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A Brief History of Space Flight with a Comprehensive Compendium of Vestibular and Sensorimotor Research Conducted Across the Various Flight Programs

M.F. Reschke
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May 2007

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1.0 INTRODUCTION

An unknown historian for the National Aviation and Space Administration (NASA) has been quoted as saying, "History is more than what happened and when. It is many stories told as one story, within the narrative of an age." While the intent of this particular historian is not available to us today, his words clearly describe the progression of NASA from its beginning to the present. Pieces of NASA's history are, however, missing. A student studying the history of space travel will find descriptions of the early pioneers who helped establish NASA and the Soviet space agencies. Serious students will find libraries devoted to the bureaucracy of flight, written by the managers and project engineers. They will find books describing the engineering of rockets and spacecraft required to take us from the Earth to the boundaries of space and beyond. Whole museums have been established charting our course from man's first powered flight to the technological marvel of the International Space Station (ISS). What the students will not find is a comprehensive history of the role that life sciences played in our quest for space flight.

Clearly, this short report cannot serve as a comprehensive review of the history of life sciences. It will, however, provide a brief history of space flight, serve as a valuable resource for neurovestibular and sensorimotor space flight experiments conducted by all countries through 2005 (Appendix A), and finally, it will provide a comprehensive set of space flight physiology references with an emphasis on sensorimotor documents (Appendix B). Therefore, the intent and purpose of this historical overview of neuroscience and space flight is two-fold: First to equip researchers with a single, common reference document, and second, to allow those who helped create this history, a record of accomplishment.

2.0 FLIGHT PROGRAMS

To date, astronauts from more than 30 different countries have flown in space and countless more have participated in some capacity with space research. However, only three countries, the United States, Russia and China, possess the means to launch humans into orbit. Figure 1 is a summary timeline showing the manned and unmanned space flights conducted by each country's space program. The timeline begins with the launch of Sputnik-1 on October 4, 1957, marking the beginning of a rich history of unique scientific and technological achievements in human space flight that has spanned more than 40 years.

2.1 The Soviet and Russian Human Space Program

The Soviet Union initiated the age of space with the launch of Sputnik-1 in October of 1957, and quickly followed this remarkable achievement by launching a dog named Laika aboard Sputnik-2.

Sergei Pavlovitch Korolev (1906-1966), Russian spacecraft designer and headed the Vostok and Voskhod projects, as well as the early Zond and Cosmos series.

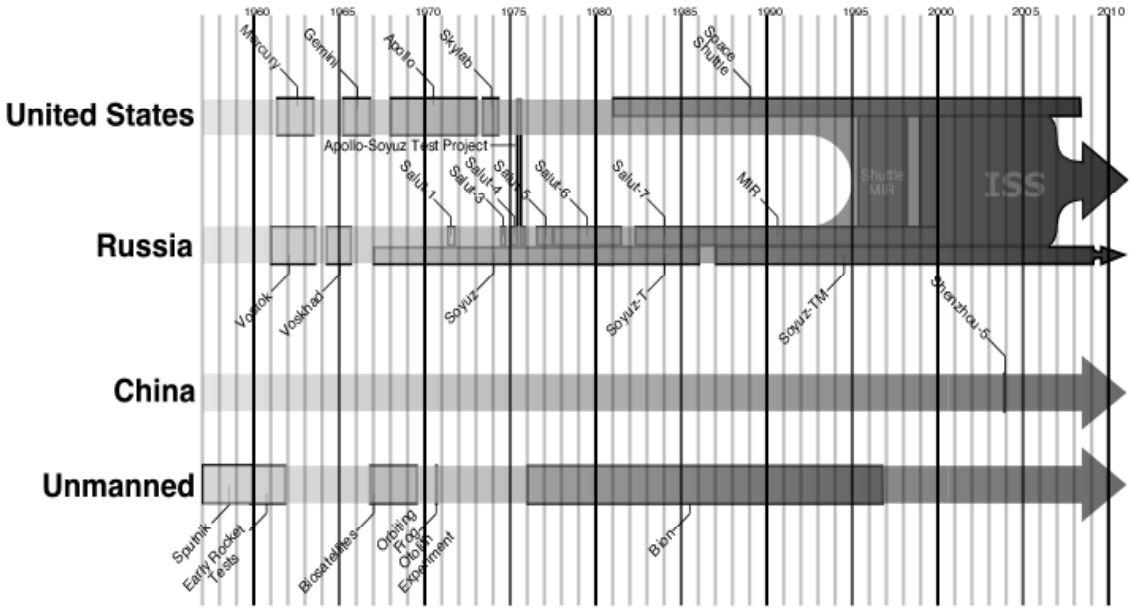

Figure 1: Timeline of spaceflight programs

The ***Sputnik*** (1957-1960) program was followed by the ***Vostok*** (1961-1963) Program, which after several suborbital and orbital flights, launched the first human, Yuri A. Gagarin, into Earth orbit aboard Vostok-1 on April 12, 1961. Vostok was followed by the ***Voskhod*** (1964-1965) flights, an interim program designed to prepare for the more mature ***Soyuz*** (1967-present) flights. The early Soyuz flights were designed more with the aspirations of circumlunar and moon landings, but were quickly adapted to support the Soviet Union's space station programs. ***Almaz***, was the Soviet's first station program scheduled for use in Earth orbit, and was intended more for military reconnaissance than research. When it became clear that the intended Proton launch vehicle could not be man-rated, it was decided to use the Soyuz spacecraft as a crew transport vehicle. The modified space station was called ***Salyut*** *(1971-1986)*. Subsequent Almaz stations were also called Salyut in an attempt to conceal the existence of two separate space station programs. Salyut-1 was launched on April 19, 1971, and became a major step in developing a platform that would help establish a continued human presence in space. Salyut-7 was followed by the ***Mir*** (1986-2001) space station, February 19, 1986. Mir was never a static platform, but continued to evolve throughout its life span as a true permanently inhabited space station. Before the Mir station was forced into the Earth's atmosphere, its inhabitants watched the dissolution of the Soviet Union, the formation of the new Russian Republic, and the establishment of cooperative agreements between Russia and the United States, allowing U.S. astronauts to serve as crewmembers along side Russian cosmonauts. The ***Shuttle-Mir*** (1994-1998) and ***NASA-Mir*** (1995-1998) programs represented the final scientific endeavors aboard Mir, and paved the way for future cooperation aboard the ***International Space Station*** *(1998-present)*.

2.2 The United States Human Space Program

The Beginning

Before NASA was formed, the National Advisory Committee for Aeronautics (NACA) was started by President Woodrow Wilson to supervise and direct the scientific study of the problems of flight. The NACA determined which problems should be experimentally worked on and discussed their solutions and their application to practical questions. The NACA also directed and conducted research and experiments in aeronautics. NASA became operational on October 1, 1958 -- one year after the Soviets launched Sputnik 1, the world's first artificial satellite.

NASA was created on October 1, 1958, in response to the Soviet Union's launch of Sputnik-1, and charged by the President of the United States, Dwight Eisenhower, with launching a person into space in an environment that would allow effective performance, and to recover that person safely. Project ***Mercury*** (1958-1963) was the result of that charge initiated by Eisenhower. All together there were two sub-orbital and four orbital missions, the longest lasted for 22 orbits of the Earth.

Planning for the ***Gemini*** (1961-1966) program began in May of 1961, even before the first Mercury flight was complete. One of the primary purposes of the Gemini flights was to demonstrate the feasibility of "long duration" space flight. There were a total of 12 Gemini flights, all leading toward the singular idea of putting a man on the Moon and returning him safely home. With this goal in mind, the Apollo program was singular and straight forward. The previous Mercury and Gemini programs identified no medical or physiological problems that would prevent missions with durations of two weeks or longer. Never-the-less, ***Apollo*** (1967-1972) was supported by NASA's largest biomedical effort to date, and for the first time a number of significant biomedical findings were identified. These included vestibular disturbances, lower than expected food consumption (most likely attributable to the presence of vestibular disturbances), dehydration and weight loss, decreased postflight orthostatic tolerance, decreased exercise tolerance, recording of postflight cardiac arrhythmias, and a decreased red cell mass and plasma volume. [1]

Unlike the Soviet program where Titov experienced motion sickness aboard Vostok 2, no United States astronaut had experienced (or perhaps reported) this malady prior to the Apollo flights. NASA's ***Skylab*** (1973-1974) program represented a complete departure in direction. It offered

Ingesting Food In Microgravity

It is interesting to note that the success of the animal space flights was not as reassuring as it sounded. Many individuals were still concerned about the ability of man to perform in a weightless environment. One concern was the effect that microgravity may have on the ability of astronauts to eat, swallow and process food during flight. Out of the vast folklore surrounding the time just prior to launching humans into space was the story told by Don Griggs. Mr. Griggs was the test director for the Air Force, and later NASA's parabolic flight programs. NASA scientists (almost always an unknown group of scientists in NASA's folklore, but the stories probably stem from a series of weightless experiments performed in 1958 by Gerathewohl) were to test an individual's ability to ingest food from the early prototype of food in a toothpaste tube during the microgravity portion of parabolic flight. When the flight, made in a military fighter jet at Wright-Patterson Air Force Base, landed the backseat subject with the tube of food had not been able to accomplish the task. The "scientists" thinking that they may have discovered a problem with eating in microgravity, were concerned until they learned that the subject had been so enthralled by the experience of weight-essness, that he had simply forgotten to eat the food. [2] [3]

the Unites States the first opportunity to explore the problems of habitability and biology associated with exposure to microgravity over extended periods of time. Skylab was comprised of four separate flights. Skylab I placed the orbiting laboratory into space (comprised of the S-IVB stage of a Saturn V booster rocket), and was equipped to house three astronauts for an uninterrupted period of at least three months. Skylab flights 2, 3 and 4 kept crews aloft for 28, 59 and 84 days, respectively. The extended duration of these flights meant that scientists could study and evaluate physiological responses, including long term adaptation, to microgravity. A secondary feature of Skylab was the volume of the orbital workshop. For the first time, astronauts were free to move about unlike any time before. This freedom of movement was instrumental in attaining adaptation levels that were well established. Skylab was also the first flight that provided for a complex set of vestibular experiments to be flown.[4]

After a lengthy hiatus, NASA participated in the ***Apollo-Soyuz Test Project*** (ASTP, 1975). Unlike other flights, ASTP was a joint program between the United States and the Soviet Union, whose objectives were primarily political. For the record, ASTP was to test systems for rendezvous and docking that might be useful should the need for an international space rescue ever be needed. Due to a misconfigured valve during reentry, most of ASTP postflight science was lost. During descent of the Apollo command module, after nine days in orbit, the United States crew was exposed to toxic gases (nitrogen tetroxide) that entered the command module through a cabin pressure relief valve that had mistakenly been left open in the landing preparation sequence during an inadvertent firing of the reaction control system. This incident is notable only because it was direct evidence of potential effects of space flight on neurological function.

ASTP was followed by the ***Space Shuttle*** (1981-present) Program. The first launch of the shuttle occurred on April 12, 1981, and was uniquely different than previous programs for several reasons: (1) it employed a reusable orbiter, (2) reentry required the crew to pilot the craft to an unpowered landing, (3) the shuttle was the first U.S. spacecraft having a standard sea-level atmospheric pressure and gas mixture (Mercury, Gemini and Apollo operated at 0.33 atm with 100% oxygen. Skylab also operated at 0.33 atm with 70% oxygen and 30% nitrogen), and (4) the shuttle provided the ability to fly dedicated Spacelab modules where significant science investigations could be conducted in microgravity, opening opportunities for investigators around the world to participate in the United States' space flight program. The space shuttle has been instrumental in NASA's transition to the ***International Space Station***. In its infancy, the ISS is a natural progression from the Russian Mir to a platform, that once completed, will host the nations of the world in living and working aboard the most complex structure ever assembled on orbit.

2.3 Additional Human Space Programs

While the United States and Russia have dominated space flight, there have been multiple nations from around the world who have participated in various human flight programs primarily through cooperative agreements with either the U.S. or Russia. Specifically, the ***European Space Agency*** (ESA), founded in 1975, has been a major contributor to space based research. ESA has participated in multiple flights including Spacelab missions 1, 2, and 3, Deutsch-1, Spacelab Life Sciences-1, the International Microgravity Lab-1 and the Japanese Spacelab-J. In addition to those projects

sponsored by ESA, individual ESA member states have maintained space flight programs specific to their country. In particular France, Germany, the United Kingdom, Austria and others have partnered with both the U.S. and Russian flights to fly complex life science experiments. The ***Japanese National Space Development Agency*** (NASDA), like ESA, has maintained an active flight program, and has undertaken the development of a multipurpose laboratory to operate in conjunction with the ISS. The ***Canadian Space Agency*** (CSA), established in 1989, has been an active participant in all of the major flight programs, and has developed unique hardware for flight. In addition The CSA, ESA and NASDA have selected and flown astronauts during the shuttle flight phase. ***China*** is new to the space age. The Chinese have developed serious launch capabilities and have placed taikonauts into orbit, and have plans to develop and build a space station of their own.

3.0 SPACE FLIGHT: AN ENGINEERING AND SCIENTIFIC MARVEL

On March 16, 1926, Dr. Robert H. Goddard successfully launched the first liquid fueled rocket. The launch took place at Auburn, Massachusetts, and is regarded by flight historians to be as significant as the Wright Brothers flight at Kitty Hawk.

Whether the dawn of space flight began with primitive man gazing upon the heavens or with the fatal flight of Icarus, we know that modern man predicted our escape from Earth's atmosphere as early as 1911 when Tsiolkovsky noted in a letter to a friend that "Humanity will not remain on the Earth forever, but in the pursuit of light and space will at first timidly penetrate beyond the limits of the atmosphere, and then will conquer all the space around the Sun." [5] From mythology represented by Daedalus and Icarus, the physics of Archimedes, Newton, Galileo, and Copernicus, the foresight of DaVinci, Jules Verne and H.G. Wells, to the realization of space flight by Tsiolkovsky, Oberth, Von Braun, Korolev, Yuri Gagarin and Neil Armstrong; the history of modern space travel with its effect on sensory function began in the fifth decade of the twentieth century.

Sam, the Rhesus monkey, after his ride in the Little Joe-2 (LJ-2) spacecraft. A U.S. Navy destroyer safely recovered Sam after he experienced three minutes of weightlessness during the flight.

Those familiar with the initial plans to rocket humans into space will recall that flight surgeons expressed concern that the body organs depended on sustained gravity and would not function in a reduced gravity environment. Others worried over the combined effects of acceleration, weightlessness, and the heavy deceleration during atmospheric entry. Still other experts as early as 1950 were concerned especially about perception and vestibular function. Heinz Haber and Otto Gauer speculated that the brain receives signals on the position, direction, and support of the body from four mechanisms: pressure on the nerves and organs, muscle, posture, and the vestibular organs. Modification of any one of these

inputs, they theorized, would disrupt normal functioning of the autonomic nervous system with the ultimate inability to act (1950). [6] Fortunately the human nervous system has proven to be enormously plastic. Clearly, man can adapt to the forces associated with space flight, however, the microgravity environment of space flight does have an impact on the human physiology, and we have recently entered an era where countermeasures must be developed that will not only allow crewmembers to live in space for prolonged periods of time, but also prepare those same crewmembers to encounter the gravitational fields of the Earth and other worlds following flight. It is interesting to note that soon after NASA began flying humans in space, a series of special symposiums were initiated to address the problems that flight had on astronaut's orientation systems. Addressing the members of the first symposium in 1965 on The Role Of The Vestibular Organs In The Exploration Of Space, Dr. Walton Jones noted in his opening remarks that,

> …the disturbing symptoms experienced in weightlessness require much detailed study….Most experts, I believe are convinced that we will solve these problems; but, we will not be absolutely sure until we have conducted some experiments in orbit under the weightless condition for considerable time.[7]

More than 40 years later, we are still addressing many of the original problems. While it might appear that what we have learned from the past helps us transition smoothly in the resolution of problems; that progression is at best an illusion. Scientific discovery does not progress linearly, but is born out of revolution. Old paradigms are attacked by the formation of new scientific communities that advance new paradigms. Perhaps we are awaiting a new research community to challenge the old paradigms and initiate a much needed revolution.

First Indication Of Self-Motion While On-Orbit?

As Glenn prepared his periscope for viewing his first sunrise in orbit he saw literally thousands of "little specks, brilliant specks, floating around outside the capsule." Glenn's first impression was that the spacecraft was tumbling or that he was looking into a star field, but a quick hard look out of the capsule window corrected this momentary illusion. He definitely thought the luminescent "fireflies," as he dubbed the specks, were streaming past his spacecraft from ahead. They seemed to flow leisurely but not to be originating from any part of the capsule. As Friendship 7 sped over the Pacific expanse into brighter sunlight, the "fireflies" disappeared. [8]

The initiation of manned space flight and the apparent rational movement from one flight program to the next is perhaps an example of the illusion that science and engineering progress in a linear fashion. When it became clear that space travel would become a reality, most believed that we would leave the Earth for space by progressing on logical building blocks. That is, first we would send animals up in rockets before exposing human beings to the feared rigors of space flight. In 1957, the soviet's launched the first man made satellite (Sputnik-1) into low Earth orbit. Later that same year, Sputnik-2 was launched carrying a dog named Laika, the first living creature to be boasted into space. Sputnik-2 was followed two years later with the suborbital launch of one Rhesus and one squirrel monkey in the nose cone of a U.S. ballistic missile. The monkeys survived 38 g and 9 min of microgravity. Although both monkeys survived the landing, one died later under anesthesia during the removal of implanted electrodes.

Between 1959 and 1961 three other U.S. monkeys made successful suborbital flights in Mercury capsules. In 1961, the Chimpanzee, Ham, made the first 3 orbit flight in a Mercury-Redstone capsule on January 31, 1961. Prior to human flight, 12 other dogs, many mice, rats and a variety of plants were sent into space for longer and longer periods of time.

Biometric data collected from this menagerie suggested that there were no adverse effects attributable to orbital flight, and on the basis of these results, it was concluded that the physical and mental demands that humans would encounter during space flight would not be a problem. The next steps were obvious. First, a human would be sent into space as a passenger in a capsule (Programs Vostok and Mercury). Second, the launch capabilities would increase to include two astronauts, and these crewmembers would be given some control over the capsule (Programs Soyuz and Gemini). Third, a reusable space vehicle would be developed to take humans into space and return them (Program Space Shuttle). Fourth, a permanent space station would be constructed in low Earth orbit using the reusable vehicle as a transportation system (Programs Mir and ISS). Finally, lunar and interplanetary flights could be launched from the station using lower thrust space vehicles. Of course this is not how we have progressed. Scientific, engineering and political revolutions have taken us off course.

By the time of the last Mercury flight in May 1963, the focus of the U.S. space program had already shifted. President John F. Kennedy had announced the goal of reaching the Moon only three weeks after Shepard's relatively simple 15-minute suborbital flight, and by 1963, only 500 of the 2,500 people working at NASA's Manned Spacecraft Center were still working on Mercury-the remainder were already busy on Gemini and Apollo.

4.0 THE STRUGGLE OF LIFE SCIENCES FOR RECOGNITION WITHIN NASA

It is now acknowledged that the first space flights had little or few impacts on the human sensorimotor systems, and although there may have been hints that spatial orientation systems were somewhat different in microgravity, NASA's management had little interest in the life sciences. In a well-written publication on the early history of NASA, Homer Newell explores the space administration's view of space biology. [9] He writes that life sciences were something of an enigma to the highest levels of management within NASA. Maybe this was because no one in the upper levels of management had training in the life sciences, but Newell believes that there was more to it than that. His thesis was that you could sense in the life science community within the U.S. a fascination with the novelty of space flight, but that there was a real skepticism within the community regarding the application of space flight to the discipline of life sciences. Interestingly, little has really changed over the years.

Apollo 7 astronauts breakfast with NASA officials. Walter Cunningham, second from left; Donn F. Eisele, second from left across table and Walter M. Schirra, Jr., next to Eisele. Kenneth Kleinknecht, Manager, Apollo Spacecraft Office. Courtesy of NASA

NASA's philosophy concerning the life sciences was and remains simple: where science was the objective, make the most of space techniques to advance the disciplines; in other areas do only what was essential to meet the need. According to Newell, a natural outcome of this philosophy was to disperse the different life science activities throughout the agency, placing each in the organizational entity it served. Even when life science administration was concentrated at NASA headquarters in Washington, little was done to modify this underlying practice. [9]

The Gender Question

There is little doubt that the Soviet Union scored a number of firsts in the race to space. They began the race with the launch of Sputnik in October of 1957, they placed the first human into space (Gagarin), they were the first to orbit the Earth (Gagarin), they performed the first extra vehicular activity (EVA) in orbit (Leonov), and the Soviet Union flew the first woman, Valentina Tereshkova aboard Vostok 6, in space. Sally Ride did not fly, as the first U.S. woman in space until 20 years after Tereshkova flew for the Soviet Union, despite the fact that nearly three years prior to the Tereshkova flight, NASA had tested, and for the most part, approved up to 13 women for space flight through a privately funded Lovelace Air Force project. The bid of these women failed before a special subcommittee of the House Committee on Science and Astronautics with the testimony of NASA representatives George Low and Astronauts John Glenn and Scott Carpenter who stated that the women could not qualify as astronaut candidates. NASA required all astronauts to be graduates of military jet test piloting programs and have engineering degrees. In 1962, no women could meet these requirements.

Throughout the Apollo and Skylab flights, space medicine and the labs associated with the clinical aspects made great strides. [4] Although space medicine, which in the NASA make-up formed a part of manned space flight organization, achieved extensive results, space biology and exobiology produced only modest returns during the 1960s. This is not a complete negative. There are many who view NASA's life sciences as an operational program. "Pure" biological research can be funded by other federal agencies. This philosophy is as appropriate today as it was in 1960.

Regardless of its history, the discipline of life science within NASA remains a stepchild with little hope of improving in the next several years. It is interesting to note that Newell entitled his chapter, within his book on the early years of space science, on life science as having "No Place In The Sun". [9]

5.0 SPACE FLIGHT TIMELINES AND BREADTH OF INVESTIGATIONS

The history of manned space flight spans more than 40 years, beginning with the landmark flight of Yuri Gagarin on April 12,1961, on Vostok 1. It is evident from the timeline (Figure 1) that there is very little down-time when space flight activity did not occur. In fact, activity increased as space flight matured, and since Nov. 2000, there has been a continuous human presence in space on the ISS. It is believed that this trend of continuous human presence in space will progressively persist, as the duration of astronaut time in orbit or in transition between planets and moons becomes common place.

Apollo 17 panoramic view taken at Taurus-Littrow "Station 5". Courtesy of NASA

So how much time have humans spent orbiting the Earth? To get an accurate

count, the time must be calculated as man-hours since, at times, there are multiple astronauts flying on the same mission. Up through the end of April 2005 (through the ISS Expedition-10 flight), 964 humans (437 not including re-flights) have collectively spent an astounding 670,759.62 cumulative man-hours, or 76.57 man-years in space (Figure 2). It is interesting to note that although the U.S. has launched the most manned vehicles into space (144 for the U.S. as opposed to 99 for the Russians) and sent the most humans into space (731 for the U.S. as opposed to 232 for the Russians), the Russians have spent roughly 42% more time in space than the U.S. (Figure 3). This is because the majority of the Russian flights were long-duration flights to orbiting laboratories such as the Salyut and Mir space stations, while the majority of U.S. flights were short-duration shuttle missions.

Astronaut Deke Slayton discusses the upcoming Mercury Atlas-9 mission with Flight Director Chris Kraft in the Mercury Control Center. Courtesy of NASA

Figure 4 is a frequency distribution of flight durations. It shows that the average flight duration is about 29 days and the median flight duration is 10 days, meaning that the majority of life science experiments have been performed on crewmembers on short duration missions. There are only 43 crewmembers with flight durations of 6 months or greater, and of those, only four have flight durations of one year or greater. It is difficult to make conclusions about the effects of long duration space flight with data from only a handful of subjects, especially when different hardware and protocols were used to collect the data, and the fact that 35 of the 43 long duration subjects were from Russia, of which we have mostly anecdotal data. The ISS is currently the only platform available for performing long-duration human physiological experiments. These 3 to 4 month long ISS flights may not be adequate length for testing the effects of long-duration space flight when, with our current rocket technology, it would take over eight months to reach Mars. [10]

From our research, we have found that a total of 2,258 human, animal, and non-human life sciences experiments have been conducted on orbit and pre- and postflight by all countries, excluding Russia, through Expedition 10 (Figure 5). We did not include Russia in this total due to our unsuccessful attempts at locating experimental records at the time the metrics were calculated. The only records located were those performed during joint ventures between Russia and other countries, such as the Shuttle/Mir, Euro/Mir and ISS programs. From these joint ventures, Russia has conducted about 175 life science experiments from the periods of 1961 – 1989 and 2002 – 2005. We realize that these numbers fall short of an accurate representation of the totals achieved by our Soviet and Russian counterparts. One further point needs to be made. It is important to realize that although many reliable sources were used to compile the life sciences database presented in this paper, these numbers are not exact since we have no way to verify the information in these sources, but they do give us a good estimate to help illustrate the point.

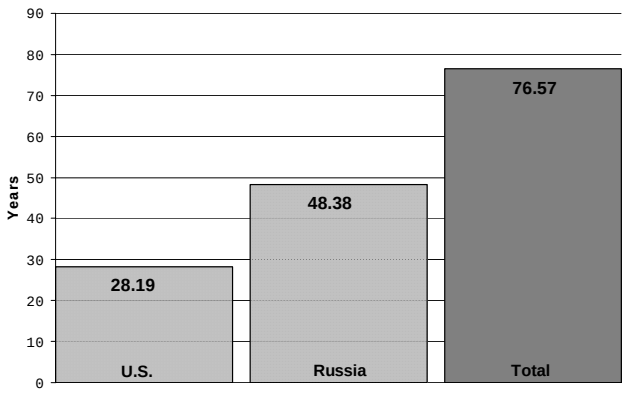

Figure 2: Man years spent in space through Expedition 10 (April 2005)

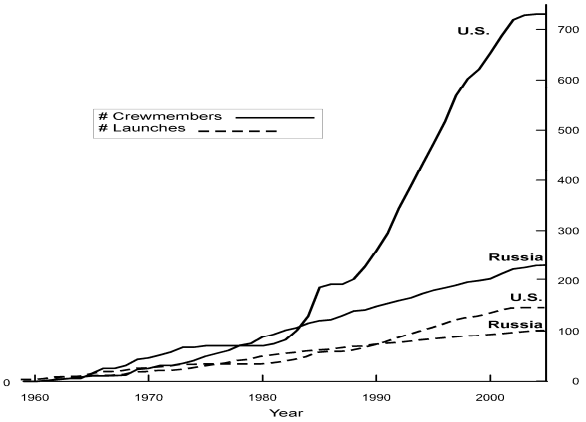

Figure 3: Cumulative number of astronauts and cosmonauts and cumulative number of manned launches for the United States and Russia

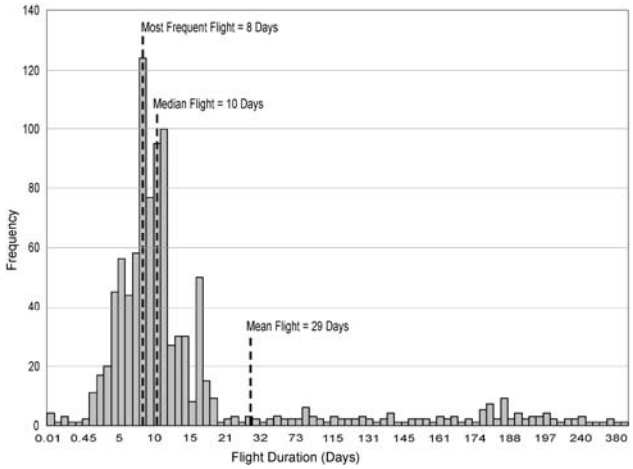

Figure 4: Flight frequency

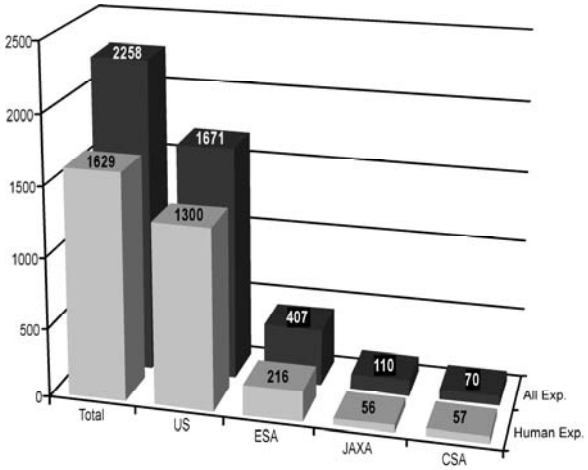

Figure 5: Number of all life sciences spaceflight experiments (human and animal) versus human life sciences spaceflight experiments

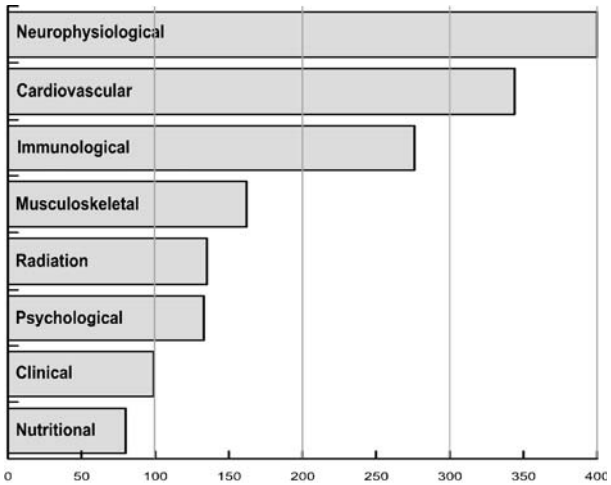

Figure 6: Total number of human physiological experiments performed by all countries (except Russia) up through Expedition 10 (April 2005)

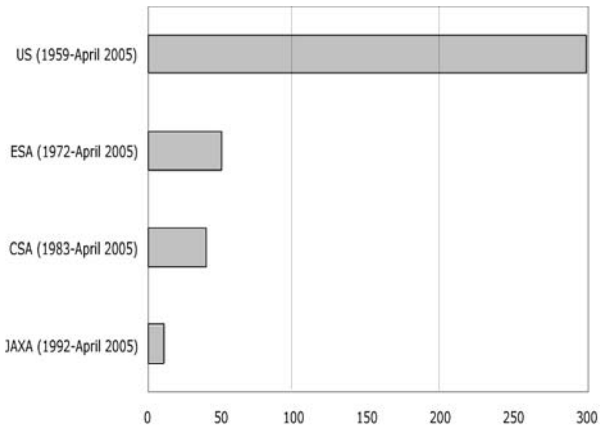

Figure 7: Total number of neurophysiological experiments conducted up through Expedition 10 (April 2005)

Alan Shepard undergoes a flight simulation test. Courtesy of NASA

Although animal studies are a vital aid to understanding space physiology, they are not a perfect analogue to humans. Taking only the number of experiments conducted on humans, there is a drop in the number of investigations to 1,629. Even though 1,629 seems like a significant number of human physiological experiments, when it is broken down into the various science disciplines, it is apparent how few experiments have actually been performed (Figure 6). Cardiovascular and neurovestibular account for the majority of life science experiments. The U.S. has conducted about 300 of the 400 neurovestibular experiments to date which averages to about 7 – 8 experiments each year (Figure 7). This number is not very encouraging when you consider that they were performed over a 40-year period, with different research methods, different hardware, and on mostly short duration missions. The knowledge attained from these short duration experiments may not be adequate to predict the physiological changes an astronaut experiences on long duration missions. Until life sciences and the development of countermeasures become a priority in the NASA community, astronauts will continue to endure the undesirable physiological changes brought about by space flight.

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APPENDIX A: NEUROVESTIBULAR EXPERIMENTS CONDUCTED DURING SPACE FLIGHT

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
Vostok-3	11-Aug-62	Nikolayev	3:22:25	Electro-oculography (EOG) Electroencephalography (EEG) Galvanic Skin Response (GSR) Sensory-motor Coordination tests
Vostok 4	12-Aug-62	Popovich	2:22:59	Same as Vostok-3
Vostok 5	14-Jun-63	Bykovsky	4:23:06	Same as Vostok-3
Vostok 6	16-Jun-63	Tereshkova	2:22:50	Same as Vostok-3
Voskhod 1	12-Oct-64	Komarov Feoktistov Yegorov	1:00:17	Eye movements measured with EOG Writing and eyes-closed printing tests with galvanic vestibular stimulation
Voskhod 2	18-Mar-65	Belyaev Leonov	1:02:02	Neurological Investigations included sensory and stereognostic testing
Gemini 5	21-Aug-65	L. Gordon Cooper Charles Conrad, Jr.	07:22:55	Human Otolith Function (M009) Visual Acuity in the Space Environment (S008)
Gemini 7	4-Dec-65	Frank Borman James A. Lovell	13:18:35	Human Otolith Function (M009) Inflight Sleep Analysis (M008) Visual Acuity in the Space Environment (S008)
Apollo 7	11-Oct-68	Walter M. Schirra, Jr. Donn F. Eisele R. Walter Cunningham	10:20:09	Apollo Flight Crew Vestibular Assessment (AP006)
Soyuz-3	26-Oct-68	Georgiy T. Bergovoy	3:22:51	Muscle Electromyography (EMG) activity at rest and after exercise investigations
Apollo 8	21-Dec-68	Frank Borman James A. Lovell, Jr. William A. Anders	06:03:01	Apollo Flight Crew Vestibular Assessment (AP006)
Soyuz-4	14-Jan-69	Vladimir Shatalov	2:23:23	Muscle Electromyography (EMG) activity at rest and after exercise investigations
Soyuz-5	15-Jan-69	Boris V. Volynov Aleksey A. Yeliseyev Yevgeniy V. Khrunov	3:00:56	Muscle Electromyography (EMG) activity at rest and after exercise investigations
Apollo 9	3-Mar-69	James A. McDivitt David R. Scott Russell L. Schweickart	10:01:01	Apollo Flight Crew Vestibular Assessment (AP006)

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
Apollo 10	18-May-69	Eugene A. Cernan Thomas P. Stafford John W. Young	08:0:03	Apollo Flight Crew Vestibular Assessment (AP006)
Biosatellite III	28-Jun-69	Bonnie (pig-tailed monkey)	8:19:00	Digital Computer Analysis of Neurophysiological Data from Biosatellite III (P-1001B) Sleep and Wake States in Biosatellite III Monkey: Visual and Computer Analyses of Telemetered Electroencephalographic Data (P-1001C) Sleep/Wake Activity Patterns of a Pig-Tailed Monkey During Nine Days of Weightlessness (P-1001D)
Apollo 11	16-Jul-69	Neil A. Armstrong Edwin E. Aldrin Jr. Michael Collins	8:03:09	Apollo Flight Crew Vestibular Assessment (AP006)
Soyuz-6	11-Oct-69	Georgiy Shonin Valery N. Kubasov	4:22:42	Muscle Electromyography (EMG) activity at rest and after exercise investigations
Soyuz-7	12-Oct-69	A.V. Filipchenko Vladislav N. Volkov Viktor N. Gorbatko	4:22:41	Muscle Electromyography (EMG) activity at rest and after exercise investigations
Apollo 12	14-Nov-69	Charles Conrad, Jr. Richard F. Gordon, Jr. Alan L. Bean	10:4:36	Apollo Flight Crew Vestibular Assessment (AP006)
Apollo 13	11-Apr-70	James A. Lovell, Jr. John L. Swigert, Jr. Fred W. Haise, Jr.	5:22:55	Apollo Flight Crew Vestibular Assessment (AP006)
Soyuz-9	1-Jun-70	Andriyan G. Nikolayev Vitali I. Sevastyanov	17:16:59	EEG Sleep Monitoring Posture Study Locomotion Muscle EMG
OFO-A (Scout Satellite)	9-Nov-70	2 Bull Frogs	6:00:00	Orbiting Frog Otolith Experiment: Preliminary Results (OFO-1.1) Orbiting Frog Otolith Experiment: Secondary Spike Analysis (OFO-1.2) Orbiting Frog Otolith Experiment: Comparison to Control Studies (OFO-1.3)
Apollo 14	31-Jan-71	Alan B. Shepard, Jr. Stuart A. Roosa Edgar D. Mitchell	9:00:02	Apollo Flight Crew Vestibular Assessment (AP006)
Soyuz-11	6-Jun-71	Georgiy T. Dobrovolsky Vladislov N. Volkov Viktor I. Patsayev	23:18:22	Neurological testing of grip strength, kinesthetic sensitivity, visual acuity, color and contrast sensitivity, convergence and accommodation

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
Apollo 15	26-Jul-71	David R. Scott Alfred M. Worden James B. Irwin	12:17:12	Apollo Flight Crew Vestibular Assessment (AP006)
Apollo 16	16-Apr-72	John W. Young Charles M. Duke, Jr. Thomas K. Mattingly II	11:01:51	Apollo Flight Crew Vestibular Assessment (AP006)
Apollo 17	7-Dec-72	Eugene A. Cernan Harrison H. Schmitt Ronald E. Evans	12:13:52	Apollo Flight Crew Vestibular Assessment (AP006)
Skylab 2	25-May-73	Conrad Kerwin Weitz	28:00:50	Human Vestibular Function (M131)
Skylab 3	28-Jul-73	Bean Garriott Lousma	59:12:09	Human Vestibular Function (M131)
Skylab 4	16-Nov-73	Carr Gibson Pogue	84:01:16	Human Vestibular Function (M131) Motor Sensory Performance (ED41)
Soyuz-17: Salyut-4	10-Jan-75	Gubarev Grechko	29:13:20	Vestibular monitoring
Soyuz-19: ASTP	15-Jul-75	Leonov Kubasov	5:22:31	Achilles Tendon Reflex (ASTP003)
Apollo 18: ASTP	15-Jul-75	Stafford Slayton Brand	9:01:28	Achilles Tendon Reflex (ASTP003) Electromyographic Analysis of Skeletal Muscle (ASTP009)
Soyuz-21 (on Salyut-5)	6-Jul-76	Boris Volynov Vitali Zholobov	49:06:23	Investigation of sensitivity threshold of vestibular system to galvanic stimulation. Evaluated gustatory sensations in weightlessness
Soyuz-24 (on Salyut-5)	7-Feb-77	Viktor Gorbatko Yuri Glazkov	17:17:26	Investigation of sensitivity threshold of vestibular system to galvanic stimulation. Evaluated gustatory sensations in weightlessness

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
Soyuz-26 (on Salyut-6)	10-Dec-77	Yuri Romanenko Georgi Grechko	96:10:00	First test of the "Cuban Boot" to simulate Earth loads on foot proprioceptors Gustometry EEG Monitoring Effect of Plantar Stimulation on SMS Reaction Time Attention and Memory Test Investigation of tactile sensation Coordination Tests Color Sensitivity and Visual Acuity Posture Tests SMS Questionnaire Optokinetic Stimulation
Soyuz-27 (on Salyut-6)	10-Jan-78	Vladimir Dzhanibekov Oleg Makarov	5:22:58	Same as Soyuz-26
Soyuz-28 (on Salyut-6)	2-Mar-78	Aleksey Gubarev Vladimir Remek	7:22:15	Same as Soyuz-26
Soyuz-29 (on Salyut-6)	15-Jun-78	Vladimir Kovalyonok Aleksandr Ivanchenkov	139:14:47	Same as Soyuz-26
Soyuz-31 (on Salyut-6)	27-Jun-78	Pyotr Klimuk Miroslaw Hermaszewski	7:22:02	Same as Soyuz-26
Soyuz-32 (on Salyut-6)	25-Feb-79	Vladimir Lyakhov Valeri Ryumin	175:00:35	Same as Soyuz-26
Soyuz-33 (on Salyut-6)	10-Apr-79	Nikolay Rukavishnikov Georgi Ivanov	1:22:23	Same as Soyuz-26
Soyuz-35 (on Salyut-6)	9-Apr-80	Leonid Popov Valeri Ryumin	184:20:11	Same as Soyuz-26
Soyuz-36 (on Salyut-6)	26-May-80	Valeri Kubasov Bertalan Farkas	7:20:45	Same as Soyuz-26
Soyuz-T2 (on Salyut-6)	5-Jun-80	Yuri Malyshev Vladimir Aksenov	3:22:19	Same as Soyuz-26
Soyuz-37 (on Salyut-6)	23-Jun-80	Viktor Gorbatko Tuan Pham	7:20:41	Same as Soyuz-26
Soyuz-38 (on Salyut-6)	18-Sep-80	Yuri Romanenko Mendez Tamayo	7:20:43	Same as Soyuz-26
Soyuz-T3 (on Salyut-6)	27-Nov-80	Leonid Kizim Oleg Grigoryevich Gennadi Strekalov	12:19:07	Same as Soyuz-26

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
Soyuz-T4 (on Salyut-6)	12-Mar-81	Vladimir Kovalyonok Viktor Savinykh	74:17:37	Same as Soyuz-26
Soyuz-39 (on Salyut-6)	22-Mar-81	Vladimir Dzhanibekov Jugderdemidiyn Gurragcha	7:20:42	Same as Soyuz-26
STS-1 (Columbia)	12-Apr-81	John Young Robert Crippen	2:06:20	DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness
Soyuz-40 (on Salyut-6)	14-May-81	Leonid Popov Dumitru Prunariu	7:20:41	Same as Soyuz-26
STS-2 (Columbia)	12-Nov-81	Joseph H. Engle Richard H. Truly	2:06:13	DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness
STS-3 (Columbia)	22-Mar-82	Jack R. Lousma C. Gordon Fullerton	8:00:04	DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness
Soyuz-T5 (on Salyut-7)	13-May-82	Anatoli Berezevoi Valentin Lebedev	210:09:04	Audiometry Gustometry EEG Monitoring Effect of Plantar Stimulation on SMS Attention and Memory Tests Investigation of tactile sensation Coordination Tests Color Sensitivity and Visual Acuity Posture Tests SMS Questionnaire Optokinetic Stimulation
Soyuz-T6 (on Salyut-7)	24-Jun-82	Vladimir Dzhanibekov Aleksandr Ivanchenkov Jean-Loup Chretien	7:21:50	Same as Soyuz-T5
STS-4 (Columbia)	27-Jun-82	Thomas K. Mattingly Henry W. Hartsfield	7:01:09	DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness
Soyuz-T7 (on Salyut-7)	19-Aug-82	Leonid Popov Aleksandr Serebrov Svetlana Savitskaya	7:21:52	Same as Soyuz-T5
STS-5 (Columbia)	11-Nov-82	Vance D. Brand Robert F. Overmyer Joseph P. Allen William B. Lenoir	5:02:14	DSO 404 1/8: Extra ocular Motion (EOM) Studies, pre, In and Post flight DSO 403 1/2: Head and Eye Motion During shuttle Launch and Entry DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness DSO 405: Acceleration Detection Sensitivity DSO 408: Near Vision Acuity and Contrast Sensitivity

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-6 (Challenger)	4-Apr-83	Paul Weitz Karol J. Bobko Donald Peterson Story Musgrave	5:02:14	DSO 404 2/8: Extra ocular Motion (EOM) Studies, pre, In and Post flight DSO 404 6/8: Eye Head Motion during Ascent, Entry, and On Orbit (Gyroscopic Head Motion Measurements) DSO 403 2/2: Head and Eye Motion During shuttle Launch and Entry DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness DSO 405: Acceleration Detection Sensitivity
Soyuz-T8 (on Salyut-7)	20-Apr-83	Vladimir Titov Gennadi Strekalov Aleksandr Serebrov	2:00:17	Same as Soyuz-T5
STS-7 (Challenger)	18-Jun-83	Robert Crippen Frederick H. Hauck John Fabian Sally Ride Norman Thagard	6:02:23	DSO 404 7/8: On-Orbit Head and Eye Tracking Task - Optokinetic Studies DSO 404 3/8: Extra ocular Motion (EOM) Studies Pre, In and Postflight DSO 404 8/8: Extra ocular Motion (EOM) Studies Pre, In and Postflight (Saccadic Tracking) DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness DSO 405: Acceleration Detection Sensitivity DSO 403: Head and Eye Motion During shuttle Launch and Entry DSO 417: In-flight Countermeasures for SMS DSO 408: Near Vision Acuity and Contrast Sensitivity
Soyuz-T9 (on Salyut-7)	27-Jun-83	Vladimir Lyakhov Aleksandr Aleksandrov	149:10:45	Same as Soyuz-T5
STS-8 (Challenger)	30-Aug-83	Richard Truly Daniel C. Brandenstein Dale Gardner Guion Bluford William Thornton	6:01:08	DSO 404 8/8: Extra Ocular Motion (EOM) Studies, Pre, In, and post flight (saccadic Tracking) DSO 404 4/8: Extra Ocular Motion (EOM) Studies, Pre, In, and post flight DSO 404 6/8: Eye Head Motion during Ascent, Entry and on Orbit (Gyroscopic Head motion measurements) DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness DSO 405: Acceleration Detection Sensitivity DSO 403: Head and Eye Motion During shuttle Launch and Entry DSO 417: In-flight Countermeasures for SMS DSO 408: Near Vision Acuity and Contrast Sensitivity

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-9 (Columbia)	28-Nov-83	John Young Brewster Shaw Owen Garriott Robert Parker Byron Lichtenberg Ulf Merbold	10:07:47	DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness Vestibular Experiments (1NS102) Vestibulo-Spinal Reflex Mechanisms using Hoffman Reflex (1NS104) Effects of Rectilinear Acceleration, Optokinetic and Caloric Stimulation on Human Vestibular Reactions and Sensations Eye Movements During Sleep Mass Discrimination During Weightlessness
Soyuz-T10 (on Salyut-7)	8-Feb-84	Leonid Kizim Vladimir Solovyov Oleg Atkov	236:22:49	Same as Soyuz-T5
Soyuz-T11 (on Salyut-7)	3-Apr-84	Yuri Malyshev Gennadi Strekalov Rakesh Sharma	7:21:40	Same as Soyuz-T5
STS-41C (Challenger)	6-Apr-84	Robert Crippen Terry Hart Francis Scobee George Nelson James Van Hoften	6:23:40	DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness DSO 408: Near Vision Acuity and Contrast Sensitivity
Soyuz-T12 (on Salyut-7)	17-Jul-84	Vladimir Dzhanibekov Svetlana Savitskaya Igor Volk	11:19:14	Same as Soyuz-T5
STS-41D (Discovery)	30-Aug-84	Henry Hartsfield Michael Coats Judith Resnik Steven Hawley Richard Mullane Charles Walker	6:00:56	DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness DSO 408: Near Vision Acuity and Contrast Sensitivity DSO 440: Crew Visual Performance
STS-41G (Challenger)	5-Oct-84	Robert Crippen Jon McBride Kathryn Sullivan Sally Ride David Leestma Marc Garneau Paul Scully-Power	8:05:23	DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness DSO 408: Near Vision Acuity and Contrast Sensitivity DSO 440: Crew Visual Performance

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-51A (Discovery)	8-Nov-84	Frederick Hauck David Walker Anna Fisher Dale Gardner Joseph Allen	7:23:44	DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness DSO 614: Head and Gaze Stability During Locomotion
STS-51C (Discovery)	24-Jan-85	Thomas Mattingly II Loren Shriver Ellison Onizuka James Buchli Gary Payton	3:01:33	DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness DSO 408: Near Vision Acuity and Contrast Sensitivity DSO 440: Crew Visual Performance DSO 614: Head and Gaze Stability During Locomotion
STS-51D (Discovery)	12-Apr-85	Karol Bobko Donald Williams Rhea Seddon Jeffrey Hoffman S. David Griggs Charles Walker Senator E. Jake Garn	6:23:55	DSO 404: Extra Ocular Motion (EOM) Studies, pre, In and Post flight DSO 401: Validation of Predictive Tests and Countermeasures for Space Motion Sickness DSO 614: Head and Gaze Stability During Locomotion
STS-51B (Challenger)	29-Apr-85	Robert Overmyer Frederick Gregory Don Lind Norman Thagard William Thornton Lodewijk van den Berg Taylor G. Wang	7:00:08	DSO 451: Eye-Hand Coordination During SMS
Soyuz-T13 (on Salyut-7)	6-Jun-85	Vladimir Dzhanibekov Viktor Savinykh	112:03:12	Same as Soyuz-T5
STS-51G (Discovery)	17-Jun-85	Daniel C. Brandenstein John Creighton Shannon Lucid John Fabian Steven Nagel Patrick Baudry Sultan Salman Al-Saud	7:01:38	DSO 455: Clinical Characterization of SMS Posture Sensory-motor adaptation visual-vestibular interaction

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-51F (Challenger)	29-Jul-85	Gordon Fullerton Roy Bridges F. Story Musgrave Anthony England Karl Henize Loren W. Acton John-David F. Bartoe	7:22:45	DSO 614: Head and Gaze Stability During Locomotion
STS-51I (Discovery)	27-Aug-85	Joseph Engle Richard Covey James D. A. van Hoften John M. Lounge William F. Fisher	7:02:17	DSO 455: Clinical Characterization of SMS
Soyuz-T14 (on Salyut-7)	17-Sep-85	Vladimir Vasyutin Georgi Grechko Aleksandr Volkov	64:21:52 (Vasyutin & Volkov) 8:21:13 (Grechko)	Same as Soyuz-T5
STS-51J (Atlantis)	3-Oct-85	Karol Bobko Ronald Grabe David Hilmers Robert L. Stewart William A. Pailes	4:01:44	DSO 451: Eye-Hand Coordination During SMS
STS-61A (Challenger)	30-Oct-85	Henry Hartsfiel Steven Nagel James Buchli Guion Bluford Bonnie Dunbar Reinhard Furrer Ernst Messerschmid Wubbo Ockels	7:00:44	Vestibular Adaptation (284065) - Using the German Vestibular Sled European experiments on the vestibular system Tonometry Spatial description: aspects of cognitive adaptation Causation of inversion illusions and space sickness Mass discrimination and adaptation to weightlessness Arm positioning
STS-61B (Atlantis)	26-Nov-85	Brewster Shaw Bryan O'Connor Mary Cleave Sherwood Spring Jerry Ross Rodolfo Neri Vela Charles Walker	6:21:04	DSO 455: Clinical Characterization of SMS DSO 614: Head and Gaze Stability During Locomotion

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-61C (Columbia)	12-Jan-86	Robert Gibson Charles Bolden Jr. Franklin Chang-Diaz Steven Hawley George Nelson Congressman Bill Nelson	6:02:03	DSO 455: Clinical Characterization of SMS DSO 614: Head and Gaze Stability During Locomotion DSO 451: Eye-Hand Coordination During SMS DSO 459: Otolith Tilt-Translation Reinterpretation DSO 204: Visual Observations from Space
Cosmos 1887	29-Sep-87	Drema and Yerosha (Rhesus Monkeys); Various bugs; Rats	13:00:00	Effect of Microgravity on: II. Metabolic Enzymes of Hippocampus and Spinal Cord (COS 1887-35) - Rat
Soyuz-TM5: Mir	7-Jun-88	Anatoli Solovyev Viktor Savinykh Aleksandr Alexandrov	9:20:10	Psychomotor studies
STS-26	29-Sep-88	Frederick Hauck Richard Covey John Lounge George Nelson David Hilmers	4:01:00	DSO 459: Otolith Tilt-Translation Reinterpretation DSO 204: Visual Observations from Space
Soyuz-TM7 Aragatz	26-Nov-88	Aleksandr Volkov Sergey Krikalev Jean-Loup Chretien	24:18:07	Study of postural and locomotor systems and the state of sensorial organs (I, II, III)
STS-28 (Columbia)	8-Aug-89	Brewster Shaw, Jr Richard Richards James Adamson David Leestma Mark N. Brown	5:01:00	DSO 459: Otolith Tilt-Translation Reinterpretation DSO 605: Postural Equilibrium Control During Landing/Egress
Cosmos 2044	15-Sep-89	Zhakonya and Zabiyaka (Rhesus monkeys) Male specific pathogen free Wistar Rats	14:00:00	Adaptation of Optokinetic Nystagmus to Microgravity (COS 2044-8) Effect of Microgravity on: II. Metabolic Enzymes, Neurotransmitter Amino Acids, and Neurotransmitter Associated Enzymes in Selected Regions of the Central Nervous System (COS 2044-47) Functional Neuromuscular Adaptation to Space Flight (8809A13 2/2) Metabolic and Morphologic Properties of Muscle Fibers and Motor Neurons after Space flight: II. Ventral Horn Cell Responses to Space flight and Suspension (COS 2044-28) Studies of Vestibular Primary Afferents in Normal, Hyper- and Hypogravity (COS 2044-40)

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-33 (Discovery)	22-Nov-89	Frederick Gregory John Blaha F. Story Musgrave Manley Carter, Jr Kathryn Thornton	5:00:06	DSO 468: Preflight Adaptation Training (PAT)
STS-36 (Atlantis)	28-Feb-90	John Creighton John Casper Richard Mullane David Hilmers Pierre Thout	4:10:18	DSO 468: Preflight Adaptation Training (PAT) DSO 605: Postural Equilibrium Control During Landing/Egress
STS-41 (Discovery)	6-Oct-90	Richard Richards Robert Cabana William Shepherd Bruce Melnick Thomas Akers	4:02:10	DSO 605: Postural Equilibrium Control During Landing/Egress DSO 604OI-3: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements)
STS-35 (Columbia)	2-Dec-90	Vance Brand Guy Gardner Jeffrey Hoffman John Lounge Robert Parker Samuel Durrance Ronald Parise	8:23:05	DSO 468: Preflight Adaptation Training (PAT) DSO 605: Postural Equilibrium Control During Landing/Egress
STS-39 (Discovery)	28-Apr-91	Michael Coats Charles L. Veach Donald McMonagle Richard Hieb Gregory Harbaugh Guion Bluford Blaine Hammond	8:07:22	DSO 604 OI-3: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 605: Postural Equilibrium Control During Landing/Egress
STS-40 (Columbia)	5-Jun-91	Bryan D. O'Connor Sidney Gutierrez James Bagian Tamara Jernigan Rhea Seddon Drew Gaffney Millie Hughes Fulford	9:02:14	Vestibular Experiments in Spacelab (178072 1/2) DSO 605: Postural Equilibrium Control During Landing/Egress

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-43 (Atlantis)	2-Aug-91	John Blaha Michael Baker Shannon Lucid James Adamson G. David Low	8:21:21	DSO 604 OI-3B: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 614: Head and Gaze Stability During Locomotion DSO 605: Postural Equilibrium Control During Landing/Egress
STS-48 (Discovery)	12-Sep-91	John Creighton Kenneth Reightler, Jr Mark N. Brown Charles Gemar James F. Buchli	5:08:27	DSO 614: Head and Gaze Stability During Locomotion DSO 604OI-1: Visual-Vestibular Integration as a Function of Adaptation (Perceptual reporting)
AustroMir	2-Oct-91	Franz Artur Viehboeck	7:22:12	Eye-head-arm coordination and spinal reflexes in weightlessness SLEEP experiment Directional hearing in microgravity Orientation effects from optokinetic stimulations
STS-44 (Atlantis)	24-Nov-91	Frederick D. Gregory Terence T. Henricks Mario Runco, Jr James F. Voss F. Story Musgrave Thomas J. Hennen	6:22:50	DSO 604OI-3A: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 604OI-1: Visual-Vestibular Integration as a Function of Adaptation (Perceptual reporting) DSO 614: Head and Gaze Stability During Locomotion DSO 605: Postural Equilibrium Control During Landing/Egress
STS-42 (Discovery)	22-Jan-92	Steven Oswald Norman Thagard David C. Hilmers William Readdy Roberta Bondar Ulf Merbold	8:01:14	Microgravity Vestibular Investigations (284058)
German Mir Mission '92	17-Mar-92	Klaus-Dietrich Flade	7:21:52	Sleep and Circadian Rhythm Illusions of Verticality
STS-45 (Atlantis)	24-Mar-92	Charles Bolden Brian Duffy Kathryn Sullivan David Leestma C. Michael Foale Byron Lichtenberg Dirk Frimout	8:22:09	DSO 614: Head and Gaze Stability During Locomotion DSO 604OI-1: Visual-Vestibular Integration as a Function of Adaptation (Perceptual reporting)

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-49 (Endeavour)	7-May-92	Daniel Brandenstein Kevin Chilton Pierre Thout Kathryn Thornton Richard Hieb Thomas Akers Bruce Melnick	8:21:17	DSO 604OI-3B: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 604OI-1: Visual-Vestibular Integration as a Function of Adaptation (Perceptual reporting) DSO 614: Head and Gaze Stability During Locomotion DSO 605: Postural Equilibrium Control During Landing/Egress
STS-50 (Columbia)	25-Jun-92	Richard Richards Ken Bowersox Bonnie Dunbar Ellen Baker Carl Meade Lawrence DeLucas Eugene Trinh	13:19:30	DSO 614: Head and Gaze Stability During Locomotion DSO 620: Physiological Evaluation of Astronaut Seat Egress Ability at Wheels Stop DSO 605: Postural Equilibrium Control During Landing/Egress
Antares	27-Jul-92	Michel Tognini	13:18:56	Haptic perception in weightlessness Study of adaptive process in human proprioceptive functions at cognitive and sensory-motor levels in weightlessness Symmetry detection
STS-46 (Atlantis)	31-Jul-92	Loren Shriver Andrew Allen Jeffrey Hoffman Franklin Chang-Diaz Claude Nicollier Marsha Ivins Franco Malerba	7:23:15	DSO 614: Head and Gaze Stability During Locomotion DSO 604 OI-1: Visual-Vestibular Integration as a Function of Adaptation (Perceptual reporting)
STS-47 (Endeavour)	12-Sep-92	Robert Gibson Curtis L. Brown Mark C. Lee N. Jan Davis Jay Apt Mae Jemison Mamoru Mohri	7:22:30	DSO 614: Head and Gaze Stability During Locomotion Autogenic Feedback Training Exercise (AFTE) As a Preventative Method for Space Adaptation Syndrome (178195 2/3)
STS-52 (Columbia)	22-Oct-92	James Wetherbee Michael Baker Charles L. Veach William Shepherd Tamara Jernigan Steven MacLean	9:20:56	DSO 604OI-3B: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 604OI-1: Visual-Vestibular Integration as a Function of Adaptation (Perceptual reporting) DSO 605: Postural Equilibrium Control During Landing/Egress

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-53 (Discovery)	2-Dec-92	David Walker Robert Cabana Guion Bluford James Voss Michael Clifford	7:07:19	DSO 604OI-3B: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 604OI-1: Visual-Vestibular Integration as a Function of Adaptation (Perceptual reporting) DSO 614: Head and Gaze Stability During Locomotion DSO 605: Postural Equilibrium Control During Landing/Egress
Cosmos 2229	29-Dec-92	2 Rhesus Monkeys	12:00:00	Adaptation to Microgravity of Oculomotor Reflexes (AMOR): Otolith-Ocular Reflexes (8809A08) Functional Neuromuscular Adaptation to Space Flight (8809A13 2/2) Studies of Vestibular Neurons in Normal, Hyper- and Hypogravity (8809A16)
STS-54 (Endeavour)	13-Jan-93	John Casper Donald McMonagle Mario Runco Gregory Harbaugh Susan Helms	5:23:38	DSO 604OI-3A: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 604OI-1: Visual-Vestibular Integration as a Function of Adaptation (Perceptual reporting) DSO 605: Postural Equilibrium Control During Landing/Egress
STS-56 (Discovery)	8-Apr-93	Kenneth Cameron Stephen Oswald C. Michael Foale Kenneth Cockrell Ellen Ochoa	9:06:08	DSO 605: Postural Equilibrium Control During Landing/Egress
STS-57 (Endeavour)	21-Jun-93	Ronald Grabe Brian Duffy G. David Low Nancy Sherlock Peter Wisoff Janice Voss	9:23:44	DSO 604OI-3B: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 604OI-1: Visual-Vestibular Integration as a Function of Adaptation (Perceptual reporting) DSO 614: Head and Gaze Stability During Locomotion
Altair	1-Jul-93	Jean-Pierre Haignere	21:16:08	Study of role of visual motor in operational activities: Mental Rotation Study of role of visual motor in operational activities: Symmetry detection Haptic perception in weightlessness Study of limb/body movement in microgravity
STS-51 (Discovery)	12-Sep-93	Frank Culbertson William Readdy James Newman Daniel Bursch Carl Walz	9:20:11	DSO 604OI-3A: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 604OI-1: Visual-Vestibular Integration as a Function of Adaptation (Perceptual reporting) DSO 605: Postural Equilibrium Control During Landing/Egress

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-58 (Columbia)	18-Oct-93	John Blaha Richard Searfoss M. Rhea Seddon William S. McArthur David A. Wolf Shannon W. Lucid Martin Fettman	14:00:12	DSO 604OI-3B: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 614: Head and Gaze Stability During Locomotion DSO 620: Physiological Evaluation of Astronaut Seat Egress Ability at Wheels Stop DSO 605: Postural Equilibrium Control During Landing/Egress; Vestibular Experiments in Spacelab (178072 2/2)
STS-61 (Endeavour)	2-Dec-93	Richard O. Covey Kenneth D. Bowersox F. Story Musgrave Kathryn C. Thornton Claude Nicollier Jeffrey A. Hoffman Thomas D. Akers	10:19:58	DSO 604OI-3B: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements)
STS-60 (Discovery)	3-Feb-94	Charles F. Bolden Kenneth S. Reightler N. Jan Davis Ronald M. Sega Franklin R. Chang-Diaz Sergei K. Krikalev	8:07:09	Eye-Head Coordination During Target Acquisition (4.2.1) Alterations in Postural Equilibrium Control Associated with Long Duration Space Flight (4.2.4c) Biomechanics of Movement During Locomotion (4.2.4a) The Effects of Long-Duration Space Flight on Eye, Head, and Trunk Coordination During Locomotion (4.2.4d) Autonomic and Gastric Function Associated with Space Motion Sickness
STS-62 (Columbia)	4-Mar-94	John H. Casper Andrew M. Allen Pierre J. Thuot Charles D. Gema Marsha S. Ivins	13:23:16	DSO 604OI-3B: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 614: Head and Gaze Stability During Locomotion DSO 605: Postural Equilibrium Control During Landing/Egress
STS-59 (Endeavour)	9-Apr-94	Sidney M. Gutierrez Kevin P. Chilton Linda M. Godwin Jay Apt Michael R. Clifford Thomas D. Jones	11:05:49	DSO 604OI-3B: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements)

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-65 (Columbia)	8-Jul-94	Robert D. Cabana James D. Halsell Richard J. Hieb Carl E. Walz Leroy Chiao Donald A. Thomas Chiaki Naito-Mukai	14:17:55	DSO 614: Head and Gaze Stability During Locomotion
STS-64 (Discovery)	9-Sep-94	Richard N. Richards L. Blaine Hammond, Jr Jerry M. Linenger Susan J. Helms Carl J. Meade Mark C. Lee	10:22:49	DSO 605: Postural Equilibrium Control During Landing/Egress DSO 614B: Head and Gaze Stability During Locomotion (Path Integration) DSO 604OI-3B: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements)
STS-68 (Endeavour)	30-Sep-94	Michael A. Baker Terrence W. Wilcutt Thomas D. Jones Steven L. Smith Daniel W. Bursch Peter J. K. Wisoff	11:05:46	DSO 604OI-3C: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 614B: Head and Gaze Stability During Locomotion (Path Integration) DSO 605: Postural Equilibrium Control During Landing/Egress
EuroMIR 94	4-Oct-94	Ulf Merbold	31:12:35	Posture and movement in microgravity STAMP Experiment - perception of figure symmetry by the two cerebral hemispheres Circadian rhythms and sleep during a 30-day space mission Adaptation of basic vestibulo-oculomotor mechanism to altered gravity conditions Otolith adaptation to different levels of microgravity Spatial orientation and spatial sickness.
STS-66 (Atlantis)	3-Nov-94	Donald R. McMonagle Curtis L. Brown, Jr. Ellen Ochoa Scott E. Parazynski Joseph R. Tanner Jean-Francois Clervoy	10:22:34	DSO 605: Postural Equilibrium Control During Landing/Egress DSO 614B: Head and Gaze Stability During Locomotion (Path Integration) DSO 604OI-3B: Visual-Vestibular Integration as a Function of Adaptation(eye and head movements)
STS-63 (Discovery)	3-Feb-95	James D. Whetherbee Eileen M. Collins C. Michael Foale Janice E. Voss Bernard A. Harris Vladimar G. Titov	8:06:28	Eye-Head Coordination During Target Acquisition (4.2.1) Anticipatory Postural Activity (POSA) (4.2.4b) Biomechanics of Movement During Locomotion (4.2.4a) Autonomic and Gastric Function Associated with Space Motion Sickness

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-67 (Endeavour)	2-Mar-95	Stephen S. Oswald William G Gregory Tamar E. Jernigan John M. Grunsfeld Wendy B. Lawrence Ronald A. Parise Samuel T. Durrance	16:15:08	DSO 605: Postural Equilibrium Control During Landing/Egress DSO 614B: Head and Gaze Stability During Locomotion (Path Integration) DSO 604OI-3C: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements)
Mir 18 NASA 1	14-Mar-95	Vladimir Dezhurov Gennady Strekalov Norman Thagard	115:08:43	The Effectiveness of Manual Control During Simulation of Flight Tasks (PILOT) Anticipatory Postural Activity (POSA) (4.2.4b) Alterations in Postural Equilibrium Control Associated with Long Duration Space Flight (4.2.4c) Eye-Head Coordination During Target Acquisition (4.2.1) The Effects of Long-Duration Space Flight on Eye, Head, and Trunk Coordination During Locomotion (4.2.4d)
STS-71 (Atlantis) (on Mir 19)	27-Jun-95	Robert L. Gibson Charles J. Precourt Ellen S. Baker; Bonnie J. Dunbar Gregory J Harbaugh Anatoly Solovyev Nikolai Budarin	9:19:22 (STS-71 crew) 75:11:20 (Mir 19 crew - Solovyev & Budarin)	Eye-Head Coordination During Target Acquisition (4.2.1) Anticipatory Postural Activity (POSA) (4.2.4b) Alterations in Postural Equilibrium Control Associated with Long Duration Space Flight (4.2.4c) The Effects of Long-Duration Space Flight on Eye, Head, and Trunk Coordination During Locomotion (4.2.4d) Biomechanics of Movement During Locomotion (4.2.4a) Autonomic and Gastric Function Associated with Space Motion Sickness
STS-70 (Discovery)	13-Jul-95	Terrence T. Henricks Kevin R. Kregel Nancy Jane Currie Donald A. Thomas Mary Ellen Weber	8:22:20	DSO 604OI-1: Visual-Vestibular Integration as a Function of Adaptation (Perceptual reporting)
EuroMIR 95	3-Sep-95	Thomas Reiter	179:01:41	Postural modifications in microgravity Differential effects of otolith input on ocular lateropulsion, cyclorotation, perceived visual vertical, straight ahead, and tonic neck reflexes in man Influence of gravity on the preparation and execution of voluntary movements
STS-69 (Endeavour)	7-Sep-95	David M. Walker Kenneth D. Cockrell James S. Voss James H. Newman Michael L. Gernhardt	10:20:28	DSO 604OI-3B: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 605: Postural Equilibrium Control During Landing/Egress

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-73 (Columbia)	20-Oct-95	Kenneth D. Bowersox Kent V. Rominger Kathryn C. Thornton Catherine G. Coleman Michael E. Lopez-Alegria Fred W. Leslie Albert Sacco, Jr.	15:21:53	DSO 605: Postural Equilibrium Control During Landing/Egress DSO 604OI-3C: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 604OI-1: Visual-Vestibular Integration as a Function of Adaptation (Perceptual reporting)
STS-74 (Atlantis)	12-Nov-95	Kenneth D. Cameron James D. Halsell Jerry L. Ross William S. McArthur Chris A Hadfield	8:04:31	DSO 604OI-1: Visual-Vestibular Integration as a Function of Adaptation (Perceptual reporting)
STS-72 (Endeavour)	11-Jan-96	Brian Duffy Brent W. Jett Leroy Chiao Daniel T. Barry Winston E Scott Koichi Wakata	8:22:01	DSO 604OI-3C: Visual-Vestibular Integration as a Function of Adaptation (eye and head movements) DSO 604OI-1: Visual-Vestibular Integration as a Function of Adaptation (Perceptual reporting)
Soyuz-TM23 (on Mir 21)	21-Feb-96	Yuri Onufrienko Yuri Usachev	193:19:07	Anticipatory Postural Activity During Long Duration Space Flight (9400423) The Effects of Long Duration Space Flight on Gaze Control (9401647) The Effects of Long-Duration Space Flight on Eye, Head, and Trunk Coordination During Locomotion (9307191) Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity
STS-76 NASA 2 (on Mir 21)	22-Mar-96	Shannon Lucid	188:04:01	Anticipatory Postural Activity During Long Duration Space Flight (9400423) The Effects of Long Duration Space Flight on Gaze Control (9401647)
STS-78 (Columbia)	20-Jun-96	Terrence T. Henricks Kevin R. Kregel Susan J. Helms; Richard M. Linnehan Charles E. Brady, Jr. Jean-Jeaques Favier Robert Brent Thirsk	16:21:48	COIS: Canal Otolith Integration Studies Torso Rotation Experiment (TRE)
Soyuz-TM24 (on Mir 22)	17-Aug-96	Valery Korzun Alexandr Kaleri	196:17:26	The Effects of Long-Duration Space Flight on Eye, Head, and Trunk Coordination During Locomotion (9307191) Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-79 (Atlantis) NASA 3 (on Mir 22)	16-Sep-96	John Blaha	128:05:29	Recovery of Neurological Function in Long Duration Crewmembers (MSD075)
STS-81 (Atlantis) NASA 4 (on Mir 23)	12-Jan-97	Jerry M. Linenger	132:04:01	The Effects of Long-Duration Space Flight on Eye, Head, and Trunk Coordination During Locomotion (9307191) Recovery of Neurological Function in Long Duration Crewmembers (MSD075) Sleep Investigations (9401639) Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity Sensory Adaptation – Countermeasures and correction of adaptation to space syndrome and of motion sickness Lokomotsi – Kinematic and dynamic locomotion characteristics prior and after space flight Tendometria – Microgravity impact on induced muscular contraction
Soyuz-TM25 (on Mir 23)	10-Feb-97	Aleksandr Lazutkin Vasiliy Tsibliev Reinhold Ewald	184:22:07 (Lazutkin & Tsibliev) 19:16:34 (Ewald)	Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity Motor Control: Study of hypo-gravitational ataxia syndrome Sleep and Vestibular Adaptation (9401663) Sleep Investigations (9401639)
STS-84 (Atlantis) NASA 5 (on Mir 23 & 24)	15-May-97	Michael Foale	144:13:48	Sleep Investigations (9401639)
Soyuz-TM26 (on Mir 24)	5-Aug-97	Anatoli Solovyov Pavel Vinogradov	197:17:34	Sleep Investigations (9401639) Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity Sensory Adaptation – Countermeasures and correction of adaptation to space syndrome and of motion sickness Lokomotsi – Kinematic and dynamic locomotion characteristics prior and after space flight Tendometria – Microgravity impact on induced muscular contraction

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-86 (Atlantis)	25-Sep-97	James D. Wetherbee Michael J. Bloomfield Vladimar G. Titov Scott E. Parazynski Jean-Loup J.M. Chretien Wendy B. Lawrence	10:19:22	DSO 207: Adaptation to Linear Acceleration After Space Flight (pre/post only)
STS-86 (Atlantis) NASA 6 (on Mir 24)	25-Sep-97	David Wolf	127:20:02	Sleep Investigations (9401639)
STS-89 (Endeavour) NASA 7 (on Mir 25)	22-Jan-98	Andrew Thomas	140:15:13	Recovery of Neurological Function in Long Duration Crewmembers (MSD075)
Soyuz-TM27 (on Mir 25)	29-Jan-98	Talgat Musabayev Nikolai Budarin	207:12:51	Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity
STS-90 (Columbia) NEUROLAB MISSION	17-Apr-98	Richard A. Searfoss Scott D. Altman Richard M. Linnehan Dafydd Rhys Williams Kathryn P. Hire Dr. Jay C. Buckey Dr. James A. Pawelczyk	15:21:50	Visuo-Motor Coordination during Space Flight (9301008) Role of Visual Cues in Spatial Orientation (9301136) Spatial Orientation of the Vestibulo-Ocular Reflex (9301047) Visual-Otolithic Interaction in Microgravity (9301126) Integration of Neural Cardiovascular Control in Space Artificial Neural Networks and Cardiovascular Regulation (9301081) Autonomic Neurophysiology in Microgravity (9301095) Autonomic Neuroplasticity in Weightlessness (9301049) Frames of Reference and Internal Models (9301111) Integration of Neural Cardiovascular Control in Space (9301294) Sleep and Respiration in Microgravity (9301198)
Soyuz-TM28 (on Mir 26)	13-Aug-98	Gennadi Padalka Sergey Avdeyev Yuri Baturin	379:14:51 (Avdeyev) 198:16:31 (Padalka) 11:19:41 (Baturin)	Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-95 (Discovery)	29-Oct-98	Curtis L. Brown Steven W. Lindsey Scott E. Parazynski Stephen K. Robinson Pedro Duque Chiaki Mukai John H. Glenn	8:21:44	DSO 605: Post-flight Recovery of Postural Equilibrium
Soyuz-TM29 (on Mir 27)	20-Feb-99	Viktor Afanasyev Jean-Pierre Haignere Ivan Bella	188:20:16 (Afanasyev & Haignere) 7:21:56 (Bella)	Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity
Soyuz-TM30 (on Mir 28)	4-Apr-00	Sergey Zalyotin Aleksandr Kaleri	72:19:42	Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity
STS-106 (Atlantis)	8-Sep-00	Terrence W. Wilcutt Scott D. Altman Daniel C. Burban Edward T. Lu Richard A. Mastracchio Yuri Ivanovich Malenchenko Boris V. Morukov	11:19:12	DSO 499: Eye Movements and Motion Perception Induced by Off-Vertical Axis Rotation (OVAR) at Small Angles of Tilt After Space flight
Soyuz-TM31 Expedition 1	31-Oct-00	William Shepherd Yuri Gidzendko Sergei Krikalev	140:23:28	MR042L Functional Neurological Assessment (Posture) Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity Sensory Adaptation – Countermeasures and correction of adaptation to space syndrome and of motion sickness Lokomotsi – Kinematic and dynamic locomotion characteristics prior and after space flight Tendometria – Microgravity impact on induced muscular contraction
STS-102 (Discovery)	8-Mar-01	James D. Wetherbee James M. McNeal Andrew S. Thomas Paul W. Richards	12:19:50	Effects of Altered Gravity on Spinal Cord Excitability (H-Reflex)

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-102 Expedition 2	8-Mar-01	Yuri Usachev Susan Helms James Voss	167:06:41	Effects of Altered Gravity on Spinal Cord Excitability (H-Reflex) MR042L Functional Neurological Assessment (Posture) Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity Sensory Adaptation – Countermeasures and correction of adaptation to space syndrome and of motion sickness Lokomotsi – Kinematic and dynamic locomotion characteristics prior and after space flight Tendometria – Microgravity impact on induced muscular contraction
STS-100	19-Apr-01	Kent V. Rominger Jeffrey S. Ashby Chris A. Hadfield Scott E. Parazynski John L. Phillips Umberto Guidoni Yuri Valentinovich Lonchakov	10:19:58	DSO 499: Eye Movements and Motion Perception Induced by Off-Vertical Axis Rotation (OVAR) at Small Angles of Tilt After Space flight
STS-104	12-Jul-01	Steven W. Lindsey Charles O. Hobaugh Michael L. Gernhardt James F. Reilly Janet L. Kavandi	12:18:36	Spatial Reorientation Following Space flight (DSO 635)
STS-105	10-Aug-01	Scott J. Horowitz Frederick W. Sturckow Daniel T. Barry Patrick G. Forrester	11:21:13	Spatial Reorientation Following Space flight (DSO 635)
STS-105 Expedition 3	10-Aug-01	Frank Culbertson Vladimir Dezhurov Mikhail Tyurin	128:20:45	Effects of Altered Gravity on Spinal Cord Excitability (H-Reflex) MR042L Functional Neurological Assessment (Posture) Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity Sensory Adaptation – Countermeasures and correction of adaptation to space syndrome and of motion sickness Lokomotsi – Kinematic and dynamic locomotion characteristics prior and after space flight Tendometria – Microgravity impact on induced muscular contraction

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
Soyuz-TM33 Andromede Mission	21-Oct-01	Viktor Afansyev Claudie Andre-Deshays Haignere Konstantin Kozeyev	8:59:35	Cognitive process for 3-D orientation perception and navigation in weightlessness (COGNI)
STS-108 Expedition 4	5-Dec-01	Yuri Onufrienko Dan Bursch Carl Walz, FE	195:19:39	Effects of Altered Gravity on Spinal Cord Excitability (H-Reflex) MR042L Functional Neurological Assessment (Posture) Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity Sensory Adaptation – Countermeasures and correction of adaptation to space syndrome and of motion sickness Lokomotsi – Kinematic and dynamic locomotion characteristics prior and after space flight Tendometria – Microgravity impact on induced muscular contraction
STS-109	1-Mar-02	Scott D. Altman Duane G. Carey John M. Grunsfeld Nancy J. Currie James H. Newman Richard M. Linnehan Michael J. Massimino	10:22:11	Spatial Reorientation Following Space flight (DSO 635)
Soyuz-TM34 Marco Polo Mission	25-Apr-02	Yuri Gidzenko Roberto Vittori Mark Shuttleworth	9:21:25	An investigation of space radiation effects on the functional state of the central nervous system and an operator's working capacity (ALTEINO)
STS-111 Expedition 5	5-Jun-02	Valery Korzun Peggy Whitson Sergei Treschev	184:22:14	Promoting Sensory-motor Response Generalizability: A Countermeasure to Mitigate Locomotor Dysfunction After Long-duration Space Flight (Mobility) MR042L Functional Neurological Assessment (Posture) Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity Sensory Adaptation – Countermeasures and correction of adaptation to space syndrome and of motion sickness Lokomotsi – Kinematic and dynamic locomotion characteristics prior and after space flight Tendometria – Microgravity impact on induced muscular contraction

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
STS-111	5-Jun-02	Kenneth D. Cockrell Paul S. Lockhart Franklin R. Chang-Diaz Philippe Perrin	13:20:36	DSO 499: Eye Movements and Motion Perception Induced by Off-Vertical Axis Rotation (OVAR) at Small Angles of Tilt After Space flight Spatial Reorientation Following Space flight (DSO 635)
STS-112 (Atlantis)	7-Oct-02	Jeffrey S. Ashby Pamela A. Melroy David A. Wolf Piers J. Sellers Sandra H. Magnus Fyodor Yurchikhin	10:19:58	DSO 499: Eye Movements and Motion Perception Induced by Off-Vertical Axis Rotation (OVAR) at Small Angles of Tilt After Space flight Spatial Reorientation Following Space flight (DSO 635)
Soyuz-TMA1 Belgian Odissea Mission	30-Oct-02	Sergey Zalyotin Frank De Winne Yuri Lonchakov	10:20:53	Directed attention brain potentials in virtual 3-D space in weightlessness (NEUROCOG) DSO 634: Sleep-wake actigraphy and light exposure during space flight (SLEEP) Stress, cognition and physiological response during space flight (COGNISPACE) Sympathoadrenal activity in humans during space flight (SYMPATHO)
STS-113 Expedition 6		Ken Bowersox Don Pettit Nikolai Budarin	161:01:17	Promoting Sensory-motor Response Generalizability: A Countermeasure to Mitigate Locomotor Dysfunction After Long-duration Space Flight (Mobility) MR042L Functional Neurological Assessment (Posture) Profilaktika – Study of the action mechanism and efficacy of various countermeasures aimed at preventing locomootr system disorders in weightlessness Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity Sensory Adaptation – Countermeasures and correction of adaptation to space syndrome and of motion sickness Lokomotsi – Kinematic and dynamic locomotion characteristics prior and after space flight Tendometria – Microgravity impact on induced muscular contraction
STS-113	24-Nov-02	James D. Wetherbee Paul S. Lockhart Michael E. Lopez-Alegria John B. Herrington Kenneth D. Bowersox	13:18:48	DSO 499: Eye Movements and Motion Perception Induced by Off-Vertical Axis Rotation (OVAR) at Small Angles of Tilt After Space flight

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
Soyuz-TMA2 Expedition 7	26-Apr-03	Ed Lu Yuri Malenchenko	13:18:48	Promoting Sensory-motor Response Generalizability: A Countermeasure to Mitigate Locomotor Dysfunction After Long-duration Space Flight (Mobility) MR042L Functional Neurological Assessment (Posture) Profilaktika – Study of the action mechanism and efficacy of various countermeasures aimed at preventing locomootr system disorders in weightlessness Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity Sensory Adaptation – Countermeasures and correction of adaptation to space syndrome and of motion sickness Lokomotsi – Kinematic and dynamic locomotion characteristics prior and after space flight Tendometria – Microgravity impact on induced muscular contraction
Soyuz-TMA3 Expedition 8	18-Oct-03	Michael Foale Alexander Kaleri Pedro Duque	194:18:35 (Foale & Kaleri) 09:21:02 (Duque)	Promoting Sensory-motor Response Generalizability: A Countermeasure to Mitigate Locomotor Dysfunction After Long-duration Space Flight (Mobility) MR042L Functional Neurological Assessment (Posture) Profilaktika – Study of the action mechanism and efficacy of various countermeasures aimed at preventing locomootr system disorders in weightlessness Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity Sensory Adaptation – Countermeasures and correction of adaptation to space syndrome and of motion sickness Lokomotsi – Kinematic and dynamic locomotion characteristics prior and after space flight Tendometria – Microgravity impact on induced muscular contraction

Mission	Launch Date	Crew-Members	Flight Duration (D:H:M)	Neurological And Sensorimotor Experiments
Soyuz-TMA4 Expedition 9	19-Apr-04	Gennady Padalka Mike Fincke Andre Kuipers	187:21:17 (Padalka & Fincke) 10:20:52 (Kuipers)	Promoting Sensory-motor Response Generalizability: A Countermeasure to Mitigate Locomotor Dysfunction After Long-duration Space Flight (Mobility) Eye Tracking Device to measure effects of weightlessness on body coordination, balance, orientation and posture to assess their relation to space sickness (ETD) Study of the effects of weightlessness on motion and an astronaut's susceptibility to space sickness (MOP) MR042L Functional Neurological Assessment (Posture) Profilaktika – Study of the action mechanism and efficacy of various countermeasures aimed at preventing locomootr system disorders in weightlessness Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity Sensory Adaptation – Countermeasures and correction of adaptation to space syndrome and of motion sickness Lokomotsi – Kinematic and dynamic locomotion characteristics prior and after space flight Tendometria – Microgravity impact on induced muscular contraction
Soyuz-TMA5 Expedition 10	14-Oct-04	Leroy Chiao Salizhan Sharipov Yuri Shargin	192:19:2 (Chiao & Salizhan) 9:21:29 (Shargin)	Promoting Sensory-motor Response Generalizability: A Countermeasure to Mitigate Locomotor Dysfunction After Long-duration Space Flight (Mobility) MR042L Functional Neurological Assessment (Posture) Profilaktika – Study of the action mechanism and efficacy of various countermeasures aimed at preventing locomootr system disorders in weightlessness Motor Control – study of hypo-gravitational ataxia syndrome Ravnovesie – Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity Sensory Adaptation – Countermeasures and correction of adaptation to space syndrome and of motion sickness Lokomotsi – Kinematic and dynamic locomotion characteristics prior and after space flight Tendometria – Microgravity impact on induced muscular contraction

APPENDIX B: HUMAN SPACE EXPERIMENTS RESOURCES

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This short report provides a brief history of space flight, serves as a valuable resource for neurovestibular and sensorimotor space flight experiments conducted by all countries through 2005, and finally, it provides a comprehensive set of space flight physiology references with an emphasis on sensorimotor documents. Therefore, the intent and purpose of this historical overview of neuroscience and space flight is two-fold: First to equip researchers with a single, common reference document, and second, to allow those who helped create this history, a record of accomplishment.

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