

TWO WELLS PRIMARY SCHOOL SPACE MISSION

The space mission for the Two Wells Primary School involves testing different the methods of shielding commercial electronics to survive the Cosmic Radiation in space.

*Proposal for the SA
Schools Space
Mission*

Experiment Context

What is Cosmic Radiation?

Cosmic Radiation also known as Cosmic Rays are atom fragments that mostly originate from outside our solar system and rain down on earth. Some of the lower energy particles originate from our own sun during solar storms. Down on Earth we are largely protected from these particles by our atmosphere, however in the extremely low atmosphere of Low Earth Orbit (LEO) satellites, they are blamed for many electronic problems.

There are 3 types of cosmic radiation: Alpha, Beta and Gamma. These different types of radiation have different levels of energy that allow them to penetrate more deeply through materials. The highest energy particles require 10s of centimetres of water to stop them. Our scientist team is researching materials and techniques to use to shield electronics in space to reduce the chances of damage caused by this radiation.

How does Cosmic Radiation damage electronics?

Radiation that affects electronics is categorized into three groups: total ionizing dose, single event effects, and displacement damage.

“Total ionizing dose effects in electronics are the result of damage that usually builds up over a long period of time in an insulating region of an electronic device. This changes the device properties, which results in performance degradation and eventually can cause the device to fail completely. Displacement damage is also a cumulative effect but this occurs in the electronic device’s semiconductor material. These effects also cause the device to deteriorate at first and possibly fail if it is exposed to enough radiation. Single event effects are caused by the passage of a single particle through a sensitive region in an electronic device. There are many types of single event effects, which can be either non-destructive or destructive to the device. The severity of the effect can be so small that it can go unnoticed. At the other extreme it could cause a system to shut down.”¹

How do we stop/shield from Cosmic Radiation?

It is difficult to shield electronics from all forms of cosmic radiation. Water can stop some types of radiation, however it is heavy, requires a lot of it, and if leaks can potentially damage the electronics. Potentially hydrogen would work, but it is highly explosive.

NASA scientists been experimenting with a polyethylene-based material called RXF1 that's even stronger and lighter than aluminium¹. If these materials are suitable for shielding humans on long missions to Mars, materials similar to this could be used for shielding electronics in satellites in conjunction with other materials used for rigidity. Modern 3D printing technology may allow us to more easily and cheaply print shielding that is adequate

The Experiment

The goal of our experiment is to investigate the shielding of electronics against cosmic radiation in space. Electronics will be shielded by different methods and exposed to cosmic radiation. The electronics will be monitored to determine if and when it fails. We will also be monitoring different aspects of the environment like the radiation levels, temperature and light levels, to determine if these variables are linked to the failures. Measuring light levels will allow us to determine when we are pointing directly at the sun. An identical experiment set up and operational at the school on earth will provide a control to determine whether failures are random and component based, or isolated to the space environment. This will operate within our STEM learning space along with a constantly updated display of results from the ISS experiment. These results could be streamed online to allow other schools to also monitor the status of our experiment.

The future benefits of the results of our experiment may assist developers to reduce the mass and expenses of putting small satellites into space by allowing them to use commercial components appropriately shielded and potentially have them last longer in space before they fail.

The experiment has to be contained in approximately 1 litre of volume and 300g mass. Our experiment is scalable, and the number of electronics units under test (UUT), and hence the different methods of shielding being tested, can be increased or decreased to meet the volume and weight restrictions.

Functional Design

Our experiment contains 5 functional sections: The Fat Controller, Sensor System, Interfaces, Mechanical and Power Supply.

The Fat Controller

The Fat Controller has functions of the Raspberry Pi Operating System, Data Server to communicate result to earth (via the ISS) and Results Communication to get the test results from the Arduino micro controllers. The Fat controller helps us with these things:

- Interrogate Arduinos
 - Ask each for Arduino health
 - Ask each for LED health.
- Collate Data
- Time Stamp
- Format Data Stream
- Self-Test
- Send to ISS server

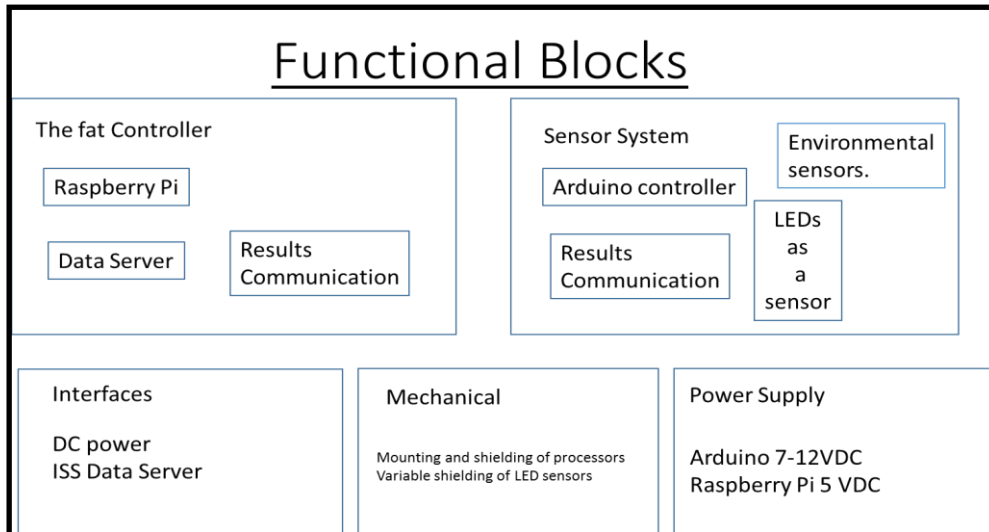


Figure 1 Functional Allocation

Sensor System

The Sensor System contains the Arduino micro controllers, the Results Communication that sends results to the Fat Controller, LEDs as sensors of electronic failure due to cosmic radiation, and environmental sensors for temperature, radiation and light level. The Sensor System does this:

- Arduino to control
 - LED sequencing
 - LED current monitoring to detect failures
 - Collect and encode results and send them to the central controller
- Environmental Sensors
- Arduino Self-Test

Interfaces

Functions as the external interfaces to the ISS.

- DC Power
- ISS Data Server

Power Supply

The Power Supply functions manage power supplied from ISS and distribute to:

- Raspberry Pi 5 VDC
- Arduino 7-12 VDC

Mechanical

The mechanical functions include the mounting and shielding of processors and variable shielding of LED sensors. The main enclosure helps us with these things:

- House Experiment
- External Connectors to ISS
- Separate shields for individual LED sensors
- Provide access between individual subsystems

Mass Budget

There are still unknowns in the mass budget mostly due to the physical requirements of the enclosure that will survive the vacuum of space. The external casing will be constructed from aluminium and polycarbonate. The number of shield materials being tested can be modified to suit the final space and weight available.

Monitoring Processor (Raspberry Pi Model 2 or 3)	45g	Enclosure	???
Test Processors [Each] (Raspberry Pi Zero)	9g	Miscellaneous cabling	???
Arduino Micro	13g	Radiation Sensors	???
Power conditioning circuit	???		

Table 1 Major Item Weights

Safety

This experiment does not plan to use any batteries, or potentially explosive materials. It also does not use any biological samples that may have difficulty with customs in other countries. There are no moving parts, reducing the chances that the experiment will fail in the physical testing.

Results

The analysis of the results of the experiment will be conducted by the students at the school at the time where possible with the raw data and the analysed results published on the internet for other schools and organisations to analyse themselves and discuss.

School Context

Two Wells Primary School is a category 3 school of disadvantage and is located approximately 45 kilometres north of Adelaide in a small town. There about 350 students in 13 classes from Reception to year 7. Three classes of students from year 3 to year 7 are spending two lessons per week working with volunteer professionals on the space mission. Our space mission group has been split up into 9 different teams which are: Scientists, System Engineers, Unit Under Test [UUT] Engineers, Controller Engineers, 3D Enclosure Engineers, Test Engineers, Multimedia production, Documentation and Media Liaison. Teams are composed of older and younger students to ensure we maintain knowledge/skills when Year 7 students graduate, as this program will run for several years.

Team Roles

Project Management - One student identified as the Project Manager, with an assistant responsible for overseeing all the tasks of the other groups and monitoring the overall schedule and progress of the project. Additionally, the head of each of the other functional groups would also form part of this team. They meet weekly on Friday mornings before recess.

Scientists – 1 group of students, headed up by a Lead Scientist that is responsible for the research into our area of investigation, and come up with the proposed methods of shielding that we will test as part of this mission. They ensure that the engineering design will meet the mission requirements.

Engineers - 5 groups as follows. Each with one student designated as the Lead Engineer of the group.

3D Enclosure Engineers - Create the 3D model of the shield that will be used as part of the testing.

Unit Under Test (UUT) Engineers - Implement the requirements allocated to the Arduino. Work with the Controller Engineers to develop an interface to receive requests and send results to the Fat Controller.

Controller Engineers - Implement the requirements allocated to the Raspberry Pi. Work with the UUT Engineers to develop an interface to request and receive results from the Arduinos.

Systems Engineers - Responsible for integrating the whole system together. Work on power conditioning and overall mechanical design.

Test Engineers - Responsible for developing and implementing tests before the unit goes to the official offsite testing.

Promotion – 3 groups responsible for producing the information that communicates our ideas to the public and industry. Each group has a student leader.

Film/Multimedia Production - Responsible for combining the information supplied by all the other teams into a 5 minute presentation that explains our proposal.

Document Production - Responsible for combining the information supplied by all the other teams into the 3 - 8 page

document to be presented with our proposal.

Media Liaison - Responsible for communicating the progress of our experiment via Newsletters, the internet, the print media as well as TV

Industry and Tertiary Institution Links

As part of the development of this proposal we have already established links to both industry and tertiary institutions. Since the inception of this experiment we have been in contact with Nova Systems located in Hewett, SA to ensure that our proposal is viable. Through their space experts they have assisted us in refining our experiment. Correspondence with Professor Bruce Dawson from the Department of Physics at The University of Adelaide has also assisted us in clarifying the requirements for shielding electronics and potentially monitoring the location of the ISS to determine whether radiation effects are caused by entering the van Allen belt.

Three of our regular parent volunteers are engineers for the Department of Defence, one of whom is registered as a helper via the Scientist in Schools program. These volunteers are assisting in developing the skills of the students needed to implement our proposed experiment. In the next phase of the program, we intend to pursue further volunteers to assist in the areas of mechanical design, testing and project management.

Australian Curriculum Links

Appendix A details the Australian Curriculum links that this SA Schools Space Mission covers. It includes the relevant links for all the year levels involved in the program. Initially the skills developed within each team will be isolated, however, as the program progresses we will ensure that the learning is shared between all the students involved. The student area experts will teach those who are unfamiliar with the other fields. We will continue to include a range of ages as the program develops to ensure that we maintain skills and knowledge about the program at the school.

When we start receiving results from our experiment, all classes within the school will analyse the results at their developmental level.

STEM Learning

The teams in our experiment have all identified different areas of learning through their STEM involvement. We interviewed the team leaders and they told us what STEM related things they learned throughout the process of the space mission so far.

Tyler (Head Scientist) – “My group and I have learned more about the science behind space and technology”

Zoe (System Engineer) – “Our group learnt about the mathematical side of things, and how to change our design to fit within the limits.”

Scott (Lead UUT Engineer) – “My group has learned how the Arduino works all the connections, how to change the lights and the speed of them flashing.”

Lockie (Lead Control Engineer) – “My group learned more about the technology and the math behind programing”

Ashlee (3D Printing) – “Our group learned how to use a 3D printer also what materials and methods needed. Along with designing and measuring how big or small the object would need to be.”

Charlotte (Test Engineer) – “We learned more about space, g-force and radiation also what we need to test.”

Ella (Lead Media Liaison) - ‘My group learned how to make your own website and all the tech behind that.’

Despina (Multi-Media) - ‘We learned about Cosmic Radiation and how it impacts on our experiment and our electronics such as iPads, cameras and computers.’

Victoria (Lead Documentation) – “As I was interviewing the other groups I learned a lot about Cosmic Radiation and Arduinos, how they work and why they are important.”

ⁱ Smith, DeLee, What is Space Radiation, NASA 2017, https://lws-set.gsfc.nasa.gov/space_radiation.html, accessed 1/9/2017.

ⁱⁱ Barry, P., Plastic Spaceships, NASA, 2005.

ⁱⁱⁱ Barghouty, A. and Thibeault, S., The Exploration Atmospheres Working Group's Report on Space Radiation Shielding Materials, NASA, 2006.

Appendix A: Two Wells PS ISS Project Australian Curriculum Links

Australian Curriculum Area Description		Year 3	Year 4	Year 5	Year 6	Year 7
Science Understanding						
<i>Chemical sciences</i>	Natural and processed materials have a range of physical properties that can influence their use		ACSSU074			
Science as a Human Endeavour						
<i>Nature and development of science</i>	Science involves making predictions and describing patterns and relationships	ACSHE050	ACSHE061			
	Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions			ACSHE081	ACSHE098	
	Scientific knowledge has changed peoples' understanding of the world and is refined as new evidence becomes available					ACSHE119
	Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures					ACSHE223
<i>Use and influence of science</i>	Scientific knowledge is used to solve problems and inform personal and community decisions			ACSHE083	ACSHE100	
	People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity					ACSHE121
Science Inquiry Skills						
<i>Questioning and predicting</i>	With guidance, identify questions in familiar contexts that can be investigated scientifically and make predictions based on prior knowledge	AC SIS053	AC SIS064			
	With guidance, pose clarifying questions and make predictions about scientific investigations			AC SIS231	AC SIS232	
	Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge					AC SIS124
<i>Planning and conducting</i>	With guidance, plan and conduct scientific investigations to find answers to questions, considering the safe use of appropriate materials and equipment	AC SIS054	AC SIS065			
	Consider the elements of fair tests and use formal measurements and digital technologies as appropriate, to make and record observations accurately	AC SIS055	AC SIS066			
	Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks			AC SIS086	AC SIS103	
	Decide variables to be changed and measured in fair tests, and observe measure and record data with accuracy using digital technologies as appropriate			AC SIS087	AC SIS104	
	Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed					AC SIS125
	Measure and control variables, select equipment appropriate to the task and collect data with accuracy					AC SIS126
<i>Processing and analysing data and information</i>	Use a range of methods including tables and simple column graphs to represent data and to identify patterns and trends	AC SIS057	AC SIS068			
	Compare results with predictions, suggesting possible reasons for findings	AC SIS215	AC SIS216			
	Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate			AC SIS090	AC SIS107	

Australian Curriculum Area Description		Year 3	Year 4	Year 5	Year 6	Year 7
	Compare data with predictions and use as evidence in developing explanations			ACSIS218	ACSIS221	
	Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate					ACSIS129
	Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence					ACSIS130
<i>Evaluating</i>	Reflect on investigations, including whether a test was fair or not	ACSIS058	ACSIS069			
	Reflect on and suggest improvements to scientific investigations			ACSIS091	ACSIS108	
	Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements					ACSIS131
<i>Communicating</i>	Represent and communicate observations, ideas and findings using formal and informal representations	ACSIS060	ACSIS071			
	Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts			ACSIS093	ACSIS110	
	Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate					ACSIS133
Design and Technologies						
<i>Knowledge and Understanding</i>	Recognise the role of people in design and technologies occupations and explore factors, including sustainability that impact on the design of products, services and environments to meet community needs	ACTDEK010	ACTDEK010			
	Investigate how forces and the properties of materials affect the behaviour of a product or system	ACTDEK011	ACTDEK011			
	Investigate the suitability of materials, systems, components, tools and equipment for a range of purposes	ACTDEK013	ACTDEK013			
	Examine how people in design and technologies occupations address competing considerations, including sustainability in the design of products, services, and environments for current and future use			ACTDEK019	ACTDEK019	
	Investigate how electrical energy can control movement, sound or light in a designed product or system			ACTDEK020	ACTDEK020	
	Investigate characteristics and properties of a range of materials, systems, components, tools and equipment and evaluate the impact of their use			ACTDEK023	ACTDEK023	
	Analyse ways to produce designed solutions through selecting and combining characteristics and properties of materials, systems, components, tools and equipment					ACTDEK034
<i>Processes and Production Skills</i>	Critique needs or opportunities for designing and explore and test a variety of materials, components, tools and equipment and the techniques needed to produce designed solutions	ACTDEP014	ACTDEP014			
	Generate, develop, and communicate design ideas and decisions using appropriate technical terms and graphical representation techniques	ACTDEP015	ACTDEP015			

Australian Curriculum Area Description		Year 3	Year 4	Year 5	Year 6	Year 7
	Select and use materials, components, tools, equipment and techniques and use safe work practices to make designed solutions	ACTDEP016	ACTDEP016			
	Evaluate design ideas, processes and solutions based on criteria for success developed with guidance and including care for the environment	ACTDEP017	ACTDEP017			
	Plan a sequence of production steps when making designed solutions individually and collaboratively	ACTDEP018	ACTDEP018			
	Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions			ACTDEP024	ACTDEP024	
	Generate, develop and communicate design ideas and processes for audiences using appropriate technical terms and graphical representation techniques			ACTDEP025	ACTDEP025	
	Select appropriate materials, components, tools, equipment and techniques and apply safe procedures to make designed solutions			ACTDEP026	ACTDEP026	
	Negotiate criteria for success that include sustainability to evaluate design ideas, processes and solutions			ACTDEP027	ACTDEP027	
	Develop project plans that include consideration of resources when making designed solutions individually and collaboratively			ACTDEP028	ACTDEP028	
	Critique needs or opportunities for designing and investigate, analyse and select from a range of materials, components, tools, equipment and processes to develop design ideas					ACTDEP035
	Generate, develop, test and communicate design ideas, plans and processes for various audiences using appropriate technical terms and technologies including graphical representation techniques					ACTDEP036
	Select and justify choices of materials, components, tools, equipment and techniques to effectively and safely make designed solutions					ACTDEP037
	Independently develop criteria for success to evaluate design ideas, processes and solutions and their sustainability					ACTDEP038
	Use project management processes when working individually and collaboratively to coordinate production of designed solutions					ACTDEP039
Digital Technologies						
<i>Knowledge and Understanding</i>	Identify and explore a range of digital systems with peripheral devices for different purposes, and transmit different types of data	ACTDIK007	ACTDIK007			
	Recognise different types of data and explore how the same data can be represented in different ways	ACTDIK008	ACTDIK008			
	Examine the main components of common digital systems and how they may connect together to form networks to transmit data			ACTDIK014	ACTDIK014	
	Examine how whole numbers are used to represent all data in digital systems			ACTDIK015	ACTDIK015	
	Investigate how data is transmitted and secured in wired, wireless and mobile networks, and how the specifications affect performance					ACTDIK023
	Investigate how digital systems represent text, image and audio data in binary					ACTDIK024
<i>Processes and Production Skills</i>	Collect, access and present different types of data using simple software to create information and solve problems	ACTDIP009	ACTDIP009			

Australian Curriculum Area Description	Year 3	Year 4	Year 5	Year 6	Year 7
Define simple problems, and describe and follow a sequence of steps and decisions (algorithms) needed to solve them	ACTDIP010	ACTDIP010			
Implement simple digital solutions as visual programs with algorithms involving branching (decisions) and user input	ACTDIP011	ACTDIP011			
Explain how student solutions and existing information systems meet common personal, school or community needs	ACTDIP012	ACTDIP012			
Plan, create and communicate ideas and information independently and with others, applying agreed ethical and social protocols	ACTDIP013	ACTDIP013			
Acquire, store and validate different types of data, and use a range of software to interpret and visualise data to create information			ACTDIP016	ACTDIP016	
Define problems in terms of data and functional requirements drawing on previously solved problems			ACTDIP017	ACTDIP017	
Design a user interface for a digital system			ACTDIP018	ACTDIP018	
Design, modify and follow simple algorithms involving sequences of steps, branching, and iteration (repetition)			ACTDIP019	ACTDIP019	
Implement digital solutions as simple visual programs involving branching, iteration (repetition), and user input			ACTDIP020	ACTDIP020	
Explain how student solutions and existing information systems are sustainable and meet current and future local community needs			ACTDIP021	ACTDIP021	
Plan, create and communicate ideas and information, including collaboratively online, applying agreed ethical, social and technical protocols			ACTDIP022	ACTDIP022	
Acquire data from a range of sources and evaluate authenticity, accuracy and timeliness					ACTDIP025
Analyse and visualise data using a range of software to create information, and use structured data to model objects or events					ACTDIP026
Define and decompose real-world problems taking into account functional requirements and economic, environmental, social, technical and usability constraints					ACTDIP027
Design the user experience of a digital system, generating, evaluating and communicating alternative designs					ACTDIP028
Design algorithms represented diagrammatically and in English, and trace algorithms to predict output for a given input and to identify errors					ACTDIP029
Implement and modify programs with user interfaces involving branching, iteration and functions in a general-purpose programming language					ACTDIP030
Evaluate how student solutions and existing information systems meet needs, are innovative, and take account of future risks and sustainability					ACTDIP031
Plan and manage projects that create and communicate ideas and information collaboratively online, taking safety and social contexts into account					ACTDIP032

