RISKVI Case Study

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***Abstract*—RISK-V FPGAs are attracting chip developers worldwide due to their open source and ease of configuration. These FPGAs can be used in space applications. Implementing fast and reliable hardware on nanosatellites had to be tested under extreme circumstances. This report evaluates the impact of the operating system on the reliability of RISC-V based FPGAs against configuration memory upsets.**

***Index Terms*—RISC-V, FPGAs, nanosatellites, configuration memory upsets**

I. Introduction

Field-programmable gate arrays(FPGAs) are becoming attractive for nanosats due to the improvements in performance and in-field reconfigurability of new generations of SRAM-based FPGAs. A nanosat or nanosatellite(Fig. 1) is anything that weighs between 1 and 10 kilograms. They are becoming attractive for space travel due to improvements in performance and in-field reconfigurability. The software running on the FPGAs is called Embedded Operating System. An Embedded OS is a specialized operating system designed to perform a specific task for a device that is not a computer. The main job of an embedded OS is to run the code that allows the device to do its job, and it makes software development easier. Current operating systems that are qualified for space missions

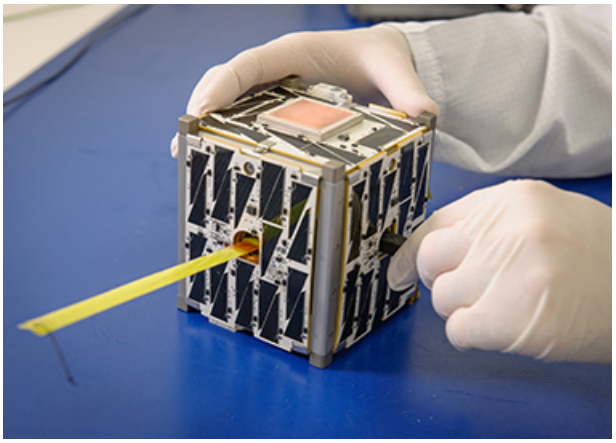

Fig. 1. A real life nanosat.

are generally very costly. Consequently, general-purpose OS-powered nanosat missions, such as Linux systems, have been deployed in the past. Leppinen [1] stated that choosing Linux limits the choice of hardware. Another major drawback is that Linux is not designed to be a real-time operating system. A real-time operating system is an OS that guarantees real-time applications a certain capability within a specified deadline. In some cases, design changes can reduce the number of hard real-time applications. The remaining constraints require another dedicated controller to handle the real-time problem.

II. Background

The reliability of these OSs for a given hardware platform needs to be evaluated before their actual deployment. Wali et al. [2] assessed the effects of the Linux OS on the fault tolerance of applications running on a RISC-V SoC(System on Chip) implemented in a Xilinx FPGA. To address the evaluation of the effects, we need to define the background. Although previous studies analyzed the fault tolerance of OS in embedded platforms, the following report will focus on radiation-induced configuration memory upsets on the reliability of applications running on a Linux RISC-V FPGA. Radiation-induced configuration memory upsets are a type of computer hardware failure caused by exposure to ionizing radiation from space. The radiation can create a charge that alters the state of a memory cell, causing a bit flip when the chip is exposed. It can result in errors in data storage or retrieval. In some cases, it can crash the system.

A. FPGA Fault Injection

The method of testing is FPGA fault injection. It is defined as the validation technique of fault-tolerant systems where the observation of the system's behavior in presence of faults is done explicitly by the injection of faults in the system. Tawfeek et al. categorized the fault injection technique into three categories in [3]. In our case,

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Keep your text and graphic files separate until after the text has been formatted and styled. Do not number text heads—LaTeX will do that for you.

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Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

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Number equations consecutively. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in:

$$a + b = \gamma \tag{1}$$

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Please use "soft" (e.g., `\eqref{Eq}`) cross references instead of "hard" references (e.g., `(1)`). That will make it possible to combine sections, add equations, or change the order of figures or citations without having to go through the file line by line.

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Do not use `\nonumber` inside the `{array}` environment. It will not stop equation numbers inside `{array}` (there won't be any anyway) and it might stop a wanted equation number in the surrounding equation.

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- Do not use the word "essentially" to mean "approximately" or "effectively".
- In your paper title, if the words "that uses" can accurately replace the word "using", capitalize the "u"; if not, keep using lower-cased.
- Be aware of the different meanings of the homophones "affect" and "effect", "complement" and "compliment", "discreet" and "discrete", "principal" and "principle".
- Do not confuse "imply" and "infer".
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- There is no period after the "et" in the Latin abbreviation "et al.".
- The abbreviation "i.e." means "that is", and the abbreviation "e.g." means "for example".

An excellent style manual for science writers is [7].

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TABLE I
TABLE TYPE STYLES

Table Head	**Table Column Head**		
	Table column subhead	***Subhead***	***Subhead***
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[a]Sample of a Table footnote.

Fig. 2. Example of a figure caption.

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity "Magnetization", or "Magnetization, M", not just "M". If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write "Magnetization (A/m)" or "Magnetization {A[m(1)]}", not just "A/m". Do not label axes with a ratio of quantities and units. For example, write "Temperature (K)", not "Temperature/K".

ACKNOWLEDGMENT

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REFERENCES

Please number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use "Ref. [3]" or "reference [3]" except at the beginning of a sentence: "Reference [3] was the first ..."

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the abstract or reference list. Use letters for table footnotes.

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For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

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