

AD REFERENDUM

**-ARRANGEMENT
BETWEEN
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION OF
THE UNITED STATES OF AMERICA
AND
THE CANADIAN SPACE AGENCY
REGARDING THE PROVISION, BY CANADA, OF A SPECIAL
PURPOSE DEXTEROUS MANIPULATOR
AND OTHER GOODS AND SERVICES
TOWARDS FULFILLMENT OF ITS
COMMON SYSTEM OPERATIONS RESPONSIBILITIES
WITHIN THE CONTEXT OF THE INTERNATIONAL SPACE STATION
(ISS) PROGRAM**

1.0 Introduction

This Arrangement is entered into pursuant to the Agreement among the Government of the United States of America, Governments of Member States of the European Space Agency, the Government of Japan and the Government of Canada on Cooperation in the Detailed Design, Development, Operation and Utilization of the Permanently Manned Civil Space Station (the "1988 IGA") and the Memorandum of Understanding between the Ministry of State for Science and Technology of Canada (MOSST) and the National Aeronautics and Space Administration (NASA) of the United States of America on Cooperation in the

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Detailed Design, Development, Operation and Utilization of the Permanently Manned Civil Space Station (the "1988 MOU"), which 1988 IGA and 1988 MOU have been revised and will be superseded by a new IGA (the "new IGA"), and a new MOU (the "new MOU") between the Canadian Space Agency (CSA) and NASA, hereinafter collectively referred to as the "Space Station Agreements"

On March 1st, 1989, CSA assumed responsibility from MOSST for the execution of the Canadian Space Station Program.

This Arrangement details the understandings reached between CSA and NASA ("the Parties") for the provision, by Canada, of a Space Station Special Purpose Dexterous Manipulator (the "SPDM"), and of other goods and services towards fulfillment of its financial responsibilities for common system operations costs ("CSOC") under the Space Station Agreements.

2.0 Background

2.1 Under the 1988 MOU, CSA was to contribute the Mobile Servicing System (MSS) as a Canadian element, containing several components, including the Mobile Servicing Center (MSC), the MSS unique internal control station equipment, the SPDM and the MSS Maintenance Depot (MMD). The MSC, a subset of the MSS, is composed of the Space Station Remote Manipulator System (SSRMS), the U.S. provided Mobile Transporter (MT) and the Mobile Remote Servicer (MRS) Base System (MBS). Because of the CSA robotic system's role in assembly and maintenance of the Space Station, the CSA contribution is considered essential to the ISS. In return for this system and its support and maintenance, CSA received under the 1988 MOU, 3% of all Space Station user accommodations and utilization resources, while being responsible for 3% of the Space Station CSOC.

In 1994 the Canadian federal government directed CSA to revise its Space Station participation. In May 1994, NASA and CSA agreed on Arrangements for Enhanced Cooperation in Space Between NASA and CSA ("the 1994 Enhanced Cooperation Arrangement") in which NASA assumed, in part, certain CSA responsibilities for MSS. As part of the 1994 Enhanced Cooperation Arrangement, CSA's utilization accommodations and resource allocations, crew flight

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opportunities and CSOC obligation, were reduced from 3.0% to 2.7% and CSA deferred indefinitely the initiation of its Space Station utilization. In return, NASA received the .3% in utilization accommodations and resources, along with the commensurate CSOC obligation. In addition, the 1994 Enhanced Cooperation Arrangement stipulated that CSA would complete the detailed design of the SPDM but would defer the decision regarding its manufacture until April 1997. In the event CSA elected not to contribute the SPDM, its utilization allocation would be reduced by an additional .4%, which would be transferred to NASA, leaving CSA with 2.3%.

This Arrangement defines the conditions under which Canada will develop and operate the SPDM identified in the Space Station Agreements and the Space Station-related provisions of the 1994 Enhanced Cooperation Arrangement. While CSA's allocations of utilization accommodations and resources and flight opportunities are as stated in the Space Station Agreements, this Arrangement implements the provisions of Article 9 of the new MOU regarding offsets of CSOC responsibilities and defines the portion of those allocations that CSA is entitled to use without further responsibility for CSOC payment.

3.0 Purpose, Scope and Relationship to the Space Station Agreements

3.1 This Arrangement constitutes an Implementing Arrangement pursuant to the Space Station Agreements.

3.2 Notwithstanding the roles and responsibilities specified in the 1988 MOU, the Parties to this Arrangement will have responsibilities concerning the SPDM and other MSS activities, as specified herein. In the event of any inconsistencies between this Arrangement and the Space Station Agreements, the Space Station Agreements will take precedence. The Parties intend the terms of this Arrangement to be consistent with NASA's bilateral MOUs with the other International Space Station partners.

3.3 NASA and CSA will, upon signature of this Arrangement, begin to implement the understandings outlined herein regarding CSA's provision of the SPDM and other goods and services to offset its Space Station CSOC obligation.

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3.4 This Arrangement, except as otherwise specifically indicated, is not intended to supersede or otherwise modify previous agreements reached by the technical teams or any understanding already contained in program documentation. In the event of any inconsistencies between such previous agreements or understandings and this Arrangement, this Arrangement will take precedence. In addition, this Arrangement fully implements the understandings in the 1994 Enhanced Cooperation Arrangement as those understandings relate to the SPDM.

4.0 Definition of Terms

4.1 For the purposes of this Arrangement:

- a.) the term "engineering support" means engineering activities associated with sustaining engineering and operations of flight element;
- b.) the term "follow-on spares" means orbital replacement units considered necessary to sustain the functional performance of the flight element(s) following on-orbit assembly and verification;
- c.) the term "initial spares" means orbital replacement units considered necessary to sustain the functional performance of the flight element(s) during on-orbit assembly and verification;
- d.) the term "maintenance" means on-orbit replacement of orbital replacement units (ORUs);
- e.) the term "one (1) rack year" means the on-orbit use of one (1) rack equivalent for one (1) year;
- f.) the term "one (1) external adapter site year" means the on-orbit use of one (1) external adapter site equivalent for one (1) year;
- g.) the term "operations support" means on-orbit and ground activities associated with all operations of the flight element(s), including real and

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non-real time flight element performance monitoring, real time on-orbit and ground based flight element operations, and training;

h.) the term "repair and overhaul" means on ground repair or refurbishment (overhaul) of flight element orbital replacement units;

i.) the term "sustaining engineering" means on-ground engineering activities to ensure the continued functional performance of the flight elements and engineering associated with the design of flight element modifications, such as design changes to correct latent defects, design changes to accommodate replacement of obsolete parts.

5.0 Overall Terms, Conditions and Assumptions

5.1 Offset Arrangement

5.1.1 Offset

In consideration for provision of the SPDM and other goods and services specified in this Arrangement, CSA will receive an offset towards its financial responsibility for CSOC as follows: offset of CSOC responsibilities associated with 2 rack years and 2 external adapter site years and 2% of non-Russian utilization resources.

5.1.2 Optional Additional Offset

CSA will have an option for an additional offset as follows: CSA will receive an offset of CSOC responsibilities associated with an additional 3.25 rack years and 4 additional external adapter site years and continued use of 2% of non-Russian utilization resources if:

a.) CSA assumes the repair and overhaul responsibilities and certain integrated logistics support responsibilities that were transferred to NASA under the 1994 Enhanced Cooperation Arrangement; and

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b.) CSA undertakes additional training responsibilities as follows. Recognizing the need for inter-system and proficiency training on the SPDM for flight crews and ground support personnel using the Space Station Training Facility, Prototype Part Task Trainer, and Dexterous Manipulator Trainer (TBD), if CSA accepts this option, CSA will provide SPDM flight software source code and SPDM simulation software models to NASA for NASA to integrate into the Trick MSS simulation and Space Station Training Facility (SSTF) environment. Dissemination and application of this CSA source code will be in accordance with procedures and controls established between NASA and CSA for the MSC flight software source code. CSA will provide to NASA any changes to the SPDM flight software source code and SPDM simulation software models to allow NASA to maintain the simulation at the latest flight configuration. CSA will provide SPDM documentation similar to that agreed for the MSC in Bilateral Data Exchange Agreements, Lists and Schedules. NASA will be invited to SPDM reviews in the same manner as was agreed for MSC reviews and documented in the NASA-CSA Joint Management Plan.

CSA is to exercise this option by no later than March 31, 1998. In the event NASA is required to take action to support these responsibilities prior to March 31, 1998, NASA may do so, provided it notifies CSA as soon as practicable after learning of the need for earlier action.

5.2 Terms, Conditions and Assumptions Applicable to Basic and Optional Offsets

5.2.1 General Responsibilities

Each Party will be responsible for support of its own elements, in accordance with the Space Station Agreements, unless otherwise specified in this Arrangement. Further, the MSS, as an integral part of the Space Station infrastructure, relies on several NASA-provided Space Station sub-systems. Consequently, many of the MSS test, integration and verification activities are shared between NASA and CSA.

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5.2.2 Timing of Utilization

Specific plans for the timing of the utilization enabled by the exercise of the Arrangement would be developed through normal program planning mechanisms (the Partner Utilization Plans, the Consolidated Operations and Utilization Plan, and tactical planning documents). The utilization will occur during a period of ten years or such other period as may be mutually agreed. CSA utilization rights will begin as specified in the new MOU.

5.2.3 Notice of Intent to Use Allocation

This offset will allow CSA to use its allocations of utilization accommodations and resources at the rate specified in this Arrangement without the need to provide additional compensation or services towards CSA's CSOC obligations. CSA will retain the rights to use its full allocations as detailed in the Space Station Agreements, subject to a corresponding obligation to fulfill its CSOC responsibilities for any use not covered by an offset in accordance with the approach set forth in the Space Station Agreements. To ensure the allocations are fully utilized by CSA or another entity, CSA will provide timely notice of its intent to use or forfeit part or all of its allocations for any use not covered by the offset. The NASA and CSA User Operations Panel members will agree on the minimum required notice of CSA's intent to use or not use its allocation. At a minimum, notice will be given 2 years in advance of operations. In the event CSA does not elect to use its full allocation, NASA will assume the allocation not used by CSA and will similarly assume responsibility for the CSOC associated with that allocation. In the event CSA reaches an agreement with another entity whereby that entity is granted use of CSA's utilization allocation, such use will be subject to the Space Station Agreements and CSA will remain responsible for ensuring such use is in compliance with the Space Station Agreements. Any such agreement with another entity will not absolve CSA of its obligations with regard to the SPDM.

5.2.4 Maximum Utilization Rate

Maximum rate of usage under this Arrangement will not exceed 1 rack and 1 external adapter site and 2% of non-Russian utilization resources in any given year.

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CSA may vary its utilization rate annually to a maximum of 1 rack per year and an external adapter site, in any given year.

5.2.5 Provision of ISPR

NASA will make available International Standard Payload Rack (ISPR) accommodations (with EXPRESS rack insert, if necessary) for CSA payloads. NASA will also provide integration of CSA payloads to the rack level.

5.2.6 Responsibilities for Launch Services

NASA will provide standard Shuttle launch services for launch and return of the SPDM, its spares and the MSC spares. Other launch related activities, including delivery to NASA and prelaunch activities are as defined in Section 6 herein. NASA agrees to provide standard launch and return services on a non-reimbursable basis for the SPDM, its spares and the MSC spares on the Shuttle and to deliver the SPDM, its spares and the MSC spares to the ISS and return them to Earth. NASA will provide a Spacelab pallet, arm and body frame flight support equipment, and associated integration for the SPDM launch. NASA further agrees to perform deployment, on-orbit activation and checkout for the SPDM with the cooperation and technical support of CSA technical and operations specialists. In addition to the flight support equipment provided by NASA and described above, CSA will also provide flight support equipment in the form of component flight support equipment to attach the SPDM launch configuration components to the NASA-provided flight support equipment. The interface will be as defined in "SPDM Component FSE to NASA Interface Structure FSE Interface Control Document", a mutually agreed Space Station Program Document. Payment for any Non-Standard Shuttle Services provided by NASA to CSA will be the responsibility of CSA unless otherwise agreed. CSA will remain responsible for purchasing launch and, as desired, return transportation services for its payloads.

5.2.7 Ownership

Pursuant to Article 6.1 of the new IGA, CSA will retain ownership of the SPDM.

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CSA is responsible for element unique and task training for the Canadian elements of the MSS for Space Station crew members and ground support personnel. Further, CSA will provide such training to crew members from any Partner without charge under the conditions specified in Article 11.6 of the new MOU. CSA's net contribution to training has been taken into account in determining the value of CSA's offset. NASA will provide training, at NASA facilities, without charge, to CSA's Space Station crew . "

5.2.9 Failure to Provide All or Part of the SPDM

In the event that CSA does not provide all or part of the SPDM, CSA will ensure that such can be procured by NASA in Canada under the equivalent conditions that would be applied to CSA. If the SPDM or any part thereof that is not provided by CSA is not available to NASA in Canada in accordance with agreed specifications and schedules and at reasonable prices to be agreed, NASA will be free to produce the SPDM or any such part thereof in the United States. For this purpose, CSA will ensure the availability of the necessary licensing arrangements.

5.2.10 SPDM Requirements

NASA and CSA will jointly agree on a CSA/NASA Mobile Servicing System (MSS) Special Purpose Dexterous Manipulator System Requirements Document, and both Parties will have the opportunity to fully participate in the SPDM technical reviews to ensure adequate visibility into the SPDM development process.

6.0 Respective Responsibilities of CSA and NASA

Notwithstanding the terms and conditions contained in Article 5 herein and Article 6 of the 1988 MOU, and consistent with the responsibilities of the Parties as specified in Article 6 of the new MOU, the Parties will have the following responsibilities with regard to the SPDM and other goods and services pursuant to this Arrangement:

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- 6.1 Except as otherwise specified in this Arrangement, CSA will assume full financial and technical responsibility for the SPDM design, development, manufacture, integration and test, and delivery
- 6.2 CSA will support NASA's overall Space Station system engineering and integration responsibility, including NASA's activities for SPDM to Space Station integration, and support NASA's launch site processing of the SPDM.
- 6.3 NASA and CSA will cooperate in an ongoing technical review of all existing and future ISS extravehicular dexterous robotic tasks as follows:
- a.) validate the capability of the existing NASA Robotic System Engineering Laboratory at JSC to verify compliance of ORUs and external payloads with the latest agreed version of the Robotic Systems Integration Standards, SSP 30550 and with applicable sections of the latest agreed version of the MSS to User (Generic) Interface Control Document, SSP 42004;
 - b.) determine if ORUs and external payloads are compatible with the SPDM by review of results of tests conducted by NASA or another partners to verify compliance with RSIS and SSP 42004;
 - c.) determine if the SPDM capabilities, including standard tools, could perform an extravehicular dexterous robotic task involving ORUs and external payloads from b., above, notwithstanding whether the requirements of the RSIS and SSP 42004 are met; and
 - d.) develop and verify operations procedures and timelines for all extravehicular dexterous robotic tasks determined from b. and c., above, to be feasible.

In the event that an extravehicular dexterous robotic task is initially determined to be unfeasible, NASA and CSA will develop and analyze options to resolve the issues which impede successful completion of that task.

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6.4 CSA will design, develop and manufacture a SPDM which will provide capabilities defined in the joint CSA/NASA Mobile Servicing System (MSS) Special Purpose Dexterous Manipulator System Requirements Document number CSA-SS-SRD-0011, latest agreed revision (the "SPDM SRD").(Note: The SRD content may be incorporated into the MSS Segment Specification. In that event, the jointly agreed MSS Segment Specification and the MSS To User ICD will become the governing requirements documents for the SPDM.)

6.5 CSA will perform SPDM system engineering and integration, including risk management activities, in accordance with Article 6 of the new MOU.

6.6 CSA will conduct SPDM reviews and will participate in related NASA Space Station reviews in accordance with Article 6 of the new MOU.

6.7 CSA will deliver the SPDM to NASA to a location in the United States to be determined by NASA, and in accordance with the Space Station assembly schedule and provide support for SPDM Launch Package Integration, modal test and verification and certification.

6.8 CSA will assist NASA in the launch, interface verification and on-orbit assembly of the SPDM in accordance with the new MOU and agreed assembly, activation and verification plans.

6.9 CSA will be responsible, with the support of NASA, for certification of the SPDM-element and the CSA-provided SPDM-element subsystems.

6.10 CSA will be responsible, with the assistance of NASA, for the on-orbit activation and performance verification of the SPDM in accordance with the new MOU and agreed assembly, activation and verification plans.

6.11 CSA is responsible for the on-orbit performance of the SPDM consistent with the new MOU.

6.12 Details of the timing of the deployment, on-orbit activation and checkout of the SPDM will be determined through agreed program assembly and verification plans.

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6.13 CSA will have continuing responsibilities for the SPDM in accordance with the new MOU and as detailed herein, including maintenance, sustaining engineering, integrated logistics support, spares, required ground support equipment, operations and training support, repair and overhaul, and training in Canada. For SPDM training, CSA will conduct the following training tasks: analysis of SPDM tasks; preparation of SPDM Course Training Standards (CTS); preparation of SPDM Course Training Plan (CTP); and courseware development of Training and Learning aids.

6.14 CSA will establish, in Canada, a SPDM Task Verification Facility (STVF) and simulation facilities for supporting SPDM development and operations work. CSA will be responsible for STVF capabilities, including the provision of a RWS functionality if required. CSA will also provide upgrades to its MSS Engineering Support Center (ESC) and Space Operations Support Center to accommodate SPDM off-line and real time support. The CSA facilities will be used for Canadian element-unique activities, including real time support to SPDM operations, and to support common system operations as agreed with NASA.

6.15 CSA will provide MSS (SSRMS, MBS and SPDM) task analysis, including support to NASA in the ISS Design Analysis Cycles for procedures required to berth and assemble the Russian Science Power Platform (SPP). CSA will continue to support NASA in the SPP effort until successful installation of the SPP on ISS by:

- a.) performing SSRMS berthing analysis of the SPP to Service Module. Analysis will be performed for both a quasi-static push method and a kinetic method of berthing. Each method will possibly require multiple configurations (i.e. folded and unfolded probe latches). Configuration will be defined and agreed to within the joint berthing team;
- b.) providing results of the analysis to NASA for joint review with RSC-Energia;
- c.) participating in the test and verification planning and supporting analysis of test results; and

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d.) supporting NASA in the assessment of EVA assisted berthing methods for the SPP. The support will involve the definition of and analysis of the SSRMS's positioning capabilities of the SPP docking probe relative to the Service Module docking cone.

6.16 CSA's responsibility for support of analytic analyses for payload activities by the SPDM will correspond to CSA's responsibility for the SSRMS as described in the new MOU.

6.17 CSA will provide, as agreed by the NASA and CSA Space Station Program Managers, Space Station Remote Manipulator System (SSRMS) software upgrades identified in the Mobile Servicing System (MSS) End-to-End Review, April 1997.

6.18 As part of the offset, CSA will provide six personnel, or their equivalent, to provide MSS operations support services (analysis and mission planning). These individuals will be stationed at locations to be agreed by NASA and CSA operations teams. The provision of these personnel and the value of their services has been taken into account in determining the value of CSA's offset.

Done at _____, in duplicate, this ___ day of _____, 1997.

For NASA

For CSA
