Nov 62	Falling Sphere	Good
H. J-N	1 Nov 62	Impedance	Good
H. J-N	1 Nov 62	Impedance	Good
Nike-C	1 Nov 62	Falling Sphere	No 2nd stage ignition

In November of 1961, UARL researchers began to take part in an effort to characterize trails left by Intercontinental Missiles (ICBMs). The first experiment involved the launch of an Atlas D missile at Atlantic Missile Range from which instrument packages were dropped during powered flight. The instruments fell through the missile's trail and collected data on the ionization it produced in the atmosphere. UARL scientists performed experiments of this type for one Titan II and four Atlas D missiles, thereby contributing to the knowledge needed for the design of ballistic missile tracking systems.[16]

Also at this time, researchers from Utah State University's Electro Dynamics Laboratories (EDL), founded in 1959 by Doran J. Baker, became involved in atmospheric research. Instruments developed by this group were used to characterize rocket plume radiance in collaboration with the UARL's Ballistic Missile Trail program. Another project on which these two groups cooperated was a study of spacecraft emissions in the atmosphere. By

Table 2. Organizational History of Space and Atmospheric Research Programs in Utah[17]



characterizing these emissions, aerospace vehicles could be more easily detected and tracked.[18] These experiments took place between 1963 and 1966.

In 1964, UARL researchers began to study aurora displays. Between February of that year and March of 1969 ten payloads were launched from Churchill Research Range (CRR) in Manitoba, Canada.[19] Since aurora produce masking effects detrimental to ballistic missile early warning systems, these studies had clear national defense applications, especially during the cold war. Aurora research would become a major point of emphasis for atmospheric researchers from Utah in the 1970s and 1980s.[20] Also in 1969, UARL scientists conducted an extensive measurements program on the effects on the lower atmosphere of a solar proton event called the Polar Cap Absorption of 1969, or PCA 69.

In 1970, a major event in the organizational history of space research in Utah occurred when the core of the Upper Air Research Lab moved from the University of Utah to Utah State University in Logan. Table 2 shows the organizational history of space research in Utah.

The transfer to Utah State University allowed for increased collaboration between Utah space and atmospheric researchers. Also at this time, the development of miniaturized electronics permitted more experiments to be placed on a single rocket. Poker Flats Research Range in Alaska became the primary site for aurora research, which was the major point of emphasis during the 1970s.[21]

Aurora phenomena result from collisions of electrons and protons from the sun with energized atoms and molecules in the Earth's atmosphere. These interactions cause electromagnetic energy to be released from the atoms and molecules, which we witness as brilliant colors from the visible part of the spectrum.[22] Some of this energy however, including infrared emissions, cannot be seen without the aid of special instruments.

The infrared emissions were of great interest to atmospheric researchers in the 1970s because of their relevance to ballistic missile early warning systems. Since these missiles would have to be detected and tracked against atmospheric backgrounds under many different conditions, scientists sought to model the atmospheric effects of various disturbances, including aurora, airglow, and nuclear explosions. Another reason infrared emissions drew interest at this time was that in the infrared region spectral "windows" exist through which targets can be viewed with little or no atmospheric interference. Aurora research helped to precisely define these windows.[23] Utah researchers developed several instruments to study infrared spectral emissions, including the Field-Widened Interferometer and the Rocketborne Field-Widened Interferometer.

Until 1976, nearly all atmospheric research projects taken on by Utah scientists were funded by the Air Force Cambridge Research Laboratory (AFCRL). At this time, however, other sources, such as NASA and the Defense Nuclear Agency (DNA) began to fund research projects as well. One of the most important experiments taken on at this time was the EXCEED project, in which high powered electron guns were used to create aurora which were subsequently recorded and measured by rocketborne instruments. Since these aurora events were artificially created, they could be accurately defined and assessed.[24] This project continued until 1990, when the highly successful EXCEED III was launched. All 35 instruments on this experiment performed as designed.[25]

Also of great importance in the 1980s was the CIRRIS project, which was funded by NASA and the Department of Defense (DoD). These cryogenically cooled experiments were to be carried into orbit by Space Shuttles, from which they would measure earth limb infrared emissions. Unfortunately, the CIRRIS 1 project of 1982 experienced technical problems and was not able to collect any data. CIRRIS 1a, on the other hand, was extremely successful. Launched in April of 1991 on the *Discovery* Shuttle after several years of delay caused by the explosion of the Challenger in 1986, it arrived in orbit in conjunction with a massive aurora event and was able to collect excellent data.[26]

The Space Dynamics Lab became a leader at this time in Cryogenic systems development. Since instruments measuring infrared emissions must be kept extremely cold to avoid contaminating their own field of view, cryogenics became an area of great importance to SDL researchers.[27] The first of these systems relied on liquid helium or other elements to keep the instruments cold, and therefore had life spans of only a few days or weeks; though the instruments would continue to function properly, no data could be collected because all of the coolant had boiled off. SDL's SABER experiment, which was the main sensor on NASA's TIMED satellite of 2001, employed a mechanical cooling system that was able to keep instruments cool for much longer, eliminating a major obstacle to infrared projects.[28]

The 1990s saw both the continuation of infrared emissions studies and expansion into new types of space research. SPIRIT III, the largest and one of the most successful projects in SDL history, was the primary instrument aboard NASA's Midcourse Space Experiment (MSX) satellite launched in April of 1996. Designed to gather infrared data of relevance to the development of future space defense systems, SPIRIT III collected a great deal of information before its coolant ran out on February 26, 1997. This project was funded by the Ballistic Missile Defense Organization (BMDO).[29]

SDL researchers took on several other interesting projects in the 1990s, some of which were carried out in conjunction with Russian scientists. In one of these programs, plant growth chambers were placed on the Russian Mir orbiting spacecraft in an effort to understand plant growth in space.[30] Also initiated in this decade, the Russian American Observation Satellites (RAMOS) experiment involved the use of two satellites with imaging instrumentation capable of taking stereo-optical measurements in both visual and infrared regions. These satellites were designed to perform the dual tasks of environmental monitoring and data collection for future missile defense systems.[31] Despite some language and diplomatic barriers, the RAMOS project is an ongoing effort and still of great importance at SDL today.

As stated at the beginning of this paper, researchers in Utah have developed and conducted over 400 space and atmospheric experiments since 1949; I have here been able to touch on only a few of the more outstanding examples of these. At present SDL is not only a growing and highly successful institution, it is also a framework which allows us to understand technological development in important ways. Well into the 1980s, space and atmospheric research in Utah were dominated by the needs of national defense created by the cold war. Both research funding and experimental objectives reflect this influence. In the time since the end of that conflict, SDL researchers have expanded the programs and capabilities of their institution in many ways. While some projects still have defense applications, programs with relevance to the environment, education, and even a possible expedition to Mars have also become common.[32] Finally, SDL now receives some of its funding from commercial contractors, such as Morton-Thiokol and Boeing. This shift occurred in the context of world events, and by understanding how these events "shaped" space and atmospheric technology in Utah, we are better able to understand the crucial influence society has on technology.

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[1] Space Dynamics Laboratory, *Company Information* [Company Website]; available from http://www.sdl.usu.edu/comp-info/index; Internet; accessed 15 April 2003.

[2] Doran J. Baker, "The University, Electrical Engineering and Space Travel" (Faculty Honor Lecture, March 1979), Special Collections, Merrill Library, Utah State University, Utah.

[3] Doran J. Baker, "The Upper Air Research Laboratory: University of Utah 1948-1970" (Collegium held at Space Dynamics Laboratory Research and Technology Park, August 25, 1995), Special Collections, Merrill Library, Utah State University, Utah.

[4] Doran J. Baker, "V-2 Attempts by Utahns to Search Outer Space" (Keynote address delivered at the 7th banquet, Utah State University, April 1999), Special Collections, Merrill Library, Utah State University, Utah.

[5] Utah State University, "An Overview of Space and Atmospheric Research at Space Dynamics Lab USU" (unpublished paper produced by the SDL describing research, 1989), Special Collections, Merrill Library, Utah State University, Utah.

[6] Utah State University and Space Dynamics Laboratory, "An Overview of Space Dynamics Laboratories" (unpublished paper produced by SDL describing lab capabilities, 1985), Special Collections, Merrill Library, Utah State University, Utah.

[7] Utah State University, "Overview of Space Research, Space Dynamics Laboratory, Utah State University" (unpublished paper produced by SDL for General Gary Schnelzer of the Space Defense Initiative Organization, 1989), Special Collections, Merrill Library, Utah State University, Utah.

[8] Donald MacKenzie and Judy Wajcman, eds., *The Social Shaping of Technology,* 2d ed. (Buckingham: Open University Press, 1999).

[9] Janet Abbatte, "Cold War and White Heat: the Origins and Meanings of Packet Switching," in *The Social Shaping of Technology*, 2nd ed. (Buckingham: Open University Press, 1999).

[10] Baker, "Upper Air Research Laboratory," 6.

[11] Glenn D. Allred, "Vehicle Launch Summary" (unpublished manuscript given to the author by Glenn Allred in April, 2003).

[12] Ibid.

[13] Baker, "Upper Air Research Laboratory," 14-15.

[14] Glenn D. Allred, "The Route to Here" (oral presentation given at the dedication of the RP5 facilities, Logan, Utah, November 15, 2002).

[15] Allred, "Vehicle Launch Summary."

[16] Baker, "Upper Air Research Laboratory," 15.

[17] Ibid., 18.

[18] Ibid., 16.

[19] Allred, "Vehicle Launch Summary."

[20] Utah State University and Space Dynamics Laboratory, "An Overview of Space Dynamics Laboratories," 3.

[21] Allred, "Route to Here."

[22] William L. Masterton and Cecile Nespral Hurley, *Chemistry: Principles and Reactions,* 2nd ed. (Philadelphia: Saunders College Publishing, 1997), 167.

[23] Utah State University and Space Dynamics Laboratory, "CIRRIS 1a: Description and Capabilities" (an unpublished manuscript written by SDL describing the CIRRIS 1a mission, 1984), Special Collections, Merrill Library, Utah State University, Utah, 1.

[24] Allred, "Route to Here."

[25] Allred, "Vehicle Launch Summary."

[26] Glenn Allred, Interview by author, tape recording, Smithfield, UT, 7 March , 2003.

[27] Utah State University, "Overview of Space Research," 4.

[28] Glenn Allred, Interview by author.

[29] Allred, "Vehicle launch Summary."

[30] Allred, "Route to Here."

[31] Brent Bartschi, David Burt, and Glen Wada, "Russian American Observation Satellites (RAMOS)" (paper presented at the 1st Annual International Small Satellite Conference and Exhibition, Korolyov, Moscow Region, 16-20 November, 1998); available from http://www.sdl.usu.edu/programs/ramos/; Internet; accessed 15 March, 2003.

[32] One program in particular, the "Mars Micromission," may involve the development and flight of a propeller driven airplane through the Martian atmosphere. Space Dynamics Laboratory, *Mars Micromission* [Company Website]; available from http://www.sdl.usu.edu/programs/mars-micro/; Internet; accessed 15 April 2003.