**Budget justification**

This section describes our justification for the budget submitted for consideration as a NASA APRA Proposal. This budget element explains the total cost the University of Arizona (UA) is expected to incur during the period of performance of this project ( January 1, 2018 – December 31, 2020) the estimates include all labor costs, research materials and services, subcontracts, travel and indirect (F&A) charges.

**Basis of Estimate:** The cost estimate is based on the experience and judgement of the University of Arizona’s experts who have performed projects that are similar in nature to the Large Balloon Reflector. The team starts with an estimated schedule of tasks to complete the work and then staffs the tasks with appropriate personnel at a level of effort based on historical experience. For items and tasks we do not have the facilities or expertise to produce in house we find qualified vendors such as Johns Hopkins applied Physics Lab, The Jet Propulsion Laboratory of Pasadena, and the southwest Research Institute to perform those tasks or produce those items, and we have used their quotes when relevant.

**Labor**

Labor costs are predicated upon the level of effort (work commitment) for each position as a percentage of a full time equivalent. (FTE)

**Table B1: Proposed Work Effort**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Project Role** | **Name** | **Work Effort- Yr 1** | **Work Effort- Yr 2** | **Work Effort- Yr 3** |
| **Sr. Personnel** |  |  |  |  |
| Principal Investigator | Christopher Walker | 8% | 8% | 8% |
| Deputy Principal Investigator | Craig Kulesa | 25% | 25% | 25% |
| Co-Investigator | Michael hart | 7% | 7% | 7% |
| Project Manager | Brian Duffy | 25% | 25% | 25% |
| Instrument scientist | Abe Young | 25% | 25% | 25% |
| Science Programmer | William Peters | 8% | 15% | 15% |
| Mechanical Engineer | Ruben Dominguez | 8% | 15% | 15% |
| **Students** |  |  |  |  |
| Graduate Student 1 | TBD | 100% | 100% | 100% |
| Undergraduate Student 1 | TBD | 10% | 10% | 10% |

**Personnel**

**Christopher Walker**, the Principal Investigator is a Professor of Astronomy and Electrical Engineering at the University of Arizona. Walker is responsible for the overall completion of the project as well as meeting scientific objectives. He will contribute 1 month’s effort per year of the project.

**Craig Kulesa** the Deputy Principal Investigator is an associate Astronomer at the Steward Observatory. Kulesa will contribute 3 months effort per year to this project. He will assist the PI in management duties and will be the instrument team lead.

**Michael Hart** a co-investigator is an Astronomer at the Steward Observatory. He is responsible for the design, construction and integration of the sodium Laser Guide Star System and will contribute one month effort per year to the project.

**Brian Duffy** the project manager. Currently a project manager at the Steward Observatory. Duffy will providing project management support: Management tasks are essential for the completion of the project objectives. These management tasks include but are not restricted to: coordination with Steward Observatory management, local coordination of tasks and resources, documentation and plans generation, financial tracking as well as management of test flight campaigns.

**Abram Young**, Instrument Scientist. Young is currently a Specialist, Technical/Research at the University of Arizona. Young will contribute 3 moths per year to the project and lead the design, testing and integration of the instrument bias control system.

**William Peters** is a Staff Scientist at the Steward Observatory. Peters will contribute 3 months per year to the project.

**Bud Hill**, Electrical engineer will provide 176 hours of support to this project. He will support the design, testing and implementation bias control system.

**Ruben Dominguez**, Mechanical Engineer will provide 3 months per year of support to this project. He will design and construct the instruments gimbal mount and provide mechanical and technical support to the instrument for integration for flight.

**Explanation of Labor Rates:** Appointed and Classified staff hourly rates are calculated using a 2088 hour work year or a 174 hour work month. Faculty are allowed a total of 464 hours during the summer term. Academic faculty work 1600 hours during the academic term. The faculty summer rate is calculated using 155 hours per month (464 / 3 months). The summer supplemental compensation hourly rate is calculated using the following formula: *Rate =* *(Academic Salary)\*.00072.* Graduate students are allowed to work a total of 800 hours during the academic term and 414 hours during the summer term (on average each year).

|  |  |  |  |
| --- | --- | --- | --- |
| **Table 2: Non-Capital and Capital Equipment** |  |  |  |
|  |  |  |  |
| **Item** | **Unit Price** | **Total** | **Vendor** |
| **Non-Capital** |  |  |  |
| Non-Capital Computing Equipment |  | $4,500.00 | Newegg |
| Publication Costs: (twox10page paper@150p) |  | $3,000.00 | Astrophysical Journal |
| Electronic Components, connectors, cabling, lab supplies, gases |  | $15,000.00 | Various |
| Mechanical Integration, Materials and supplies |  | $7,500.00 | Various |
| Machining Services |  | $12,000.00 | In-House |
| Shipping |  | $16,000.00 | Various |
| Bias control system |  | $25,000.00 | Various |
| Graduate Student Tuition Remission |  | $36,918 | UA |
| **Capital** |  |  |  |
| Sodium guide Star System : Andor F42-MB-1-D02-S43 CCD camera |  | $32,460.00 | Andor |
| Sodium guide Star System : Toptica TA-SHG Pro 1 W diode laser |  | $110,000.00 | Toptica |

**Non-Capital and Capital Equipment**

**Non-capital:** Includes funds for the upgrade of computers used for data reduction**.**

Publication costs are estimated for two, 10 page papers at a page rate of 150. Funds are requested for the purchase of materials, wiring, cabling connectors and supplies for the construction of the bias control system as well as packaging and mounting these components aboard the gondola for a high altitude balloon mission

**Capital Equipment:** Funds are requested to purchase a Toptica TA-SHG Pro 1 W diode laser and an Andor F42-MB-1-D02-S43 CCD camera as the basis to form a sodium guide star system.

**Shipping:** Funds for shipping include necessary custom crates as well as shipping costs. Components will be shipped between UA and SWRI during initial integration and then between UA and the CSBF Facility in Ft Sumner, NM for final flight integration and test flights.

**Subcontracts:**

The **Johns Hopkins Applied Physics Laboratory** will be contracted to develop and build the LBR service gondola and its Avionics and power systems to be suspended below the carrier balloon, the LBR fine attitude sensor suite to be mounted on top of the carrier balloon and to support I&T and flight activities at the launch site for 2 flights from Fort Sumner, NM. JHUAPL is selected for their long history of balloon science as well as their partnership with the highly successful Stratospheric Terahertz Observatory and its recent flights over Antarctica.

The **Jet Propulsion Laboratory** in Pasadena will design and deliver the 557 GHz Receiver systems required for this project to be a success. JPL is an unrivaled leader in this area and has a long history of developing and building this technology.

**Southwest Research Institute will build on its successful collaboration with the PI during the NIAC LBR grant from 2014. SWRI will continue its work to develop** and demonstrate the technology required to realize a suborbital, telescope suitable for operation from radio to THz frequencies. The telescope consists of an inflatable, half-aluminized spherical reflector deployed within a much larger carrier stratospheric balloon. Besides serving as a launch vehicle, the carrier balloon provides a stable mount for the enclosed telescope. Looking up, the LBR will serve as a telescope. Looking down, the LBR can be used for remote sensing or telecommunication activities. By combining successful suborbital balloon and ground-based telescope technologies, a telescope free of >95% of the Earth’s atmospheric absorption in the far-infrared can be realized. NIAC LBR was a multi-institution effort between the University of Arizona (the PI institution), SWRI, JPL, and APL. All key partners on the current APRA proposal.

**Space Science and Exploration Consulting group** will provide systems engineering support to the project.

**Smithsonian Astrophysical Observatory** will be contracted to support the project as a Science Team member working with the PI and Deputy PI to define the science goal for each LBR flight and to supply data reduction and archiving expertise after test flights.

**Travel:** Travel costs are included for site visits at APL. JPL and SWRI In each year of the project. These visits are essential for the PI to coordinate and manage a project with subcontracts in four different states. The cost is determined from current airfare, parking, and state of Arizona lodging and M&IE rates for Columbia Md, Pasadena CA and San Antonio TX.

In years 2 and 3 scientific balloon campaigns will be conducted in Ft Sumner NM. These campaigns are a major undertaking which requires the shipment of large amounts of scientific and engineering equipment as well as a large team of technical experts to a remote location in eastern NM. The six week campaigns are planned based on our experience with previous balloon hang tests and test flights. A team of ten scientists, engineers and students will be required to reside in Ft Sumner for varying lengths of time between 4-6 weeks.