

**ORDER FOR SUPPLIES OR SERVICES**

1. CONTRACT/PURCH. ORDER/ AGREEMENT NO. DASG60-02-D-0011	2. DELIVERY ORDER/ CALL NO. 003305	3. DATE OF ORDER/CALL 2002 Jul 09	4. REQ./ PURCH. REQUEST NO. T-9191W-BASIC	5. PRIORITY DX-A2	
6. ISSUED BY US ARMY SPACE AND MISSILE DEFENSE COMMAN P.O. BOX 1500 HUNTSVILLE AL 35807-3801		7. ADMINISTERED BY DCMA HUNTSVILLE BUILDING 4505, SUITE 301 MARTIN ROAD REDSTONE ARSENAL AL 35898-0001			

9. CONTRACTOR TELEDYNE SOLUTIONS, INC 5000 BRADFORD DRIVE HUNTSVILLE AL 35805	CODE 1P9G8	FACILITY	10. DELIVER TO FOB POINT BY (Date) <b>SEE SCHEDULE</b>	11. MARK IF BUSINESS IS <input type="checkbox"/> SMALL <input type="checkbox"/> SMALL DISADVANTAGED <input type="checkbox"/> WOMEN-OWNED
			12. DISCOUNT TERMS	
			13. MAIL INVOICES TO THE ADDRESS IN BLOCK See Item 15	

14. SHIP TO <b>SEE SCHEDULE</b>	15. PAYMENT WILL BE MADE BY NASA JOHNSON SPACE CENTER ATTN: LF231 FUNDING AND COMMERCIAL ACCOUNTING SECTION HOUSTON TX 77058	<b>MARK ALL PACKAGES AND PAPERS WITH IDENTIFICATION NUMBERS IN BLOCKS 1 AND 2.</b>
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16. TYPE OF ORDER	DELIVERY/ CALL	<input checked="" type="checkbox"/>	This delivery order/call is issued on another Govt. agency or in accordance with and subject to terms and conditions of above numbered contract.
	PURCHASE		Reference your quote dated Furnish the following on terms specified herein. REF:

ACCEPTANCE. THE CONTRACTOR HEREBY ACCEPTS THE OFFER REPRESENTED BY THE NUMBERED PURCHASE ORDER AS IT MAY PREVIOUSLY HAVE BEEN OR IS NOW MODIFIED, SUBJECT TO ALL OF THE TERMS AND CONDITIONS SET FORTH, AND AGREES TO PERFORM THE SAME.

NAME OF CONTRACTOR	SIGNATURE	TYPED NAME AND TITLE	DATE SIGNED (YYYYMMDD)
<input type="checkbox"/> If this box is marked, supplier must sign Acceptance and return the following number of copies:			

17. ACCOUNTING AND APPROPRIATION DATA/ LOCAL USE  
**See Schedule**

18. ITEM NO.	19. SCHEDULE OF SUPPLIES/ SERVICES	20. QUANTITY ORDERED/ ACCEPTED*	21. UNIT	22. UNIT PRICE	23. AMOUNT
	<b>SEE SCHEDULE</b>				

* If quantity accepted by the Government is same as quantity ordered, indicate by X. If different, enter actual quantity accepted below quantity ordered and encircle.	24. UNITED STATES OF AMERICA	25. TOTAL \$1,142,857.00
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26. QUANTITY IN COLUMN 20 HAS BEEN <input type="checkbox"/> INSPECTED <input type="checkbox"/> RECEIVED <input type="checkbox"/> ACCEPTED, AND CONFORMS TO THE CONTRACT EXCEPT AS NOTED  DATE _____ SIGNATURE OF AUTHORIZED GOVT. REP. _____	27. SHIP NO.	28. DO VOUCHER NO.	29. DIFFERENCES	30. INITIALS
	<input type="checkbox"/> PARTIAL <input type="checkbox"/> FINAL	32. PAID BY		33. AMOUNT VERIFIED CORRECT FOR

36. I certify this account is correct and proper for payment. DATE _____ SIGNATURE AND TITLE OF CERTIFYING OFFICER _____	31. PAYMENT <input type="checkbox"/> COMPLETE <input type="checkbox"/> PARTIAL <input type="checkbox"/> FINAL	34. CHECK NUMBER	35. BILL OF LADING NO.
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37. RECEIVED AT	38. RECEIVED BY	39. DATE RECEIVED (YYYYMMDD)	40. TOTAL CONTAINERS	41. S/R ACCOUNT NO.	42. S/R VOUCHER NO.
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## Section B - Supplies or Services and Prices

ITEM NO	SUPPLIES/SERVICES	MAX QUANTITY	UNIT	UNIT PRICE	MAX AMOUNT
0001	SETAC - FP Labor COST	1	Lot	UNDEFINED	UNDEFINED
	Provide services outlined in the scope of work (SOW), as defined in a given task order (T/O), at the fixed prices/government labor category specified in Section B paragraph entitled, "GOVERNMENT LABOR CATEGORIES AND ASSOCIATED FIXED PRICES PER DPPH"				
	PURCHASE REQUEST NUMBER: T-9191W-BASIC				
				MAX COST	\$1,006,857.00

FOB: Destination

ITEM NO	SUPPLIES/SERVICES	MAX QUANTITY	UNIT	UNIT PRICE	MAX AMOUNT
0003	Consultants COST	1	Lot	UNDEFINED	UNDEFINED
	Provide services outlined in the scope of work (SOW) at the cost reimbursable amounts as approved on a task-order-by-task-order basis. Total Fee, including prime and subcontractor/consultant, shall not exceed 3% of the estimated costs. This CLIN is valid during the three-year base period as well as any/all award term extensions earned by the contractor.				
	PURCHASE REQUEST NUMBER: T-9191W-BASIC				
				MAX COST	\$0.00

FOB: Destination

ITEM NO	SUPPLIES/SERVICES	MAX QUANTITY	UNIT	UNIT PRICE	MAX AMOUNT
0004		1	Lot	UNDEFINED	UNDEFINED

Materials and STE  
COST

Provide materials, special test equipment (STE), and associated services outlined in the individual task orders at the cost reimbursable amounts as approved by the T/OM and the Contracting Officer. NO FEE ON THIS CLIN. This CLIN is valid during the three-year base period as well as any/all award term extensions earned by the contractor.

PURCHASE REQUEST NUMBER: T-9191W-BASIC

MAX COST \$0.00

FOB: Destination

ITEM NO	SUPPLIES/SERVICES	MAX QUANTITY	UNIT	UNIT PRICE	MAX AMOUNT
0005		1	Lot	UNDEFINED	UNDEFINED

Travel  
COST

Travel as directed in the individual task orders. Travel must be completed within the cost reimbursable amounts allowed per the Joint Travel Regulations and the DCAA-approved Company-Implemented Policy and Procedures. NO FEE ON THIS CLIN. This CLIN is valid during the three-year base period as well as any/all award term extensions earned by the contractor.

PURCHASE REQUEST NUMBER: T-9191W-BASIC

MAX COST \$136,000.00

FOB: Destination

BLOCK 17/BLOCK 18 CONTINUED

BLOCK 17 (DD1155) CONTINUED:

TASK ORDER FUNDS REQUIRED \$ 1,142,857

TASK ORDER FUNDS AVAILABLE \$ 311,364

UNFUNDED BALANCE \$ 831,493

BLOCK 18 (DD1155) CONTINUED: In the performance of this Task Order (T/O), the contractor shall provide the total Direct Productive Person Hours (DPPHs), plus or minus 10 percent, as stated for fixed-price labor categories stated in Section B of the contract listed in Block 1 of the DD Form 1155. These DPPHs shall be billed at the fixed price stated in Exhibit V of the contract. The contractor shall not exceed the DPPHs, nor the total

dollars, stated for consultant below. The contractor is allowed to provide up to 10 percent less than the DPPHs stated for consultant and still expend the total dollars as stated in the T/O. Furthermore, under no circumstance shall the contractor exceed the dollars stated for Materials, Travel, or Total T/O.

LABOR CATEGORIES: Labor categories are as listed in the contract, Section B, paragraph entitled "GOVERNMENT LABOR CATEGORIES AND ASSOCIATED FIXED PRICES PER DPPH"

	DPPHs ORDERED	NTE AMOUNT
FIXED-PRICE LABOR TOTAL	 DPPHs	\$ 1,006,857
*CONSULTANT TOTAL	 DPPHs	\$ 0
T/O TOTAL LABOR	 DPPHs	\$ 1,006,857
MATERIAL	NTE	\$ 0
TRAVEL	NTE	\$ 136,000
T/O TOTAL		\$ 1,142,857

\*\*Consultant requirements must have prior written approval of the Administrative Contracting Officer (ACO) (via subcontract consent package) before any costs are incurred under the consultant CLIN.

## Section C - Descriptions and Specifications

### B POP

PERIOD OF PERFORMANCE: 9 Jul 02 – 23 APR 05

### F MTRL

ESTIMATED COST FOR MATERIALS AND/OR SPECIAL TEST EQUIPMENT: The contractor has no authority to incur material costs without the explicit prior written approval of the contracting officer. Prior to forwarding requests to the contracting officer, the contractor shall obtain the Task Order Monitor's concurrence. Electronic Mail (email) shall be utilized for both steps in this process. Under no circumstance shall the contractor incur materials costs in excess of the NTE amount stated herein. NTE: \$0

### A SOW

SYSTEMS ENGINEERING  
FOR  
A 3-DIMENSIONAL IMAGING LADAR RELATIVE NAVIGATION SENSOR  
TO SUPPORT  
2<sup>ND</sup> GENERATION RLV AUTOMATED RENDEZVOUS AND CAPTURE  
STATEMENT OF WORK

#### 1.0 PURPOSE

1.1 The Space Launch Initiative (SLI) has identified Automated Rendezvous and Mating (AR&M) as an important new capability for a 2<sup>nd</sup> Generation Reusable Launch Vehicle (2GRLV). This capability will require a sensor or sensor suite that is compact, lightweight, and has low power consumption. Development and demonstration of a single, compact, light weight, low power, robust 3-Dimensional Imaging Ladar relative navigation sensor that is capable of supporting automated rendezvous and mating operations with passive cooperative and non-cooperative targets (skin reflection with and without retroreflectors) from a range of 50km to dock, including 6-DOF information within 100 meters of the target, could significantly reduce weight, power consumption, cost, logistics, training, and complexity relative to today's typical family of different sensor types with associated sensor hand-over discontinuities.

1.2 Imaging lidars, which do not require retroreflectors on the target, are a primary candidate for AR&M sensors. Not only can these sensors provide 6-DOF information, but they also have the potential to improve maneuvering safety during proximity operations and docking and to aid inspection operations. This technology can also provide cross-cutting capabilities for landing and hazard detection. Imaging laser radars can support automation of rendezvous operations and allow for circumnavigation of the target spacecraft during approach or separation. This approach accommodates target spacecraft that might be reorienting in attitude while the chaser vehicle approaches along a line of sight to the target (when docking reflectors may be periodically obscured).

## 2.0 SCOPE

This Statement of Work establishes the systems engineering, simulation, modeling, test and evaluation efforts necessary to validate the technologies required to implement a 3DIL to support rendezvous, docking, proximity operations for advanced space systems, and to bring those technologies to TRL 6 by the end of Fiscal Year 2006. It specifically does not include the technology development efforts necessary to advance those technologies to that level. Those developments will be accomplished through separate NASA procurements based upon the system engineering findings and recommendations resulting from this statement of work.

## 3.0 APPLICABLE AND REFERENCE DOCUMENTS

The following documents, of the latest version available, provide a context for this statement of work.

### 3.1.2 Other Documents (TBS)

ANSI-Z-136.1-2000                      Laser Eye Safety

## 4.0 TECHNICAL REQUIREMENTS

### 4.1 LADAR Requirements Development and Design Definition

Development of technology is best optimized within the context of a balanced and integrated system architecture. Furthermore, efficient technology development should maximize the use of related efforts currently underway or dependably planned by other government agencies or labs. Therefore, the contractor shall use the AR&M system requirements, review AR&M scenarios and architectures, develop candidate 3DIL concepts for automated rendezvous and capture, and finally conduct an assessment of the status of technology needed to implement these concepts.

#### 4.1.1 3DIL Concept Development

##### 4.1.1.1 3DIL Concept Definition

The contractor shall identify alternative approaches and concepts for 3DIL. All major system elements, functional interfaces and general performance characteristics shall be identified. These architectures shall consider, but not be limited to: ground station derived ephemeris, GPS derived ephemeris, differential GPS guidance, passive only tracking, laser radar derived range augmentation of passive tracking, monopulse laser radar, laser radar imaging and appropriate combinations in determining the breadth of the 3DIL function in the total AR&M phase of the mission.

##### 4.1.1.2 Candidate Scenario Development

The contractor shall review AR&M scenarios. The purpose is to examine the range of performance that would be required of each of the candidate concepts. Candidate scenarios may include, but are not limited to:

- Normal rendezvous and mating operations with the International Space Station,
- Hubble servicing missions,
- Rendezvous and mating with a normally functioning small satellite for servicing or minor repair having cooperative targets,
- Rendezvous and mating with a small satellite having an attitude control system failure and cooperative targets,
- Rendezvous and mating with a normally functioning small satellite for servicing or minor repair which does not have cooperative targets,
- Rendezvous and mating with a small satellite having an attitude control system failure which does not have cooperative targets,
- and other scenarios defined by NASA.

Satellites without cooperative targets shall include those for which the external geometric shape is well known and those for which the current geometric conformation may be uncertain. Scenarios shall consider fully autonomous operation, supervised automatic operation, local manual operation based upon AR&M sensor derived data and tele-robotic operation. The contractor shall emphasize in-plane maneuvers, however, the anticipated impact(s) on concept design and performance of out-of-plane rendezvous will be identified.

#### 4.1.1.3 3DIL Sensor Requirements Definition

The contractor shall define the specific performance requirements of the 3DIL Relative Navigation Sensor.

#### 4.1.1.4 3DIL Sensor Concepts Definition

The contractor shall identify candidate sensor concepts that may satisfy the previously defined sensor concept requirements. The contractor shall identify all major components for these concepts, the functional interfaces between the components and the key performance characteristics of the critical components. The contractor shall assess the performance of the defined sensor concepts

#### 4.1.1.5 Technology Development Plan

##### 4.1.1.5.1 Technology Assessment

The contractor shall review and evaluate candidate technologies that may be used to implement the defined sensor concepts. The status of these technologies shall be determined relative to the NASA Technology Readiness Level (TRL) scale. The contractor shall assess the risk of maturing these technologies to TRL 6 for those technologies that have not already achieved that level of readiness.

##### 4.1.1.5.2 Technology Roadmap Development

The contractor shall review the development of candidate technologies and closely related technologies by other government agencies. This review will include unclassified technology and activities classified by the Department of Defense and other government agencies. The contractor shall recommend development activities that will permit those technologies that have not yet reached the readiness level identified at TRL 6 and which are not currently undergoing comparable development within other government agencies to be matured to that level. These recommendations will be summarized in a recommended Technology Road Map. The Roadmap will specifically identify those opportunities for joint or synergistic development with other agencies.

#### 4.1.2 Modeling and Simulation

The contractor shall prepare models, simulations, and analytical tools to evaluate the performance of candidate 3DIL concepts and critical components. The contractor shall employ previously developed models, commercial off-the-shelf (COTS) software and government-developed models to the maximum extent practical.

#### 4.2 Critical Components Evaluation

##### 4.2.5 Protoflight Concept Recommendation

Based upon the results of the evaluation of critical components and the requirements placed upon the components by the various candidate sensor architectures, the contractor shall prepare recommendations for the preferred concept and the performance and support requirements.

##### 4.2.6 Modeling and Simulation

The contractor shall refine the previously developed models, simulations and analytical tools. The contractor shall utilize these models to assess the performance of the recommended protoflight 3DIL. This performance assessment shall incorporate the performance demonstrated during critical component tests and evaluations and the performance anticipated at the end of technology development.

#### 4.3 Engineering Model/Breadboard Evaluation

##### 4.3.1 Engineering Model Development

The contractor shall recommend performance characteristics, architectures and evaluation strategies for an engineering model or breadboard that will be used to validate the performance of the recommended protoflight 3DIL.

##### 4.3.5 Modeling and Simulation

The contractor shall refine the previously developed models, simulations and analytical tools. The contractor shall use these models to assess the performance of the Engineering Model. This performance assessment shall incorporate the performance demonstrated during critical component tests and evaluations and the performance anticipated at the end of technology development.

#### 4.4 Protoflight 3DIL Test and Evaluation

##### 4.4.1 Protoflight 3DIL Development

The contractor shall review and monitor the design efforts and the hardware development efforts for the protoflight instrument.

###### 4.4.1.1 Preliminary Design Review

The contractor shall prepare a recommended agenda for the Preliminary Design Review (PDR) for the Protoflight 3DIL. The contractor shall identify and recommend specific criteria for satisfactory completion of the PDR. The contractor shall attend, support and participate in the PDR. The contractor shall identify any issues, risks and/or deficiencies present in the design. The contractor shall recommend corrective actions or procedures for the identified risks, issues and/or deficiencies. The contractor shall monitor the progress made toward the resolution of the identified issues, risks and/or deficiencies and report on this progress to the government.

###### 4.4.1.2 Critical Design Review

The contractor shall prepare a recommended agenda for the Critical Design Review (CDR) for the Protoflight 3DIL. The contractor shall identify and recommend specific criteria for satisfactory completion of the CDR. The contractor shall attend, support and participate in the CDR. The contractor shall identify any issues, risks and/or deficiencies present in the design. The contractor shall recommend corrective actions or procedures for the identified risks, issues and/or deficiencies. The contractor shall monitor the progress made toward the resolution of the identified issues, risks and/or deficiencies and report on this progress to the government.

##### 4.4.2 Test and Evaluation Plans and Procedures Definition

The contractor shall prepare, document and deliver recommendations for the test and evaluation plans for the Protoflight 3DIL. When appropriate, the contractor shall also prepare, document and deliver test procedure recommendations. Recommended test procedures shall identify candidate test sites and facilities, and the capabilities and/or limitations of these test sites and facilities.

##### 4.4.3 Test and Evaluation Review

The contractor shall monitor tests conducted on the Protoflight 3DIL. When necessary, the contractor shall witness these tests.

## 5.0 PROGRAM REQUIREMENTS

### 5.1 Documentation

#### 5.1.1 Reports

##### 5.1.1.1 Status Reports

The contractor shall prepare monthly status reports that identify accomplishments, plans, and issues associated with the effort.

##### 5.1.1.2 Technical Memoranda

The contractor shall document significant findings in Technical Memoranda. Technical Memoranda shall employ standard contractor format for these reports.

## 6.0 SCHEDULE

### 6.1 Milestones

Critical performance milestones are shown in the Table below.

Event	Date
Kick-Off Meeting	14 days ATP
Technology Roadmap Delivered	7 months ATP
Component Technology Test Complete	24 months ATP
Engineering Model Test Complete	34 months ATP
Protoflight ground tests Complete	3 Qtr FY 06

After Authority to Proceed (9 Jul 02)

### E TVL

ESTIMATED TRAVEL: Except for the locations listed below, the contractor has no authority to incur travel costs without explicit prior written approval (email acceptable) of the Task Order Monitor. Under no circumstance shall the contractor incur travel costs in excess of the NTE amount stated herein. NTE: \$136K

Washington DC, Houston, TX, Boston, MA, Toronto, ON, Tucson, AZ, Colorado Springs, CO, Albuquerque, NM, Huntsville, AL, St. Louis, MO

### D DELIVERABLES

#### DELIVERABLES:

Item/Title	CDRL#	# Copies	Delivery Date
Procurement Requirements Task Order Management Plan	A001	1 *	Per CDRL
Status Reports	A002	1 *	Monthly

FMER	A003	1 *	Per CDRL
Interim Technical Report	A004	1 *	As Required
Sensor System Requirements	A004	1 *	13 Sep 02
3DIL Concepts Description and Analysis	A004	1*	05 Sep 03
Technology Assessment	A004	1 *	05 Sep 03
Technology Roadmap to Achieve TRL 6 by 2006	A004	1 *	19 Sep 03
Specifications and Drawings	A004	1 *	As Required
Component Technology Test Report	A004	1 *	19 Jul 04
Design & Test Reports	A005	1 *	At Completion
Final Technical Report	A005	2 */**	23 April 05
Conference Minutes	A006	1 *	Per CDRL
Data Accession List	A007	1 *	Per CDRL

\* Plus Electronic Version.

\*\* One (1) hardcopy to the T/OM, and one (1) hardcopy to the SMDC Command Library (SMDC-IM-PL/Fred Mathews)

#### C KEY PERS

KEY PERSONNEL: TBD

#### G SPEC INST

SPECIAL INSTRUCTIONS:

Cost data shall be segregated/reported/vouchered/paid at the ACRN level.

The "Limitation of Funds" is applicable at the ACRN level.

The effort described in the Task Order Statement of Work, which is anticipated to be performed in FY02, FY03, FY04, and FY05, is subject to the Clause at FAR 52.232-18, Availability of Funds.

All of the terms and conditions of the contract listed in Block 1 above are applicable to this T/O.

All of the provisions and clauses of the contract listed in Block 1 above are applicable to this T/O.

No Government Furnished Property or Test Facilities are available for use in performance of this Task Order.

It is incumbent upon the contractor and/or subcontractor to ensure that appropriate Technical Assistance Agreements (TAAs) and/or applicable export licenses are in place before conducting any activity under the SOW which requires such approval and documentation.

H DIST

PROVIDE-TASK ORDER MONITOR:

[REDACTED]

MAILING ADDRESS:

[REDACTED]

PROGRAM MGMT POC:

[REDACTED]

MAILING ADDRESS:

[REDACTED]

## Section F - Deliveries or Performance

## DELIVERY INFORMATION

CLIN	DELIVERY DATE	QUANTITY	SHIP TO ADDRESS	UIC
0001	N/A	N/A	N/A	N/A
0003	N/A	N/A	N/A	N/A
0004	N/A	N/A	N/A	N/A
0005	N/A	N/A	N/A	N/A

Section G - Contract Administration Data

ACCOUNTING AND APPROPRIATION DATA

AA: 721-30-75-EV-6A-EV2590-EV41; MA=00, FS=29, PY=02, A/C=802/30111 PR#02149EVI(N) MIPR: T-9191W-Basic  
COST 000000000000  
CODE:  
AMOUNT: \$285,714.00

AB: WBS: 72-376-70-10-67; Cost Ctr: 72EV11; Fund Ctr: 72-376-70; Fund: HSF542003D; PR 4200020713  
AMOUNT: \$25,650.00