Application for space flight

Application Status:	Draft → Submitted → Revised → Accepted
Organization:	Mathematical Grammar School
Purpose of Payload:	**Component #1** I want to find out the effects of spaceflight (cosmic radiation, low temperatures, high acceleration) on the data stored on memory chips. Memory is a crucial part of almost all electronic devices and with private spaceflight becoming reality we might see everyday electronics being sent into space on a regular basis, so acquiring more knowledge of how cosmic radiation and high acceleration affect memory will be very important when coming up with ways to protect it. Small X-ray films, commonly used by dentists, will be placed in between sets of chips in hopes of detecting the cosmic radiation passing through the experiment cube. Hypothesis: The conditions of spaceflight will change the data stored on memory chips, and ionizing cosmic radiation passing through the experiment will be detected by the x-ray films. **Component #2** Memory chips have wide applications, from everyday electronic devices to the inner workings of satellites, space stations and flight computers, and more of these devices are being launched into space regularly. I want to know the effects spaceflight has on small memory storage devices because of the important role they have in space missions and future space flight, where non specialized devices, such as cellphones and cameras will also most likely be sent into space on commercial flight spacecraft. **Component #3** Most if not all electronic devices sent into space are equipped with memory chips protected against radiation, but with the power of some forms of radiation even that protection might not be adequate. Cosmic radiation hitting certain parts of a memory chip may result in "single event upsets", which occur when a single high energy particle hits a memory chip and causes a change in the state of a memory cell in which a single bit is stored. This can result in a logical "1" being changed to a logical "0", or vice versa. Depending on how many bits were changed, and what was stored on the chip the data can become corrupted, harder to read or entirely unreadable. Finding out more about the effects cosmic radiation can have on memory chips can help with the development of better protection, both for spacecraft, and for everyday devices being sent into space.
Experiment Name:	Memory in Space
Platform:	Rocket

Experiment Description:

Materials:

1. Memory chips

The memory chips used in this experiment are 25Q16B and are very cheap. They can store 16 megabits each. The full capacity of each chip will be used to store only logical "1s" because it has been shown that radiation changes logical "1s" to "0s" more easily than vice-versa on most memory chips, meaning radiation will be more likely to change the data.

2. Dental X-ray film

The normal use of these films does not require them to be too big, and as a result they are almost the perfect size for the experiment cube. RDX-58E films will be used for this experiment, but most have similar sizes. They are around 32x45 mm when packaged meaning they have to be cut to ~32x38 mm. They will be kept in the package to prevent light exposure. The films normally come with lead foil for radiation protection, but it will be pulled out of the package in order to detect radiation more easily.

3. Glue

Different types of glue will be used to glue the chips to the film package, in order to observe the effects extreme changes in temperature have on them, and find the most reliable one for future experiments. The types of glue used will be hot glue, gel superglue, liquid superglue, universal (UHU or similar) glue and double sided duct tape. Their combined weight will be around 1 gram when applied.

4. Cushion

Most of this experiments weight consists of ballast. In order for the experiment to survive the initial acceleration and not get crushed, the ballast will be placed into a cube of plastic foam/sponge (such as "nerf" foam) weighing around 1 gram, with a margin of ±0.5 grams.

5. Ballast

For ballast a glass marble with a 30 mm diameter will be placed into the foam cube. The marble weighs 32 g, so the mass of the experiment will reach around 63 grams total. Then airsoft pellets, small plastic beads that weigh 0.12 grams each, will be added until the total weight reaches 64 grams.

Weight:
Film -- 1.4 g x 6 = 8.4 g
Chips -- 0.077g x 20 x 6 = 9.24 g
Foam -- ~1 g
Cube – 11 g
Glue – ~1 g
Ballast -- (Marble)32 g + (Airsoft pellets)
8.4 + 9.25 + 1 + 11 + 1 + 32 = 63.65 g + airsoft pellets = ~64 g

Assembly:

1. Write logical "1s" to 120 25q16B memory chips, using an EZP2013 portable USB programmer.

2. Cut the dental x-ray film, with its package, to ~32x38 mm. Pull out the lead foil with a pair of tweezers. Do this in a dark room in order to not expose the film to too much light. Red light can be used as the film is not sensitive to it.

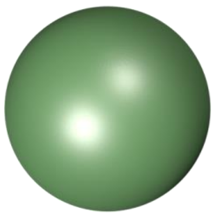
3. Glue 20 chips, distributed in 4 rows and 5 columns to the film package. (Repeat this process six times, to make one for each side of the cube, using different glue for each film). The chips, with their pins are 7.9x5.3 mm², and can be placed easily on the film with little space in between.

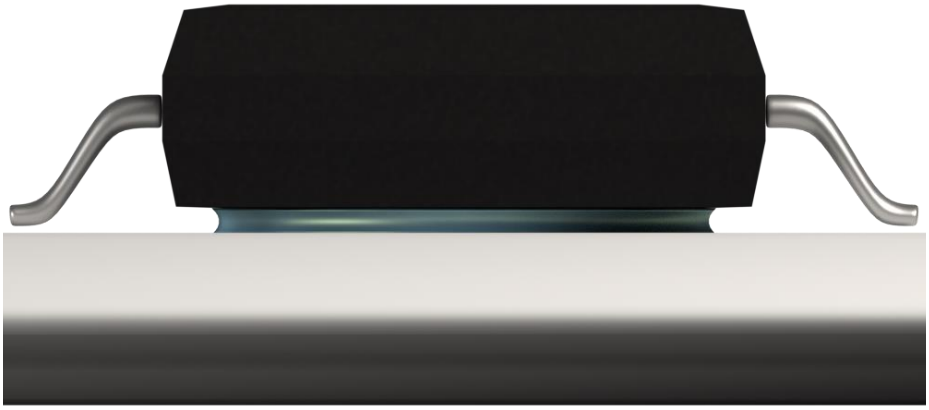
4. Put the first film and chips into the bottom of the cube, with the chips facing

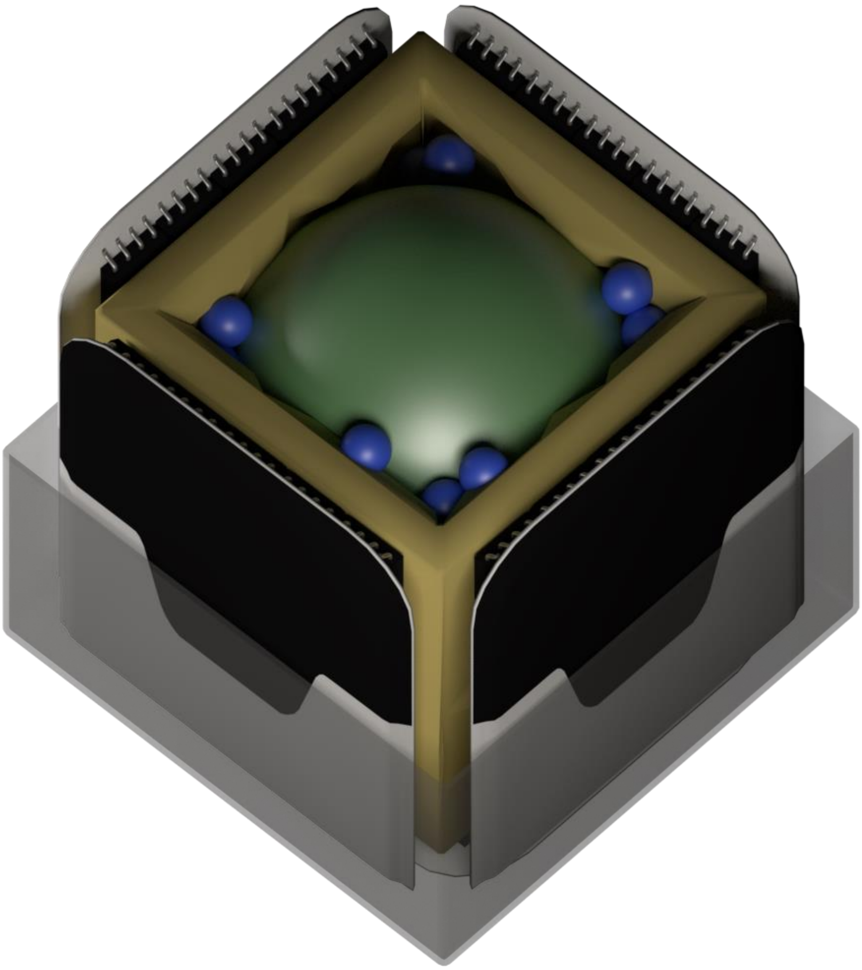
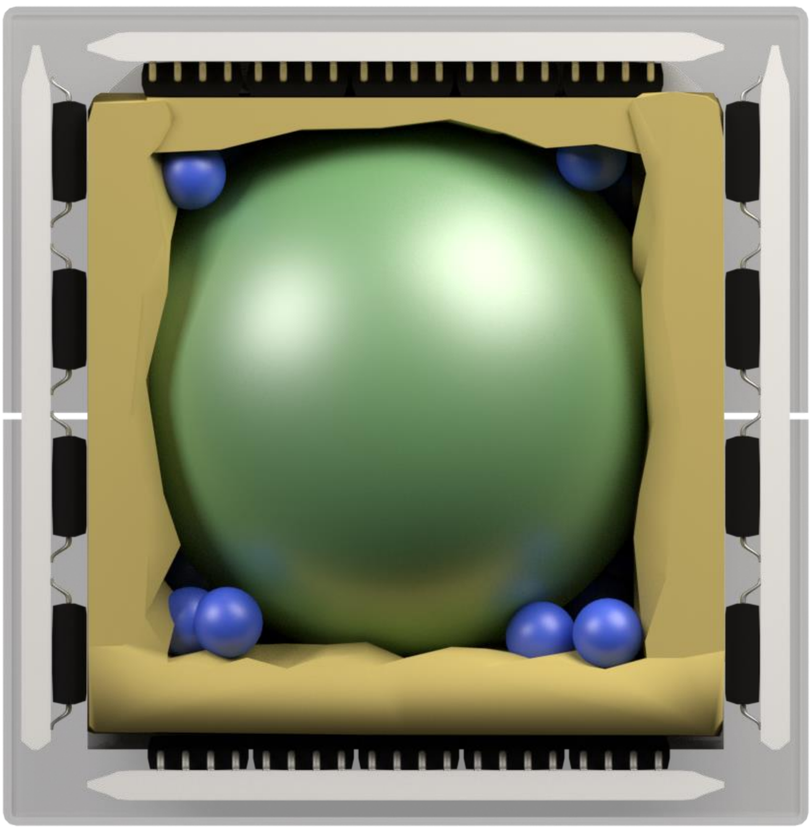
	upwards. **5.** Put four more on the sides of the cube, with the chips facing inwards. **6.** Cut out a cube of foam approximately 40x40x40 mm^3, and then cut out foam near the top of the cube so the ballast would fit. **7.** Squeeze the foam cube into the experiment cube. It should hold the film tightly to the sides. **8.** Add the marble into the hole in the foam cube. **9.** Measure the whole experiment, with the ballast It should weigh ~63 grams. Add the plastic pellets until the weight reaches 64 grams. **10.** Cover the ballast with some more foam, if it is needed to secure the marble in place. Place the last film on top with the chips facing downwards and close the box.
Payload Analysis Plan:	On Earth's surface, ionizing radiation is much weaker than in space, meaning memory devices are protected against radiation damage. Errors can still occur, but they usually come in the form of "soft errors", meaning they will not change the data stored in the memory. They can only interfere with devices while they are working and reading from the memory. These errors have much less impact than "hard errors" which can happen if a high energy particle passes through the memory and actually changes the data stored in it. This is called a "single event upset". I predict that the memory chips sent into space will have more errors than the control memory chips left on earth because of the increased exposure to radiation when in the ionosphere. I also predict that the x-ray dental film stored in the cube will, when developed, show visible traces of ionizing radiation. The film is sensitive to more than just x-rays, and will also help us find out which memory chips exactly were hit by radiation. After flight, the chips will be read and checked for errors or changes with the same programmer used do write to them, and will be compared to the control chips left on earth. I hope to find out if the radiation the chips were exposed to change any values stored in them, or made them unreadable with the programmer. I will also examine the different types of glue and see which one performed the best, for future experiments.
Communication Plan:	This experiment was designed in order to test the effects of radiation on regular memory chips when sent into space. I believe the results of this experiment, and any future ones will be important to the designers of future space technology, as well as the general public in the near future. Considering private space flight is becoming reality it is important to test everyday memory devices to radiation exposure, because technology such as phones, cameras, etc. may soon be sent into space. I believe the effects of radiation and sudden temperature changes on device memory are a very important subject for future and current space flight. I am sure NASA and other space agencies will be interested in the results, and future of this experiment. The experiment can yield multiple positive and negative results: In case every single memory chip remains unchanged, we will know that the chances of damage during shorter flights are very small, considering this experiment carries 120 chips distributed evenly on the inside of the 4x4x4 cm cube. This will be good news for agencies sending devices or people to space for a very short time, but long term effects on memory are yet to be observed, possibly in future experiments. In case data is changed after flight, it will mean that radiation protection is needed even for shorter flights with everyday electronics. This would be the anticipated result, but the amount of radiation damage that the chips will suffer remains unknown until the experiment is conducted. The data can be changed only slightly, or damaged to the point of unreadability and the difference between those outcomes is very important in planning future space missions or commercial space flight. For the simplicity of this experiment and the best chances

of finding changes to memory no chip is radiation hardened or protected. The future of this experiment can consist of sending different types of memory with different types of protection into space for longer periods of time. I will communicate the results of the experiment to my class and the "Mathematical Grammar" school in Belgrade. My intention is to get more students from my class interested in "Cubes in Space" for next year. The results will then be published onto my schools website and communicated to all interested schools in Serbia. If the results prove to be significant, a paper will be written on the subject of the "Cubes in Space" program and the result of this experiment. It will then be offered to the school magazine, and other scientifically popular magazines in Serbia.
I think the results of this experiment will be important to companies and agencies involved in future commercial space flights, and the general public. If proven so, the results will be distributed further out to the international space community.

Links:
Radiation Damage in Electronic Memory Devices
https://www.hindawi.com/journals/ijp/2013/170269/
EN25Q16 Memory Chip casing dimensions datasheet
http://html.alldatasheet.com/html-pdf/313070/EON/EN25Q16-100QI/2304/32/EN25Q16-100QI.html
PRIMAX RDX-58E dental film
http://www.primax-berlin.de/all/pdf/rdx58e.pdf

Components	Name	Mass	Dimensions
	Memory chip	0.077 g	~7.9 mm x 5.3 mm
	X-ray dental film	1.4 g (after cutting, lead foil removed)	~32 mm x 38 mm (after cutting)
	Foam cube	~ 1 g	40 mm x 40 mm x 40 mm
	Glass marble	~32 g	Diameter ~ 30 mm
	Plastic airsoft pellet	Diameter ~ 6 mm	~0.12 g

Assembly	Description
	Back of the cut x-ray film package, with 20 memory chips glued onto it
	The placement of the glue on each microchip

Assembly	Description
	Isometric view of the whole experiment, placed in the bottom part of the cube, with the box open, and top film not yet placed
	Cut-out view of the completely finished experiment, closed in the cube, with additional sponge on top to secure the ballast in place.

All models were done in Blender, a free, open source 3d modelling tool.