

# ORDER FOR SUPPLIES OR SERVICES

1. Order No. **CRAVE-EC5-DO43**      2. Date of Order  
See Block 10 Below

**NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.**

Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office:  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org./Buyer: BH2/Adrian D. Clayton

4. Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For: **Accountable Property**  
Order No.: CRAVE-EC5-DO43

Tel No.: 281-483-8498      Fax: 281-244-0995  
E-mail: adrian.d.clayton@nasa.gov

5. Contractor:  
Hamilton Sundstrand Space Systems International, Inc.  
Attention: Angela Hillin  
2200 Space Park Dr.  
Ste. 100  
Houston, TX 77058

6. Deliver On or Before: ATP + 31 Weeks  
F.O.B. Point: DESTINATION  
Discount Terms: Net 30 Days.

Phone: 281-336-6316    x      Fax: 860-998-7029  
TIN:      CAGE CODE: 71120

7. BILLING ADDRESS:  
NASA Johnson Space Center  
Attn: LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No.: CRAVE-EC5-DO43

8. Type of Order:  
 PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_  
 DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor  is,  is not required. Sign below if required and return to contracting officer.  
Name: Angela S. Hillin (Person authorized to sign)  
Signature: AS Hillin      Date: 05 June 2009

10. Name: Ronald Johnson  
Signature: Ronald Johnson      Date: 7/21/09  
CONTRACTING OFFICER

11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	SUB-SCALE AMINE SWING BED DEVELOPMENT FOR EVA  PERIOD OF PERFORMANCE. ATP + 31 weeks  The contractor shall perform and deliver to all requirements of CRAVE  DO 43 as described in the DO Statement of Work.					

12. For JSC Internal Use Only:  
Requisition No.: N/A       COMP.     PART.    PPC: \_\_\_\_\_  
Rissue To: EC/Ralph Marak x:3-9144

13. Total  
\$ 274,138

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED     ACCEPTED     RECEIVED  
TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.  
BY: \_\_\_\_\_  
Authorized U.S. Government Representative      Date \_\_\_\_\_

SCHEDULE

ITEM	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED

# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
NNJ05HB39B, DO42

2. Date of Order  
See Block 10 Below

NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.  
Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office:  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org./Buyer: BH2/Adrian D. Clayton

Tel No.: 281-483-8498 Fax: 281-244-0995  
E-mail: [adrian.d.clayton@nasa.gov](mailto:adrian.d.clayton@nasa.gov)

4. Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For: Accountable Property  
Order No.: NNJ05HB39B, DO42

5. Contractor:  
Hamilton Sundstrand Space Systems Internat'l Inc.  
Attn: Angela S. Hillin  
2200 Space Park Drive, Suite 100  
Houston, TX 77058-3663

Phone: 281-336-6316 x      Fax: 860-998-7029

TIN:      CAGE CODE: 71120

6. Deliver On or Before: April 8, 2009 - November 1, 2009  
F.O.B. Point: DESTINATION  
Discount Terms: Net 30 Days.

7 BILLING ADDRESS:  
NASA Johnson Space Center  
Attn: LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No.: NNJ05HB39B, DO42

8. Type of Order:  
 PURCHASE: Please furnish the following in accordance with the conditions specified on this order Reference: \_\_\_\_\_  
 DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor [] is, [] is not required. Sign below if required and return to contracting officer.  
Name: \_\_\_\_\_ (Person authorized to sign)  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_

10. Name: Ronald Johnson  
Signature: Ronald Johnson Date: 4/8/09  
CONTRACTING OFFICER

11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	Space Suit Oxygen Systems Test Rig Design and Development for Exploration Technology					
	PERIOD OF PERFORMANCE: 04/08/09 - 11/01/09 (Phase 1)					
	The contractor shall perform and deliver to all requirements of CRAVE DO42 Phase 1 (Base) as described in the DO Statement of Work.	b4			b4	
	<b>Total: \$264,881</b>					

continued page 2

12. For JSC Internal Use Only:  
Requisition No.: N/A  
Rissue To: EC/Ralph Marak x:39144

COMP.     PART    PPC: \_\_\_\_\_

13. Total  
\$ 264,881 NTE

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED     ACCEPTED     RECEIVED  
TO CONFORM TO THE CONTRACT  
ACCEPTANCE WILL BE AT JSC UNLESS  
OTHERWISE NOTED

BY: \_\_\_\_\_

Authorized U S. Government Representative \_\_\_\_\_ Date \_\_\_\_\_

**SCHEDULE**

ITEM	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	<p>Option</p> <p>The Government may require the contractor to continue to perform services under this delivery order. The Contracting Officer may unilaterally exercise the Option by issuing Revision 1 to DO 42. The Government reserves the right not to exercise the Option. Should the Option be exercised, the delivery order revision will be issued at the costs shown below.</p> <p style="text-align: center;">b4</p> <p style="text-align: right;">Total: \$477,695</p> <p>THIS IS A CPFF DELIVERY ORDER</p>	b4			\$477,695	

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
 LYNDON B. JOHNSON SPACE CENTER  
 HOUSTON, TX 77058**

COST REIMBURSABLE INDEFINITE-DELIVERY  
 INDEFINITE-QUANTITY (IDIQ) TASK ORDER  
 Hamilton Sundstrand Space Systems Intl., Inc.  
 Contract NNJ05HB39B

<i>Task Order Number</i>	<i>Revision Number</i>	<i>Purchase Request Number</i>
39	3	Funded at Contract Level
<i>SOW WBS</i>	<i>Fiscal Year</i>	<i>Technical Monitor/Division/Extension</i>
	FY09	COTR: Ralph Marak/EC ext:3-9144

**Task Order Title**

PLSS FAN ASSEMBLY DEVELOPMENT FOR EXPLORATION TECHNOLOGY

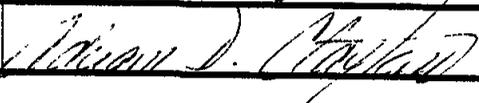
**Description/Purpose**

This purpose of this delivery order revision is to extend the period of performance from November 30, 2009 – March 16, 2010. (November 13, 2008 – March 16, 2010)

	<u>Previous Value</u>	<u>Current Action</u>	<u>Total Value</u>
<b>Cost</b>	by	by	by
<b>Fee</b>			
<b>Total</b>	\$ 536,373.00	\$ 0	\$ 536,373.00

**THE CONTRACTOR IS NOT AUTHORIZED TO EXCEED THE TASK ORDER VALUE SPECIFIED HEREIN. THIS IS A COST PLUS FIXED FEE TASK ORDER.**

**NASA Approval**

<i>Contracting Officer</i>	<i>Signature</i>	<i>Date</i>
Adrian D. Clayton		10/08/2009

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
 LYNDON B. JOHNSON SPACE CENTER  
 HOUSTON, TX 77058**

COST REIMBURSABLE INDEFINITE-DELIVERY  
 INDEFINITE-QUANTITY (IDIQ) TASK ORDER  
 Hamilton Sundstrand Space Systems Intl., Inc.  
 Contract NNJ05HB39B

<i>Task Order Number</i>	<i>Revision Number</i>	<i>Purchase Request Number</i>
39	2	Funded at Contract Level
<i>SOW WBS</i>	<i>Fiscal Year</i>	<i>Technical Monitor/Division/Extension</i>
	FY09	COTR: Ralph Marak/EC ext:3-9144

**Task Order Title**

PLSS FAN ASSEMBLY DEVELOPMENT FOR EXPLORATION TECHNOLOGY

**Description/Purpose**

This delivery order revision is for additional scope of work as delineated in proposal # ESDPC-09F-0214. The period of performance remains unchanged.

	Previous Value	Current Action	Total Value
<b>Cost</b>	bf	bf	bf
<b>Fee</b>			
<b>Total</b>	\$ 486,504.00	\$ 49,869.00	\$ 536,373.00

**THE CONTRACTOR IS NOT AUTHORIZED TO EXCEED THE TASK ORDER VALUE SPECIFIED HEREIN. THIS IS A COST PLUS FIXED FEE TASK ORDER.**

**NASA Approval**

<i>Contracting Officer</i>	<i>Signature</i>	<i>Date</i>
Ronald Johnson	<i>Ronald Johnson</i>	9/23/09

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
 LYNDON B. JOHNSON SPACE CENTER  
 HOUSTON, TX 77058**

COST REIMBURSABLE INDEFINITE-DELIVERY  
 INDEFINITE-QUANTITY (IDIQ) TASK ORDER  
 Hamilton Sundstrand Space Systems Intl., Inc.  
 Contract NNJ05HB39B

<i>Task Order Number</i>	<i>Revision Number</i>	<i>Purchase Request Number</i>
39	1	Funded at Contract Level
<i>SOW WBS</i>	<i>Fiscal Year</i>	<i>Technical Monitor/Division/Extension</i>
	FY09	COTR: Ralph Marak/EC ext:3-9144

**Task Order Title**

PLSS FAN ASSEMBLY DEVELOPMENT FOR EXPLORATION TECHNOLOGY

**Description/Purpose**

The purpose of this delivery order revision is to execute a no-cost extension. The period of performance shall be extended from July 31, 2009 to November 30, 2009.

*The contract value remains unchanged.*

**THE CONTRACTOR IS NOT AUTHORIZED TO EXCEED THE TASK ORDER VALUE SPECIFIED HEREIN. THIS IS A COST PLUS FIXED FEE TASK ORDER.**

**NASA Approval**

<i>Contracting Officer</i>	<i>Signature</i>	<i>Date</i>
Ronald Johnson	<i>Ronald Johnson</i>	<i>3/9/09</i>

# ORDER FOR SUPPLIES OR SERVICES

1. Order No. **NNJ05HB39B, D039**  
2. Date of Order  
See Block 10 Below

**NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.**

3. Issuing Office.  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org./Buyer. **BH2/Mary Thomas**

4. Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For: **Accountable Property**  
Order No.. **NNJ05HB39B, D039**

Tel No. **281-483-8828** Fax. **281-244-0995**  
E-mail: **mary.f.thomas@nasa.gov**

5 Contractor:  
Hamilton Sundstrand Space Systems Internat'l Inc  
Attn: Angela Hillin  
2200 Space Park Drive, Suite 100  
Houston, TX 77058  
  
Phone: 281-336-8316 x      Fax: 860-998-7029  
  
TIN: 06-1165586      CAGE CODE: 71120

6. Deliver On or Before **11/10/08 to 07/31/09**  
F O B. Point. **DESTINATION**  
Discount Terms: Net 30 Days

7 BILLING ADDRESS.  
NASA Johnson Space Center  
Attn. LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No.: NNJ05HB39B, D039

8 Type of Order.  
 PURCHASE. Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_  
 DELIVERY Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number \_\_\_\_\_

9. Written acceptance of this order by contractor  is,  is not required. Sign below if required and return to contracting officer  
Name: \_\_\_\_\_ (Person authorized to sign)  
Signature \_\_\_\_\_ Date: \_\_\_\_\_

10. Name: **Ronald Johnson**  
Signature: *Ronald Johnson* Date: *11/10/08*  
**CONTRACTING OFFICER**

11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
1	<p>PLSS FAN ASSEMBLY DEVLPMT FOR EXPLORATION TECHNOLOGY</p> <p>PERIOD OF PERFORMANCE 11/10/08 to 07/31/09</p> <p>The contractor shall perform and deliver to all requirements for the design and fabrication of a development PLSS fan assembly including fan, motor, and associated electronics and controller, and successful demonstration of the fan assembly as described in the SOW The contractor shall deliver two fan assemblies to NASA at contract completion</p>	64			64	

CONTINUED PAGE 2

12 For JSC Internal Use Only  
Requisition No.. **N/A**       COMP     PART    PPC: \_\_\_\_\_  
Rissue To: **EC/Ralph Marak, x39144**

13 Total  
**\$ NTE 486,504**

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT  
ACCEPTANCE WILL BE AT JSC UNLESS  
OTHERWISE NOTED.      BY: \_\_\_\_\_

Authorized U S. Government Representative      Date \_\_\_\_\_

SCHEDULE

ITEM	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	<p>Recap DO Value:</p> <p>Cost: <i>64</i></p> <p>Fee:</p> <p>Total: \$486,504</p> <p>THIS IS A CPFF DELIVERY ORDER</p>					

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE-EC5-037**

**PROPOSAL INSTRUCTIONS:**  X  DRAFT – COMMENTS DUE BY: March 10, 2008  
  FINAL -- PROPOSAL DUE BY: April 21, 2008

**DO TITLE:** PLSS Water Pump Development for Exploration Technology  
**DO Type:**  X  CPFF   FFP

**DO Contact Information in Addition to the CRAVE Contract Specialist or CO:**  
**TMR:**  Joe Gensler  Phone:  (281) 483-0025   
**DO Manager:**  Luis Trevino  Phone:  (281) 483-9141   
**DO Mgr. Alternate:**  Heather Paul  Phone:  (281) 483-3678

**Concurrences:**

<u> Luis Trevino </u> DO Manager	<u> Raul Blanco </u> DO Mgr. Management	<u> Joe Gensler </u> COTR
<u> Kimberly Baird </u> Division TMR	<u> N/A </u> S & MA	<u> Ron Johnson </u> Contracting Officer

**Task Contains Flight Hardware, Flight Software or GSE?**   Yes  X  No  
**Program Supported:**   Shuttle   ISS  X  EVA  X  Advanced   Cx

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**WBS:**  X  1.0 EVA   2.0 FCE   3.0 EVR   ECLSS   5.0 ATCS   6.0 CHcCS

*For purposes of complying with FAR 52.232-22, Limitation of Funds, the total amount allotted by the Government to contract is specified in clause B.6, Contract Funding. The funding listed in B.6 is the amount allotted for all Delivery Orders on the contract combined.*

*All terms and conditions of the contract apply to this Delivery Order. In the event of a conflict between the contract and this Delivery Order, the contract shall prevail.*

*WBS reporting shall be done in accordance with applicable WBS reporting categories, as shown above and in the contract within Section C, Table 1.*

PLSS Water Pump Development for Exploration Technology

**Background / Problem Description:**

The current EMU PLSS water pump is a centrifugal multi-vane-type that operates at high revolutions per minute (rpm) (~ 20,200 rpm). This centrifugal pump is sensitive to gas bubbles and can require priming before EVA, resulting in additional EVA preparation time. The current EMU PLSS uses a special pressurizing system that maintains the water loop at 15 pounds per square inch (psi). A dedicated 15 psi oxygen regulator provides backpressure to the Shuttle PLSS feedwater bladder tanks in order to minimize outgassing and bubble formation during EVA operations. The Shuttle PLSS also uses a gas trap and a centrifugal water separator to remove gas from the water loop. Additionally, the Shuttle EMU pump has experienced cavitation issues and has shown susceptibility to water impurities on at least one occasion causing vane growth.

For future missions such as those required of the Constellation Space Suit Element (CSSE), the space suit will employ new technologies to ensure a safe, supportable, sustainable, and extensible suit system that allows for useful work to be performed by the crew during launch, landing, in-space, and on the lunar and Martian surfaces. The suit system protects the crew from nominal and off nominal environments associated with Constellation Program (CxP) mission phases. In order to meet the identified requirements for protecting crew during EVA, the PLSS water loop will use potable water from the vehicle or habitat that has been nominally delivered at 8 psi.

The CSSE PLSS schematic is shown in *Figure 1: CSSE PLSS Schematic*.

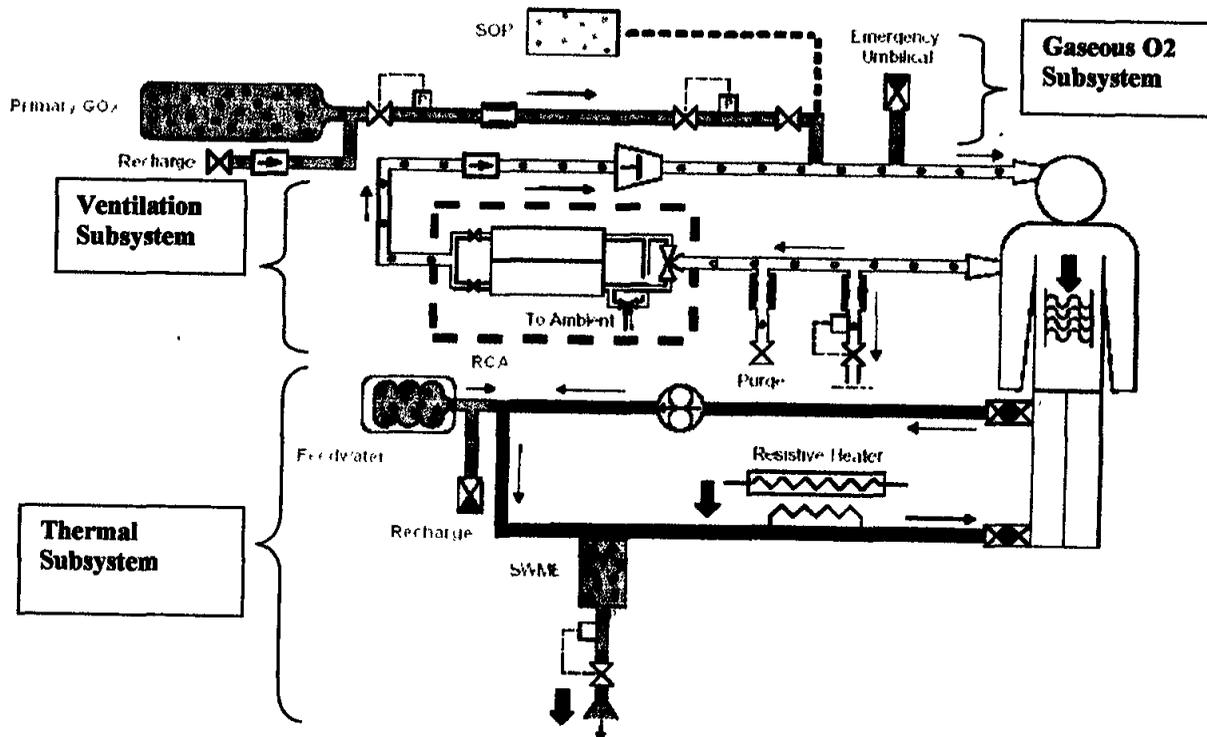


Figure 0-1: Simplified Baseline CSSE PLSS Schematic

requirements. For development design purposes, focus shall be on the lunar design with protection for key design features for the Mars capability

**Surface Temperatures for the Custom Unit Pump (CUP):**

35 F to 100 F (1.7degC to 38 degC)

**Water Flowrate and Pressure Rise through CUP:**

82 kg/hr (180lbm/hr) minimum at 69 kPad (10 psid)

91 kg/hr (200lbm/hr) minimum at 35 kPad (5 psid)—DESIGN POINT

**CUP Inlet Water Pressures:**

23 - 69 kPag [3.3 - 10 psig] in Vacuum EVA environment

Pressure units are absolute units at vacuum, and are referenced to ambient pressure in airlock and ground ops

**CUP Useful Life:**

2000 hrs minimum (twice EVA life)

**CUP Water Quality:**

The water pump and PLSS shall accept potable water from Vehicle Interface Element, with and without silver biocide, as specified in the Potable Water Table (TBD-CSSE-136). (see Reference 2, CXP70024, for guidelines).

**CUP External Operating Environment:**

The CUP and its support equipment shall be designed for ambient test operation, with recommended changes included to allow for a vacuum compatibility design.

**CUP Standby and StartUp Capability:**

After power is turned off to the CUP, the CUP shall be capable of startup at any time when the initial water inlet is between 35 F to 100 F (1.7degC to 38 degC.)

**CUP Motor Type:** Permanent magnet type

**CUP Overall Power Consumption:** 15 Watts +/-10% maximum overall at 5 psid

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE-EC5-037**

<b>Materials Usage List</b>	A materials list which details all the materials the contractor incorporated in the design and in the fabrication of the CUPS. This list should also provide the status of each material in the Marshall Space Flight Center MAPTIS database. If the material(s) is not listed in MAPTIS, the contractor shall provide a preliminary plan for having the material processed and documented per the Materials Analysis Tracking and Control (MATCO) system.	3 EA paper and CD (PDF and Word format)	Contract Completion	N/A
<b>Operating Manual for CUP Test Unit</b>	An operating manual for the CUP test unit delivered to NASA, to include motor as well as pump operating specifications		Contract Completion	
<b>Drawings</b>	All assembly and major part drawings used in the fabrication of the CUP hardware.	3 EA	Contract Completion	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-037**

**SCHEDULE**

**Start Date:** May 5, 2008

**Finish Date:** September 22, 2008

<b>ITERIM MILESTONES</b>	<b>DUE DATES (Weeks After ATP)</b>
<b>Kick-off Meeting</b>	<b>1</b>
<b>Review/Study of Custom Unit Pump Design and Requirements</b>	<b>2</b>
<b>Midterm Presentation to NASA</b>	<b>10</b>
<b>Final Formal Presentation to NASA</b>	<b>18</b>
<b>Hardware Delivery</b>	<b>18</b>
<b>Generate/Publish Final Report</b>	<b>20</b>

Milestones, along with subjective measurements, are to be used for measuring performance. For schedule detail see Microsoft Project file located on the CRAVE web site for this DO listed under the Government Cost Estimate below.

**Total Government Estimate for this DO: \$150,000**

**TOTAL COST ESTIMATE FOR THIS DO: \$**

**FEE: \$ (If Applicable)**

**TO BE REMOVED FROM DO & INCLUDED IN RFO LETTER:**

Proposal Evaluation Criteria:

1. Proposed Technical Concept, including design, understanding, development/ hardware production capability and schedules;
2. Cost/Price: Except when it is determined not to be in the Government's best interests, the Government will evaluate price of proposals, by adding the total price, including options. Evaluation of options will not obligate the Government to exercise the options;
3. Proposed Achievement of Small Business Goals;
4. Past Performance; and
5. Other: \_\_\_\_\_

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-037**

**DATA REQUIREMENTS**

**All DRs contained in the contract are applicable and required unless marked N/A below.**

NOTES: 1. GREY SCALED ROWS NEED NO ADDITIONAL/REQUIRED FILL-INS.  
2. ON ALL OTHER ROWS, IF NECESSARY, FILL IN ADDITIONAL  
RQMTS/DELIVERIES IN LAST COLUMN.

DRD #	DATA TYPE	DRD TITLE	DUE	FREQUENCY	REQUIRED FOR DO? Y/N	ADDITIONAL REQUIREMENTS
1	Written Approval	FlightGFE Configuration Management Plan	With Proposal	Once	N	
2	Mandatory Submittal	Regular Status Report/ Summary Review	Thirty (30) days following contract start	Bi-Monthly	Y	Progress reports required twice monthly
3	Written Approval	Project Technical Requirements Specification	Per DO schedule	Once with Revisions	N	
4	Mandatory Submittal	GFE Systems Requirements Data Package	Specified in DO	Once with Revisions	N	
5	Written Approval	Flight GFE Projects Requirements & Verification Document	Specified in DO	Once with Revisions	N	
6	Mandatory Submittal	Preliminary Design Review Data Package	Specified in DO	Once with Revisions	N	
7	Written Approval	Flight GFE Workmanship Specifications List	Specified in DO	Once with Revisions	N	
8	Written Approval	Project Schedule	PDR or 10% effort complete Milestone	Once w/Revisions (due w/DO proposal updates & details provided as DO progresses)	Y	MS Project Format
9	Written Approval	Flight GFE Interface Control Document	Specified in DO	Once with Revisions	N	
10	Written Approval	GFE End Item Specification	Specified in DO	Once with Revisions	N	
11	Mandatory Submittal	Flight GFE Failure Analysis Report	As agreed by TMR in DO	As Required	N	
12	Written Approval	Flight GFE Verification and Validation Plan	As Specified in EA-023	Once with Revisions	N	
13	Written Approval	GFE Software Requirements Specification	Specified in DO	Once with Revisions	N	
14	Written Approval	GFE Software Development Plan	Specified in DO	Once with Revisions	N	
15	Written Approval	GFE Software Design Document	Specified in DO	As Required	N	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-037**

DRD #	DATA TYPE	DRD TITLE	DUE	FREQUENCY	REQUIRED FOR DO? Y/N	ADDITIONAL REQUIREMENTS
16	Written Approval	Engineering Drawings	With final report	Once with Revisions	Y	
17	Written Approval	EEE Parts Lists and Analysis Report		As Required	N	
18	Mandatory Submittal	Critical Design Review Data Package		Once with Revisions	N	
19	Mandatory Submittal	Engineering Drawing Change Proposal		As Required	N	
20	Written Approval	GFE Qualification Test Procedure		Once with Revisions	N	
21	Written Approval	Flight Product User's Guide		Once with Revisions	N	
22	Mandatory Submittal	Software Code		As Required	N	
23	Written Approval	Information Technology (IT) Security Program Plan and Reports	(30) days after DO award, and as specified in JPG 2810.1	JPG 2810.1	N	
24	Written Approval	Certification Plan		Once with Revisions	N	
25	Mandatory Submittal	Certification Report		Once with Revisions	N	
26	Mandatory Submittal	Engineering Analysis		As Required	N	
27	Mandatory Submittal	Acceptance Data Package		One Time	N	
28	Mandatory Submittal	Export Control Audit Results	After award of 1st DO yearly on Sept 30 thereafter	Yearly	N	
29	Written Approval	Quality Plan	With Proposal	Once with Revisions	<b>Attachment J-11</b>	
30	Written Approval	Patent Rights-Retention	As Required	As Required	<b>Y (If Applicable)</b>	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-037**

DRD #	DATA TYPE	DRD TITLE	DUE	FREQUENCY	REQUIRED FOR DO? Y/N	ADDITIONAL REQUIREMENTS
31	Written Approval	Shuttle/Station Payload Safety Data Package		As Required	N	
32	Mandatory Submittal	Limited Life Systems List		As Required	Y	
33	Written Approval	Space Station GFE Failure Modes and Effects Analysis and Critical Items List		As Required	N	
34	Written Approval	Space Shuttle GFE Safety and Analysis Report & Hazard Report		As Required	N	
35	Written Approval	Software Quality Assurance Plan Report	90 Days Prior to Software Development	Once with Revisions	N	
36	Written Approval	ISS Hazard Report		As Required	N	
37	Upon Request	Reliability and Maintainability Plan	With Proposal	One Time	Attachment J-9	
38	Written Approval	Government Certification Approval Request (GCAR)		As Required	N	
39	Written Approval	Risk Assessment Executive Summary Report (RAESR)		As Required	N	
40	Written Approval	Problem Reporting and Corrective Action (PRACA)		As Required	N	
41	Upon Request	Nonconformance Record		As Required	N	
42	Mandatory Submittal	Government Industry Data Exchange Program and NASA Advisory Problem Data		Once with Revisions	N	
43	Written Approval	Electrical Electronic and Electromechanical (EEE) Parts Control Plan		Once with Revisions	N	
44	Mandatory Submittal	Certification Data Package		Once with Revisions	N	
45	Written Approval	Certification and Acceptance Requirements Document		Once with Revisions	N	
46	Upon Request	Wage/Salary and Fringe Benefit Data	Thirty (30) days after issuance of each DO	Once	N	
47	Written Approval	GFE Acceptance Test Procedure		One Time	N	
48	Mandatory Submittal	Flight GFE Verification & Validation Report		Once with Revisions	N	
49	Mandatory Submittal	Space Shuttle GFE Failure Modes and Effects Analysis (FMEA) and Critical Items List		As Required	N	
50		Reserved	---	---	---	---

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRIVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-037**

<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>ADDITIONAL REQUIREMENTS</b>
51	Mandatory Submittal	NASA Contractor Financial Management Reporting	After Issuance of 1st DO	Monthly	<b>Y</b>	
52	Written Approval	Government Property Management Plan	With Proposal	Once with Revisions	<b>Attachment J-7</b>	
53	Mandatory Submittal	System Safety Plan	With Proposal	One Time	<b>Attachment J-10</b>	
54	Written Approval	R-Quality Plan Template	With Proposal/ Revisions as Required	<b>Only applicable to B-CRAVE contracts in accordance with the SOW and the DRD</b>	<b>Y</b>	

**Type 1 = Written Approval      Type 2 = Mandatory Submittal      Type 3 = Submittal Upon Request**

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
 LYNDON B. JOHNSON SPACE CENTER  
 HOUSTON, TX 77058**

COST REIMBURSABLE INDEFINITE-DELIVERY  
 COST PLUS FIXED FEE DELIVERY ORDER  
 University of Alabama at Birmingham Center  
 Contract NNJ05HB42B

<i>Task Order Number</i>	<i>Amendment Number</i>	<i>Purchase Request Number</i>
38	4	Funded at Contract Level
<i>SOW WBS</i>	<i>Fiscal Year</i>	<i>Technical Monitor/Division/Extension</i>
	FY09	COTR: Ralph Marak/EC ext:3-9144 Sharon Campana/EC2 ext:4-5508

**Task Order Title**

GLACIER

**Description/Purpose**

This delivery order revision is issued to correct revision #2. Option #8 is hereby exercised for the following flights: 1) 19A (STS-131) & ULF-5 (STS-133).

The contractor shall perform the subject tasks in accordance with delivery order description.

Summary	Previous	This Action	Current Value
		(Rev 3)	
Cost	bt	bt	bt
Fee			
<b>TOTAL</b>	<b>\$ 3,765,523.60</b>	<b>\$ 78,500.10</b>	<b>\$ 3,844,023.60</b>

**THE CONTRACTOR IS NOT AUTHORIZED TO EXCEED THE TASK ORDER VALUE SPECIFIED HEREIN. THIS IS A COST PLUS FIXED FEE TASK ORDER.**

**NASA Approval**

<i>Contracting Officer</i>	<i>Signature</i>	<i>Date</i>
Ronald Johnson	<i>Ronald Johnson</i>	9/9/09

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
 LYNDON B. JOHNSON SPACE CENTER  
 HOUSTON, TX 77058**

COST REIMBURSABLE INDEFINITE-DELIVERY  
 COST PLUS FIXED FEE DELIVERY ORDER  
 University of Alabama at Birmingham Center  
 Contract NNJ05HB42B

<i>Task Order Number</i>	<i>Amendment Number</i>	<i>Purchase Request Number</i>
38	3	Funded at Contract Level
<i>SOW WBS</i>	<i>Fiscal Year</i>	<i>Technical Monitor/Division/Extension</i>
	FY09	COTR: Ralph Marak/EC ext:3-9144 Sharon Campana/EC2 ext:4-5508

**Task Order Title**

GLACIER

**Description/Purpose**

This delivery order revision is issued to exercise option #8 as incorporated under revision #2 of this contract. This option is exercised for the following flights: 1) 19A (STS 131) & ULF4 (STS 132).

The contractor shall perform the subject tasks in accordance with delivery order description.

Summary	Previous	This Action	Current Value
		(Rev 3)	
Cost	bt	bt	bt
Fee			
<b>TOTAL</b>	\$ 3,687,023.40	\$ 78,500.10	\$ 3,765,523.50

**THE CONTRACTOR IS NOT AUTHORIZED TO EXCEED THE TASK ORDER VALUE SPECIFIED HEREIN. THIS IS A COST PLUS FIXED FEE TASK ORDER.**

**NASA Approval**

<i>Contracting Officer</i>	<i>Signature</i>	<i>Date</i>
RONALD JOHNSON	Ronald Johnson	8/20/09

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
 LYNDON B. JOHNSON SPACE CENTER  
 HOUSTON, TX 77058**

COST REIMBURSABLE INDEFINITE-DELIVERY  
 COST PLUS FIXED FEE DELIVERY ORDER  
 University of Alabama at Birmingham Center  
 Contract NNJ05HB42B

<i>Task Order Number</i>	<i>Amendment Number</i>	<i>Purchase Request Number</i>
38	2	Funded at Contract Level
<i>SOW WBS</i>	<i>Fiscal Year</i>	<i>Technical Monitor/Division/Extension</i>
	FY09	COTR: Ralph Marak/EC ext:3-9144 Sharon Campana/EC2 ext:4-5508

**Task Order Title**

GLACIER

**Description/Purpose**

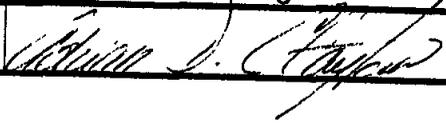
This delivery order: 1) identifies the scope of work to be performed during the period of performance beginning July 1, 2008 through December 31, 2010; 2) incorporates Option 7 and Option 8 within the delivery order description.

The contractor shall perform the subject tasks in accordance with the attached delivery order description.

Summary	Previous	This Action	Current Value
		(Rev 2)	
Cost	b4	b4	b4
Fee			
<b>TOTAL</b>	\$ 2,217,849.40	\$ 1,469,174.00	\$ 3,687,023.40

**THE CONTRACTOR IS NOT AUTHORIZED TO EXCEED THE TASK ORDER VALUE SPECIFIED HEREIN. THIS IS A COST PLUS FIXED FEE TASK ORDER.**

**NASA Approval**

<i>Contracting Officer</i>	<i>Signature</i>	<i>Date</i>
Adrian D. Clayton Contracting Officer		8/7/2009



# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
DO-CRAVE-EC2-DO38, Glacier

2. Date of Order  
See Block 10 Below

**NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.**  
Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office:  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org /Buyer: BH2/Mary Thomas  
  
Tel No.: 281-483-8828 Fax: 281-244-0995  
E-mail: mary.f.thomas@nasa.gov

4. Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For: **Accountable Property**  
  
Order No.: DO-CRAVE-EC2-DO38, Glacier

5 Contractor:  
  
University of Alabama @ Birmingham Center  
Attn: Lee Moradi  
1530 3<sup>rd</sup> Avenue South  
Birmingham, Alabama 35294-4400  
  
Phone: 205-975-2718 x      Fax: 205-975-1709  
  
TIN: 63-6005396      CAGE CODE: 0DV74

6. Deliver On or Before: 7/1/08 to 12/31/09  
  
F O B. Point. Destination  
  
Discount Terms: Net 30 Days.

7 BILLING ADDRESS:  
NASA Johnson Space Center  
Attn: LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No.. DO-CRAVE-EC-DO38, Glacier

8. Type of Order:  
 PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9 Written acceptance of this order by contractor [] is, [] is not required. Sign below if required and return to contracting officer  
  
Name: \_\_\_\_\_ (Person authorized to sign)  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_

10. Name: Ronald Johnson  
  
Signature: Ronald Johnson Date: 4/26/08  
CONTRACTING OFFICER

11 Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
1	<p>GLACIER</p> <p>The contractor shall perform and deliver to all base requirements of CRAVE-EC2-DO38 as described in the Statement of Work</p> <p>Period of Performance: July 1, 2008 to December 31, 2009</p> <p>OPTION</p> <p>The Government may require the contractor to continue to perform services under this delivery order. The Contracting Officer may exercise any Option by issuing a revision to the DO. The Government</p> <p>(continued next page)</p>	by	by	by	by	

12 For JSC Internal Use Only.  
Requisition No: N/A       COMP.     PART    PPC: \_\_\_\_\_  
Rissue To: EC/Joe Gensler. x30025

13. Total  
  
\$ NTE 1,555,851 36

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED     ACCEPTED     RECEIVED  
  
TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.  
  
BY \_\_\_\_\_  
Authorized U.S. Government Representative      Date \_\_\_\_\_

**SCHEDULE**

ITEM	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	reserves the right not to exercise any Options Should an Option be exercised, the delivery order revision will be issued using the cost proposed.					
2	Option 1 - Launch Support for Glacier for 1 Mission					
3	Option 2 - Integration and Verification of an Additional ISS Mission					
4	Option 3 - Operations Support for Glacier					
5	Option 4 - Crew Training for Glacier					
6	Option 5 - Landing Support for Glacier					
7	Option 6 - Real Time Operations					
THIS IS A CPFF DELIVERY ORDER						
RECAP OF DO VALUE						
	COST—	THIS ACTION	CUM VALUE			
	FEE	<i>bl</i>	<i>bl</i>			
	TOTAL	\$1,555,851.36	\$1,555,851.36			

*bl*

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
 LYNDON B. JOHNSON SPACE CENTER  
 HOUSTON, TX 77058**

COST REIMBURSABLE INDEFINITE-DELIVERY  
 INDEFINITE-QUANTITY (IDIQ) TASK ORDER  
 Hamilton Sundstrand Space Systems International, Inc.  
 NNJ05HB39B

<i>Task Order Number</i>	<i>Amendment Number</i>	<i>Purchase Request Number</i>
37	3	Funded at Contract Level
<i>SOW WBS</i>	<i>Fiscal Year</i>	<i>Technical Monitor/Division/Extension</i>
	FY09	COTR: EC/Ralph Marak, 39144 / EC5/Luis Trevino

**Task Order Title**

Portable Life Support System (PLSS) Water Pump Development for Exploration Technology

**Description/Purpose**

Revision 2 to DO 37 is issued to extend the completion date to 10/31/2009 at no additional cost to the Government. All other terms and conditions of the DO remain unchanged.

Recapitulation of the DO Value:

Summary	Current Value
Cost	64
Fee	
<b>TOTAL</b>	<b>\$ 143,178.00</b>

**THE CONTRACTOR IS NOT AUTHORIZED TO EXCEED THE TASK ORDER VALUE SPECIFIED HEREIN. THIS IS A COST PLUS FIXED FEE TASK ORDER.**

**NASA Approval**

<i>Contracting Officer</i>	<i>Signature</i>	<i>Date</i>
Ronald Johnson	<i>Ronald Johnson</i>	8/13/09

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
 LYNDON B. JOHNSON SPACE CENTER  
 HOUSTON, TX 77058**

COST REIMBURSABLE INDEFINITE-DELIVERY  
 INDEFINITE-QUANTITY (IDIQ) TASK ORDER

<b>Task Order Number</b>	<b>Amendment Number</b>	<b>Purchase Request Number</b>
37	Revision 2	Funded at Contract Level
<b>SOW WBS</b>	<b>Fiscal Year</b>	<b>Technical Monitor/Division/Extension</b>
	FY09	COTR: EC/Ralph Marak, 39144 / EC5/Luis Trevino

**Task Order Title**

Portable Life Support System (PLSS) Water Pump Development for Exploration Technology

**Description/Purpose**

Revision 2 to DO 37 is issued to extend the completion date to 01/31/2009 at no additional cost to the Government. All other terms and conditions of the DO remain unchanged.

Recapitulation of the DO Value:

Summary	Current Value
Cost	bf
Fee	
<b>TOTAL</b>	<b>\$ 143,178.00</b>

**THE CONTRACTOR IS NOT AUTHORIZED TO EXCEED THE TASK ORDER VALUE SPECIFIED HEREIN. THIS IS A COST PLUS FIXED FEE TASK ORDER.**

**NASA Approval**

<b>Contracting Officer</b> RONALD JOHNSON CONTRACTING OFFICER	<b>Signature</b> <i>Ronald Johnson</i>	<b>Date</b> 12/18/08
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# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
NNJ05HB39B, CRAVE D037R1

2. Date of Order  
See Block 10 Below

**NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.**

Certified for National Defense under DPAS (15 CFR 700) DO-C9

3 Issuing Office.  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org./Buyer: BH2/Mary Thomas

Tel No: 281-483-8828 Fax: 281-244-0995  
E-mail: mary.f.thomas@nasa.gov

4. Ship To.  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For: **Accountable Property**  
Order No.: NNJ05HB39B, CRAVE D037R1

5. Contractor.  
Hamilton Sundstrand  
Attn. Angela Hillin  
2200 Space Park Drive  
Houston, TX 77058

Phone: 281-336-6316 x Fax: 860-998-7029

TIN: 06-1165586 CAGE CODE: 71120

6. Deliver On or Before: 06/05/08 - 12/31/08  
F O B. Point: DESTINATION  
Discount Terms. Net 30 Days

7 BILLING ADDRESS  
NASA Johnson Space Center  
Attn. LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No : NNJ05HB39B, CRAVE D037R1

8 Type of Order:  
 PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor [] is, [] is not required Sign below if required and return to contracting officer.

Name: \_\_\_\_\_ (Person authorized to sign)

Signature \_\_\_\_\_ Date: \_\_\_\_\_

10. Name: Ronald Johnson

Signature: Ronald Johnson Date 11/5/08  
CONTRACTING OFFICER

### 11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
1	PORTABLE LIFE SUPPORT SYSTEM (PLSS) WATER PUMP DEVELOPMENT FOR EXPLORATION TECHNOLOGY  Revision 1 to DO 37 is issued to extend the completion date to 12/31/08 at no additional cost to the Government. All other terms and conditions of the DO remain unchanged.  RECAP DO VALUE <u>b4</u> Total: \$143,178					<u>b4</u>

12. For JSC Internal Use Only

Requisition No.: N/A  COMP  PART PPC \_\_\_\_\_

Rissue To: EC/Ralph Marak, 39144 For: EC5/Luis Trevino

13 Total

\$ NTE 143,178

14 Quantities in "Quantity Accepted" Column Have Been

INSPECTED  ACCEPTED  RECEIVED

TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS  
OTHERWISE NOTED.

BY.

\_\_\_\_\_  
Authorized U S Government Representative

\_\_\_\_\_  
Date

# ORDER FOR SUPPLIES OR SERVICES

1 Order No.  
NNJ05HB39B, CRAVE DO37

2 Date of Order  
See Block 10 Below

NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO  
Certified for National Defense under DPAS (15 CFR 700) DO-C9

3 Issuing Office:  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org./Buyer BH2/Mary Thomas

4 Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For **Accountable Property**  
Order No.: NNJ05HB39B, CRAVE DO37

Tel No. 281-483-8828 Fax. 281-244-0995  
E-mail: mary.f.thomas@nasa.gov

5 Contractor:  
Hamilton Sundstrand  
Attn: Angela Hillin  
2200 Space Park Drive  
Houston, TX 77058

6 Deliver On or Before: 06/05/08 - 10/22/08  
F.O B Point DESTINATION  
Discount Terms Net 30 Days

Phone. 281-336-6316 x Fax: 860-998-7029  
TIN. 06-1165586 CAGE CODE: 71120

7. BILLING ADDRESS.  
NASA Johnson Space Center  
Attn. LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No NNJ05HB39B, CRAVE D037

8. Type of Order  
 PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_  
 DELIVERY. Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor [] is, [] is not required Sign below if required and return to contracting officer  
Name: \_\_\_\_\_ (Person authorized to sign)  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_

10 Name Ronald Johnson

Signature Ronald Johnson Date: 6/2/08  
CONTRACTING OFFICER

11 Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
1	PORTABLE LIFE SUPPORT SYSTEM (PLSS) WATER PUMP DEVELOPMENT FOR EXPLORATION TECHNOLOGY  PERIOD OF PERFORMANCE. 06/05/08 - 10/22/08  The contractor shall perform and deliver to all requirements for the design and fabrication of a development PLSS water pump to be designated as the Custom Unit Pump (See attached SOW) There are no options in the delivery order  RECAP DO VALUE:  Total \$143,178	34				

12. For JSC Internal Use Only

Requisition No. N/A  COMP  PART PPC \_\_\_\_\_  
Rissue To. EC/Joe Gensler, x30025 For EC5/Luis Trevino

13 Total  
\$ 143,178 NTE

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED  ACCEPTED  RECEIVED

TO CONFORM TO THE CONTRACT  
ACCEPTANCE WILL BE AT JSC UNLESS  
OTHERWISE NOTED. BY \_\_\_\_\_

Authorized U S Government Representative \_\_\_\_\_ Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

1. Order No. CRAVE DO33R2	2. Date of Order See Block 10 Below	NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO Certified for National Defense under DPAS (15 CFR 700) DO-C9
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3. Issuing Office: NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org /Buyer: <u>BH2/Mary Thomas</u>  Tel No. <u>281-483-8828</u> Fax. <u>281-244-0995</u> E-mail: <u>mary.f.thomas@nasa.gov</u>	4 Ship To: Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b>  Order No: <u>CRAVE DO33R2</u>
---	---

5 Contractor: Hamilton Sundstrand Management Services, Inc Attention: Angela Hillin 2200 Space Park Drive, Suite 100 Houston, TX 77058-3677  Phone. 281-336-6316 x      Fax: 860-998-7029  TIN. 06-1165586      CAGE CODE 71120	6 Deliver On or Before: <u>See Block 11 Below</u>  F O.B. Point. <u>Destination</u>  Discount Terms Net 30 Days.
	7. BILLING ADDRESS: NASA Johnson Space Center Attn. LF231/Accounts Payable Group Houston, TX 77058-3696 Order No: <u>CRAVE DO33R2</u>

8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY. Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor [ <input type="checkbox"/> ] is, [ <input checked="" type="checkbox"/> ] is not required Sign below if required and return to contracting officer  Name: _____ (Person authorized to sign)  Signature: _____ Date: _____	10. Name <u>Ronald Johnson</u>  Signature: <u>Ronald Johnson</u> Date: <u>5/6/08</u> CONTRACTING OFFICER
--	---

11. Schedule						
ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
1	SUBLIMATOR DRIVEN COLDPLATE (SDC)  This no-cost revision is issued to extend the period of performance for Phase 1 from 01/31/08 to 5/09/08, in order to complete documentation. All other terms and conditions of Phase 1 remain unchanged.  Period of Performance: 9/11/07 - 5/09/08 (Phase 1)					
2	OPTION.  The Government may require the contractor to continue to perform services under this delivery order. The Contracting Officer may unilaterally exercise the Option by issuing Revision 1 to DO 33 The government reserves the right not to exercise the Option  (continued next page)	64			64	

12. For JSC Internal Use Only: Requisition No.: <u>N/A</u> Rissue To: <u>EC/Joe Gensler, x30025</u>  <input checked="" type="checkbox"/> COMP. <input type="checkbox"/> PART.    PPC _____	13 Total  \$ 80,221
--	---------------------------

14 Quantities in "Quantity Accepted" Column Have Been

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.

BY: \_\_\_\_\_

Authorized U S Government Representative      Date \_\_\_\_\_

**SCHEDULE**

ITEM	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	<p>Should the Option be exercised, the delivery order revision will be priced as negotiated under the base delivery order.</p> <p>OPTION Period of Performance. 1/14/08-7/14/08 (Phase II)</p> <p>THIS IS A CPFF DELIVERY ORDER.</p>					

# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
CRAVE DO33R1

2. Date of Order  
See Block 10 Below

NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.

Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office:  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org./Buyer BH2/Mary Thomas

Tel No. 281-483-8828 Fax: 281-483-4173  
E-mail: mary.f.thomas@nasa.gov

4. Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For: **Accountable Property**  
Order No.: CRAVE DO33R1

5. Contractor:  
Hamilton Sundstrand Management Services, Inc.  
Attention: Nancy L. Broyan  
2200 Space Park Drive, Suite 100  
Houston, TX 77058-3677

Phone. 281-333-8704 x      Fax. 860-660-6798

TIN: 06-1165586      CAGE CODE 71120

6. Deliver On or Before: See Block 11 Below  
F.O B. Point: Destination  
Discount Terms: Net 30 Days.

7. BILLING ADDRESS:  
NASA Johnson Space Center  
Attn. LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No.: CRAVE DO33R1

8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number. \_\_\_\_\_

9. Written acceptance of this order by contractor [] is, [] is not required. Sign below if required and return to contracting officer.

Name: \_\_\_\_\_ (Person authorized to sign)

Signature: \_\_\_\_\_ Date: \_\_\_\_\_

10. Name. Ronald Johnson

Signature: Ronald Johnson Date: 12/20/07  
CONTRACTING OFFICER

## 11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
1	SUBLIMATOR DRIVEN COLDPLATE (SDC) This no-cost revision is issued to extend the period of performance for Phase 1 to January 31, 2008. All other terms and conditions of Phase 1 remain unchanged. Period of Performance: 9/11/07-1/31/08 (Phase 1)					
2	OPTION: The Government may require the contractor to continue to perform services under this delivery order. The Contracting Officer may unilaterally exercise the Option by issuing Revision 1 to DO 33. The government reserves the right not to exercise the Option. (continued next page)	64			64	

12. For JSC Internal Use Only:

Requisition No: N/A       COMP.     PART.    PPC. \_\_\_\_\_  
Rissue To: EC/Joe Gensler\_x30025

13. Total  
\$ 80,221

14. Quantities in "Quantity Accepted" Column Have Been

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS  
OTHERWISE NOTED.

BY: \_\_\_\_\_

Authorized U.S. Government Representative

Date \_\_\_\_\_

**SCHEDULE**

ITEM	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	<p>Should the Option be exercised, the delivery order revision will be priced as negotiated under the base delivery order.</p> <p>OPTION Period of Performance: 1/14/08-7/14/08 (Phase II)</p> <p>THIS IS A CPFF DELIVERY ORDER.</p>					

# ORDER FOR SUPPLIES OR SERVICES

1. Order No. CRAVE-EC-033	2. Date of Order See Block 10 Below	NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO. Certified for National Defense under DPAS (15 CFR 700) DO-C9
------------------------------	--	---

3. Issuing Office NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org./Buyer <u>BH2/Mary Thomas</u>  Tel No.: <u>281-483-8828</u> Fax: <u>281-483-4173</u> E-mail. <u>mary.f.thomas@nasa.gov</u>	4. Ship To Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b>  Order No.: <u>CRAVE-EC-033</u>
--	--

5 Contractor: Hamilton Sundstrand Management Services, Inc. Attention: Kenneth Ridley 1 Hamilton Road Windsor Locks, CT 06096  Phone: 860-654-4034 x      Fax. 860-654-3318  TIN. 06-1165586      CAGE CODE 71120	6 Deliver On or Before <u>See Block 11 Below</u>  F O.B Point <u>Destination</u>  Discount Terms: Net 30 Days.  7 BILLING ADDRESS: NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No.. CRAVE-EC-033
---	--

8. Type of Order.

PURCHASE Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor [ <input type="checkbox"/> ] is, [ <input checked="" type="checkbox"/> ] is not required Sign below if required and return to contracting officer  Name: _____ (Person authorized to sign) Signature: _____ Date: _____	10. Name: <u>Ronald Johnson</u>  Signature: <u><i>Ronald Johnson</i></u> Date: <u>7/11/07</u> CONTRACTING OFFICER
--	--

11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
1	<b>SUBLIMATOR DRIVEN COLDPLATE (SDC)</b> The contractor shall perform and deliver to all base requirements of CRAVE-EC-033 as described in the attached Statement of Work  Period of Performance. 9/11/07-12/18/07 (Phase 1)	54			64	
2	<b>OPTION.</b> The Government may require the contractor to continue to perform services under this delivery order The Contracting Officer may unilaterally exercise the Option by issuing Revision 1 to DO 33. The government reserves the right not to exercise the Option.  (continued next page)					

12 For JSC Internal Use Only. Requisition No.: <u>N/A</u> <input checked="" type="checkbox"/> COMP <input type="checkbox"/> PART    PPC _____ Rissue To <u>EC/Joe Gensler, x30025</u>	13. Total \$ 80,221
---	------------------------

14 Quantities in "Quantity Accepted" Column Have Been

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED BY \_\_\_\_\_

Authorized U S Government Representative      \_\_\_\_\_  
Date

**SCHEDULE**

ITEM	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	<p>Should the Option be exercised, the delivery order revision will be priced as negotiated under the base delivery order</p> <p>OPTION Period of Performance. 1/14/08-7/14/08 (Phase II)</p> <p>THIS IS A CPFF DELIVERY ORDER.</p>					



**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
**DELIVERY ORDER #: CRAVE-EC-033 Sublimator Driven Coldplate**

**Narrative Task Description**

**Background / Problem Description:**

NASA JSC has begun several architecture studies for the upcoming lunar lander and lunar outpost. In performing these assessments, they discovered an innovative way to perform thermal control. The idea for this unique piece of hardware is being referred to as the sublimator driven coldplate (SDC). The SDC is a novel thermal control technique and has several advantages over a traditional thermal control scheme. The principal advantage is the ability to eliminate the need for a pumped fluid loop, potentially saving mass, power, and complexity. The SDC concept relies on evaporative heat rejection techniques, it is primarily useful for short duration operations. Additionally, the concept relies on a conductive path between the heating component and the heat rejection device. Therefore, it is mostly a relevant technology for a vehicle with a relatively low heat rejection requirement.

The design of the sublimator driven coldplate will meet the following requirements:

1. The SDC design shall not require any power during nominal operation.
2. The SDC shall be capable of rejecting a minimum of 2.5 kW for a minimum period of 6.5 hours.
3. The SDC shall not exceed a surface area of 4500 in<sup>2</sup> and the maximum dimensional extents shall not exceed 98 inches.  
The SDC maximum surface temperature shall not exceed 43°C during operation assuming that the 2.5 kW is uniformly distributed on the 4500 in<sup>2</sup> available surface area.
5. The design of the SDC shall require only a single penetration in the vehicle pressure shell.
6. The SDC shall be capable of withstanding a load of 5.0 g's with 133 kg of avionics mounted on the unit.
7. The SDC shall use de-ionized water as the sublimator working fluid.

The current statement of work will be subdivided into two separate phases. The first phase will require the contractor to design and perform thermal and structural analysis for the SDC and also present the results at a conceptual design review. The proposed SDC concepts will be evaluated at the conclusion of phase 1.

**Phase I Task Description:**

As mentioned above, this task will be separated into two phases. All of the requirements stated in the previous section will be applicable to both phases of this DO.

The first phase will essentially consist of the work necessary to create a SDC design which could be easily fabricated. The first phase will conclude with a conceptual design review that will be attended by both the selected contractor as well as the government representatives. The first phase will include the following tasks:

1. Development of a sublimator driven coldplate design.
2. Thermal analysis of the chosen SDC design.

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE-EC-033 Sublimator Driven Coldplate**

3. Structural analysis of the chosen SDC design.
4. Drawing package for SDC design in Pro-Engineer format.
5. Presentation of the results at a design review, which will be attended by the government. The expectations of the design review package is that it will include the following:
  - a. A Pro-Engineer drawing package of sufficient detail that the SDC could be fabricated.
  - b. A review and summary for all of the concepts that were evaluated during the development of the preferred SDC design.
  - c. The structural and thermal analysis for the final SDC design.
  - d. Recommendations for future SDC trade studies.

**Phase I Deliverables/Products:**

Product	Description	Qty	Due	Class
Other Products				
Drawing Package	Phase 1: Drawings for SDC in Pro-E format			
Analysis Report	Phase 1 Structural and Thermal Analysis report in MS Office editable format			
Presentation	Phase 1: Conceptual Design Review package			

**SCHEDULE – Phase I (Basic Period)**

<b>Start Date:</b> 11 September 2007	<b>Finish Date:</b> 18 December 2007
<b>INTERIM MILESTONES</b>	
Contract	18 December 2007
Milestones, along with subjective me performance. For schedule detail see Microsoft Project file located on the CRAVE web site for this DO listed under the Government Cost Estimate below.	

**Government Estimate Located in RFO File in Microsoft Project File On CRAVE Web Site**  
**The file is titled: 2007-06-19\_SDC-Project-Plan-Phase1.mpp**

**Total Government Estimate for this DO: \$ 217,862.**

Option 1:

Option 2:

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE-EC 033 Sublimator Driven Coldplate**

**TOTAL COST ESTIMATE FOR THIS DO: \$**

**FFE: \$ (If Applicable)**

**OPTION 1: N/A**

**OPTION 2: N/A**

**DATA REQUIREMENTS**

All DRs contained in the contract are applicable and required unless marked N/A below

- Notes: 1. Grey Scaled Rows Need No Additional/Required Fill-ins.  
2. On all other rows, If Necessary, Fill in Additional Rqmts/Deliveries in last Column.

<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>COMMENTS</b>
1	Written Approval	Flight GFE Configuration Management Plan	With Proposal	Once	Attachment J-8	
2	Mandatory Submittal	Regular Status Report/ Summary Review	Thirty (30) days following contract start	Monthly	Y	
3	Written Approval	Project Technical Requirements Specification	If Required for DO See Comments	Once with Revisions	N	
4	Mandatory Submittal if Flt H/W	GFE Systems Requirements Data Package	If Required for DO See Comments	Once with Revisions	N	
5	Written Approval	Flight GFE Projects Requirements & Verification Document	If Required for DO See Comments	Once with Revisions	N	
6	Mandatory Submittal if Flt H/W	Preliminary Design Review Data Package	If Required for DO See Comments	Once with Revisions	N	
7	Written Approval	Flight GFE Workmanship Specifications List	If Required for DO See Comments	Once with Revisions	N	
8	Administrative	Project Schedule	PDR or 10% effort complete Milestone	Once w/Revisions (due w/DO proposal updates & details provided as DO progresses)	Y	
9	Written Approval	Flight GFE Interface Control Document	If Required for DO See Comments	Once with Revisions	N	
10	Written Approval	GFE End Item Specification	If Required for DO See Comments	Once with Revisions	N	
11	Mandatory Submittal if Flt H/W	Flight GFE Failure Analysis Report	If Required for DO See Comments	As Required	N	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE-EC-033 Sublimator Driven Coldplate**

<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>COMMENTS</b>
12	Written Approval	Flight GFE Verification and Validation Plan	As Specified in EA-023	Once with Revisions	N	
13	Written Approval	GFE Software Requirements Specification	If Required for DO See Comments	Once with Revisions	N	
14	Written Approval	GFE Software Development Plan	If Required for DO See Comments	Once with Revisions	N	
15	Written Approval	GFE Software Design Document	If Required for DO See Comments	As Required	N	
16	Written Approval	Engineering Drawings	If Required for DO See Comments	Once with Revisions	Y	PRO-E Format
17	Written Approval	EFE Parts Lists and Analysis Report	If Required for DO See Comments	As Required	N	
18	Mandatory Submittal if Flt H/W	Critical Design Review Data Package	If Required for DO See Comments	Once with Revisions	N	
19	Mandatory Submittal if Flt H/W	Engineering Drawing Change Proposal	If Required for DO See Comments	As Required	N	
20	Written Approval	GFE Qualification Test Procedure	If Required for DO See Comments	Once with Revisions	N	
21	Written Approval	Flight Product User's Guide	If Required for DO See Comments	Once with Revisions	N	
22	Mandatory Submittal if Flt H/W	Software Code	If Required for DO See Comments	As Required	N	
23	Written Approval	Information Technology (IT) Security Program Plan and Reports	(30) days after DO award and as specified in JPG 2810.1	JPG 2810.1	Attachment J-4 Due 30 days after DO award	
24	Written Approval	Certification Plan	If Required for DO See Comments	Once with Revisions	N	
25	Mandatory Submittal if Flt H/W	Certification Report	If Required for DO See Comments	Once with Revisions	N	
26	Mandatory Submittal if Flt H/W	Engineering Analysis	If Required for DO See Comments	As Required	Y	Contractor will submit results from final structural and thermal analysis

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE-EC-033 Sublimator Driven Coldplate**

<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>COMMENTS</b>
27	Mandatory Submittal if Flt H/W	Acceptance Data Package	If Required for DO See Comments	One Time	N	
28	Mandatory Submittal	Export Control Audit Results	After award of 1st DO yearly on Sept. 30 thereafter	Yearly	Y	
29	Written Approval	Quality Plan	With Proposal	Once with Revisions	<b>Attachment J-11</b>	Only if contractor is using the R-Quality Plan template instead of ISO, and only if they need to make changes to it
30	Written Approval	Patent Rights-Retention	As Required	As Required	<b>Y (If Applicable)</b>	
31	Written Approval	Shuttle/Station Payload Safety Data Package	If Required for DO See Comments	As Required	N	
32	Mandatory Submittal if Flt H/W	Limited Life Systems List	If Required for DO See Comments	As Required	N	
33	Written Approval	Space Station GFE Failure Modes and Effects Analysis and Critical Items List	If Required for DO See Comments	As Required	N	
34	Written Approval	Space Shuttle GFE Safety and Analysis Report & Hazard Report	If Required for DO See Comments	As Required	N	
35	Written Approval	Software Quality Assurance Plan Report	90 Days Prior to Software Development	Once with Revisions	<b>Y (If Applicable)</b>	N/A - no software is being produced
36	Written Approval	ISS Hazard Report	If Required for DO See Comments	As Required	N	
37	Upon Request	Reliability and Maintainability Plan	With Proposal	One Time	<b>Attachment J-9</b>	
38	Written Approval	Government Certification Approval Request (GCAR)	If Required for DO See Comments	As Required	N	
39	Written Approval	Risk Assessment Executive Summary Report (RAESR)	If Required for DO See Comments	As Required	N	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE EC-033 Sublimator Driven Coldplate**

<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>COMMENTS</b>
40	Written Approval	Problem Reporting and Corrective Action (PRACA)	2 business days of problem isolation but no later than 10 days after detection	As Required	N	
41	Upon Request	Nonconformance Record	If Required for DO See Comments	As Required	N	
42	Mandatory Submittal If Required	Government Industry Data Exchange Program and NASA Advisory Problem Data	Reported one time when discrepancy occurs	Once with Revisions	N	
43	Written Approval	Electrical Electronic and Electromechanical (EEE) Parts Control Plan	If Required for DO See Comments	Once with Revisions	N	
44	Mandatory Submittal if Flt H/W	Certification Data Package	If Required for DO See Comments	Once with Revisions	N	
45	Written Approval	Certification and Acceptance Requirements Document	At CDR	Once with Revisions	N	
46	Upon Request	Wage/Salary and Fringe Benefit Data	Thirty (30) days after issuance of each DO	Once	N	
47	Written Approval	GFE Acceptance Test Procedure	If Required for DO See Comments	One Time	N	
48	Mandatory Submittal if Flt H/W	Flight GFE Verification & Validation Report	If Required for DO See Comments	Once with Revisions	N	
49	Mandatory Submittal if Flt H/W	Space Shuttle GFE Failure Modes and Effects Analysis (FMEA) and Critical Items List	If Required for DO See Comments	As Required	N	
50		<b>Reserved</b>	---	---	---	---
51	Mandatory Submittal	NASA Contractor Financial Management Reporting	After Issuance of 1st DO	Monthly	Y	
52	Written Approval	Government Property Management Plan	With Proposal	Once with Revisions	<b>Attachment J-7</b>	
53	Mandatory Submittal	System Safety Plan	With Proposal	One Time	<b>Attachment J-10</b>	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
 DELIVERY ORDER # CRAVE-FC-033 Sublimator Driven Coldplate**

<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>COMMENTS</b>
54	Written Approval	R-Quality Plan Template	With Proposal/ Revisions as Required	Only applicable to B-CRAVE contracts in accordance with the SOW and the DRD	Y	Only if contractor is using the R- Quality Plan template instead of ISO. and only if they need to make changes to it

Type 1 = Written Approval

Type 2 = Mandatory Submittal

Type 3 = Submittal Upon Request

**GOVERNMENT FURNISHED PROPERTY: NONE**

**CHANGES TO DRDs: NONE**

**CHANGES TO GOVERNMENT FURNISHED PROPERTY: NONE**

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE-FC-033 Sublimator Driven Coldplate**

**Background / Problem Description:**

After completion of Phase I, the drawings necessary to fabricate a SDC will have already been completed. At this time, the government can exercise an option to fabricate the SDC design. This engineering development unit (EDU) will be delivered to the government at the conclusion of Phase II for thermal vacuum testing. Therefore, the EDU shall be of sufficient quality to be tested at JSC thermal vacuum facilities. The criteria for the selection of Phase II will be total hardware cost, mass, and fabrication complexity. Additionally, an assessment will be made of the proposed feedwater utilization for the selection of Phase II. The feedwater utilization is defined in the attached test report, "Contaminant Insensitive Sublimator EDU Test Report".

**Phase II Task Description:**

The second phase will begin with the contract award and will conclude with the delivery of an EDU. All of the aforementioned requirements are applicable to both Phase I and Phase II. The second phase will primarily involve the fabrication of the hardware. The second phase will include the following tasks:

1. The SDC design will be built and delivered to the government for thermal vacuum testing.
2. The contractor will submit a final report to the government. This final report will include the following:
  - a. Sublimator Driven Coldplate drawing package
  - b. Lessons learned from the design and fabrication process
  - c. Recommendations for future design iterations following the stated requirements
  - d. The results from the final structural and thermal analyses
  - e. Proposed test points for the government led thermal vacuum testing

**Phase II Deliverables/Products:**

<b>Product</b>	<b>Description</b>	<b>Qty</b>	<b>Due</b>	<b>Class</b>
<b>Hardware</b>				
Prototype	Phase II SDC EDU prototype			
<b>Other Products</b>				
Final Report	Phase II Final report including final drawings in Pro E format, lessons learned, recommendations, proposed test points			

**SCHEDULE – Phase II (Basic Period)**

Start Date: 14 Aug 2008

Finish Date: 11 July 2008

CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE EC-033 Sublimator Driven Coldplate

INTERIM MILESTONES	DUE DATES
Phase II/Initial Contract	
SDC engineering development unit delivery	14 July 2008
SDC final report	14 July 2008
Milestones, along with subjective measurements, are to be used for measuring performance. For schedule detail see Microsoft Project file located on the CRAVE web site for this DO listed under the Government Cost Estimate below.	

Government Estimate Located in RFO File in Microsoft Project File On CRAVE Web Site  
The file is titled: 2007-06-19\_SDC-Project-Plan-Phase2.mpp

Total Government Estimate for this DO: \$ 217,862

Option 1:

Option 2: *64*

TOTAL COST ESTIMATE FOR THIS DO: \$

FFF: \$ (If Applicable)

OPTION 1: N/A

OPTION 2: N/A

GOVERNMENT FURNISHED PROPERTY: NONE

CHANGES TO DRDs: NONE

CHANGES TO GOVERNMENT FURNISHED PROPERTY: NONE

# ORDER FOR SUPPLIES OR SERVICES

1 Order No.  
NNJ05HB39B, CRAVE DO31

2 Date of Order  
See Block 10 Below

NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.  
Certified for National Defense under DPAS (15 CFR 700) DO-C9

3 Issuing Office  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org./Buyer BH2/Mary Thomas

4 Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For **Accountable Property**  
Order No NNJ05HB39B, CRAVE DO31

Tel No: 281-483-8828 Fax: 281-483-4173  
E-mail: mary.f.thomas@nasa.gov

5 Contractor  
Hamilton Sundstrand Management System  
Attn: Kenneth Ridley  
1 Hamilton Road  
Windsor Locks, CT 06096

6 Deliver On or Before See Block 11 Below  
F O B Point. Destination  
Discount Terms. Net 30 Days

Phone 860-654-4034 x Fax 860-654-3318  
TIN. 06-1165586 CAGE CODE: 71120

7 BILLING ADDRESS  
NASA Johnson Space Center  
Attn: LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No.: NNJ05HB39B, CRAVE DO31

8. Type of Order  
 PURCHASE. Please furnish the following in accordance with the conditions specified on this order Reference. \_\_\_\_\_  
 DELIVERY. Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number. \_\_\_\_\_

9. Written acceptance of this order by contractor  is,  is not required. Sign below if required and return to contracting officer

10. Name: Ronald Johnson

Name: \_\_\_\_\_ (Person authorized to sign)

Signature: \_\_\_\_\_ Date \_\_\_\_\_

Signature Ronald Johnson Date 9/24/07  
CONTRACTING OFFICER

### 11 Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	LARGE AREA REPAIR FASTENER DRIVER AND CADDY  The contractor shall perform and deliver to all the requirements of the Statement of Work for CRAVE DO 31  Period of Performance 9/25/07 - 7/15/08  <u>64</u> Total = \$572,055	<u>64</u>				<u>64</u>

12 For JSC Internal Use Only

Requisition No: N/A  COMP  PART PPC \_\_\_\_\_  
Rissue To: EC/Joe Gensler, x30025

13. Total  
\$ \$572,055

14 Quantities in "Quantity Accepted" Column Have Been

INSPECTED  ACCEPTED  RECEIVED

TO CONFORM TO THE CONTRACT  
ACCEPTANCE WILL BE AT JSC UNLESS  
OTHERWISE NOTED BY \_\_\_\_\_

Authorized U S Government Representative

Date \_\_\_\_\_

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC-031 LAR**

**PROPOSAL INSTRUCTIONS:**     DRAFT -- COMMENTS DUE BY: 07/16/07 COB  
  X   FINAL -- PROPOSAL DUE BY: 08/20/07 COB

**DO TITLE:** Large Area Repair Fastener Driver and Caddy  
**DO Type:**   X   CPFF     FFP

**DO Contact Information in Addition to the CRAVE Contract Specialist or CO:**  
**TMR:** Joe Gensler Phone: (281) 483-0025  
**DO Manager:** Ben Greene Phone: (281) 483-3657  
**DO Mgr. Alternate:** Heather Bergman Phone: (281) 483-6053

**Concurrences:**

<u>Ben Greene</u> DO Manager	<u>Harold Reimers</u> DO Mgr. Management	<u>Joe Gensler</u> COTR
<u>Ralph Marak</u> Division TMR	<u>Steve Miller</u> S & MA	<u>Ron Johnson</u> Contract Officer

**Task Contains Flight Hardware, Flight Software or GSE?**   X   Yes     No  
**Program Supported:**   X   Shuttle     ISS   X   EVA     Advanced  
**WBS:**   X   1.0 EVA     2.0 FCE     3.0 EVR     ECLSS     5.0 ATCS     6.0 CHcS

*For purposes of complying with FAR 52 232-22, Limitation of Funds, the total amount allotted by the Government to contract is specified in clause B 6, Contract Funding. The funding listed in B.6 is the amount allotted for all Delivery Orders on the contract combined.*

*All terms and conditions of the contract apply to this Delivery Order. In the event of a conflict between the contract and this Delivery Order, the contract shall prevail.*

*WBS reporting shall be done in accordance with applicable WBS reporting categories, as shown above and in the contract within Section C, Table 1.*

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE-EC-031 LAR**

**Narrative Task Description**

**Background / Problem Description:**

1 0 Objective

The STS-107 Columbia accident was attributed to debris liberated from the external tank during launch and impacting the reinforced carbon-carbon (RCC) wing leading edge of the Orbiter. Since then, several concepts have been developed and flown for repair of the Orbiter Thermal Protection System (TPS), however, to date none have been developed which have the capability to repair the kind of damage that likely caused the STS-107 TPS failure. The Orbiter Project Office has asked the TPS repair community to continue development of a concept known as Large Area Repair (LAR) for flight on the upcoming Hubble servicing mission. EC7 has been tasked to develop the EVA hardware necessary for installation and verification of the LAR repair system for this project.

2 0 Need for Large Area Repair (LAR)

Current RCC Repair Systems are limited in the size and type of damage that they can repair. The two systems currently certified for flight are known as the Crack Repair System and the Plug Repair System. The Crack Repair System uses a single part pre-ceramic polymer known as NOAX (Non-Oxide Adhesive eXperimental) that is only capable of repairing cracks, coating damage, and small holes (< 0.375" in diameter). The Plug Repair System is capable of repairing larger damage, but its capability is limited to holes smaller than 4 inches.

Because of the limitation of these repair systems, the Orbiter Project Office has been funding R&D for concepts that have the capability to repair larger damage in RCC Panels with minimal impact to stowage. The LAR concept was presented to the PRCB earlier this year (2007) and was selected for additional funding for flight development.

The LAR system is currently comprised of a thin, flexible, Carbon Silicon Carbide laminate that would be attached to the RCC Panel around the perimeter with composite or high temperature super alloy fasteners such as TZM (Titanium Zirconium Molybdenum) (see figures 2.0-1 and 2.0-2). In order to perform the LAR installation and verify it is ready for entry, a collection of EVA and IVA hardware must be provided.

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC-031 LAR**

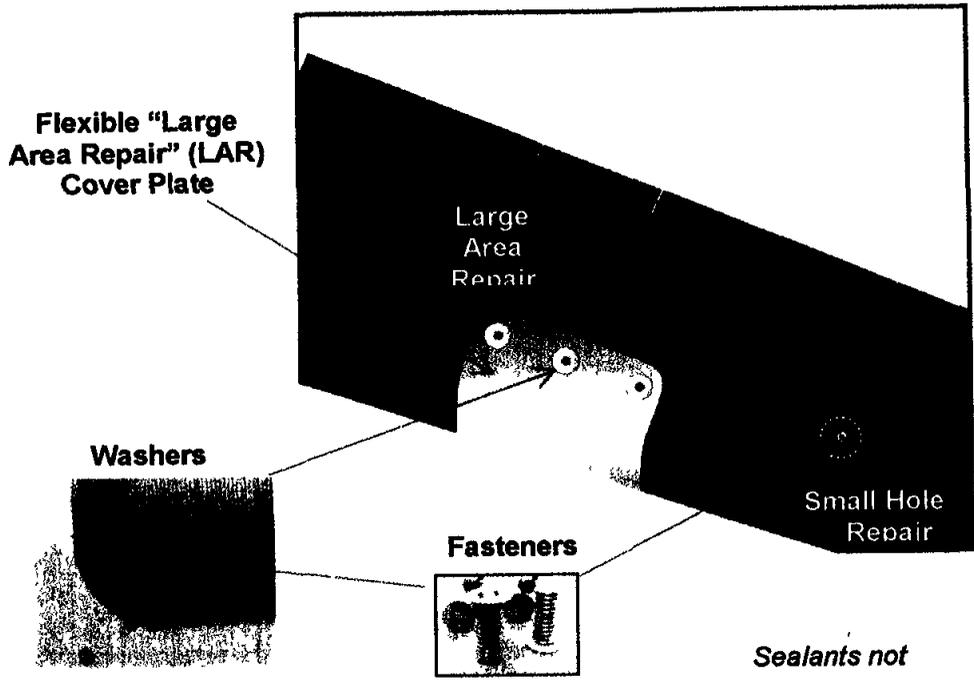


Figure 2.0-1: Diagram of LAR System Installed on Shuttle WLE

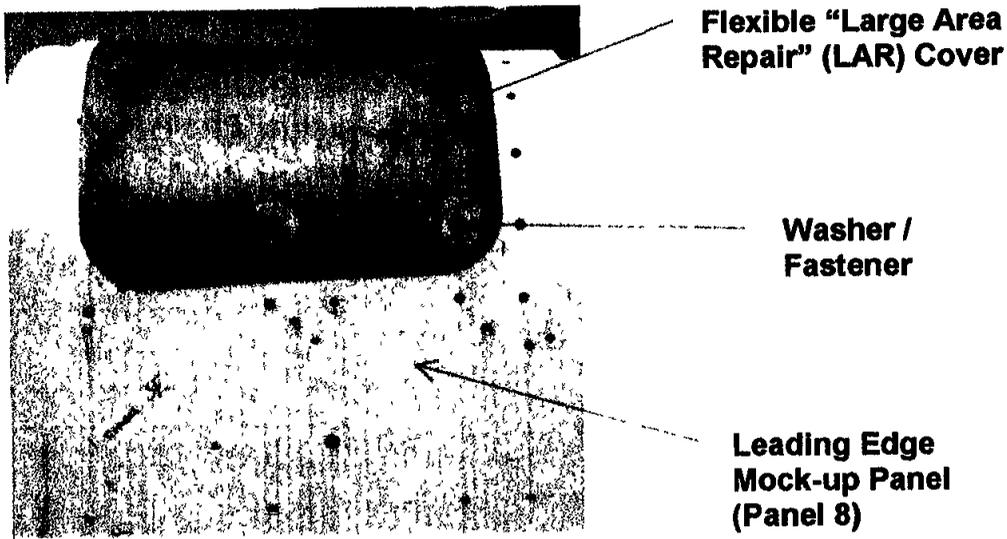


Figure 2.0-2. Image of Sample LAR Cover Plate Attached to Panel Mockup

  
**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
**DELIVERY ORDER #: CRAVE-EC-031 LAR**

3 0 Prior Work

A number of tools developed for the RCC Repair Project can be used to aid in the installation and verification of the LAR, however, the majority of them will need minor modifications, testing, and/or certification updates. In addition, a significant knowledge base exists in the TPS Repair community at JSC to draw upon during the development of the hardware required for LAR installation. Many on-orbit and ground based evaluations have been performed that have greatly increased the repair team's knowledge of what our EVA repair capabilities are.

Task Description.

The contractor is to perform the necessary tasks required to design, develop, test, and certify a subset of tools needed for installation and verification of the LAR System. Those tools are as follows.

- Fastener Gripper/Driver – required to provide temporary restraint of the LAR fastener during installation and be capable of driving it in to the RCC. New hardware
- Fastener Caddy – required to provide temporary restraint and staging of LAR fasteners for installation into the Gripper/Driver and subsequent installation into the RCC. New hardware.

The designs shall comply with applicable EVA GDRD (JSC-26626) requirements and follow EA-WI-023 for all project milestones and applicable documentation. Number and classification of hardware components required will be defined in requirements to follow. No part of the designs will be proprietary and NASA will have full access and ownership of all engineering drawings, CAD models, procedures, and related documentation. The drawings will be released in the Electronic Drawing Control Center. All drawings will use JSC standard processing (i.e., PRC) callouts. All documentation (requirements documents, assembly procedures, etc) will be released through the JSC document system. All certification documentation (CARD, RAESR, GCAR, etc.) shall be delivered to NASA in an editable electronic format.

Contractors must submit a minimum of one concept of each design for consideration.

If the use of JSC facilities is required to perform any of the required acceptance testing described in the CARDS (such as use of the thermal test facilities), this must be clearly stated in the contractor's response. NASA/JSC will make the appropriate accommodations to schedule the JSC facilities to perform the desired task upon request.

**1. Requirements**

**1.1. Fastener Gripper/Driver**

**1.1.1.** Design, develop, test, and certify an EVA tool that will interface with the LAR fastener and thread and torque it in to the RCC

**1.1.1.1.** Tether/Driver should keep the fastener captive until the fastener is fully threaded into the RCC panel (until the fastener starts to protrude from the backside IML of the panel). There is no visual confirmation that fastener will have penetrated the back side of the IML panel but current plans are to monitor fastener engagement by torque count.

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE-EC-031 LAR**

- 1.1.1.2.** Tether/Driver should interface with the Fastener and Washer (ref figure 1.1 1-1) and allow for alignment of the washer in a particular orientation. The LAR Fastener Washer has curvature in one axis that must be aligned with the curvature of the panel it is being installed on (ref figure 2 0-1 and 2 0-2 for images of Washer and Fastener installation). The Washer is an integral part of the Fastener and captive but is allowed to rotate with respect to the Fastener. ~~The design of the Tether/Driver will determine at what point in the fastener installation the washer alignment will be performed.~~ However, once the fastener has been installed and torqued it will be extremely difficult to change its orientation. Drawings of the Fastener and Washer will be provided.

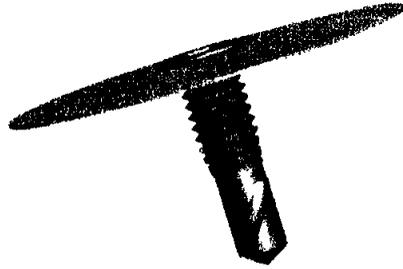


Figure 1.1 1-1 Sketch sample of LAR Fastener and Washer combination

- 1.1.1.3.** Tether/Driver should be reloadable. Once one fastener has been installed, another fastener should be able to be loaded from the Fastener Caddy (see section on Fastener Caddy below) EVA by the same crewmember that installed the first fastener.
- 1.1.1.4.** The Tether/Driver should interface with the PIVT. ~~The PIVT is an adjustable torque limiting device which is necessary to prevent overloading the fasteners during installation. The PIVT is currently still under development.~~
- 1.1.1.5.** The Tether/Driver should interface with the standard hex-head interface on the LAR Fastener.
- 1.1.1.6.** The Tether/Driver should not permit inadvertent release of the fastener during installation. ~~No specific retention force for this interface has been determined but the Tether/Driver is the only means of positive control for the fastener. Therefore, it is critical the two components separate only when the crewmember chooses to separate them. Little to no axial force is required to start thread engagement because the holes are tapped by the drilling operation. Previous test have shown the threads in the RCC are capable of withstanding about 100 lb of axial force.~~
- 1.1.1.7.** The Tether/Driver should be able to be installed on the fastener head by the EVA crewmember.
- 1.1.1.8.** The Tether/Driver should be certified for installation of at least 16 LAR Fasteners and Washers.
- 1.1.1.9.** The Tether/Driver should be made of standard J-1 hardware approved materials. Contact with the top surface of the fastener should be minimized.

~~Deleted: to be able to limit installation torques on the LAR Fastener~~

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**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
**DELIVERY ORDER # CRAVE-EC-031 LAR**

or limited to low force contact because it is coated with an oxidation resistant coating that can be scratched under load

**1.2. Fastener Caddy**

**1.2.1.** Design, develop, test, and certify an EVA tool that will hold LAR Fasteners and stage them for installation/loading into the Tether/Driver (reference previous tool requirements)

**1.2.1.1.** Fastener Caddy should hold at least 16 LAR fasteners and Washers.

**1.2.1.2.** Caddy should maintain positive control of fasteners until they are staged for installation into the Tether/Driver

**1.2.1.3.** Caddy should interface with the Tether/Driver to allow for reloading of the fasteners staged in the Caddy

**1.2.1.4.** ~~The Fastener Caddy should be made of standard EVA hardware approved materials. Contact with the top surface of the fastener should be minimized or limited to low force contact because it is coated with an oxidation resistant coating that can be scratched under load~~

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**1. Reporting**

The contractor shall provide weekly technical status, a bi-monthly schedule review, and monthly financial management reports as directed in the data requirements table

**2. Government Provided Equipment**

See Government Furnished Property section

  
**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
**DELIVERY ORDER # CRAVE-EC-031 LAR**

**Deliverables/Products:**

<b>Product</b>	<b>Description</b>	<b>Qty</b>	<b>Due</b>	<b>Class</b>
<b>Hardware</b>				
Mock Up	None	N/A	N/A	N/A
Prototype	None	N/A	N/A	N/A
Certification	Full Class I Flight certification	AR	5/31/08	N/A
Flight	2 Fastener Tether/Drivers 2 Fastener Caddies	2 ea	5/31/08	I
Training	1 High Fidelity Fastener Tether/Driver 1 High Fidelity Fastener Caddy	1 ea	5/31/08	III
Other	1 Qual Fastener Tether/Driver 1 Qual Fastener Caddy	1 ea	5/31/08	I
Other	Electronic editable format of CARDS, RAESRs, and GCARs Microsoft Word format required	AR	5/31/08	N/A
<b>Test</b>	Functional testing (acceptance and qualification)	AR	5/31/08	I/ qual
<b>Software</b>	N/A	N/A	N/A	N/A
<b>Other Products</b>	Acceptance Data Package (ADP) for each flight and qualification units	1 per each flight / qual unit	5/31/08	N/A
<b>Other Products</b>	GCAR	2	5/31/08	N/A

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #. CRAVE-EC-031 LAR**

**SCHEDULE**

**Start Date: September 25, 2007**

**Finish Date: July 15, 2008**

<b>ITERIM MILESTONES</b>	<b>DUE DATES</b>
System Requirements Review (SRR)	Suggested date 10/1/07
Preliminary Design Reviews (PDR)	Suggested date 11/15/07
Critical Design Reviews (CDR)	Suggested date 1/16/08
Hardware Fabrication Complete	Suggested date 5/15/08
Hardware Qual / Acceptance Testing Complete	Suggested date 6/16/08
Certification Complete	Suggested date 6/30/08
SAR	Suggested date 7/7/08
Hardware Delivery	7/15/08

Milestones, along with subjective measurements, are to be used for measuring performance. For schedule detail see Microsoft Project file located on the CRAVE web site for this DO listed under the Government Cost Estimate below.

**Government Estimate Located in RFQ File in Microsoft Project File On CRAVE Web Site**  
**The file is titled: Not provided in this DO**

**Total Government Estimate for this DO: \$500K**

Option 1: \$\_\_\_\_\_ (See Attachment 1)

Option 2: \$\_\_\_\_\_ (See Attachment 2)

**TOTAL COST ESTIMATE FOR THIS DO: \$(Contractor Complete)**

**FEE: \$ (If Applicable)**

**OPTION 1: \$ N/A (See Attachment 1)**

**OPTION 2: \$ N/A (See Attachment 2)**

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE-EC-031 LAR**

**DATA REQUIREMENTS**

**NOTES: 1. GREY SCALED ROWS NEED NO ADDITIONAL/REQUIRED FILL-INS.  
2. ON ALL OTHER ROWS, IF NECESSARY, FILL IN ADDITIONAL  
RQMTS/DELIVERIES IN LAST COLUMN.**

<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>COMMENTS</b>
1	Written Approval	Flight GFE Configuration Management Plan	With Proposal	Once	Attachment J-8	
2	Mandatory Submittal	Regular Status Report/ Summary Review	Thirty (30) days following contract start	Monthly	Y	Weekly Tech status
3	Written Approval	Project Technical Requirements Specification	If Required for DO See Comments	Once with Revisions	N	
4	Mandatory Submittal if Flt H/W	GFE Systems Requirements Data Package	If Required for DO See Comments	Once with Revisions	N	
5	Written Approval	Flight GFE Projects Requirements & Verification Document	If Required for DO See Comments	Once with Revisions	N	
6	Mandatory Submittal if Flt H/W	Preliminary Design Review Data Package	If Required for DO See Comments	Once with Revisions	Y	
7	Written Approval	Flight GFE Workmanship Specifications List	If Required for DO See Comments	Once with Revisions	Y	
8	Written Approval	Project Schedule	PDR or 10% effort complete Milestone	Once w/Revisions (due w/DO proposal, updates & details provided as DO progresses)	Y	
9	Written Approval	Flight GFE Interface Control Document	If Required for DO See Comments	Once with Revisions	Y	
10	Written Approval	GFE End Item Specification	If Required for DO See Comments	Once with Revisions	N	
11	Mandatory Submittal if Flt H/W	Flight GFE Failure Analysis Report	If Required for DO See Comments	As Required	Y	
12	Written Approval	Flight GFE Verification and Validation Plan	As Specified in WI-EA-023	Once with Revisions	Y	
13	Written Approval	GFE Software Requirements Specification	If Required for DO See Comments	Once with Revisions	N	
14	Written Approval	GFE Software Development Plan	If Required for DO See Comments	Once with Revisions	N	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE-EC-031 LAR**

DRD #	DATA TYPE	DRD TITLE	DUE	FREQUENCY	REQUIRED FOR DO? Y/N	COMMENTS
15	Written Approval	GFE Software Design Document	If Required for DO See Comments	As Required	N	
16	Written Approval	Engineering Drawings	If Required for DO See Comments	Once with Revisions	Y	Pro-E format CAD Models and Drawing files
17	Written Approval	EEE Parts Lists and Analysis Report	If Required for DO See Comments	As Required	Y	No EEE parts
18	Mandatory Submittal if Flt H/W	Critical Design Review Data Package	If Required for DO See Comments	Once with Revisions	Y	
19	Mandatory Submittal if Flt H/W	Engineering Drawing Change Proposal	If Required for DO See Comments	As Required	Y	
20	Written Approval	GFE Qualification Test Procedure	If Required for DO See Comments	Once with Revisions	Y	
21	Written Approval	Flight Product User's Guide	If Required for DO See Comments	Once with Revisions	N	
22	Mandatory Submittal if Flt H/W	Software Code	If Required for DO See Comments	As Required	N	
23	Written Approval	Information Technology (IT) Security Program Plan and Reports	(30) days after DO award, and as specified in JPG 2810.1	JPG 2810.1	Attachment J-4 Due 30 days after DO award	
24	Written Approval	Certification Plan	If Required for DO See Comments	Once with Revisions	Y	
25	Mandatory Submittal if Flt H/W	Certification Report	If Required for DO See Comments	Once with Revisions	Y	
26	Mandatory Submittal if Flt H/W	Engineering Analysis	If Required for DO See Comments	As Required	Y	
27	Mandatory Submittal if Flt H/W	Acceptance Data Package	If Required for DO See Comments	One Time	Y	Supplied for qual and Flight Units
28	Mandatory Submittal	Export Control Audit Results	After award of 1st DO, yearly on Sept 30 thereafter	Yearly	Y	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC-031 LAR**

DRD #	DATA TYPE	DRD TITLE	DUE	FREQUENCY	REQUIRED FOR DO? Y/N	COMMENTS
29	Written Approval	Quality Plan	With Proposal	Once with Revisions	Attachment J-11	Only if contractor is using the R-quality plan template instead of ISO, and only if they need to make changes to it.
30	Written Approval	Patent Rights-Retention	As Required	As Required	Y (If Applicable)	
31	Written Approval	Shuttle/Station Payload Safety Data Package	If Required for DO See Comments	As Required	N	
32	Mandatory Submittal if Flt H/W	Limited Life Systems List	If Required for DO See Comments	As Required	Y	
33	Written Approval	Space Station GFE Failure Modes and Effects Analysis and Critical Items List	If Required for DO See Comments	As Required	N	If applicable
34	Written Approval	Space Shuttle GFE Safety and Analysis Report & Hazard Report	If Required for DO See Comments	As Required	Y	If applicable
35	Written Approval	Software Quality Assurance Plan Report	90 Days Prior to Software Development	Once with Revisions	N	
36	Written Approval	ISS Hazard Report	If Required for DO See Comments	As Required	Y	If applicable
37	Upon Request	Reliability and Maintainability Plan	With Proposal	One Time	N	
38	Written Approval	Government Certification Approval Request (GCAR)	If Required for DO See Comments	As Required	Y	
39	Written Approval	Risk Assessment Executive Summary Report (RAESR)	If Required for DO See Comments	As Required	Y	
40	Written Approval	Problem Reporting and Corrective Action (PRACA)	2 business days of problem isolation but no later than 10 days after detection	As Required	Y	
41	Upon Request	Nonconformance Record	If Required for DO See Comments	As Required	Y	
42	Mandatory Submittal	Government Industry Data Exchange Program and NASA Advisory Problem Data	Reported one time when discrepancy occurs	Once with Revisions	Y	
43	Written Approval	Electrical, Electronic, and Electromechanical (EEE) Parts Control Plan	If Required for DO See Comments	Once with Revisions	Y	
44	Mandatory Submittal if Flt H/W	Certification Data Package	If Required for DO See Comments	Once with Revisions	Y	
45	Written Approval	Certification and Acceptance Requirements Document	At CDR	Once with Revisions	Y	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #. CRAVE-EC-031 LAR**

DRD #	DATA TYPE	DRD TITLE	DUE	FREQUENCY	REQUIRED FOR DO? Y/N	COMMENTS
46	Upon Request	Wage/Salary and Fringe Benefit Data	Thirty (30) days after issuance of each DO	Once	N	
47	Written Approval	GFE Acceptance Test Procedure	If Required for DO See Comments	One Time	Y	
48	Mandatory Submittal if Flt H/W	Flight GFE Verification & Validation Report	If Required for DO See Comments	Once with Revisions	Y	
49	Mandatory Submittal if Flt H/W	Space Shuttle GFE Failure Modes and Effects Analysis (FMEA) and Critical Items List	If Required for DO See Comments	As Required	N	If applicable
50		Reserved	---	---	---	---
51	Mandatory Submittal	NASA Contractor Financial Management Reporting	After Issuance of 1st DO	Monthly	Y	
52	Written Approval	Government Property Management Plan	With Proposal	Once with Revisions	Attachment J-7	
53	Mandatory Submittal	System Safety Plan	With Proposal	One Time	Attachment J-10	
54	Written Approval	R-Quality Plan Template	With Proposal/ Revisions as Required	Only applicable to B-CRAVE contracts in accordance with the SOW and the DRD	N	

Type 1 = Written Approval      Type 2 = Mandatory Submittal      Type 3 = Submittal Upon Request

**GOVERNMENT FURNISHED PROPERTY** - The list of items below will be provided as Government Furnished Property.

Item	Part Number	Quantity	Value
DPT Go/No-Go Gage	SDG38114281-001	1	\$2,000 each
LAR Fastener	TBD	1	\$2,000 each
LAR Fastener Washer	TBD	1	\$2,000 each

# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
NNJ05HB39B, CRAVE -EC-030

2. Date of Order  
See Block 10 Below

NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.

Certified for National Defense under DPAS (15 CFR 700) DO-C9

3 Issuing Office:  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org./Buyer BH2/Mary Thomas

4 Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For **Accountable Property**  
Order No. NNJ05HB39B, CRAVE-EC-030

Tel No: 281-483-8828 Fax: 281-483-4173  
E-mail: mary.f.thomas@nasa.gov

5. Contractor:  
Hamilton Sundstrand Management Services, Inc.  
Attention: Kenneth Ridley  
1 Hamilton Road  
Windsor Locks, CT 06096

6 Deliver On or Before. See Block 11 Below  
F.O.B Point Destination  
Discount Terms: Net 30 Days.

Phone: 860-654-4034 x      Fax: 860-654-3318  
TIN. 06-1165586      CAGE CODE: 71120

7 BILLING ADDRESS:  
NASA Johnson Space Center  
Attn LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No. NNJ05HB39B, CRAVE-EC-030

8. Type of Order.  
 PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number \_\_\_\_\_

9 Written acceptance of this order by contractor  is,  is not required. Sign below if required and return to contracting officer  
Name: \_\_\_\_\_ (Person authorized to sign)  
Signature: \_\_\_\_\_ Date \_\_\_\_\_

10 Name: Ronald Johnson

Signature: Ronald Johnson Date: 9/19/07  
CONTRACTING OFFICER

### 11 Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	<p>LARGE AREA REPAIR PISTOL GRIP TOOL DRILL AID</p> <p>The contractor shall perform and deliver to all the requirements of the Statement of Work for CRAVE DO 30</p> <p>Period of Performance 09/25/2007 to 07/15/2008</p> <p>THIS IS A CPFF DELIVERY ORDER</p>					

12 For JSC Internal Use Only:

Requisition No N/A       COMP     PART    PPC. \_\_\_\_\_  
Rissue To. EC/Joe Gensler, x30025

13 Total  
\$ 470,943

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED     ACCEPTED     RECEIVED  
TO CONFORM TO THE CONTRACT  
ACCEPTANCE WILL BE AT JSC UNLESS  
OTHERWISE NOTED

BY \_\_\_\_\_

Authorized U S Government Representative

Date \_\_\_\_\_



**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE-EC-030 LAR**

**Narrative Task Description**

**Background / Problem Description:**

**1.0 Objective**

The STS-107 Columbia accident was attributed to debris liberated from the external tank during launch and impacting the reinforced carbon-carbon (RCC) wing leading edge of the Orbiter. Since then, several concepts have been developed and flown for repair of the Orbiter Thermal Protection System (TPS), however, to date none have been developed which have the capability to repair the kind of damage that likely caused the STS-107 TPS failure. The Orbiter Project Office has asked the TPS repair community to continue development of a concept known as Large Area Repair (LAR) for flight on the upcoming Hubble servicing mission. EC7 has been tasked to develop the EVA hardware necessary for installation and verification of the LAR repair system for this project.

**2.0 Need for Large Area Repair (LAR)**

Current RCC Repair Systems are limited in the size and type of damage that they can repair. The two systems currently certified for flight are known as the Crack Repair System and the Plug Repair System. The Crack Repair System uses a single part pre-ceramic polymer known as NOAX (Non-Oxide Adhesive eXperimental) that is only capable of repairing cracks, coating damage, and small holes (< 0.375" in diameter). The Plug Repair System is capable of repairing larger damage, but its capability is limited to holes smaller than 4 inches.

Because of the limitation of these repair systems, the Orbiter Project Office has been funding R&D for concepts that have the capability to repair larger damage in RCC Panels with minimal impact to stowage. The LAR concept was presented to the PRCB earlier this year (2007) and was selected for additional funding for flight development.

The LAR system is currently comprised of a thin, flexible, Carbon Silicon Carbide laminate that would be attached to the RCC Panel around the perimeter with composite or high temperature super alloy fasteners such as TZM (Titanium Zirconium Molybdenum) (see figures 2.0-1 and 2.0-2). In order to perform the LAR installation and verify it is ready for entry, a collection of EVA and IVA hardware must be provided.

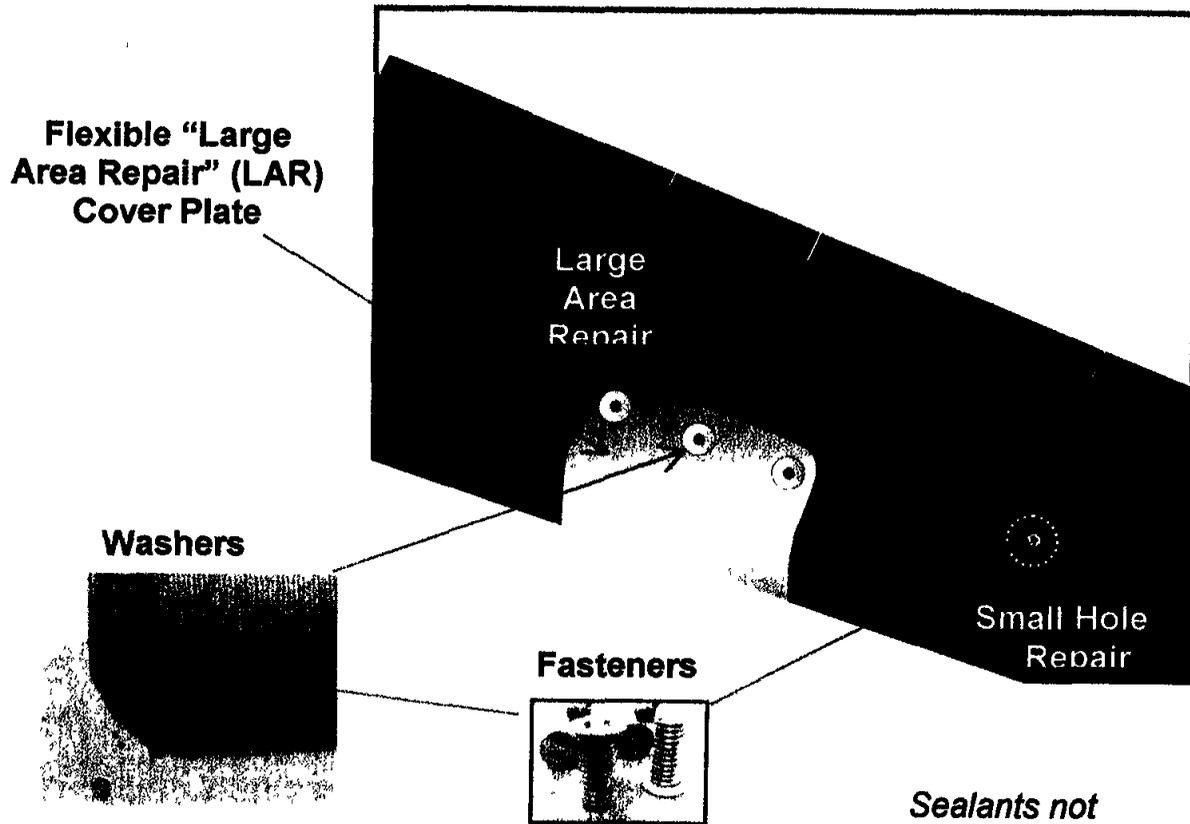


Figure 2.0-1: Diagram of LAR System Installed on Shuttle WLE

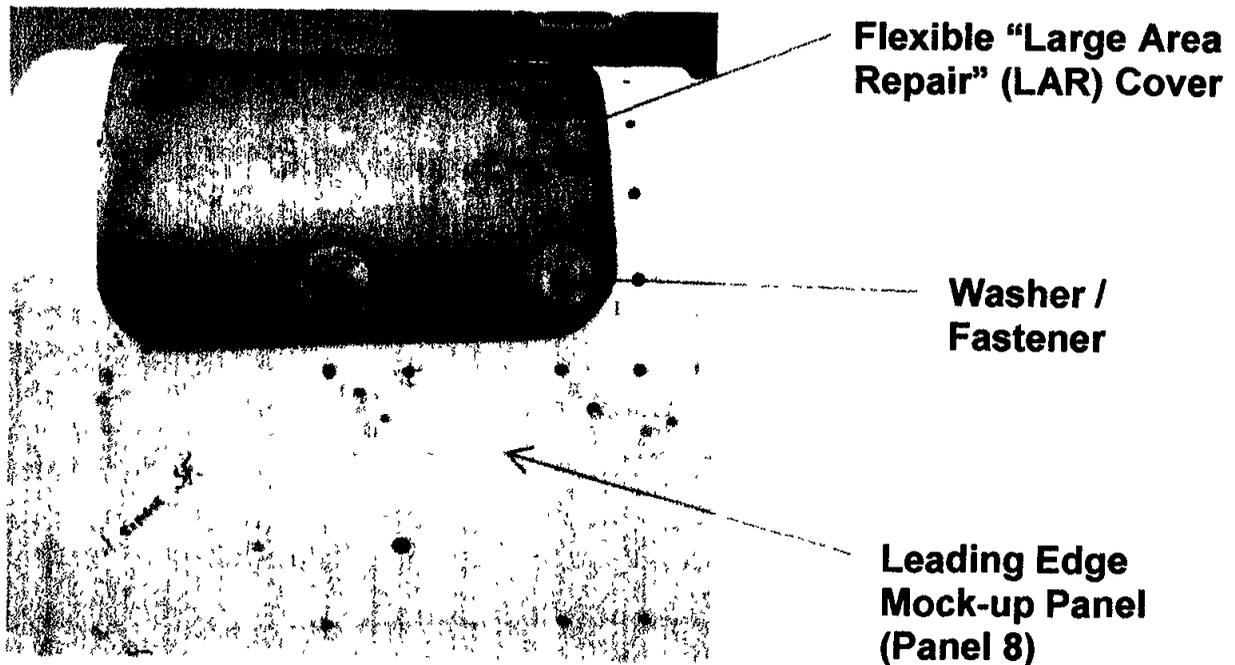


Figure 2.0-2. Image of Sample LAR Cover Plate Attached to Panel Mockup

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC-030 LAR**

**3.0 Prior Work**

A number of tools developed for the RCC Repair Project can be used to aid in the installation and verification of the LAR, however, the majority of them will need minor modifications, testing, and/or certification updates. In addition, a significant knowledge base exists in the TPS Repair community at JSC to draw upon during the development of the hardware required for LAR installation. Many on-orbit and ground based evaluations have been performed that have greatly increased the repair team's knowledge of what our EVA repair capabilities are.

**Task Description.**

The contractor is to perform the necessary tasks required to design, develop, test, and certify the following hardware needed for installation and verification of the LAR System:

- PGT Drill Aid – required to provide a means of guaranteeing perpendicular drilling and installation of the fastener into the RCC. New hardware.
  - Quantity two (2) Class I (Flight) Units
  - Quantity one (1) Class I (Qual) Unit
  - Quantity one (1) Class III Trainer Unit

The design shall comply with applicable EVA GDRD (JSC-26626) requirements and follow EA-WI-023 for all project milestones and applicable documentation. Number and classification of hardware components required will be defined in requirements to follow. No part of the designs will be proprietary and NASA will have full access and ownership of all engineering drawings, CAD models, procedures, and related documentation. The drawings will be released in the Electronic Drawing Control Center. All drawings will use JSC standard processing (i.e., PRC) callouts. All documentation (requirements documents, assembly procedures, etc) will be released through the JSC document system. All certification documentation (CARD, RAESR, GCAR, etc.) shall be delivered to NASA in an editable electronic format.

Contractors must submit a minimum of one concept design for consideration.

If the use of JSC facilities is required to perform any of the required acceptance or qualification testing (such as use of the thermal test facilities), this must be clearly stated in the contractor's response. NASA/JSC will make the appropriate accommodations to schedule the JSC facilities to perform the desired task upon request.

**1. Requirements**

**1.1. PGT Drill Aid**

1.1.1. Design, develop, test, and certify an EVA tool that will interface with the Pistol Grip Tool (PGT) with a Small RCC Drill attached (P/N: SED33118888-301) and provide alignment so an EVA Crewmember can drill perpendicular holes into an RCC Panel during an EVA LAR Repair.

1.1.1.1. Design should interface with existing PGT features such as the rotating bayonet fitting if required.

1.1.1.2. Drill Aid should provide alignment for drilling on all Orbiter RCC Panels and T-seals.

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC-030 LAR**

- 1.1.1.3. Drill Aid should provide perpendicular alignment to the RCC panel within +/- 5° (TBR).
  - 1.1.1.4. The Drill Aid should be usable by a single crewmember in a foot restraint.
  - 1.1.1.5. The Drill Aid should not require any more perpendicular force to the RCC panel to operate than that required for drilling. Drilling into RCC is already pushing the limits of worksite stability and any additional load required to perform the operation could make the task unacceptable.
  - 1.1.1.6. The Drill Aid should be capable of drilling at least 16 holes in an RCC panel.
  - 1.1.1.7. The Drill Aid should be IVA installed and remain installed during the entire EVA.
- 1.1.2. As a goal, the Drill Aid should provide perpendicular alignment for installation of LAR Fasteners using the TBD Fastener Tether/Driver tool. The Tether/Driver will interface with a standard 3/8" square drive, such as the one provided on the PGT. DPT will be the likely interface.

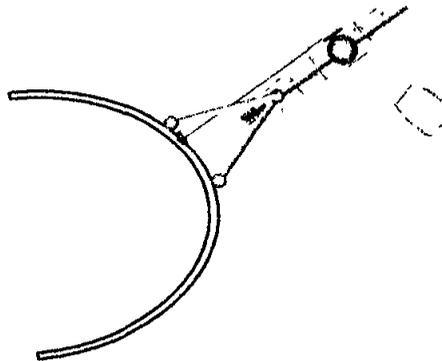


Figure 1.1 1-1: Conceptual diagram of a PGT Drill Aid

**1. Reporting**

The contractor shall provide weekly technical status, a bi-monthly schedule review, and monthly financial management reports as directed in the data requirements table.

**2. Government Provided Equipment**

See Government Furnished Property section

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC-030 LAR**

**Deliverables/Products:**

<b>Product</b>	<b>Description</b>	<b>Qty</b>	<b>Due</b>	<b>Class</b>
<b>Hardware</b>				
<b>Mock Up</b>	None	N/A	N/A	N/A
<b>Prototype</b>	None	N/A	N/A	N/A
<b>Certification</b>	Full Class I Flight certification	AR	5/31/08	N/A
<b>Flight</b>	PGT Fully Certified Flight Ready Units	2	5/31/08	I
<b>Training</b>	High fidelity PGT Drill Aid trainer	1	5/31/08	III
<b>Other</b>	Qualification Unit	1	5/31/08	I
<b>Other</b>	Electronic editable format of CARDS, RAESRs, and GCARs. Microsoft Word format required.	AR	5/31/08	N/A
<b>Test</b>	Functional testing (acceptance and qualification)	AR	5/31/08	I / qual
<b>Software</b>	N/A	N/A	N/A	N/A
<b>Other Products</b>	Acceptance Data Package (ADP) for each flight and qualification units	1 per each flight / qual unit	5/31/08	N/A
<b>Other Products</b>	GCAR	1	5/31/08	N/A

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC-030 LAR**

**SCHEDULE**

**Start Date: September 25, 2007**

**Finish Date: July 15, 2008**

<b>ITERIM MILESTONES</b>	<b>DUE DATES</b>
<b>System Requirements Review (SRR)</b>	<b>Suggested date 10/1/07</b>
<b>Preliminary Design Reviews (PDR)</b>	<b>Suggested date 11/15/07</b>
<b>Critical Design Reviews (CDR)</b>	<b>Suggested date 1/16/07</b>
<b>Hardware Fabrication Complete</b>	<b>Suggested date 5/15/08</b>
<b>Hardware Qual / Acceptance Testing Complete</b>	<b>Suggested date 6/16/08</b>
<b>Certification Complete</b>	<b>Suggested date 6/30/08</b>
<b>SAR</b>	<b>Suggested date 7/7/08</b>
<b>Hardware Delivery</b>	<b>7/15/08</b>

Milestones, along with subjective measurements, are to be used for measuring performance. For schedule detail see Microsoft Project file located on the CRAVE web site for this DO listed under the Government Cost Estimate below.

**Government Estimate Located in RFO File in Microsoft Project File On CRAVE Web Site**  
**The file is titled: Not provided for this DO**

**Total Government Estimate for this DO: \$400K**

**Option 1: \$\_\_\_\_\_ (See Attachment 1)**

**Option 2: \$\_\_\_\_\_ (See Attachment 2)**

**TOTAL COST ESTIMATE FOR THIS DO: \$(Contractor Complete)**

**FEE: \$ (If Applicable)**

**OPTION 1: \$ N/A (See Attachment 1)**

**OPTION 2: \$ N/A (See Attachment 2)**

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC-030 LAR**

**DATA REQUIREMENTS**

**NOTES: 1. GREY SCALED ROWS NEED NO ADDITIONAL/REQUIRED FILL-INS.  
2. ON ALL OTHER ROWS, IF NECESSARY, FILL IN ADDITIONAL  
RQMTS/DELIVERIES IN LAST COLUMN.**

<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>COMMENTS</b>
1	Written Approval	Flight GFE Configuration Management Plan	With Proposal	Once	Attachment J-8	
2	Mandatory Submittal	Regular Status Report/ Summary Review	Thirty (30) days following contract start	Monthly	Y	Weekly Tech status
3	Written Approval	Project Technical Requirements Specification	If Required for DO See Comments	Once with Revisions	N	
4	Mandatory Submittal if Flt H/W	GFE Systems Requirements Data Package	If Required for DO See Comments	Once with Revisions	N	
5	Written Approval	Flight GFE Projects Requirements & Verification Document	If Required for DO See Comments	Once with Revisions	N	
6	Mandatory Submittal if Flt H/W	Preliminary Design Review Data Package	If Required for DO See Comments	Once with Revisions	Y	
7	Written Approval	Flight GFE Workmanship Specifications List	If Required for DO See Comments	Once with Revisions	Y	
8	Written Approval	Project Schedule	PDR or 10% effort complete Milestone	Once w/Revisions (due w/DO proposal, updates & details provided as DO progresses)	Y	
9	Written Approval	Flight GFE Interface Control Document	If Required for DO See Comments	Once with Revisions	Y	
10	Written Approval	GFE End Item Specification	If Required for DO See Comments	Once with Revisions	N	
11	Mandatory Submittal if Flt H/W	Flight GFE Failure Analysis Report	If Required for DO See Comments	As Required	Y	
12	Written Approval	Flight GFE Verification and Validation Plan	As Specified in WI-EA-023	Once with Revisions	Y	
13	Written Approval	GFE Software Requirements Specification	If Required for DO See Comments	Once with Revisions	N	
14	Written Approval	GFE Software Development Plan	If Required for DO See Comments	Once with Revisions	N	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #. CRAVE-EC-030 LAR**

<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>COMMENTS</b>
15	Written Approval	GFE Software Design Document	If Required for DO See Comments	As Required	N	
16	Written Approval	Engineering Drawings	If Required for DO See Comments	Once with Revisions	Y	Pro-E format CAD Models and Drawing files
17	Written Approval	EEE Parts Lists and Analysis Report	If Required for DO See Comments	As Required	Y	If Required
18	Mandatory Submittal if Flt H/W	Critical Design Review Data Package	If Required for DO See Comments	Once with Revisions	Y	
19	Mandatory Submittal if Flt H/W	Engineering Drawing Change Proposal	If Required for DO See Comments	As Required	Y	
20	Written Approval	GFE Qualification Test Procedure	If Required for DO See Comments	Once with Revisions	Y	
21	Written Approval	Flight Product User's Guide	If Required for DO See Comments	Once with Revisions	N	
22	Mandatory Submittal if Flt H/W	Software Code	If Required for DO See Comments	As Required	N	
23	Written Approval	Information Technology (IT) Security Program Plan and Reports	(30) days after DO award, and as specified in JPG 2810.1	JPG 2810.1	<b>Attachment J-4 Due 30 days after DO award</b>	
24	Written Approval	Certification Plan	If Required for DO See Comments	Once with Revisions	Y	
25	Mandatory Submittal if Flt H/W	Certification Report	If Required for DO See Comments	Once with Revisions	Y	
26	Mandatory Submittal if Flt H/W	Engineering Analysis	If Required for DO See Comments	As Required	Y	
27	Mandatory Submittal if Flt H/W	Acceptance Data Package	If Required for DO See Comments	One Time	Y	Supplied for qual and Flight Units
28	Mandatory Submittal	Export Control Audit Results	After award of 1st DO, yearly on Sept. 30 thereafter	Yearly	Y	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC-030 LAR**

<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>COMMENTS</b>
29	Written Approval	Quality Plan	With Proposal	Once with Revisions	Attachment J-11	Only if contractor is using the R-quality plan template instead of ISO, and only if they need to make changes to it.
30	Written Approval	Patent Rights-Retention	As Required	As Required	Y (If Applicable)	
31	Written Approval	Shuttle/Station Payload Safety Data Package	If Required for DO See Comments	As Required	N	
32	Mandatory Submittal if Flt H/W	Limited Life Systems List	If Required for DO See Comments	As Required	Y	
33	Written Approval	Space Station GFE Failure Modes and Effects Analysis and Critical Items List	If Required for DO See Comments	As Required	N	If applicable
34	Written Approval	Space Shuttle GFE Safety and Analysis Report & Hazard Report	If Required for DO See Comments	As Required	Y	If applicable
35	Written Approval	Software Quality Assurance Plan Report	90 Days Prior to Software Development	Once with Revisions	N	
36	Written Approval	ISS Hazard Report	If Required for DO See Comments	As Required	Y	If applicable
37	Upon Request	Reliability and Maintainability Plan	With Proposal	One Time	N	
38	Written Approval	Government Certification Approval Request (GCAR)	If Required for DO See Comments	As Required	Y	
39	Written Approval	Risk Assessment Executive Summary Report (RAESR)	If Required for DO See Comments	As Required	Y	
40	Written Approval	Problem Reporting and Corrective Action (PRACA)	2 business days of problem isolation but no later than 10 days after detection	As Required	Y	
41	Upon Request	Nonconformance Record	If Required for DO See Comments	As Required	Y	
42	Mandatory Submittal	Government Industry Data Exchange Program and NASA Advisory Problem Data	Reported one time when discrepancy occurs	Once with Revisions	Y	
43	Written Approval	Electrical, Electronic, and Electromechanical (EEE) Parts Control Plan	If Required for DO See Comments	Once with Revisions	Y	If required
44	Mandatory Submittal if Flt H/W	Certification Data Package	If Required for DO See Comments	Once with Revisions	Y	
45	Written Approval	Certification and Acceptance Requirements Document	At CDR	Once with Revisions	Y	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE-EC-030 LAR**

DRD #	DATA TYPE	DRD TITLE	DUE	FREQUENCY	REQUIRED FOR DO? Y/N	COMMENTS
46	Upon Request	Wage/Salary and Fringe Benefit Data	Thirty (30) days after issuance of each DO	Once	N	
47	Written Approval	GFE Acceptance Test Procedure	If Required for DO See Comments	One Time	Y	
48	Mandatory Submittal if Flt H/W	Flight GFE Verification & Validation Report	If Required for DO See Comments	Once with Revisions	Y	
49	Mandatory Submittal if Flt H/W	Space Shuttle GFE Failure Modes and Effects Analysis (FMEA) and Critical Items List	If Required for DO See Comments	As Required	Y	If Applicable
50		Reserved	---	---	---	---
51	Mandatory Submittal	NASA Contractor Financial Management Reporting	After Issuance of 1st DO	Monthly	Y	
52	Written Approval	Government Property Management Plan	With Proposal	Once with Revisions	Attachment J-7	
53	Mandatory Submittal	System Safety Plan	With Proposal	One Time	Attachment J-10	
54	Written Approval	R-Quality Plan Template	With Proposal/Revisions as Required	Only applicable to B-CRAVE contracts in accordance with the SOW and the DRD	N	

Type 1 = Written Approval      Type 2 = Mandatory Submittal      Type 3 = Submittal Upon Request

**GOVERNMENT FURNISHED PROPERTY - The list of items below will be provided as Government Furnished Property.**

Item	Part Number	Quantity	Value
3/8" Male Drive Go/No-Go Gage	SDG38114280-001	1	\$ 2000 each
DPT Go/No-Go Gage	SDG38114281-001	1	\$ 2000 each
DPT PIP Pin Gage	SDG38114295-001	1	\$ 2000 each
PGT	GE1557000	1	\$1,000,000 ea
(available by October 15, 2007)			

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
 LYNDON B. JOHNSON SPACE CENTER  
 HOUSTON, TX 77058**

COST REIMBURSABLE INDEFINITE-DELIVERY  
 INDEFINITE-QUANTITY (IDIQ) Delivery ORDER  
 Hamilton Sundstrand Space Systems Intl., Inc.  
 Contract NNJ05HB39B

<i>Task Order Number</i>	<i>Revision Number</i>	<i>Purchase Request Number</i>
27	3	Funded at Contract Level
<i>SOW WBS</i>	<i>Fiscal Year</i>	<i>Technical Monitor/Division/Extension</i>
	FY09	COTR: Ralph Marak/EC ext:3-9144

**Task Order Title**

COMMON HELMET STUDY AND RISK MITIGATION:  
 OPTION 1, TASK 1 – FABRICATION OF TWO HELMET PROTOTYPES

**Description/Purpose**

This delivery order revision encompasses the contractors over-run request. The over-run is comprised of ILC Dover & Hamilton Sundstrand Space Systems Intl., Inc. at the value of \$65,098.53. This value is the net increase of the subject delivery order after mitigation actions were taken on behalf of the contractor.

**THE CONTRACTOR IS NOT AUTHORIZED TO EXCEED THE TASK ORDER VALUE SPECIFIED HEREIN. THIS IS A COST PLUS FIXED FEE TASK ORDER.**

Recapitulation of Delivery Order Value:

	Previous Revision	This Revision (Rev. 3)	Total
Cost	b4	b4	b4
Fee			
<b>Total</b>	\$ 513,955.86	\$ 65,098.53	\$ 579,054.39

**NASA Approval**

<i>Contracting Officer</i>	<i>Signature</i>	<i>Date</i>
Ronald Johnson	Ronald Johnson	8/14/09

# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
**GRAVE DO27R2**

2. Date of Order  
See Block 10 Below

**NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.**

Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office:  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org./Buyer: BH2/Mary Thomas  
  
Tel No 281-483-8828 Fax 281-244-0995  
E-mail: mary.f.thomas@nasa.gov

4. Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For **Accountable Property**  
Order No. GRAVE DO27R2

5. Contractor:  
Hamilton Sundstrand  
Attention: Nancy L. Broyan  
2200 Space Park Drive, Suite 100  
Houston, TX 77058-3677  
  
Phone 281-333-8704 x      Fax: 860-660-6798  
  
TIN: 06-1165586      CAGE CODE: 71120

6. Deliver On or Before 6/13/07 to 09/09/08  
F O B. Point: Destination  
Discount Terms. Net 30 Days

7. BILLING ADDRESS.  
NASA Johnson Space Center  
Attn: LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No.: GRAVE DO27R2

8. Type of Order:  
 PURCHASE. Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY. Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor ( ) is, ( ) is not required. Sign below if required and return to contracting officer  
Name: \_\_\_\_\_ (Person authorized to sign)  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_

10. Name: Ronald Johnson  
Signature: Ronald Johnson Date: 11/6/08  
CONTRACTING OFFICER

11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
1	COMMON HELMET STUDY AND RISK MITIGATION OPTION 1. TASK 1. FABRICATION OF TWO HELMET PROTOTYPES  Revision 2 to DO 27 is issued to extend the period of performance to 9/9/08. All other terms and conditions of the DO remain unchanged.  RECAP OF DO VALUE:  COST FEE <u>bt</u>  TOTAL \$513,955.86					<u>bt</u>

12. For JSC Internal Use Only:  
Requisition No N/A       COMP.     PART    PPC: \_\_\_\_\_  
Rissue To: EC/Ralph Marak, x39144

13. Total  
\$ NTE 513,955.86

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED     ACCEPTED     RECEIVED  
TO CONFORM TO THE CONTRACT  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED BY \_\_\_\_\_

Authorized U S Government Representative \_\_\_\_\_ Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

1. Order No. **CRAVE DO27R1**      2. Date of Order  
See Block 10 Below

**NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.**  
Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office:  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org./Buyer BH2/Mary Thomas

Tel No: 281-483-8828      Fax. 281-483-4173  
E-mail mary.f.thomas@nasa.gov

4. Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For: **Accountable Property**  
Order No. CRAVE DO27R1

5. Contractor:  
Hamilton Sundstrand Management Services, Inc  
Attention: Nancy L. Broyan  
2200 Space Park Drive, Suite 100  
Houston, TX 77058-3677

Phone: 281-333-8704 x      Fax 860-660-8798  
TIN: 06-1165586      CAGE CODE: 71120

6. Deliver On or Before: 6/13/07 to 8/15/08  
F O B Point Destination  
Discount Terms Net 30 Days

7. BILLING ADDRESS  
NASA Johnson Space Center  
Attn: LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No. CRAVE DO27R1

8. Type of Order:  
 PURCHASE Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_  
 DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor [] is, [] is not required Sign below if required and return to contracting officer.  
Name: \_\_\_\_\_ (Person authorized to sign)  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_

10 Name: Ronald Johnson  
Signature: Ronald Johnson Date: 11/24/08  
CONTRACTING OFFICER

11 Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED												
1	<p><b>COMMON HELMET STUDY AND RISK MITIGATION</b> <b>OPTION 1, TASK 1, FABRICATION OF TWO HELMET PROTOTYPES</b></p> <p>This revision is issued to exercise Option 1-Task 1 to fabricate two helmet prototypes. The delivery order value is increased by \$358,126 from \$155,829.86 to \$513,955.86. The period of performance is extended to August 15, 2008</p> <p>RECAP OF DO VALUE:</p> <table border="1"> <tr> <td></td> <td>PRIOR</td> <td>THIS ACTION</td> <td>CUM</td> </tr> <tr> <td>COST FEE</td> <td><u>b4</u></td> <td><u>b4</u></td> <td><u>b4</u></td> </tr> <tr> <td>TOTAL</td> <td>\$155,829.86</td> <td>\$358,126</td> <td>\$513,955.86</td> </tr> </table>		PRIOR	THIS ACTION	CUM	COST FEE	<u>b4</u>	<u>b4</u>	<u>b4</u>	TOTAL	\$155,829.86	\$358,126	\$513,955.86	<u>b4</u>			<u>b4</u>	
	PRIOR	THIS ACTION	CUM															
COST FEE	<u>b4</u>	<u>b4</u>	<u>b4</u>															
TOTAL	\$155,829.86	\$358,126	\$513,955.86															

12. For JSC Internal Use Only.  
Requisition No. N/A       COMP     PART    PPC \_\_\_\_\_  
Rissue To. EC/Joel Gensier, x30025

13 Total  
\$ NTE 513,955.86

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED     ACCEPTED     RECEIVED  
TO CONFORM TO THE CONTRACT  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED BY: \_\_\_\_\_

Authorized U S Government Representative \_\_\_\_\_ Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
NNJ05HB39B, CRAVE-EC5-DO27

2 Date of Order  
See Block 10 Below

NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.

Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office:  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org /Buyer. BH2/Mary Thomas  
  
Tel No.. 281-483-8928 Fax: 281-483-4173  
E-mail: mary.f.thomas@nasa.gov

4. Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For **Accountable Property**  
  
Order No.. NNJ05HB39B, CRAVE-EC5-DO27

5. Contractor  
Hamilton Sundstrand Management Services, Inc  
Attention: Kenneth Ridley  
1 Hamilton Road  
Windsor Locks, CT 06086  
  
Phone: 860-654-4034 x Fax. 860-654-3318  
  
TIN. 06-11655866 CAGE CODE.

6 Deliver On or Before: 6/13/07 thru 10/31/07  
  
F O.B. Point: DESTINATION  
  
Discount Terms. Net 30 Days.

7 BILLING ADDRESS.  
NASA Johnson Space Center  
Attn: LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No.. NNJ05HB39B, CRAVE-EC5-D027

8. Type of Order:  
 PURCHASE: Please furnish the following in accordance with the conditions specified on this order Reference: \_\_\_\_\_  
 DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor  is,  is not required. Sign below if required and return to contracting officer  
Name: \_\_\_\_\_ (Person authorized to sign)  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_

10. Name: Ronald Johnson  
  
Signature: Ronald Johnson Date: 6/13/07  
CONTRACTING OFFICER

11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	<b>COMMON HELMET STUDY AND RISK MITIGATION</b>					
1	The contractor shall perform and deliver to all baseline trade study requirements of CRAVE-EC5-DO27 as described in the Statement of Work Period of Performance. 6/13/07 thru 10/31/07	64	64	64	64	
2	OPTION 1: The Government may require the contractor to continue to perform services under this delivery order. The Contracting Officer may unilaterally exercise Option 1 by issuing Revision 1 to DO 27 The Government reserves the right not to exercise Option 1  (continued next page)					

12. For JSC Internal Use Only:  
Requisition No.. N/A  COMP  PART. PPC \_\_\_\_\_  
Rissue To. EC/Joe Gensler, x30025 For EC5/Brian Daniel

13. Total  
  
\$ 155,829.86

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED  ACCEPTED  RECEIVED  
TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED BY.

Authorized U.S. Government Representative \_\_\_\_\_ Date \_\_\_\_\_

**SCHEDULE**

ITEM	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	Should the Option be exercised, the resultant delivery order revision will be priced as negotiated under the base delivery order.	b4	b4	b4	b4	
	OPTION 1 Period of Performance: 11/1/07 thru 4/11/08					
	DO VALUE RECAP.					
	Baseline: <i>b4</i> Option.					
	THIS IS A CPFF DELIVERY ORDER					

# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
 NNJ05HB39B, CRAVE-EC-DO26

2. Date of Order  
 See Block 10 Below

NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.

Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office:  
 NASA Johnson Space Center, 2101 Nasa Parkway  
 Houston, TX 77058-3696  
 Org./Buyer: BH2/Mary Thomas

Tel No.: 281-483-8828 Fax: 281-483-4173  
 E-mail: mary.f.thomas@nasa.gov

4. Ship To:  
 Transportation Officer, Building 421  
 NASA Johnson Space Center  
 Houston, TX 77058-3696  
 Mark For: **Accountable Property**  
 Order No.: NNJ05HB39B, CRAVE-EC-DO26

5. Contractor:  
 Hamilton Sundstrand Management System  
 Attn: Kenneth Ridley  
 1 Hamilton Road  
 Windsor Locks, CT 06086

Phone: 860-654-4034 x      Fax: 860-654-3318

TIN: 06-11655866      CAGE CODE:

6. Deliver On or Before: 05/14/07 thru 08/27/07

F.O.B. Point: DESTINATION

Discount Terms: Net 30 Days.

7. BILLING ADDRESS:  
 NASA Johnson Space Center  
 Attn: LF231/Accounts Payable Group  
 Houston, TX 77058-3696  
 Order No.: NNJ05HB39B, CRAVE-EC-DO26

8. Type of Order:  
 PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor [] is, [] is not required. Sign below if required and return to contracting officer.

Name: \_\_\_\_\_ (Person authorized to sign)  
 Signature: \_\_\_\_\_ Date: \_\_\_\_\_

10. Name: Ronald Johnson

Signature: Ronald Johnson Date: 5/11/07  
 CONTRACTING OFFICER

11 Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
1	CRAVE-EC-DO26, INTERFACE FOR REMOVABLE/REPLACEABLE THERMAL MICROMETEOROID GARMENT  Period of Performance: 05/14/07 thru 08/27/07  The contractor shall perform and deliver to all requirements of CRAVE-EC-DO26 as described in the attached Statement of Work.  RECAP OF DELIVERY ORDER VALUE: Cost: <u>b4</u> - <del>see</del> <u>b4</u> Total: \$114,594.81  THIS IS A CPFF DELIVERY ORDER	<u>b4</u>			<u>b4</u>	

12. For JSC Internal Use Only:

Requisition No.: N/A       COMP.     PART.    PPC: \_\_\_\_\_  
 Rissue To: EC/Joe Gensler, x30025      FOR: EC/Lindsay Aitchison, x38657

13. Total  
 \$ 114,594.81

14. Quantities in "Quantity Accepted" Column Have Been

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT.  
 ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED BY \_\_\_\_\_

Authorized U.S. Government Representative

Date \_\_\_\_\_

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
**DELIVERY ORDER #: CRAVE-EC5-DO26**

**PROPOSAL INSTRUCTIONS:**        DRAFT -- COMMENTS DUE BY: April 12, 2007  
  X   FINAL -- PROPOSAL DUE BY: April 19, 2007

**DO TITLE:** Interface for Removable/Replaceable Thermal Micrometeoroid Garment

DO Type:   X   CPFF        FFP

**DO Contact Information in Addition to the CRAVE Contract Specialist or CO:**

COTR:   Joe Gensler/EC7   Phone: (281) 483-0025

DO Manager: Lindsay Aitchison/EC5 Phone: (281) 483-8657

DO Mgr. Alternate: Terry Hill/EC5 Phone: (281) 483-8135

**Concurrences:**

\_\_\_\_\_  
**Lindsay Aitchison**  
DO Manager

\_\_\_\_\_  
**Craig Dinsmore**  
DO Mgr. Management

\_\_\_\_\_  
**Joe Gensler**  
COTR

\_\_\_\_\_  
**Raul Blanco**  
Division TMR

\_\_\_\_\_  
**Ron Johnson**  
CRAVE Contracting Officer

Task Contains Flight Hardware, Flight Software or GSE?        Yes   x   No

Program Supported:        Shuttle        ISS   X   EVA        Advanced   X   Cx

WBS:   X   1.0 EVA        2.0 FCE        3.0 EVR        ECLSS        5.0 ATCS        6.0 CHeCS

*For purposes of complying with FAR 52.232-22, Limitation of Funds, the total amount allotted by the Government to contract is specified in clause B.6, Contract Funding. The funding listed in B.6 is the amount allotted for all Delivery Orders on the contract combined.*

*All terms and conditions of the contract apply to this Delivery Order. In the event of a conflict between the contract and this Delivery Order, the contract shall prevail.*

WBS reporting shall be done in accordance with applicable WBS reporting categories, as shown above and in the contract within Section C, Table 1.

Narrative Task Description

**Background / Problem Description:**

Thermal, Micrometeoroid Garments (TMG) have been worn by astronauts performing extravehicular activities (EVA) since the Gemini era. While designs have changed over the years, the purpose of the garment has not. The TMG provides protection to astronauts during Extra-Vehicular Activities (EVAs) by insulating against heat and radiation and providing boundary layers to dissipate the energy of micrometeoroid impacts. The Apollo Program TMG was integrated with the pressure garment restraint layer directly and served the additional purpose of dust barrier. The current TMG design used on the Shuttle EMU is a multi-layer fabric that can be separated from the pressure garment restraint layer. The TMG is attached to the EMU via various methods including loop tape, Velcro, and zippers prior to flight (see Figure 2-4). TMGs in general cover every part of the pressure garment that is exposed to deep space and/or dust environments.



Figure 2: Loop tape connection between EMU neckring and HUT TMG section

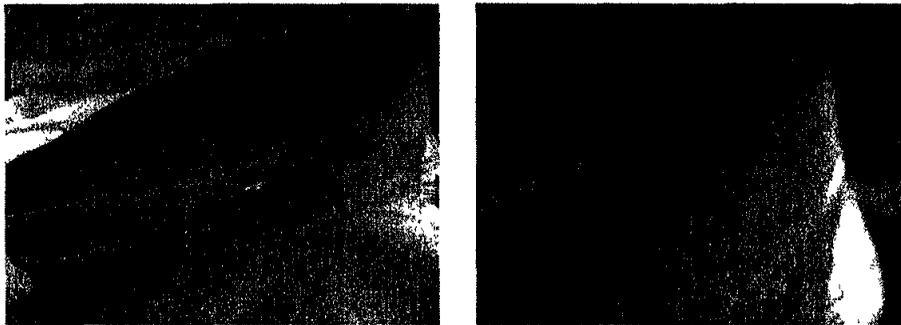
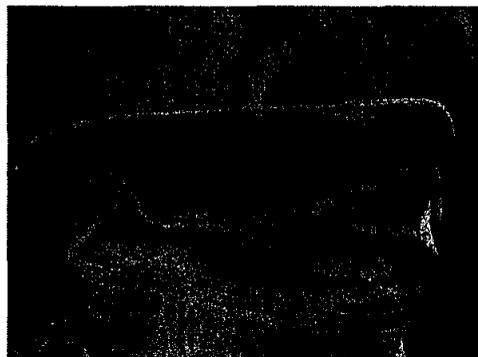


Figure 3: Zipper connection between EMU waist and brief TMG sections



CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-DO26

Figure 4: Velcro connection between EMU brief and leg TMG sections

**Purpose of the Current Effort**

The area of interest for this contract is to determine the feasibility of TMGs that can be easily removed/replaced by crewmembers during a mission by focusing specifically on the interface design. The TMG-to-pressure garment restraint interface developed for the DO is expected to act as a common interface for other pressure garment restraint layer covers as well (e.g. a fire retardant cover layer for launch and entry or a thermal, micrometeoroid, dust garment (TMDG) for surface exploration). Therefore, the contractor shall brainstorm potential interface concepts, conduct trade studies and analyses, and evaluate the concepts to downselect to preferred TMG interface technologies, materials, and interface designs. A good example of this design process can be found in the book titled "The Mechanical Design Process," by David Ullman. At the completion of the design process and downselect, the contractor shall present their design concepts and analyses to NASA in the form of a final report and presentation. At the presentation, the contractor shall provide NASA with functional, to scale prototype(s) of the TMG interface segment design(s) the contractor selected.

**Task Description:**

**Assumptions:**

It is assumed that the TMG will not be a single layer of material.

**Definitions**

*Interface segment:* Each section of the TMG shall be secured to the pressure garment restraint layer in such a way as to perform its functional tasks. An interface segment is therefore defined as the interface between a singular section of TMG and the pressure garment restraint layer and/or TMG segment-to-TMG segment. There does not have to be a common design across all of the interface segments. Each interface segment includes both the TMG side of the interface and the pressure garment side (e.g. restraint layer, bladder assembly, bearings, disconnects) of the interface.

*Interface:* The term interface in this DO refers to the collection of all TMG interface segments.

*Thermal Micrometeoroid Garment (TMG):* For the purpose of this DO, the TMG is defined as a 7-layer material lay-up of 0.375 in (0.953 cm) thickness, the outermost layer of which is orthofabric and innermost layer is Neoprene-coated Nylon. Samples of EMU TMG will be available for inspection by the contractor. The other cover layers that are expected to share an interface common to that being developed for the TMG in this DO can be assumed to have similar characteristics to the TMG definition provided.

*Dust:* For the purpose of this DO, the term dust can be approximated to the lunar soil simulant JSC-1, the properties of which are listed on the following website:

<http://ares.jsc.nasa.gov/HumanExplore/Exploration/EXLibrary/DOCS/EIC050.HTML> .

*Neutral Buoyancy Laboratory(NBL) Environment:* The NBL environment is defined in Table 1-2.

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
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Table 1-2

Test	Range
Temperature	82-88°F
pH	7.4-7.8
Conductivity	Average range 150-180 US/CM
C12 Residual	1.0 – 5.0 ppm
Alkalinity	80 – 120 ppm
Calcium Hardness	175 – 300 ppm
C12 Combined	0.0 – 0.2

**Trade Studies and Analyses**

The contractor shall review/study, but not be limited to, the data provided by NASA to become familiar with and knowledgeable of the interface designs used for the Shuttle EMU and other prototype space suits. The contractor shall conduct the trade studies and analyses to develop design concepts for the TMG interface which meet all requirements and attempt to meet all goals as stated below. If the goals cannot be achieved, the contractor shall provide information demonstrating the effort to meet the goals and rationale for why meeting the goal was not possible.

The trade studies and analyses of the TMG interface development shall include but not be limited to the items listed below. The rationale behind the results for each trade shall be described in detail in the final report.

**Trades**

1. Sensitivity of interface to different pressure garment architectures
2. Dust tolerance (keep dust from migrating between the restraint layer and TMG; durability of materials with respect to dust exposure; use of interface after repeated and prolonged exposure to dust environment; etc.)
3. Number of TMG segments required (effects on suited mobility, don/doff time, etc.)
4. Location of interface points (effects on suited mobility, don/doff time, etc.)
5. Ratio of interface system weight to total TMG system weight
6. Complexity of interface (number of components, training required, don/doff time)

**Goals**

1. The interface should minimize the number of TMG components per interface segment.
2. The interface should prevent migration of dust from the outer most TMG layer to the pressure garment restraint layer.
3. The interface should prevent the TMG from increasing joint torques more than 10% above their respective values during both pressurized and unpressurized operations.

*Rationale: Some TMG interface designs cause the TMG material to lay across joints such that a significant amount of force (friction torsional resistance, tension loading, etc.) develops between the pressure garment restraint layer and the innermost layer of the TMG.*

4. The interface should remain secure during suited activities.

*Rationale: The interface should ensure that TMG remains in its nominal position throughout an EVA so that the pressure garment and crewmember remain protected at all times.*

5. The TMG interface should minimize stowage volume of the TMG.

6. The interface should allow all TMG components to be donned in less than 6 minutes by an unsuited IV crewmember.

7. The interface should prevent the TMG from decreasing crewmember range of motion more than 10% above their respective values during both pressurized and unpressurized operations.

8. The interface should prevent the TMG segments from negatively impacting the crewmember's work envelope.

9. The interface should allow for line of sight between the suited crewmember and their on-suit controls and gauges.

10. The heat leak between the TMG without interface and seams and the TMG with interface and seams should be 10% or less in a cold vacuum environment.

11. The interface should allow the TMG segments to be placed such that all other external space suit interfaces are accessible while suited pressurized and unpressurized.

*Rationale: The locations and types of interfaces will affect the accessibility to other external suit such as umbilicals and restraints.*

#### **Requirements**

1. The interface shall allow all portions of the pressure garment below the neck ring (excluding gloves and boots) to be covered with a section of TMG, as outlined in Figure 4.

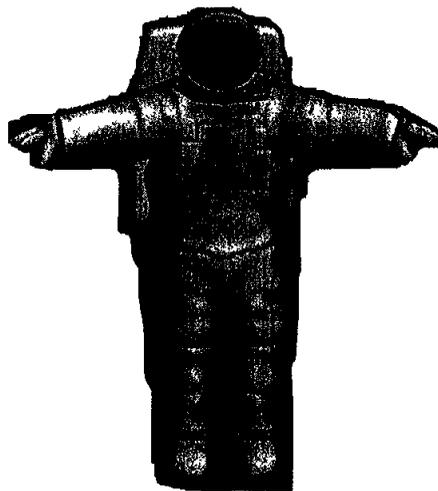


Figure 4: General outline of area to be covered by TMG segments

2. The interface shall be compatible and operable with a pressurized gloved hand.

3. The interface shall allow TMG to be donned on a pressurized suit.

4. The interface shall allow the TMG to be donned on an unpressurized suit.

5. The interface system shall weigh less than 24.0 oz (680 g).

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-DO26**

6. The interface shall retain all functionality for a minimum 60 connect-disconnect cycles, ten with a clean interface and fifty with a dusty interface.
7. The interface shall have a shelf life of 10 years.
8. The interface shall be compatible with a 100% oxygen environment.
9. The interface shall be compatible with the NBL environment.
10. The strength loss between the pressure garment restraint without the interface and with the interface should be such that the 2.0 factor of safety for softgoods is not reduced.

**Technical Document Library**

The contractor shall have access to the following documents and drawings via the online technical library:

1. CAD model of MK-III prototype space suit
2. EMU Mini-Data Book Section 1.0

**Progress Reports**

The contractor shall be required to provide NASA twice monthly status briefs detailing the current status of their work, what has been accomplished, what work is planned for the next two weeks, what issues/problems/risks (if any) have arisen, and their plan to mitigate any issues/problems/risks. These status reports may be submitted via email. Additionally, the contractor shall participate in weekly telecons to address problems as they arise.

**Conduct Mid-Term Presentation**

The contractor is to present their intermediate findings to NASA at a mid-term presentation. The presentation shall detail results from the trade studies and analyses conducted to date and provide insight toward the design concepts that are being developed.

**Fabricate Functional Interface Segment Prototype(s)**

At the presentation, the contractor shall provide NASA with functional, to scale prototype of the TMG interface segment design the contractor selected. The prototype interface shall be made to the specification and of the materials specified in the design. If the contractor has elected to design multiple interface segments to address the different issues associated with the various TMG segments, the contractor shall provide functional, to scale prototypes for each interface segment.

**Generate Final Report**

The contractor is to generate and publish a report detailing the results of the various trade studies conducted by the contractor, the interface design drawings they have developed, procedures for use and maintenance of interface concept, and their conclusions about the proposed interface design.

**Conduct Final Report Presentation**

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-DO26**

The contractor is to present their final report to NASA detailing the results of the various trade studies conducted by the contractor, the interface design concepts they have developed, and their conclusions about the proposed interface design.

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-DO26**

**Appendix**

**Deliverables/Products:**

<b>Product</b>	<b>Description</b>	<b>Qty</b>	<b>Due</b>	<b>Class</b>
<b>Hardware</b>				
	Example TMG interface segment(s) – Contractor shall provide a 12 inch long sample of both sides of the selected interface design; if more than one type of interface is selected for the interface system, the contractor shall provide a sample of each type of interface	1 ea.	Base Contract Completion	CIII
<b>Test</b>	N/A			
<b>Software</b>	N/A			
<b>Other Products</b>				
TMG Interface Design Concept Report	A well documented report detailing the results of the various trade studies conducted, the interface design concepts the contractor has developed, a preliminary requirements verification plan, instructions for use and implementation of interface with TMG and pressure garment, and their conclusions.	3 EA paper and CD (PDF and Word format)	Base contract Completion	N/A
Preliminary Materials Usage List	A preliminary list which details all the materials the contractor plans to use in the fabrication of the TMG interface. This list should also provide the status of each material in the Marshall Space Flight Center MAPTIS database. If the material(s) is not listed in MAPTIS, the contractor shall provide a preliminary plan for having the material processed and documented per the Materials Analysis Tracking and Control (MATCO) system.	3 EA paper and CD (PDF and Word format)	Base contract Completion	N/A

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
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TMG Interface Design Drawings	All engineering drawings for assembly and subassembly components of all TMG interface segments	3 EA paper and CD (Pro/E format)	Base contract Completion	N/A
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**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-DO26**

<b><u>SCHEDULE</u></b>	
<b>Start Date: May 14, 2007</b>	<b>Finish Date: August 27, 2007</b>

<b>INTERIM MILESTONES</b>	<b>DUE DATES (Weeks after ATE)</b>
<b>Kick Off Meeting</b>	<b>1</b>
<b>Review/Study of Current TMG Interface Designs</b>	<b>2</b>
<b>Mid-term Presentation</b>	<b>8</b>
<b>Generate/Publish Final Report</b>	<b>14</b>
<b>Formal Report Presentation to NASA</b>	<b>15</b>

<b>Total Government Estimate for this DO: <u>\$135,000</u></b> <b>Option 1: <u>\$N/A</u></b>
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<b>TOTAL COST ESTIMATE FOR THIS DO: \$</b> <b>FEE: \$ (If Applicable)</b> <b>OPTION 1: \$ (See Attachment 1)</b> <b>OPTION 2: \$ (See Attachment 2)</b> <b>OPTION 3: \$ (See Attachment 3)</b>
--

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-DO26**

**DATA REQUIREMENTS**

All DRs contained in the contract are applicable and required unless marked N/A below.

**NOTES: 1. GREY SCALED ROWS NEED NO ADDITIONAL/REQUIRED FILL-INS.  
2. ON ALL OTHER ROWS, IF NECESSARY, FILL IN ADDITIONAL  
RQMTS/DELIVERIES IN LAST COLUMN.**

DR#	DATA TYPE	DRD #/FILE	DUE	FREQUENCY	REQUIRED FOR DO?	ADDITIONAL REQUIREMENTS
1	Written Approval	Flight GFE Configuration Management Plan	With Proposal	Once	N	
2	Mandatory Submittal	Regular Status Report/Summary Review	Five working (5) days following contract start	Twice Monthly	Y	Status Email
3	Written Approval	Flight GFE Technical Requirements Specification		Once with Revisions	N	Informal specifications as described in the DO
4	Mandatory Submittal	GFE Systems Requirements Data Package		Once with Revisions	N	
5	Written Approval	Flight GFE Projects Requirements Verification Document		Once with Revisions	N	
6	Mandatory Submittal	Preliminary Design Review Data Package		Once with Revisions	N	
7	Written Approval	Flight GFE Workmanship Specifications List		Once with Revisions	N	
8	Written Approval	Project Schedule	Kick-off Meeting	Once w/Revisions (due w/DO proposal updates & details provided as DO progresses)	Y	In MS Project Format
9	Written Approval	Flight GFE Interface Control Document		Once with Revisions	N	
10	Written Approval	GFE End Item Specification		Once with Revisions	N	
11	Mandatory Submittal	Flight GFE Failure Analysis Report		As Required	N	
12	Written Approval	Flight GFE Verification and Validation Plan		Once with Revisions	N	
13	Written Approval	GFE Software Requirements Specification		Once with Revisions	N	
14	Written Approval	GFE Software Development Plan		Once with Revisions	N	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-DO26**

ORD	TYPE	DESCRIPTION	DOB	FREQUENCY	REQUIRED FOR DO	ADDITIONAL REQUIREMENTS
15	Written Approval	GFE Software Design Document		As Required	N	
16	Written Approval	Engineering Drawings	With final report	Once with Revisions	Y	
17	Written Approval	E/E Parts Lists and Analysis Report		As Required	N	
18	Mandatory Submittal	Critical Design Review Data Package		Once with Revisions	N	
19	Mandatory Submittal	Engineering Drawing Change Proposals		As Required	N	
20	Written Approval	GFE Qualification Test Procedure		Once with Revisions	N	
21	Written Approval	Eliminator User's Guide		Once with Revisions	N	
22	Mandatory Submittal	Software Code		As Required	N	
23	Written Approval	Information Technology (IT) Security Program Plan and Reports		ITG 2810.1	N	
24	Written Approval	Certification Plan		Once with Revisions	N	
25	Mandatory Submittal	Certification Report		Once with Revisions	N	
26	Mandatory Submittal	Engineering Analysis	With final report	As Required	Y	Trade Study and Design Concept Report (PDF and Word format)
27	Mandatory Submittal	Acceptance Data Package		One Time	N	
28	Mandatory Submittal	Export Control Audit Results	After award of 1st DO, yearly on Sept. 30 thereafter	Yearly	N	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-DO26**

DRD	DATA TYPE	DRD TITLE	DRD	FREQUENCY	REQUIRED FOR DOWNS	ADDITIONAL REQUIREMENTS
29	Written Approval	Quality Plan	With Proposal	Once with Revisions	Attachment J-II	
30	Written Approval	Patent Rights Retention	As Required	As Required	N	
31	Written Approval	Shuttle/Station Payload Safety Data Package		As Required	N	
32	Mandatory Submittal	Limited Life Systems List		As Required	N	
33	Written Approval	Space Station GFE Failure Modes and Effects Analysis and Critical Items List		As Required	N	
34	Written Approval	Space Shuttle GFE Safety and Analysis Report & Hazard Report		As Required	N	
35	Written Approval	Software Quality Assurance Plan Report		Once with Revisions	N	
36	Written Approval	ISS Hazard Report		As Required	N	
37	Upon Request	Reliability and Maintainability Plan		One Time	N	
38	Written Approval	Government Certification Approval Request (GCAR)		As Required	N	
39	Written Approval	Risk Assessment Executive Summary Report (RAESR)		As Required	N	
40	Written Approval	Problem Reporting and Corrective Action (PRACA)		As Required	N	
41	Upon Request	Nonconformance Record		As Required	N	
42	Mandatory Submittal	Government Industry Data Exchange Program and NASA Advisory Problem Data		Once with Revisions	N	
43	Written Approval	Electrical, Electronic, and Electromechanical (EEE) Parts Control Plan		Once with Revisions	N	
44	Mandatory Submittal	Certification Data Package		Once with Revisions	N	
45	Written Approval	Certification and Acceptance Requirements Document		Once with Revisions	N	
46	Upon Request	Wage/Salary and Fringe Benefit Data		Once	N	
47	Written Approval	GFE Acceptance Test Procedure		One Time	N	
48	Mandatory Submittal	Flight GFE Verification & Validation Report		Once with Revisions	N	


  
**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
**DELIVERY ORDER #: CRAVE-EC5-DO26**

DRD	DATA TYPE	DRD TITLE	DUE	FREQUENCY	REQUIRED FOR DO?	ADDITIONAL REQUIREMENTS
49	Mandatory Submittal	Space Shuttle GFE Failure Modes and Effects Analysis (FMEA) and Critical Items List		As Required	N	
50		Reserved				
51	Mandatory Submittal	NASA Contractor Financial Management Reporting	After Issuance of 1st DO	Monthly	N	
52	Written Approval	Government Property Management Plan	With Proposal	Once with Revisions	Attachment J-7	
53	Mandatory Submittal	System Safety Plan	With Proposal	One Time	Attachment J-10	
54	Written Approval	R-Quality Plan Template	With Proposal/Revisions as Required	Only applicable to B CRAVE contracts in accordance with the SOW and the DRD	Y	

Type 1 = Written Approval      Type 2 = Mandatory Submittal      Type 3 = Submittal Upon Request

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-DO26**

**GOVERNMENT FURNISHED PROPERTY**

**The CRAVE contracts do not anticipate the Government providing any property or test facilities unless requested by the contractor in their response to a request for bid.**

**In some rare cases (such as sustaining engineering task) it is know ahead of time that government property will be provided to the contractor. In those cases the following list filled out to allow the proper control of government property:**

**A. List of Property the Contractor Shall Replace with modified or upgraded versions:**

<b>Item</b>	<b>Quantity</b>	<b>Acquisition Cost</b>	<b>Use of Property Location</b>	<b>Date to be Furnished to the Contractor</b>

*[Insert a description of the item(s), quantity, acquisition cost, and date the property will be furnished to the Contractor] - List of Property will be added as requirements are further identified and the determination to provide property is determined to be in the best interest of the Government.*

**B. List of Property the Contractor will return in the same configuration:**

<b>Item</b>	<b>Quantity</b>	<b>Acquisition Cost</b>	<b>Use of Property Location</b>	<b>Date to be Furnished to the Contractor</b>

*[Insert a description of the item(s), quantity, acquisition cost, and date the property will be furnished to the Contractor] - List of Property will be added as requirements are further identified and the determination to provide property is determined to be in the best interest of the Government.*

# ORDER FOR SUPPLIES OR SERVICES

1. Order No. NNJ05HB39B, D025R1	2. Date of Order See Block 10 Below	NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO. Certified for National Defense under DPAS (15 CFR 700) DO-C9
------------------------------------	--	---

3. Issuing Office. NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org /Buyer: <u>BH2/Mary Thomas</u>  Tel No: <u>281-483-8828</u> Fax: <u>281-483-4173</u> E-mail: <u>mary.f.thomas@nasa.gov</u>	4. Ship To Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For <b>Accountable Property</b>  Order No.: <u>NNJ05HB39B, D025R1</u>
---	---

5. Contractor:  Hamilton Sundstrand Management Services, Inc 2200 Space Park Drive, Suite 100 Houston, TX 77058  Phone. 860-654-4034 x      Fax. 860-654-3318  TIN 06-11655866      CAGE CODE:	6. Deliver On or Before: <u>4/26/07 to 8/20/07</u>  F O B Point. <u>DESTINATION</u>  Discount Terms: Net 30 Days.  7. BILLING ADDRESS: NASA Johnson Space Center Attn LF231/Accounts Payable Group Houston, TX 77058-3696 Order No.. NNJ05HB39B, D025R1
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8. Type of Order  
 PURCHASE. Please furnish the following in accordance with the conditions specified on this order. Reference \_\_\_\_\_  
 DELIVERY. Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number \_\_\_\_\_

9. Written acceptance of this order by contractor <input type="checkbox"/> is, <input checked="" type="checkbox"/> is not required. Sign below if required and return to contracting officer  Name: _____ (Person authorized to sign) Signature: _____ Date: _____	10. Name: <u>Ronald Johnson</u>  Signature: <u>Ronald Johnson</u> Date: <u>7/27/07</u> CONTRACTING OFFICER
---	---

11 Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	LIQUID COOLING GARMENT TRADE STUDY AND PROTOTYPE  Revision 1 to CRAVE D025 is issued to extend the baseline period of performance to 8/20/07 at no additional cost to the Government All other other terms and conditions remain the same.	b4		b4	b4	

12 For JSC Internal Use Only: Requisition No: <u>N/A</u> <input type="checkbox"/> COMP <input type="checkbox"/> PART.    PPC: _____ Rissue To: <u>EC/Joe Gensler, x30025</u> For. <u>EC5/Lindsay Aitchison</u>	13 Total \$ 113,784
--	------------------------

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED     ACCEPTED     RECEIVED  
 TO CONFORM TO THE CONTRACT ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.  
 BY: \_\_\_\_\_  
 Authorized U S Government Representative      Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

<b>1. Order No.</b> NNJ05HB39B, CRAVE-EC5-DO25	<b>2. Date of Order</b> See Block 10 Below	<b>NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.</b> Certified for National Defense under DPAS (15 CFR 700) DO-C9	
<b>3. Issuing Office:</b> NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org./Buyer: <u>BH2/Mary Thomas</u>  Tel No.: <u>281-483-8828</u> Fax: <u>281-483-4173</u> E-mail: <u>mary.f.thomas@nasa.gov</u>		<b>4. Ship To:</b> Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b>  Order No.: <u>NNJ05HB39B, CRAVE-EC5-DO25</u>	
<b>5. Contractor:</b>  Hamilton Sundstrand Management Services, Inc 2200 Space Park Drive, Suite 100 Houston, TX 77058  Phone 860-854-4034 x      Fax. 860-854-3318  TIN: 06-11655866      CAGE CODE 71120		<b>6. Deliver On or Before:</b> <u>4/28/07 to 8/3/07</u>  F.O.B. Point: <u>DESTINATION</u>  Discount Terms: Net 30 Days.  <b>7. BILLING ADDRESS:</b> NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No. NNJ05HB39B, CRAVE-EC5-DO25	
<b>8. Type of Order:</b> <input type="checkbox"/> PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: _____ <input type="checkbox"/> DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: _____			

<b>9. Written acceptance of this order by contractor</b> <input type="checkbox"/> is, <input checked="" type="checkbox"/> is not required. Sign below if required and return to contracting officer.  Name: _____ (Person authorized to sign) Signature: _____ Date: _____	<b>10. Name:</b> <u>Ronald Johnson</u>  Signature: <u>Ronald Johnson</u> Date: <u>4/25/07</u> CONTRACTING OFFICER
---	--

11. Schedule						
ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
1	LIQUID COOLING GARMENT TRADE STUDY AND PROTOTYPE  The contractor shall perform and deliver to all baseline trade study requirements of CRAVE-EC-DO25 as described in the Statement of Work.	64				64
2	OPTION 1:  The Government may require the contractor to continue to perform services under this delivery order. The Contracting Officer may unilaterally exercise Option 1 by issuing Revision 1 to DO 25. The Government reserves the right not to exercise Option 1  (continued next page)					

<b>12. For JSC Internal Use Only:</b> Requisition No.: <u>N/A</u> <input type="checkbox"/> COMP. <input type="checkbox"/> PART    PPC: _____ Rissue To: <u>EC/Joe Gensler, x30025</u> For: <u>EC5/Lindsay Aitchison</u>	<b>13. Total</b>  <p style="text-align: center; font-size: 1.2em;">\$ 113,784</p>
---	---

<b>14. Quantities in "Quantity Accepted" Column Have Been</b> <input type="checkbox"/> INSPECTED <input type="checkbox"/> ACCEPTED <input type="checkbox"/> RECEIVED  TO CONFORM TO THE CONTRACT. ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.	BY: _____ Authorized U.S. Government Representative      Date _____
---	--

SCHEDULE

ITEM	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	<p>Should the Option be exercised, the resultant delivery order revision will be priced as negotiated under the base delivery order.</p> <p>OPTION 1 Period of Performance: 08/6/07 through 11/20/07</p> <p>THIS IS A CPFF DELIVERY ORDER.</p>	64			64	

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
 LYNDON B. JOHNSON SPACE CENTER  
 HOUSTON, TX 77058**

COST REIMBURSABLE INDEFINITE-DELIVERY  
 INDEFINITE-QUANTITY (IDIQ) TASK ORDER  
 University of Alabama at Birmingham  
 Contract NNJ05HB42B

<i>Delivery Order Number</i>	<i>Revision Number</i>	<i>Purchase Request Number</i>
16	5	Funded at Contract Level
<i>SOW WBS</i>	<i>Fiscal Year</i>	<i>Technical Monitor/Division/Extension</i>
	FY09	COTR: Ralph Marak/EC ext:3-9144

**Task Order Title**

REFRIGERATOR – FREEZER SERVICES

**Description/Purpose**

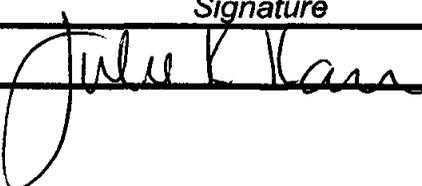
The purpose of this delivery order revision is to execute the tasks required for this revision as identified in the attached revised delivery order description. The recapitulation of the delivery order value is shown below per this revision.

Delivery Order 16 Value Recapitulation:

	<b>Prior</b>	<b>This Action DO 16, Rev 5</b>	<b>Cum Value</b>
<b>Cost</b>	<i>b4</i>	<i>b4</i>	<i>b4</i>
<b>Fee</b>	-	-	-
<b>Total</b>	\$3,367,572.31	\$32,900.70	\$3,400,473.01

**THE CONTRACTOR IS NOT AUTHORIZED TO EXCEED THE TASK ORDER VALUE SPECIFIED HEREIN. THIS IS A COST PLUS FIXED FEE TASK ORDER.**

**NASA Approval**

<i>Contracting Officer</i>	<i>Signature</i>	<i>Date</i>
Julie K. Karr		11/9/09

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
 LYNDON B. JOHNSON SPACE CENTER  
 HOUSTON, TX 77058**

COST REIMBURSABLE INDEFINITE-DELIVERY  
 INDEFINITE-QUANTITY (IDIQ) TASK ORDER  
 University of Alabama at Birmingham  
 Contract NNJ05HB42B

<i>Delivery Order Number</i>	<i>Revision Number</i>	<i>Purchase Request Number</i>
16	4	Funded at Contract Level
<i>SOW WBS</i>	<i>Fiscal Year</i>	<i>Technical Monitor/Division/Extension</i>
	FY09	COTR: Ralph Marak/EC ext:3-9144

**Task Order Title**

REFRIGERATOR – FREEZER SERVICES

**Description/Purpose**

The purpose of this delivery order revision is to execute the tasks required for this revision as identified in the attached revised delivery order description. The recapitulation of the delivery order value is shown below per this revision.

Delivery Order 16 Value Recapitulation:

	<b>Prior</b>	<b>This Action DO 16, Rev 4</b>	<b>Cum Value</b>
<b>Cost</b>	<i>bf</i>	<i>bf</i>	<i>bf</i>
<b>Fee</b>			
<b>Total</b>	\$ 3,337,630.11	\$ 29,942.20	\$ 3,367,572.31

**THE CONTRACTOR IS NOT AUTHORIZED TO EXCEED THE TASK ORDER VALUE SPECIFIED HEREIN. THIS IS A COST PLUS FIXED FEE TASK ORDER.**

**NASA Approval**

<i>Contracting Officer</i>	<i>Signature</i>	<i>Date</i>
Ronald Johnson	<i>Ronald Johnson</i>	7/30/09

# ORDER FOR SUPPLIES OR SERVICES

1. Order No. NNJ05HB42B, CRAVE DO16R3	2. Date of Order See Block 10 Below	NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO. Certified for National Defense under DPAS (15 CFR 700) DO-C9
--	--	---

3. Issuing Office. NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org./Buyer: <u>BH2/Mary Thomas</u>  Tel No.: <u>281-483-8928</u> Fax <u>281-244-0995</u> E-mail: <u>mary.f.thomas@nasa.gov</u>	4. Ship To: Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b>  Order No. <u>NNJ05HB42B, CRAVE DO16R3</u>
---	--

5. Contractor: University of Alabama @ Birmingham Center Attn. Lee Moradi, CBSE 100 1530 3 <sup>rd</sup> Avenue South Birmingham, Alabama 35294-4400  Phone: 205-975-2718 x      Fax: 205-975-1709  TIN: 63-6005396      CAGE CODE: 0DV74	6. Deliver On or Before: <u>9/14/06 to 12/31/09</u>  F.O B. Point: <u>DESTINATION</u>  Discount Terms: Net 30 Days.  7. BILLING ADDRESS. NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No : <u>NNJ05HB39B, CRAVE DO16R3</u>
---	---

8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9 Written acceptance of this order by contractor [ <input type="checkbox"/> ] is, [ <input checked="" type="checkbox"/> ] is not required Sign below if required and return to contracting officer  Name: _____ (Person authorized to sign) Signature: _____ Date _____	10 Name: <u>Ronald Johnson</u>  Signature: <u>Ronald Johnson</u> Date <u>12/17/08</u> CONTRACTING OFFICER
--	--

11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED																					
1	<b>REFRIGERATOR-FREEZER SERVICES</b>  Revision 3 to DO 16 is issued to increase the DO value by <u>b4</u> from <u>b4</u> manifest. All other terms and conditions of the DO remain unchanged This change is a result of the revised manifest.  RECAP OF DO VALUE  <table style="width:100%"> <tr> <td></td> <td style="text-align: center;">Prior</td> <td style="text-align: center;">This Action</td> <td style="text-align: center;">CUM Value</td> <td></td> <td></td> <td></td> </tr> <tr> <td style="text-align: right;">Cost Fee-</td> <td style="text-align: center;"><u>b4</u></td> <td style="text-align: center;"><u>b4</u></td> <td style="text-align: center;"><u>b4</u></td> <td></td> <td></td> <td></td> </tr> <tr> <td style="text-align: right;">TOTAL</td> <td style="text-align: right;">\$2,939,730.11</td> <td style="text-align: right;">\$397,900</td> <td style="text-align: right;">\$3,337,630.11</td> <td></td> <td></td> <td></td> </tr> </table>		Prior	This Action	CUM Value				Cost Fee-	<u>b4</u>	<u>b4</u>	<u>b4</u>				TOTAL	\$2,939,730.11	\$397,900	\$3,337,630.11				<u>b4</u>			<u>b4</u>	
	Prior	This Action	CUM Value																								
Cost Fee-	<u>b4</u>	<u>b4</u>	<u>b4</u>																								
TOTAL	\$2,939,730.11	\$397,900	\$3,337,630.11																								

12 For JSC Internal Use Only Requisition No.: <u>N/A</u> <input type="checkbox"/> COMP <input type="checkbox"/> PART    PPC _____ Rissue To: <u>EC/Ralph Marak, x39144</u> FOR <u>EC2/Sharon Campana, x45508</u>	13 Total \$ \$3,337,630.11 NTE
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14 Quantities in "Quantity Accepted" Column Have Been

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.      BY \_\_\_\_\_

Authorized U S Government Representative      Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

1. Order No. NNJ05HB42B, CRAVE DO16R2	2. Date of Order See Block 10 Below	NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO Certified for National Defense under DPAS (15 CFR 700) DO-C9
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3. Issuing Office: NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org./Buyer <u>BH2/Mary Thomas</u>  Tel No. <u>281-483-8828</u> Fax: <u>281-483-4173</u> E-mail. <u>mary.f.thomas@nasa.gov</u>	4. Ship To Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For <b>Accountable Property</b>  Order No. <u>NNJ05HB42B, CRAVE DO16R2</u>
--	--

5 Contractor: University of Alabama @ Birmingham Center Attn: Lee Moradi 1530 3 <sup>rd</sup> Avenue South Birmingham, Alabama 35294-4400  Phone: 205-975-2718 x      Fax. 205-975-1709  TIN: 63-6005396      CAGE CODE: 0DV74	6. Deliver On or Before <u>9/14/06 to 12/31/09</u>  F.O B Point: <u>DESTINATION</u>  Discount Terms. Net 30 Days  7 BILLING ADDRESS: NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No.: NNJ05HB39B, CRAVE DO16R2
--	--

8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference. \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor <input type="checkbox"/> is, <input checked="" type="checkbox"/> is not required. Sign below if required and return to contracting officer.  Name: _____ (Person authorized to sign) Signature: _____ Date: _____	10. Name: <u>Ronald Johnson</u>  Signature: <u>Ronald Johnson</u> Date: <u>8/17/07</u> CONTRACTING OFFICER
--	---

11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	REFRIGERATOR-FREEZER SERVICES Period of Performance 9/14/06 to 12/31/09					
	Revision 2 to DO 16 is issued to increase the DO value as a result of Sortie flights 13A.1, 15A, and 1J/A Sortie flight 1J/A has been excelerated The DO value is increased by <u>bf</u> to \$2,939,730 11	<u>bf</u>			<u>bf</u>	

12 For JSC Internal Use Only: Requisition No. <u>N/A</u> <input type="checkbox"/> COMP <input type="checkbox"/> PART.    PPC: _____ Rissue To: <u>EC/Joe Gensler, x30025</u> FOR: <u>EC/Warren Ruemmele, x33662</u>	13 Total  \$ 2,939,730.11
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14 Quantities in "Quantity Accepted" Column Have Been

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED. BY \_\_\_\_\_

Authorized U S Government Representative      Date \_\_\_\_\_

**ORDER FOR SUPPLIES OR SERVICES**

1. Order No. NNJ05HB42B, CRAVE DO16R1	2. Date of Order See Block 10 Below	NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO. Certified for National Defense under DPAS (15 CFR 700) DO-C9
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3. Issuing Office: NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org./Buyer. <u>BH2/Mary Thomas</u>  Tel No.: <u>281-483-8828</u> Fax: <u>281-483-4173</u> E-mail: <u>mary.f.thomas@nasa.gov</u>	4 Ship To: Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b>  Order No. <u>NNJ05HB42B, CRAVE DO16R1</u>
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5. Contractor: University of Alabama @ Birmingham Center Attn: Lee Moradi 1530 3 <sup>rd</sup> Avenue South Birmingham, Alabama 35294-4400  Phone: 205-975-2718 x      Fax. 205-975-1709  TIN: 63-6005396      CAGE CODE: 0DV74	6 Deliver On or Before: <u>9/14/06 to 12/31/09</u> F.O.B. Point. <u>DESTINATION</u> Discount Terms: Net 30 Days.  7 BILLING ADDRESS: NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No.: NNJ05HB39B, CRAVE DO16R1
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8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9 Written acceptance of this order by contractor <input type="checkbox"/> is, <input checked="" type="checkbox"/> is not required Sign below if required and return to contracting officer  Name: _____ (Person authorized to sign) Signature: _____ Date: _____	10. Name: <u>Ronald Johnson</u>  Signature: <u>Ronald Johnson</u> Date: <u>4/4/07</u> CONTRACTING OFFICER
---	--

11 Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
<b>REFRIGERATOR-FREEZER SERVICES</b>						
Period of Performance: 9/14/06 to 12/31/09						
Revision 1 to DO16 is issued to exercise the following prepriced Options which will provide Galley refrigerator/freezer services to the ISS program The ISS Mission will begin on ULF2 (STS-126) currently scheduled for launch 10/9/08 or 10/23/08						
1	Option 3e, One ISS FY09 First ISS Mission	<u>64</u>	<u>64</u>	<u>64...</u>	<u>64</u>	
2	Option 4, Three ISS Mission Extensions (6 months worth of extensions to provide a total of 24 months of-on-orbit operation)					
(continued)						

12. For JSC Internal Use Only. Requisition No.: <u>N/A</u> <input type="checkbox"/> COMP. <input type="checkbox"/> PART.    PPC: _____ Rissue To: <u>EC/Joe Gensler, x30025</u> FOR: <u>EC/Warren Ruemmele, x33662</u>	13 Total  \$ 2,839,245.11 NTE
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14. Quantities in "Quantity Accepted" Column Have Been

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.

BY: \_\_\_\_\_  
Authorized U S. Government Representative      Date \_\_\_\_\_

**SCHEDULE**

ITEM	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	<p>RECAP OF DELIVERY ORDER VALUE:</p> <p>BASE <u>        </u> <i>64</i></p> <p>CUM. TOTAL        \$2,839,245.11</p> <p>THIS IS A CPFF DELIVERY ORDER</p>					



# Flight Assignment Working Group (FAWG) Planning Manifest

NASA Official: John Cagganoff  
Prepared for USFDOC/Office of Space  
Chief updated: 9-May-2007

## 103

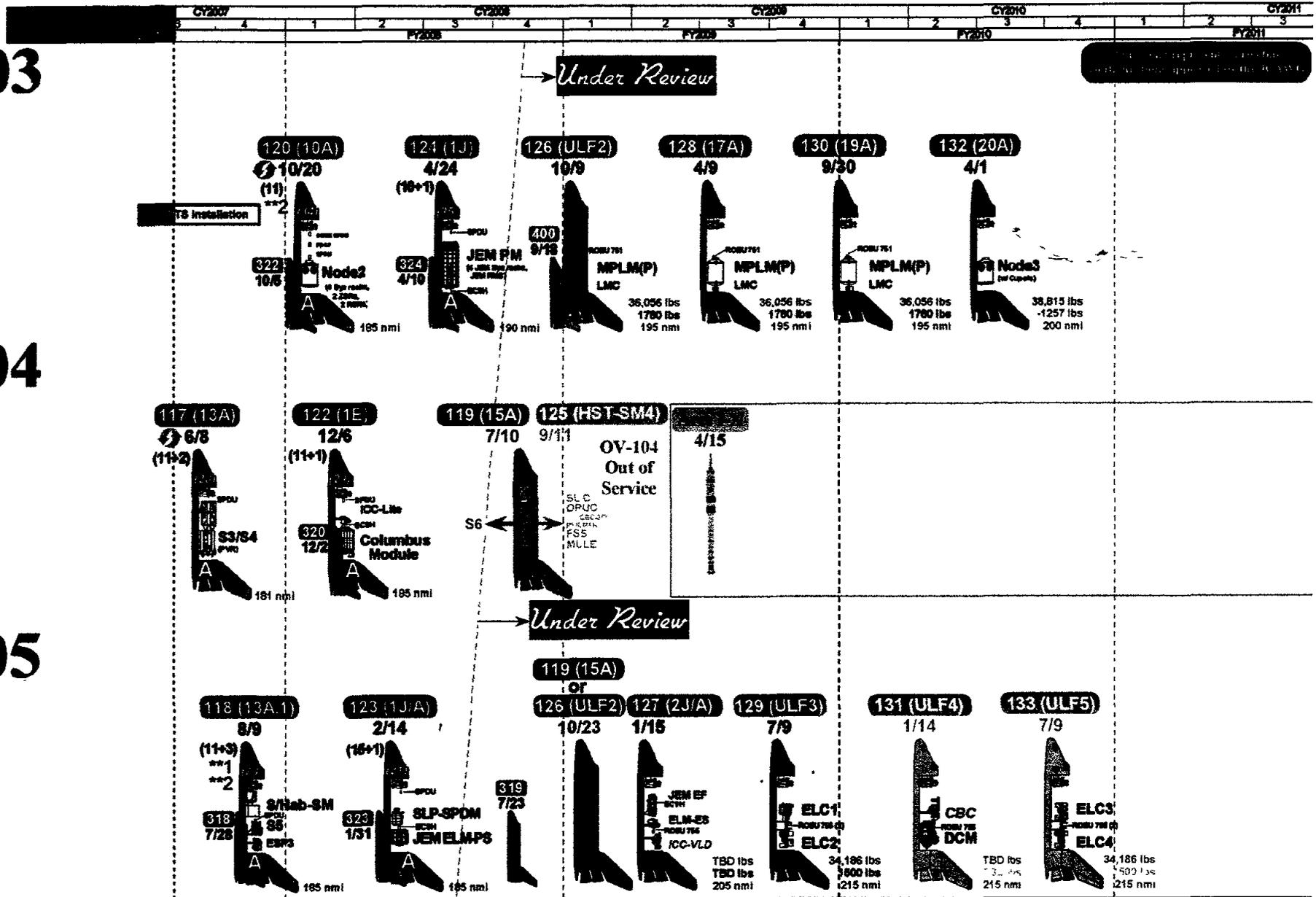
Discovery

## 104

Atlantis

## 105

Endeavour



Flight Rate	FY-5/CY-4	FY-6/CY-4	FY-7/CY-3	FY-8/CY-0
May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar	22 7 7 18 8 4	11 8 30 10 22		
Launches/Flight Days	Beta Exceedance			
Contingency Logistic Flights	Contingency Shuttle Crew Support (CSCS) (Empty Cargo Bay)			
WFO Launch Rate (baseline)	Launch Date			
Mission duration	Crew Rotation			
# of times the OV has flown	Assessed launch date			
Crew Augmentation	Cargo Bay Elements			
Launch Pad	Not included in the FORD			
	ISS Chargeable weight (lbs) AFW (lbs)			
	Rendezvous altitude (ft)			

Under Review  
Green AFM: Flight specific vehicle & launch month  
\*AFM: Generic specific vehicle & launch month

\*\*\* New Capabilities (MCS controlled)  
1. Avionics Bay 1, 2 & 3A Enhanced Cooling (Rear Air-Breathing) Capability  
2. Station/Shuttle Power Transfer System (SSPTS) Capability - extends flight duration 15 days. (STS-118 (13A.1) & sub except OV-104 flight)

## ORDER FOR SUPPLIES OR SERVICES

1. Order No. DO-CRAVE-EC2-DO16	2. Date of Order See Block 10 Below	NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO. Certified for National Defense under DPAS (15 CFR 700) DO-C9
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3. Issuing Office: NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org./Buyer: BH2/Mary Thomas  Tel No.: 281-483-8828      Fax: 281-244-0895 E-mail: mary.f.thomas@nasa.gov	4. Ship To: Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: Accountable Property  Order No.: DO-CRAVE-EC2-DO16
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5. Contractor: The University of Alabama at Birmingham Center for Biophysical Sciences and Engineering CBSE 100, 1530 3 <sup>rd</sup> Avenue South, Birmingham, Alabama 35294-4400  Phone: (205)975-2718    x      Fax: (205)975-1709  TTN: 63-8005396      CAGE CODE: 0DV74	6. Deliver On or Before: <u>See Statement of Work</u>  F.O.B. Point: <u>Destination</u>  Discount Terms: <u>Net 30 Days.</u>  7. BILLING ADDRESS: NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No.: DO-CRAVE-EC2-DO16
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8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: NNJ05HB42B

9. Written acceptance of this order by contractor <input checked="" type="checkbox"/> is, <input type="checkbox"/> is not required. Sign below if required and return to contracting officer. Name: <u>Jane Fant</u> (Person authorized to sign) Signature: <u>Jane Fant</u> Date: <u>9-18-06</u>	10. Name: <u>Robert Kolb</u>  Signature: <u>Robert Kolb</u> Date: <u>9-19-06</u> <b>CONTRACTING OFFICER</b>
---	--

**11. Schedule**

ITEM NO.	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
1	<b>DO-CRAVE-EC2-DO16, Refrigerator-Freezer Services</b>  Basic: The contractor shall perform and deliver to all requirements for DO-CRAVE-EC2-DO16, Refrigerator-Freezer Services.  Option: NASA may exercise options in this DO to satisfy the maximum mission need. The government may exercise the priced option described on the next page by notification to the contractor no later than 15 days before the completion of the basic delivery order requirement. The government may also elect to exercise an option more than once.  Period of Performance: 8/14/06 to 12/31/09	64	64	64	64	

12. For JSC Internal Use Only: Requisition No.: _____ <input type="checkbox"/> COMP. <input type="checkbox"/> PART. PPC: _____ Issue To: <u>EC/Joe W. Gensler. x30025</u> For: <u>EC/Warren Ruummele. x33662</u>	13. Total  <p style="text-align: center; font-size: 1.2em;"><b>\$1,793,479.11</b></p>
--	---

14. Quantities in "Quantity Accepted" Column Have Been

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.

BY: \_\_\_\_\_ Date: \_\_\_\_\_  
Authorized U.S. Government Representative

**SCHEDULE**

ITEM	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	<p>Option 1a, ROCC Separate Upgrade for sortie flight support</p> <p>Option 1b, MERLIN Galley Food Warmer (FY 08 rates)</p> <p>Option 1c, MERLIN Galley Food Warmer First ISS Mission * ** (FY08 rates)</p> <p>Option 2a, One additional FY07 STS Sortie *</p> <p>Option 2b, One additional FY08 STS Sortie *</p> <p>Option 2c, One additional FY09 STS Sortie *</p> <p>Option 2d, One additional FY10 STS Sortie *</p> <p>Option 3a, One ISS FY07 First ISS Mission *</p> <p>Option 3b, One ISS FY07 ISS Mission (not first) *</p> <p>Option 3c, One ISS FY08 First ISS Mission *</p> <p>Option 3d, One ISS FY08 ISS Mission (not first) *</p> <p>Option 3e, One ISS FY09 First ISS Mission *</p> <p>Option 3f, One ISS FY09 ISS Mission (not first) *</p> <p>Option 3g, One ISS FY10 First ISS Mission *</p> <p>Option 3h, One ISS FY10 ISS Mission (not first) *</p> <p> PERIOD OF PERFORMANCE: 9/14/08 to 12/31/09</p> <p> * = Unit price uses rates in effect at end date of Sortie or ISS Mission. Actual price shall use CRAVE rate schedules.</p> <p>ISS or Reflight options assume the Base Option is active.</p> <p>Additional costs would be incurred on FY10 flights due to the Basic Option ending at 12/31/09 (i.e. quarterly reviews, Management, etc.)</p> <p>** = Assumes option for first ISS mission for MERLIN has been exercised.</p>					

*04*

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
 LYNDON B. JOHNSON SPACE CENTER  
 HOUSTON, TX 77058**

COST REIMBURSABLE INDEFINITE-DELIVERY  
 INDEFINITE-QUANTITY (IDIQ) Delivery ORDER  
 Hamilton Sundstrand Space Systems Intl., Inc.  
 Contract NNJ05HB39B

<i>Task Order Number</i>	<i>Revision Number</i>	<i>Purchase Request Number</i>
10	8	Funded at Contract Level
<i>SOW WBS</i>	<i>Fiscal Year</i>	<i>Technical Monitor/Division/Extension</i>
	FY10	COTR: Ralph Marak/EC ext:3-9144

**Task Order Title**

**ISS URINE MONITORING SYSTEM SHUTTLE DTO UNIT ASSEMBLY  
 AND FLIGHT CERTIFICATION**

**Description/Purpose**

This delivery order revision encompasses a definitization of Proposal #ESDPC-09R-0264 for a cost overrun and reconciliation due to: 1) an error in recapitulation between revisions five and six; 2) an error of not de-scoping Option 1 in revision 6. The period of performance is extended from September 30, 2009 to December 7, 2009. (April 11, 2006 – December 7, 2009)

**THE CONTRACTOR IS NOT AUTHORIZED TO EXCEED THE TASK ORDER VALUE SPECIFIED HEREIN. THIS IS A COST PLUS FIXED FEE TASK ORDER.**

**Recapitulation of Delivery Order Value:**

	Previous Revision	This Revision (Rev. 8)	Total
Cost	b4	b4	b4
Fee			
<b>Total</b>	<b>\$ 2,770,439.00</b>	<b>\$ 179,963.00</b>	<b>\$ 2,950,402.00</b>

**NASA Approval**

<i>Contracting Officer</i>	<i>Signature</i>	<i>Date</i>
Adrian D. Clayton		10-1-09

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
 LYNDON B. JOHNSON SPACE CENTER  
 HOUSTON, TX 77058**

COST REIMBURSABLE INDEFINITE-DELIVERY  
 INDEFINITE-QUANTITY (IDIQ) Delivery ORDER  
 Hamilton Sundstrand Space Systems Intl., Inc.  
 Contract NNJ05HB39B

<i>Task Order Number</i>	<i>Revision Number</i>	<i>Purchase Request Number</i>
10	7	Funded at Contract Level
<i>SOW WBS</i>	<i>Fiscal Year</i>	<i>Technical Monitor/Division/Extension</i>
	FY09	COTR: Ralph Marak/EC ext:3-9144

**Task Order Title**

**ISS URINE MONITORING SYSTEM SHUTTLE DTO UNIT ASSEMBLY  
 AND FLIGHT CERTIFICATION**

**Description/Purpose**

This delivery order revision encompasses the contractors Request for Equitable Adjustment, the additional analysis for International Partners in launch and landing, and extension of the baseline as delineated in proposal number ESDPC-09F-0099 Revision 1. The period of performance is extended to September 30, 2009.

**THE CONTRACTOR IS NOT AUTHORIZED TO EXCEED THE TASK ORDER VALUE SPECIFIED HEREIN. THIS IS A COST PLUS FIXED FEE TASK ORDER.**

**Recapitulation of Delivery Order Value:**

	Previous Revision	This Revision (Rev. 7)	Total
<b>Cost</b>	b4	b4	b4
<b>Fee</b>			
<b>Total</b>	\$ 2,047,253.00	\$ 723,186.00	\$ 2,770,439.00

**NASA Approval**

<i>Contracting Officer</i>	<i>Signature</i>	<i>Date</i>
Ronald Johnson	<i>Ronald Johnson</i>	8/11/09

# ORDER FOR SUPPLIES OR SERVICES

1. Order No. NNJ05HB39B, CRAVE DO10R6	2. Date of Order	<b>NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.</b> Certified for National Defense under DPAS (15 CFR 700) DO-C9
--	------------------	--

3. Issuing Office: NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org./Buyer: <u>BH2/Mary Thomas</u>  Tel No: <u>281-483-8828</u> Fax <u>281-244-0995</u> E-mail: <u>mary.f.thomas@nasa.gov</u>	4. Ship To. Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b>  Order No <u>NNJ05HB39B CRAVE DO10R6</u>
--	--

5. Contractor: Hamilton Sundstrand Space Attn: Nancy Broyan 2200 Space Park Drive, Suite 100 Houston, TX 77058-3677  Phone: 281-333-8704 x      Fax: 860-660-6798  TIN: 06-1165866      CAGE CODE. 71120	6. Deliver On or Before <u>April 11, 2006 - June 15, 2009</u> F.O B Point: <u>Destination</u> Discount Terms: Net 30 Days.  7 BILLING ADDRESS NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No.: NNJ05HB39B, CRAVE DO10R6
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8. Type of Order

PURCHASE. Please furnish the following in accordance with the conditions specified on this order Reference: \_\_\_\_\_

DELIVERY. Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number \_\_\_\_\_

9. Written acceptance of this order by contractor <input type="checkbox"/> is, <input checked="" type="checkbox"/> is not required. Sign below if required and return to contracting officer.  Name: _____ (Person authorized to sign) Signature: _____ Date _____	10 Name: <u>Ronald Johnson</u>  Signature: <u>Ronald Johnson</u> Date: <u>4/13/08</u> CONTRACTING OFFICER
---	--

11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	ISS URINE MONITORING SYSTEM SHUTTLE DTO UNIT ASSEMBLY AND FLIGHT CERTIFICATION					
1	Revision 6 to DO 10 is issued to revise the Statement of Work (SOW), extend the DO completion date, and increase the DO value. The attached SOW is revised to complete and/or include the following tasks. Extended Baseline Option: complete the fabrication, modifications, functional integration testing, and flight certification of Class I hardware.	64			64	
2	Option 1: perform a test sequence on JSC reduced gravity aircraft (DC9) to verify key system performance parameters.					
(continued page 2)						

12. For JSC Internal Use Only: Requisition No.: <u>N/A</u> <input type="checkbox"/> COMP. <input type="checkbox"/> PART.   PPC: _____ Rissue To <u>EC/Joe Gensler, x30025</u> FOR <u>EC3/Branelle R Cibuzar</u>	13. Total  <b>\$ 2,047,253 NTE</b>
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14 Quantities in "Quantity Accepted" Column Have Been

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.      BY \_\_\_\_\_

Authorized U S Government Representative      Date \_\_\_\_\_

**SCHEDULE**

ITEM	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED												
3	<p>Option 3 Identify ISS UMS modifications and tests required for integration of an on-orbit Urine Analysis System (UAS) to interface with the ISS UMS</p> <p>The DO completion date is extended to June 15, 2009.</p> <p>The DO value is increased by \$1,325,659 from \$721,594 to \$2,047,253</p> <p>RECAP DO VALUE:</p> <table border="0"> <thead> <tr> <th></th> <th>PRIOR</th> <th>THIS ACTION</th> <th>CUM VALUE</th> </tr> </thead> <tbody> <tr> <td>COST FEE</td> <td><i>b4</i></td> <td><i>b4</i></td> <td><i>b4</i></td> </tr> <tr> <td>TOTAL</td> <td>\$721,594</td> <td>\$1,325,659</td> <td>\$2,047,253</td> </tr> </tbody> </table>		PRIOR	THIS ACTION	CUM VALUE	COST FEE	<i>b4</i>	<i>b4</i>	<i>b4</i>	TOTAL	\$721,594	\$1,325,659	\$2,047,253	<i>b4</i>			<i>b4</i>	
	PRIOR	THIS ACTION	CUM VALUE															
COST FEE	<i>b4</i>	<i>b4</i>	<i>b4</i>															
TOTAL	\$721,594	\$1,325,659	\$2,047,253															



**Narrative Task Description**

**Background / Problem Description:**

This Delivery Order (DO) is being updated to encompass additional objectives. The Baseline and Option 2 objectives were completed in March of 2007.

**1.0 Objectives**

Delivery Order Baseline was completed in March 2007. The primary objective of completing fabrication, calibration, and functional integration testing of the class I hardware for the DTO ISS UMS was complete.

**1.1 Delivery Order Option 1.**

The secondary objective (a DO option) will be to perform a test sequence on JSC reduced gravity aircraft (DC9) to verify key system performance parameters.

**1.2 Delivery Order Option 2.**

DO Option 2 was completed in March 2007. The tertiary objective (a DO option) to identify additional hardware modifications and tests required for integration with the Russian Waste Collector System (ACY&K) and the ISS Waste & Hygiene Compartment (WHC) was completed.

**1.3 Delivery Order Extended Baseline**

**Delivery Order Extended Baseline. The primary objective is to complete the fabrication, modifications, functional integration testing, and flight certification of class I hardware for the Shuttle Detailed Test Objective (DTO) ISS Urine Monitoring System (UMS). Formal certification testing is required. The ISS UMS current configuration was intended for integration with the space shuttle as a DTO, the DTO unit will need to be modified to integrate into the Russian Waste Collector System (ACY&K) and the ISS Waste & Hygiene Compartment (WHC).**

**1.4 Delivery Order Option 3.**

**The fifth objective (a DO option) will be to identify ISS UMS modifications and tests required for integration of an on-orbit Urine Analysis System (UAS) to interface with the ISS UMS.**

**2.0 Need for ISS UMS Shuttle DTO Completion**

The Shuttle DTO ISS UMS unit was in the process of being assembled when the work was impacted by a combination of competing Return To Flight (RTF), hardware issues, and contract limitations. The current unit assembly is 100% completed with calibration testing complete. No functional integration testing has occurred. The completion and certification of the DTO ISS UMS unit is required for integration with the ACY&K and WHC. It is critical that the unit be modified to integrated with the ACY&K and WHC, complete certification testing, verify its volume accuracy measurements, void-to-void cross contamination, and ability to obtain sample syringe samples.

**3.0 Prior Work**

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The ISS UMS is a successor design to the existing Shuttle UMS, which flew on seven Shuttle flights since its initial development in 1979. The Shuttle UMS experienced three primary operational anomalies during all seven Shuttle flights. Specifically, these anomalies were liquid carry-over, inaccurate void volume measurements, and cross-contamination in void samples.

The ISS UMS is a system designed to collect an individual crewmember's void, gently separate urine from air, accurately measure urine void volume, allow for urine void sample acquisition, and discharge the remaining urine into the Waste Collector Subsystem (WCS). The ISS UMS interfaces upstream of the WCS and uses the WCS' airflow to draw urine into its own urine/air separator. A detailed description of the ISS UMS physical characteristics, design, and operation is included in the reference material (Critical Design Review presentation) but an overview is provided below. The ISS UMS was designed to JSC 39326 Rev - 'ISS UMS End Item Specification'.

The ISS UMS is comprised of two physically separate modules, specifically the Avionics Module (AM) and Mechanical Module (MM). The AM contains the majority of the electronics and is the primary crew interface. The AM was developed on-site by a combination of civil servant and support contractor labor. The JSC AM team provides all the software and documentation for the AM and SAM.

The MM contains all fluid handling and measurement components, including: rotary separator bowl, motor, solenoid valves, plumbing, sample syringe acquisition port, and pressure sensors. The MM was developed by an outside off-site contractor. Portions of the MM rotary separator the motor are proprietary. Additionally, the MM contains a Signal and Power Module (SAM) that was provided by the JSC AM team. The SAM provides power conversion, signal processing, and communication with the AM. The Contractor is not responsible for the performance of the AM and SAM.

In addition to the AM and MM, the ISS UMS also consists of ancillary support hardware including external fluid hoses, electrical cables, urine diverter valve, sample syringe kit, and validation syringe kit. MM test stands were developed for simulating vehicle flush water connection, air flow, and crew member urination and are available.

There are two basic configurations of the ISS UMS. The Engineering Unit ISS UMS is a high fidelity functional unit consisting of the AM, MM, SAM, and the ancillary equipment. The Engineering Unit is class III hardware is assembled, calibrated, and available for evaluation and performing of the work.

**The ISS UMS completed a successful Critical Design Review (CDR) in 30 September 2003. Fabrication, procurement and assembly of the hardware is mostly complete. The Shuttle DTO Unit ISS UMS is partially assembled. The Shuttle DTO AM, SAM, and MM are class I hardware are available for performing the work.**

**Task Description:**

The Contractor shall build upon the previous ISS UMS Shuttle DTO work to perform all project management, modifications (mechanical, electrical, and software), calibration, functional test procedures, and flight certification processes. The effort shall follow NASA standard procedures for developing flight hardware, as described in NASA document EA-WI-023. The Contractor shall review the Government Furnished Equipment (GFE), drawings, and

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documentation to identify and define the remaining work. Any GFE hardware damaged by the Contractor during the performance of the work shall be replaced or repaired at the discretion of the Government. The Contractor shall provide all materials, documents, personnel, and facilities not explicitly listed as GFE to complete the work. The Contractor shall provide all coordination, transportation, and documentation required to move identified GFE to the Contractor's facilities to perform the work. At the completion of the work, the Contractor shall provide all coordination, transportation, and documentation required to move identified GFE to JSC. The Government reserves the right to exercise or terminate the **Extended Baseline** and any combination of DO options at any time during the performance period. The Government reserves the right to not exercise any work.

**1.0 DO Baseline - COMPLETED**

**1.0.A.) Provided Government Furnished Equipment, Materials, and Services**

The Government shall provide the items listed in GFE table with the following exceptions. The Government shall not provide any prior work that previous contractor or supplier has explicitly identified as proprietary. Process specifications or detail drawings not available shall be developed by the Contractor as necessary to perform the work. The Government does not anticipate that the proprietary motor or separator design information is required for this work. In addition to the identified GFE, the government shall provide the following: (1) Pseudo-urine test solutions not to exceed 40 liters, (2) Analysis of cross-contamination sample syringes, (3) AM, SAM, and any necessary software modifications, (4) On site support for coordination of JSC test activities, 0.5 people for 3 months, (5) All external MM labels, and (6) Tool calibration by the JSC calibration service. If the Government does not supply the GFE/GSE hardware within 30 days prior to the end of the period of performance, the Contractor is not responsible for the integration of those components, equivalently it is permissible for the Contractor to deliver any hardware with open documents.

**1.0.B.) Mechanical Module Assembly Completion**

The Contractor shall complete the partial assembly of the Shuttle DTO MM, quantity of one. The unit shall be completed and maintained as class I hardware. The Contractor shall be responsible for all hardware assembly, Task Performance Sheets (TPS), correcting hardware deficiencies, drawing updates, and report summaries. Drawings shall be in ProE format. Drawing changes shall be documented and released in the JSC Engineering Drawing Control Center (EDCC). The Contractor shall provide all tools necessary for assembly. The Contractor shall provide all mechanical and electrical components required to complete the assemblies that are not listed as GFE. The completed MM assembly shall be defined per drawing HSMS1700 configuration -01.

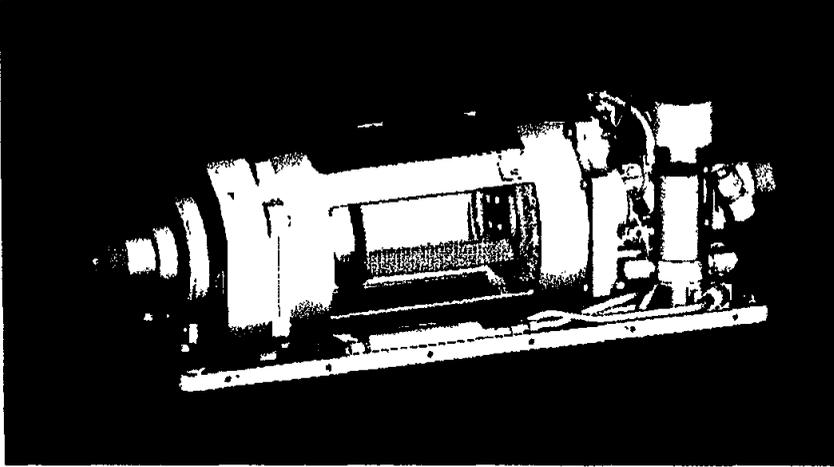
The Contractor shall complete the assembly of the (quantity one) spare Sample Port Assembly HSMS1740-01.

The following describes the major characteristics of MM assembly completeness (minor deviations from these descriptions may exist). Quantity Sample Port Assembly HSMS1740-01 is 98% complete (needs decals). One spare Sample Port Assembly is 0% complete. All major machined piece parts have been completed (may require receiving inspection of spares). All major procured piece parts are present. Bulk materials (i.e., solder, epoxy, bonding agents, alodine, locking compounds, etc.) may not be present or may be out of shelf life. The SAM is

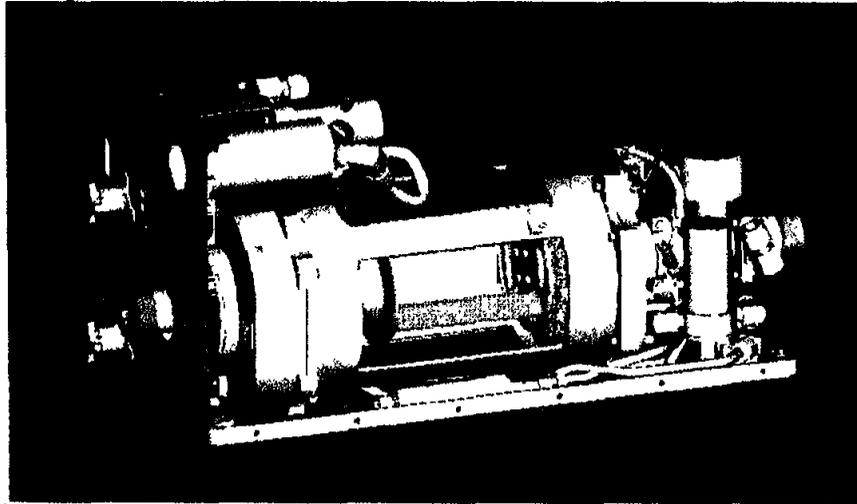
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not mounted or integrated. The electrical cabling is ~50% complete. The plumbing is ~60% complete. The external labeling and Velcro has not been performed. The Lower Plate Assembly (HSMS1737-01) is 80% complete. The MM Front Plate Assembly (HSMS1739-01) is 90% complete. The Right Side Assembly (HSMS1738-01) is ~100% complete. The remainder of subassemblies are ~90% complete.

**ISS UMS Shuttle DTO Unit Baseplate Assembly. Approximate level of assembly completeness.**



**ISS UMS Shuttle DTO Unit Baseplate and Front Panel Assemblies. Both assemblies mostly completed but not assembled to each other.**



ISS UMS Sample Port Assembly. Approximate level of assembly completeness.



**1.0.C.) ISS UMS Accessory Assembly Completion**

The Contractor shall assemble quantity two each of the following hose configurations. The units shall be completed and maintained as class I hardware. The Contractor shall be responsible for all hardware assembly, Task Performance Sheets (TPS), correcting hardware deficiencies, drawing updates, and report summaries. Drawings shall be in ProE format. Drawing changes shall be documented and released in the JSC Engineering Drawing Control Center (EDCC). The Contractor shall provide all tools necessary for assembly. The completed hose assemblies shall be defined per drawing and configuration number:

ISS UMS Flush Water Hose Assembly: SEG33114396-601

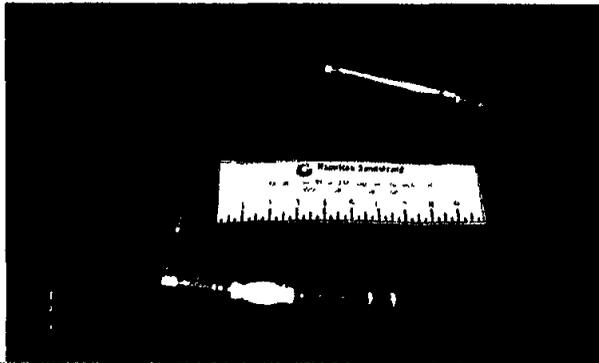
ISS UMS Primary Urinal Hose SEG33113461-301

ISS UMS Effluent Urinal Hose SEG33113461-302

ISS UMS Bypass Urinal Hose SEG33113461-303

The following describes the major characteristics of hose assembly completeness (minor deviations from these descriptions may exist). All drawings are unreleased by ~90% completed. All major machined piece parts have been completed. All major procured piece parts are present. Bulk materials (i.e., solder, epoxy, bonding agents, alodine, locking compounds, etc...) may not be present or may be out of shelf life. The hose assemblies are 0% complete.

ISS UMS Flush Water Hose Assembly is similar complexity (to Shuttle UMS version), except influent fluid connection, hose length, and labeling are different.




  
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ISS UMS Primary Urinal Hose (top white hose) and ISS UMS Effluent Urinal Hose (bottom white hose) are similar in complexity (to Shuttle UMS versions), , except influent fluid connection, hose length, and labeling are different. The By-pass hose is similar but only ~6-in long.



**1.0.D.) ISS UMS Integration Drawings/Documents**

The Contractor shall update the following integration drawings. Drawings shall be in ProE format. Drawing changes shall be documented and released in the JSC Engineering Drawing Control Center (EDCC).

SJC33113507	ISS UMS (Top AM+MM+ hoses and electrical cables)	0%
SDG33113466	ISS UMS Decals	95%
SLG33113459	ISS UMS AM-MM Interface Control Drawing	90%
SLD33113460	ISS UMS to Shuttle Interface Control Drawing	90%
SEG33113461	ISS UMS Urinal Hose	
SEG33114396	ISS UMS Flush Water Hose Assembly	
Updated Drawing list		95%
SJD33113508	*ISS UMS Shuttle Mission Kit	0%

\*Deliver an unreleased draft on CD

**1.0.E.) ISS UMS MM Calibration Tests**

The Contractor shall perform calibration tests on the ISS UMS MM (from Task 1.B) while maintaining the units' class I status. The Contractor shall perform calibration tests to enable the

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ISS UMS Shuttle DTO unit to meet the performance requirements of JSC 39326 sections 3.2.1.1 and subsections and sections 3.2.1.2.1 through 3.2.1.2.3. Calibration tests include but are not limited to the following parameters: Calibration of pressure vs separator liquid volume, evaporation corrections, pressure hysteresis correction constants, urine specific gravity/viscosity correction constants, and urine temperature constants, and fluid line charging constants. The constant parameters that the Contractor shall develop for the software constants file 'AM Constants.xls' are defined in JSC 39875 appendixes A and B. The UMS Tester Software (JSC 62330) is available as a tool in the generation of some constants. The UMS Tester Software is compatible with the Microsoft operating system. Some constants are generated with manually collected data or with streaming data capture from commercial Microsoft products (i.e., HyperTerminal). The operational steps of the ISS UMS during normal operations are defined in the following documents:

JSC 39875 Rev -, Software Requirements Specification for the ISS UMS

JSC 39876 Rev -, Software Design Document for ISS UMS.

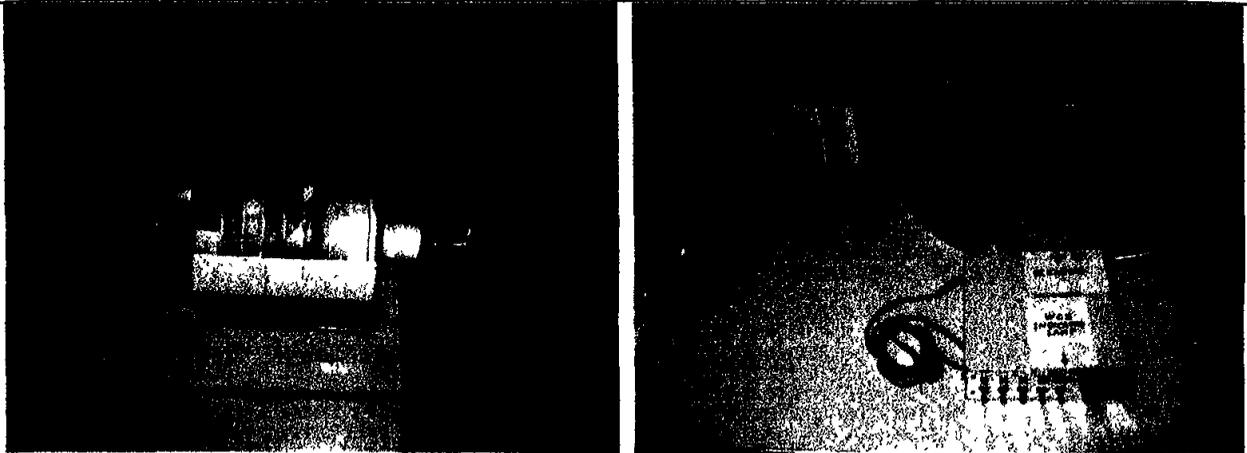
JSC 62330 Rev -, Software Version Description Document for ISS UMS Ground Support Equipment Test Set SW, UMS Tester Certification Release 1.0b12.

JSC 62603 Rev A, Software Requirements Specification of ISS UMS GSE Test Set Software (Tester, MM Simulator, AM Simulator).

The list of GFE includes test hard that is available for Contractor use in performing of the tests. The following photos show the Engineering Unit of the ISS UMS with the available test equipment defined in attachment EC3-010-C (flush water test stand not shown and still in original shipping packaging).



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The Contractor shall provide a report summarizing the methods, test setups, and results used in developing the constants. The detailed TPS sheets shall be included as attachments to the report. The Contractor shall deliver all test data and test files electronically.

**1.0.F.) ISS UMS Functional Tests**

The Contractor shall perform functional tests on the ISS UMS (combined MM, AM, and accessories as defined in SLG33113459 and SJC33113507) to demonstrate that that hardware modules work together as a system to meet the requirements outlined in Task 1.E of this document. The functional tests are not certification tests. The functional tests are classified as 'engineering evaluation'. Except as noted subsequently, all functional tests shall be performed with GFE provided pseudo-urine or a Contractor provided fluid approved by the Government.

A minimum of 50 challenge void volumes shall be used representing a Gaussian-like distribution of void volumes centered around 350-ml. The final challenge void volumes and sampling method used shall be determined by the Contractor and agreed to by NASA. The Contractor shall use the sampling port to draw a minimum of one sample syringe per challenge void volume. The sample syringes shall be preserved and provided to the Government for analysis of cross contamination.

Additionally, a minimum of 5 challenge voids will be performed at each of the following volumes ~35 ml, ~90 ml, ~105 ml, 600 ml, and 900 ml. The final challenge void volumes used shall be determined by the Contractor and agreed to by NASA. No sampling is required.

Additionally, the Contractor shall conduct a minimum of 20 void challenges with body temperature human urine across the ISS UMS volume range of 25-900 ml. The Contractor shall use the ISS UMS sampling port to draw sample syringe samples per ISS UMS EIS JSC 39326 section 3.2.1.1.3.3 (and subsections). The sample syringes and samples of influent urine shall be preserved and provided to the Government for analysis of urine constituents.

The Contractor shall verify that the MM, AM, and accessories are physically compatible at the interfaces defined in the ICD.

The Contractor shall perform function tests JSC 39326 sections 3.1.2.2.1.5.1 through 3.1.2.2.1.6, 3.1.2.3 (and subsections),

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The Contractor shall provide a report summarizing the methods, test setups, and results used in developing the constants. The detailed TPS sheets shall be included as attachments to the report. The Contractor shall deliver all test data and test files electronically.

**1.0.G.) ISS UMS Demonstration Tests**

The Contractor shall perform demonstration tests on the ISS UMS for the Government for the purpose of promoting the ISS UMS program and facilitating integration with ISS. The Contractor shall support up to five separate operational demonstrations. Demonstrations shall not last more than three hours. The Government will provide a minimum of five working days notice. The final scheduling shall be determined by the Contractor to minimize impacts to the Contractor's work. The Government may bring unknown specific gravity and volume samples of pseudo-urine or human urine as challenges during the demonstrations. The demonstration tests are classified as 'engineering evaluation' and formal test reports are not required.

**1.0.H.) ISS UMS Hardware Assessment**

The Contractor shall review the GFE hardware inventory after completion of the assembly and test phase and provide a report indicating the applicability of each line item for future ISS UMS work. The Contractor shall consider each line item and recommend to the Government to maintain inventory as is, downgrade, or disposal.

**1.1 DO Option 1 – Reduced Gravity Aircraft Tests**

The Contractor shall perform functional tests on the ISS UMS to demonstrate that that hardware modules work together as a system to meet the requirements outlined in Task 1.0.F of this document. The tests are not certification tests. The functional tests are classified as 'engineering evaluation'. Except as noted subsequently, all functional tests shall be performed with GFE provided pseudo-urine or a Contractor provided fluid approved by the Government.

**1.1.A) Provided Government Furnished Equipment, Materials, and Services**

The Government shall provide the items listed in GFE table with the following exceptions. The Government shall not provide any prior work that previous contractor or supplier has explicitly identified as proprietary. Process specifications or detail drawings not available shall be developed by the Contractor as necessary to perform the work. The Government does not anticipate that the proprietary motor or separator design information is required for this work. In addition to the identified GFE the government shall provide the following.

Pseudo-urine test solutions not to exceed 20 liters.

Analysis of cross-contamination sample syringes.

Cost of the DC9 reduced gravity flight for three days for five participants (two civil servants and three Contractors)

**1.1.B) Flight Preparation and Documentation**

The Contractor shall prepare all test, hazard analysis, and safety documentation for the JSC Reduced Gravity Aircraft Program period 33809. The ISS UMS shall be maintained as class I hardware. The Contractor shall be responsible for all hardware assembly, TPS, correcting hardware deficiencies, drawing updates, and report summaries. Drawing shall be in ProE format. Drawing changes shall be documented and released in the JSC EDCC. The Contractor shall provide all tools necessary for assembly.

**1.1.C) Flight Demonstration Tests**

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The Contractor shall repeat the 20-void sample test performed in Task 1.0.F

The Contractor shall perform function tests JSC 39326 sections 3.2.1.2.8 through 3.2.1.2.9.3.

The Government reserves the right to identify additional tests based on the results of the Extended Baseline Task test results.

The Contractor shall clean and return the ISS UMS to its original condition after the flight.

The Contractor shall provide a report summarizing the methods, test setups, and results used in developing the constants. The detailed TPS sheets shall be included as attachments to the report. The Contractor shall deliver all test data and test files electronically.

**1.2 DO Option 2 – Modifications Required for ISS Use - COMPLETED**

The Shuttle DTO unit will need to be modified to accommodate the Russian Waste Collector System (ACY&K) and the ISS Waste & Hygiene Compartment (WHC). The ISS Program Office (ISSPO) is currently negotiating the ACY&K contract with the Russians. The goal is to minimize UMS operating time to less than 4 minutes, while maintaining science requirements. If the science requirements need to be reduced to meet this goal, the Contractor shall provide a rational and an estimated reduced requirement.

**1.2.A) Provided Government Furnished Equipment, Materials, and Services**

The Government shall provide the items listed in GFE table with the following exceptions. The Government shall not provide any prior work that previous contractor or supplier has explicitly identified as proprietary. Process specifications or detail drawings not available shall be developed by the Contractor as necessary to perform the work. The Government does not anticipate that the proprietary motor or separator design information is required for this work. For purpose of Contractor estimating, the government would provide the following.

Pseudo-urine test solutions not to exceed 40 liters.

Analysis of cross-contamination sample syringes.

Software modifications to the SAM and AM.

Limited ACY&K interface and performance documentation defining the interfaces of the WHC and Russian ACY&K is available. An informational overview will be provided by NASA within one week of exercise of this option. The following general impacts to the ISS UMS Shuttle DTO design are known and shall be used by the Contractor for responding to the DO

**1.2.B) General ISS UMS Design Modification Requirements**

**1.2.B.i)** The nominal operating time of the ISS UMS will need to be minimized. The Contractor shall estimate the impact of conducting additional testing or hardware modifications to reduce the time required to sample pressures, reduce the time to drain and vacuum the separator bowl and plumbing, and the time to flush the bowl

**1.2.B.ii)** The use of periodic upstream urine pretreatment chemicals per EIS (JSC39326 section 3.3.1.2) will need to be modified. The Contractor shall estimate the impact of conducting additional testing or hardware modifications to either make the ISS UMS compatible with Russian ACY&K pretreatment chemicals or verify that flush water alone is sufficient for maintaining sustained ISS UMS on-orbit operations. The Russian ACY&K pretreatment chemical solution is comprised of: 36.5% H<sub>2</sub>SO<sub>4</sub>, 54.5% H<sub>2</sub>O, and 9% CrO<sub>3</sub>. The pretreated urine

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pH is between 1.3 and 2.0. If Russian pre-treat is used, double containment must be implemented in the ISS UMS hardware

**1.2.B.iii)**The Contractor shall estimate the impact of conducting additional testing or hardware modifications to reduce the air pressure drop through the ISS UMS.

**1.2.B.iv)**The Contractor shall estimate the impact of hardware modifications to allow for: (1) direct connection to the Russian ACY&K urinal funnel via an adapter; (2) direct connection to the WHC electrical and flush water connectors, and (3) replacement of fixed handles with standard ISS detachable handles.

**1.2.B.v)**The Contractor shall estimate the impact of conducting additional testing to determine the cycle life of the sample port assembly for sustained ISS UMS on-orbit operations.

**1.2.B.vi)**The Contractor shall estimate and indicate which software functions would require modification by indicating modifications to JSC 39875 appendixes A and B.

**1.2.B.vii)**The Contractor shall provide a report summarizing the cost/duration/assumptions of impacts of each modification, any additional unidentified modifications, Contractor resources available/suitable for work, and a work plan with a preliminary schedule. The Contractor shall provide a cost break out of the additional cost required to implement any AM and SAM software-electrical changes (rather than them being supplied as GFE).

**1.3 DO Extended Baseline – Modifications Required for ACY&K/WHC Integration & Flight Certification**

The Shuttle DTO unit will need to be modified and certified to accommodate the Russian Waste Collector System (ACY&K) and the ISS Waste & Hygiene Compartment (WHC). The Critical Item Development Specification for the International Space Station (ISS) Waste and Hygiene Compartment (WHC) calls out ISS UMS interfaces. An Interface Control Document (ICD) or equivalent shall be developed for interfacing with the WHC. An ICD or equivalent shall be developed for interfacing with the ACY&K. Consider the following modifications for both the flight ISS UMS and the engineering ISS UMS: ISS UMS plumbing replacement, software modifications, vacuum drain time, required flush water, separator bowl upgrades, laptop to hardware cabling. The operating time of UMS shall be reduced to less than 4 minutes, while maintaining science requirements. If the science requirements need to be reduced to meet this goal, the Contractor shall provide a rational and an estimated reduced requirement.

The Contractor will be required to perform a delta System Requirements Review (SRR), Systems Design Review (SDR), and a Systems Acceptance Review (SAR) on the ISS UMS with modifications for ACY&K and WHC.

**1.3.A) Provided Government Furnished Equipment, Materials, and Services**

The Government shall provide the items listed in GFE table with the following exceptions. The Government shall not provide any prior work that previous contractor or supplier has explicitly identified as proprietary. Process specifications or detail drawings not available shall be developed by the Contractor as necessary to perform the work. The Government does not anticipate that the proprietary motor or separator design information is required for this work. In addition to the identified GFE, the government shall provide the following: (1) Pseudo-urine test solutions not to exceed 100 liters, (2) Analysis of cross-contamination sample syringes, (3) GFE certified laptop, (4) All external MM labels, (5) Tool calibration by the JSC calibration service,

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**(6) WHC interface drawings, (7) ACY performance characteristics, and (8) Baseline software code.**

**If the Government does not supply the GFE/GSE hardware within ATP plus 3 months the Contractor is not responsible for the integration of those components.**

**1.3.C) Specific ISS UMS Design Modification Requirements**

**1.3.C.i) The nominal operating time of the ISS UMS will need to be minimized. The Contractor shall conduct hardware modifications and additional testing to reduce the time required to sample pressures, reduce the time to drain and vacuum the separator bowl and plumbing, and the time to flush the bowl.**

**1.3.C.ii) The use of periodic upstream urine pretreatment chemicals per EIS (JSC39326 section 3.3.1.2) will need to be modified. The Contractor shall conduct additional testing or hardware modifications to either make the ISS UMS compatible with Russian ACY&K pretreatment chemicals or verify that flush water alone is sufficient for maintaining sustained ISS UMS on-orbit operations. The Russian ACY&K pretreatment chemical solution is comprised of: 36.5% H<sub>2</sub>SO<sub>4</sub>, 54.5% H<sub>2</sub>O, and 9% CrO<sub>3</sub>. The pretreated urine pH is between 1.3 and 2.0. If Russian pre-treat is used, double containment must be implemented in the ISS UMS hardware**

**1.3.C.iii) The Contractor shall provide software modifications as summarized in the Option 2 deliverable summary report, as well as any additional software modifications required for the functional performance of ISS UMS.**

**1.3.C.iv) The Contractor shall provide hardware modifications to allow for: (1) direct connection to the WHC electrical, flush water, and urine connections, (2) replacement of fixed handles with standard ISS detachable handles,**

**1.3.C.v) The Contractor shall provide software compatible with a GFE provided laptop.**

**1.3.C.vi) The Contractor shall provide a means of soft attachment for the ISS UMS to attach to the WHC.**

**1.3.C.vii) The Contractor shall conduct additional testing to determine the cycle life of the sample port assembly for sustained ISS UMS on-orbit operations.**

**1.3.C.viii) The Contractor shall conduct additional testing to determine the life time of the ISS UMS.**

**1.3.D.) ISS UMS Integration Drawings/Documents**

**The Contractor shall update the following integration drawings. Drawings shall be in ProE format. Drawing changes shall be documented and release in the JSC Engineering Drawing Control Center (EDCC). Drawings will be updated or developed to reflect new ISS UMS configuration, including GFE laptop and integration to WHC and ACY&K.**

<b>SJC33113507</b>	<b>ISS UMS (Top AM+MM+hoses and electrical cables)</b>
<b>SDG33113466</b>	<b>ISS UMS Decals</b>
<b>SLG33113459</b>	<b>ISS UMS AM-MM Interface Control Drawing</b>

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<b>SLD33113460</b>	<b>ISS UMS to Shuttle Interface Control Drawing</b>
<b>SEG33113461</b>	<b>ISS UMS Urinal Hose</b>
<b>SEG33114396</b>	<b>ISS UMS Flush Water Hose Assembly</b>
<b>SJD33113508</b>	<b>ISS UMS Shuttle Mission Kit</b>
<b>Updated Drawing List</b>	

**TO BE REMOVED FROM DO & INCLUDED IN RFO LETTER:**

**UNIQUE CHARACTERISTICS: N/A**

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DELIVERY ORDER #: CRAVE-EC3-010 Rev. 6**

**Deliverables/Products:**

<b>Product</b>	<b>Description</b>	<b>Qty</b>	<b>Due</b>	<b>Class</b>
<b>Hardware</b>				
<b>Mock Up</b>	None	-N/A-	-N/A-	-N/A-
<b>Prototype</b>	None	-N/A-	-N/A-	-N/A-
<b>Flight</b>	<b>Baseline: ISS UMS Top Assembly (P/N SJC33113507) tested as specified in "task description" section. (includes one of each of the following spares)</b>	1	9 Feb. 2007 (note 1)	I
	<b>Baseline: Spare Sample Port Assembly HSMS1740-01</b>	1	9 Feb. 2007	
	<b>Baseline: Spare ISS UMS Primary Urinal Hose SEG33113461-301</b>	1	9 Feb. 2007	I
	<b>Baseline: Spare ISS UMS Effluent Urinal Hose SEG33113461-302</b>	1	9 Feb. 2007	I
	<b>Baseline: Spare ISS UMS Bypass Urinal Hose SEG33113461-303</b>	1	9 Feb. 2007	I
	<b>Baseline: Spare ISS UMS Flush Water Hose Assembly: SEG33114396-601</b>	1	9 Feb. 2007	I
	<b>Option 1: ISS UMS Top Assembly (P/N SJC33113507) refurbished after DC9 flight.</b>	1	22 Sept 2006 (note 1)	I
	<b>Option 2: None</b>	-N/A-	-N/A-	-N/A-
	<b>Extended Baseline: ISS UMS Top Assembly (P/N SJC33113507) flight certified</b>	1	15 June 2009	I
	<b>Extended Baseline: Spare Sample Port Assembly HSMS 1740-01</b>	1	15 June 2009	I
	<b>Extended Baseline: Spare ISS UMS Primary Urinal Hose SEG33113461-301</b>	1	15 June 2009	I
	<b>Extended Baseline: Spare ISS UMS Effluent Urinal Hose SEG33113461-302</b>	1	15 June 2009	I

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
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	<b>Extended Baseline: Spare ISS UMS Bypass Urinal Hose SEG3113461- 303</b>	<b>1</b>	<b>15 June 2009</b>	<b>I</b>
	<b>Extended Baseline: Spare ISS UMS Flush Water Hose Assembly SEG33114396-601</b>	<b>1</b>	<b>15 June 2009</b>	<b>I</b>
<b>Training</b>	None	-N/A-	-N/A-	-N/A-
<b>Other</b>	None	-N/A-	-N/A-	-N/A-

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
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<b>Test</b>	Baseline: Report of all pressure, electrical, and functional tests performed during assembly of MM, Sample Port Assembly, and Accessories (1.0.B and 1.0.C).	1	9 Feb. 2007	-N/A-
	Baseline: Detailed report of all calibration methods, test setups, and results in development of constants to achieve system performance requirements. (1.0.E and 1.0.F)	1	9 Feb. 2007	-N/A-
	Option 1: Detailed report of all assembly modifications, calibration methods, test setups, and results in development of constants to achieve system performance requirements. (1.1.B and 1.1.C)	1	22 Sept 2006	-N/A-
<b>Data Pack</b>	Extended Baseline: Revision to ISS UMS End Item Specification (JSC 39326)	1	15 June 2009	
	Extended Baseline: Interface Control Document or equivalent. ISSUMS to WHC and ISSUMS to ACY&K	2	15 June 2009	
	Extended Baseline: Signed Government Certification Acceptance Request (GCAR)	1	15 June 2009	
	Extended Baseline: SRR data package per EA-WI-023	1	15 June 2009	
	Extended Baseline: SDR data package per EA-WI-023	1	15 June 2009	
	Extended Baseline: SAR data package per EA-WI-023	1	15 June 2009	
	Extended Baseline: Acceptance Data Package (ADP) per EA-WI-023	1	15 June 2009	
	Extended Baseline: Certification Data Package (CDP) per EA-WI-023	1	15 June 2009	
<b>Software</b>	Extended Baseline: Modified ISS UMS software compatible with a GFE laptop.	1	15 June 2009	I

  
**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
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<b>Other Products</b>	<b>Baseline:</b> All drawings requiring modification or completion as outlined in 1.0.A through 1.0.G). Drawings in Pro-E electronic format ready for uploading into EDCC and in Adobe pdf format. Updated electronic drawing list in Microsoft Excel format. Residual hardware recommendation report.	1	9 Feb 2007	-N/A-
	<b>Option 1:</b> All drawings requiring modification or completion as outlined in 1.1 A through 1.1.C) Drawings in Pro-E electronic format ready for uploading into EDCC and in Adobe pdf format. Updated electronic drawing list in Microsoft Excel format.	1	22 Sept 2006	-N/A-
	<b>Option 2:</b> Cost and schedule ROM report broken out by drawing, assembly, calibration, life testing, and materials procurement to enable the ISS to be compatible with the Russian ACY&K (1.2.A through 1.2.B.vii).	1	16 Mar. 2007	-N/A-
	<b>Option 2:</b> Initial draft of technical impacts	1	16 Feb. 2007	N/A
	<b>Extended Baseline:</b> All drawings released into EDCC. Drawings in Pro-E electronic format and in Adobe pdf format. Updated electronic drawing list in Microsoft Excel format. Residual hardware recommendation report.	1	15 June 2009	N/A

**Note 1: If option 1 executed, then delivery milestone is replaced with option 1 flight hardware delivery milestone.**


**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
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<b><u>SCHEDULE</u></b>	
<b>Start Date: 28 February 2008</b>	<b>Finish Date: 15 June 2009</b>

<b>INTERIM MILESTONES</b>	<b>DUE DATES</b>
See attached schedule (Attachment EC3-010-D)	See attached schedule (Attachment EC3-010-D)
Delivery of all remaining ISS UMS flight and non-flight GFE	

Milestones, along with subjective measurements, are to be used for measuring performance. For schedule detail see Microsoft Project file located on the CRAVE web site for this DO listed under the Government Cost Estimate below.

**Government Estimate Located in RFO File in Microsoft Project File On CRAVE Web Site**  
**The file is titled: xxxxxx.mpp**

**Total Government Estimate for this DO Baseline: \$163,000**  
**Option 1: \$ 111,000 (See Task Description for Option 1)**  
**Option 2: \$ 26,000 (See Task Description for Option 2)**  
**DO Extended Baseline: 1,167,000**

**TOTAL COST ESTIMATE FOR THIS DO: \$**

**FEE: \$ (If Applicable)**

**OPTION 1: \$ N/A (See Attachment 1)**

**OPTION 2: \$ N/A (See Attachment 2)**

**TO BE REMOVED FROM DO & INCLUDED IN RFO LETTER:**

Proposal Evaluation Criteria:

1. Proposed Technical Concept, including design, understanding, development/ hardware production capability and schedules;
2. Cost/Price: Except when it is determined not to be in the Government's best interests, the Government will evaluate price of proposals, by adding the total price, including options. Evaluation of options will not obligate the Government to exercise the options;
3. Proposed Achievement of Small Business Goals;
4. Past Performance; and
5. Other: \_\_\_\_\_

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC3-010 Rev. 6**

**DATA REQUIREMENTS**

All DRDs contained in the contract are applicable and required unless marked N/A below.

**NOTES: 1. GREY SCALED ROWS NEED NO ADDITIONAL/REQUIRED FILL-INS.**

**A. ON ALL OTHER ROWS, IF NECESSARY, FILL IN ADDITIONAL**

**RQMTS/DELIVERIES IN LAST COLUMN.**

<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>ADDITIONAL REQUIREMENTS</b>
1	Written Approval	FlightGFE Configuration Management Plan	With Proposal	Once	Attachment J-8	
2	Mandatory Submittal	Regular Status Report/ Summary Review	Thirty (30) days following contract start	Monthly	Y	
3	Written Approval	Project Technical Requirements Specification	Per DO schedule	Once with Revisions	Y	<b>Extended Baseline: Revisions to JSC-39326</b>
4	Mandatory Submittal	GFE Systems Requirements Data Package	Specified in DO	Once with Revisions	Y	-N/A-
5	Written Approval	Flight GFE Projects Requirements & Verification Document	Specified in DO	Once with Revisions	Y	-N/A-
6	Mandatory Submittal	Preliminary Design Review Data Package	Specified in DO	Once with Revisions	N	-N/A-

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
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DRD #	DATA TYPE	DRD TITLE	DUE	FREQUENCY	REQUIRED FOR DO? Y/N	ADDITIONAL REQUIREMENTS
7	Written Approval	Flight GFE Workmanship Specifications List	Specified in DO	Once with Revisions	Y	<b>Baseline:</b> List of Contractor specifications used (following govt approval) as alternatives to those listed on GFE provided drawings. <b>Option 1:</b> List of Contractor specifications used (following govt approval) as alternatives to those listed on GFE provided drawings. <b>Option 2:</b> none. <b>Extended Baseline:</b> List of Contractor specifications used (following govt approval) as alternatives to those listed on GFE provided drawings.
8	Written Approval	Project Schedule	Specified in DO	Once w/Revisions (due w/DO proposal, updates & details provided as DO progresses)	Y	<b>Baseline:</b> Detailed schedule shall include required dates for GFE test solutions and any NASA facilities. <b>Option 1:</b> Detailed schedule shall include required dates for GFE test solutions and any NASA facilities. <b>Option 2:</b> none <b>Extended Baseline:</b> Detailed schedule shall include required dates for GFE test solutions and any NASA facilities.

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC3-010 Rev. 6**

<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>ADDITIONAL REQUIREMENTS</b>
9	Written Approval	Flight GFE Interface Control Document	Specified in DO	Once with Revisions	Y	<b>Baseline:</b> Updated drawings as specified in DO. <b>Option 1:</b> None <b>Option 2:</b> None <b>Extended Baseline:</b> Updated drawings as specified in DO.
10	Written Approval	GFE End Item Specification	Specified in DO	Once with Revisions	Y	-N/A-
11	Mandatory Submittal	Flight GFE Failure Analysis Report	On demand	As Required	Y	-N/A-
12	Written Approval	Flight GFE Verification and Validation Plan	As Specified in EA-023	Once with Revisions	Y	-N/A-
13	Written Approval	GFE Software Requirements Specification	As specified in EA-023	Once with Revisions	Y	-N/A-
14	Written Approval	GFE Software Development Plan	Specified in DO	Once with Revisions	Y	-N/A-
15	Written Approval	GFE Software Design Document	Specified in DO	As Required	Y	-N/A-
16	Written Approval	Engineering Drawings	Specified in DO	Once with Revisions	Y	<b>Baseline:</b> Revisions to existing drawings as specified in task description section. <b>Option 1:</b> DC9 installation drawings and test modifications to Class I hardware only. <b>Option 2:</b> none. <b>Extended Baseline:</b> Revisions to existing drawings as specified in task description section.
17	Written Approval	EEE Parts Lists and Analysis Report	Specified in DO	As Required	Y	-N/A-
18	Mandatory Submittal	System Design Review Data Package	Specified in DO	Once with Revisions	Y	-N/A-

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
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<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>ADDITIONAL REQUIREMENTS</b>
19	Mandatory Submittal	Engineering Drawing Change Proposal	As needed	As Required	Y	Baseline: As needed. Option 1: As needed. Option 2: None Extended Baseline: As needed.
20	Written Approval	GFE Qualification Test Procedure	Specified in DO	Once with Revisions	Y	N/A but see DRD 26.
21	Written Approval	Flight Product User's Guide	Specified in DO	Once with Revisions	Y	-N/A-
22	Mandatory Submittal	Software Code	Specified in DO	As Required	Y	
23	Written Approval	Information Technology (IT) Security Program Plan and Reports	(30) days after DO award, and as specified in JPG 2810 1	JPG 2810.1	Attachment J-4 Due 30 days after DO award	
24	Written Approval	Certification Plan	Specified in DO	Once with Revisions	Y	-N/A-
25	Mandatory Submittal	Certification Report	Specified in DO	Once with Revisions	Y	-N/A-
26	Mandatory Submittal	Engineering Analysis	Specified in DO	As Required	Y	Baseline: Includes analysis and procedures required for constants Option 1: Includes analysis and procedures for DC9 preparations and flight. Option 2: Includes analysis basis for proposed changes.
27	Mandatory Submittal	Acceptance Data Package	Specified in DO	One Time	Y	-N/A-
28	Mandatory Submittal	Export Control Audit Results	After award of 1 <sup>st</sup> DO, yearly on Sept 30 thereafter	Yearly	Y	
29	Written Approval	Quality Plan	With Proposal	Once with Revisions	Attachment J-11	
30	Written Approval	Patent Rights-Retention	As Required	As Required	Y (If Applicable)	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
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<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>ADDITIONAL REQUIREMENTS</b>
31	Written Approval	Shuttle/Station Payload Safety Data Package	Specified in DO	As Required	N	-N/A-
32	Mandatory Submittal	Limited Life Systems List	Specified in DO	As Required	Y	<b>Baseline:</b> Updates to existing LLSL only. <b>Option 1:</b> None <b>Option 2:</b> None
33	Written Approval	Space Station GFE Failure Modes and Effects Analysis and Critical Items List	As Early in process as possible.	As Required	Y	-N/A-
34	Written Approval	Space Shuttle GFE Safety and Analysis Report & Hazard Report	Specified in DO	As Required	N	-N/A-
35	Written Approval	Software Quality Assurance Plan Report	90 Days Prior to Software Development	Once with Revisions	Y (If Applicable)	
36	Written Approval	ISS Hazard Report	Specified in DO	As Required	y	-N/A-
37	Upon Request	Reliability and Maintainability Plan	With Proposal	One Time	Attachment J-9	
38	Written Approval	Government Certification Approval Request (GCAR)	Specified in DO	As Required	Y	-N/A-
39	Written Approval	Risk Assessment Executive Summary Report (RAESR)	Specified in DO	As Required	Y	-N/A-
40	Written Approval	Problem Reporting and Corrective Action (PRACA)	2 business days of problem isolation but no later than 10 days after detection	As Required	Y	NASA to spearhead PRACA investigations. Failure investigations to be supported per DRD-11. Contractor must give written notice to NASA on any PRACA reportable items per JSC 28035. NASA will be responsible for entering and closing item within the PRACA system.
41	Upon Request	Nonconformance Record	Specified in DO	As Required	Y	<b>Baseline:</b> Y <b>Option 1:</b> Y <b>Option 2:</b> None

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
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DRD #	DATA TYPE	DRD TITLE	DUE	FREQUENCY	REQUIRED FOR DO? Y/N	ADDITIONAL REQUIREMENTS
42	Mandatory Submittal	Government Industry Data Exchange Program and NASA Advisory Problem Data	Reported one time when discrepancy occurs	Once with Revisions	Y	Baseline: Y Option 1: Y Option 2: Y Extended Baseline: Y. NASA DO Technical Manager to be point of contact for review and assessment of NASA Advisory/GIDEP documents. This includes all parts, materials, specifications, processes, test equipment or safety.
43	Written Approval	Electrical, Electronic, and Electromechanical (EEE) Parts Control Plan	Specified in DO	Once with Revisions	Y	-N/A-
44	Mandatory Submittal	Certification Data Package	Specified in DO	Once with Revisions	Y	-N/A-
45	Written Approval	Certification and Acceptance Requirements Document	At CDR	Once with Revisions	Y	-N/A-
46	Upon Request	Wage/Salary and Fringe Benefit Data	Thirty (30) days after issuance of each DO	Once	N	-N/A-
47	Written Approval	GFE Acceptance Test Procedure	Specified in DO	One Time	N	-N/A-
48	Mandatory Submittal	Flight GFE Verification & Validation Report	Specified in DO	Once with Revisions	Y	-N/A-
49	Mandatory Submittal	Space Shuttle GFE Failure Modes and Effects Analysis (FMEA) and Critical Items List	Specified in DO	As Required	N	-N/A-
50		Reserved	---	---	---	---
51	Mandatory Submittal	NASA Contractor Financial Management Reporting	After Issuance of 1 <sup>st</sup> DO	Monthly	Y	
52	Written Approval	Government Property Management Plan	With Proposal	Once with Revisions	Attachment J-7	
53	Mandatory Submittal	System Safety Plan	With Proposal	One Time	Attachment J-10	
54	Written Approval	R-Quality Plan Template	With Proposal/Revisions as Required	Only applicable to B-CRAVE contracts in accordance with the SOW and the DRD	Y	

**Type 1 = Written Approval      Type 2 = Mandatory Submittal      Type 3 = Submittal Upon Request**

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC3-010 Rev. 6**

**GOVERNMENT FURNISHED PROPERTY**

**The CRAVE contracts do not anticipate the Government providing any property or test facilities unless requested by the contractor in their response to a request for bid.**

**In some rare cases (such as sustaining engineering task) it is know ahead of time that government property will be provided to the contractor. In those cases the following list filled out to allow the proper control of government property:**

**B. List of Property the Contractor Shall Replace with modified or upgraded versions:**

<b>Item</b>	<b>Quantity</b>	<b>Acquisition Cost</b>	<b>Use of Property Location</b>	<b>Date to be Furnished to the Contractor</b>
<b>Class I, ISS UMS MM (P/N HSMS1700-01)</b>	<b>1</b>	<b>\$150,000</b>		<b>15-days after DO award</b>
<b>Class I, ISS UMS AM SEG33113462-301</b>	<b>1</b>	<b>\$30,000</b>	<b>Hamilton Sundstrand Management Services (HSMS), 2200 Space Park Drive, Suite 100, Houston, TX 77058</b>	<b>15-days after DO award</b>
<b>Class I, Interface Cable Assy., W Cable, SEG33114393-301</b>	<b>1</b>	<b>\$2,500</b>		<b>15-days after DO award</b>
<b>ISS UMS flight and non-flight components and supplies</b>	<b>See attachment EC3-010-A (344 line items)</b>	<b>\$1,500,000</b>		<b>15-days after DO award (Items to be incorporated in to higher level assemblies by Contractor)</b>
<b>Various ISS UMS flight and non-flight hardware</b>	<b>See attachment EC3-010-B (30 line items)</b>	<b>\$20,000</b>		<b>15-days after DO award (Items to be incorporated in to higher level assemblies by Contractor)</b>

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC3-010 Rev. 6**

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*[Insert a description of the item(s), quantity, acquisition cost, and date the property will be furnished to the Contractor] – List of Property will be added as requirements are further identified and the determination to provide property is determined to be in the best interest of the Government.*

**C. List of Property the Contractor will return in the same configuration:**

<b>Item</b>	<b>Quantity</b>	<b>Acquisition Cost</b>	<b>Use of Property Location</b>	<b>Date to be Furnished to the Contractor</b>
<b>Class III ISS UMS Engineering unit and test hardware (see attachment EC3-010-C)</b>	<b>See attachment EC3-010-C (11 line items)</b>	<b>\$166,679.</b>	<b>Hamilton Sundstrand Management Services (HSMS), 2200 Space Park Drive, Suite 100, Houston, TX 77058</b>	<b>15-days after DO award</b>
<b>ISS UMS MM Drawing E-Package Compact Disks (Pro-E format)</b>	<b>8 compact disks</b>	<b>\$800</b>	<b>Hamilton Sundstrand Management Services (HSMS), 2200 Space Park Drive, Suite 100, Houston, TX 77058</b>	<b>15-days after DO award</b>

*[Insert a description of the item(s), quantity, acquisition cost, and date the property will be furnished to the Contractor] - List of Property will be added as requirements are further identified and the determination to provide property is determined to be in the best interest of the Government.*

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC3-010 Rev. 6**

**GOVERNMENT FURNISHED PROPERTY  
(Continued)**

**C. List of Property the Contractor Shall Replace if Damaged or lost during the course of the effort:**

<b>Item</b>	<b>Quantity</b>	<b>Acquisition Cost</b>	<b>Use of Property Location</b>	<b>Date to be Furnished to the Contractor</b>
<b>None</b>	<b>None</b>	<b>None</b>	<b>None</b>	<b>None</b>

*[Insert a description of the item(s), quantity, acquisition cost, and date the property will be furnished to the Contractor] – List of Property will be added as requirements are further identified and the determination to provide property is determined to be in the best interest of the Government.*

**15- List of Property the Government Will Replace if Damaged or lost during the course of the effort:**

<b>Item</b>	<b>Quantity</b>	<b>Acquisition Cost</b>	<b>Use of Property Location</b>	<b>Date to be Furnished to the Contractor</b>
<b>Class I, Interface Cable Assy., W Cable, SEG33114393-301</b>	<b>1</b>	<b>\$2,500</b>	<b>JSC, Building 44 Bond Room, 2101 NASA Parkway Houston, TX 77058</b>	<b>15-days after DO award</b>
<b>Class I, ISS UMS SAM SEG33113467-301</b>	<b>1</b>	<b>\$20,000</b>		<b>15-days after DO award</b>
<b>Class I, Laptop SEG33115360-30X (or alternate)</b>	<b>1</b>	<b>\$10,000</b>	<b>Hamilton Sundstrand Management Services (HSMS), 2200 Space Park Drive, Suite</b>	<b>120 days after DO award</b>

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
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			<b>100, Houston, TX 77058</b>	
<b>Class III, Laptop SEG33115360- 30X (or alternate)</b>	<b>1</b>	<b>\$6,000</b>	<b>Hamilton Sundstrand Management Services (HSMS), 2200 Space Park Drive, Suite 100, Houston, TX 77058</b>	<b>45 days after DO award</b>

*[Insert a description of the item(s), quantity, acquisition cost, and date the property will be furnished to the Contractor] - List of Property will be added as requirements are further identified and the determination to provide property is determined to be in the best interest of the Government.*

# ORDER FOR SUPPLIES OR SERVICES

1. Order No. NNJ05HB39B, DO10R5      2. Date of Order \_\_\_\_\_

NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.  
Certified for National Defense under DPAS (15 CFR 700) DO C9

3. Issuing Office:  
NASA Johnson Space Center, 2101 NASA Parkway  
Houston, TX 77058-3696  
Org./Buyer: BH2/Mary Thomas

Tel. No.: 281-483-8828      Fax: 281-244-0995

E-mail: mary.f.thomas@nasa.gov

4. Ship To:      Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For: Accountable Property  
Order No.: NNJ05HB39B, DO10R5

5 Contractor:  
Hamilton Sundstrand Management Services  
Attn: Kenneth Ridley, Mail Stop 1A-2-W59  
1 Hamilton Road  
Windsor Locks, CT 06086

Phone: 860-654-4034      x      Fax: 860-654-3318

TIN: 06-1165866      Cage Code: 71120

6. Deliver On or Before.  
See Statement of Work

F.O.B. Point: Destination

Discount Terms: Net 30 days.

7. Billing Address:  
NASA Johnson Space Center  
Attn: LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No.: NNJ05HB39B, DO10R5

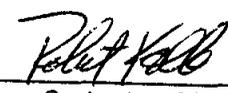
8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: CRAVE DO10R5

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number \_\_\_\_\_

9. Written acceptance of this order by contractor  
 is,  is not required.  
Sign below if required and return to contracting officer.  
Name: \_\_\_\_\_ (Person authorized to sign)  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_

10. Name: Robert Kolb

  
Contracting Officer      1-10-07  
Date

11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	<p>***THIS IS NOT AN OBLIGATING DOCUMENT***</p> <p>ISS URINE MONITORING SYSTEM SHUTTLE DTO UNIT ASSEMBLY COMPLETION</p> <p>Revision 5 to CRAVE DO 10 is issued to revise the SOW, revise the delivery dates, and increase the delivery order value.</p> <p>The baseline DO value is increased by <u>64</u> which no fee is given for the <u>64</u>. The baseline value is revised from <u>before</u> continued on page 2</p>					

12. For JSC Internal Use Only.  
Requisition No.: N/A       COMP     PART    PPC  
Reissue To: EC/Joe Gensler, x30025

13. Total  
**\$396,069**

14. Quantities in "Quantity Accepted" Column Have Been:  
 INSPECTED     ACCEPTED     RECEIVED

BY \_\_\_\_\_  
TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED

Authorized U.S. Government Representative      Date \_\_\_\_\_

Order No.  
NNJ05HB39B, DO10R5

**ORDER FOR SUPPLIES OR SERVICES**  
(Continuation Sheet)

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED															
	<p>Option 2 value is increased by \$357.00 from \$32,472 to \$32,829. The new cumulative delivery order value including Option 2 is \$396,069</p> <p>Changes to the SOW have been vertically bar-marked and underlined in the attached replacement SOW.</p>																				
	<p>RECAP OF BASE DO VALUE:</p> <table border="0"> <tr> <td></td> <td>PRIOR VALUE</td> <td>CURRENT VALUE</td> <td></td> </tr> <tr> <td>Cost</td> <td></td> <td><i>b4</i></td> <td></td> </tr> <tr> <td>Fee</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Total</td> <td>\$ 260,525 + 102,715</td> <td>= \$363,240</td> <td></td> </tr> </table>		PRIOR VALUE	CURRENT VALUE		Cost		<i>b4</i>		Fee				Total	\$ 260,525 + 102,715	= \$363,240					
	PRIOR VALUE	CURRENT VALUE																			
Cost		<i>b4</i>																			
Fee																					
Total	\$ 260,525 + 102,715	= \$363,240																			
	<p>RECAP OF OPTION 2 VALUE</p> <table border="0"> <tr> <td></td> <td>PRIOR VALUE</td> <td>CURRENT VALUE</td> <td></td> </tr> <tr> <td>Cost</td> <td></td> <td><i>b4</i></td> <td></td> </tr> <tr> <td>Fee</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Total</td> <td>\$32,472 + 357</td> <td>= \$32,829</td> <td></td> </tr> </table>		PRIOR VALUE	CURRENT VALUE		Cost		<i>b4</i>		Fee				Total	\$32,472 + 357	= \$32,829					
	PRIOR VALUE	CURRENT VALUE																			
Cost		<i>b4</i>																			
Fee																					
Total	\$32,472 + 357	= \$32,829																			

# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
NNJ05HB39B, DO10R4

2. Date of Order  
See Block 10 Below

**NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.**  
Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office:  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org./Buyer: BH2/Mary Thomas  
  
Tel No.: 281-483-8828 Fax: 281-244-0995  
E-mail: mary.f.thomas@nasa.gov

4. Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For: **Accountable Property**  
  
Order No.: NNJ05HB39B, DO10R4

5. Contractor:  
  
Hamilton Sundstrand Management Services  
2200 Space Park Drive, Suite 100  
Houston, TX 77058  
  
Phone: 281-336-6334 x      Fax  
  
TIN: 06-1165866      CAGE CODE: 71120

6. Deliver On or Before: October  
F.O.B. Point: Destination  
Discount Terms: Net 30 Days.

7. BILLING ADDRESS:  
NASA Johnson Space Center  
Attn: LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No.: NNJ05HB39B, DO10R4

8. Type of Order:  
 PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_  
 DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor [] is, [] is not required. Sign below if required and return to contracting officer.  
Name: \_\_\_\_\_ (Person authorized to sign)  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_

10. Name: Robert Kolb  
Signature:  Date: 9.30.06  
CONTRACTING OFFICER

11. Schedule

ITEM NO.	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	THIS IS NOT AN OBLIGATING DOCUMENT					
	Revision 4 to CRAVE DO10, ISS Urine Monitoring System Shuttle DTO Unit, is issued to extend the performance period for the baseline from 9/30/06 to 10/27/06 at no additional cost to the Government. The Delivery Order value remains unchanged.					64
	THIS IS A CPFF DELIVERY ORDER. FUNDING IS AT THE CONTRACT LEVEL.					

12. For JSC Internal Use Only:  
Requisition No.: N/A       COMP.     PART.    PPC: \_\_\_\_\_  
Rissue To: EC/Joe Gensler, x30025

13. Total  
\$ NTE \$1,909,928.55

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED     ACCEPTED     RECEIVED  
TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.      BY: \_\_\_\_\_

Authorized U.S. Government Representative      Date

# ORDER FOR SUPPLIES OR SERVICES

1. Order No. DO-CRAVE-EC3-010, Rev. 2	2. Date of Order See Block 10 Below	<b>NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.</b> Certified for National Defense under DPAS (15 CFR 700) DO-C9
--	--	--

3. Issuing Office: NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org./Buyer: <u>BH2/Mary Thomas</u>  Tel No.: <u>281-483-8828</u> Fax: <u>281-244-0995</u> E-mail: <u>mary.f.thomas@nasa.gov</u>	4. Ship To: Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b>  Order No.: <u>DO-CRAVE-EC3-010, Rev. 2</u>
--	---

5. Contractor:  Hamilton Sundstrand Management Services 2200 Space Park Drive, Suite 100 Houston, TX 77058  Phone: 281-336-8334 x      Fax:  TIN: 06-1165866      CAGE CODE: 71120	6. Deliver On or Before: <u>9/30/06</u>  F.O.B. Point: <u>Destination</u>  Discount Terms: Net 30 Days.	7. BILLING ADDRESS: NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No.: <u>DO-CRAVE-EC3-010, Rev. 2</u>
--	---	--

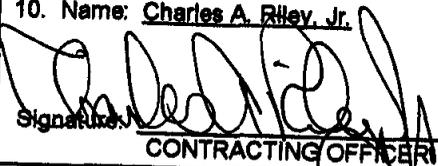
8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor  is,  is not required. Sign below if required and return to contracting officer.

Name: \_\_\_\_\_ (Person authorized to sign)  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_

10. Name: Charles A. Riley, Jr.  
Signature:  Date: 9/2/06  
CONTRACTING OFFICER

11. Schedule

ITEM NO.	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	ISS URINE MONITORING SYSTEM SHUTTLE DTO UNIT ASSEMBLY COMPLETION  Revision 2 to DO-CRAVE-EC3-010 is issued to correct an administrative error by deleting Revision 1 to DO-CRAVE-EC3-010 in its entirety. The \$100,000 funding applied on Revision 1 has been deobligated and reapplied to the contract through Modification 16.					

12. For JSC Internal Use Only:  
Requisition No.: N/A       COMP.     PART.    PPC: \_\_\_\_\_

Rissue To: EC/Joe Gensler, x30025

13. Total \$ \_\_\_\_\_

14. Quantities in "Quantity Accepted" Column Have Been

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.

BY: \_\_\_\_\_

Authorized U.S. Government Representative \_\_\_\_\_ Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
DO-CRAVE-EC3-010, Rev. 1

2. Date of Order  
See Block 10 Below

NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.

Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office:  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org./Buyer: BH2/Mary Thomas

Tel No.: 281-483-8928 Fax: 281-244-0995  
E-mail: mary.f.thomas@nasa.gov

4. Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For: Accountable Property  
Order No.: DO-CRAVE-EC3-010, Rev. 1

5. Contractor:  
  
Hamilton Sundstrand Management Services  
2200 Space Park Drive, Suite 100  
Houston, TX 77058

Phone: 281-336-6334 x      Fax:  
  
TIN: 06-1165666      CAGE CODE: 71120

6. Deliver On or Before: 9/30/06  
F.O.B. Point: Destination  
Discount Terms: Net 30 Days.

7. BILLING ADDRESS:  
NASA Johnson Space Center  
Attn: LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No.: DO-CRAVE-EC3-010, Rev. 1

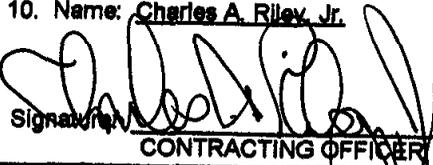
8. Type of Order:  
 PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor [] is, [] is not required. Sign below if required and return to contracting officer.

Name: \_\_\_\_\_ (Person authorized to sign)  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_

10. Name: Charles A. Riley, Jr.

Signature:  Date: 09/27/06  
CONTRACTING OFFICER

### 11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	ISS URINE MONITORING SYSTEM SHUTTLE DTO UNIT ASSEMBLY COMPLETION  The purpose of Revision 1 to DO-CRAVE-EC3-010 is to <sup>bf</sup> funding for Cost from <sup>bf</sup> and increase: <sup>bf</sup> an increase of: <sup>bf</sup> and an increase of <sup>bf</sup>					

12. For JSC Internal Use Only:

Requisition No.: 4200160731       COMP.     PART.    PPC: \_\_\_\_\_  
Issue To: EC/Joe Gensler, x30025

13. Total  
\$ NTE 360,525

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.      BY: \_\_\_\_\_

Authorized U.S. Government Representative      Date: \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

1 Order No.  
DO-CRAVE-EB2-007

2 Date of Order  
SEE BLOCK 10

NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.  
Certified for National Defense under DPAS (15 CFR 700) DO-C9

3 Issuing Office  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org /Buyer: BH2/Mike Ballard

Tel No 281-244-5350 Fax \_\_\_\_\_  
E-mail michael.d.ballard@nasa.gov

4 Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For: **Accountable Property**  
Order No. DO-CRAVE-EB2-007

5. Contractor.  
The University of Alabama at Birmingham Center for  
Biophysical Sciences and Engineering CBSE 100, 1530 3rd  
Avenue South Birmingham, Alabama 35294-4400

Phone (205) 975-2718 x \_\_\_\_\_ Fax: (205) 975-1709  
TIN: 63-6005396 CAGE CODE 0DV74

6 Deliver On or Before SEE BLOCK 11  
F O B. Point Birmingham, Alabama  
Discount Terms: Net 30 Days.

7 BILLING ADDRESS:  
NASA Johnson Space Center  
Attn: LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No. DO-CRAVE-EB2-007

8. Type of Order.  
 PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_  
 DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: NNJ05HB42B

9. Written acceptance of this order by contractor  is,  is not required Sign below if required and return to contracting officer  
Name: Richard Marchese, Ph.D. (Person authorized to sign)  
Signature: [Signature] Date: 8-18-05

10. Name: N L Dawn Alexander  
Signature: [Signature] Date: 8/26/05  
CONTRACTING OFFICER

11 Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	The Contractor shall perform and deliver to all requirements for DO-CRAVE-EB2-007 The Period of Performance for this DO is 8/29/2005 - 10/31/2005 (excluding any options)	64		64	64	

12 For JSC Internal Use Only  
Requisition No \_\_\_\_\_  
Rissue To \_\_\_\_\_  
 COMP  PART PPC \_\_\_\_\_

13 Total  
\$ 8,908 \_\_\_\_\_

14 Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED  ACCEPTED  RECEIVED  
TO CONFORM TO THE CONTRACT  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED BY \_\_\_\_\_

Authorized U S Government Representative \_\_\_\_\_ Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
 DO-CRAVE-EC3-010

2. Date of Order  
 See Block 10

NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.

Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office.  
 NASA Johnson Space Center, 2101 Nasa Parkway  
 Houston, TX 77058-3696  
 Org./Buyer: BH4/Michael Ballard

Tel No.: 281-244-5350 Fax: \_\_\_\_\_  
 E-mail: michael.d.ballard@nasa.gov

4. Ship To:  
 Transportation Officer, Building 421  
 NASA Johnson Space Center  
 Houston, TX 77058-3696  
 Mark For: **Accountable Property**

Order No.: DO-CRAVE-EC3-010

5. Contractor:  
 Hamilton Sundstrand Management Services  
 2200 Space Park Drive  
 Houston, TX 77058

Phone: 281-336-6334 x \_\_\_\_\_ Fax: \_\_\_\_\_  
 TIN: 06-1165866 CAGE CODE: 71120

6. Deliver On or Before. See SOW

F.O B Point Destination

Discount Terms. Net 30 Days.

7. BILLING ADDRESS:  
 NASA Johnson Space Center  
 Attn: LF231/Accounts Payable Group  
 Houston, TX 77058-3696  
 Order No.: DO-CRAVE-EC3-10

8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: NNJ05HB39B

9. Written acceptance of this order by contractor  is,  is not required. Sign below if required and return to contracting officer

Name: Lynd M. Ballins (Person authorized to sign)  
 Signature: [Signature] Date: 3-22-06

10. Name: J. R. Carpentier

Signature: [Signature] Date: 4-11-06  
 CONTRACTING OFFICER

11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	The Contractor shall perform and deliver to all requirements for: DO-CRAVE-EC3-10: Urine Monitoring System (UMS) SOW is attached  Value. <u>bf</u>  Total \$260,525					

12. For JSC Internal Use Only:

Requisition No.: N/A  COMP  PART. PPC: \_\_\_\_\_

Rissue To: Joe Gensler/EC

13. Total  
 \$ 260,525

14. Quantities in "Quantity Accepted" Column Have Been

INSPECTED  ACCEPTED  RECEIVED

TO CONFORM TO THE CONTRACT.  
 ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.

BY: \_\_\_\_\_  
 Authorized U.S. Government Representative

Date: \_\_\_\_\_

**ORDER FOR SUPPLIES OR SERVICES**

1. Order No NNJ05HB39B, DO3R8	2 Date of Order See Block 10 Below	<b>NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO</b>
Certified for National Defense under DPAS (15 CFR 700) DO-C9		

3 Issuing Office NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org /Buyer: 4BH2/Mary Thomas  Tel No : 281-483-8828 Fax 281-244-0995 E-mail. mary.f.thomas@nasa.gov	4 Ship To Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b>  Order No NNJ05HB39B, DO3R8
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5 Contractor:  Hamilton Sundstrand Space Systems Attn: Angela Hillin 2200 Space Park Drive, Suite 100 Houston, TX 77058-3677  Phone 281-336-6316 x Fax 860-998-7029  TIN 06-1165886 CAGE CODE 71120	6. Deliver On or Before: 05/05/05 - 12/21/09  F O B Point. <u>Destination</u>  Discount Terms: Net 30 Days.
7. BILLING ADDRESS NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No.: NNJ05HB39B, DO3R8	

8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor <input type="checkbox"/> is, <input checked="" type="checkbox"/> is not required. Sign below if required and return to contracting officer  Name: _____ (Person authorized to sign) Signature: _____ Date: _____	10. Name: <u>Ronald Johnson</u>  Signature: <u>Ronald Johnson</u> Date: <u>12/15/08</u> CONTRACTING OFFICER
---	--

11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED											
1	<p><b>MULTI-ENVIRONMENT EVAPORATIVE HEAT SINK (MEHS)</b></p> <p>Period of Performance. 05/05/05 - 12/21/09</p> <p>Revision 8 to CRAVE DO 3 is issued to correct the DO value An additional \$39,840 in cost is being added to perform the HX Braze Study-Phase II work All other terms and conditions of the DO remain unchanged.</p> <table border="1"> <tr> <td>RECAP OF DO VALUE:</td> <td>Prior Value</td> <td>This Action</td> <td>Cum Value</td> </tr> <tr> <td>COST FEE-</td> <td></td> <td>b4</td> <td></td> </tr> <tr> <td>TOTAL</td> <td>\$1,658,885.55</td> <td>\$39,840</td> <td>\$1,698,725.55</td> </tr> </table>	RECAP OF DO VALUE:	Prior Value	This Action	Cum Value	COST FEE-		b4		TOTAL	\$1,658,885.55	\$39,840	\$1,698,725.55	b4			b4
RECAP OF DO VALUE:	Prior Value	This Action	Cum Value														
COST FEE-		b4															
TOTAL	\$1,658,885.55	\$39,840	\$1,698,725.55														

12. For JSC Internal Use Only Requisition No. <u>N/A</u> <input checked="" type="checkbox"/> COMP. <input type="checkbox"/> PART. PPC _____ Rissue To: <u>EC/Ralph Marak, x39144</u> For <u>EC/Ryan Stephan</u>	13. Total \$ NTE \$1,698,725.55
---	------------------------------------

14. Quantities in "Quantity Accepted" Column Have Been

INSPECTED  ACCEPTED  RECEIVED

TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED BY \_\_\_\_\_

Authorized U S Government Representative \_\_\_\_\_ Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

1. Order No. NNJ05HB39B, DO3R7	2. Date of Order See Block 10 Below	<b>NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.</b> Certified for National Defense under DPAS (15 CFR 700) DO-C9
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3. Issuing Office: NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org /Buyer: 4BH2/Mary Thomas  Tel No. 281-483-8828      Fax. 281-244-0995 E-mail: <a href="mailto:mary.f.thomas@nasa.gov">mary.f.thomas@nasa.gov</a>	4. Ship To: Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b> Order No.. NNJ05HB39B, DO3R7
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5 Contractor  Hamilton Sundstrand Space Systems Attn. Angela Hillin 2200 Space Park Drive, Suite 100 Houston, TX 77058-3677  Phone: 281-336-6316    x      Fax: 880-998-7029  TIN: 06-1165866      CAGE CODE: 71120	6 Deliver On or Before: <u>05/05/05 - 12/21/09</u>  F O B. Point. <u>Destination</u>  Discount Terms. Net 30 Days  7 BILLING ADDRESS: NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No.. NNJ05HB39B, DO3R7
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8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number \_\_\_\_\_

9. Written acceptance of this order by contractor [ <input type="checkbox"/> ] is, [ <input checked="" type="checkbox"/> ] is not required Sign below if required and return to contracting officer.  Name: _____ (Person authorized to sign)  Signature _____ Date: _____	10 Name: <u>Ronald Johnson</u>  Signature _____ Date: _____ <b>CONTRACTING OFFICER</b>
--	---

**11. Schedule**

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED												
1	<b>MULTI-ENVIRONMENT EVAPORATIVE HEAT SINK (MEHS)</b>  Period of Performance. 05/05/05 - 12/21/09  Revision 7 to CRAVE DO 3 is issued to perform the task HX Braze Study, Phase II as outlined in the revised SOW dated 9/2/08 The DO value is increased by \$320,095 from \$1,338,790 55 to \$1,658,885 55. The period of performance is extended to 12/21/09.  <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 25%;">RECAP OF DO VALUE:</td> <td style="width: 10%;">Prior Value</td> <td style="width: 10%;">This Action</td> <td style="width: 15%;">Cum Value</td> </tr> <tr> <td style="text-align: center;">COST FEE</td> <td></td> <td style="text-align: center;"><i>bf</i></td> <td></td> </tr> <tr> <td style="text-align: right;">TOTAL</td> <td style="text-align: right;">\$1,338,790 55</td> <td style="text-align: right;">\$320,095</td> <td style="text-align: right;">\$1,658,885 55</td> </tr> </table>	RECAP OF DO VALUE:	Prior Value	This Action	Cum Value	COST FEE		<i>bf</i>		TOTAL	\$1,338,790 55	\$320,095	\$1,658,885 55	<i>bf</i>			<i>bf</i>	
RECAP OF DO VALUE:	Prior Value	This Action	Cum Value															
COST FEE		<i>bf</i>																
TOTAL	\$1,338,790 55	\$320,095	\$1,658,885 55															

12. For JSC Internal Use Only: Requisition No.. <u>N/A</u> <input checked="" type="checkbox"/> COMP <input type="checkbox"/> PART    PPC _____ Rissue To: <u>EC/Ralph Marak, x39144</u> For: <u>EC/Ryan Stephan</u>	13. Total  \$ NTE \$1,658,885 55
---	--

14. Quantities in "Quantity Accepted" Column Have Been

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.

BY: \_\_\_\_\_

Authorized U S. Government Representative      Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

1. Order No. NNJ05HB39B, DO3R6	2. Date of Order See Block 10 Below	NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO Certified for National Defense under DPAS (15 CFR 700) DO-C9
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3 Issuing Office: NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org./Buyer <u>4BH2/Mary Thomas</u>  Tel No.: <u>281-483-8828</u> Fax: <u>281-244-0995</u> E-mail: <u>mary.f.thomas@nasa.gov</u>	4 Ship To: Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b>  Order No.: <u>NNJ05HB39B, DO3R6</u>
---	---

5 Contractor:  Hamilton Sundstrand Management Services Attn: Angela Hillin 2200 Space Park Drive, Suite 100 Houston, TX 77058-3677  Phone: 281-336-6316 x      Fax: 860-998-7029  TIN: 06-1165866      CAGE CODE: 71120	6 Deliver On or Before: <u>05/05/05 - 07/11/08</u>  F O.B. Point: <u>Destination</u>  Discount Terms: Net 30 Days.  7. BILLING ADDRESS: NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No.: <u>NNJ05HB39B, DO3R6</u>
--	---

8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY. Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number \_\_\_\_\_

9. Written acceptance of this order by contractor [ <input type="checkbox"/> ] is, [ <input checked="" type="checkbox"/> ] is not required. Sign below if required and return to contracting officer  Name: _____ (Person authorized to sign) Signature: _____ Date: _____	10. Name: <u>Ronald Johnson</u>  Signature: <u>Ronald Johnson</u> Date: <u>5/6/08</u> CONTRACTING OFFICER
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11 Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	MULTI-ENVIRONMENT EVAPORATIVE HEAT SINK (MEHS)  Period of Performance: 05/05/05 - 07/11/08  Revision 6 to CRAVE DO 3 is issued to extend the period of performance to July 11, 2008 at no additional cost to the Government  CUM DO VALUE RECAP: COST <u>64</u> FEE TOTAL                    \$1,338,790.55					<u>64</u>

12. For JSC Internal Use Only Requisition No. <u>N/A</u> <input checked="" type="checkbox"/> COMP. <input type="checkbox"/> PART    PPC. _____ Rissue To: <u>EC/Joe Gensler, x30025</u> For: <u>EC/Ryan Stephan</u>	13. Total \$ 1,338,790.55 NTE
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14 Quantities in "Quantity Accepted" Column Have Been

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED BY \_\_\_\_\_

Authorized U S Government Representative      Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

<b>1. Order No.</b> NNJ05HB39B, DO3R5	<b>2. Date of Order</b> See Block 10 Below	<b>NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.</b> Certified for National Defense under DPAS (15 CFR 700) DO-C9	
<b>3 Issuing Office:</b> NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org./Buyer: <u>4BH2/Mary Thomas</u>  Tel No : <u>281-483-8828</u> Fax: <u>281-483-4173</u> E-mail: <u>mary.f.thomas@nasa.gov</u>		<b>4. Ship To:</b> Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b>  Order No. : <u>NNJ05HB39B, DO3R5</u>	
<b>5. Contractor:</b>  Hamilton Sundstrand Management Services Attn: Kenneth Ridley-Mail Stop 1A-2-W59 1 Hamilton Road Windsor Locks, CT 06096  Phone: 860-654-4034 x      Fax: 860-654-3318  TIN: 06-1165866      CAGE CODE 71120		<b>6. Deliver On or Before:</b> <u>05/05/05 - 04/04/08</u>  F O B Point. <u>Destination</u>  Discount Terms. Net 30 Days  <b>7. BILLING ADDRESS:</b> NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No.: <u>NNJ05HB39B, DO3R5</u>	

**8. Type of Order:**

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number. \_\_\_\_\_

<b>9. Written acceptance of this order by contractor</b> <input type="checkbox"/> is, <input checked="" type="checkbox"/> is not required. Sign below if required and return to contracting officer.  Name: _____ (Person authorized to sign) Signature: _____ Date: _____	<b>10 Name:</b> <u>Ronald Johnson</u>  Signature: <u>Ronald Johnson</u> Date: <u>11/6/07</u> <b>CONTRACTING OFFICER</b>
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**11. Schedule**

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED																				
	<b>MULTI-ENVIRONMENT EVAPORATIVE HEAT SINK (MEHS)</b>  Period of Performance: <u>05/05/05 - 04/04/08</u>  Revision 5 to CRAVE DO 3 is issued to revise the SOW, increase the DO value, and extend the period of performance. Changes to the SOW have been vertically-bar marked in the attached.  <b>DO VALUE RECAP:</b> <table style="width:100%; border-collapse: collapse;"> <tr> <td style="width:15%;"></td> <td style="width:15%;">PRIOR</td> <td style="width:15%;">THIS ACTION</td> <td style="width:15%;">CUM VALUE</td> <td style="width:15%;"></td> </tr> <tr> <td>COST</td> <td align="center"><u>64</u></td> <td align="center"><u>64</u></td> <td align="center"><u>64</u></td> <td></td> </tr> <tr> <td>FEE</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td><b>TOTAL</b></td> <td align="right"><b>\$1,149,005.55</b></td> <td align="right"><b>\$189,785</b></td> <td align="right"><b>\$1,338,790.55</b></td> <td></td> </tr> </table> PERIOD OF PERFORMANCE: <u>05/05/05 - 04/04/08</u>		PRIOR	THIS ACTION	CUM VALUE		COST	<u>64</u>	<u>64</u>	<u>64</u>		FEE					<b>TOTAL</b>	<b>\$1,149,005.55</b>	<b>\$189,785</b>	<b>\$1,338,790.55</b>		64			64	
	PRIOR	THIS ACTION	CUM VALUE																							
COST	<u>64</u>	<u>64</u>	<u>64</u>																							
FEE																										
<b>TOTAL</b>	<b>\$1,149,005.55</b>	<b>\$189,785</b>	<b>\$1,338,790.55</b>																							

<b>12 For JSC Internal Use Only:</b> Requisition No.: <u>N/A</u> <input checked="" type="checkbox"/> COMP. <input type="checkbox"/> PART    PPC: _____ Rissue To: <u>EC/Joe Gensler, x30025</u> For: <u>EC/Ryan Stephan</u>	<b>13. Total</b>  <b>\$ 1,338,790.55 NTE</b>
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**14. Quantities in "Quantity Accepted" Column Have Been**

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.

BY \_\_\_\_\_

Authorized U S Government Representative \_\_\_\_\_ Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

1. Order No. NNJ05HB39B, DO3R4	2. Date of Order See Block 10 Below	NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO. Certified for National Defense under DPAS (15 CFR 700) DO-C9
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3 Issuing Office NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org /Buyer: 48H2/Mary Thomas  Tel No.: 281-483-8828 Fax: 281-483-4173 E-mail: mary.f.thomas@nasa.gov	4 Ship To: Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b>  Order No. NNJ05HB39B, DO3R4
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5. Contractor:  Hamilton Sundstrand Management Services Attn. Kenneth Ridley-Mail Stop 1A-2-W59 1 Hamilton Road Windsor Locks, CT 06096  Phone: 860-654-4034 x      Fax: 860-654-3318  TIN: 06-1165866      CAGE CODE: 71120	6 Deliver On or Before <u>5/5/05 to 12/31/07</u>  F O B Point: <u>Destination</u>  Discount Terms: Net 30 Days.  7. BILLING ADDRESS: NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No.: NNJ05HB39B, DO3R4
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8. Type of Order:

PURCHASE. Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY. Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor <input type="checkbox"/> is, <input checked="" type="checkbox"/> is not required. Sign below if required and return to contracting officer.  Name: _____ (Person authorized to sign) Signature: _____ Date: _____	10. Name: <u>Rob Kolb</u>  Signature:  Date: <u>8/14/07</u> CONTRACTING OFFICER
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11. Schedule						
ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	DO-CRAVE-EC-003, MULTI-ENVIRONMENT EVAPORATIVE HEAT SINK (MEHS) Period of Performance. 05/05/05 - 012/31/07 Revision 4 to CRAVE DO3 is issued to extend the period of performance to 12/31/07 at no additional cost to the Government. All other terms and conditions remain the same.				64	64

12. For JSC Internal Use Only: Requisition No.. <u>N/A</u> <input checked="" type="checkbox"/> COMP. <input type="checkbox"/> PART.    PPC: _____ Rissue To <u>EC/Joe Gensler, x30025</u> For: <u>EC/David T. Westheimer</u>	13. Total \$ 1,149,005.55 NTE
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14. Quantities in "Quantity Accepted" Column Have Been

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.

BY: \_\_\_\_\_

Authorized U.S. Government Representative      Date \_\_\_\_\_

**ORDER FOR SUPPLIES OR SERVICES**

1. Order No. NNJ05HB39B, DO3R3	2. Date of Order See Block 10 Below	NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO. Certified for National Defense under DPAS (15 CFR 700) DO-C9
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3. Issuing Office: NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org./Buyer: <u>BH2/Mary Thomas</u>  Tel No.. <u>281-483-8828</u> Fax <u>281-483-4173</u> E-mail: <u>mary.f.thomas@nasa.gov</u>	4. Ship To: Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b>  Order No.. <u>NNJ05HB39B, DO3R3</u>
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5 Contractor:  Hamilton Sundstrand Management Services Attn: Kenneth Ridley-Mail Stop 1A-2-W59 1 Hamilton Road Windsor Locks, CT 06096  Phone: 860-654-4034 x      Fax: 860-654-3318  TIN: 08-1165866      CAGE CODE: 71120	6. Deliver On or Before: <u>5/5/05 to 7/20/07</u>  F O B Point: <u>Destination</u>  Discount Terms. Net 30 Days.  7 BILLING ADDRESS: NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No.. <u>NNJ05HB39B, DO3R3</u>
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8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

9. Written acceptance of this order by contractor [ <input type="checkbox"/> ] is, [ <input checked="" type="checkbox"/> ] is not required. Sign below if required and return to contracting officer.  Name: _____ (Person authorized to sign) Signature: _____ Date: _____	10 Name: <u>Ronald Johnson</u> <div style="text-align: right; margin-right: 50px;">6/4/07</div> Signature: <u>Ronald Johnson</u> Date: <u>6/4/07</u> CONTRACTING OFFICER
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11 Schedule						
ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	DO-CRAVE-EC-003, MULTI-ENVIRONMENT EVAPORATIVE HEAT SINK (MEHS) Period of Performance: 05/05/05 - 07/20/07 Revision 3 to CRAVE DO3, is issued to the change the SOW to increase the quantity of Energy Storage Heat Exchangers from 1 to 3. change the deliverables dates, and increase the DO value. <u>b4</u> The revised SOW is enclosed.					
1	Energy Storage Heat Exchangers	<u>b4</u>				<u>b4</u>
2	Phase 1 MEHS change in design					
(continued next page)						

12. For JSC Internal Use Only: Requisition No.: <u>N/A</u> <input checked="" type="checkbox"/> COMP. <input type="checkbox"/> PART    PPC: _____ Rissue To: <u>EC/Joe Gensler, x30025</u> For <u>EC/David T. Westheimer</u>	13. Total \$ 1,149,005 55 NTE
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14. Quantities in "Quantity Accepted" Column Have Been

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.

BY: \_\_\_\_\_

Authorized U.S Government Representative      Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

<b>1. Order No.</b> NNJ05HB39B, DO3R2	<b>2. Date of Order</b> See Block 10 Below	<b>NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.</b> Certified for National Defense under DPAS (15 CFR 700) DO-C9	
<b>3. Issuing Office:</b> NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org /Buyer: <u>BH2/Mary Thomas</u>  Tel No.: <u>281-483-8828</u> Fax: <u>281-483-4173</u> E-mail: <u>mary.f.thomas@nasa.gov</u>		<b>4. Ship To:</b> Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b>  Order No.. <u>NNJ05HB39B, DO3R2</u>	
<b>5. Contractor:</b>  Hamilton Sundstrand Management Services Attn: Kenneth Ridley-Mail Stop 1A-2-W59 1 Hamilton Road Windsor Locks, CT 06096  Phone: 860-654-4034 x      Fax: 860-654-3318  TIN: 06-1165866      CAGE CODE: 71120		<b>6. Deliver On or Before:</b> _____  F O B. Point: <u>Destination</u>  Discount Terms: Net 30 Days.	
		<b>7 BILLING ADDRESS:</b> NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No : <u>NNJ05HB39B, DO3R2</u>	

**8. Type of Order:**

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: \_\_\_\_\_

<b>9. Written acceptance of this order by contractor</b> ( <input type="checkbox"/> is, <input checked="" type="checkbox"/> is not required. Sign below if required and return to contracting officer.  Name: _____ (Person authorized to sign) Signature: _____ Date: _____	<b>10. Name:</b> <u>Ronald Johnson</u>  Signature: <u>Ronald Johnson</u> Date: <u>3/30/07</u> CONTRACTING OFFICER
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11 Schedule																								
ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED																		
	DO-CRAVE-EC-003, MULTI-ENVIRONMENT EVAPORATIVE HEAT SINK (MEHS) Period of Performance: 05/05/05 - 07/15/07 Revision 2 to CRAVE DO3, is issued to the change the SOW. Changes have been vertically bar-marked in the attached replacement SOW The Delivery Order value is increase as follows:  <table style="width:100%; border-collapse: collapse;"> <tr> <td style="width:20%;"></td> <td style="width:20%; text-align: center;">PRIOR VALUE</td> <td style="width:20%; text-align: center;">THIS ACTION</td> <td style="width:20%; text-align: center;">REVISED VALUE</td> <td colspan="2"></td> </tr> <tr> <td>COST FEE</td> <td style="text-align: center;">64</td> <td style="text-align: center;">64</td> <td style="text-align: center;">64</td> <td colspan="2"></td> </tr> <tr> <td>TOTAL</td> <td style="text-align: center;">\$713,664</td> <td style="text-align: center;">\$149,685</td> <td style="text-align: center;">\$863,349</td> <td colspan="2"></td> </tr> </table> THIS IS A CPFF DELIVERY ORDER. FUNDING IS AT THE CONTRACT LEVEL.		PRIOR VALUE	THIS ACTION	REVISED VALUE			COST FEE	64	64	64			TOTAL	\$713,664	\$149,685	\$863,349			64			64	
	PRIOR VALUE	THIS ACTION	REVISED VALUE																					
COST FEE	64	64	64																					
TOTAL	\$713,664	\$149,685	\$863,349																					

<b>12. For JSC Internal Use Only:</b> Requisition No.: <u>N/A</u> <input checked="" type="checkbox"/> COMP. <input type="checkbox"/> PART.    PPC: _____ Rissue To: <u>EC/Joe Gensler, x30025</u> For <u>EC/David T Westheimer</u>	<b>13. Total</b> \$ 863,349 NTE
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**14. Quantities in "Quantity Accepted" Column Have Been**

INSPECTED     ACCEPTED     RECEIVED

TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.

BY: \_\_\_\_\_  
Authorized U.S. Government Representative      Date \_\_\_\_\_

**Narrative Task Description**

**Background / Problem Description:**

Current NASA flight evaporative heat rejection technologies are not flexible enough to remove and reject heat throughout the entire mission profile, which includes total pressures and partial pressures of components from Earth sea level conditions to the vacuum of space. The goal of this delivery order, from the basic period through the option periods, is to acquire a prototype of a gravity insensitive, scalable or modular, evaporative heat rejection system called a Multi-Environment Evaporative Heat Sink (MEHS) that can remove up to W of energy from a closed-loop coolant fluid, and reject the energy through evaporation of another fluid. The system must be able to operate in any environmental condition seen throughout the mission cycle in total pressures ranging from 0 to 101 kPa and partial pressures of fluids from 0 to expected Earth sea level conditions, enabling the MEHS to perform from Earth to orbit and on the moon. The prototype delivered should be ready for integrated testing with other thermal systems to be considered at Technology Readiness Level (TRL) 6 after that testing.

**Task Description:**

The development of the MEHS unit can be broken down into three periods, which are separated into option periods, as shown further in this DO, to continue at each transition point (though in the revision some parts will be executed in parallel).

In Phase I, the basic portion of this DO, the contractor shall develop designs of one or more MEHS concepts and one or more MEHS Engineering Development Units (EDUs) to test those concepts. The contractor shall select a fluid or fluids to be evaporated in the full spectrum of required environments while considering safety and performance. The contractor shall perform thermal and fluid analysis to demonstrate performance predictions and demonstrate that a full size unit could meet MEHS requirements of 6000 W of heat rejection, gravity insensitive performance, and no more than 44 kPa pressure drop (6.5 psid) in the closed-loop heat transfer fluid line, assuming 133 kg/hr (293 lb/hr) at an inlet temperature of 42°C (108°F). The contractor shall deliver drawings or sketches of sufficient detail of the MEHS EDU(s) to demonstrate the feasibility of the preferred concepts. The EDUs are not required to be full scale, but should represent portions of a scaleable or modular concept that can reject 6000 W at full size. The contractor shall develop a strawman test plan to show that the critical questions yet remaining can be addressed by testing the designs and that the number and design of EDUs planned is sufficient. The test plan will also identify any additional hardware such as back pressure valves, heaters, and controllers, required to test the EDU designs. The preferred design concept(s), including analysis results and drawings shall be delivered and presented to NASA at a Conceptual Design Review (CpDR) at the end of the basic (Phase I) period of performance of this DO. NASA will have the option to continue the contract to Phase II after this review as shown below.

  
**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
**DELIVERY ORDER #: CRAVE-1003**

**Deliverables/Products:**

Product	Description	Qty	Due	Class
<b>Hardware</b>				
Mock Up				
Prototype				
Certification				
Flight				
Training				
Other				
<b>Test</b>				
<b>Software</b>				
<b>Other Products</b>	MEHS Strawman Test Plan	1	11/25/05	
	MEHS EDU CpDR Package (Including Drawings/Sketches)	1	11/25/05	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
 DELIVERY ORDER #: CRAVE-DC-003**

**SCHEDULE -- Phase I (Basic Period)**  
**Start Date: May 2, 2005**                      **Finish Date: November 30, 2005**

MILESTONES	DUE DATES
Phase 1/Initial Contract	
MEHS EDU Design Review	November 30, 2005

Milestones, along with subjective measurements, are to be used for measuring performance. For schedule detail see Microsoft Project file located on the CRAVE web site for this DO listed under the Government Cost Estimate below.

Government Estimate Located in [RPO File in Microsoft Project File OR CRAVE Web Site](#)  
 The file is titled: [MEHS Design Review](#)  
 Total Government Estimate for all DO's: [\\$1,000,000](#)  
 Other Government Estimate for all DO's: [\\$1,000,000](#) (See Attachment 1)  
 Other Government Estimate for all DO's: [\\$1,000,000](#) (See Attachment 2)

**TOTAL COST ESTIMATE FOR THIS DO: \$**

**FEE: \$ (If Applicable)**

**OPTION 1: \$ (See Attachment 1)**

**OPTION 2: \$ (See Attachment 2)**



**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRVMEHSC003**

REQ #	DELIVERABLE	DESCRIPTION	EDUC	PROFICIENCY	REQUIRED FOR USE	COMMENTS
16	Vehicle Approval	Approved drawings	CRVMEHSC003	Vehicle systems	Y	Sketches at MEHS EDU CpDR, Engineering drawings at MEHS Prototype PDR/CDR
17	Vehicle Approval	MEHS Plans (assembly)	CRVMEHSC003	Vehicle systems	N	
18	Vehicle Approval	Final Design Data	CRVMEHSC003	Vehicle systems	Y	Data package is part of combined PDR/CDR package, not additional and separate
19	Vehicle Approval	Approved drawings	CRVMEHSC003	Vehicle systems	N	Any drawings for prototype parts are for the contractor's use/ responsibility to manage. The only drawings NASA is interested in are at final presentation, so there should be no changes if there is only one final delivery
20	Vehicle Approval	MEHS Plans (assembly)	CRVMEHSC003	Vehicle systems	N	
21	Vehicle Approval	Approved drawings	CRVMEHSC003	Vehicle systems	N	
22	Vehicle Approval	Vehicle CAD	CRVMEHSC003	Vehicle systems	Y	As required to allow operation of MEHS prototype in integrated testing after Phase III
23	Vehicle Approval	Approved drawings	CRVMEHSC003	Vehicle systems	U (limited to 2000000000)	
24	Vehicle Approval	Approved drawings	CRVMEHSC003	Vehicle systems	N	
25	Vehicle Approval	Approved drawings	CRVMEHSC003	Vehicle systems	N	
26	Vehicle Approval	Approved drawings	CRVMEHSC003	Vehicle systems	Y	Outlined in Phase I task, expected as part of design in Phase II and III

  
**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
**DELIVERY ORDER #: CRAVE1600**

REQ #	DELIVERY	DESCRIPTION	UNIT	FREQUENCY	REQUIRED FOR TOP	COMMENTS
17	Mandatory Approval	Acceptance Data Package	1 (Availability of Components)	One time	Y	For MEHS prototype after checkout and verification testing
18	Mandatory Approval	LAZOR Control Software	1 (Availability of Software)	One time		
19	Written Approval	Interface	1 (Availability of Interface)	One time	Condition 1-11	Only if change to software or hardware of LAZOR and only if this change is chargeable
20	Written Approval	Open Flight Kit	1 (Availability)	One time	Condition 1-11	
21	Written Approval	Final Configuration and Safety Package	1 (Availability)	One time	N	
22	Written Approval	Final Software	1 (Availability)	One time	N	
23	Written Approval	Space Station 2.0 Software which includes ground station software	1 (Availability)	One time	N	
24	Written Approval	Space Station 2.0 Software and Analysis Report (SAR) Report	1 (Availability)	One time	N	
25	Written Approval	3D Model/Quality Assurance Data Sheet	1 (Availability)	One time	Condition 1-11	
26	Written Approval	Software Report	1 (Availability)	One time	N	
27	Written Approval	Availability and Maintainability Plan	1 (Availability)	One time	Condition 1-11	
28	Written Approval	Feasibility of Location Approval Request (FALOR)	1 (Availability)	One time	N	
29	Written Approval	Job Assignment and Control	1 (Availability)	One time	N	
30	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
31	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
32	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
33	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
34	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
35	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
36	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
37	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
38	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
39	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
40	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
41	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
42	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
43	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
44	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
45	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
46	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
47	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
48	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
49	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
50	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
51	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
52	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
53	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
54	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
55	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
56	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
57	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
58	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
59	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
60	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
61	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
62	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
63	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
64	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
65	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
66	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
67	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
68	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
69	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
70	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
71	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
72	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
73	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
74	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
75	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
76	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
77	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
78	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
79	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
80	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
81	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
82	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
83	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
84	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
85	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
86	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
87	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
88	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
89	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
90	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
91	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
92	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
93	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
94	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
95	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
96	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
97	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
98	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
99	Written Approval	Software Requirements Case	1 (Availability)	One time	N	
100	Written Approval	Software Requirements Case	1 (Availability)	One time	N	


**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
**DELIVERY ORDER #: CRAVE-DC-008**

PRN #	DATES (Y/M)	DESCRIPTION	DATE	FREQUENCY	REQUIRED FOR DO Y/N	COMMENTS
33	10/2014	Electrical System and Engine Fuel (DEF) Tank Control Panel	10/2014	Once	Y	
34	10/2014	Verification Data Package	10/2014	Once	N	
35	10/2014	Operation and Maintenance Requirements Document	10/2014	Once	N	
36	10/2014	Vehicle Sales and Usage Report	10/2014	Once	Y	
37	10/2014	RFID Operations User Procedure	10/2014	Once	N	
38	10/2014	High Quality Assurance & Validation Report	10/2014	Once	N	
39	10/2014	Spaceframe and Publications and Labels Analysis, EPC and Label House File	10/2014	Once	N	
40	10/2014	10/2014	10/2014	10/2014		
41	10/2014	10/2014	10/2014	10/2014		
42	10/2014	10/2014	10/2014	10/2014		
43	10/2014	10/2014	10/2014	10/2014		
44	10/2014	10/2014	10/2014	10/2014		
45	10/2014	10/2014	10/2014	10/2014		
46	10/2014	10/2014	10/2014	10/2014		
47	10/2014	10/2014	10/2014	10/2014		
48	10/2014	10/2014	10/2014	10/2014		
49	10/2014	10/2014	10/2014	10/2014		
50	10/2014	10/2014	10/2014	10/2014		
51	10/2014	10/2014	10/2014	10/2014		
52	10/2014	10/2014	10/2014	10/2014		
53	10/2014	10/2014	10/2014	10/2014		
54	10/2014	10/2014	10/2014	10/2014		
55	10/2014	10/2014	10/2014	10/2014		
56	10/2014	10/2014	10/2014	10/2014		
57	10/2014	10/2014	10/2014	10/2014		
58	10/2014	10/2014	10/2014	10/2014		
59	10/2014	10/2014	10/2014	10/2014		
60	10/2014	10/2014	10/2014	10/2014		
61	10/2014	10/2014	10/2014	10/2014		
62	10/2014	10/2014	10/2014	10/2014		
63	10/2014	10/2014	10/2014	10/2014		
64	10/2014	10/2014	10/2014	10/2014		
65	10/2014	10/2014	10/2014	10/2014		
66	10/2014	10/2014	10/2014	10/2014		
67	10/2014	10/2014	10/2014	10/2014		
68	10/2014	10/2014	10/2014	10/2014		
69	10/2014	10/2014	10/2014	10/2014		
70	10/2014	10/2014	10/2014	10/2014		
71	10/2014	10/2014	10/2014	10/2014		
72	10/2014	10/2014	10/2014	10/2014		
73	10/2014	10/2014	10/2014	10/2014		
74	10/2014	10/2014	10/2014	10/2014		
75	10/2014	10/2014	10/2014	10/2014		
76	10/2014	10/2014	10/2014	10/2014		
77	10/2014	10/2014	10/2014	10/2014		
78	10/2014	10/2014	10/2014	10/2014		
79	10/2014	10/2014	10/2014	10/2014		
80	10/2014	10/2014	10/2014	10/2014		
81	10/2014	10/2014	10/2014	10/2014		
82	10/2014	10/2014	10/2014	10/2014		
83	10/2014	10/2014	10/2014	10/2014		
84	10/2014	10/2014	10/2014	10/2014		
85	10/2014	10/2014	10/2014	10/2014		
86	10/2014	10/2014	10/2014	10/2014		
87	10/2014	10/2014	10/2014	10/2014		
88	10/2014	10/2014	10/2014	10/2014		
89	10/2014	10/2014	10/2014	10/2014		
90	10/2014	10/2014	10/2014	10/2014		
91	10/2014	10/2014	10/2014	10/2014		
92	10/2014	10/2014	10/2014	10/2014		
93	10/2014	10/2014	10/2014	10/2014		
94	10/2014	10/2014	10/2014	10/2014		
95	10/2014	10/2014	10/2014	10/2014		
96	10/2014	10/2014	10/2014	10/2014		
97	10/2014	10/2014	10/2014	10/2014		
98	10/2014	10/2014	10/2014	10/2014		
99	10/2014	10/2014	10/2014	10/2014		
100	10/2014	10/2014	10/2014	10/2014		

**GOVERNMENT FURNISHED PROPERTY**

None Required

**CHANGES TO DRDs:** **NONE**

**CHANGES TO GOVERNMENT FURNISHED PROPERTY:** **NONE**

ATTACHMENT 1

The Government may exercise the option described below for the option value listed on the DO cover page by written notification to the contractor 15 days before the completion of the Basic delivery order requirement.

**OPTION 1 TITLE: Multi-Environment Evaporative Heat Sink (MEHS) - PHASE II**

**Background / Problem Description:**

After completion of Phase I, a concept or concepts have been developed for a gravity insensitive, scalable or modular, evaporative heat rejection technology. Analysis performed on the concepts demonstrated that the design(s) can remove up to 4700 W of energy from a closed loop coolant fluid, and reject the energy through evaporation of another fluid. The 4700 W performance is based on earlier requirements. Phase I may have demonstrated the 6000 W performance now needed, though it was not required at the time, but the change to 6000 W will be required in Phase II and Phase III. Analysis showed that the design will operate in any environmental conditions seen throughout the mission cycle in total pressures ranging from 0 to 101 kPa and partial pressures of fluids from 0 to expected Earth sea level conditions, enabling the MEHS to perform from Earth to orbit and on the moon. Simulations, analyses and conceptual designs contain assumptions, simplifications, and have an associated uncertainty in the results that require that the designs be built and tested for a thorough evaluation of the design. Testing can also highlight control, integration, and operation issues that must be considered in the design of a higher fidelity prototype.

**Task Description:**

In Phase II, the contractor shall build one or more EDU units sufficient to evaluate the designs developed in Phase I. The contractor shall complete construction of the EDU(s), and deliver a completed test plan at a Test Readiness Review (TRR) for the first milestone of Phase II. This TRR can be conducted remotely through teleconference or other methods. In the second activity in Phase II, the contractor shall test the EDU(s), demonstrating heat rejection, hot side fluid pressure drop, transition between working fluids if multiple fluids are selected, materials choices, evaporating fluids choices, and any other issues identified as critical questions in the Phase I review and the test plan. The tests will also be used to correlate and validate the models built in Phase I analysis. The contractor shall prepare and deliver a test report presented as part of a Design Review Technical Interchange Meeting (TIM) for the prototype to be constructed in Phase III. This status will ensure that lessons learned from the EDU testing are incorporated into the prototype. To make acceleration of the project feasible, Phase II and Phase III will be conducted concurrently.

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**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
**DELIVERY ORDER #: CRAVE-EC-03**


**Deliverables/Products:**

Product	Description	Qty	Due	Class
<b>Hardware</b>				
Mock Up	MEHS EDU(s) not delivered to NASA	0		
Prototype				
Certification				
Flight				
Training				
Other				
<b>Test</b>	Testing performed internally by contractor	0		
<b>Software</b>				
<b>Other Products</b>	MEHS TRR Package	1	11/10/06	
	MEHS EDU Test Report Package	1	1/26/07	
	<u>MEHS Design Review TIM</u>	1	<u>1/26/07</u>	

... [1]

  
**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
**DELIVERY ORDER #: ~~CRV100~~**

<b>SCHEDULE</b>	
Start Date: February 7, 2005	Finish Date: January 26, 2007

MILESTONES	COMPLETION DATES
<b>Phase II/Option 1</b>	
MEHS EDU Build Completion	November 10, 2006
MEHS EDU Test Plan and TRR	November 10, 2006
MEHS EDU Testing Complete	December 8, 2006
MEHS EDU Post-Test Report	January 26, 2007
MEHS Design Review TIM	January 26, 2007
Milestones, along with subjective measurements, are to be used for measuring performance. For schedule detail see Microsoft Project file located on the CRAVE web site for this DO listed under the Government Cost Estimate below.	

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MEHS EDU Testing Complete

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**Deleted:** 1  
December 8, 2006

**Deleted:** MEHS Design Review TIM

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**CHANGES TO DRDs:** ~~None~~ – DRD list already specifies whether review packages apply to EDU or prototype.

**CHANGES TO GOVERNMENT FURNISHED PROPERTY:** ~~None~~

ATTACHMENT 2

The Government may exercise the option described below for the option value listed on the DO cover page by written notification to the contractor 30 days before the completion of option 1.

**OPTION 2 TITLE: Multi-Environment Evaporative Heat Sink (MEHS) – Phase III**

**Background / Problem Description:** NASA requires a prototype unit of a multi-environment evaporative heat sink that can be evaluated in integrated testing with other thermal systems to support future missions and vehicle development such as a Crew Exploration Vehicle (CEV) or lunar lander. The goal of this delivery order is to acquire a prototype of a gravity insensitive, scalable or modular, evaporative heat rejection technology that can remove up to 6000 W of energy from a closed loop coolant fluid, and reject the energy through evaporation of another fluid. The system must be able to operate in any environmental conditions seen throughout the mission cycle in total pressures ranging from 0 to 101 kPa and partial pressures of fluids from 0 to expected Earth sea level conditions, enabling the MEHS to perform from Earth to orbit and on the moon. It has also been shown that the use of phase change materials to store energy, in conjunction with using evaporants may lead to decreased mass for the entire thermal control system. The prototype delivered should be ready for integrated testing with other thermal systems to be considered at TRL 6 after that testing. Conceptual designs have been developed and evaluated on an EDU scale. However, integration issues, control issues, scaling issues need to be addressed and design improvements from knowledge gained in EDU testing must be integrated into a single prototype that represents the best solution to providing evaporative heat rejection in earth and space environments.

CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER # CRAVE-EC-00

**Task Description:**

In Phase III, the contractor shall design final full-scale MEHS prototype and control system based on the lessons learned and insight gained from testing the EDU(s) in Phase II and additional analysis to predict full-scale performance. As part of the control system design, the contractor will perform analysis and design work on the requirements, design, and performance of high fidelity valves that will be required for flight hardware. These valves are not required to be installed in the prototype, but design results and analysis should be documented and delivered with the prototype. The contractor will work in coordination with NASA to establish interface control documents (ICDs) and deliver interface definitions for the MEHS prototype, control system requirements, identify required supporting hardware, and other issues to allow the completed prototype to be included in integrated thermal system testing. The contractor will present the completed design at a combination Preliminary Design Review/Critical Design Review (PDR/CDR). The contractor will construct the MEHS prototype and control system. The final prototype shall be of a high enough fidelity to be classified as Technology Readiness Level 6 after integrated testing is conducted. The contractor shall perform initial checkout testing to verify that the prototype meets the basic requirements, and then deliver the MEHS prototype and control system to NASA.

In addition, a development fidelity energy storage heat exchanger that use a phase change material will be fabricated to supplement the cooling provided by the Multi-environment Evaporative Heat Sink. Each of these heat exchangers shall have a phase change temperature of  $50^{\circ}\text{F} \pm 5^{\circ}\text{F}$ . The energy storage heat exchanger can be made up of multiple modules, but have a total heat storage capacity of between 500 and 3500 kJ. Construction methods of this heat exchanger shall be similar to those used in the energy storage heat exchangers under development for the Orion vehicle.

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
**DELIVERY ORDER #: ~~CRAVE-BC002~~**

**SCHEDULE**  
**Start Date: February 7, 2006**                      **Finish Date: July 15, 2007**

Deleted: June 29

PROGRAM MILESTONES	DATE DUE
<b>Phase III/Option 2</b>	
MEHS Prototype Design Review	May 26, 2006
MEHS Control Software Delivery	June 8, 2007
MEHS Prototype Delivery	June 8, 2007
Energy Storage Heat Exchanger	July 15, 2007

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Milestones, along with subjective measurements, are to be used for measuring performance. For schedule detail see Microsoft Project file located on the CRAVE web site for this DO listed under the Government Cost Estimate below.

**CHANGES TO DRDs:** ~~NONE~~ - DRD list already specifies whether review packages apply to EDU or prototype

**CHANGES TO GOVERNMENT FURNISHED PROPERTY:** ~~NONE~~

  
**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT**  
**DELIVERY ORDER #: CRAVE1000**

**Deliverables/Products:**

Product	Description	Qty	Date	Class
<b>Hardware</b>				
Mock Up				
Prototype	Prototype unit MEHS shipped to JSC for integrated testing with other thermal systems	1	June 8, 2007	
Certification				
Flight				
Training	Training of JSC civil servants or support contractor personnel necessary to enable operation and integration of the MEHS prototype after delivery	1	June 15, 2007	
Other				
Test	Testing performed internally by contractor	0	June 1, 2007	
Software	Control software required to operate the MEHS prototype in an integrated system	1	June 8, 2007	
Other Products	MEHS prototype combined PDR/CDR package	1	May 26, 2006	
	MEHS prototype ICDs	1	March 30, 2007	
	Flight Valve Design and Analysis Package	1	June 29, 2007	
	<u>Verification of MEHS prototype unit to agreed upon requirements and criteria from prototype design review based on prototype preliminary test results</u>	1	<u>June 8, 2007</u>	
	<u>Energy Storage Heat Exchanger</u>	1	<u>7/15/07</u>	

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# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
DO-CRAVE-EC-003 Rev. 1

2. Date of Order  
See Block 10

NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.

Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office:  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org./Buyer: BH2/Michael Ballard

4. Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For. **Accountable Property**  
Order No.: DO-CRAVE-EC-003 Rev 1

Tel No.: 281-244-5350 Fax: \_\_\_\_\_  
E-mail: michael.d.ballard@nasa.gov

5. Contractor:  
Hamilton Sundstrand Management Services  
2200 Space Park Drive  
Houston, TX 77058

6. Deliver On or Before: See SOW  
F.O.B. Point: Destination  
Discount Terms: Net 30 Days.

Phone: 281-336-6334 x \_\_\_\_\_ Fax: \_\_\_\_\_  
TIN: 06-1165866 CAGE CODE: 71120

7. BILLING ADDRESS:  
NASA Johnson Space Center  
Attn: LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No.: DO-CRAVE-EC-003 Rev 1

8. Type of Order.  
 PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_  
 DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: NNJ05HB39B

9. Written acceptance of this order by contractor [] is, [] is not required. Sign below if required and return to contracting officer.  
Name: Lynn M. Collins (Person authorized to sign)  
Signature: [Signature] Date: 3-22-06

10. Name: J. R. Carpentier  
Signature: [Signature] Date: 2-14-06  
CONTRACTING OFFICER

### 11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	The Contractor shall perform and deliver to all requirements for: DO-CRAVE-EC-003: Multi-Environment Evaporative Heat Sink (MEHS) This represents revision 1 to this delivery order the purpose of this revision is to modify the SOW as attached.  Previous DO value This Revision: <u>64</u> Total: _____ Total \$713,664					

12. For JSC Internal Use Only.  
Requisition No.: N/A  COMP.  PART. PPC. \_\_\_\_\_  
Rissue To: Joe Gensler/EC

13. Total  
\$ 713,664\_

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED  ACCEPTED  RECEIVED  
TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED. BY \_\_\_\_\_

Authorized U S Government Representative \_\_\_\_\_ Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
 DO-CRAVE-EC-003

2. Date of Order

**NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.**  
 Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office:  
 NASA Johnson Space Center, 2101 Nasa Parkway  
 Houston, TX 77058-3696  
 Org./Buyer: BH2/Michael Ballard  
  
 Tel No.: 281-244-5350 Fax: \_\_\_\_\_  
 E-mail: michael.d.ballard@nasa.gov

4. Ship To:  
 Transportation Officer, Building 421  
 NASA Johnson Space Center  
 Houston, TX 77058-3696  
 Mark For: **Accountable Property**  
  
 Order No.: DO-CRAVE-EC-003

5. Contractor:  
 Hamilton Sundstrand Management Services, Inc.  
 2200 Space Park Drive  
 Houston, TX 77058  
  
 Phone: 281-336-6309 x \_\_\_\_\_ Fax: 281-660-6798  
  
 TIN: 06-1165866 CAGE CODE: 71120

6. Deliver On or Before: \_\_\_\_\_  
 F.O.B. Point: \_\_\_\_\_  
 Discount Terms: Net 30 Days.

7. BILLING ADDRESS:  
 NASA Johnson Space Center  
 Attn: LF231/Accounts Payable Group  
 Houston, TX 77058-3696  
 Order No.: DO-CRAVE-EC-003

8. Type of Order:  
 PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_  
 DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: NNJ05HB 2 598

9. Written acceptance of this order by contractor  is,  is not required. Sign below if required and return to contracting officer.  
 Name: Nancy L. Brovan, Sr. Contracts Mgr (Person authorized to sign)  
 Signature: [Signature] Date: 4/15/05

10. Name: N. L. Dawn Alexander  
 Signature: [Signature] Date: 4/22/05  
 CONTRACTING OFFICER

11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	The Contractor shall perform and deliver to all requirements for: DO-CRAVE-EC-003: Multi-Environment Evaporative Heat Sink (MEHS) The Period of Performance for this DO is: 05/05/05 - 11/30/05 - Phase I					

64

12. For JSC Internal Use Only:  
 Requisition No.: \_\_\_\_\_  
 Rissue To: \_\_\_\_\_  
 COMP.  PART. PPC: \_\_\_\_\_

13. Total  
 \$ NTE: \_\_\_\_\_

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED  ACCEPTED  RECEIVED  
 TO CONFORM TO THE CONTRACT.  
 ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.

BY: \_\_\_\_\_  
 Authorized U.S. Government Representative \_\_\_\_\_  
 Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
DO-CRAVE-EC5-002 Rev. 2

2. Date of Order  
See Block 10

**NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.**

Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office:  
NASA Johnson Space Center, 2101 Nasa Parkway  
Houston, TX 77058-3696  
Org./Buyer: BH2/Michael Ballard

Tel No.: 281-244-5350 Fax: \_\_\_\_\_  
E-mail: michael.d.ballard@nasa.gov

4. Ship To:  
Transportation Officer, Building 421  
NASA Johnson Space Center  
Houston, TX 77058-3696  
Mark For: **Accountable Property**  
Order No.: DO-CRAVE-EC5-002 Rev. 2

5. Contractor:  
Hamilton Sundstrand Management Services  
2200 Space Park Drive, Suite 100  
Houston, TX 77058

Phone: 281-336-6309 x \_\_\_\_\_ Fax: 860-660-6898  
TIN: 06-1165866 CAGE CODE: 71120

6. Deliver On or Before: 3/28/06  
F.O.B. Point: Destination  
Discount Terms: Net 30 Days.

7. BILLING ADDRESS:  
NASA Johnson Space Center  
Attn: LF231/Accounts Payable Group  
Houston, TX 77058-3696  
Order No.: DO-CRAVE-EC5-002 Rev. 2

8. Type of Order:  
 PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: NNJ05HB39B

9. Written acceptance of this order by contractor  is,  is not required. Sign below if required and return to contracting officer.

Name: Lynn M. Rollins (Person authorized to sign)  
Signature: [Signature] Date: 11/10/05

10. Name: N. L. Dawn Alexander

Signature: [Signature] Date: 11/10/05  
CONTRACTING OFFICER

## 11. Schedule

ITEM NO.	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	<p>The contractor shall perform and delivery all requirements for:</p> <p>DO-CRAVE--EC5-002: Advanced Space Suit and Portable Life Support Subsystem (PLSS) Packaging Design Study.</p> <p>This is revision 2 to this delivery order. The purpose of this revision is to:</p> <p>1. Extend the period of performance to 3/28/06.</p> <p>2. Modify the SOW. Changes are vertically bar-marked and a replacement page is attached.</p> <p>3. Increase delivery order value from: <u>b4</u> by <u>b4</u> to <u>b4</u></p>					

12. For JSC Internal Use Only:

Requisition No.: \_\_\_\_\_  COMP.  PART. PPC: \_\_\_\_\_  
Rissue To: Gretchen Thomas/EC X37664

13. Total  
\$ 770,739.55

14. Quantities in "Quantity Accepted" Column Have Been  
 INSPECTED  ACCEPTED  RECEIVED

TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED.

BY: \_\_\_\_\_

Authorized U.S. Government Representative

Date \_\_\_\_\_

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-002**

**DO TITLE:** Advanced Space Suit and Portable Life Support Subsystem Packaging Design Study

**DO Type:**  CPF  FFP

**DO Contact Information in Addition to the CRAVE Contract Specialist or CO:**

**COTR:** Joe Gensler Phone (281) 483-0025

**DO Manager:** Gretchen Thomas Phone (281) 483-7674

**DO Alternate:** Michael Rouen Phone (281) 483-9242

**Concurrences:**

<u>(original signed)</u>	<u>(original signed)</u>	<u>(original signed)</u>
<b>Gretchen Thomas</b>	<b>Craig Dinsmore</b>	<b>Joe Gensler</b>
<b>DO Manager</b>	<b>DO Mgr. Management</b>	<b>COTR</b>

<u>(original signed)</u>	<u>(original signed)</u>	_____
<b>B. Michael Lawson</b>	<b>Steve Miller</b>	
<b>Division TMR</b>	<b>S &amp; MA</b>	

**Task Contains Flight Hardware, Flight Software or GSE?**  Yes  No

**Program Supported:**  Shuttle  ISS  EVA  Advanced Spiral 2

**WBS:**  1.0 EVA  2.0 FCE  3.0 EVR  ECLSS  5.0 ATCS  6.0 ChCS

*For purposes of complying with FAR 52.232-22, Limitation of Funds, the total amount allotted by the Government to contract is specified in clause B.6, Contract Funding. The funding listed in B.6 is the amount allotted for all Delivery Orders on the contract combined.*

*All terms and conditions of the contract apply to this Delivery Order. In the event of a conflict between the contract and this Delivery Order, the contract shall prevail.*

*WBS reporting shall be done in accordance with applicable WBS reporting categories, as shown above and in the contract within Section C, Table 1.*

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-002**

**Narrative Task Description**

**Background / Problem Description:**

**Packaging Definition**

For this study, Portable Life Support Subsystem (PLSS) packaging is defined by the following ground rules.

1. Any item performing a major, useful life support function is a component to be packaged and is not packaging. Examples are oxygen bottles, radio, sublimator, battery, sensors, and regulators. Components are those things that show up on a PLSS schematic such as that shown in Figure 1.
2. Harnesses, connectors, switches, brackets, wiring, and plumbing are packaging.
3. Structure is packaging, even in such special cases as the Shuttle valve module housing, which is a module that cartridge mounts several components and provides the interconnections for them.

For this study, the PLSS consists of both the primary and the back up life support systems necessary to maintain a fail safe design.

**Packaging History**

In the history of human space flight there have been three PLSS packages designed and flown, the Apollo PLSS, the Shuttle PLSS and the Russian ORLAN PLSS. The Apollo PLSS was a weight constrained design and it led to the package shown in the following PDF scanned from the Hamilton Standard Apollo PLSS mini data book. (See Technical Library: Apollo\_PLSS\_Packaging\_.pdf)

The Apollo PLSS packaging was a weight constrained design. In the Apollo PLSS package, the water tank formed the upright leg and the LiOH cartridge formed the horizontal leg of a "T" structure that was the structural backbone of the package. As the Apollo program progressed, there was a major change to go from a four hour capable PLSS to an 8 hour capable PLSS. The LiOH cartridge could accommodate the longer duration by using the same amount of a more efficient LiOH, but the water tank could not hold the additional water needed. Increasing the water tank size required the addition of an auxiliary reservoir to the side of the PLSS.

The Shuttle PLSS was a volume constrained design which led to the packaging shown in the following PDF file scanned from the Hamilton Sundstrand, NASA Extravehicular Mobility Unit (EMU) LSS / SSA Data Book. (See Technical Library: Shuttle\_PLSS\_Packaging\_.pdf)

This design was done with the thought that changes in duration requirements as experienced in Apollo should be easy to accommodate. Consequently, the package was laid out so that the time

dependent items were separate from the time independent items. The package also had the requirement that it be maintainable on the ground between flights. This led to the valve module with its cartridge mounted components. The need for flexibility has also been experienced in the Shuttle program. To accommodate use on the ISS, the PLSS CO<sub>2</sub> absorption system was changed to be a regenerable system (METOX) and the battery was upgraded for additional wet shelf life. Both of these components were on the outside of the package; and therefore, could grow in one dimension to allow those changes at the expense of changing the front to back allowable dimension. In addition, in-flight maintainability has been added by the addition of captive fasteners to the ground maintainable components. But again, in the Shuttle package, the water tank forms the backbone of the structure and a major change in thermal control system would require the package design be significantly redesigned or abandoned for a new design.

### **Prior Studies**

Two key studies<sup>1</sup> concerning the impact of packaging on system weight have shown that PLSS packaging weighs from 50% (Orlan-DMA backpack and unit) to 130% (Shuttle PLSS and SOP) as much as the components packaged. The Apollo PLSS packaging weighed 70% of the components packaged. Here the PLSS is taken to be both the primary and emergency portable life support systems. In a Pareto diagram (Figure 2), packaging is the leading contributor to system weight. This fact led NASA to address packaging as a technology that needed development for the specific purpose of reducing its weight.

A key consideration in the design of a packaging arrangement is how the system will be maintained. A Prior study<sup>2</sup> by Landis, Simonds and Stinson provides guidance concerning maintainability.

An in-house design study<sup>3</sup> was accomplished by NASA in the 1998 time frame to seek ways to reduce the weight of PLSS packaging, and at the same time, develop a packaging scheme that would make PLSS technology changes less costly than the current packaging methods. Experience over time shows that the exact technology change needed cannot easily be predicted. Consequently, there is a need to avoid packaging methods that embed a particular schematic, such as the Apollo and Shuttle embed the water based thermal control technology by making the water tank the structural backbone. If light weight is a consideration though, it is difficult not to use the structure of one or more of the components as the package structure. For this reason a major effort in the in-house design study was to be creative in how packaging for a PLSS is

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<sup>1</sup> *Packaging Factors for Portable Life Support Subsystems Based on Apollo and Shuttle Systems*, Gretchen A. Thomas, 23<sup>rd</sup> ICES, Colorado Springs, Colorado, July, 1993, 932182 and *Space Suit Life Support System Packaging Factors*, I.P. Abramov, R. K. Sharipov, A.I. Skoog, and Nikolaus Herber, 24<sup>th</sup> ICES, Friedrichshafen, Germany, June, 1994, 941380

<sup>2</sup> "In-Flight Maintainability for an Advanced Extravehicular Mobility Unit: Key to System Availability." Phillip A. Landis, Charles H. Simonds, Richard G. Stinson, 24<sup>th</sup> ICES, 1994, 941554.

<sup>3</sup> The design methods and results used in that study are documented in "PLSS Packaging Design." Michael Rouen, ICES 1999-01-1994. The Mock-up design and development are documented in "Advanced Spacesuit Portable Life Support System Packaging Concept Mock-Up Design & Development," Mary K. O'Connell, Howard G. Slade, Richard G. Stenson, ICES 1999-01-1995

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accomplished. A functional decomposition was accomplished to define just what a PLSS packaging design is required to do. Overall PLSS packaging must:

**Protect, Connect and Hold the PLSS and its components together internally and externally while providing access to PLSS components internally for maintenance and for technology change without extensive redesign impact.**

This is both a concise statement of PLSS packaging functionality and a statement of a key requirement to allow low cost schematic flexibility. During the study, 15 concepts were generated, and using two rounds of the Decision-matrix<sup>4</sup> method, the most promising concepts were reduced to three. No further progress could be made using the Decision-matrix method to discriminate between the remaining three concepts, so it was decided to build mock-ups of each concept (Figure 3). This was done and followed by another round of the Decision-matrix method based on the experience gained from building the mockups. From this effort, the final concept was decided to be a combination of the mother-board and foam concepts. This combination of the mother-board and foam concepts is called the Flex PLSS and is the starting point for this study.

### **PLSS Interfaces**

From a packaging stand point, the PLSS primary interface is with the rest of the suit system. The PLSS will be mounted to the back of the suit or distributed on the suit in some other fashion, and the suit is planned to be a back entry suit, making the hatch of the suit the PLSS front wall. There is no constraint on the hatch structure other than those associated with making the connection interfaces (latch dog arrangement and shape), so the hatch web could be hard or soft as works out best for PLSS packaging. The PLSS package must be able to allow rotation of the hatch without the PLSS hitting the suit system in such a manner that a sufficient opening to the hatch area is not available. The hatch must rotate at least 90 degrees and larger rotations are potentially desirable. The PLSS must not interfere with suit arm mobility, so there are surfaces on each side of the suit that are suit design dependent forming an exclusion zone as illustrated in the figure below of the "Angel Wings" on the Mark III Suit Frame.



"Angel Wings" on the Mark III Suit Frame

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<sup>4</sup> See Ullman, D. G.: *The Mechanical Design Process*, McGraw Hill, 1992, chapter 8

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The PLSS packaging concept must also support interfaces for PLSS and suit system controls. Consequently, intrusions into the exclusion zone will purposely be made to allow gloved hand actuation of controls.

The second most significant interfaces the PLSS must accommodate, along with the rest of the space suit system, are interfaces with mounting provisions on airlock walls, rover seats, and vehicle storage areas. These loads are significant and it is not apparent that the proper load path is through the PLSS. The proper load path is probably through one or more of the rings illustrated in gray in the above figure with the leading candidates being the ring at the hatch latch dog area and the waist area ring. In each case, the PLSS packaging technique must accommodate lead-ins and guides that allow a crew person in the suit to insert the PLSS into the attachment mechanism and have the PLSS guide the suit system to the proper place for final attachment.

### **New Technology Applicable to the Design of Advanced space suit and Flex PLSS Packaging**

Considerable new technology has become available to aid the design of the intended advanced space suit and Flex PLSS concept.

Solid modeling software enables the design of the flexible supports by allowing the subtraction of part models from the flexible support model so the complicated shape of the flexible support needed to hold a part can now be easily generated. The desired tool of this type for use on this study is Pro E.

Packaging design using foam as an energy absorber is a handbook<sup>5</sup> process when packaging for shipping is concerned. But even in this well developed field, new insights and techniques coming from better understanding of cellular solids are available. Specifically, the methods of design using the energy absorption diagram contained in *Cellular solids Structure and properties*, Second edition, Lorna J. Gibson and Michael F. Ashby, Cambridge University Press, need to be investigated.

Also of interest to the analysis of a packaging arrangement are finite elements modeling tools. Both the general tools available through Pro E, and specially designed tools need to be investigated. Specialty tools of interest come from the automobile industry, which has made progress in the analysis of low speed impact situations, which is the class of problems that PLSS packaging design is a part of. These tools may not only aid the design process, but may shorten the testing needed to recertify a packaging design after a new technology has been inserted.

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<sup>5</sup> See for example: *Package Cushioning Design*, MIL-HDBK-304C, 1 June 1997. *Theory and Practice of Cushion Design*, SVM-2, by Gordon S. Mustin, 1968, The Shock and Vibration Information Center United States Department of Defense. *Fundamentals of Packaging Dynamics*, Richard K Brandenburg, Ph.D., and Julian June-Ling, Ph.D., School of Packaging Michigan State University, 5<sup>th</sup> Edition, 1993, L.A.B

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**New Challenges Applicable to the Design of an Advanced Space Suit and Flex PLSS Packaging**

Exploration operating environment brings significant differences to the problem as compared to an earth based application. Specific environments of concern are the extreme cold (affect the material's dynamic response), varying pressure (vacuum to earth normal), abrasive lunar and fine Martian dust and oxygen emersion as the result of system recharging or failure cases. All of these environmental considerations place constraints on the choice of materials to be used in the flexible elements of the packaging design. Consequently, the extensive base of materials data used for earth based design may have to be extended.

In addition, the need to maintain the system in the use environment as opposed to the current ground based laboratory environment brings added challenges to the packaging design.

**Purpose of Current Effort**

The current effort has a two fold purpose. It is to:

1. Bring the Advanced space suit integrated Flex PLSS concept from its current state of development to a PDR and build a proof of concept mockup of the proposed design, and
2. "Design" the Design Process of how to design a Flex PLSS and how to design the modifications of a package to accommodate new technology and upgrade the proof of concept mockup with a design change using the process. As part of the evaluation process for the Design Process task, the contractor shall demonstrate the use of a non-linear dynamic analysis for an impact case.

The latter effort must specifically consider the impact of new design tools and methods such as analysis tools and better understanding of materials. So this procurement is not only for a design but for a design process that is well documented and available for use in the future.

**Task Description:**

**Process to be Followed**

**Form Design Teams**

Two interdisciplinary design teams are to be formed. One, the Advanced Space Suit and Flex PLSS PDR Team, is to be an interdisciplinary design team that has the personnel needed to bring the Advanced Space Suit Integrated Flex PLSS to a PDR level. The second team, the Design Process Team, is also to be formed as an interdisciplinary team with minimal but key overlap with the Flex PLSS PDR Team. The contractor is to plan to accomplish the entire job without dependence on NASA effort. NASA effort will provide operational experience and additional depth of study but shall not be planned into the critical path to accomplish the study requirements. The potential availability of Government participants for these two teams is described in the Appendix.

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### **Develop Tasks Assignments**

Tasks assignments must be made for each team with the Flex PLSS PDR Team leading off first. Since the exact nature of the expertise potentially available from NASA is needed in order to do a complete plan, an adjustment to the plan provided in the contractor's bid is expected to formalize the NASA participation. This planning adjustment shall not affect the scope of the contractor's work, but can increase or decrease the scope of NASA participation from that included in the bid plan tasks.

### **Schedule Project**

Two separate but interrelated schedules are to be developed. The Flex PLSS PDR Team schedule will lead the Design Process Team schedule by at least a month so that the problems of how to design can be experienced by the Flex PLSS PDR Team before the Design Process Team begins work. Since the exact schedule availability of the expertise potentially available from NASA is needed in order to do a complete plan, an adjustment to the plan schedule provided in the contractor's bid is expected to formalize the NASA participation. This schedule adjustment shall not affect the scope of the contractor's work but can increase or decrease the scope of NASA participation from that included in the bid plan tasks.

### **Form Teams**

Team composition shall be based not only on the technical expertise needed but with due considerations for the different roles<sup>6</sup> needed to form an effective design team. The design teams are to be limited in the number of people to those who are required to form effective teams. The teams shall solicit the input of expertise outside the team as needed to accomplish the task at hand.

### **Define the Problem**

Success of a design process depends heavily on good problem definition, which is not a trivial exercise. As a minimum, the following steps shall be accomplished to well define the problem of Advanced Space Suit Integrated PLSS Packaging Design.

### **Review Prior Work**

The following prior work shall be reviewed as needed to begin the process of understanding the problem. Where entirely new technology or techniques have come to fore, this study is expected to address those issues. Consequently, this review task is expected to be a task of limited scope.

1. NASA in house study leading to the Flex PLSS concept
2. *Cellular solids Structure and properties*, Second edition, Lorna J. Gibson and Michael F. Ashby, Cambridge University Press sections associated with the energy absorption diagram method of cushion design.
3. Traditional Packaging Design Methods

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<sup>6</sup> For example see 3.5.2 *Team Roles*, Page 55 of Ullman's Second Edition.

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4. Other prior work as identified by the contractor.

### **Develop PLSS Interfaces and Operational Modes that Affect Packaging**

In the Background section above, the PLSS interfaces have been described in general terms. The purpose of the interfaces part of this task is to firm up those interfaces to the extent necessary to accomplish a packaging preliminary design. The second part of this task is to understand / generate the operational modes of the PLSS sufficiently to drive out the impacts of those modes on the packaging design. For a starting point in understanding the operational modes of a PLSS, use the following studies:

1. "Extravehicular Activity at a Lunar Base," September 1988
2. "Extravehicular Activity in Mars Surface Exploration," May 1989

The Shuttle PLSS schematic shall be used as the schematic that is being packaged. This gives a well known set of components and component interfaces to work with so that a realistic packaging effort can be accomplished. Not all of the components can be used without adjustment. For example, the water tank is not applicable since it is built into the packaging. In such cases a simple straight forward PDR level redesign of that component will be done for use in this effort.

### **Update the Functional Decomposition**

For the Flex PLSS PDR task, the function decomposition accomplished during the NASA in-house study shall be updated and tiered down to drive out "what" is needed to complete the PLSS packaging design. This decomposition is specifically done without regard to "how" the functions are to be accomplished. The purpose of the functional decomposition is to break the problem down in a way that generates the greatest understanding of the PLSS packaging design and forms a basis to allow the generation of creative solutions for the ways to accomplish those functions.

For the design process task, a "process decomposition" shall be accomplished to drive out and define all of the design and analysis tasks that must be accomplished to complete a Flex PLSS design through hardware certification. The decomposition is specifically done without regard to "how" the task is to be accomplished. The purpose of the process decomposition is to break the design process down in a way that generates the greatest understanding of the packaging design process and forms a basis to allow the evaluation and generation of creative solutions for the way to accomplish the task.

### **Develop Specifications**

As a basis for the customer specification, the Advanced Technology Space Suit Design Requirements Document, July 1999 shall be used. This specification shall be reviewed and those portions of it applicable to this effort updated as necessary. The customer specification captures the specifications generated by the end use of the PLSS.

  
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For the Flex PLSS PDR task, Engineering “Mini specifications” shall be prepared for each function that must be met to “tier down” the customer specification to the measurable, verifiable specifications needed for engineering design of the Flex PLSS packaging. These specifications shall capture the essence of the engineering requirements for any functional component or subsystem that satisfies the functional need. Except in rare cases, these specifications shall be contained on one page for each function.

For the design process task, a process specification shall be generated that defines the requirements of the design process. One element of this specification is that a redesign of a package shall not require more than 25% of the effort required for the original design of the package and, as a goal, no more than 10%.

### **Develop Evaluation Criteria**

For the Flex PLSS PDR task, evaluation criteria and their rankings shall be developed prior to the effort to generate concepts for solutions to the various design problems so that the figures of

merit for concepts are well understood by those who generate the concepts and to avoid the pitfall of subliminally designing selection criteria that favor particular concepts. In terms of criteria ranking, safety (both flight and ground operational), shall rank first. Another criterion that must be used is the ability of the concept to support flexibility and commonality.

For the design process task, evaluation criteria shall also be generated although it is recognized that these criteria will be more general and not subject to traditional engineering analysis since they are more about how to do good engineering than how to do a specific design. The ability of the design process to be used in non NASA applications shall be used as a criterion for the design process effort.

### **Develop Concepts**

The basic premise is that to find a good idea of how to accomplish a function, many ideas must be generated. So a divergent convergent path is planned.

### **Search for Function Satisfying Ideas**

For the Flex PLSS PDR task, this activity is meant to be a primary place where creativity has a chance to happen at the functional level. The idea is to generate as many concepts as possible for each of the lowest level functions identified in the functional decomposition. A concept is an idea that is sufficiently developed so that its behavior in the intended use can be evaluated.

For the design process task, this activity is also meant to be a primary place where creativity has a chance to happen at the process task level. The idea is to search for multiple ways and tools to accomplish a process task.

### **Generate Concepts**

For the Flex PLSS PDR task, this activity is meant to be the primary place where creativity has a chance to happen at the PLSS packaging level within the bounds of the over all Advanced space suit integrated Flex PLSS concept. For this activity a concept is a combination of the concepts generated to satisfy each function which is capable of accomplishing the entire PLSS packaging job. System level considerations shall be used to keep the number of concepts within bounds.

For the design process task, this activity is meant to be the place where the various design tools and methods are brought together into a complete process. Issues of data transferability and compatibility between tools etc. are expected to be addressed at this task level. Again, system level considerations such as design time efficiency shall be used to keep the number of concepts within bounds.

### **Document Concepts**

Since there is expected to be a range of technological maturity in the concepts (i.e. the concepts currently in use in flight systems versus a wholly new concept that is the result of a creative search), it is important that all concepts be described and documented to a similar degree for comparison purposes.

For the Flex PLSS PDR task, at the functional concept level a Failure Modes and Effects Analysis (FMEA) will be generated for each viable concept. For the PLSS packaging level, a FMEA will be generated using as a basis all of the functional concept level FMEAs and including system interactions so that the safety of each packaging concept can be judged. As concepts are being generated, the FMEAs are expected to be a design tool; consequently, they must be generated early in the process. Although the FMEA is usually thought of as a hardware related tool, the basic concept is still applicable to the design process task. The design process concepts must be analyzed to identify where a failure to enter correct information, select correct software modes, etc. could lead to a design that is unsafe. This analysis would be an impossible job if every possible path in a complicated software package such as a finite element package had to be analyzed, but that is not the intent. The intent is to stay at the process level and search for possible unsafe failure modes.

### **Evaluate Concepts**

Criteria are expected to lend themselves to two types of comparison to requirements, absolute and relative. Where the criteria are to be evaluated in a relative manner, the Decision-matrix<sup>7</sup> method shall be used. Several rounds of evaluation are expected both at the lower function level and at the PLSS level for the Flex PLSS Preliminary Design Review (PDR) task and at the process level for the design process task.

### **Design Iteration**

Following completion of the design process steps described above, the contractor shall repeat the following process steps for a subset of three packaging concepts as determined by the first round

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<sup>7</sup> Guidance on how to use the Decision-matrix method is contained in Ullman, 2<sup>nd</sup> Edition, Chapter 8.

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of evaluation. Step 3 (Generate Concepts) and Step 4 (Document Concepts) shall be supported by detailed structural, impact, and thermal analyses (see list below) sufficient to allow objective evaluation of the Evaluation Criteria

1. Develop Concepts
2. Search for Function Satisfying Ideas
3. Generate Concepts

The purpose of this iteration is to refine the three concepts as determined by the first round of evaluation, and to create more detailed engineering models of the concepts such that they can support the detailed analyses to be performed.

4. Document Concepts

The supporting analyses includes CG determination, insulation and thermal conductance properties, level of impact protection, weight, and volume.

5. Evaluate Concepts

The purpose of this iteration is to down-select from three concepts to a final one concept.

### **Select and Present Concepts**

For the Flex PLSS PDR task this involves taking the output of the Evaluate Concepts task above and selecting the final concept that provides the path to proceed. The effort to prepare the PDR documentation package and respond to any PDR Review Item Discrepancies (RIDs) is also part of this task.

For the design process task this involves taking the output of the Evaluate Concepts task above and selecting the final design process arrangement. The effort to prepare the process specification document is part of this task.

### **Build a Mockup of the Chosen Design**

A mockup of sufficient detail to illustrate the viability of the chosen designed PLSS packaging shall be built and demonstrated at the Contractor's facility. This mockup shall also be brought on-site (in accordance with contract procedures; i.e. use of Form 1149 and process through Building 421) demonstrated at NASA JSC at the Revised Concept Design Review, or as otherwise agreed to by NASA and the Contractor. PLSS components are not expected to be of their expected final materials but every attempt to use the selected materials for the flexible elements shall be made. Any testing of the mockup by the contractor is to be informal engineering testing. NASA may choose to subject the mockup to informal vibration and shock testing after completion of this DO.

### **Change a Major Technology and Repackage**

Because the Flex PLSS PDR task precedes the Design Process task, it is not expected that the selected design process will have been used to arrive at the Flex PLSS PDR packaging solution. In order to exercise the selected design process, at the time of the PDR, NASA will select one of the major systems for a technology change. That technology change shall be brought up to a PDR level using the chosen design process and a second PDR held with PDR documentation and RID closure as required. The mockup, discussed above, will then be upgraded as called out by

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the design change. A review of the functioning of the design process will be accomplished and documented as part of the final report. The final designed mockup shall be delivered to NASA JSC in accordance with contract procedures and Form DD 250.

**Questions to be Addressed within the Performance of this DO**

How can a Flex PLSS be put together such that it does not become a three dimensional puzzle to reassemble after an in-spacecraft disassembly for maintenance?

What criteria are used to decide which components are hard mounted on the mother board and which are flexibly mounted?

Where is the best place for the motherboard? Between the PLSS and suit seems the obvious place but, since there is possibly a need to harden the shell to protect the radiator and enclose the flexible items, might the shell be a location for the motherboard? Is there any other not so obvious place that may be best?

In the dusty lunar and Martian environments, how can the components be kept from being sanded to destruction by the rubbing of the flexible mounting against the components with dust acting as an abrasive? Is it better to have the foam be a little bit sticky and so attach to the components and avoid any rubbing?

How is heat dissipation accommodated for a component that is flex mounted? How is heat dissipation accommodated for in a component that is mother-board mounted but surrounded by flexible mounting on all but one side?

What part, if any, does "wireless" instrumentation play in or become a requirement for success of the Flex PLSS concept?

How are the flexible mounting elements affected by the pressure cycling of airlock traverses?

How do we handle crash loads, which are often the structural sizing loads? Should components be strong enough to handle crash loads or can the components be fragile and packaging protect them from the crash loads? Ideally, both should not have to handle the crash loads but that is what is done now. Crewmember slips trips and falls (the number one safety issue on earth) may become the structural sizing case if the crash load case during launch is avoided by putting the hardware in lockers or does not turn out to be the sizing case. How should the Flex PLSS flexible packaging be designed for this case? Is there need for a trade off between making the components or system robust enough to handle this case or could the use of an air bag concept be used to protect from this case? Is the radiator a natural impact absorbing structure or should it be designed to be impact absorbing?

Is it advantageous or potentially damaging to use inflatable soft mounting (either gas inflated or closed cell foam that inflates with decreasing pressure) to hold components in place?

How does the design support maintenance in the "use environment" (in space on the lunar surface)? How much time is required for access to each maintenance item?

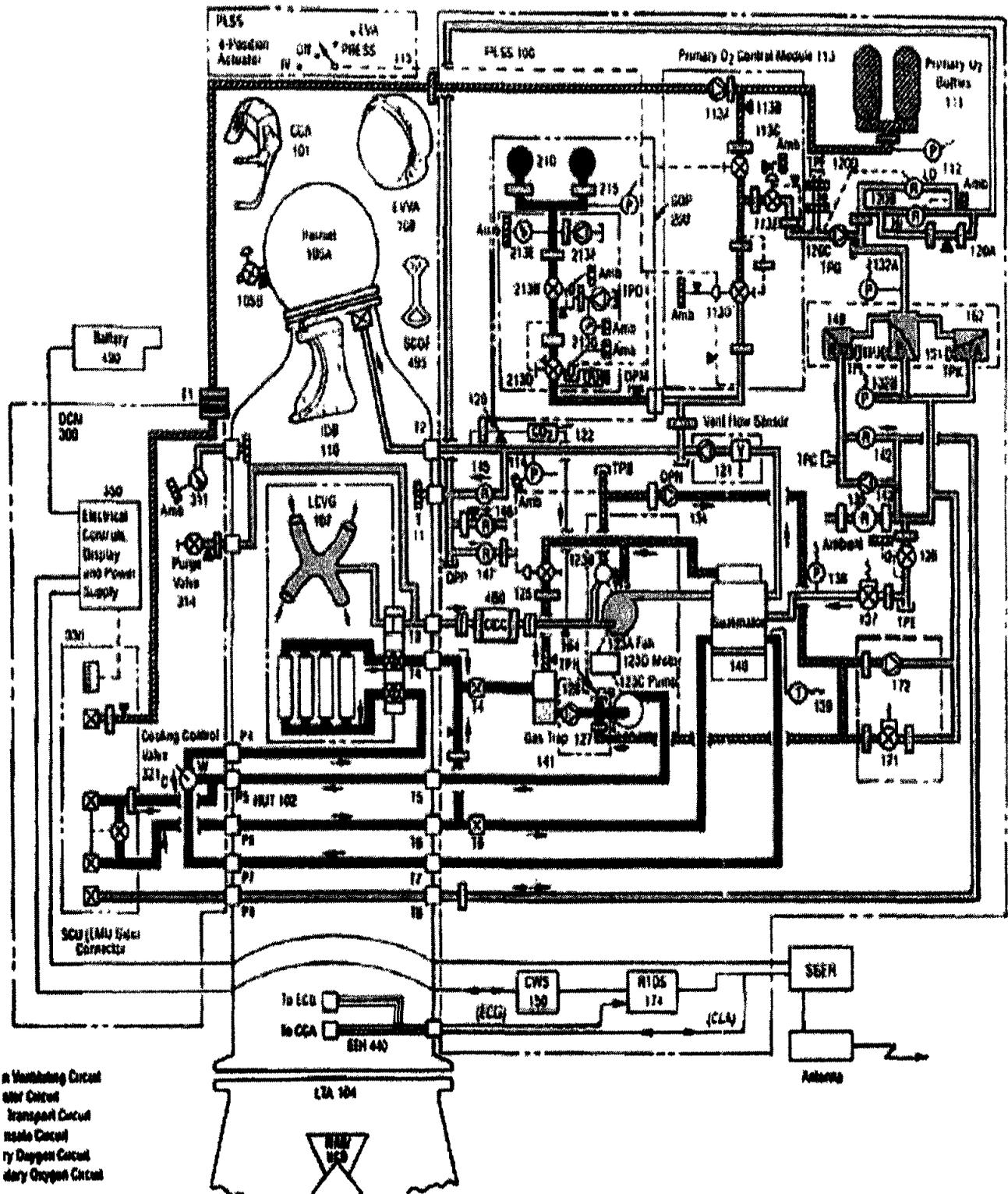
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**Appendix**

<b>Potentially Available NASA Background and Expertise</b>
<p>Experience as group lead for NASA for advanced PLSS technology. Expertise in Systems Engineering &amp; Integration, ventilation and thermal technology; 10+ years experience as NASA project manager for advanced and flight systems. Experience acting in the shaper role on design teams.</p>
<p>Experience as PLSS group lead for NASA during the development of the Shuttle EMU. Approximately 20 years experience as Lead of PLSS Advanced Technology efforts. Possession of at least 25% proficiency in Pro E modeling. Experience as Leader of NASA in house concept selection effort and expertise with significant study of design methods including techniques to foster creativity. Experience acting in the coordinator role on design teams.</p>
<p>Experience as mechanical designer of flight hardware for 25 years. 70% proficient in Pro-E modeling. Familiarity with design standards, drawing control, model control, NASA's Design and Data Management System (DDMS) Expertise in secondary role on design team as "Implementer" or as "Shaper" and "Team Worker" roles and able to work in the "Completer-Finisher" role.</p>
<p>Experience with design of various payload and EVA tools and equipment, EVA systems engineering, integration of space suit with vehicle, EVA operations and training, human/robotics interaction, advanced EVA concepts and designs, use of advanced technologies in EVA systems, and Design team roles, such as: Creator, Resource-investigator, Monitor-evaluator</p>
<p>Experience with Advanced EVA for approximately 9 years, including insulation testing and research, airlock concept development, and PLSS packaging concepts. Experience as lead for the PLSS ventilation system. Experience in all design team roles, including a coordinator, shaper, or implementer.</p>

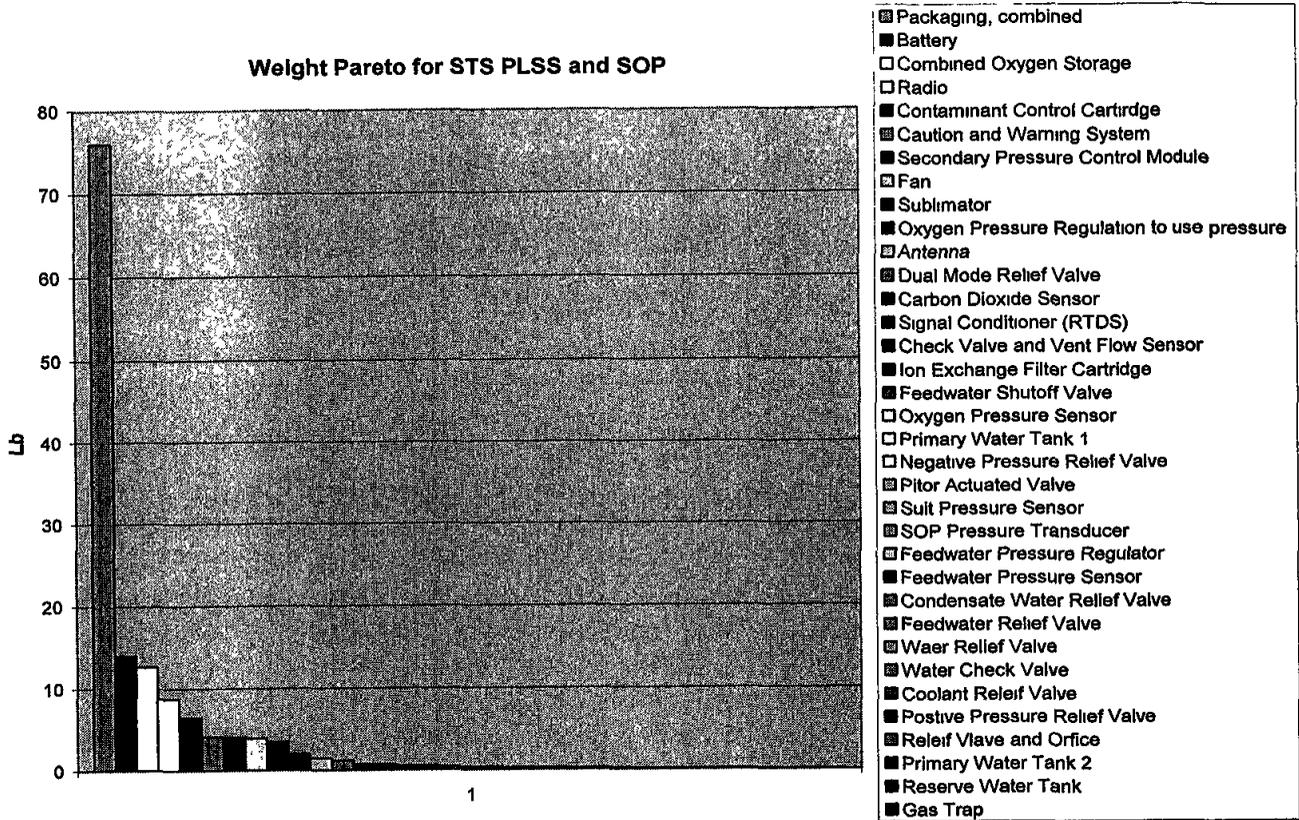
**Note: Please refer to specifics concerning Potentially Available NASA Expertise in the above "Process to be Followed" section, within this DO.**

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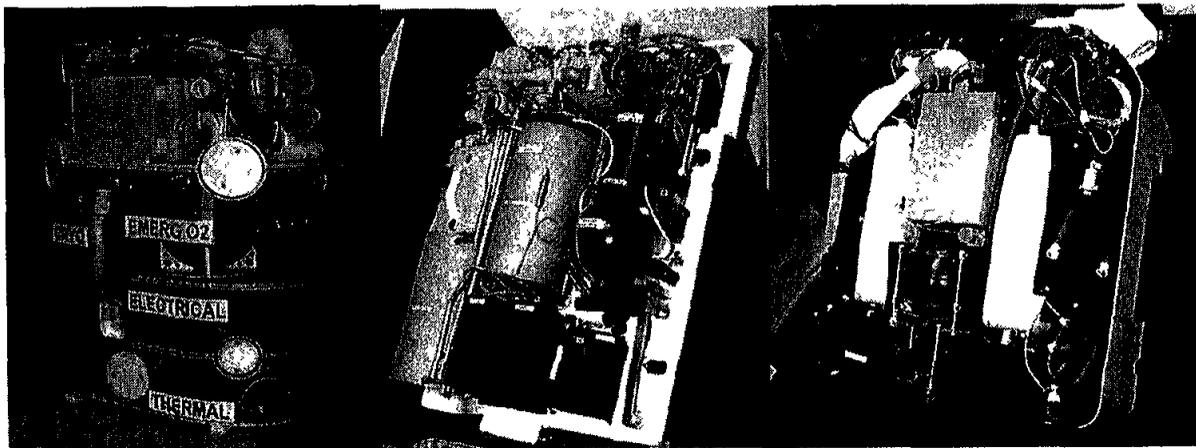


**Figure 1 - Shuttle EMU Schematic**

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**Figure 2 - Shuttle PLSS Weight Pareto Diagram**



**Figure 3 - Mock Ups of Lego, Mother Board and Foam PLSS Packaging Concepts**

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**Technical Library Contents --**

- Advanced Technology Space Suit Design Requirements Document, July 1999
- "Extravehicular Activity at a Lunar Base," September 1988, ESSEX Co., NAS 9-17779
- "Extravehicular Activity in Mars Surface Exploration," May 1989, ESSEX Co., NAS 9-17779
- PLSS Packaging Study 12-01-04ForDO.mpp

**Deliverables/Products:**

<b>Product</b>	<b>Description</b>	<b>Qty</b>	<b>Due</b>	<b>Class</b>
<b>Hardware</b>				
Mock Up	High fidelity mock up of the Flex PLSS which starts in the base line design configuration and is transitioned to the revised design configuration during the effort.	1	At Completion	
<b>Other Products</b>				
Base Line Concept Report	A report for a base line design advanced space suit integrated Flex PLSS packaging.	1		
Revised Concept Report	A report for the revised design advanced space suit integrated PLSS packaging incorporating a major technology change.	1		
Final Report for Flex PLSS PDR Task	Flex PLSS PDR Task Final Report describing all effort and including all technical analysis accomplished. The report must address: (1) the questions listed above and others generated during the study (2) commonality analysis task accomplished (3) information needed to upgrade the mission study support tool (EVASSAT) that is used to support advanced mission and vehicle studies to include packaging weight and volume.	1	At Completion	

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<b>Product</b>	<b>Description</b>	<b>Qty</b>	<b>Due</b>	<b>Class</b>
Final Report for Design Process Task	Design Process Task Final Report describing all effort and including all technical analysis accomplished. The report must also include: (1) Reports on applicability of various design tools and why particular tools are recommended for use in the design process (i.e. low speed crash software from auto industry, Pro E tools, others identified during the design process task.). (2) An assessment of how well a dynamics design tool can be calibrated by test and then used to certify other cases of impact and vibration loads. Specific guidance on how much testing is required and how much deviation from the test cases can be accommodated by the dynamics design tool to accomplish certification by analysis (3) an analysis of the functioning of the design process as experienced during the technology change task.	1	At Completion	
Packaging Design Process document	A well documented design process using non proprietary tools.	1	At Completion	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-002**

**SCHEDULE**

**Start Date: April 21, 2005**

**Finish Date: March 28, 2006**

<b>ITERIM MILESTONES</b>	<b>DUE DATES (Weeks after ATP)</b>
<b>Kick Off Meeting</b>	<b>1</b>
<b>Flex PLSS PDR Task</b>	
<b>Problem Definition Review</b>	<b>4</b>
<b>Concept Design Review</b>	<b>36</b>
<b>Revised Concept Design Review</b>	<b>43</b>
<b>Design Process Task</b>	
<b>Problem Definition Review</b>	<b>8</b>
<b>Concept Design Review</b>	<b>40</b>
<b>Final Documentation</b>	<b>46</b>
<p><b>Milestones, along with subjective measurements, are to be used for measuring performance. For schedule detail see Microsoft Project file located on the CRAVE web site for this DO listed under the Government Cost Estimate below.</b></p>	

**Government Estimate Located in RFQ File in Microsoft Project File On CRAVE Web Site  
The file is titled: PLSS Packaging Study 12-01-04ForDO.mpp**

**Total Government Estimate for this DO: \$ 430 K**

**Option 1: \$ N/A (See Attachment 1)**

**Option 2: \$ N/A (See Attachment 2)**

**TOTAL COST ESTIMATE FOR THIS DO: \$693,895.36**

**FEE: \$76,844.19**

**OPTION 1: \$ N/A (See Attachment 1)**

**OPTION 2: \$ N/A (See Attachment 2)**

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-002**

**DATA REQUIREMENTS**

**NOTES: 1. GREY SCALED ROWS NEED NO ADDITIONAL/REQUIRED FILL-INS.  
2. ON ALL OTHER ROWS, IF NECESSARY, FILL IN ADDITIONAL  
RQMTS/DELIVERIES IN LAST COLUMN.**

DRD #	DATA TYPE	DRD TITLE	DUE	FREQUENCY	REQUIRED FOR DO? Y/N	COMMENTS
1	Written Approval	FlightGFE Configuration Management Plan	With Proposal	Once	Attachment J-8	
2	Mandatory Submittal	Regular Status Report/ Summary Review	Thirty (30) days following contract start	Monthly	Y	
3	Written Approval	Project Technical Requirements Specification	If Required for DO See Comments	Once with Revisions	Y	Informal specifications as described in the SOW
4	Mandatory Submittal if Flt H/W	GFE Systems Requirements Data Package	If Required for DO See Comments	Once with Revisions	N	
5	Written Approval	Flight GFE Projects Requirements & Verification Document	If Required for DO See Comments	Once with Revisions	N	
6	Mandatory Submittal if Flt H/W	Preliminary Design Review Data Package	If Required for DO See Comments	Once with Revisions	Y	The concept design reviews shall include all documentation called for in a PDR except flight hardware approval rigor is not required.
7	Written Approval	Flight GFE Workmanship Specifications List	If Required for DO See Comments	Once with Revisions	N	
8	Written Approval	Project Schedule	PDR or 10% effort complete Milestone	Once w/Revisions (due w/DO proposal, updates & details provided as DO progresses)	Y	
9	Written Approval	Flight GFE Interface Control Document	If Required for DO See Comments	Once with Revisions	N	
10	Written Approval	GFE End Item Specification	If Required for DO See Comments	Once with Revisions	Y	Informal specifications as described in the SOW
11	Mandatory Submittal if Flt H/W	Flight GFE Failure Analysis Report	If Required for DO See Comments	As Required	N	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-002**

<b>DRD #</b>	<b>DATA TYPE</b>	<b>DRD TITLE</b>	<b>DUE</b>	<b>FREQUENCY</b>	<b>REQUIRED FOR DO? Y/N</b>	<b>COMMENTS</b>
12	Written Approval	Flight GFE Verification and Validation Plan	As Specified in EA-023	Once with Revisions	Y	Informal verification planning as needed to define the design process and how analysis are used in the certification process
13	Written Approval	GFE Software Requirements Specification	If Required for DO See Comments	Once with Revisions	N	
14	Written Approval	GFE Software Development Plan	If Required for DO See Comments	Once with Revisions	N	
15	Written Approval	GFE Software Design Document	If Required for DO See Comments	As Required	N	
16	Written Approval	Engineering Drawings	If Required for DO See Comments	Once with Revisions	Y	Without flight hardware approval rigor. Build from Pro E models.
17	Written Approval	EEE Parts Lists and Analysis Report	If Required for DO See Comments	As Required	N	
18	Mandatory Submittal if Flt H/W	Critical Design Review Data Package	If Required for DO See Comments	Once with Revisions	N	
19	Mandatory Submittal if Flt H/W	Engineering Drawing Change Proposal	If Required for DO See Comments	As Required	N	
20	Written Approval	GFE Qualification Test Procedure	If Required for DO See Comments	Once with Revisions	N	
21	Written Approval	Flight Product User's Guide	If Required for DO See Comments	Once with Revisions	N	
22	Mandatory Submittal if Flt H/W	Software Code	If Required for DO See Comments	As Required	N	
23	Written Approval	Information Technology (IT) Security Program Plan and Reports	(30) days after DO award, and as specified in JPG 2810.1	JPG 2810.1	Attachment J-4 Due 30 days after DO award	
24	Written Approval	Certification Plan	If Required for DO See Comments	Once with Revisions	N	
25	Mandatory Submittal if Flt H/W	Certification Report	If Required for DO See Comments	Once with Revisions	N	
26	Mandatory Submittal if Flt H/W	Engineering Analysis	If Required for DO See Comments	As Required	Y	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-002**

DRD #	DATA TYPE	DRD TITLE	DUE	FREQUENCY	REQUIRED FOR DO? Y/N	COMMENTS
27	Mandatory Submittal if Flt H/W	Acceptance Data Package	If Required for DO See Comments	One Time	N	
28	Mandatory Submittal	Export Control Audit Results	After award of 1st DO, yearly on Sept. 30 thereafter	Yearly	Y	
29	Written Approval	Quality Plan	With Proposal	Once with Revisions	Attachment J-11	Only if contractor is using the R-Quality Plan template instead of ISO, and only if they need to make changes to it
30	Written Approval	Patent Rights-Retention	As Required	As Required	Y (If Applic'ble)	
31	Written Approval	Shuttle/Station Payload Safety Data Package	If Required for DO See Comments	As Required	N	
32	Mandatory Submittal if Flt H/W	Limited Life Systems List	If Required for DO See Comments	As Required	N	
33	Written Approval	Space Station GFE Failure Modes and Effects Analysis and Critical Items List	If Required for DO See Comments	As Required	N	
34	Written Approval	Space Shuttle GFE Safety and Analysis Report & Hazard Report	If Required for DO See Comments	As Required	N	
35	Written Approval	Software Quality Assurance Plan Report	90 Days Prior to Software Development	Once with Revisions	Y (If Applic'ble)	
36	Written Approval	ISS Hazard Report	If Required for DO See Comments	As Required	N	
37	Upon Request	Reliability and Maintainability Plan	With Proposal	One Time	Attachment J-9	
38	Written Approval	Government Certification Approval Request (GCAR)	If Required for DO See Comments	As Required	N	
39	Written Approval	Risk Assessment Executive Summary Report (RAESR)	If Required for DO See Comments	As Required	Y	As needed to define the design process and as described in the SOW. Flight hardware approval rigor is not required.
40	Written Approval	Problem Reporting and Corrective Action (PRACA)	2 business days of problem isolation but no later than 10 days after detection	As Required	N	
41	Upon Request	Nonconformance Record	If Required for DO See Comments	As Required	N	

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-002**

DRD #	DATA TYPE	DRD TITLE	DUE	FREQUENCY	REQUIRED FOR DO? Y/N	COMMENTS
42	Mandatory Submittal	Government Industry Data Exchange Program and NASA Advisory Problem Data	Reported one time when discrepancy occurs	Once with Revisions	N	
43	Written Approval	Electrical, Electronic, and Electromechanical (EEE) Parts Control Plan	If Required for DO See Comments	Once with Revisions	N	
44	Mandatory Submittal if Flt H/W	Certification Data Package	If Required for DO See Comments	Once with Revisions	N	
45	Written Approval	Certification and Acceptance Requirements Document	At CDR	Once with Revisions	N	
46	Upon Request	Wage/Salary and Fringe Benefit Data	Thirty (30) days after issuance of each DO	Once	N	
47	Written Approval	GFE Acceptance Test Procedure	If Required for DO See Comments	One Time	N	
48	Mandatory Submittal if Flt H/W	Flight GFE Verification & Validation Report	If Required for DO See Comments	Once with Revisions	N	
49	Mandatory Submittal if Flt H/W	Space Shuttle GFE Failure Modes and Effects Analysis (FMEA) and Critical Items List	If Required for DO See Comments	As Required	N	
50		<b>Reserved</b>	---	---	---	---
51	Mandatory Submittal	NASA Contractor Financial Management Reporting	After Issuance of 1st DO	Monthly	Y	
52	Written Approval	Government Property Management Plan	With Proposal	Once with Revisions	Attachment J-7	
53	Mandatory Submittal	System Safety Plan	With Proposal	One Time	Attachment J-10	
54	Written Approval	R-Quality Plan Template	With Proposal/ Revisions as Required	Only applicable to B-CRAVE contracts in accordance with the SOW and the DRD	N	Only if contractor is using the R-Quality Plan template instead of ISO, and only if they need to make changes to it

**Type 1 = Written Approval      Type 2 = Mandatory Submittal      Type 3 = Submittal Upon Request**

**CREW, ROBOTICS AND VEHICLE EQUIPMENT (CRAVE) CONTRACT  
DELIVERY ORDER #: CRAVE-EC5-002**

**GOVERNMENT FURNISHED PROPERTY**

**None Required**

**CHANGES TO DRDs: NONE**

**CHANGES TO GOVERNMENT FURNISHED PROPERTY: NONE**  
*(IF YES, THEN INSERT GOVERNMENT FURNISHED PROPERTY TABLES)*

## ORDER FOR SUPPLIES OR SERVICES

1. Order No. DO-CRAVE-EC5-002 Rev.1	2. Date of Order See Block 10	<b>NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.</b> Certified for National Defense under DPAS (15 CFR 700) DO-C9
--	----------------------------------	--

3. Issuing Office: NASA Johnson Space Center, 2101 Nasa Parkway Houston, TX 77058-3696 Org./Buyer: <u>BH2/Michael Ballard</u>  Tel No.: <u>281-244-5350</u> Fax: _____ E-mail: <u>michael.d.ballard@nasa.gov</u>	4. Ship To: Transportation Officer, Building 421 NASA Johnson Space Center Houston, TX 77058-3696 Mark For: <b>Accountable Property</b>  Order No.: <u>DO-CRAVE-EC5-002</u>
--	---

5. Contractor: Hamilton Sundstrand Management Systems 2200 Space Park Drive, Suite 100 Houston, TX 77058  Phone: 281-336-6334 x _____ Fax: _____  TIN: _____ CAGE CODE: _____	6. Deliver On or Before: <u>See DO</u>  F.O.B. Point: <u>Destination</u>  Discount Terms: Net 30 Days.  7. BILLING ADDRESS: NASA Johnson Space Center Attn: LF231/Accounts Payable Group Houston, TX 77058-3696 Order No.: DO-CRAVE-EC-002
--	--

8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: NNJ05HB39B

9. Written acceptance of this order by contractor <input checked="" type="checkbox"/> is, <input type="checkbox"/> is not required. Sign below if required and return to contracting officer.  Name: _____ (Person authorized to sign) Signature: _____ Date: _____	10. Name: <u>N. L. Dawn Alexander</u>  Signature: <u><i>Dawn Alexander</i></u> Date: <u>7/19/05</u> CONTRACTING OFFICER
--	--

11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	The purpose of this revision is to: 1. Extend the period of performance to October 25, 2005 2. Add the requirement for the contractor to conduct an informal concept review on Aug. 1, 2005.  This revision has no effect on Delivery Order value					

12. For JSC Internal Use Only: Requisition No.: _____ <input type="checkbox"/> COMP. <input type="checkbox"/> PART. PPC: _____ Rissue To: _____	13. Total \$ _____
---	-----------------------

14. Quantities in "Quantity Accepted" Column Have Been

INSPECTED  ACCEPTED  RECEIVED

TO CONFORM TO THE CONTRACT.  
ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED. BY \_\_\_\_\_

Authorized U.S. Government Representative \_\_\_\_\_ Date \_\_\_\_\_

# ORDER FOR SUPPLIES OR SERVICES

1. Order No.  
 DO-CRAVE-EC5-002

2. Date of Order

**NOTE: MARK ALL PACKAGES AND PAPERS WITH ORDER NO.**

Certified for National Defense under DPAS (15 CFR 700) DO-C9

3. Issuing Office:

NASA Johnson Space Center, 2101 Nasa Parkway  
 Houston, TX 77058-3696  
 Org./Buyer: BH2/Michael Ballard

4. Ship To:

Transportation Officer, Building 421  
 NASA Johnson Space Center  
 Houston, TX 77058-3696  
 Mark For: **Accountable Property**

Order No.: DO-CRAVE-EC5-002

Tel No.: 281-244-5350 Fax: \_\_\_\_\_  
 E-mail: michael.d.ballard@nasa.gov

5. Contractor:

Hamilton Sundstrand Management Services, Inc.  
 2200 Space Park Drive  
 Houston, TX 77058

6. Deliver On or Before: 10-04-05

F.O.B. Point: Origin

Discount Terms: Net 30 Days.

Phone: 281-336-6309 x \_\_\_\_\_ Fax: 860-660-6798

TIN: 06-1165866 CAGE CODE: 71120

7. BILLING ADDRESS:

NASA Johnson Space Center  
 Attn: LF231/Accounts Payable Group  
 Houston, TX 77058-3696  
 Order No.: DO-CRAVE-EC-002

8. Type of Order:

PURCHASE: Please furnish the following in accordance with the conditions specified on this order. Reference: \_\_\_\_\_

DELIVERY: Except for the Terms and Conditions of Purchase Order listed on the following page, this delivery order is subject to instructions contained on this form and is issued subject to the terms and conditions of contract number: NNJ05HB 378

9. Written acceptance of this order by contractor [] is, [] is not required. Sign below if required and return to contracting officer.

Name: Nancy L. Brogan (Person authorized to sign)

Signature: Nancy L. Brogan Date: 4/8/05

10. Name: N. L. Dawn Alexander

Signature: Dawn Alexander Date: 4/21/05  
 CONTRACTING OFFICER

## 11. Schedule

ITEM NO	DESCRIPTION	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	QUANTITY ACCEPTED
	The Contractor shall perform and deliver to all requirements for: DO-CRAVE-EC5-002: Advanced Space Suit and Portable Life Support Subsystem (PLSS) Packaging Design Study The Period of Performance for this DO is: 04-21-05 thru 10-4-05				64	

12. For JSC Internal Use Only:

Requisition No.: \_\_\_\_\_  COMP  PART. PPC: \_\_\_\_\_  
 Rissue To: \_\_\_\_\_

13. Total

\$ NTE: 429,538.89

14. Quantities in "Quantity Accepted" Column Have Been

INSPECTED  ACCEPTED  RECEIVED

TO CONFORM TO THE CONTRACT.  
 ACCEPTANCE WILL BE AT JSC UNLESS OTHERWISE NOTED

BY \_\_\_\_\_

Authorized U.S. Government Representative

Date \_\_\_\_\_