INTERNATIONAL STRATEGIC PLAN FOR SPACE LIFE SCIENCES
Developed by the
International Space Life Sciences Working Group
(1995; rev. 1, October 2004)

I. INTRODUCTION

A. The International Space Life Sciences Working Group

Throughout the 1980s, the space agencies of the United States (National Aeronautics and Space Administration, NASA), Canada (Canadian Space Agency, CSA), France (Centre National d'Études Spatiales, CNES), Germany (Deutsches Zentrum für Luft- und Raumfahrt, DLR), Japan (National Space Development Agency of Japan, NASDA), and the European Space Agency (ESA) each pursued cooperative projects in the space life sciences through bilateral and multilateral agreements. By 1989, the growth of these life sciences programs reflected increased levels of maturity, ambition and complexity that argued for collective action to enable the future to develop in a strong, mutually beneficial way. Thus, discussions among the agencies' senior life sciences officials finally led to the formation of the International Space Life Sciences Strategic Planning Working Group, later called International Space Life Sciences Working Group (ISLSWG). Its overall mission was to develop a unified approach for space life sciences that would encompass the scientific and operational goals of the agencies, and that would extend to all space platforms and to current and future research activities on them. The first official meeting of the working group took place in October 1991; it formally adopted its Charter (see Appendix A), and began to function. The strategic plan that the Working Group was chartered to develop was drafted, released for agency review in 1994 and formally adopted in June 1995. Events and developments in recent years including the integration of the National Space Agency of Ukraine (NSAU) into the Working Group now calls for a revision of the original version of the Strategic Plan (for more detailed information on the individual member agencies, see Appendix B).

B. Purpose and Benefit of the Plan

This international strategic plan, developed by representatives of six space agencies, provides the multiagency framework for the development of the field of space life sciences in the 21st Century. This plan: presents the interests and goals of each participating space agency in the same format in order to identify the mutual interests and programmatic compatibilities of the various agencies; serves to enhance communication and unity among and between the participating space life sciences communities around the world; and enables a more complete coordination of the international development and utilization of space flight and special ground research facilities.

An international strategic plan is beneficial to all participants because the resources of the individual agencies and nations are insufficient to carry out the vigorous research program appropriate in the space life sciences. Pooling of resources and talent will strengthen everyone. Sound planning by the various space agencies will promote and increase the effectiveness of interactions among scientists around the world. While still maintaining individual agency autonomy for their own programmatic decisions, the member agencies have committed to support the unification of a world space life sciences community for the benefit of scientific progress in our field. The accomplishments achieved so far, such as joint recruitment, peer review and selection of flight experiments via International Life Sciences Research Announcements, coordination of facility development, and joint Research Area Workshops to review the status and to define future research strategies, clearly justify this approach (see Appendix C for detailed information on the accomplishments).

II. OVERALL GOALS OF THE PLAN

A. Definition of Space Life Sciences

Space is characterized by a unique set of environmental conditions. Its primary attributes are **microgravity** and **radiation**. The microgravity of low earth orbit provides the only way we can escape the effects of Earth's gravity for a long enough period to study the role that gravity has played and is still playing in the evolution and function of organisms. Microgravity has, therefore, become a new investigative tool that allows us to address questions of fundamental biological importance. This research involves determining the effects of gravity, from microgravity to hypergravity, on life forms from single cells and its constituents to whole organisms, including the human body. Space **radiation** studies and supporting ground research constitute a useful way to acquire further insight into fundamental biological processes. The different **magnetic fields** and **reduced convection** in space flight afford unique opportunities to probe biological mechanisms in new ways. Based on these deliberations the following definition for space life sciences is deduced:

Space life sciences is that area of life sciences research and technology that is concerned with interactions between living systems and any of the attributes of the space environment. The term "living systems" includes **all** of the **fundamental bioprocesses** of which they are comprised. The space life sciences include, but are not limited to, the following activities:

- the understanding of fundamental life processes by investigating how living systems respond and adapt to the space environment;
- the use of the capability afforded by space flight to understand the impact of biology on the Earth's ecological balance;
- the understanding of the origin, evolution, and distribution of life in the universe;
- the provision of operational medical support to all space missions involving humans and the development of protective and therapeutic means to cope with the hazards of space exploration; and
- the development of the scientific and technical foundation for expanding human presence beyond Earth orbit

Such research activities are supportive of the **three primary thrusts of the space life sciences:**

A. To develop an expanded understanding of living systems and ecology in the universe

B. To provide the scientific foundation and technological support systems to enable safe and productive human space activity

C. To use the knowledge acquired in the pursuit of space life sciences to improve the quality of life on Earth

During the last 20 years, significant scientific progress has taken place in all of these areas of space life sciences because of international cooperation. International space missions have utilized the U.S. Shuttle/Spacelab laboratory in space (SL-1, D-1, SLS-1, IML-1, SL-J, D-2, SLS-2, IML-2, Shuttle-to-MIR, NEUROLAB) and the Russian (Soviet) systems, Biocosmos and MIR. Such cooperation has been fostered by the development of strong working relationships among all of the major space-faring nations (see Appendix D for information on bi- and multilateral cooperations).

B. The Overall Goals

A major function of this strategic plan is to promote an understanding of the rationale for and importance of appropriate international cooperation in the space life sciences. The agencies participating in the development of this plan have reached agreement that the two primary goals defined below should form the foundation of all international activity in the space life sciences. These two goals relate to the conduct of research in space and to the exchange of knowledge and information within the international scientific community.

Goal 1: Strengthen Space Research

To strengthen space research by using an international framework to exploit the space environment for the optimal production of new scientific information in the space life sciences;

and

Goal 2: Enhance Knowledge and Information Exchange

To enhance the capability to coordinate and facilitate the international exchange of scientific and technological information and knowledge in order to:

- Improve the scientific foundation of our understanding of the processes related to life, health, and disease;
- Strengthen the scientific underpinning of programs to assure safe and productive human space flight; and
- Contribute meaningfully to the development of various applications of space technologies and biotechnologies to the solutions of the scientific and medical problems on Earth.

These goals transcend the specific scientific programs conducted by any of the individual space agencies and together span all of the current and potential activities in the space life sciences. The first is concerned with all aspects of the actual scientific studies in the space life sciences while the second is focused on the distribution and use of both the scientific results and the advanced technology resulting from these space studies.

III. A STRATEGY FOR SPACE LIFE SCIENCES

A. Guiding Principles for the International Strategy

In the following, strategies are elaborated to achieve each of the above goals. These strategies are consistent with the current plans of each of the member agencies. Through this plan, a framework is defined that facilitates the identification of opportunities for coordination and cooperation utilizing the full range of space carriers, platforms, ground-based facilities, and scientific expertise for the ultimate good of the international space life sciences community.

A number of fundamental principles form a common ground of understanding and the basis for this strategy among the members. These guiding principles cut across all of the management elements of the plan, and the understanding that they engender provides a unified conceptual basis for the plan:

- Promote the highest quality scientific investigations, consistent with the particular constraints defined by a research opportunity;

- Preserve the autonomy of each of the member space agencies participating in cooperative activities;

- Optimize the utilization of scarce resources by avoiding unnecessary duplication of equipment, by sharing equipment and flight opportunities, and by cooperating with all members whenever possible; and

- Recognize that access to space is a precious resource and that it should be shared among members whenever feasible to maximize science return.

B. Strategic Implementation Elements

The approach to achieve each of the strategic goals is based on the application of implementation elements common to each of the member agencies and directed to achieve specific objectives required to meet the strategic goals. These implementation elements and their associated objectives for meeting the Strategic Goals are presented below.

Goal 1 – Strategy to Strengthen Space Research

- Management and Policy

  Each member agency will provide resources to support the Working Group including the attendance of the Working Group representative(s) at regular meetings to exchange program status and actively implement the strategic plan. These meetings will generally be held twice yearly, and member agencies will rotate responsibility for hosting these meetings.

  The member agencies will promote mechanisms for making space research an international activity by alerting Agency management of potential international space research opportunities and encouraging agencies to make opportunities available to the international community.

- Discipline Review and Planning

The member agencies will define scientific research areas in the space life sciences using common terms and promote the dissemination of these common terms among their respective science communities (see Appendix E). It is expected that this will enhance effective communication among agency personnel and allow the scientific communities to more clearly advocate various programs in a uniform way.

The member agencies will conduct international workshops and reviews of the status of space research in each scientific research area in order to define the critical science questions and determine the relative importance of these questions. The results of these workshops and reviews will be published, preferably in refereed scientific journals so that the status of knowledge and critical questions in each research area may be readily available to the international science community. As time, research results, and new hypotheses and methods warrant, research areas will be revisited periodically.

- Science Solicitation, Review, and Selection

The member agencies will make flight opportunities available to the international scientific community on a competitive basis using a wide distribution of announcements of opportunities. The processes used for the evaluation and selection of space flight investigations will be standardized and a common core set of evaluation and selection criteria will be used by all agencies to select flight investigations.

- Flight and Ground Facility Development and Sharing

The member agencies will optimize the use of existing space hardware and ground facilities and promote the sharing of this hardware by preparing a catalog or website listing(s) of space hardware and ground facilities for all scientific research areas. These critical resources and associated information will be available to the international science community in a companion document accompanying international solicitations for flight experiment research. As such, members will make such hardware available through appropriate agreements, as needed. Moreover, members will exchange information on the planning for new hardware and facilities and coordinate the developments as appropriate.

Goal 2 - Strategy to Enhance Knowledge and Information Exchange

- Management and Policy

The member agencies will work to develop policies to assure international exchange of scientific information in order to optimize the yield of space research to meet agency science objectives and priorities.

- Investigator Community Development

The member agencies will devote resources to informing the scientific community at large about the scientific results obtained from space studies in life sciences such as space-related scientific sessions at regular meetings of the major scientific societies. Whenever appropriate dedicated meetings will be held and reports prepared to facilitate information exchange, collaboration, and leveraging of research resources.

This will serve to encourage development of stronger partnerships between space agencies and traditional science funding agencies within each country or region.

- Data Archiving, Distribution, and Utilization

The member agencies will promote archiving of space flight data and publicize the availability of such data to the international scientific community. In addition, a uniform approach to data and bibliographic archiving that minimizes the difficulty associated with obtaining data and results should be established.

- Educational Activities

The international exchange of graduate and postgraduate students in the space life sciences should be encouraged and educational materials should be developed and made available to all agencies for distribution in their respective countries or regions.

- Public Outreach and Information

The member agencies will use appropriate communication media to insure a wide dissemination of information concerning space life sciences programs and results. Wide circulation of this material will encourage the dialogue between the space life sciences community and the non-space life sciences community regarding the real and potential Earth benefits of space research.

IV. CHALLENGES AND VISION FOR THE NEXT 10 YEARS AND BEYOND

The 21st century will – not the least by utilization of the International Space Station – lead to a stable era of research in space with a healthy and dynamic community. In order to be successful in this endeavour an unprecedented level and quality of international cooperation among agencies that traditionally have exercised almost complete management autonomy in the pursuit of their individual goals and objectives is required. Only with this approach, the next logical steps in human spaceflight including the exploration of Mars can be achieved. More specifically, our goals for the next 5-10 years therefore include:

- Enhancing international coordination between space agencies to increase space research opportunities, facilitate access to space laboratories, and assist in making scientific operations in space routine;

- Advancing the understanding of the influence of gravity on living systems thereby probing and challenging fundamental biological principles;

- Moving toward greater understanding of the mechanisms underlying physiological adaptation to space flight and developing ways to present or protect crews from the undesirable effects of extended exposure to the environment of space;

- Attaining a fuller understanding of the toxicological and microbial hazards within and outside spacecraft and develop more effective monitoring and preventive measures to ensure the safety and productivity of crew members during long-term exposure the space environment;

- Establishing accurate probabilities (in excess of natural incidence) of deleterious health effects resulting from the space radiation environment, including carcinogenic and mutagenic effects;

- Assisting in the application of new knowledge and technology to the alleviation of disease and other health problems on Earth;

- Moving forward in the development of technologies and procedures necessary for comprehensive life support systems leading to a closed, regenerative life support system which can be made possible by improvements in waste management systems, sensors, bioregeneration, and air and water reclamation, coupled with active thermal control;

- Addressing through space human factors research high-risk areas in crew performance and define requirements and develop systems to support mission work analysis, workload assessment, scheduling, and communication interfaces. Among other applications, this work will improve crew selection and training, habitability, human-machine systems, and automation interfaces;

- Developing improved management interfaces and outreach processes to enlarge scientific community participation in space life sciences research, and make research results more accessible by the scientific community.

V. SUMMARY: KEY FEATURES OF THE STRATEGIC PLAN

Strategy for Goal 1 "Strengthen Space Research"

- Support regular meetings of the Working Group
- Internationalize Space Research Opportunities and Make Flight Opportunities Available to International Community on Competitive Basis
- Standardize Definitions of Research Areas
- Review International Research Progress and Assess Critical Questions in Disciplines
- Standardize the Process used to Evaluate and Select Space Investigations
- Optimize the Use of Existing Space Hardware and Special Ground Facilities Among International Community
- Coordinate the Planning and Development of New Space Hardware or Special Ground Facilities

Strategy for Goal 2 "Enhance Knowledge and Information Exchange"

- Encourage the Development of Agency Management Policies that Assure the Exchange of Scientific Information
- Inform the Scientific Community of the Results of Space Missions, e.g. by Developing an Annual Report of International Space Research Activities
- Encourage the Development of Partnerships Between Space Agencies and Traditional Science Funding Agencies Within Each Country
- Support the Preservation of Space Flight Data and Provide the International Scientific Community with Access to these Data
- Encourage the International Exchange of Graduate and Postgraduate Students
- Support the Development of Educational Materials Related to the Space Life Sciences and Coordinate Activities as Appropriate
- Develop an International Report on the Benefits of Space Life Sciences Research

Appendix A. **Charter for the Working Group**

INTERNATIONAL SPACE LIFE SCIENCES WORKING GROUP (ISLSWG)

Charter

15 March 1990, revised October 20, 2004 and September 29, 2005

1.0 Background

During the 1980's, each of the member agencies with an interest in and commitment to the space life sciences has pursued vigorous international cooperative programs and projects on a bilateral or multilateral basis. By 1989, the various space life sciences programs within these agencies reached a level of maturity which justified coordinated strategic planning to cope effectively with future multilateral research programs and implementation issues, leading to the idea of an international working group.

2.0 Purpose of the Charter

The purpose of this Charter is to establish the International Space Life Sciences Working Group (originally named International Space Life Sciences Strategic Planning Working Group, hereinafter called the Working Group), to define its mission and set up its rules.

3.0 Working Group Mission

The mission of the Working Group is to achieve coordinated strategic planning and implementation for space life sciences activities. To reach this goal a Strategic Plan is established, regularly updated and implemented.

4.0 Strategic Plan

The resultant Strategic Plan will contain a common set of goals and objectives derived from the current plans of each of the participating agencies. This plan will include both current and future activities in the space life sciences and will provide a framework that facilitates the identification of opportunities for coordination and cooperation utilizing the full range of space carriers and platforms.

5.0 Other Activities

The Working Group may coordinate, by consensus of all participating agencies, other multilateral activities related to the Strategic Plan. These activities may require the formation of implementation teams with a membership determined by the agencies actually involved in the specific programs or projects requiring multilateral coordination.

6.0 Scope of the Charter

This Charter is applicable to those agencies which agree to participate in this Working Group by signature, contribute to the development of the Strategic Plan and/or its regular update, and seek the implementation of the cooperative programs defined in this plan. This Charter is limited to those programs agreed upon and described in the Strategic Plan, and does not supersede any existing bilateral or multilateral agreements and/or ongoing projects of any participating agency.

7.0 Working Group Membership

Each agency participating in this Working Group will officially designate in writing up to two representatives to serve on this Working Group. The member agencies as of the effective date of this Charter in its revised form are the National Aeronautics and Space Administration (NASA), the European Space Agency (ESA), and the national space agencies of Canada, France, Germany, Italy, Japan, and the Ukraine. Changes in individual representation shall be effected by written notification from an authorized official of the Charter agency to the Working Group co-chairpersons.

Upon request, other governmental agencies with programs in the space life sciences will be considered for membership in this Working Group, as appropriate. Inclusion of new member agencies shall be effected by amendment of this Charter.

8.0 Working Group Chairpersons and Executive Secretary

The Working Group will have two co-chairpersons selected annually from among the representatives on the Working Group. One co-chairperson will be from NASA. An Executive Secretary will be chosen annually by the Working Group. The Co-chairpersons are responsible for developing the agenda for each Working Group meeting, with the assistance of the Executive Secretary. The Executive Secretary is responsible for the preparation and distribution of the minutes of each meeting, and is supported in this activity by the agency hosting the meeting.

9.0 Meetings

Meetings of the Working Group will in principle be held twice a year, and as determined by the Co-chairpersons. Meetings will be hosted on a rotating basis by each participating agency.

Regular meeting attendance is strongly encouraged to ensure effective coordination among the Charter agencies. If a Charter agency fails to participate in two consecutive meetings of the full Working Group, the co-chairpersons will consult with that Charter agency regarding the desirability of continued participation in the Working Group.

10.0 Minutes

Minutes will be prepared by the Executive Secretary and distributed to the Working Group members no later than 45 days following each meeting. Each member agency is responsible for assuring that the minutes are reviewed by the appropriate agency personnel, and that additions, deletions, and corrections are returned to the Executive Secretary within 30 days of the receipt of the minutes. Approval of the minutes by the members will take place at the subsequent meeting.

11.0 Agency Coordination

The agency representatives to the Working Group are responsible for making certain that appropriate senior management personnell and relevant advisory committees, if any, from their agency are fully aware of the activities of the Working Group. The agency representatives are responsible for securing the necessary approvals for all such activities according to the rules and procedures of that agency.

12.0 Expenses

Each agency will bear the costs of discharging its respective responsibilities related to the activities of this Working Group without transfer of funds, including travel and subsistence of its own personnel as required to attend meetings.

13.0 Duration and Amendment of Charter

This Charter will become effective upon signature of at least four of the Charter agencies listed in Section 7.0 above. This Charter can be amended by written agreement of each Charter agency. This Charter will continue in effect for five (5) years from this effective date. After this period, the Charter may be renewed by amendment.

14.0 Termination of Participation

An individual representative or Charter agency may terminate their participation in this Working Group with 90 days prior written notification to the co-chairpersons.

Appendix B. Agency/Program Descriptions (February 2006)

Agenzia Spaziale Italiana (ASI)

ASI, the Italian Space Agency, was established in 1988 to develop a National Space Plan, PSN, based on a strategic approach including the following guidelines:

- Development of public utility services;
- Development of space infrastructures and instrumental technological products to achieve technological excellence and industrial competitiveness;
- Strengthen and enhance Italian space scientific knowledge to gain scientific excellence;
- Establishment of international cooperation;
- Complementary policies, among which the development of technological transfer opportunities and growth of Small and Medium Enterprises, SME.

The ASI Life Sciences Programme, began in 1989 as part of an overall scientific programme. Today, the Programme, Medicine and Biotechnologies, MED, has the objective to gain knowledge through space research in order to transfer it to medical applications on Earth.

The Programme is focused on three main application oriented research areas aiming to define clinical protocols and develop adequate therapeutic and preventive measures:

- Osteoporosis and Muscle Atrophy, OSMA, aiming at a better understanding of the mechanisms of the muscle-skeleton system adaptation in hypogravity conditions and inactivity;
- Disorders of Cardiorespiratory and Motor Control, DCMC, to understand the mechanisms underlying the cognitive and motor perception disorders and cardiovascular deconditioning;
- Biotechnological Applications, MoMa (from Molecule to Man), studying the effects of cosmic radiation and microgravity on the biological systems, and transferring the acquired knowledge to diagnostic, therapeutic and preventive applications.

To achieve the goals of the MED Programme, ASI is developing different facilities to be used onboard the International Space Station also in the frame of the bilateral and international cooperations.

Canadian Space Agency (CSA)

The Canadian Space Agency (CSA) was established in 1989 with the mandate to promote the peaceful use and development of space for the social and economic benefit of Canadians. However, Canada's experience in space began in 1962 with the launching of the Alouette 1 research satellite. Canada was the third country in the world after Russia and the United States to design and build its own satellite. The CSA has headquarters in the Montreal Metropolitan.

The Space Life Sciences program of the Canadian Space Agency brings together researchers from academia, industry, and various organizations to learn how humans adapt to life in space and how they again adapt upon their return to Earth. Particular areas of interest include bone and muscle loss, adaptations of the heart and other body systems and organs to weightlessness, whether organisms mature differently in space than on Earth, effects of space radiation on living things and space psychology.

The primary objectives of the CSA's Life Sciences program are:
1. To understand the role of gravity in life processes.
2. To better understand how life functions and adapts to the environment of space and readapts upon return to the conditions on Earth
3. To obtain knowledge and develop technology to produce safer space travel and improve life on Earth.

These three objectives are met through a vigorous multi-step research program that is broadly split into three phases: (a) building a competitive community, (b) developing mission opportunities and (c) producing scientific results for Canadians.

As a member of the International Space Life Sciences Working Group, the CSA works co-operatively with other Space Agencies to provide research opportunities. By working together, costly duplication of space hardware is avoided and the precious resources are pooled and used to the maximum in a true expression of the international goodwill that has always characterized the ISS. Space Life Sciences stimulates both the academic and industrial sectors within Canada. Meeting the challenges of working in the space environment keeps Canada on the leading edge of science and technology.

Centre National d'Études Spatiales (CNES)

CNES, the French Space Agency, created in 1961, was commissioned by the government to outline the broad objectives of French space policy, to develop the necessary scientific and technical tools, and to ensure their synergy.

France implements a coherent and balanced program which features six major goals:

- Guarantee autonomous access to space for France and Europe;
- Reinforce the main applications of space (telecommunications and Earth observation);
- Coordinate civilian and military developments for space utilization;
- Develop the technologies needed for future space activities;

- Promote space research in the field of space sciences;
- Participate in programs of orbital infrastructures and in-orbit experiments

CNES life sciences began in 1970 and has become an important program for on-orbit experimentation and cooperation with the US, Russia and ESA. The main fields of investigation, whether ground or flight, are:

- Neurosciences: sensorimotor, cognition, and development;
- Cardiovascular physiology: blood pressure and heart rate regulation;
- Musculoskeletal physiology: atrophy and osteoporosis;
- Gravitational biology, radiobiology, and dosimetry;
- Exobiology.

The flights of French astronauts have greatly contributed, and will continue to do so in the future, to the successful accomplishments of the scientific programs. CNES has initiated a national Institute for Space Medicine in Toulouse, called MEDES, which provides logistic support for CNES.

Planetary exploration, and in particular its human component, is becoming a key element of CNES activities.

Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center, DLR)

The German Life Sciences Program is managed – like all other space programs and activities in Germany – by the German Aerospace Center (DLR). In addition to its important role as major research center in the areas of aeronautics, space flight, transport, and energy DLR is thus the space agency for Germany acting on behalf of the German government according to the Space Activities Act (Raumfahrtaufgaben-Übertragungsgesetz). As such DLR has three major responsibilities:

- To establish the German Space Program with its three integrated parts on behalf of the German government (natl. Program, DLR intramural R&D program, ESA microgravity programs)
- To implement the program by e.g. placing contracts to industry for the development of experiment facilities, by providing flight opportunities, and by funding of research institutes (universities, Max-Planck- and other research institutes)
- To establish international coordination and cooperation (bi- and multilateral)

Based on its political objectives a new space program was approved by the German government in May 2001, which defines the overall goals and objectives as well as the strategic cornerstones, by which these goals should be achieved. In this context also the goals and priorities of the Life Sciences Program were intensively and critically discussed with experts inside and outside of space activities. The overall goal is defined as

- To gain scientific knowledge by fundamental and application-oriented research in life sciences by utilizing the extraordinary environmental conditions of space, especially microgravity

Three main scientific areas are in the focus of the program:

- Fundamental biology of gravity and radiation responses with special emphasis on signal transduction of gravity, mainly in plants and microorganisms as well as questions of dosimetric mapping of radiation and of the origin and distribution of life

- Biotechnological application of the microgravity environment in order to improve biotechnological processes as products (protein crystallization, tissue engineering, bioreactor technology for biological life support systems)

- Integrative human physiology aiming at a better understanding of the function of the various systems of the human body and its integrative interplay with special regard to the adaptation to altered gravity conditions (cardiovascular, vestibular, bone and muscle, nutrition research, psychophysiological fitness, telemedicine)

For achieving these scientific objectives special facilities and flight opportunities are necessary. German space companies have a long-standing experience in the development and building of such facilities. This experience is currently being used for the development of a number of facilities especially for the International Space Station in close coordination and cooperation mainly with ESA and NASA. Also, utilization of the Bremen Drop Tower, of TEXUS sounding rockets and of parabolic flights with the CNES airbus will further be made possible.

Especially in the era of the International Space Station most activities are embedded in the framework of close international cooperation. Besides the European Space Agency (ESA), DLR's bilateral and multilateral partners include, above all, the USA, but also Russia, France, Canada, Japan, and China.

European Space Agency (ESA)

The European Space Agency, ESA, is an international organization whose task is "to provide for and to promote, for exclusively peaceful purposes, cooperation among European states in space research and technology and their space applications." ESA has 14 Member States: Austria, Belgium, Finland, France, Denmark, Germany, Italy, Ireland, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom. Canada takes part in some projects under a cooperative agreement.

The Agency was born in 1975 from the merging of two organizations that had already been involved in the European space effort since the early '60s: ESRO (the European Space Research Organization) in charge of developing satellites, and ELDO (the European Launcher Development Organization) involved in developing and building a European launcher. ESA is to Europe what NASA is to the USA. It draws up a European space plan and has the task of carrying it out. ESA's involvement spans the fields of space science, Earth observation, telecommunications, space segment technologies including orbital stations and platforms, ground infrastructures and space transportation systems, as well as basic research in microgravity (the technical term for "almost complete absence of gravity").

ESA has its headquarters in Paris, France. This is where ESA's Director General has his office and where the Agency's governing body, the Council, meets. The Council is made up of government representatives from the various Member States and is supported by a number of committees dealing with the science program, industrial policy, international relations and administrative and financial matters. The various program directorates are also housed at ESA Headquarters, together with the administrative services. Headquarters has a staff of approximately 350.

The Agency has a number of establishments (ESTEC, ESOC, ESRIN and EAC), a launch base at Kourou in French Guiana, a liaison office in Washington, DC, an office in Brussels for relations with the European Community, and a liaison office in Moscow for common projects with Russia.

Microgravity research first appeared in the 1970's when both Americans and Soviets carried out experiments during some of their manned space flights. The interest of European scientists in the new research field was stimulated when Europe decided to develop Spacelab as a European contribution to the U. S. Space Shuttle program. During the late 1970's several multi-user experiment facilities such as furnaces, growth chambers and a vestibular research facility (Sled) were developed in Europe, specifically for use in Spacelab on its first flight.

ESA's Microgravity Research Program covers a wide range of fields such as solidification physics (e.g., crystal growth, metallurgy), physical chemistry, and fluid sciences. It also includes the life sciences, whose span includes biology, biotechnology, human physiology, and medicine. The Agency's Microgravity Program formally started on 15 January 1982, when Member States agreed that such a program, of which the initial step (Phase 1) lasting four years was to be carried out as an optional program. The Phase 1 included several basic elements, one of which was dedicated to the life sciences: development and flight of Biorack, a multipurpose facility for cell biology, on the Spacelab mission D-1.

In 1985, Phase 2 of the Microgravity Program, covering the period 1985-88 was approved and 11 Member States participated in this program. The Challenger disaster in January 1986 resulted in a serious discontinuity, of six years' duration, of Spacelab flight opportunities with European participation. This accident led to delays in payload development and to a partial reorientation of the program. More emphasis was given to Sounding Rockets and a cooperation in biological payloads (Biokosmos flights) was established in 1987 with the former Soviet Union. Therefore, in 1988 the First Extension of Phase 2 was approved; it lasted until January 1992 at which time Spacelab flights with European participation (IML-1) were resumed.

Up to now, the most important flight opportunities for microgravity research experiments were provided by Spacelab missions. Today, after five Spacelab missions with ESA participation, there are several hundreds of scientists and engineers in Europe who are working on various aspects of research exploiting the microgravity environment in space in the context of ESA's Microgravity Program. The five Spacelab missions just mentioned were the first Spacelab mission, SL-1, carried out as a joint ESA/NASA mission in late 1983, the German Spacelab missions, D-1 and D-2, with a strong ESA participation flown in October/November 1985 and April 1993 respectively, and the International Microgravity Laboratory missions, IML-1 and IML-2, both with a major ESA participation and flown in January 1992 and July 1993 respectively.

In addition, about 200 short duration experiments were carried out with sounding rockets (typically seven minutes of microgravity duration). Also, carriers of the former Soviet Union, mainly the unmanned retrievable spacecraft called Biokosmos or Foton, were used in the aftermath of the Challenger accident in ESA's Microgravity Program. Other experimental opportunities are provided by drop towers (a few seconds) and aircraft flying parabolic trajectories (approximately 20 seconds). In addition, the EURECA mission in 1992/93 provided a very useful opportunity for long duration experiments.

In 1992, the Microgravity Program Board adopted a resolution on the future structure of the Microgravity Program, which was approved by the Council at Ministerial level. The Resolution stated that in future the Agency's Microgravity activities should be split into two distinct financially independent elements:

- A basic European Microgravity Research Program (EMIR) for covering basic research activities and ensuring a continuation of the microgravity experimentation possibilities to the user community on a long-term basis.
- A program to develop the facilities required for microgravity experiments to be carried out in the Columbus Attached Laboratory (MFC = Microgravity Facilities for Columbus).

In 2001 a new Research Plan and Program was approved. The Research Plan is based on 14 identified Research Cornerstones in Physical and Life Sciences, and the Programmed is named ELIPS (ESA program in Life and Physical Sciences and Applications). In addition the Aurora Program launched in 2001 and focusing on future human Mars missions includes the conduction of Life Science studies regarding Exobiology and Preparation for Human Planetary Exploration.

The Agency solicits experiment proposals with Announcements of Opportunity which are followed by science and technical peer reviews that make recommendations about flying experiments in space. Final selection rests with the responsible HSR Program Board (Human Spaceflight and Research). The necessary guidance and advice in scientific matters rest with the Life Sciences Working Group, composed of outside ESA scientists and experts in the relevant fields of research.

Japan Aerospace Exploration Agency (JAXA)

Foundation

In the middle of the 20th century three organization were established in Japan: The Institute of Space and Astronautical Science (ISAS), which was devoted to space and planetary research; the National Aerospace Laboratory of Japan (NAL), which focused on research and development of next-generation aviation; and the National Space Development Agency of Japan (NASDA), which was responsible for development of large-size launch vehicles, as represented by H-IIA, satellites, and the International Space Station.

On October 1, 2003, ISAS, NAL and NASDA were merged into one independent administrative institution: the Japan Aerospace Exploration Agency (JAXA). The consolidation of these three formerly independent organizations will allow a continuous and systematic approach to space exploration, from basic research to development and practical application.

Short Historical Milestone of the Space life science before JAXA was established.

1980 Space experiments of 62 were selected as the candidates to fly on Space Shuttle.
1989 Japanese government agreed to join International Space Station Program.
1992 SL-J (Fuwatto '92) was launched to implement 35 Japanese Experiments. (The first step of Japanese space utilization experiments.)
1994 International Micro gravity Labolatory-2(IML-2)
1998 STS-95 Space HAB mission

Organization

Japan's Space Development Program is planned and supervised by the Space Activities Commission, an advisory committee to the Prime MinsterJAXA is supervised by the Ministry of Education, Culture, Sports, Science and Technology. JAXA organization is consists of four independent program offices: Office of Space Flight and Operations, Office of Space Applications, Institute of Space Technology and Aeronautics and Institute of Space and Aeronautics Science. The Human Space Systems and Utilization Program Office in the Office of Space Flight and operations of JAXA is in charge of the development of JEM (KIBO) for ISS, the promotion and the implementation of space utilization research, both orbital experiment and ground based research, and the development of experiment hardware for ISS-JEM.

Location

Headquarters: 7-44-1 Jindaiji Higashi-machi, Chofu-shi, Tokyo 182-8522, Phone +81-422-40-3000

Tokyo Office: Marunouchi Kitaguchi Building, 1-6-5 Marunouchi, Chiyoda-ku, Tokyo 100-8260, Switchboard (main switchboard) Phone: +81-3-6266-6400

Office of Space Systems: Tsukuba Space Center (TKSC) 2-1-1, Sengen, Tsukuba-shi, Ibaraki 305-8505, Phone: +81-298-68-4000, Fax: 81-298-68-2950

Launch Site:
1. Tanegashima Island, Kagoshima Prefecture, Japan. (for H-II)
2. Uchinoura, Kagoshima Prefecture, Japan. (for M-V)

Tracking stations
There are several tracking stations for vehicles and satellites.(Katsuura, Tanegashima, Okinawa etc.)

Overseas Offices: Washington D.C., Los Angeles, Houston, KSC, Paris, Bonn, Bangkok

Programmatic Aspect
JAXA emphasize the significance of space utilization including Life Sciences on the following points:
(1) Fulfillment of curiosity; fundamental science. Origin of life, mechanisms of living system.
(2) Contribution to social welfare, medical care, environment.
(3) Expansion of human activity to space, human space exploration.

Fundamental science is aggressive area in Japan. Research on the human space exploration is expected to grow in near future.

Emphasis in Life Science Research
Fundamental Biology
(1) Clarification of Cascade of Biological Reactions Originated from the Change in the Gravity Environment. (The word “cascade” is used here to imply a wider range of reactions in the all hierarchy of living system from molecule to whole body.)
(2) Multi-Generation Study of Living Organisms under Space Environment

Medical Sciences
(1) Elucidating the Mechanism of the Body Responses to the Stress under Space Environment
(2) Study on the Adaptation of Human Body to the Extended Exposure to Space Condition and the Development of Countermeasure
(3) Study on the Human Factor in the connection with Long Duration Space Flight

National Aeronautics and Space Administration (NASA)

The National Aeronautics and Space Administration came into existence October 1, 1958, established by an Act of Congress July 16, 1958. The immediate cause for the creation of a civilian space agency was the Soviet Union' launch of Sputnik 1, the world's first artificial satellite. NASA was formed from the National Advisory

Committee for Aeronautics (NACA), the Vanguard Division of the Naval Research Laboratory, the Jet Propulsion Laboratory, the Development Operations Division of the Army Ballistic Missile Agency, and the Missile Firing Laboratory to lead the nation in civil aeronautics and space. NASA has taken us to the edge of the solar system and beyond, exploring every planet, to include Earth and its moon, with the exception of Pluto, using the Surveyor, Ranger, Lunar Orbiter, Pioneer, Viking, and Voyager scientific spacecraft. Earth satellites have allowed for worldwide communication and improved weather prediction, crop inventories, and oceanic, geological, and urban development studies.

The first decade of NASA's space activity was dominated by the challenge issued by President John F. Kennedy in May 1961, to place a man on the moon and return him safely to Earth by the end of the decade. On July 20, 1969, Apollo 11 astronaut Neil Armstrong became the first human to step on the Moon. This achievement built upon the preceding Mercury and Gemini projects which demonstrated a human tolerance for space flight and the capability to build the launch vehicles and spacecraft necessary for such a complex mission. The last Apollo mission in December 1972 was followed by three Skylab missions (1973-74) which adapted Apollo hardware into an "orbiting workshop" to study the effects of long-duration space flight on humans and to make astrophysical observations, particularly of the sun. In July 1975, Americans joined hands with Soviet cosmonauts during the first large-scale international cooperative human space flight, the Apollo-Soyuz Test Project (ASTP), but six years lapsed before another human flight. First flown in 1981, the space shuttle was designed to provide routine access to space (as well as to the international space station) by incorporating the qualities of winged aircraft with rocket propelled spacecraft to form a reusable system. The space shuttle deployed a variety of satellites and space probes during the first 24 missions that preceded the Challenger accident of January 28, 1986. Though never able to attain its originally planned flight rate, the shuttle was redesigned and returned to flight in October 1988 and has flown nearly 70 successful missions through the end of 1994.

NASA's programs in the space life sciences are managed by several organizations. All of these programs are focused on ensuring the health, safety, and productivity of humans in space, or on acquiring fundamental scientific knowledge in the space life sciences, or on both. The major goals of the space life sciences within NASA are to:

- Effectively use microgravity and the other characteristics of the space environment to enhance our understanding of fundamental biological processes;

- Understand the origin, evolution, and distribution of life in the universe;

- Provide operational medical support to all space missions involving humans;

- Develop the scientific and technological foundations for a safe, productive human presence in space for extended periods and in preparation for exploration; and

- Apply this knowledge and technology to improve our nation's competitiveness, education, and the quality of life on Earth.

In 2001, with the installation of a new administration, the NASA Vision and Mission were clearly articulated:

The NASA Vision:

To improve life here,
To extend life to there,
To find life beyond.

The NASA Mission:

To understand and protect our home planet
To explore the universe and search for life
To inspire the next generation of explorers
…as only NASA can.

The implication of the statement "…as only NASA can" is that the agency will pursue those research and technology activities and elements that uniquely address the Vision and Mission.

On January 14, 2004, the President directed NASA to embark on a robust space exploration program that will advance the Nation's scientific, security, and economic interests. This is the fundamental goal of the Vision for Space Exploration. NASA's exploration program will catalyze new discovery and understanding, inspire the next generation of explorers, lead to peaceful exploration of the Solar System by many nations, spark commerce between Earth and space, invigorate America's high-technology industry, and benefit life on Earth.

The Vision for Space Exploration defines a new U.S. space exploration policy. In support of this policy, through a renewed spirit of discovery, NASA will:

- Implement a sustained and affordable human and robotic program to explore the Solar System and beyond
- Extend human presence across the Solar System, starting with a human return to the Moon by the year 2020, in preparation for the human exploration of Mars and other destinations
- Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about destinations for future human exploration
- Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.

The Research and Technology Development Division of the Exploration Systems Mission Directorate manages research in fundamental and applied physical, biological, and biomedical areas, as well as related technology development. Research and technology development in all areas is focused to ensure the health, safety, and performance of human space explorers during and following exploration missions.

NASA operates nine Field Centers from its Headquarters in Washington, DC. These include: Ames Research Center, Moffett Field, CA; Dryden Flight Research Center, Edwards, CA; Goddard Space Flight Center, Greenbelt, MD;

Jet Propulsion Laboratory, Pasadena, CA; Lyndon B. Johnson Space Center, Houston, TX; John F. Kennedy Space Center, Kennedy Space Center, FL; Langley Research Center, Hampton, VA; GlennResearch Center at Lewis Field, Cleveland, OH; Marshall Space Flight Center, Huntsville, AL; John C. Stennis Space Center, Stennis Space Center, MS.

National Space Agency of Ukraine

The National Space Agency of Ukraine (NSAU) was created in 1992 with the mandate to develop and execute the state policy in space exploration and utilization. NSAU has headquarters in Kiev.

Since the creation of NSAU, the most of government-sponsored space activities in Ukraine are being carried out in the framework of the National Space Program. One of the priorities of this program is scientific space research, including research in the domain of life sciences. NSAU space life sciences program is being managed by the Department of Space Programs and Scientific Research.

Space biology began to develop in Ukraine in the early 1970s. Since 1974, about 60 biological experiments, with bacteria and plants, which were in the physiologically active state during space flight, have been performed on board the biosatellites in cooperation with the Institute of Medical and Biological Problems (IMBP), Moscow, the spaceships and orbital stations SALYUT and MIR in cooperation with the ENERGIYA Association, Moscow, under the international SOYUZ-APOLLO, CYTOS, CHLORELLA, AZOLLA, PROTOPLAST, etc. and national space biological programs. Simultaneously, the series of ground-based experiments which simulated the influence of all space flight factors were performed. More than 50 biotechnological experiments under the programs TAVRIYA and MICROFOR have been performed on the orbital stations SALYUT and MIR.

In 1997 the Collaborative Ukrainian Experiment was carried out onboard STS-87 Space Shuttle Columbia mission. The main goal of CUE was to study plant growth and development at the molecular, cellular and organism levels under microgravity conditions during the 16-day space flight. Since 1993, fundamental and applied developments in Ukraine are the part of the National Space Program; they are being funded by NSAU and performed in the institutes of the National Academy of Sciences of Ukraine, Academy of Medical Sciences of Ukraine, universities and other organizations.

Priorities in space life sciences program are aimed at:

1) the elucidation of cellular, subcellular and molecular mechanisms of the biological effects of microgravity and the creation of space cell biotechnologies based on the changes in cell metabolism (primary and secondary) in microgravity, and
2) working out the concepts on growth, development and resistance of organisms in space flight as a background for development of biotechnologies for Controlled Ecological Life Support System (CELSS).

Fundamental areas:

- cell biology in microgravity; elucidation of cell and molecular mechanisms of gravisensitivity of living organisms;
- the role of calcium ions in the biological effects of microgravity; determination of gravity- and calcium-dependent cell processes;
- developmental biology of plants and animals in microgravity; obtaining the secondary and next generations of plants by seed reproduction;
- the aging process in microgravity, its rate and patterns under the influence of altered gravity;
- interrelations of prokaryotic (pathogenic, associating and symbiotic) and eukaryotic organisms in microgravity, and the estimation of pathogenicy of bacteria and viruses in these conditions.

Applied areas:

- working out space cell biotechnologies and improvement of electrophoresis technologies in microgravity for obtaining the preparations of biologically active substances and homogenous cell populations for medicine, pharmaceutical industry and agriculture;
- creation of technologies of space plant growth and waste utilization on the basis of cultivation of Californian worm for use in CELSS onboard the space vehicles;
- development of new hardware for carrying out biological and biotechnological space experiments;
- working out the program of biological and biotechnological experiments onboard the biosatellites, space ships and orbital stations with a view to create the experimental basis for new scientific concepts and biotechnologies.

In order to fulfill space life sciences program, NSAU takes efforts in establishing close international cooperation with Russia, USA, and other partners.

Appendix C: Accomplishments (April 2006)

To strengthen space research and to enhance knowledge and information exchange are defined in the Strategic Plan as the two overall goals. Also, strategic measures and activities to achieve these goals are identified. This appendix gives a summary on accomplishments already achieved ranging from a history of meetings, overview on research area workshops held, international research announcements issued, agreements signed and major missions jointly realized.

History of ISLSWG Meetings

As defined in the Charter of the Working Group, meetings should be held twice a year, being hosted on a rotating basis by each participating agency. This rule has been followed very regularly as can be seen from the list of ISLSWG meetings below.

Date	Location	Co-Chairs	Exec. Secretary
10/91	Montreal (CSA)	White (NASA), Oser (ESA)	Mortimer (CSA)
04/92	Frascati (ESA)		
09/92	Paris (CNES)		
06/93	Washington (NASA)	White (NASA), Mortimer (CSA)	Ruyters (DARA)
10/93	Cocoa Beach (NASA)		
03/94	Norderney (DARA)		
09/94	Cordes (CNES)		
04/95	Tsukuba (NASDA)	White (NASA), Nagaoka (NASDA)	Guell (CNES)
10/95	Vancouver (CSA)		
04/96	Frascati (ESA)		
10/96	Bonn (DARA)	White (NASA), Ruyters (DARA)	Mortimer (CSA)
03/97	Washington (NASA)		
10/97	Paris (CNES)	Vernikos (NASA), Guell (CNES)	
04/98	Cocoa Beach (NASA)		
10/98	Tokyo (NASDA)	Vernikos (NASA), Schmitt (ESA)	
04/99	Frascati (ESA)		
09/99	Ottawa (CSA)	Vernikos (NASA), Matsumiya (NASDA)	

04/00	Friedrichshafen (DLR)	
10/00	Avignon (CNES)	Ahlf (NASA), Matsumiya (NASDA)
04/01	Kiev (NSAU)	Ruyters (DLR), Schmitt (ESA)
12/01	KSC (NASA)	
05/02	Banff (CSA)	Ostrach (NASA), Pustovyi (NSAU)
09/02	Tsukuba (NASDA)	Ostrach (NASA), Matsumiya (NASDA)
04/03	Catania (ESA)	Ostrach (NASA), Viso (CNES) Tilman (NASA)
10/03	Rottach-Egern (DLR)	
06/04	Strasbourg (CNES)	Ostrach (NASA), Buckley (CSA)
10/04	Kiev (NSAU)	
04/05	Monterey (NASA)	Ostrach (NASA), Gräf (DLR)
09/05	Montreal (CSA)	
04/06	Tokyo (JAXA)	Ostrach (NASA), Koyama (JAXA)

International Research Area Workshops and Publications

As an important strategic means for achieving the first overall goal of the Strategic Plan, which is to strengthen space research, a series of so-called International Research Area Workshops has been established.

The overall objectives of these workshops were defined as:

- to review international research progress in each research area
- to define the critical questions for future research, and
- to determine the relative importance of these questions

The workshops were chartered to produce reports on the results achieved for use by the space agencies in their scientific and programmatic planning. Also, the results were made available to the international scientific community by publications in high ranking scientific journals. Twelve of these workshops have been successfully held in the meantime.

Research Area	**Location and Date**	**Publication**
Cardiovascular Research (1996)	Dallas, Sept. '95	Medicine & Science in Sports & Exercise 28
Plant Biology	Bad Honnef, June '96	Planta 203, Suppl. (1997)
Muscle Research (1997	Bern, Oct. '96	Intl. Journal of Sports Medicine 18, Suppl. 4
Bone Research (1998)	Tokyo, Nov. '96	Bone 22, N° 5
Neuroscience Reviews 28,	Paris, April '97	Brain Research N°s 1/2 (1998)
Radiation Biology	Banff, Nov. '97	Mutation Research 430, N° 2 (1999)
Cell + Molecular Biology	Leuven, June '98	FASEB J. 13, Suppl. (1999)
Integrative Physiology (2000)	Bad Honnef, Sept. '98	Eur. J. Physiol. 441
Human Factors Research Env. Med.	Tokyo, July '99	Aviation, Space, 71 (2000)
Developmental Biology Summary: see http://www.fundamentalbiology.arc.nasa.gov/ISLSWG_index.html (2000)	Woods Hole, Sept. '99	
Group Interactions	Banff, May, 2002	Aviation, Space, Env. Med. (2003)
Microecology	Tokyo, Nov. 2002	Microbial Ecology (2003)

History of International Life Sciences Research Announcements:

The establishment of a process for joint recruitment, peer review and selection of scientific projects in life sciences is certainly one of the major accomplishments of the Working Group. Beginning in 1996, five International Life Sciences Research Announcements have been released since then. The process has obtained wide recognition in the scientific community and in other scientific organisations and has been taken as a model also by other programs. The table below gives the statistics for the results of the scientific reviews of the proposals submitted.

2004

	# Proposals	#90-100	#80-90	#70-80	#60-70	#50-60	#Below 50	# Selected
CNES	13		2	2	4	3	2	3
CSA	8		2	2	2	1	1	3
DLR	21	1	4	5	1	8	2	8
ESA	37	1	2	3	9	14	8	5
NASA	61	4	13	12	11	12	9	12
JAXA	7	1	2	2	1	1		5
NSAU	4			1	1	1	1	1
Total	**151**	**7**	**25**	**27**	**29**	**40**	**23**	**37**

2001

	# Proposals	#90-100	#80-90	#70-80	#60-70	#50-60	#Below 50	# Selected
CNES	3		1	1			1	0
CSA	3	1					2	1
DLR	12	1	1	3	2		5	2
ESA	24		2	6	3	8	5	6
NASA	52	2	10	14	13	12	1	11
NASDA	15	1	1	4	5	2	2	6
NSAU	12				1	5	6	0
Total	**121**	**5**	**15**	**28**	**24**	**27**	**22**	**26**

1999

	# Proposals	#90-100	#80-90	#70-80	#60-70	#50-60	#Below 50	# Selected
CNES	12			2	6	3	1	1
CSA	9		1	3	1	2	2	1
DLR	12	1	1	2	4	3	1	3
ESA	15			3	4	3	5	1
NASA	45	2	11	12	11	4	5	10
NASDA	24		1	2	5	8	8	1

Total	**117**	**3**	**14**	**24**	**31**	**23**	**22**	**17**

1998

	# Proposals	**> 90**	**85 - 89**	**80 - 84**	**75 - 79**	**71 - 74**	**65 - 70**	**# Selected**
CNES	13			2			5	2
CSA	11			4	2	1	1	3
DLR	14			1	3	1	7	4
ESA	19	1	4	1	4	1	2	7
NASA	56	1	7	4	9	8	12	13
NASDA	41			2	5	4	5	4
Total	**154**	**2**	**11**	**14**	**23**	**15**	**32**	**33**

1996

	Proposals	**#90-100**	**#80-90**	**#70-80**	**#60-70**	**#50-60**	**#Below 50**	**# Selected**
CNES	14	1	1	1	5	2	4	3
CSA	19			3	3	8	5	2
DLR	27		3	3	7	4	10	5
ESA	42	2	3	5	12	5	15	5
NASA	47	2	7	8	5	6	19	9
Total	**149**	**5**	**14**	**20**	**32**	**25**	**53**	**24**

Agreements signed

As a result of the discussions in the Working Group a number of multi- and bilateral protocols and agreements have been concluded that reflect the joint efforts of the participating agencies with regard to the conduct of scientific experiments and the development of experiment facilities:

- In April 1996, CNES, CSA, DARA, ESA, NASDA, and NASA established the **Protocol on the International Approach to Life Sciences Recruitment, Review and Selection for the International Space Station** (ISS).

- In March 1997, ESA and NASA concluded a **Memorandum of Understanding (MOU) Enabling Early Utilization Opportunities of the ISS**. In June 2001, ESA and NASA concluded an agreement for launch and joint utilization of the **European Modular Cultivation System** in partial fulfilment of the MOU.

- In April 1998, CSA and NASA concluded an **Arrangement for the Visuo-Motor Coordination Facility and H-Reflex Simulator for the Neurolab Program**.

- Also in April 1998, NASDA and NASA concluded an **Agreement for the Vestibular Function Experimental Units and associated Neural Data Acquisition System for the Neurolab Program**.

- In July 1999, CNES and NASA established an agreement for joint utilization of an **Integrated Cardiovascular Monitoring System (ICMS)** aboard the Space Shuttle.

- In August 1999, NASDA and NASA concluded an agreement for utilization of NASDA's **Bonner Ball Neutron Detector** aboard the ISS.

- In October 1999, NASA and DLR established an agreement for the **Dosimetric Mapping Experiment** on the ISS.

- In December 1999, ESA and NASA concluded an agreement for joint utilization of the **Human Research Facility and the European Physiology Module** aboard the ISS. This agreement included the **Eye Tracking Device** and the **Lower Body Negative Pressure Device** provided by DLR.

- In May 2000, CSA and NASA entered into an interim agreement for development of **Insect Habitat** hardware for utilization on the ISS.

- In October 2000, NSAU and NASA established a cooperative **Agreement In Life Sciences, Microgravity Sciences, and Telemedicine** research. Nearly forty Ukrainian research projects were subsequently conducted.

- In November 2000, ESA and NASA entered into an agreement for utilization of the **Advanced Respiratory Monitoring System, Biopack, and Animal Enclosure Modules aboard Space Shuttle Mission STS-107**.

- In July 2002, ESA and NASA established a cooperative materials science and biomedical research program during **ISS Flight 5S** with ESA astronaut Frank De Winne.

- In September 2002, **The Arrangement Among the Canadian Space Agency, the European Space Agency, the National Aeronautics and Space Administration of the United States of America, and the National Space Development Agency of Japan Concerning International Space Life Sciences Flight Experiments on the International Space Station** (the ISLSWG Comprehensive Arrangement) was signed.

- Based on the ISLSWG Comprehensive Arrangement, in January 2003, NASA concluded bilateral agreements with CSA, ESA and NASDA for the **Sharing of Biospecimen Tissues from STS-107**. NASA and JAXA subsequently concluded an agreement in January 2004, to provide JAXA researchers with access to biospecimen tissue archived at Ames Research Center.

- Also based on the ISLSWG Comprehensive Arrangement, NASA exchanged letters with ESA in April 2003 for Implementation of an experiment entitled, "**Human Orientation and Sensory Motor Coordination in prolonged Weightlessness**," and separately for conducting **Baseline Data Collection** activities in Russia.

- In November 2003, NASA and ESA concluded an agreement for development, launch and operation of the **Matroshka** hardware aboard the International Space Station.

- In April 2004, NASA and CNES concluded an agreement for collaboration on the **First International Caenorhabditis Elegans Experiment (ICE-First)** aboard the International Space Station. Researchers supported by CNES, CSA, JAXA, NASA and Russia participated in this mission.

- In August 2004, CNES, ESA and NASA concluded an agreement for **Bed Rest Studies** beginning in 2005. CSA joined the cooperative program in July 2005.

- In November 2004, DLR, the Russian Academy of Science, and NASA concluded an agreement for Phase I cooperation on a ground-based **Artificial Gravity** program with human-rated centrifuges.

- In December 2004, ESA and NASA entered into a cooperative agreement for launch and utilization of ESA's **ANITA** hardware aboard the ISS.

- Prior to conclusion of the Arrangement, NASA concluded the following agreements:

  - NASA-CSA Agreement for provision of an Insect Habitat aboard ISS
  - NASA-NSAU Agreement in Life Sciences, Microgravity Sciences, and Telemedicine
  - NASA-DLR Agreement for Lower Body Negative Pressure Device and 3-D Eye Tracking System
  - NASA-ESA Agreement for the Human Research Facility – European Physiology Module
  - NASA-ESA Agreement for the European Modular Cultivation System
  - NASA-NASDA Agreement for the Bonner Ball Neutron Detector
  - NASA-DLR Agreement for the Dosimetric Mapping Experiment (1999)

Major Missions and Projects Accomplished by the Working Group

Since a full chronology on the milestones of international cooperation in the space life sciences since 1980 is presented as Appendix D of this document, here only two major accomplishments achieved by the Working Group will be discussed in some more detail. These two examples are the NEUROLAB Shuttle mission and a series of joint bedrest studies.

NEUROLAB (STS-90):

NEUROLAB (STS-90) represents a major achievement in various aspects. It was NASA's contribution to the "Decade of the Brain" and as such a dedicated neuroscience research flight, conducted in partnership also with the National Institutes of Health (NIH), the National Science Foundation (NSF), and the Department of Defense. The research program was defined by the International Space Life Sciences Working Group after a joint recruitment, peer review and selection of experiments. The Announcement of Opportunity had resulted in 172 proposals from scientists worldwide, 26 projects could finally be selected for flight.

The mission presented an unprecedented challenge of techical complexity with sophisticated experiments representing a number of "firsts" in space life sciences research. The successful demonstration of microneurography in the DLR provided LBNP (Lower Body Negative Pressure Device), extracellular muliple unit recording, general anesthesia, and complex surgical procedures have set the stage for transition to the International Space Station as a research platform.

The lessons learned from issuing a joint announcement of opportunity with subsequent peer review and selection have paved the way for structuring the International Life Sciences Research Announcements and for implementing the selected projects on ISS. As such, NEUROLAB – which was the last Spacelab mission – was also a successful case study for the Working Group.

Bedrest Studies:

Bedrest studies are a well accepted terrestrial model for a number of microgravity effects on the human body. In the past such studies have been perfomed in various countries under a variety of different conditions. It is the accomplishment of the Working Group to coordinate and harmonize these bedrest studies and also share the cost. Following bedrest studies have been conducted recently or are planned for the near future:

2001/2002 ESA/CNES/NASDA Long-Term Bedrest Study at MEDES (Toulouse)
2001-2003 ESA/DLR Short-Term Bedrest Study at DLR (Cologne)
2005 ESA/CNES/NASA Long-Term Bedrest Study with Females at MEDES (Toulouse)

Appendix D: <u>**Milestones of International Cooperation in the Space Life Sciences since 1980 (April 2006)**</u>

Since the late 1970s/early 1980s the member agencies of this Working Group have pursued cooperative projects in space life sciences. In many cases, bilateral working groups were established between the life sciences programs of the agencies to exchange information on the respective activities, to discuss possible cooperations, and to implement joint projects. After the foundation of the International Space Life Sciences Working Group these responsibilities were more and more taken over by this body. Of course, for specific purposes bilateral meetings are still being held.

The following Appendix summarizes milestones of bi- and multilateral cooperation in the Space Life Sciences since 1980 in a chronological fassion.

The Eighties (1980 to 1989):

1980

- Preparations under way for the first Spacelab mission on the U.S. space shuttle

1982

- Flight of French cosmonaut on USSR Soyuz T-6 mission

1983

- First Spacelab Mission (SL-1) with one ESA astronaut
- USSR flight of Cosmos biosatellite 1514 with international payload

1984

- Flight of Canadian astronaut on shuttle mission 41-G

1985

- Initiation of cooperation between German (DFVLR) and Russian (Institute for Biomedical Problems, IBMP) scientists
- Initiation of Space Life Sciences Working Group between Germany and NASA
- Participation of French astronaut in shuttle mission 51G
- Shuttle flight of first German Spacelab mission (D-1) with 1 ESA and 2 German astronauts
- USSR flight of Cosmos biosatellite 1667 with international payload

1986

- Initiation of working group (including life sciences) between Germany and CNES

1987

- Initiation of cooperation between Germany and China (Chinese Institute of Space Medico Engineering and Chinese Academy of Sciences)
- Initiation of ground-based scientific cooperation between CNES and NASA using bedrest
- USSR flight of Cosmos biosatellite 1887 with international payload

1988

- Collaborative projects initiated between Canada and USSR
- Space Life Sciences Working Group initiated between Germany and France
- Initiation of CNES-NASA Rhesus Research Project
- Flight of French cosmonaut on USSR Mir mission

1989

- First Life Sciences Working Group Meeting between CSA and NASA
- Establishment of the German Space Agency, DARA

The Nineties (1990 to 1999):

1990

- First Joint Working Group Meeting between CSA and USSR
- Bilateral discussions initiated between CSA and CNES
- Initiation of DARA cooperation with USSR, and later certain members of the Commonwealth of Independent States, especially Russia and Kazakhstan
- Collaborative projects and scientist exchange initiated between Canada and Japan

1991

- Shuttle flight of first Spacelab mission dedicated to Life Sciences (SLS-1)

1992

- Integration of former German Democratic Republic space projects from the Intercosmos program into the agreement between the German BMFT and the Russian Academy of Sciences

- Shuttle flight of First International Microgravity Laboratory Spacelab Mission (IML-1) with one ESA astronaut and one Canadian astronaut

- Participation of one ESA and one Italian astronaut in shuttle mission STS-46

- Shuttle flight of Spacelab J Mission with major Japanese payload and Japanese astronaut

- Flight of German cosmonaut on Mir station

- Flight of French cosmonaut on Mir station

<u>1993</u>

- Formal bilateral discussions initiated between Canada and Japan

- Discussions initiated between Canada and Germany

- Shuttle flight of second Spacelab mission dedicated to Life Sciences (SLS-2)

- Shuttle flight of second German Spacelab mission (D-2) with two German astronauts

- Russian flight of Cosmos biosatellite 2229 with international payload

- Initiation of cooperation between CNES and CPK (Russian space medical group) on pre- and postflight cosmonaut studies

- Flight of French cosmonaut on Mir station

<u>1994</u>

- Shuttle flight of Second International Microgravity Laboratory Spacelab Mission (IML-2) with one Japanese astronaut

- Development of common approach to research in cardiovascular physiology between CNES and DARA/DLR

- Flight of ESA astronaut on Mir station (EUROMIR '94), largely dedicated to research in human physiology

- Trilateral agreement between CNES, DARA, and CPU Moscow on pre- and postflight cosmonaut studies

<u>1995</u>

- Flight of ESA astronaut on MIR station (EUROMIR ’95), largely dedicated to research in human physiology

- Canadian dosimetry experiments on the Russian MIR station

- International bedrest study at AMES accompanying the LMS (Life and Microgravity Sciences) shuttle mission

1996

- First flight of the CSA Aquatic Research Facility on STS-77

- LMS (Life and Microgravity Sciences) shuttle mission with great international participation

- Initiation of the NASA/MIR program with shuttle mission STS-76 including the ESA BIORACK and joint NASA/ESA utilization

- NASDA RRDM (Realtime Radiation Monitoring Device) onboard of shuttle mission STS-79

- Flight of the Russian satellite BION 11 with international payload

1997

- ESA BIORACK and NASDA Advanced RRDM on Shuttle/MIR missions STS-81 and STS-84 with joint NASA/ESA resp. NASA/NASDA utilization

- Flight of a German cosmonaut on the Russian MIR station including ESA and NASA sponsored experiments, largely dedicated to human physiology

- Collaborative Ukrainian Experiment (CUE) onboard STS-87 with Ukrainian astronaut

1998

- First flight of the DLR CEBAS minimodule (Closed Ecological Biological Aquatic System) onboard of STS-89 with joint American and German experiments

- Shuttle mission STS-90 (NEUROLAB) dedicated to neuroscience research with international payload and experiments representing the first major milestone of ISLSWG achievements

- Shuttle mission STS-95 (J. Glenn mission) with major international participation

1999

The new century (from 2000 until today):

2000

2001

- CSA Extra Vehicular Activity Radiation Monitors (EVARM) accommodated on ISS

- DLR DOSMAP dosimetric mapping device accommodated on ISS and utilized

- NASDA Neutron detecting instrument (BBND) accommodated on ISS HRF, data were shared with international community

- Joint Bedrest studies at MEDES (long-term) and at DLR Köln-Porz (short-term)

- CNES/ESA taxiflight to ISS

2002

- program of joint NSAU-Rosaviakosmos research on Russian part of ISS finalized and adopted by the two agencies

- continuation of joint bedrest studies at MEDES and DLR Köln-Porz

- Belgian/ESA taxiflight to ISS

- International Space Life Sciences Flight Experiments Agreement signed among CSA, ESA, NASA, and NASDA

2003

- Shuttle mission STS-107 with international payload

- NASA concluded bilateral agreements with CSA, ESA, and NASDA for the sharing of biospecimen tissues from STS-107

- NASA and ESA implemented experiment entitled "Human Orientation and Sensory Motor Coordination in Prolonged Weightlessness"

2004

- NASA signed an agreement to provide JAXA researchers access to biospecimen tissue archived at Ames Research Center

- NASA and ESA established collaboration on the First International Caenorhabditis Elegans Experiment (ICE-First) aboard the ISS; researchers from CNES, CSA, JAXA, NASA, and Russia participated

- NASA and ESA agreed on the development, launch, and operation of the Matroshka hardware aboard the ISS

Appendix E: International Priorities in the Space Life Sciences Disciplines incl. Definition of Thematic Areas (February 2006)

RELATIVE EMPHASIS IN COMMON LIFE SCIENCES RESEARCH AREAS

(0 = No Activity, 1 = Minor, 2 = Nominal, 3 = Major Activity; N/A = not applicable

+ = increasing, - = decreasing)

RESEARCH AREA	ASI	CNES	CSA	DLR	ESA	NASA	JAXA	NSAU
Biological Materials Science	0	1	0	1	0	0	2	2
Molecular and Cellular Biology	3	2	2	3	3	1	2+	3
Developmental and Reproductive Biology	1	2	1	1	2	0	1+	2+
Plant Biology	1+	1	0+	3	2-	0	1	3
Cardiopulmonary Physiology	1	2	3	2	2	2	1	2
Musculoskeletal Physiology	3	2	3	3	3	3	2	2
Neurosciences	2+	3	3	3	2	2	2	2
Regulatory Physiology	1+	1+	3	2	2+	2	1	1
Behavior, Performance, and Human Factors	2	2	1+	1+	1+	3	2	1
Medical Support Systems	0	3	0	2	1	2+	1+	1
Life Support Systems	1	1	0	1	2+	2+	1+	2
Environmental Health	1	0	1	0	0	1+	2	1
Radiation Health	3	2	3	2	1	3	2+	1
Exobiology	1	1	0	1+	3	0	1	1
Biospherics Research	0	1	0	0	0	1	0	1

Definitions of Space Life Sciences Research Areas

Biological Materials Science

Concerns space research related to both macromolecular crystal growth and separation processes related to biological materials.

Molecular and Cellular Biology

Examines how gravity and other space flight factors influence biological function at the molecular and cellular level, including the identification of how single cells "sense" gravity, how this information is translated into biological responses, and how cells respond to both acute and long-term variations in gravity and other flight factors.

Developmental and Reproductive Biology

Focuses on the influence of gravity and other flight factors on reproduction, genetic integrity, differentiation, growth, development, life span, senescence, and subsequent generations of animals.

Plant Biology

Concerns the effects of gravity and other flight factors on the growth, development, reproduction, movement, and orientation of plants and on the underlying mechanisms responsible for these effects.

Cardiopulmonary Physiology

Examines acute and long-term cardiovascular and pulmonary adaptation to space flight and subsequent readaptation to the normal environment of Earth, including all associated underlying mechanisms of action.

Musculoskeletal Physiology

Focuses on the responses and consequences of muscle and skeletal adaptation to space flight and subsequent readaptation to the normal environment of Earth, including all associated underlying mechanisms of action.

Neurosciences

Concerns the acute and long-term adaptation of the central and peripheral nervous system to space flight and the subsequent readaptation to the normal environment of Earth, including all associated underlying mechanisms of action.

Regulatory Physiology

Examines the following areas of acute and long-term adaptation of humans and animals to space flight and subsequent readaptation to the normal environment of Earth: circadian rhythms, endocrinology, fluid and electrolyte regulation, hematology, immunology, metabolism and nutrition, and temperature regulation.

Behavior, Performance, and Human Factors

Examines the basic mechanisms underlying the behavioral adaptation to space flight, the measurement and interpretation of performance during space flight, and the factors that influence the capabilities and limitations of crewmembers on space missions of varying duration.

Medical Support Systems

Focuses on the goal of providing preventive, diagnostic, and therapeutic capabilities for space flight operations and includes both countermeasure development and clinical studies.

Life Support Systems

Concerns the integration of biological, physical, and chemical processes to promote self-sufficiency in life support by improving the regeneration of air, water, and food, by managing and recycling metabolic and other wastes to achieve optimum resource recovery and use.

Environmental Health

Examines the effects of the spacecraft environment on humans and other organisms in order to manage those environments properly to minimize risks associated with living and working in space; includes the areas of barophysiology, microbiology, toxicology, and environmental monitoring.

Radiation Health

Focuses on developing the scientific basis for the radiation protection of humans engaged in the exploration of space, with a particular emphasis on the establishment of a firm knowledge base to support risk assessment for future long-term exploration missions.

Exobiology

Concerns research related to those processes involved in the origin, evolution, and distribution of life in the universe.

Biospherics Research

Examines ways to measure and predict biological changes on Earth on a regional and global scale and to assess the biological consequences of those changes.