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# Final Technical Report

# For NASA Dryden Grant NAG4-129

March 30, 1998

Project Title: Study of Radiation Effects Electronics at Atmospheric Altitudes

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## Summary

A test bed for the *in situ* evaluation of electronic devices for high altitude aircraft was developed. A prototype of the test bed, suitable for operation on a research aircraft, was built and readied for ground tests. The principle investigator established a working relationship with the Project APEX team at Dryden with the intent of flying the test bed "piggyback" on an Project APEX balloon in 1998. Contact was also established with NASA contractors charged with operating the ER-2 aircraft now at Dryden.

## Motivation

The progress of electronic integrated circuit (IC) fabrication techniques continues to decrease the size of device structures allowing more and more devices to be placed on a "chip". This increased device density has generally made these devices more cost effective, but also more vulnerable to damage due to ionizing radiation. NASA is currently working on technology for flight vehicles that will require sustained controlled flight at altitudes where the natural shielding of the Earth's atmosphere is greatly reduced. These high performance vehicles include the single stage to orbit (SSTO) reusable launch vehicle (The X-33 prototype due to launch in 1999) and the high speed civil transport (HSCT). Research at NASA Dryden Flight Research Center directly impacts these efforts. Future high performance aircraft will be highly reliant on sophisticated electronics for their efficient and economical operation. Given the complex nature of the radiation environment at high atmospheric altitudes and the importance of reliable electronic tolerance in this environment, a program to develop an electronics testbed to test electronic devices as a function of altitude was initiated. It was proposed that various research aircraft and balloons be used to loft the testbed and test devices for *in situ* testing.

## Project Goals

As stated in the original proposal, the primary goals of the project were as follows:

1. Build a compact, self contained test bed that will contain all needed systems to operate a variety of electronic devices, monitor their characteristics and record their performance in the high altitude radiation environment.

2. Initiate a comprehensive program that would take advantage of the various projects and flight vehicles available at Dryden to sample as wide a range of altitudes as possible.

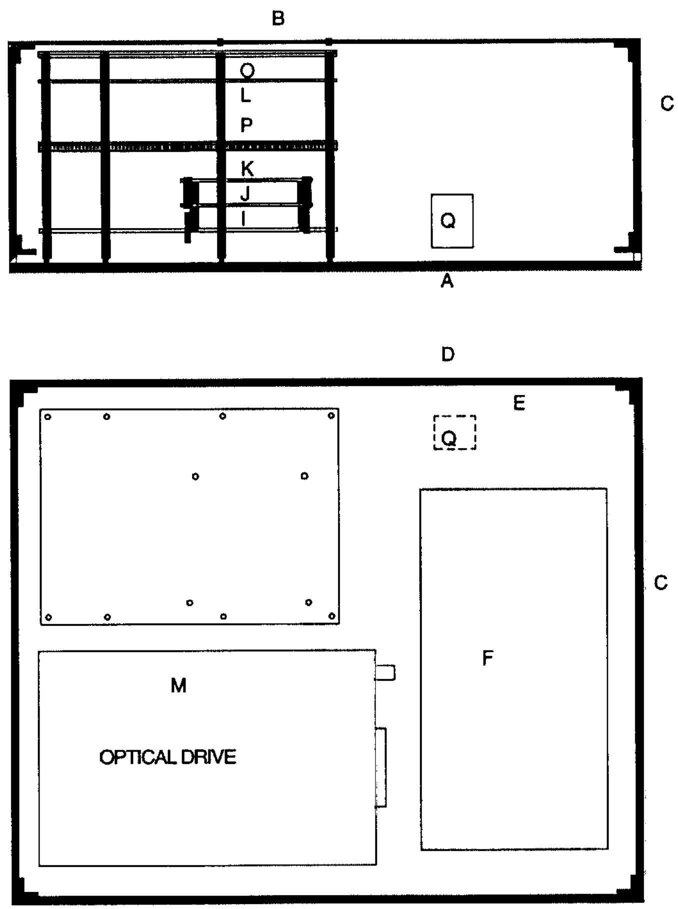
3. Prepare a modified test bed on the APEX balloon launch vehicle to take advantage of the altitudes obtainable (>100,000 feet). This altitude would be critical to the performance of electronics flying aboard the SSTO vehicle.

4. Encourage African-Americans and other minorities toward terminal degrees in fields of interest to NASA, particularly Dryden Flight Research Center.

## Project Technical Accomplishments

A prototype of the test bed is currently undergoing bench evaluation at Center for Applied Radiation Research (CARR) at Prairie View A&M University; earth based beam tests are planned in April 1998. The first aircraft flight of the test bead should be during Summer or Fall 1998. The first balloon flight is scheduled for Summer 1998. The prototype is appropriate for aircraft use, and is approximately 14x17x7 inches and weighs about 35 lbs. Figure 1 shows a schematic of the prototype test bed. Each of the components of the test bed has been chosen for their versatility and durability in harsh conditions. For example, the central processing unit (CPU) is an "embedded-PC" controller that offers full architecture and hardware and software compatibility with a PC bus, but is packaged in compact, stackable modules. The optical data storage unit is designed for high-G impact protection and has been tested by NASA Langley to be flight qualified. The overall test bed architecture is modular and therefore can easily be reconfigured for various flight test platforms. The major variation of the test beds will be those designed for aircraft flights and those for balloon flights. For the most part, electrical power will not be available on balloons. Therefore, balloon payloads will need to carry sufficient batteries for test bed operation. Aircraft platforms will usually have power available. In this case, the payload will have to have appropriate power supplies to provide the needed power for the electronics boards and the data storage unit.

Details of the various components of the prototype test bed are given below, and is shown schematically in Figure 2. The prototype is designed and programmed to measure SEE in SRAM.




NOTE: TOP AND FOUR SIDES ARE TO BE A UNIT
REMOVABLE FROM THE BASE

## SYSTEM COMPONENTS

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THE BOX

| | | | |
|---|---|---|---|
| A | BASE | 14"X17"X.25" | ALUMINUM |
| B | TOP | 14"X17"X.0625" | ALUMINUM |
| C | 2 SHORT SIDES | 14"X5.5"X.1875" | ALUMINUM |
| D | 2 LONG SIDES | 16.625"X5.5"X.1875" | ALUMINUM |
| E | ANGLE BRACES | .5"X.5"X.125" | ALUMINUM |

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F COMPUTER BATTERY PACK
WEIGHT DEPENDENT ON EXPERIMENT DURATION

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CIRCUIT BOARDS

| | | |
|---|---|---|
| I | SINGLE BOARD COMPUTER--ADVANTEC 4860 | 8"X5"X1" |
| J | IO BOARD--DIAMOND SYSTEMS F07149 | 3.55"X3.775"X.625" |
| K | SCSI-104--ADASTRA SYSTEMS mod800-400 | 3.55"X3.775"X.625" |
| L | CUSTOM SURFACE MOUNT TEST BOARD | 8"X5"X1" |
| | NOTE STACK WEIGHT | <1lb |

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ADDITIONAL DEVICES

M OPTICAL DRIVE--MOUNTAIN OPTECH P/N 2436-00
9.75"X5.75"X3.5" 2lb 13.4oz

O 2 CR39 PLASTIC SHEETS 8"X5"X.0625"

P POLYETHYLENE SHEET 8"X5.75"X.25"

Q LATCH-UP PROTECTION RELAY 1.42"X1.1"X.85"

Figure 1: Schematic of the prototype test bed currently being bench tested at Prairie View A&M University

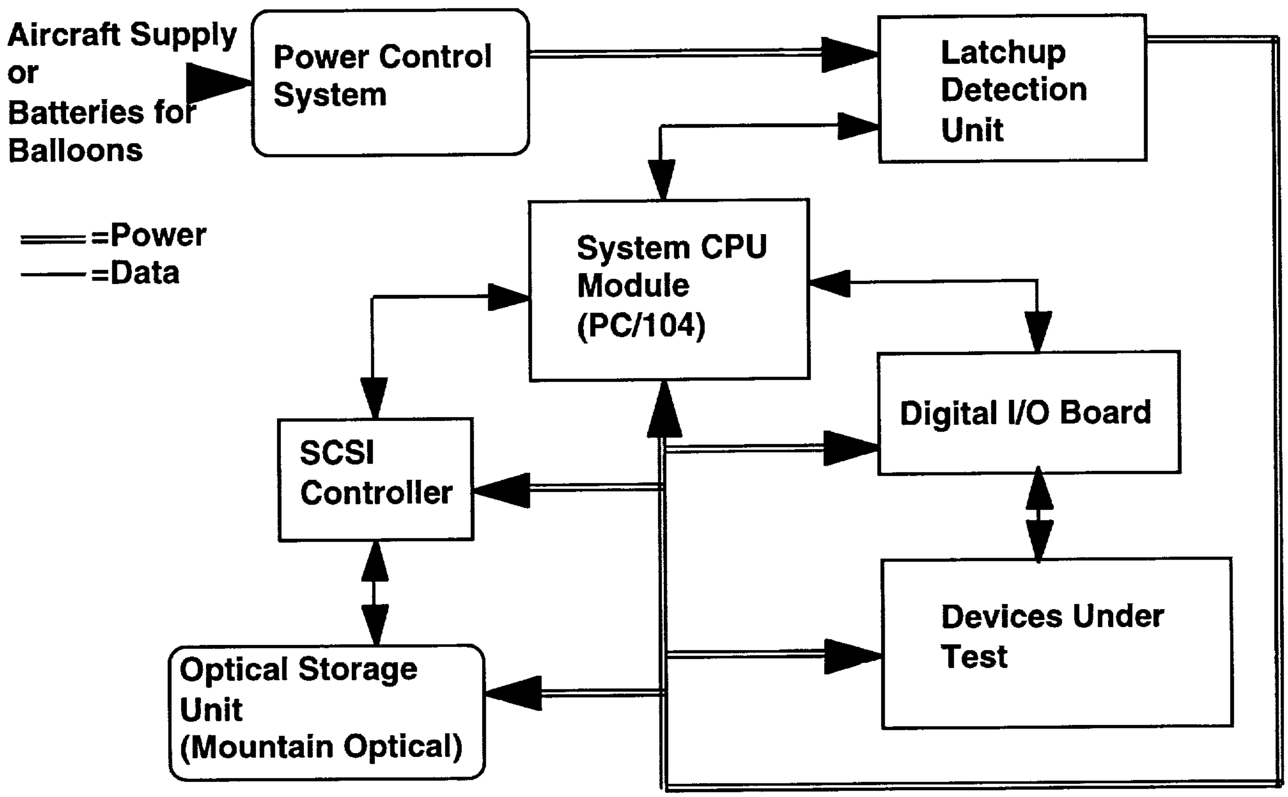


Figure 2: Schematic of test bed electronic test system.

The payload test system (ETS) consists of:

1) The test board where the DUT (devices under test) are mounted and exposed to the environment.
2) The test control board, a digital input/output board, is an interface between the main CPU board and DUT.
3) CPU board is connected to a flight qualified optical drive through a SCSI controller. The optical drive stores and execute the test code and will store the test data free from radiation effects.
4) A latch up detection board made out of discrete components resets the system so that recording of SEE is not interrupted for any significant time period.

5) Power control system: In aircraft, power supplies that transform aircraft power to ETS power will be used (as in the current prototype). For the ER-2 aircraft, the test bed will contain two Abbott power sources, one at 5V and the other at 12V. These supplies will operate from the 400Hz aircraft supply and have been flight qualified. For

balloons batteries will be used in conjunction with a power management system that will optimize battery lifetimes.

5) Associated data, control and power busses.

The test program will be stored in the optical drive. Although the computer board is buried inside the payload, it is still possible for very high energy cosmic rays to cause latch up this device, therefore the computer board is designed to be on only during test of the DUT. After the system is turned on, the test program will test the DUT through the control board, if there is a latchup in the DUT, the program will recycle the power of the test board. The sampled data will be stored in the optical drive.

Figure 3 shows the test flow of the test program developed for the test bed using C language. During the initialization, the power up time is recorded to the optical drive. Then a checkerboard pattern is written to all the DUT's on the test board. The DUT's are then interrogated periodically and any errors in the memory pattern are recorded. As noted above, some radiation induced errors require cycling the power. The test flow is such that the power will be recycled if such errors are detected. The test program will run until the power supply is turned off or is exhausted (batteries in balloon test beds.)

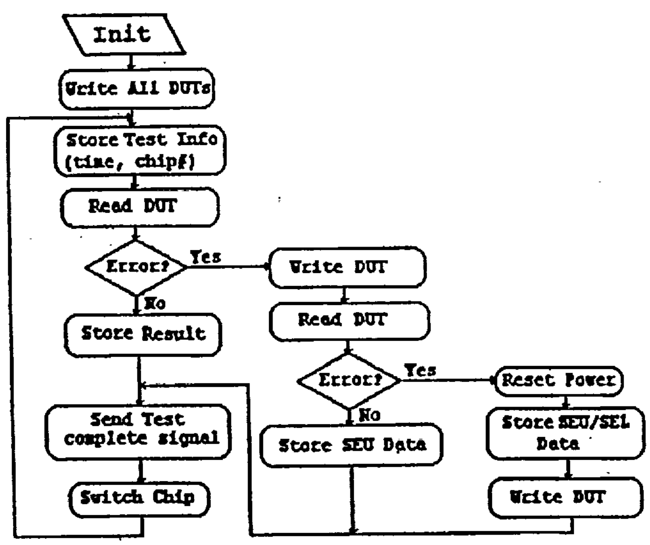


Figure 3: Test Flow Diagram

During this project specifics of the test board design, power system and payload temperature regulation have been discussed with Dryden personnel; the prototype includes the results of some of these discussions.

Figure 4 shows schematically the "piggyback" configuration envisioned for our test bed on a project APEX balloon payload. The PI, a research engineer and a PVAMU student met with the APEX project team to verify details of the payload and discuss payload integration. APEX is scheduled for flight in Fall 1998.

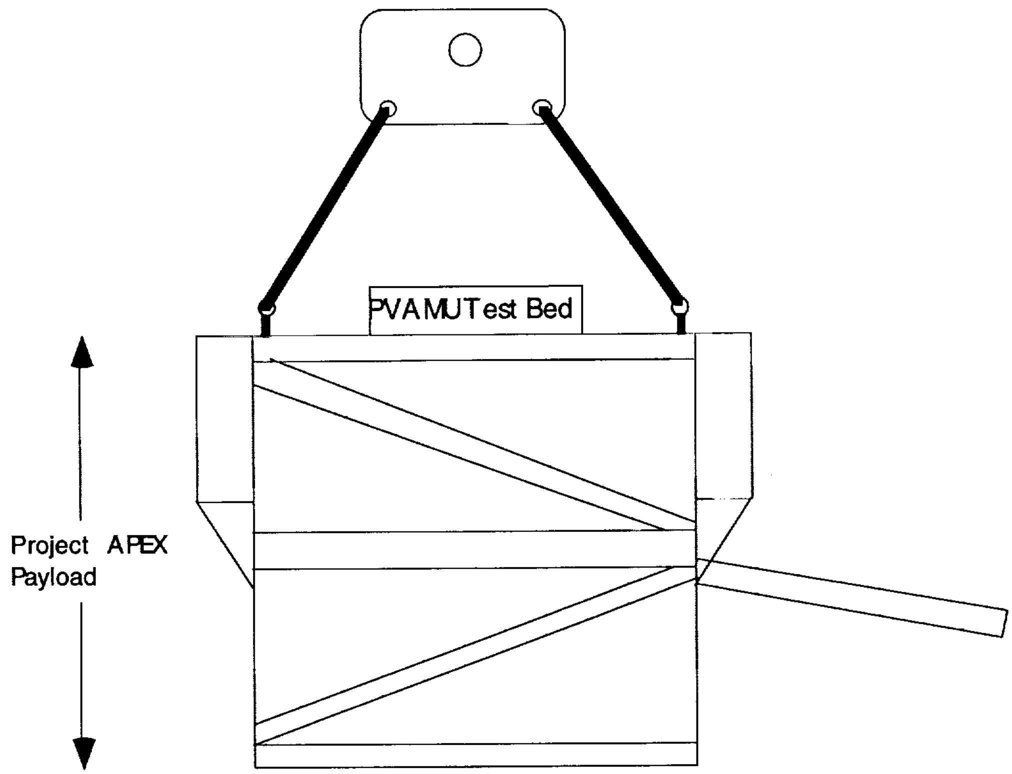


Figure 4: Schematic showing PVAMU test bed piggyback on Project APEX balloon payload

## Human Resource Accomplishments

Several PVAMU students have been associated with this project. They have worked in the areas of battery evaluation, payload integration and software development.:

1.Tammie Nichols, a PVAMU undergraduate, finished an internship at Dryden during Summer 1997. One of the projects Ms. Nichols has worked on is battery power supplies for the APEX program. Her experience at Dryden was very valuable to this project.

2. Uhl Woods, another PVAMU undergraduate, was active in the payload integration meeting with the Project APEX team and the ER-2 personnel. He also worked on the electronic test system.

3. Denedra Woods worked on software development in conjunction with other CARR affiliated personnel.

The ethnicity of all these students is African American.