JUSTIFICATION FOR OTHER THAN FULL AND OPEN COMPETITION

1. This document is a justification for other than full and open completion prepared by NASA's Goddard Space Flight Center (NASA's GSFC).

The NASA/Goddard Space Flight Center (GSFC) proposes to develop a CO2 lidar, a land topography swath-mapping lidar, and an advanced laser communication system for use on satellites. The Mercury-Cadmium-Telluride (HgCdTe) electron-avalanche photodiodes (e-APD) developed by DRS Reconnaissance, Surveillance and Target Acquisition (RSTA), Infrared Technologies Division of Dallas TX (DRS RSTA) has been identified as the prime candidate to provide detectors for all three space applications. The purposes of this solicitation are: (a) to study the effects of high-energy proton radiation damage on the DRS HgCdTe e-APD and the read-out integrated circuit (ROIC) assemblies; and (b) to supply NASA a prototype HgCdTe e-APD linear mode photon counting (LMPC) detector system for evaluation and laboratory demonstrations.

2. The nature and/or description of the action being approved:

This program will test for the radiation hardness of the HgCdTe e-APD developed by DRS RSTA to fluence levels commensurate with the anticipated operational space environment for a 5-year mission in a near earth orbit. Measurements include device quantum efficiency, dark current, avalanche gain, and ROIC noise performance as a function of proton fluence up to at least 2e11 particles per square centimeters (30krad(Si) dose) at a proton energy of 50-70 MeV. Tests will be conducted at both the HgCdTe e-APD component level and the HgCdTe e-APD-ROIC assembly level. In addition, DRS will deliver a HgCdTe e-APD 2x8 pixel LMPC focal plane array (FPA) with the integrated cooling system to NASA GSFC for laboratory demonstration and breadboard laser communication tests and a 4x4 pixel array HgCdTe e-APD system with integrated ROIC.

NASA is undertaking this study for a HgCdTe e-APD detector that meets the following requirements:

- HgCdTe e-APDs array and integrated ROIC assembly with demonstrated (published) linear mode time-resolved single-photon counting performance at nanosceonds scale;
- Quantum efficiencies >70% from 0.4 μm to 4.3 μm;
- Stable linear avalanche gain in the range of 500 to 1000;
- Dark current equivalent to <20 kcts/s/pixel dark count rate at 77°K;
- Resistive transimpedance amplifier (RTIA) ROIC with a gain-bandwidth product of $>3x10^{13}$ ohm-Hz, rms noise level < 0.075 average single photon pulse amplitude, and <3 ns FWHM output pulse width;
- Excess noise <1.4, measured directly from single photon pulse amplitude distribution;
- Digital outputs for detected single photon events with <4 ns output pulse width;
- Dark current equivalent to <20 kcts/s per pixel at 77°K;
- Timing jitter 550 ps to 800 ps;
- Demonstrated minimum time between distinguishable single photon events <10 ns;

- HgCdTe APD focal plane array, housing and cooling system to meet the above specification simultaneously;
- Same HgCdTe e-APDs but constructed in a 4x4 pixel array format at 80 um pixel spacing and >50% fill factor (no microlens array), and integrated ROIC for each pixel with >10 MHz bandwidth and <5 fW/rt-Hz spectral noise density for airborne CO2 lidar applications.

3. Description of the supplies or services required, including an estimated value:

The major objectives of this effort are:

(1). Test proton hardness of the HgCdTe n-on-p e-APD by conducting cold in-situ high bias I-V and conversion efficiency (CE) measurements on high performance (low dark current) APDs as a function of proton fluence up to 2e11 particles per square centimeters (30krad(Si) dose) at a proton energy of 50-70 MeV. Full device characterization including I-V and CE testing and annealing effect will also be performed before and after the proton radiation.

(2). Test proton radiation hardness of the HgCdTe e-APD focal plane array (FPA) with the integrated CMOS ROIC by conducting in-situ FPA performance measurement as a function of proton fluence up to 2e11 particles per square centimeters (30krad(Si) dose) at a proton energy of 50-70 MeV. A high performance HgCdTe n-on-p e-APD 80 um pitch 4x4 pixel array and CMOS ROIC FPA will be used in the test.

(3). Build, characterize, and deliver an HgCdTe e-APD LMPC system with an operational 2x8 FPA and the cooler with the same or better performance as those published in *SPIE 8033* (2011) by Beck *et al*. and Gleckler *et al*. The characterization will concentrate on parameters of importance to communications such as jitter and bit error rate with a goal to use in a 100 Mbps 16-ary PPM laser communication application.

(4). Build, characterize, and deliver a low noise low bandwdith 4x4 pixel array HgCdTe e-APD system with integrated ROIC for each pixel, >10 MHz bandwidth and <5 fW/rt-Hz spectral noise density. The focal plan assembly shall be mounted on a closed-cycle cooler for use in an airborne environment, with f/1.5 numerical aperture. The spectral response shall be >70% quantum efficiencies from 0.4 μm to 4.3 μm wavelength range. The pixel spacing shall be 80 μm with >50% fill factor without the use of a microlens array.

Milestones:

Milestone Description	Date
HgCdTe e-APD photon hardness tests	6 months after contract effective date
Proton radiation hardness testing of HgCdTe e-APD FPA with ROIC	12 months after contract effective date
Delivery of 2x8 LMPC system	29 months after contract effective date, but no later than Oct. 2014
Delivery of the 4x4 low noise low bandwidth HgCdTe e-APD system	12 months after contract effective date, but no later than July 2012

The estimated value of this work is $610,000

4. Statutory authority permitting other than full and open competition.

The statutory authority permitting other than full and open competition is 10 U.S.C 2304 (c) (1), as sited under FAR 6.302-1 "When the supplies or services required by the agency are available from only one responsible source, or, for DoD, NASA, and the Coast Guard, from only one or a limited number of responsible sources, and no other type of supplies or services will satisfy agency requirements."

5. A demonstration that the proposed contractor's unique qualifications or the nature of the acquisition requires use of the authority cited:

After conducting an in-house survey and numerous purchases and tests of a wide range of avalanche photodiode detectors from at least five vendors, including one in France, we found that DRS RSTA is the only source that has demonstrated a linear mode time-resolved photon counting APD that includes the following. The broad spectral range (0.4 μm to 4.3 μm) is unique among photon counters, making this a "first of its kind" system spanning the visible to the mid-infrared. The low excess noise ((F(M) ≈ 1) of the e-APDs allows for robust photon detection while operating at a stable linear avalanche gain in the range of 500 to 1000. The read-out integrated circuit (ROIC) design included a very high gain-bandwidth product resistive transimpedance amplifier (RTIA) ($3x10^{11}$ Ohm-Hz) and a 4 ns output digital pulse width comparator.

DRS produces two types of HgCdTe e-APD ROIC focal plane arrays (FPA); one had very low noise and low bandwidth for the detection of low frequency analog signals. DRS first developed this type of FPA with their subcontractor for another US government customer and demonstrated the performance very close to our need. They have proposed to use the same design with minor modification for our project and analysis showed they can meet all of our requirements. It is the

lowest risk approach for us to obtain the detector system for our airborne lidar. The second type of FPA has 16 high bandwidth analog and 16 LVDS digital outputs. The dark currents less than 2 picoampere at 13 Volt bias where the APD gain is 500. Single photon detection with a photon pulse signal-to-noise ratio of 13.7 above the amplifier noise floor. A photon detection efficiency of 50% at 1550 nm wavelength. The timing jitter is in the range of 550 ps to 800 ps. The demonstrated minimum time between distinguishable events is less than 10 ns. DRS was the only HgCdTe APD developer with published results. To our knowledge, DRS is the only source for a HgCdTe APD that has the above demonstrated performance that meets the NASA photon counting detector requirements.

The HgCdTe APD arrays produced by DRS RSTA uses a company proprietary design with a lateral cylindrical geometry with the p-n junction and n- multiplication region around the central via interconnect, which has unique advantages of high gain, low dark current, and high fill factor. DRS RSTA has been producing this type of HgCdTe APDs since 2006 and has published many technical articles about the devices in scientific journals and conference proceedings. DRS RSTA has already designed, manufactured and delivered a HgCdTe APD preamplifier to another US government customer in 2009. DRS RSTA has demonstrated that they can successfully produce this type of devices at low risk and on schedule.

The proton radiation damage tests specified in this procurement have to be performed on the same type of HgCdTe e-APD and ROIC that we have selected since the effects of radiation depend on the device structure and manufacturing processes. DRS RSTA is the only supplier of the HgCdTe e-APD and ROIC assembly which meets our need and hence the test samples. It is most economical and efficient for DRS to lead the radiation testing that requires multiple test samples, proprietary test setup and in depth knowledge of the device physics.

6. **Description of the efforts made to ensure that offers are solicited from as many potential sources as practicable:**

A notice to the Federal Business Opportunities (FedBizOpps) was posted on June 22, 2012 for 15 days as required by FAR Subpart 5.2.

7. **A determination by the contracting officer that the anticipated cost to the Government will be fair and reasonable**:

By signature of this document, the Contracting Officer determines that the anticipated cost to the Government will be fair and reasonable. DRS Technologies will be required to submit a proposal to be evaluated and negotiated by the Government. The proposal will contain sufficient information to determine reasonableness of the cost.

8. **Description of the market research conducted, and the results, or a statement of reasons market research was not conducted:**

Market research was conducted and several purchases and tests of HgCdTe avalanche photodiode detectors were done. Based on this research, the Government could not find a manufacturer of time-resolved single photon sensitive APDs with multiplication gain >1000 and a spectral

response from 0.4 to 4.3 um. Additionally, a sole-source synopsis will be released on or about July 1, 2012.

9. Other facts supporting the use of other than full and open competition:

None.

10. Sources, if any, that expressed an interest, in writing, in the acquisition:

This requirement was synopsized on the NASA Acquisition Internet Site (NAIS) on July 22, 2012 and closed on July 6, 2012. As a result of this posting no firms expressed capabilities that met our requirements.

11. The actions the Agency may take to remove or overcome any barriers to competition before any subsequent acquisition for the supplies or services required.

There are no barriers to overcome and no action is necessary by NASA to remove barriers to competition. No further procurements are anticipated for these types of items.

JUSTIFICATION FOR OTHER THAN FULL AND OPEN COMPETITION (JOFOC)

SIGNATURE PAGE

TECHICAL DIRECTORATE: I certify that the facts presented in this justification are accurate and complete.

Digitally signed by Xiaoli Sun
DN: cn=Xiaoli Sun, o=Laser Remote Sensing Laborotary, ou=694, email=xiaoli.sun-1@nasa.gov, c=US
Date: 2012.07.05 16:24:57 -04'00'

Signature Date

CONTRACTING OFFICER: I certify that the justification is accurate and complete to the best of my knowledge and belief.

Signature 7/24/12
Date