AGREEMENT

between

THE UNITED STATES DEPARTMENT OF ENERGY

and

THE FRENCH COMMISSARIAT A L'ENERGIE ATOMIQUE

in the field of

REMOTE SYSTEMS TECHNOLOGY

WHEREAS

The UNITED STATES DEPARTMENT OF ENERGY (DOE) and the FRENCH COMMISSARIAT A L'ENERGIE ATOMIQUE (CEA), hereinafter referred to as the Parties, are both carrying out activities on remote systems technology and their applications to hostile environment and, in consideration of the high degree of compatibility between their respective programs in terms of current activities and future interest, DOE and CEA have a mutual interest in establishing cooperation in the field of remote systems technology.

DOE and CEA believe that a cooperative program of equitable sharing of their respective research and development data, technology and experience in remote systems technology would be of mutual benefit,

DOE and CEA recognize the contribution such research and development in remote systems technology can make to safe and economic application of nuclear energy,

DOE and CEA act in certain areas related to remote systems technology through their contractors, subsidiaries or associated industrial firms,

DOE and CEA recognize the need to establish procedures for the protection of Proprietary Information,

It is the understanding of each Party that certain information is provided in confidence to the other Party, and that the undue dissemination thereof would be prejudicial to the interests of each Party and to prospects for future collaboration between DOE and CEA,

IT IS AGREED AS FOLLOWS :

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ARTICLE 1 - OBJECTIVES

1.1 The objective of this Agreement (to be called the Remote Systems Technology Agreement) shall be to establish the basis for cooperation between the Parties in the field of remote systems technology.

1.2 As a first step, this Agreement provides for an exchange of general information, including basic R & D results, between the Parties regarding the studies and research, development, demonstration and operational activities carried out by each Party in the technical areas listed below in Article 2.

Each Party shall provide sufficient information to enable the other Party to evaluate and assess the level and scope of knowledge acquired by the other in the technical areas listed in Article 2, so that the Parties are able to identify specific areas or topics which may lead to further and more extensive forms of cooperation in remote systems technology.

1.3 Such exchange of information will be governed by the provisions of Article 6 of this Agreement.

1.4 Cooperation between the Parties shall be on the basis of mutual benefit, equality and reciprocity.

ARTICLE 2 - AREAS OF COOPERATION

2.1 At the time of signing this Agreement, the following areas of cooperation have been identified :

I. Applications Feasibility

1. Signal and Power Transmission

2. Remote Viewing and Sensing

II. Remote Work Efficiency

3. Man-Machine Interface

4. Teleoperator-Task Environment Interface

III. Optimization and Refinement

5. Control Systems

6. Advanced Teleoperation

7. Electromechanical Systems

Detailed descriptions of these areas of cooperation under this Agreement are contained in the Appendix.

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2.2 The above list of areas of cooperation may be modified by mutual written agreement of the Parties.

ARTICLE 3 - CONTENT AND FORMS OF COOPERATION

Cooperation under this Agreement may include exchange of general and specific scientific and engineering information and R & D results and methods in remote systems technology by means of :

a. Exchange on a current basis of periodic, topical and letter reports.

b. Organization of, and participation in, seminars or other meetings on specific agreed topics in remote systems technology, within the areas of cooperation of Article 2.

c. Short visits by specialist teams or individuals to the experimental and operational remote systems technology facilities of the other Party, subject to the prior written agreement of the receiving Party.

d. Attachment of the staff of one Party, its contractors or subsidiaries or designees, to the remote systems technology facilities of the other Party, its contractors, subsidiaries or designees for participation in agreed research, development, design, analysis or other experimental activities, and on-going operations in the field of remote systems technology. Such attachment shall be in accordance with Article 10 of this Agreement.

e. Exchange or loan of samples, materials and/or equipment for testing.

f. Joint projects in which the Parties agree to share the work and/or costs.

g. Other specific forms of cooperation, in remote systems technology, not included above.

ARTICLE 4 - IMPLEMENTING AGREEMENTS

4.1 If it is decided to employ a form of cooperation given in paragraph 3 - e, f or g, then an Implementing Agreement between DOE and CEA or its designee shall be executed.

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4.2 Moreover, if it is contemplated to exchange information that would include detailed design information such as drawings and specifications for full-scale components and industrial equipment and associated operational procedures and experience necessary to provide a working device then either Party may request that an Implementing Agreement between DOE and CEA or its designee shall be executed.

4.3 Each Implementing Agreement shall include all detailed provisions for carrying out that activity, and shall cover such matters as technical scope, total costs, cost-sharing between the Parties, project schedule, management of the cooperation, exchange of equipment, and provisions covering exchange of Proprietary Information, patents, and information disclosure specific to the particular activity. Activities under Implementing Agreements may involve, as appropriate, associated firms, or laboratories or designees of the Parties or their contractors or subsidiaries.

ARTICLE 5 - MANAGEMENT

5.1 To supervise the execution of this Agreement, each Party shall name a Principal Coordinator. The Principal Coordinators shall normally meet each year alternately in the United States and in France, or at such other times and places as agreed.

5.2 At their meetings, the Principal Coordinators shall evaluate the status of cooperation under this Agreement. This evaluation may include a review of each Party's remote systems technology program status and plans, a review of the past year's activities and accomplishments under this Agreement, a review of the activities planned for the coming year within each of the various areas of cooperation listed in Article 2, an assessment of the balances of exchanges under this Agreement within each of the areas of cooperation listed in Article 2, and a consideration of measures required to correct any imbalances. In addition, the Principal Coordinators shall consider new proposals for cooperation in accordance with Article 2 and 3 and submit such proposals to the Parties for consideration. If such new proposals are accepted by both Parties, this Agreement shall be amended accordingly. For additionnal areas of cooperation, the Appendix shall be revised accordingly.

5.3 Day-to-day management of the cooperation under this Agreement, and/or specific areas of cooperation under Implementing Agreements, if necessary, shall be carried out by Technical Coordinators designated by the Principal Coordinators. The Technical Coordinators shall agree on specific details of cooperation in the technical areas listed in Article 2, within policy guidelines

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established by the respective Principal Coordinators. Each Technical Coordinator shall be responsible for working contacts between the Parties in his respective area of cooperation. Technical Coordinators may, in turn, appoint correspondents for the purpose of day-to-day implementation of the exchange on specific topics or areas.

5.4 At periodic meetings, or by correspondence, as appropriate, Technical Coordinators of each Party shall together review the progress and balance of the cooperation and where appropriate, make recommendations on any necessary or desirable modifications taking into account information arising from the Agreement or elsewhere. Such recommendations shall be developed by the respective Technical Coordinators and agreed to by both. Technical Coordinators shall prepare reports to the Principal Coordinators for use by the Principal Coordinators at their meetings pursuant to 5.1. The reports shall include a summary of the year's activities and the agreed-to recommendations.

5.5 Implementing Agreements executed pursuant to Article 4 for the performance of cooperative activities shall include appropriate provisions for the management of such activities.

ARTICLE 6 - INFORMATION

6.1 Each Party shall provide to the other Party on a current and timely basis information as described in Article 3 in areas listed in Article 2 and the detailed descriptions thereof in the Appendix. The Parties agree that information provided, exchanged, generated or obtained under this Agreement may be given distribution as each Party chooses, except as noted in paragraphs 6.4, 6.5, Article 7, and as provided in Implementing Agreements, which means that a Party, its Government and its nationals have a right to freely use, translate, reproduce, publish and distribute such information for any and all purposes without any requirement of compensation whatsoever.

6.2 Although this Agreement does not commit either of the Parties to transmit to the other Party any information considered to be proprietary, the Parties recognize that transmission of such Proprietary Information might prove useful to their collaboration, in which case the provisions of Sections 6.4 through 6.6 of this Agreement shall apply.

6.3 Information exchanged under this Agreement may be in either French or English.

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6.4 Definitions as used in this Article :

6.4.1 The term "information" means scientific or engineering data, results or methods of research and development, operational expertise, and any other information intended to be provided or exchanged under this Agreement.

6.4.2 For the purposes of this Agreement, "Proprietary Information" ("Informations Privilégiées" in French) shall mean information of a confidential nature as trade secrets, or commercial or financial information which is privileged or confidential, and may only include such information which :

a) has been held in confidence by its owner,

b) is of a type which is customarily held in confidence by its owner,

c) has not been transmitted by the transmitting Party to other entities (including the receiving Party) except on the basis that it be held in confidence, and

d) is not otherwise available to the receiving Party from another source without restriction on its further dissemination.

6.5 Procedures

6.5.1 A Party receiving Proprietary Information, as defined in Section 6.4.2, pursuant to this Agreement shall respect the privileged nature thereof. Any document which contains Proprietary Information shall be clearly marked with the following (or substantially similar) restrictive legend :

"This document contains Proprietary Information furnished in confidence under an Agreement dated ---------- between the UNITED STATES DEPARTMENT OF ENERGY and the FRENCH COMMISSARIAT A L'ENERGIE ATOMIQUE and shall not be disseminated outside these organizations, their contractors, licensees and the concerned departments and agencies of the Governments of the U.S. and France without prior approval of ----------".

"This notice shall be marked on any reproduction hereof, in whole or in part. These limitations shall automatically terminate when this information is disclosed by the owner without restriction."

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6.5.2 Proprietary Information, as defined in Section 6.4.2, received in confidence under this Agreement may be disseminated by the receiving Party to :

a) persons within or employed by the receiving Party, and other concerned Government departments and Government agencies in the country of the receiving Party, and

b) prime or subcontractors of the receiving Party located within the geographical limits of the receiving Party's nation, for use only within the framework of their contracts with the receiving Party in work relating to the areas of cooperation in Article 2,

c) organizations licensed by the receiving Party in the field of Remote Systems Technology for use only within the terms of such licenses ; and

d) organizations with which the receiving Party has contractual relationships and which are located in the receiving Party's nation for use only within the framework of their contracts with the receiving Party in work relating to the areas of cooperation in Article 2,

provided that any such Proprietary Information shall be disseminated on a need-to-know basis pursuant to an agreement of confidentiality and shall be marked with a restrictive legend substantially identical to that appearing in Section 6.5.1 above.

6.5.3 With the prior written consent of the Party providing Proprietary Information under this Agreement, the receiving Party may disseminate such Proprietary Information more widely than otherwise permitted in the foregoing Section 6.5.2. The Parties shall cooperate with each other in developing procedures for requesting and obtaining prior written consent for such wider dissemination, and each Party shall grant such approval to the extent permitted by its national policies, regulations, and laws.

6.6 Each Party shall exercise its best efforts to ensure that Proprietary Information received by it under this Agreement shall be controlled as provided herein. If one of the Parties becomes aware that it will be, or may reasonably be expected to become, unable to meet the non-dissemination provisions of this Article, it shall immediately inform the other Party. The Parties shall thereafter consult to define an appropriate course of action.

6.7 Information arising from seminars and other meetings arranged under this Agreement shall be treated by the Parties according to the principles specified in this Article, provided, however, no Proprietary Information orally communicated shall be subject to the limited disclosure requirements of this Agreement unless the individual communicating such information places the recipient on notice as to the proprietary character of the information communicated on or before such communication.

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6.8 Nothing contained in this Agreement shall preclude the use or dissemination of information received by a Party other than pursuant to this Agreement.

ARTICLE 7 - PATENTS

7.1 With respect to any invention or discovery conceived or first actually reduced to practice in the course of the cooperative activities undertaken by the Parties in implementing this Agreement :

7.1.1 If conceived or first actually reduced to practice by personnel of a Party (the Assigning Party) or its contractors while assigned to the other Party (the Recipient Party) or its contractors in connection with an assignment of scientists and other specialists.

7.1.1.1 The Recipient Party shall acquire all right, title and interest in and to such invention or discovery, and any patent application or patent that may result, in its own country and in third countries ; and

7.1.1.2 The Assigning Party shall acquire all right, title and interest in and to such invention, discovery, patent application or patent in its own country.

7.1.2 If conceived by or first actually reduced to practice by a Party or its contractors as a direct result of employing information which has been communicated to it under this Agreement by the other Party or its contractors, but not otherwise agreed to under a cooperative effort covered by paragraph 7.1.3.

7.1.2.1 The Party so conceiving or first actually reducing to practice such invention or discovery shall acquire all right, title and interest in and to such invention or discovery, and any patent application or patent that may result, in its own country and in third countries, and

7.1.2.2 The other Party shall acquire all right, title and interest in and to such invention, discovery, patent application or patent in its own country.

7.1.3 For other specific forms of cooperation as set forth in Articles 3.e, 3.f, and 3.g, or specific exchange of information under Article 4.2, the Parties shall provide for appropriate distribution of rights to inventions. In general, however, each Party should normally determine the rights to such inventions in its own country, and the rights to such inventions in other countries should be agreed by the Parties on an equitable basis.

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7.1.4 Notwithstanding the allocation of rights covered under paragraphs 7.1.1 and 7.1.2, in any case where one Party first actually reduces to practice after the execution of this Agreement an Invention, either conceived by the other Party prior to execution of this Agreement or conceived not in the course of the cooperative activities undertaken by the Parties in implementing this Agreement, then the Parties shall provide for an appropriate distribution of rights, taking into account existing commitments with third parties ; provided, however, that each Party shall determine the rights to such invention in its own country.

7.2 The Party owning a patent covering any invention referred to in 7.1 above shall licence the patents to nationals and licensees of the other Party, upon request of the other Party, on nondiscriminatory terms and conditions under similar circumstances. At the time of such a request, the other Party will be informed of all licenses already granted under such patent.

7.3 Each Party shall take all necessary steps to provide the cooperation from its inventors required to carry out the provisions of this article. Each Party shall assume the responsibility to pay awards or compensation required to be paid to its employees according to the laws of its country.

7.4 It is understood that after the European Patent Conventions have come into force, either Party may request a modification of this Article for the purpose of according equivalent rights as provided in this Article under the European Patent Conventions.

ARTICLE 8 - DISCLAIMER

Information transmitted by one Party to the other Party under this Agreement shall be accurate to the best knowledge and belief of the transmitting Party, but the transmitting Party does not warrant the suitability of the information transmitted for any particular use or application by the receiving Party or by any third party.

ARTICLE 9 - LIABILITIES

9.1 The Parties shall use all reasonable skill and care in carrying out their duties under this Agreement in accordance with the laws and regulations of their respective countries.

9.2 Compensation for damages incurred under this Agreement shall be in accordance with the applicable laws of the respective country of the Party concerned.

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9.3 The sending Party shall not be liable for damages of any nature, either direct or indirect, to property or personnel of the receiving Party or to any third party resulting from the use by the receiving Party of information provided under this Agreement.

ARTICLE 10 - PERSONNEL ASSIGNMENTS

10.1 Whenever an attachment of staff is contemplated under this Agreement each Party shall ensure that qualified staff are selected for attachment to the other Party.

10.2 Each such attachment of staff shall be the subject of a separate attachment agreement between the Parties.

10.3 Each Party shall be responsible for the salaries, insurance and allowances to be paid to its staff.

10.4 Each Party shall pay for the travel and living expenses of its staff while on attachment to the host Party unless otherwise agreed.

10.5 The host establishment shall arrange or do its best to arrange for comparable accommodations for the other Party's staff and their families on a mutually agreeable reciprocal basis.

10.6 Each Party shall provide all necessary assistance to the attached staff (and their families) of the other Party as regards administrative formalities.

10.7 The staff of each Party shall conform to the general and special rules of work and safety regulations in force at the host establishment.

ARTICLE 11 - LEGAL PROVISIONS

Each party's activities under this Agreement shall be in accordance with its national laws and regulations. All questions related to the Agreement shall be settled by the Parties by mutual agreement.

ARTICLE 12 - FINANCIAL OBLIGATIONS

Except when otherwise specifically agreed in writing, all costs resulting from cooperation under this Agreement shall be borne by the Party that incurs them. It is understood that the responsibilities of each Party to carry out its obligations under this Agreement are subject to the availability of appropriated funds.

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ARTICLE 13 - DURATION, AMENDMENT AND TERMINATION

13.1 This Agreement shall enter into force upon signature and, subject to Section 13.2, 13.3 and 13.4, shall continue for a three (3) year period.

13.2 This Agreement may be amended or extended by mutual written agreement of the Parties.

13.3 This Agreement may be terminated at any time at the discretion of either Party, upon six (6) months advance notification in writing by the Party seeking to terminate the Agreement. Such termination shall be without prejudice to the rights which may have accrued under this Agreement to either Party up to the date of such termination.

13.4 All joint efforts and experiments not completed at the expiration or termination of this Agreement may be continued until their completion under the terms of this Agreement.

Done in duplicate, in the English and French languages, each equally authentic, this 13th day of SEPTEMBER, 1985.

FOR THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA

James W Vaughan, Jr

NAME : James W. VAUGHAN, Jr.

TITLE : Acting Assistant Secretary for Nuclear Energy

FOR THE COMMISSARIAT A L'ENERGIE ATOMIQUE OF FRANCE

NAME : Michel RAPIN

TITLE : Directeur de l'Institut de Recherche Technologique et de Développement Industriel

George J Bradley

NAME : George J. BRADLEY

TITLE : Acting Assistant Secretary International Affairs and Energy Emergencies

APPENDIX

Detailed Description of Areas of Cooperation in Remote Systems Technology

Three broad areas of technical interest are listed in Article 2. The technical scope of these areas is described below.

I. Applications Feasibility

1. Signal and Power Transmission

As the sophistication of in-cell remote handling systems is increased, the number of data channels and electrical interconnections increases proportionately. To mitigate potentially severe remote cable handling requirements, advanced concepts for remote signal transmission must be developed to make servomanipulators and television vision reliable for large cells. Such systems involve megabaud-level bandwidth with multi-channel, bi-directional operation and error detection/correction. The two most promising technical directions presently under consideration include directed-optical laser infrared and electromagnetic (microwave) transmission. Major application issues include environmental sensitivity, facility integration, reliability, and remote maintainability. The U.S. has concentrated on the latter and France the former. An exchange of operating and analytical data will make it possible to compare the two techniques.

2. Remote Viewing and Sensing

The quality of remote viewing is known to be an important factor in manipulator operator performance. Display tradeoffs include line resolution, frame rates, gray scales, display size, color vs black and white, and steroscopic vs monocular. Techniques for camera aiming and lighting control aboard mobile maintenance systems are also very important. In addition to signal transmission, the survivability (which is the combination of operating life and remote maintainability) of remote systems, the radiation hardenability of video electronics and optics are essential.

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In addition to remote viewing, there are other methods to provide augmentative sensing which will enhance teleoperation. These include : auditory feedback (not stereo and monaural), proximity sensing in the near vicinity of handling equipment, integrated computer image sensing and processing object recognition and identification and end-effector contact sensing for tactile and touch feedback from the slave manipulators. As with other cell equipment utilizing solid-state technology and sensitive materials, radiation hardening is a key factor. Various data on several of these elements has been obtained in both countries and will be exchanged and compared.

II. Remote Work Efficiency

3. Man-Machine Interface

Recent work in both France and the United States has shown that the human factors engineering aspects of remote maintenance system design have a very significant influence upon work efficiency. Control room design parameters must be based upon proper human factors which combine anthropometry, teleoperation functions, and critical aspects of the work task environment. Displays and control sizing, layout, and allocation must be carefully selected to maximize telepresence. Comparison of work in this area done in both countries will be compared and assessed.

4. Teleoperator-Task Environment Interface

A new area of interest to both countries is systematic analysis and understanding of the basic relationships between work tasks and remote manipulation and handling equipment design. Effective methodologies for the characterization and evaluation of work tasks with respect to remote work performance and remote handling design tradeoffs would be a most desirable capability to have available. This type of analytical methodology would provide needed guidance in the specification/selection of handling geometrics (e.g., manipulator ranges of motion, etc..), effectors (e.g., grips, tooling, etc..). Work done to date in each country will be exchanged and compared.

III. Optimization and Refinement

5. Control Systems

Rapidly advancing electronics technology, particularly digital technology, is having major impact upon the realization of advanced force-reflecting servomanipulators. Design concepts utilizing the latest hardware and software technology available are essential to achieving

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future performance objectives. Expandible multiprocessor architectures which take the fullest advantage of high-speed local area networking are important in the implementation of fully integrated maintenance system control (e.g., manipulators, transporters, viewing, etc..). The software aspects of future distributed-digital control systems are as equally important. More efficient (memory and speed), realtime operating systems compatible with microprocessor-level hardware are needed to facilitate extensible high-level software languages.

6. Advanced Teleoperation

Computer supervisory control can be used to provide important new servomanipulator control aids to operators. Demonstrations (in France particularly) of automatic load weight suppression, automatic television camera tracking of end-effectors, and special geometrical processing have been completed. In geometrical processing, various forms of motion scaling and constraints have been implemented. Future work will address the coordination of the entire system at the man-machine interface in addition to the master controllers, which will include multi-system operation and obstacle avoidance.

Artificial intelligence is a popular emerging computer science intended to ultimately give computers (some of) the attributes of human intelligence necessary for decision making. Expert systems techniques are used to encode human technical expertise in software and have been successfully implemented in a wide range of application. The time is now right to begin to apply these new ideas to advanced teleoperation. Emphasis must be placed upon near-realtime operation in applications such as equipment failure diagnosis, work task planning, and obstacle avoidance.

7. Electromechanical Systems

Servomanipulator design represents one of the most complex kinematic design problems ever addressed in mechanical engineering. Even today most of the design process remains intuitive. Optimization of manipulator kinematics, including considerations of joint ranges of motion, redundant degrees of freedom, and ultimate load/dynamics capabilities, is an important development goal. Kinematic synthesis, in the ideal case, must consider the integrated motion capability of the entire handling system including the transporter, intermediate manipulator positioners, manipulators, and camera aiming.

The mechanical design, particularly in the actuators and power transmission, of servomanipulators is also complex because of the objectives of force-reflection operation. Ideally, servomanipulator designs attempt to optimize static friction, backdriveability, and inertia characteristics to provide good teleoperation characteristics. The increased use of gears and linkages to eliminate tendon drives (for reliability and maintainability) introduces greater backlash and friction nonlinearities and joint cross-coupling. The use of active force sensing to enhance bilateral force-reflection under these conditions is a new and exciting development area. Needless to say, many technical challenges remain in manipulator mechanical design.