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# Proceedings of the Infrared Detector Technical Interchange Meeting

*Compiled by*

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Proceedings of the Infrared Detector Technical Interchange Meeting
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August 27 through 28, 2024

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# Contents

# Introduction

Infrared (IR) detector technology is critical for NASA's future missions, many of which require state-of-the-art infrared payloads in support of the Science Mission Directorate (SMD), Space Technology Mission Directorate (STMD), and Exploration Mission Directorate (EOMD). Sensors utilized in IR missions span a wide gamut, including multispectral, polarimetric imaging, point-source detection, scanning dispersive hyperspectral imaging, staring interferometric hyperspectral imaging, and astronomical imaging. Space-qualified IR detectors are a leading item on NASA's critical technology lists as they are key enablers for many science missions. The objectives and IR sensor needs for future NASA missions are described in the most recent decadal surveys for Earth Science, Planetary Science, Heliophysics, and Astronomy and Astrophysics:

- *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space* [1]
- *Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023-2032* [2]
- *Solar and Space Physics: A Science for a Technological Society* [3]
- *Pathways to Discovery in Astronomy and Astrophysics for the 2020s*[4]

The NASA Engineering and Safety Center (NESC) Sensors and Instrumentation Technical Discipline Team (S&I TDT) established an IR Detector Community of Practice (CoP) in December 2023 to promote knowledge sharing among science and engineering practitioners and to assess current and future capabilities relevant to future NASA missions. The IR Detector CoP organized a Technical Interchange Meeting (TIM) that was held on August 27-28, 2024 at the Jet Propulsion Laboratory in Pasadena, CA that convened about 80 attendees from NASA HQ and Centers, Federally Funded Research and Development Centers (FFRDCs)/ University Affiliated Research Centers (UARCs), government agencies and industrial organizations to openly discuss future NASA technology needs and the latest technology developments in IR detectors that span the 2-1000 micron wavelength range.

Program managers and technologists from NASA HQ and Centers, including JPL, provided an overview of the priority IR technology needs and requirements for upcoming missions and identified significant specific research areas that will benefit from IR detector and focal plane array (FPA) technology maturation. Advanced IR detectors/FPAs will enable Earth science on terrestrial and space-based platforms, for example, in applications and observations for climate study, hydrological cycle, land surface vegetation and temperature, and coastal erosion. These instruments, with low noise and high detection efficiency, are also critical to Astrophysics applications such as characterizing faint objects (e.g. Earth-like planets around other stars), detecting fluctuations in the Cosmic Microwave Background, and studying the birth of galaxies. Similarly, for Planetary Science, these instruments can be used to find asteroids and comets, and to spectroscopically map planets in our own solar system. The establishment of research and development on material science theory and growth, read-out circuitry, device fabrication, characterization, packaging, and testing will result in enhanced performance of IR detectors/FPAs for the community. There is, however, a need for agency-wide technology leadership that will

[1] https://www.nationalacademies.org/our-work/decadal-survey-for-earth-science-and-applications-from-space
[2] https://www.nationalacademies.org/our-work/planetary-science-and-astrobiology-decadal-survey-2023-2032
[3] https://www.nationalacademies.org/our-work/a-decadal-strategy-for-solar-and-space-physics-heliophysics
[4] https://www.nationalacademies.org/our-work/decadal-survey-on-astronomy-and-astrophysics-2020-astro2020

address mission constraints related to instrument performance, mass, power, and volume since there is no existing technology that could fulfill every specific mission requirement. Depending on the mission constraints, IR detector/FPA technology is chosen to maximize return of research investment on science data.

Representatives from multiple DoD organizations and DoD-funded contractors provided overview presentations of their IR sensor portfolios and technology development roadmaps. NASA had the opportunity to assess applicability of the significant investments and advancements within the DoD community for detectors up to 15 micron in wavelength. The DoD and NASA share common long-term challenges for producing space-qualified IR sensors due to limited domestic resources for mixed-signal silicon foundries and radiation testing. To facilitate information sharing, NASA has been invited to participate in two annual meetings organized by the DoD – the FPA Technical Workshop (typically held in February) and the Market Research Forum (typically held in September). These meetings provide deep insight into the DoD’s technology roadmaps, programmatic needs driving the development activities, and the underlying investment strategies.

Beyond 15 micron wavelengths, notable progress is being made in superconducting-based detectors for single-photon counting and far-IR sensors. Representatives from leading FFRDCs and government labs such as NIST, JPL, GSFC, MIT Lincoln Laboratory and Argonne National Laboratory gave briefings on the latest results in the field of superconducting detectors, including microwave kinetic inductance detectors (MKIDs), superconducting nanowires ingle photon detectors (SNSPDs), quantum capacitance detectors (QCDs), and transition-edge sensors (TESs). Superconducting sensors offer the highest level of sensitivity and performance for space applications, but they require costly and SWAP-intensive flight cryogenics. There has been significant advancement in superconducting detector capabilities at a very rapid pace, despite the fact that R&D funding is very small by semiconductor detector standards. Many of the most immediate applications for far-IR superconducting detectors within NASA are in Astrophysics. As an example, JPL and GSFC are working jointly on PRIMA, a far-infrared Probe Explorer mission which is currently in Phase A. If selected, PRIMA will fly 120 mK MKID arrays with world-leading sensitivity and noise performance, and a cryogenic 1.8-m telescope. Superconducting detectors also offer significant performance advantages at near-IR wavelengths as well, such as time- and energy-resolved single photon counting, zero read noise and negligible dark counts, and high detection efficiency at near-IR wavelengths. These sensors are currently being used on the ground for deep-space optical communication projects such as Deep Space Optical Communications (DSOC) and Orion Artemis II Optical Communications System (aka O2O), and may have cross-cutting applications for NASA in quantum sensing applications.

The intent of this TIM was to evaluate relevant NASA-needed technologies and developments, identify opportunities for investments and collaboration, and formulate agency-level strategies to meet its near- and far- term needs for science and exploration missions. The presentations and contact information for the participants were distributed to all attendees.

## Biographies of Meeting Chairs

### Brett Nosho

**Brett Nosho** is a Senior Engineering Specialist in the Visible and Infrared Sensor Systems Department at The Aerospace Corporation. He has over 25 years of experience in the growth, fabrication and development of infrared detector materials and focal plane arrays based on HgCdTe and III-V compound semiconductor materials. Prior to joining Aerospace, he received his Ph.D. from the University of California, Santa Barbara and then spent two years as a National Research Council Research Associate at the Naval Research Laboratory. He has co-authored one book chapter, contributed to over 70 technical papers and proceedings and has been awarded 12 patents.

### Sarath Gunapala

**Sarath Gunapala** is the Deputy Section Manager of the Microdevices & Sensor Systems Section at the NASA Jet Propulsion Laboratory. He has 40 years of experience in the infrared detector and focal plane arrays development based on III-V compound semiconductor materials. He is a Fellow of SPIE, IEEE, & Optica, a senior research scientist and a Fellow of the Jet Propulsion Laboratory. Dr. Gunapala has authored over 400 publications, including 14 book chapters, and holds twenty-seven U.S. patents.

### Matthew Shaw

**Matt Shaw** is the supervisor of the Superconducting and Quantum Devices group at JPL. He also holds guest researcher appointments at Caltech and at the University of Maryland. He has led the development of SNSPD technology at JPL since 2012. Prior to joining JPL, he was a postdoc studying superconducting quantum optomechanics at Caltech.

# 1.0 Infrared Detector Technical Interchange Meeting, August 27 through 28, 2024

## 1.1 Final Agenda

| Tuesday, August 27 | | | | |
|---|---|---|---|---|
| 8:00 AM | 9:00 AM | **Arrival and Badging** | | |
| 9:00 AM | 9:05 AM | **Opening and Logistics** | Brett Nosho, Sarath Gunapala | |
| 9:05 AM | 9:10 AM | **NESC Welcome** | Upendra Singh, Mike Kirsch | |
| 9:10 AM | 9:40 AM | NASA HQ | Mario Perez | Astrophysics Update and Technology Gaps: IR Detectors |
| 9:40 AM | 10:10 AM | NASA GSFC | Bernie Rauscher | IR and Visible Detectors for Astro 2020 Missions |
| 10:10 AM | 10:30 AM | NASA LaRC | Tamer Refaat | Review of Detector Requirements and Technologies for 2-µm Lidar Applications at NASA Langley Research Center |
| **10:30 AM** | **10:40 AM** | **Break** | | |
| 10:40 AM | 11:10 AM | JPL | Charles Lawrence | Astronomical Detectors 2-1000 µm, Status and Needs |
| 11:10 AM | 11:40 AM | JPL | Jason Hyon | Enabling Future Science With EO/IR Sensing |
| **11:40 AM** | **1:00 PM** | **Lunch** | | |
| 1:00 PM | 1:15 PM | USSF | Vince Cowan | Space VIS-LWIR FPA Development & Characterization |
| 1:15 PM | 1:35 PM | Navy | Ben Conley | Infrared Sensing in a Naval Environment |
| 1:35 PM | 1:55 PM | Army/C5ISR-RTI | Sumith Bandara | Infrared Focal Plane Array Development at C5ISR-RTI |
| 1:55 PM | 2:15 PM | AFRL/RY | Charles Reyner | AFRL/RY's Infrared Detector Portfolio |
| 2:15 PM | 2:35 PM | DoD | Stephen Ambrozic | Mixed Signal Semiconductor Foundry Experience |
| **2:35 PM** | **2:45 PM** | **Break** | | |
| 2:45 PM | 3:05 PM | TIS | Jim Beletic | NASA Funded IR Detector Developments at Teledyne Imaging Sensors |
| 3:05 PM | 3:25 PM | RVS | Chad Fulk | Raytheon Vision Systems (RVS) Leader in Infrared Imaging Systems |
| 3:25 PM | 3:45 PM | HRL | Brad Jones, Minh Nguyen | HRL's Infrared Technologies & Product Offerings |
| 3:45 PM | 4:05 PM | LMSBF | Nate Wilson | Lockheed Martin Santa Barbara Focalplane Space Sensors |
| 4:05 PM | 4:25 PM | Leonardo DRS Dallas | Pradip Mitra | HgCdTe Avalanche Photodiode Detectors for NASA Applications |
| 4:25 PM | 4:45 PM | Leonardo DRS Cypress | Arvind D'Souza | Detector FAeAPD & Large Pixel Technology at Leonardo |
| 4:45 PM | 5:05 PM | L3Harris | Greg Gosian | Strained Layer Superlattice for pLEO missions |

| Wednesday, August 28 | | | | |
|---|---|---|---|---|
| 8:00 AM | 9:00 AM | **Arrival and Badging** | | |
| 9:00 AM | 9:20 AM | QmagiQ | Mani Sunduram | Infrared FPA Status at QmagiQ |
| 9:20 AM | 9:40 AM | Attollo Engineering | Justin Wehner | Attollo Engineering –Products & Capabilities |
| 9:40 AM | 10:00 AM | Anduril | Chaffra Affouda, Chris David | Infrared Sensors Development at Anduril |
| 10:00 AM | 10:20 AM | Senseeker | Ross Bannatyne | Senseeker Products & Services to Enable IR Systems |
| 10:20 AM | 10:40 AM | Cyan | John Caulfield | Small Pixel HD and UHD IR Cameras |
| **10:40 AM** | **10:50 AM** | **Break** | | |
| 10:50 AM | 11:10 AM | JPL | David Ting | Superlattice infrared detector development at JPL |
| 11:10 AM | 11:25 AM | JPL | Matt Kenyon | Uncooled Infrared/Far-Infrared Thermopile Arrays for Space-Borne, Remote-Sensing Radiometry |
| 11:25 AM | 11:40 AM | JPL | Mina Rais-Zadeh | Resonant Infrared Detectors |
| **11:40 AM** | **1:00 PM** | **Lunch** | | |
| 1:00 PM | 1:30 PM | MIT LL | Kevin Ryu,<br>Kyle McNicholas | IR Detector Development at Lincoln Laboratory;<br>Superconducting Photon Detectors at MIT Lincoln Laboratory |
| 1:30 PM | 1:50 PM | JPL | Matt Shaw | Superconducting Nanowire Single Photon Detectors and Quantum Capacitance Detectors |
| 1:50 PM | 2:10 PM | NIST | Marty Stevens | Infrared superconducting single-photon detectors at NIST: from photon number resolution to large arrays |
| 2:10 PM | 2:30 PM | JPL | Matt Bradford | Far-IR Kinetic Inductance Detector (KID) Arrays |
| 2:30 PM | 2:50 PM | NIST | Hannes Hubmayr | Superconducting IR Detector Research within NIST's Quantum Sensors Division |
| 2:50 PM | 3:10 PM | Argonne | Clarence Chang | Long-wave Detectors at Argonne for High Energy Physics |
| 3:10 PM | 3:30 PM | NASA GSFC | Karwan Rostem | Infrared TES and MKID developments at GSFC |
| 3:30 PM | 5:00 PM | **JPL Tour** | | |

## 1.2 Attendees and Contact List

| Name | Org | Email | Title |
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| Chaffra Affouda | Anduril | caffouda@anduril.com | Director, Imaging |
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| Sumith Bandara | Army, C5ISR-RTI | sumith.v.bandara.civ@army.mil | Subject Matter Expert (Focal Plane Arrays) |
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| John Caulfield | Cyan Systems | john@cyan-systems.com | CTO / Founder |
| Clarence Chang | Argonne | clchang@anl.gov | Scientist |
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| | | | |
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