Cover Page for Proposal Submitted to the National Aeronautics and Space Administration

NASA Proposal Number

20-20ACOFinal-0010

NASA PROCEDURE FOR HANDLING PROPOSALS

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SECTION I - Proposal Information

Principal Investigator	E-mail Address	Phone Number
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Street Address (1)	Street Address (2)
3101 Bee Caves Rd	110

City	State / Province	Postal Code	Country Code
Austin		78746	US

Proposal Title : **Space-rated FOSS Interrogator For Cryogenic Temperature Monitoring In Space**

Proposed Start Date	Proposed End Date	Total Budget
09 / 01 / 2020	08 / 31 / 2022	No budget required

SECTION II - Application Information

NASA Program Announcement Number	NASA Program Announcement Title
80HQTR20SOA01	Space Technology Announcement of Collaboration Opportunity (ACO)

For Consideration By NASA Organization *(the soliciting organization, or the organization to which an unsolicited proposal is submitted)*

NASA , Headquarters , Space Technology Mission Directorate

Date Submitted	Submission Method	Grants.gov Application Identifier	Applicant Proposal Identifier
06 / 22 / 2020	Electronic Submission Only		

Type of Application	Predecessor Award Number	Other Federal Agencies to Which Proposal Has Been Submitted
New		

International Participation	Type of International Participation
No	

SECTION III - Submitting Organization Information

DUNS Number	CAGE Code	Employer Identification Number (EIN or TIN)	Organization Type
079841452	7DUY5		2K

Organization Name (Standard/Legal Name)	Company Division
Sensuron, LLC	SENSURON LLC

Organization DBA Name	Division Number
SENSURON	SENSURON L

Street Address (1)	Street Address (2)
3101 BEE CAVES RD STE 110	

City	State / Province	Postal Code	Country Code
AUSTIN	TX	78746	USA

SECTION IV - Proposal Point of Contact Information

Name	Email Address	Phone Number
Pierrick Vulliez	pierrick.vulliez@sensuron.com	775-830-2059

SECTION V - Certification and Authorization

Certification of Compliance with Applicable Executive Orders and U.S. Code

By submitting the proposal identified in the Cover Sheet/Proposal Summary in response to this Research Announcement, the Authorizing Official of the proposing organization (or the individual proposer if there is no proposing organization) as identified below:

- certifies that the statements made in this proposal are true and complete to the best of his/her knowledge;
- agrees to accept the obligations to comply with NASA award terms and conditions if an award is made as a result of this proposal; and
- confirms compliance with all provisions, rules, and stipulations set forth in this solicitation.

Willful provision of false information in this proposal and/or its supporting documents, or in reports required under an ensuing award, is a criminal offense (U.S. Code, Title 18, Section 1001).

Authorized Organizational Representative (AOR) Name	AOR E-mail Address	Phone Number
Pierrick Vulliez	pierrick.vulliez@sensuron.com	775-830-2059

AOR Signature *(Must have AOR's original signature. Do not sign "for" AOR.)* Date

FORM NRESS-300 Version 4.0 Oct-15-19

PI Name : **Pierrick Vulliez**	NASA Proposal Number
Organization Name : **Sensuron, LLC**	20-20ACOFinal-0010
Proposal Title : **Space-rated FOSS Interrogator For Cryogenic Temperature Monitoring In Space**	

SECTION VI - Team Members

Team Member Role	Team Member Name	Contact Phone	E-mail Address
PI	**Pierrick Vulliez**	**775-830-2059**	**pierrick.vulliez@sensuron.com**
Organization/Business Relationship **Sensuron, LLC**		Cage Code **7DUY5**	DUNS# **079841452**
International Participation **No**	U.S. Government Agency		Total Funds Requested **0.00**

Team Member Role	Team Member Name	Contact Phone	E-mail Address
Co-I/Institutional PI	**Justin Braun**	**512-827-2040**	**justin.braun@sensuron.com**
Organization/Business Relationship **Sensuron, LLC**		Cage Code **7DUY5**	DUNS# **079841452**
International Participation **No**	U.S. Government Agency		Total Funds Requested **0.00**

Team Member Role	Team Member Name	Contact Phone	E-mail Address
Collaborator	**William Burns**	**512-333-4744**	**ben.burns@sensuron.com**
Organization/Business Relationship **Sensuron, LLC**		Cage Code **7DUY5**	DUNS# **079841452**
International Participation **No**	U.S. Government Agency		Total Funds Requested **0.00**

PI Name : **Pierrick Vulliez**	NASA Proposal Number
Organization Name : **Sensuron, LLC**	20-20ACOFinal-0010

Proposal Title : **Space-rated FOSS Interrogator For Cryogenic Temperature Monitoring In Space**

SECTION VII - Project Summary

Materials used for space missions can be subjected to broad temperature variations overtime. Cryogenic tanks used as part of these missions must be continuously monitored to ensure that their contents remain at a stable temperature and that their structural integrity is not compromised. Sensuron proposes to develop a miniature and ruggedized temperature monitoring solution that would rely on FOSS technology working along with cryogenic sensing fibers.

PI Name : **Pierrick Vulliez**	NASA Proposal Number
Organization Name : **Sensuron, LLC**	20-20ACOFinal-0010

Proposal Title : **Space-rated FOSS Interrogator For Cryogenic Temperature Monitoring In Space**

SECTION VIII - Other Project Information

Proprietary Information

Is proprietary/privileged information included in this application?

Yes

International Collaboration

Does this project involve activities outside the U.S. or partnership with International Collaborators?

No

Principal Investigator	Co-Investigator	Collaborator	Equipment	Facilities
No	**No**	**No**	**No**	**No**

Explanation :

NASA Civil Servant Project Personnel

Are NASA civil servant personnel participating as team members on this project (include funded and unfunded)?

Yes

Fiscal Year	Fiscal Year	Fiscal Year	Fiscal Year	Fiscal Year	Fiscal Year
Number of FTEs	Number of FTEs	Number of FTEs	Number of FTEs	Number of FTEs	Number of FTEs

PI Name : **Pierrick Vulliez**	NASA Proposal Number
Organization Name : **Sensuron, LLC**	20-20ACOFinal-0010

Proposal Title : **Space-rated FOSS Interrogator For Cryogenic Temperature Monitoring In Space**

SECTION VIII - Other Project Information

Environmental Impact

Does this project have an actual or potential impact on the environment?	Has an exemption been authorized or an environmental assessment (EA) or an environmental impact statement (EIS) been performed?
No	**No**

Environmental Impact Explanation:

Exemption/EA/EIS Explanation:

PI Name : **Pierrick Vulliez**	NASA Proposal Number
Organization Name : **Sensuron, LLC**	20-20ACOFinal-0010

Proposal Title : **Space-rated FOSS Interrogator For Cryogenic Temperature Monitoring In Space**

SECTION VIII - Other Project Information

Historical Site/Object Impact

Does this project have the potential to affect historic, archeological, or traditional cultural sites (such as Native American burial or ceremonial grounds) or historic objects (such as an historic aircraft or spacecraft)?

No

Explanation:

PI Name : **Pierrick Vulliez**	NASA Proposal Number
Organization Name : **Sensuron, LLC**	20-20ACOFinal-0010

Proposal Title : **Space-rated FOSS Interrogator For Cryogenic Temperature Monitoring In Space**

SECTION IX - Program Specific Data

Question 1 : Identify whether you have proposed substantially the same kind of research or technology development under any other STMD solicitation within the last twelve months. Provide STMD Solicitation Number and Application or Proposal Identifier.

Answer:

N/A

Question 2 : The proposal will be submitted under which Topic listed in this announcement?

Answer: Topic 1: Cryogenic Fluid Management and Propulsion

Question 3 : What is the Technology Readiness Level (TRL) of your proposed technology at the time of MPP (Mandatory Preliminary Proposal) submission?

Answer: 4

Question 4 : What will be the Technology Readiness Level (TRL) of your proposed technology at the end of the proposed effort?

Answer: 7

Question 5 : Provide a brief description of your technology and why is this technology worthy of STMD investment?

Answer: Sensuron proposes to develop a miniature and ruggedized temperature monitoring solution that would rely on FOSS technology working along with cryogenic sensing fibers. This would allow NASA to perform liquid level sensing and structural health monitoring of assets deployed in space missions

Question 6 : Which NASA Centers do you intend to partner with if selected?

Answers :

Armstrong Flight Research Center

Glenn Research Center

Langley Research Center

Question 7 : To help NASA obtain demographic diversity information, what is the PI's gender?

Answer: Male

Question 8 : I certify that no language changes/updates/revisions were made to the standard template SAA (Attachment 12) in this announcement.

Answer: Yes, I certify no changes have been made.

PI Name : **Pierrick Vulliez**	NASA Proposal Number
Organization Name : **Sensuron, LLC**	20-20ACOFinal-0010
Proposal Title : **Space-rated FOSS Interrogator For Cryogenic Temperature Monitoring In Space**	

SECTION X - Budget

Total Budget: No budget required

SENSURON

Space-rated FOSS Interrogator For Cryogenic Temperature Monitoring In Space

Sensuron, LLC

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www.sensuron.com

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Space Rated FOSS Interrogator

SENSURON
ENGINEERING AT THE SPEED OF LIGHT

Company overview

Sensuron LLC, 3101 Bee Caves rd #110, Austin, TX 78746

- Founded 2015 – Spun out of 4DSP
- 8 employees
- Primary markets: A&D, Medical and Civil Engineering
- Partners and customers: NASA, Boeing, Airbus, J&J, etc.

Sensuron's distributed sensing technology provides a powerful, robust, and easy-to-use tool for structural testing, thermal mapping, design optimization, structural health monitoring and shape sensing. The technology is based on Fiber Optics Sensing and enables continuous strain and temperature measurements.

Sensuron proposes to develop a miniature and ruggedized solution to monitor the temperature of cryogenic tanks in space.

The new solution would be designed in such a way that it would operate and survive in outdoors or space environment, be conduction cooled, light (<500g), low power (<15W), have no moving parts and offer an attractive price point for commercial applications ($5k). NASA has demonstrated in a laboratory environment that a miniature version of the technology is viable, thus achieving TRL 4 with an expected TRL 6 or 7 at the completion of the project.

Technology overview

Project overview

The responsibilities for the project will be shared as follows. NASA AFRC will provide requirements for a space-rated FOSS interrogator, participate in engineering reviews throughout the project, provide environmental test facilities and arrange for cryogenic sensors and test fixtures. NASA GRC and LaRC will participate to the development of environmental test plans. Sensuron will specify and design a space-rated interrogator, fabricate and assemble it, as well as provide engineering support during environmental testing and product demonstration. Project completion timeline: 18 months from the start date.

Engineering and Management resources from 3 different NASA centers and Sensuron are required to execute on this project.

	NASA AFRC	NASA GRC	NASA LaRC	Sensuron
FTE	0.92	0.38	0.40	2.83
Labor costs	$150,720	$84,889	$75,667	$553,158
Non-labor costs	$274,970			$98,000
Total	$425,690	$84,889	$75,667	$651,158
Grand total	$1,237,404			

Resources plan

2 Acronyms

AFRC	Armstrong Flight Research Center
FBG	Fiber Bragg Grating
FOSS	Fiber Optics Sensing System
GRC	Glenn Research Center
LaRC	Langley Research Center
SHM	Structural Health Monitoring
TRL	Technology Readiness Level

3 Introduction

Materials used for space missions can be subjected to broad temperature variations overtime. Cryogenic tanks used as part of these missions must be continuously monitored to ensure that their contents remain at a stable temperature and that their structural integrity is not compromised. Sensuron proposes to develop a miniature and ruggedized temperature monitoring solution that would rely on FOSS technology working along with cryogenic sensing fibers.

4 Relevance

4.1 Alignment with NASA objectives

The technology proposed by Sensuron will bring the benefits of FOSS technology to space applications, thus helping NASA achieve its strategic goals for expanding capabilities and opportunities in space. The efforts would be specifically articulated around the following goals:

- Design and assemble a space-rated FOSS interrogator
- Conduct environmental testing of space-rated FOSS interrogator to demonstrate operation in space environment
- Demonstrate operation of a space-rated FOSS Interrogator during a ground test

4.2 Technology Readiness Level

Sensuron has been commercializing FOSS technology since 2012 and has licensed NASA's invention for this purpose since 2011 (current license # DN-1346 and previously license # DN-1090 under the name of 4DSP). Over the years Sensuron released several FOSS products that have gained commercial traction in the Aerospace and Medical markets for a variety of applications such as SHM, temperature monitoring, 2D and 3D shape sensing. Sensuron's FOSS technology has demonstrated TRL 9. The solution described in this proposal is a small form factor, cost-effective and ruggedized version of FOSS technology. NASA has demonstrated in a laboratory environment that a miniature version of the FOSS technology is viable, thus achieving TRL 4. Sensuron has recently signed a new licensing agreement with NASA (DN-1443) in order to commercialize this invention. Developing a commercial solution based on this technology that would meet the requirements for NASA space missions is therefore a logical next step.

4.3 Alignment with selected topic and benefit for NASA missions

The FOSS solution would be applied to Topic # 1: Cryogenic Fluid Management and Propulsion. Cryogenic tanks require continuous temperature monitoring, which cannot be achieved by conventional temperature sensors. If a tank's contents are not kept within a specific temperature range this may generate undue stress on the tank's structure and may eventually result in catastrophic failure. The FOSS solution, because of its distributed sensing nature, its immunity to EMI and its broad temperature sensing range (from cryogenic temperature at 20°K up to 600°K consistently) would ensure that tanks temperature of both liquid propellants as well as the gaseous ullage can be monitored. It would provide input to a heating or cooling system in order to keep tanks within their operating temperature range. Since there is typically a temperature gradient between the ullage and the liquid propellant, the liquid level of the tank could also be inferred via measuring the tank temperature with high spatial fidelity (1/2" interval) using the FOSS solution.

NASA AFRC has developed and demonstrated enhanced cryogenic temperature fiber distributed sensors that are capable of measuring cryogenic temperature accurately. Traditionally, fiber optics sensors based on FBG become insensitive to temperature below 100°K, where the FBG wavelength shift response changes from linear to exponential decay. By utilizing a thin polytetrafluoroethylene-shrink sleeve as a carrier structure, additional radial load is provided to the fiber sensing array, thus increasing the overall thermal sensitivity up to 3 times versus a standard fiber sensor array, under both liquid Nitrogen testing (78°K) as well as simulated cryogenic cold loading via Helium pumping under vacuum condition down to 15°K. A sensor to sensor variance down to 0.5K at 70K has been achieved, due to the increased sensitivity of the sensor array.

4.4 NASA AFRC capabilities

The capabilities of NASA AFRC around Sensors and Systems Development would be highly beneficial to the proposed solution. NASA AFRC has been researching and developing FOSS technologies and solutions since 2002. Over the past 2 years a NASA AFRC team has been working on a temperature-tuned FOSS interrogator. This invention comprises of no-moving parts, is in a small form factor, and can be implemented at a fraction of the cost of a typical FOSS interrogator. It is ideal for fluid measurement and thermal monitoring where readings every few seconds suffice. Cryogenic sensing fibers would be attached to the temperature-tuned FOSS Interrogator for monitoring liquid level or temperature in a tank. NASA AFRCS's leadership and track record in making and qualifying FOSS technologies for different missions makes them a natural partner of Sensuron for this project.

4.5 NASA AFRC and LaRC facilities access

Access to NASA AFRC's and LaRC's Environmental Laboratories would be necessary for the successful qualification of the FOSS solution, specifically to test it across various environmental factors (vibration, shock, temperature, humidity, EMI) in order to comply with space missions' standards.

4.6 Advancement over current state-of-the-art technology

Today's state-of-the-art FOSS technology is exemplified by the RTS125+. This very capable solution offers customers the ability to measure temperature, strain and other physical parameters up to 100 times per second for 16,000 sensors simultaneously. However, the RTS125+ is pricey, bulky (6Kg, 181mm x 162mm x 330mm), consumes up to 100W and is not designed for outdoors or space use.

The new FOSS solution would be designed in such a way that it would operate and survive in outdoors or space environment, be conduction cooled, light (<500g), low power (<15W), have no moving parts and offer an attractive price point for commercial applications. The performance would be lower than state-of-the-art technology (it would be capable of monitoring 2000 sensors every 30 seconds) but would suffice for the intended applications.

4.7 Business case

The price of state-of-the-art technology is currently $125,000 with a Bill of Materials cost of $47,000. The target price for the new FOSS solution would be around $6,000 to $9,000 with an anticipated Bill of Materials cost of $2,500 to $3,500.

The new FOSS solution would become viable for a broad range of commercial applications where FOSS distributed sensing has not gained market traction yet despite its clear advantages. While in some cases it will displace some existing technologies, in other instances it will allow to measure strain and temperature in hard to reach places, thus providing new insights to engineers during the design phase and enabling a full life cycle monitoring solution where it was previously not feasible. The following table provides some examples of where the technology could be used:

Technology Capability	Aerospace	Oil & Gas	Energy (other)	Automotive	Civil engineering
Strain Measurements	Distributed load monitoring, structural health monitoring and failure prediction, composite material manufacturing and embedment, full scale testing	Well health monitoring, well equipment integrity	Wind turbine blade embedment, health monitoring, blade design and testing, composite pressure vessels monitoring	Structural integrity study of prototypes	Structural health monitoring of buildings and bridges, soil displacement
Temperature Measurements	Cryogenic tanks temperature monitoring and liquid level sensing	Storage tank liquid level, liquid stratification, distributed well temperature	Gas turbine temperature distribution, leak detection	Battery cells temperature monitoring	

Table 1: Applications for the FOSS solution in industrial markets

4.8 Impact to Commercial Space Sector

Space rated technologies to monitor strain and temperature rely on point sensors that are susceptible to Electro Magnetic Interference and suffer from the interference of cosmic rays. Also,

conventional sensing technology requires each sensor to be connected to a Data Acquisition System thus rendering installation for granular measurements impractical and prone to malfunction. The new FOSS solution, because of its distributed nature using a single fiber optic cable, makes it possible to deploy strain and temperature sensing technology across assets. The targeted applications in space would comprise of the following:

- Cryogenic temperature monitoring for tanks and composite pressure vessels.
- Cryogenic liquid level sensing for propulsion to better manage and optimize fuel consumption.
- Structural Health Monitoring of building and assemblies subjected to wide temperature variations to guarantee their structural integrity.

The FOSS technology will enable the safe deployment of assets and personnel by constantly monitoring physical parameters and reducing the risk of failure. It is cost effective, light weight and consumes little power, thus making its embedment possible in many different places which could not be efficiently monitored using conventional technologies. As a viable and ubiquitous sensing solution FOSS technology will help push the boundaries of space exploration.

5 Technological Approach

5.1 Overview of technical approach

The collaboration between NASA AFRC, NASA GRC, NASA LaRC and Sensuron will benefit from the strong and sustained relationship between their respective teams over the years. The technical and management responsibilities would be split as follows:

1. NASA AFRC
    a. Provide the requirements for a space-rated FOSS interrogator.
    b. Provide engineering review for the design and analysis of the space-rated FOSS interrogator.
    c. Provide engineering review for the fabrication and assembly of the space-rated FOSS interrogator.
    d. Provide engineering review for the software space-rated FOSS interrogator
    e. Provide environmental test facilities to test the space-rated FOSS interrogator.
    f. Provide sensors and test fixtures to demonstrate the space-rated FOSS interrogator for a representative use case (TBD).
2. NASA LaRC
    a. Participate in the development of environmental test requirements and plans.
    b. Provide environmental test facilities to test the space-rated FOSS interrogator.
3. NASA GRC
    a. Participate in the development of environmental test requirements and plans.
4. Sensuron
    a. Specify, design and analyze a space-rated FOSS interrogator to meet space standards.
    b. Develop an environmental test plan targeting component testing in the first 6 months and initial prototype testing in the first year.
    c. Fabricate and assemble the space-rated FOSS interrogator.

d. Deliver operational space-rated FOSS interrogator to NASA AFRC for environmental testing.
e. Provide engineering support during environmental testing.
f. Provide engineering support during a demonstration of the space-rated FOSS interrogator.

The development plan and schedule required to support this project are as follows.

Phase	Description	FY2021												FY2022					
		Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
A	Kickoff Meeting	■																	
B	Transfer of knowledge from NASA AFRC to Sensuron	■																	
C	Preliminary design specifications and environmental test plan, and review	■	■																
D	Design specifications and environmental test plan review and approval		■	■															
E	Preparation for individual components testing	■	■	■															
F	Vibration and Thermal for individual components - iterations 1, 2 and 3			■		■		■											
F	EMI testing for individual components, iterations 1 and 2			■		■													
G	Electrical design				■	■	■	■	■	■									
H	Mechanical design							■	■	■	■								
I	Firmware and software								■	■	■	■							
J	Prototype manufacturing and assembly										■	■	■						
K	Prototype functional validation													■					
L	Vibration and Thermal for prototype - iterations 1 and 2													■				■	
L	EMI testing for prototype - iterations 1 and 2													■				■	
L	Prototype modification													■	■	■	■	■	
M	Prototype demonstration at NASA AFRC																		■

Table 2: Project plan and schedule

From TRL4 at the beginning of the project it is anticipated that the technology would reach TRL6 or TRL7 by the completion of the effort.

5.2 Facilities

Sensuron will execute this project primarily from its offices located in Austin TX. Sensuron has internal capabilities for the design, characterization, and assembly of photonic of control electronics boards, firmware and optical modules and sub-systems. Sensuron's facilities are in compliance with all applicable environmental laws and regulations of Federal, Texas, and local Government.

5.2.1 Sensuron design

Sensuron has state-of-the-art software for prototyping and modeling of DSP algorithms. Sensuron utilizes Matlab for algorithm development and Labview for creating custom GUI interfaces with post-processing that aid in research and development, visualizing of data, and custom tools for customers. Sensuron has commercial tools for digital simulation, verification and implementation of firmware for field programmable gate arrays (FPGAs). Sensuron utilizes SVN for source code version control for all product related designs and internal development tools.

5.2.2 Sensuron Manufacturing

Sensuron outsources the actual manufacture and assembly of electrical and mechanical parts. All manufacturing and assembly efforts are performed in the United Sates by AS9100 certified companies.

5.2.3 Sensuron Test Facilities

Although Sensuron outsources most of its manufacturing and assembly of electrical and mechanical parts, these need to be further assembled and tested by Sensuron employees. Board level issues can be quickly debugged with a full suite of testing software and firmware. Sensuron has access to equipment necessary to build, troubleshoot, repair, or modify electrical products.

5.2.4 NASA facilities

NASA AFRC and LaRC will make personnel and laboratories available to Sensuron during this project. Specifically, vibration, thermal and EMI testing will take place on NASA sites. This will first consist of the testing individual components to derisk the Bill of Materials and ensure that selected parts are able to meet the environmental requirements for space applications. Second environmental testing on the prototype unit will be conducted towards the end of the project.

6 Management approach

NASA and Sensuron will collaborate closely throughout the project to ensure its smooth execution. Eric Miller and Alissa Alicea will respectively be the project managers for NASA and Sensuron. While ad hoc communication will most likely happen during the project, a predefined schedule will be required as follows.

Meeting	Duration (hours)	Recurrence	When	Where
Regular meeting	1	Every 2 weeks	From project beginning to end	Microsoft Teams
Kick off meeting	4	Once	Project start date	Microsoft Teams
Knowledge transfer from NASA to Sensuron	4	Once	One week after Kick off meeting	Microsoft Teams
Preliminary design specifications and environmental test plan review	2	Once	End of phase C	Microsoft Teams
Engineering review for the design and analysis of the space-rated FOSS interrogator	2	Once	End of phase D	Microsoft Teams
Components environmental testing outcome	2	1 to 3 times	Throughout phase F	Microsoft Teams
Engineering review for the software space-rated FOSS interrogator	2	Once	Beginning of phase I	Microsoft Teams
Engineering review for the fabrication and assembly of the space-rated FOSS interrogator	2	Once	Beginning of phase J	Microsoft Teams
Prototype environmental testing outcome	2	Once or twice	Throughout phase L	Microsoft Teams
Prototype demonstration	8	Once	Phase M	NASA AFRC

Table 3: Meetings schedule

The respective project managers on the NASA and Sensuron sides are responsible for organizing and leading the meetings, ensuring that the right resources are made available. Roles and responsibilities of the different parties are described under section 5 of this proposal.

7 Resources plan

7.1 Key project personnel

NASA:

- Allen Parker - Principle Investigator Fiber Optic Sensing Technology – NASA AFRC
- Patrick Chan - Systems and Sensor Group – NASA AFRC
- Phil Hamory - Systems and Sensor Group – NASA AFRC
- Eric Miller – FOSS Project Manager – NASA AFRC
- Hans Hansen - eCryo Project Manager – NASA GRC
- Wade May – NASA LaRC

Sensuron:

- Justin Braun – Engineering Manager, FPGA Firmware Design Engineer
- Ben Burns – Hardware Digital and Analog Design Engineer
- Mechanical Engineer (resource TBD)
- Software Design Engineer (resource TBD)
- Alissa Alicea – Project Manager

7.2 Project execution

The following phases will sequentially take place during the project and involve the NASA and Sensuron's teams.

A. Kick off meeting: define an exhaustive list of requirements.
B. Transfer of knowledge from NASA AFRC to Sensuron.
C. Preliminary design specifications and environmental test plan review.
D. Design specifications and environmental test plan review and approval.
E. Preparation for individual components testing
F. Component level incremental environmental testing.
G. Electrical Design review.
H. Mechanical design review.
I. Firmware and software design review.
J. Prototype manufacturing and assembly
K. Prototype testing in lab environment.
L. Incremental and iterative prototype environmental testing.
M. Prototype demonstration.

7.3 Sensuron costs

The following tables provide details for the Sensuron labor and non-labor costs associated with this project.

Resources in man-days per project phase	Justin Braun	Ben Burns	Alissa Alicea	Software Engineer	Mechanical Engineer	Total cost
A	1	1	1	1	1	**3,618**
B	5	5	1		5	**12,707**
C	6	25	1	1	15	**38,236**
D	6	15	1		15	**28,908**
E	15	30	1		5	**43,459**
F	6	9	1		9	**19,732**
F	6	6	1			**11,169**
G	5	80	1			**74,387**
H	5	5	1		80	**62,403**
I	60		1	50		**88,177**
J	3	3	8		3	**11,449**
K	7	30	1	20	5	**49,441**
L	3	6	1		6	**12,418**
L	3	6	1		6	**12,418**
L	10	40	8	10	40	**81,017**
M	1	1	1	1	1	**3,618**
					Total	**$553,158**

Table 4: Sensuron labor costs

Hardware, consumables, 3rd party	**Cost**
Components for phase F	25,000
BOM and NRE costs - phase J	50,000
Assembly costs - phase J	10,000
Testing equipment costs	8,000
Software tools costs	5,000
Travel	
Phase F	10,000
Phase L	14,400
Phase M	3,100
Total	**$98,000**

Table 5: Sensuron non-labor costs

7.4 NASA centers costs

	NASA AFRC	NASA GRC	NASA LaRC
FTE	0.92	0.38	0.40
Labor costs	$150,720	$84,889	$75,667
Non-labor costs	$274,970	$0	$0
Total	$425,690	$84,889	$75,667
Grand total	$586,246		

Table 6: NASA costs

Space Act Agreement (SAA)

UNFUNDED SPACE ACT AGREEMENT
BETWEEN
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AND SENSURON LLC

UNDER THE SPACE TECHNOLOGY
ANNOUNCEMENT OF COLLABORATION OPPORTUNITY 2020

ARTICLE 1. AUTHORITY AND PARTIES

In accordance with the National Aeronautics and Space Act (51 U.S.C. § 20113(e)), this Agreement is entered into by the National Aeronautics and Space Administration, located at 300 E Street SW, Washington, DC 20546 (hereinafter referred to as "NASA") and Sensuron LLC located at 3101 Bee Caves Rd, #110, Austin TX 78746 (hereinafter referred to as "Partner" or "Sensuron"). NASA and Partner may be individually referred to as a "Party" and collectively referred to as the "Parties."

ARTICLE 2. PURPOSE

This Agreement ("Agreement") shall be for the purpose of accelerating the development and testing of critical technologies for emerging space system capabilities consistent with the capabilities articulated in the STMD 2020 Announcement of Collaboration Opportunity (ACO). "The Parties' specific responsibilities, schedule, and milestones are described in one or more Responsibilities and Schedule document completed in coordination with a NASA Center and incorporated fully by reference into this Agreement. This collaboration is intended to advance commercial space-related efforts by facilitating access by Partner to NASA's extensive resources including facilities, technical expertise, hardware, and software. Each Center Responsibilities and Schedule Document will detail the specific purpose of the proposed activity, responsibilities, schedule and milestones, and any personnel, property or facilities proposed to be made available to Partner.

ARTICLE 3. RESPONSIBILITIES

The Parties agree they will use reasonable efforts to fulfill the Responsibilities set forth in any Schedule and Responsibilities Document.

ARTICLE 4. SCHEDULE

The Parties agree they will use reasonable efforts to meet the Schedule set forth in any Schedule and Responsibilities Document.

ARTICLE 5. FINANCIAL OBLIGATIONS

There will be no transfer of funds between the Parties under this Agreement and each Party will fund its own participation. All activities under or pursuant to this Agreement are subject to the availability of funds, and no provision of this Agreement shall be interpreted to require obligation or payment of funds in violation of the Anti-Deficiency Act (31 U.S.C. § 1341).

ARTICLE 6. PRIORITY OF USE

Any schedule or milestone in this Agreement is estimated based upon the Parties' current understanding of the projected availability of NASA goods, services, facilities, or equipment. In the event that NASA's projected availability changes, Partner shall be given reasonable notice of that change, so that the schedule and milestones may be adjusted accordingly. The Parties agree that NASA's use of the goods, services, facilities, or equipment shall have priority over the use planned in this Agreement. Should a conflict arise, NASA in its sole discretion shall determine whether to exercise that priority. Likewise, should a conflict arise as between two or more non-NASA Partners, NASA, in its sole discretion, shall determine the priority as between those Partners. This Agreement does not obligate NASA to seek alternative government property or services under the jurisdiction of NASA at other locations.

ARTICLE 7. NONEXCLUSIVITY

This Agreement is not exclusive; accordingly, NASA may enter into similar agreements for the same or similar purpose with other private or public entities.

ARTICLE 8. LIABILITY AND RISK OF LOSS

A. Partner waives any claims against NASA, its employees, its related entities, (including, but not limited to, contractors and subcontractors at any tier, grantees, investigators, customers, users, and their contractors and subcontractors, at any tier) and employees of NASA's related entities for any injury to, or death of, Partner employees or the employees of Partner's related entities, or for damage

to, or loss of, Partner's property or the property of its related entities arising from or related to activities conducted under this Agreement, whether such injury, death, damage, or loss arises through negligence or otherwise, except in the case of willful misconduct.

B. Partner further agrees to extend this unilateral waiver to its related entities by requiring them, by contract or otherwise, to waive all claims against NASA, its related entities, and employees of NASA and employees of NASA's related entities for injury, death, damage, or loss arising from or related to activities conducted under this Agreement.

ARTICLE 9. LIABILITY AND RISK OF LOSS - PRODUCT LIABILITY

With respect to products or processes resulting from a Party's participation in an SAA, each Party that markets, distributes, or otherwise provides such product, or a product designed or produced by such a process, directly to the public will be solely responsible for the safety of the product or process.

ARTICLE 10. LIABILITY AND RISK OF LOSS - PRODUCT LIABILITY

ARTICLE 10. INDEMNIFICATION

In the event the U.S. Government incurs any liability based upon Partner's, or Partner's Related Entity's, use or commercialization of products or processes resulting from a Party's participation under this Agreement, Partner agrees to indemnify and hold the U.S. Government harmless against such liability, including costs and expenses incurred by the U.S. Government in defending against any suit or claim for such liability.

ARTICLE 11. INTELLECTUAL PROPERTY RIGHTS - DATA RIGHTS

A. General

1. "Related Entity" as used in this Data Rights Article means a contractor, subcontractor, grantee, or other entity having a legal relationship with NASA or Partner that is assigned, tasked, or contracted to perform activities under this Agreement.
2. "Data" means recorded information, regardless of form, the media on which it is recorded, or the method of recording.
3. "Proprietary Data" means Data embodying trade secrets developed at private expense or commercial or financial information that is privileged or confidential, and that includes a restrictive notice, unless the Data is: a. known or available from other sources without restriction;

b. known, possessed, or developed independently, and without reference to the Proprietary Data;
c. made available by the owners to others without restriction; or
d. required by law or court order to be disclosed.

4. Data exchanged under this Agreement is exchanged without restriction except as otherwise provided herein.
5. Notwithstanding any restrictions provided in this Article, the Parties are not restricted in the use, disclosure, or reproduction of Data provided under this Agreement that meets one of the exceptions in 3., above. If a Party believes that any exceptions apply, it shall notify the other Party before any unrestricted use, disclosure, or reproduction of the Data.
6. The Parties will not exchange preexisting Proprietary Data under this Agreement unless authorized herein or in writing by the owner.
7. If the Parties exchange Data having a notice that the Receiving Party deems is ambiguous or unauthorized, the Receiving Party shall tell the Providing Party. If the notice indicates a restriction, the Receiving Party shall protect the Data under this Article unless otherwise directed in writing by the Providing Party.
8. The Data rights herein apply to the employees and Related Entities of Partner. Partner shall ensure that its employees and Related Entity employees know about and are bound by the obligations under this

   Article.
9. Disclaimer of Liability: NASA is not restricted in, or liable for, the use, disclosure, or reproduction of Data without a restrictive notice or for Data Partner gives, or is required to give, the U.S. Government without restriction.
10. Partner may use the following or a similar restrictive notice :

Proprietary Data Notice

The data herein does not include Proprietary Data and is not restricted under the Data Rights provisions of Space Act Agreement.

B. Data First Produced by Partner under this Agreement

If Data first produced by Partner or its Related Entities under this Agreement is given to NASA, and the Data is Proprietary Data, and it includes a restrictive notice, NASA will use reasonable efforts to protect it. The Data will be disclosed and used (under suitable protective conditions) only for U.S. Government purposes.

C. Data First Produced by NASA under this Agreement

If Partner requests that Data first produced by NASA under this Agreement be protected, and NASA determines it would be Proprietary Data if obtained from Partner, NASA will mark it with a restrictive notice and use reasonable efforts to protect it for five (5) years after its development. During this restricted period the Data may be disclosed and used (under suitable protective conditions) for U.S. Government purposes only, and thereafter for any purpose. Partner must not disclose the Data without NASA's written approval during the restricted period. The restrictions placed on NASA do not apply to Data disclosing a NASA owned invention for which patent protection is being considered.

D. Publication of Results

The National Aeronautics and Space Act (51 U.S.C. § 20112) requires NASA to provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof. As such, NASA may publish unclassified and non-Proprietary Data resulting from work performed under this Agreement. The Parties will coordinate publication of results allowing a reasonable time to review and comment.

E. Data Disclosing an Invention

If the Parties exchange Data disclosing an invention for which patent protection is being considered, and the furnishing Party identifies the Data as such when providing it to the Receiving Party, the Receiving Party shall withhold it from public disclosure for a reasonable time (one (1) year unless otherwise agreed or the Data is restricted for a longer period herein).

F. Copyright

Data exchanged with a copyright notice and with no restrictive notice is presumed to be published. The following royalty-free licenses apply:

1. If indicated on the Data that it was produced outside of this Agreement, it may be reproduced, distributed, and used to prepare derivative works only for carrying out the Receiving Party's responsibilities under this Agreement.

2. Data without the indication of 1. is presumed to be first produced under this Agreement. Except as otherwise provided in paragraph E. of this Article, and in the Invention and Patent Rights Article of this Agreement for protection of reported inventions, the Data may be reproduced, distributed, and used to prepare derivative works for any purpose.

G. Data Subject to Export Control

Whether or not marked, technical data subject to the export laws and regulations of the United States provided to Partner under this Agreement must not be given to foreign persons or transmitted outside the United States without proper U.S. Government authorization.

H. Handling of Background, Third Party Proprietary, and Controlled Government Data

1. NASA or Partner (as Disclosing Party) may provide the other Party or its Related Entities (as Receiving Party):
   a. Proprietary Data developed at Disclosing Party's expense outside of this Agreement (referred to as Background Data);
   b. Proprietary Data of third parties that Disclosing Party has agreed to protect or is required to protect under the Trade Secrets Act (18 U.S.C. §

   1905) (referred to as Third Party Proprietary Data); and

   c. U.S. Government Data, including software and related Data, Disclosing Party intends to control (referred to as Controlled Government Data).
2. All Background, Third Party Proprietary and Controlled Government Data provided by Disclosing Party to Receiving Party shall be marked by Disclosing Party with a restrictive notice and protected by Receiving Party in accordance with this Article.
3. Disclosing Party provides the following Data to Receiving Party. The lists below may not be comprehensive, are subject to change, and do not supersede any restrictive notice on the Data.
   a. Background Data:

   The Disclosing Party's Background Data, if any, will be identified in a separate technical document.

   b. Third Party Proprietary Data:

   The Disclosing Party's Third Party Proprietary Data, if any, will be identified in a separate technical document. c. Controlled Government Data:

   The Disclosing Party's Controlled Government Data, if any, will be identified in a separate technical document.

   d. NASA software and related Data will be provided to Partner under a separate Software Usage Agreement (SUA). Partner shall use and protect the related Data in accordance with this Article. Unless the SUA authorizes retention, or Partner enters into a license under 37 C.F.R. Part 404, the related Data shall be disposed of as NASA directs:

   None

4. For such Data with a restrictive notice pursuant to H.2. or such Data identified in this Article, Receiving Party shall:
   a. Use, disclose, or reproduce such Data only as necessary under this Agreement;
   b. Safeguard such Data from unauthorized use and disclosure;

c. Allow access to such Data only to its employees and any Related Entity requiring access under this Agreement;

d. Except as otherwise indicated in 4.c., preclude disclosure outside

Receiving Party's organization;

e. Notify its employees with access about their obligations under this Article and ensure their compliance, and notify any Related Entity with access about their obligations under this Article; and f. Dispose of such Data as Disclosing Party directs.

I. Oral and visual information

If Partner discloses Proprietary Data orally or visually, NASA will have no duty to restrict, or liability for disclosure or use, unless Partner:

1. Orally informs NASA before initial disclosure that the Data is Proprietary Data, and
2. Reduces the Data to tangible form with a restrictive and gives it to NASA within ten (10) calendar days after disclosure.

ARTICLE 12. INTELLECTUAL PROPERTY RIGHTS –

INVENTION AND PATENT RIGHTS

A. General

1. NASA has determined that 51 U.S.C. § 20135(b) does not apply to this Agreement. Therefore, title to inventions made (conceived or first actually reduced to practice) under this Agreement remain with the respective inventing party(ies). No invention or patent rights are exchanged or granted under this Agreement, except as provided herein.
2. "Related Entity" as used in this Invention and Patent Rights Article means a contractor, subcontractor, grantee, or other entity having a legal relationship with NASA or Partner assigned, tasked, or contracted with to perform activities under this Agreement.
3. The invention and patent rights herein apply to employees and Related Entities of Partner. Partner shall ensure that its employees and Related Entity employees know about and are bound by the obligations under this Article.

B. NASA Inventions

NASA will use reasonable efforts to report inventions made under this Agreement by its employees. Upon request, NASA will use reasonable efforts to grant Partner, under 37 C.F.R. Part 404, a negotiated license to any NASA invention made under this Agreement. This license is subject to paragraph E.1. of this Article.

C. NASA Related Entity Inventions

NASA will use reasonable efforts to report inventions made under this Agreement by its Related Entity employees, or jointly between NASA and Related Entity employees, where NASA has the right to acquire title. Upon request, NASA will use reasonable efforts to grant Partner, under 37 C.F.R. Part 404, a negotiated license to any of these inventions where NASA has acquired title. This license is subject to paragraph E.2. of this Article.

D. Joint Inventions With Partner

The Parties will use reasonable efforts to report, and cooperate in obtaining patent protection on, inventions made jointly between NASA employees, Partner employees, and employees of either Party's Related Entities. Upon timely request, NASA may, at its sole discretion and subject to paragraph E. of this Article:

1. refrain from exercising its undivided interest inconsistently with Partner's commercial business; or
2. use reasonable efforts to grant Partner, under 37 C.F.R. Part 404, an exclusive or partially exclusive negotiated license.

E. Rights to be Reserved in Partner's License

Any license granted Partner under paragraphs B., C., or D. of this Article is subject to the following:

1. For inventions made solely or jointly by NASA employees, NASA reserves the irrevocable, royalty-free right of the U.S. Government to practice the invention or have it practiced on behalf of the United States or on behalf of any foreign government or international organization pursuant to any existing or future treaty or agreement with the United States.
2. For inventions made solely or jointly by employees of a NASA Related Entity, NASA reserves the rights in 1. above, and a revocable, nonexclusive, royalty-free license retained by the Related Entity under 14 C.F.R. § 1245.108 or 37 C.F.R. § 401.14 (e).

F. Protection of Reported Inventions

For inventions reported under this Article, the Receiving Party shall withhold all invention reports or disclosures from public access for a reasonable time (1 year unless otherwise agreed or unless restricted longer herein) to facilitate establishment of patent rights.

G. Patent Filing Responsibilities and Costs

1. The invention and patent rights herein apply to any patent application or patents covering an invention made under this Agreement. Each Party is responsible for its own costs of obtaining and maintaining patents covering sole inventions of its employees. The Parties may agree otherwise, upon the reporting of any invention (sole or joint) or in any license granted.
2. Partner shall include the following in patent applications for an invention made jointly between NASA employees, its Related Entity employees and Partner employees:

The invention described herein may be manufactured and used by or for the U.S. Government for U.S. Government purposes without the payment of royalties thereon or therefore.

NASA technology available for licensing can be located by visiting the following website address – http://technology.nasa.gov.

ARTICLE 13. USE OF NASA NAME AND NASA EMBLEMS

A. NASA Name and Initials

Partner shall not use "National Aeronautics and Space Administration" or "NASA" in a way that creates the impression that a product or service has the authorization, support, sponsorship, or endorsement of NASA, which does not, in fact, exist. Except for releases under the "Release of General Information to the Public and Media" Article, Partner must submit any proposed public use of the NASA name or initials (including press releases and all promotional and advertising use) to the NASA Associate Administrator for the Office of

Communications or designee ("NASA Communications") for review and approval. Approval by NASA Office of Communications shall be based on applicable law and policy governing the use of the NASA name and initials.

B. NASA Emblems

Use of NASA emblems (*i.e.*, NASA Seal, NASA Insignia, NASA logotype, NASA Program Identifiers, and the NASA Flag) is governed by 14 C.F.R. Part 1221. Partner must submit any proposed use of the emblems to NASA Communications for review and approval.

ARTICLE 14. RELEASE OF GENERAL INFORMATION TO THE PUBLIC AND MEDIA

NASA or Partner may, consistent with Federal law and this Agreement, release general information regarding its own participation in this Agreement as desired.

Pursuant to Section 841(d) of the NASA Transition Authorization Act of 2017, Public Law 115-10 (the "NTAA"), NASA is obligated to publicly disclose copies of all agreements conducted pursuant to NASA's 51 U.S.C. §20113(e) authority in a searchable format on the NASA website within 60 days after the agreement is signed by the Parties. The Parties acknowledge that a copy of this Agreement will be disclosed, without redactions, in accordance with the NTAA.

ARTICLE 15. DISCLAIMER OF WARRANTY

Goods, services, facilities, or equipment provided by NASA under this Agreement are provided "as is." NASA makes no express or implied warranty as to the condition of any such goods, services, facilities, or equipment, or as to the condition of any research or information generated under this Agreement, or as to any products made or developed under or as a result of this Agreement including as a result of the use of information generated hereunder, or as to the merchantability or fitness for a particular purpose of such research, information, or resulting product, or that the goods, services, facilities or equipment provided will accomplish the intended results or are safe for any purpose including the intended purpose, or that any of the above will not interfere with privately-owned rights of others. Neither the government nor its contractors shall be liable for special, consequential or incidental damages attributed to such equipment, facilities, technical information, or services provided under this Agreement or such research, information, or resulting products made or developed under or as a result of this Agreement.

ARTICLE 16. DISCLAIMER OF ENDORSEMENT

NASA does not endorse or sponsor any commercial product, service, or activity. NASA's participation in this Agreement or provision of goods, services, facilities or equipment under this Agreement does not constitute endorsement by NASA. Partner agrees that nothing in this Agreement will be construed to imply that

NASA authorizes, supports, endorses, or sponsors any product or service of Partner resulting from activities conducted under this Agreement, regardless of the fact that such product or service may employ NASA-developed technology.

ARTICLE 17. COMPLIANCE WITH LAWS AND REGULATIONS

A. The Parties shall comply with all applicable laws and regulations including, but not limited to, safety; security; export control; environmental; and suspension and debarment laws and regulations. Access by a Partner to NASA facilities or property, or to a NASA Information Technology (IT) system or application, is contingent upon compliance with NASA security and safety policies and guidelines including, but not limited to, standards on badging, credentials, and facility and IT system/application access.

B. With respect to any export control requirements:

1. The Parties will comply with all U.S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 C.F.R. Parts 120 through 130, and the Export Administration Regulations (EAR), 15 C.F.R. Parts 730 through 799, in performing work under this Agreement or any Annex to this Agreement. In the absence of available license exemptions or exceptions, the Partner shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of hardware, technical data and software, or for the provision of technical assistance.

2. The Partner shall be responsible for obtaining export licenses, if required, before utilizing foreign persons in the performance of work under this Agreement or any Annex under this Agreement, including instances where the work is to be performed on-site at NASA and where the foreign person will have access to export-controlled technical data or software.

3. The Partner will be responsible for all regulatory record-keeping requirements associated with the use of licenses and license exemptions or exceptions.

4. The Partner will be responsible for ensuring that the provisions of this Article apply to its Related Entities.

C. With respect to suspension and debarment requirements:

1. The Partner hereby certifies, to the best of its knowledge and belief, that it has complied, and shall comply, with 2 C.F.R. Part 180, Subpart C, as supplemented by 2 C.F.R. Part 1880, Subpart C.

2. The Partner shall include language and requirements equivalent to those set forth in subparagraph C.1., above, in any lower-tier covered transaction entered into under this Agreement.

ARTICLE 18. TERM OF AGREEMENT

This Agreement becomes effective upon the date of the last signature below ("Effective Date") and shall remain in effect until the completion of all obligations of both Parties hereto, or two years from the Effective Date, whichever comes first.

ARTICLE 19. RIGHT TO TERMINATE

Either Party may unilaterally terminate this Agreement by providing thirty (30) calendar days written notice to the other Party.

ARTICLE 20. CONTINUING OBLIGATIONS

The rights and obligations of the Parties that, by their nature, would continue beyond the expiration or termination of this Agreement, e.g., "Liability and Risk of Loss" and "Intellectual Property Rights" related clauses shall survive such expiration or termination of this Agreement.

ARTICLE 21. POINTS OF CONTACT

The following personnel are designated as the Points of Contact between the Parties in the performance of this Agreement.

Technical Points of Contact

NASA	Sensuron LLC
Allen Parker	Justin Braun
4800 Lilly Ave	3101 Bee Caves Rd, #110
Edwards, CA 93523	Austin TX 78746
661.276.2407	512.827.2040 (o)
661.276.5332	512.367.5737
allen.r.parker@nasa.gov	Justin.braun@sensuron.com

ARTICLE 22. DISPUTE RESOLUTION

Except as otherwise provided in the Article entitled "Priority of Use," the Article entitled "Intellectual Property Rights – Invention and Patent Rights" (for those activities governed by 37 C.F.R. Part 404), and those situations where a preexisting statutory or regulatory system exists (*e.g.*, under the Freedom of Information Act, 5 U.S.C. § 552), all disputes concerning questions of fact or law arising under this Agreement shall be referred by the claimant in writing to the appropriate person identified in this Agreement as the "Points of Contact." The persons identified as the "Points of Contact" for NASA and the Partner will consult and attempt to resolve all issues arising from the implementation of this Agreement. If they are unable to come to agreement on any issue, the dispute will be referred to the signatories to this Agreement, or their designees, for joint resolution. If the Parties remain unable to resolve the dispute, then the NASA signatory or that person's designee, as applicable, will issue a written decision that will be the final agency decision for the purpose of judicial review. Nothing in this Article limits or prevents either Party from pursuing any other right or remedy available by law upon the issuance of the final agency decision.

ARTICLE 23. MODIFICATIONS

Any modification to this Agreement shall be executed, in writing, and signed by an authorized representative of NASA and the Partner.

ARTICLE 24. ASSIGNMENT

Neither this Agreement nor any interest arising under it will be assigned by the Partner or NASA without the express written consent of the officials executing, or successors, or higher- level officials possessing original or delegated authority to execute this Agreement.

ARTICLE 25. APPLICABLE LAW

U.S. Federal law governs this Agreement for all purposes, including, but not limited to, determining the validity of the Agreement, the meaning of its provisions, and the rights, obligations and remedies of the Parties.

ARTICLE 26. INDEPENDENT RELATIONSHIP

This Agreement is not intended to constitute, create, give effect to or otherwise recognize a joint venture, partnership, or formal business organization, or agency agreement of any kind, and the rights and obligations of the Parties shall be only those expressly set forth herein.

ARTICLE 27. LOAN OF GOVERNMENT PROPERTY

The parties shall enter into a NASA Form 893, Loan of NASA Equipment, for NASA equipment loaned to Partner.

ARTICLE 28. SIGNATORY AUTHORITY

The signatories to this Agreement covenant and warrant that they have authority to execute this Agreement. By signing below, the undersigned agrees to the
above terms and conditions.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION	Sensuron LLC
BY:	BY:
James L. Reuter Associate Administrator, STMD	Pierrick Vulliez CEO
DATE:_____	DATE:_6/11/2020_____

Type of Correspondence Letter Center AFRC

National Aeronautics and Space Administration

Armstrong Flight Research Center
P.O. Box 273
Edwards, CA 93523-0273

June 10, 2020

Reply to Attn of: 330

☒ Remove Legal Letter Re

Mr. Pierrick Vulliez
Sensuron
3101 Bee Cave Road Suite 110
Austin, TX 78746

☐ Remove Subject
☒ Remove REF
☐ Remove Beginning Saluation
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☒ Remove Separate Cover
☒ Remove Approval
☒ Remove 2nd Approval

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☒ Remove bcc
☒ Remove Author

Subject: Sensuron Letter of Intent

Dear Mr. Vulliez,

NASA Armstrong Flight Research Center (AFRC) is pleased to offer its support to Sensuron consistent with the attachment Responsibilities and Schedule. We understand that your requirements for such support are contingent upon your final Announcement of Collaborative Opportunity ACO Proposal receiving an award. Please include a copy of this Letter of Intent along with the accompanying Responsibilities and Schedule attachment in support of your proposal efforts to demonstrate AFRC level of commitment. However, this letter does not serve as an endorsement of your company or your proposal. By submitting this letter, the attached Responsibilities and Schedule with your proposal, you indicate your acceptance of the Responsibilities and Schedule as support for your proposal.

AFRC commits to provide related support in the areas of technical expertise and facilities (0.92 FTE and $274,970) to Sensuron for implementation of its proposal, should your proposal be selected. This commitment is dependent upon the availability of personnel and facilities to support the activity and your acceptance of the template Space Act Agreement in the ACO.

I wish you well in your proposal and AFRC is looking forward to working with you, if your proposal is accepted for award.

Sincerely,

☐ Add Concurrence Page ☐ Add Concurrence/Footer

LAURIE GRINDLE Digitally signed by LAURIE GRINDLE
Date: 2020.06.10 18:54:37 -07'00'

Laurie Grindle
Acting Director for Programs

Attachment:
Responsibilities and Schedule (3 pages)

Responsibilities and Schedule

Developed by AFRC

To Support ACO 2020 Proposal Submitted by

Sensuron

1. Responsibilities

A. NASA AFRC will use reasonable effort to:

1. Provide the requirements for a space-rated FOSS interrogator.
2. Provide engineering review for the design and analysis of the space-rated FOSS interrogator.
3. Provide engineering review for the fabrication and assembly of the space-rated FOSS interrogator.
4. Provide engineering review for the software for the space-rated FOSS interrogator
5. Provide environmental test facilities to test the space-rated FOSS interrogator.
6. Provide sensors and test fixtures to demonstrate the space-rated FOSS interrogator for a representative use case.

B. Sensuron will use reasonable efforts to:

1. Specify, design and analyze a space-rated FOSS interrogator to meet space standards.
2. Develop an environmental test plan targeting component testing in the first 6 months and initial prototype testing in the first year.
3. Fabricate and assemble the space-rated FOSS interrogator.
4. Deliver operational space-rated FOSS interrogator to NASA AFRC for environmental testing.
5. Provide engineering support during environmental testing.
6. Provide engineering support during a demonstration of the space-rated FOSS interrogator.

2. Schedule

The planned schedule for the activities with Sensuron as defined in Paragraph 1. Responsibilities are as follows:

Milestone	Date
Kickoff Meeting	Oct-21
Design specifications and environmental test plan review and approval complete	Dec-21
EMI testing for individual components, iterations 1 and 2 complete	Feb-21
Vibration and Thermal for individual components - iterations 1, 2 and 3 complete	Apr-21
Electrical design review complete	Jun-21
Mechanical design review complete	Jul-21
Firmware and software complete	Aug-21
Prototype manufacturing and assembly complete	Sep-21
Prototype functional validation complete	Oct-21
Vibration and Thermal for prototype - iterations 1 and 2 complete	Feb-22
EMI testing for prototype - iterations 1 and 2 complete	Feb-22
Prototype demonstration at NASA AFRC complete	Mar-22

3. AFRC Cost estimate

This Statement of Commitment estimates the costs of all the AFRC support for this activity. The following table reflects a summary of the costs from Oct 01, 2020, through Sept 30, 2022.

Fiscal Year	FY21	FY22	AFRC Totals
FTE	0.46	0.46	0.92
FTE	$ 73,816	$ 76,904	$ 150,720
Procurement	$ 155,434	$ 119,537	$ 274,970
Total	$ 229,250	$ 196,441	$ 425,690

4. Points of Contact

AFRC	Sensuron
Eric Miller	Pierrick Vulliez
P.O. Box 273	3101 Bee Caves Rd #110
Edwards, CA 93523	Austin, TX 78746
661-276-7041	512-827-2040
661-276-5879	512-367-5737
Eric.j.miller@nasa.gov	pierrick.vulliez@sensuron.com

5. Modifications

Any modification to this Responsibilities and Schedule document set forth herein after award shall be documented in writing, and signed by both the AFRC and the Sensuron. Modification of this Responsibilities and Schedule document does not modify the terms of the Space Act Agreement.

6. Signatory Authority

The signatory to this Responsibilities and Schedule document represents and warrants that he/she has authority to commit AFRC to support Sensuron if selected for award.

National Aeronautics and Space Administration
Armstrong Flight Research Center

LAURIE GRINDLE

Digitally signed by LAURIE GRINDLE
Date: 2020.06.10 18:55:11 -07'00'

Laurie Grindle
Acting Director for Programs

National Aeronautics and Space
Administration
Langley Research Center
Hampton, VA 23681-001

Reply to Attn of: 104

June 10, 2020

Sensuron
3101 Bee Cave Road Suite 110
Austin, TX 78746

Subject: Letter of Intent for Support under ACO 2020 Award

Dear Pierrick Vulliez,

NASA Langley Research Center is pleased to offer its support to Sensuron consistent with the attached Responsibilities and Schedule document. We understand that your requirements for such support are contingent upon your Final ACO Proposal receiving an award. Please include a copy of this Letter of Intent along with the accompanying Responsibilities and Schedule document attachment in support of your proposal efforts to demonstrate NASA Langley Research Center's level of commitment. However, this letter does not serve as an endorsement of your company or your proposal. By submitting this letter and the attached Responsibilities and Schedule document with your proposal, you indicate your acceptance of the Responsibilities and Schedule document as support for your proposal.

NASA Langley Research Center commits to provide related support in the areas of technical expertise and facilities (0.4 FTE at $75,667) to Sensuron for implementation of its proposal, should your proposal be selected. This commitment is dependent upon the availability of personnel and facilities to support the activity and your acceptance of the template Space Act Agreement in the ACO.

I wish you well in your proposal and NASA Langley Research Center is looking forward to working with you if your proposal is accepted for award.

Sincerely,

DEBORAH TOMEK

Digitally signed by DEBORAH TOMEK
Date: 2020.06.10 14:06:19 -04'00'

Deborah M. Tomek
Acting Director, Space Technology and Exploration Directorate
NASA Langley Research Center

Attachment
[Responsibilities and Schedule document see below]

cc: (w/o Attachment)

THE RESPONSIBILITIES AND SCHEDULE DOCUMENT IS REQUIRED TO BE INCLUDED AS AN ATTACHMENT TO THE CENTER LETTER OF INTENT SUPPORTING THE PROPOSAL.
SUBMISSION OF A CENTER LETTER OF INTENT AND RESPONSIBILITY AND SCHEDULE DOCUMENT IN A FINAL ACO PROPOSAL INDICATES PROPOSER'S ACCEPTANCE OF THE RESPONSIBILITIES AND SCHEDULE DOCUMENT PROPOSED BY THE CENTER IF SELECTED FOR AWARD.
PURSUANT TO ARTICLE 2 OF THE TEMPLATE SPACE ACT AGREEMENT, THE RESPONSIBILITIES AND SCHEDULE DOCUMENT IS INCORPORATED FULLY BY REFERENCE INTO THE SPACE ACT AGREEMENT AND THEREFORE WILL BE PUBLISHED WITH THE SPACE ACT AGREEMENT IN ACCORDANCE WITH ARTICLE 16 OF THE SPACE ACT AGREEMENT.

RESPONSIBILITIES AND SCHEDULE

DEVELOPED BY **NASA Langley Research Center**

TO SUPPORT ACO 2020 PROPOSAL SUBMITTED BY

Sensuron

1. RESPONSIBILITIES

A. **NASA Langley Researcher Center** will use reasonable efforts to:

1. Support weekly meetings as needed.
2. Conduct Electromagnetic Effects (EME) Testing per the customer's request. Testing will be conducted at the component level and the prototype level.
3. Prepare EME Testing procedures.
4. Produce post testing report and deliver data to Sensuron.
5. Ensure equipment calibrations are current for defined testing parameters.
6. Provide Subject Matter Expert (SME) support for Electromagnetic Effects testing. The SME can help the customer decide on proper requirements.

B. **Sensuron** will use reasonable efforts to:

1. Support weekly meetings as needed.
2. Define testing requirements.
3. Provide hardware to be tested, both the at the component level and prototype level.
4. Provide On-site testing support.
5. Provide ground support equipment to run the hardware being tested, both at the component level and prototype level.

2. SCHEDULE

The planned schedule for the activities with Sensuron as defined in Paragraph 1. RESPONSIBILITIES are as follows:

1.	Support weekly meetings as needed	Ongoing
2.	Receive the component level hardware to be tested and ground support equipment to run the hardware being tested	Jan 2021
3.	Write test procedure and prepare equipment for testing	Jan 2021
4.	EME Testing – Component Level	Feb 2021
5.	Write posttest report	Mar 2021
6.	Receive the prototype hardware to be tested and ground support equipment to run the hardware being tested	Jan 2022
7.	Write test procedure and prepare equipment for testing	Jan 2022
8.	EME Testing – Prototype	Feb 2022
9.	Write posttest report	Mar 2022

3. POINTS OF CONTACT

The following personnel are designated as the Points of Contact between the Parties in the performance of this Agreement.

NASA Langley Research Center

Wade May
Mail Stop 424
Hampton, VA 23681
757.864.4258 (o)
757.864.4342
wade.r.may@nasa.gov
(Programmatic, Schedule, Costing)

Courtney Rollins
Mail Stop 130
Hampton, VA 23681
757.864.7814
757.864.4234
courtney.h.rollins@nasa.gov
(EME Subject Matter Expert)

Sensuron

Pierrick Vulliez
3101 Bee Caves Rd #110
Austin, TX 78746
512.827.2040 (o)
512.367.5737
pierrick.vulliez@sensuron.com

4. MODIFICATIONS

Any modification to this Responsibilities and Schedule document set forth herein after award shall be documented in writing and signed by both the NASA Langley Research Center and Sensuron. Modification of this Responsibilities and Schedule document does not modify the terms of the Space Act Agreement.

5. SIGNATORY AUTHORITY

The signatory to this Responsibilities and Schedule document represents and warrants that he/she has authority to commit NASA Langley Research Center to support Sensuron if selected for award.

NASA AERONAUTICS AND SPACE ADMINISTRATION

NASA Langley Research Center

BY: DEBORAH TOMEK Digitally signed by DEBORAH TOMEK Date: 2020.06.10 14:06:52 -04'00'

Deborah Tomek

National Aeronautics and
Space Administration

John H. Glenn Research Center
Lewis Field
Cleveland, OH 44135-3191

June 18, 2020

Reply to Attn of: MT

Sensuron, LLC
Attn: Mr. Pierrick Vulliez
3101 Bee Caves Road #110
Austin, TX 78746

Subject: Letter of Intent with Sensuron, LLC for Space-Rated Fiber Optic Sensing System (FOSS) Interrogator for Cryogenic Temperature Monitoring in Space (the "Proposal")

This letter sets forth the National Aeronautics and Space Administration Glenn Research Center (NASA GRC) estimate for its support of the Proposal. Should the Proposal be accepted, NASA GRC anticipates providing the following level of support.

The NASA GRC anticipates providing subject matter engineering support for the technical review, prototype fabrication, evaluation testing, and data analysis of the space-rated FOSS. The FOSS is a miniature, ruggedized temperature monitoring system for cryogenic fluid applications.

The estimated cost for NASA GRC's anticipated support is $84,890, assuming that the effort is performed during the following timeframe: October 1, 2020, to September 30, 2022. The above cost estimate is based on projected costs for the stated time periods and is subject to change.

The intention of NASA GRC to provide the above support is nonexclusive and contingent on the selection of the Proposal, the concurrence of NASA's Office of International and Interagency Relations (if applicable), as well as the availability of appropriated funds and other required resources. The actual commitment of NASA GRC resources will be documented in an appropriate subsequent agreement between Sensuron, LLC, and NASA GRC. Enclosed, for your convenience, is a Proposal Summary outlining the details discussed in this letter.

This is a letter of intent only. This nonexclusive letter is not intended to be, and shall not constitute in any way, a binding or legal agreement, or impose any legal obligation or duty on either Sensuron, LLC, or NASA GRC. This letter does not serve as an endorsement of your organization or the Proposal.

This letter shall be interpreted and enforced in accordance with U.S. Federal law for all purposes, including but not limited to, determining the validity of the letter, the meaning of the provisions, and the rights, obligations, and remedies of the parties.

Should the Proposal be accepted, we look forward to formalizing an appropriate teaming arrangement to provide the above support. If you have any questions, please contact Jason C. Wendell, Fluid Systems Engineer, at (216) 433-2708 or jason.c.wendell@nasa.gov.

Marla E. Pérez-Davis, Ph.D.
Center Director

Enclosure

THE RESPONSIBILITIES AND SCHEDULE DOCUMENT IS REQUIRED TO BE INCLUDED AS AN ATTACHMENT TO THE CENTER LETTER OF INTENT SUPPORTING THE PROPOSAL. SUBMISSION OF A CENTER LETTER OF INTENT AND RESPONSIBILITY AND SCHEDULE DOCUMENT IN A FINAL ACO PROPOSAL INDICATES PROPOSER'S ACCEPTANCE OF THE RESPONSIBILITIES AND SCHEDULE DOCUMENT PROPOSED BY THE CENTER IF SELECTED FOR AWARD.
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RESPONSIBILITIES AND SCHEDULE

DEVELOPED BY NASA GLENN RESEARCH CENTER

TO SUPPORT ACO 2020 PROPOSAL SUBMITTED BY

SENSURON, LLC

1. RESPONSIBILITIES

A. NASA Glenn Research Center (NASA GRC) will use reasonable efforts to:

1. Participate in engineering review for the design and analysis of the space-rated Fiber Optic Sensing System (FOSS) interrogator.
2. Participate in engineering review for the environmental test plan.

B. Sensuron, LLC (Sensuron) will use reasonable efforts to:

1. Specify, design, and analyze a space-rated FOSS interrogator to meet space standards.
2. Develop an environmental test plan targeting component testing in the first six (6) months after the Effective Date and initial prototype testing in the first year after the Effective Date.
3. Fabricate and assemble the space-rated FOSS interrogator.
4. Deliver operational space-rated FOSS interrogator to NASA Armstrong Flight Research Center (AFRC) for environmental testing.
5. Provide engineering support during environmental testing.

6. Provide engineering support during a demonstration of the space-rated FOSS interrogator.

2. SCHEDULE

The planned schedule for the activities with Sensuron as defined in Paragraph 1. RESPONSIBILITIES are as follows:

Milestone	Completion Date
NASA GRC and Sensuron to participate in kickoff meeting	Approximately October 2021
NASA GRC to participates in an engineering review of the design specifications and environmental test plan	Appproximately December 2021
NASA GRC to participates in an engineering review of the electrical design	Appproximately June 2021
NASA GRC completes engineering review of the mechanical design	Appproximately July 2021
Sensuron completes FOSS prototype manufacturing and assembly	Appproximately September 2021
Sensuron completes FOSS prototype functional validation	Appproximately October 2021
NASA GRC supports prototype demonstration at NASA AFRC	Appproximately March 2022

3. POINTS OF CONTACT

The following personnel are designated as the Points of Contact between the Parties in the performance of this Agreement.

NASA GRC

Jason C. Wendell
21000 Brookpark Rd MS 100-5
Cleveland, OH 44135
216-433-2708 (Phone)
216-433-4000 (Fax)
jason.c.wendell@nasa.gov

Sensuron

Pierrick Vulliez
3101 Bee Caves Rd #110
Austin, TX 78746
512-827-2040 (Phone)
512-367-5737 (Fax)
pierrick.vulliez@sensuron.com

4. MODIFICATIONS

Any modification to this Responsibilities and Schedule document set forth herein after award shall be documented in writing, and signed by both the NASA GRC and Sensuron. Modification of this Responsibilities and Schedule document does not modify the terms of the Space Act Agreement.

5. SIGNATORY AUTHORITY

The signatory to this Responsibilities and Schedule document represents and warrants that he/she has authority to commit NASA GRC to support Sensuron if selected for award.

NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION

GLENN RESEARCH CENTER

BY: MARLA PEREZ-DAVIS Digitally signed by MARLA PEREZ-DAVIS Date: 2020.06.18 21:37:30 -04'00'

Marla E. Pérez-Davis, Ph.D.