Towards High-performance RISC-V Processing Systems for Intelligent Spacecrafts

A Data Management Plan created using DMPonline.be

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Project abstract:

Spacecrafts are relying on autonomous decision-making and artificial intelligence, which requires increasing amounts of computing power in space. However, space environments contain high levels of ionizing radiation that is harmful to integrated electronic circuits. Total Ionizing Dose effects degrade the performance of MOS transistors and lead to unreliable and slower operation. This research proposes a novel method for compensating the damaging effects by using Tunable Replica Circuits to detect degradation, and body-biasing to heal the threshold voltage of the transistor. This self-healing feature will prevent faults and prolong the lifetime of the processor in environments such as deep-space applications and extraterrestrial habitats. The research will enable high-performance processors, which can leverage computational-heavy algorithms such as Artificial Intelligence in such harsh environments. The proposed techniques will be applied to a RISC-V processor in state-of-the-art technology. The outcome of this research is essential for reliable and performance computing applications in space.

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FWO DMP (Flemish Standard DMP)

1. Research Data Summary

List and describe all datasets or research materials that you plan to generate/collect or reuse during your research project. For each dataset or data type (observational, experimental etc.), provide a short name & description (sufficient for yourself to know what data it is about), indicate whether the data are newly generated/collected or reused, digital or physical, also indicate the type of the data (the kind of content), its technical format (file extension), and an estimate of the upper limit of the volume of the data.

				Only for digital data	Only for digital data	Only for digital data	Only for physical data
Dataset Name	**Description**	**New or reused**	**Digital or Physical**	**Digital Data Type**	**Digital Data format**	**Digital data volume (MB/GB/TB)**	**Physical volume**
TID12LPP	Digital Chip for characterization of GF12LPP Total Ionizing Dose effects.	Generate new data	Physical	NA	NA	NA	<50mm³
TID12LPP_DESIGN	Design and documentation of the TID12LPP chip for Cadence Design Systems tool flow.	Generate new data	Digital	Other	.v, .sv, .txt., .tcl, .sh, .sdc, .gdsii, Makefile, .md, .pdf, .svg	<1GB	NA
TID12LPP_DATA	Data from the characterization of the TID12LPP chip with TID experiments.	Generate new data	Digital	Experimental	.csv	<10GB	NA
TRCRISCV	RISC-V processor chip with Tunable Replica Circuits implementation for radiation tolerant performance.	Generate new data	Physical	NA	NA	NA	<400mm³
TRCRISCV_DESIGN	Design and documentation of the TRCRISCV chip for Cadence Design Systems tool flow.	Generate new data	Digital	Other	.v, .sv, .txt., .tcl, .sh, .sdc, .gdsii, Makefile, .md, .pdf, .svg	<1GB	NA
TRCRISCV_DATA	Data from the characterization of the TRCRISCV chip with TID experiments.	Generate new data	Digital	Experimental	.csv	<10GB	NA
TIDTRCGEN	Tool to create TRCs for digital designs	Generate new data	Digital	Software	.tcl, .py, .sh	<1GB	NA

If you reuse existing data, please specify the source, preferably by using a persistent identifier (e.g. DOI, Handle, URL etc.) per dataset or data type:

NA

Are there any ethical issues concerning the creation and/or use of the data (e.g. experiments on humans or animals, dual use)? Describe these issues in the comment section. Please refer to specific datasets or data types when appropriate.

- No

Will you process personal data? If so, briefly describe the kind of personal data you will use in the comment section. Please refer to specific datasets or data types when appropriate.

- No

Does your work have potential for commercial valorization (e.g. tech transfer, for example spin-offs, commercial exploitation, …)? If so, please comment per dataset or data type where appropriate.

- Yes

The TRC approach and the tool created for automatic generation of TRCs (TIDTRCGEN) can be used for commercial valorization such as licensing, spin-off or tech transfer.

Do existing 3rd party agreements restrict exploitation or dissemination of the data you (re)use (e.g. Material/Data transfer agreements/ research collaboration agreements)? If so, please explain in the comment section to what data they relate and what restrictions are in place.

- Yes

All PDK, IP , CDS and Technology specific data en measurements are strictly confidential and cannot be shared. Normalization of data needs to be performed before publication.
This relates to at least TID12LPP_DESIGN, TID12LPP_DATA, TRCRISCV_DESIGN and TRCRISCV_DATA.

Are there any other legal issues, such as intellectual property rights and ownership, to be managed related to the data you (re)use? If so, please explain in the comment section to what data they relate and which restrictions will be asserted.

- Yes

All data that falls under restrictive licensing or is protected by NDA cannot be shared with others. This includes PDKs, IP and CDS documentation, certain design data and measurement data.

2. Documentation and Metadata

Clearly describe what approach will be followed to capture the accompanying information necessary to keep data understandable and usable, for yourself and others, now and in the future (e.g., in terms of documentation levels and types required, procedures used, Electronic Lab Notebooks, README.txt files, Codebook.tsv etc. where this information is recorded).

TID12LPP_DESIGN, TRCRISCV_DESIGN: Specification of the chip in the form of pdf or markdown. This includes port definitions, operation conditions, block diagrams, timing diagrams and descriptions of functionality.
TID12LPP_DATA, TRCRISCV_DATA: Description of the test procedures, test equipment and parameters. The measured parameters and units are provided. Brief descriptions about the performed tests are provided.

Will a metadata standard be used to make it easier to find and reuse the data? If so, please specify (where appropriate per dataset or data type) which metadata standard will be used. If not, please specify (where appropriate per dataset or data type) which metadata will be created to

make the data easier to find and reuse.

- No

The datasets of experiments cannot be published due to legal issues.
Conclusions and normalized figures based on the datasets will be published in papers and conference proceedings.

3. Data storage & back-up during the research project

Where will the data be stored?

Designs are archived to a ESAT GitLab repository and on the ESAT Linux file system when the chip is send to the foundry or when the researcher leaves the research group. This allow to maintain a 1-to-1 mapping of the chip-to-design and allows the research group to further develop the chip when the researcher leaves. When making an archive, the active project is copied to a backup project which can be accesses as a normal project, without write permissions. Generally, archives are never deleted.
A snapshot of the measurement results is saved on the Linux file system after each test campaign.

How will the data be backed up?

We rely on backup services are provided by the Dept. Electrical Engineering (ESAT) of KU Leuven. A backup of the linux folder is made periodically by the system group.
We use ESAT GitLab to synchronize a design with multiple users. This platform is also used to archive and backup the design.

Is there currently sufficient storage & backup capacity during the project? If yes, specify concisely.
If no or insufficient storage or backup capacities are available, then explain how this will be taken care of.

- Yes

There is at least 200GB of storage available for me.

How will you ensure that the data are securely stored and not accessed or modified by unauthorized persons?

During the design phase, multiple people might need access to my design. At least my corresponding supervisor might require access to my design. We use the ESAT GitLab to synchronize a design with multiple users. Strict access control can be set for these private design projects.

What are the expected costs for data storage and backup during the research project? How will these costs be covered?

Free

4. Data preservation after the end of the research project

Which data will be retained for at least five years (or longer, in agreement with other retention policies that are applicable) after the end of the project? In case some data cannot be preserved, clearly state the reasons for this (e.g. legal or contractual restrictions, storage/budget issues, institutional policies...).

All design files, documentation and experimental data must be retained for 10 years after the completion of the project.

Where will these data be archived (stored and curated for the long-term)?

At the Dept. Electrical Engineering (ESAT) of KU Leuven archives.

What are the expected costs for data preservation during the expected retention period? How will these costs be covered?

Free

5. Data sharing and reuse

Will the data (or part of the data) be made available for reuse after/during the project? In the comment section please explain per dataset or data type which data will be made available.

- No (closed access)

The chip designs and measurement results fall under restricted access due to licensing and IP.

If access is restricted, please specify who will be able to access the data and under what conditions.

Everyone who has explicit legal permission and rights to view the protected technology.

Are there any factors that restrict or prevent the sharing of (some of) the data (e.g. as defined in an agreement with a 3rd party, legal restrictions)? Please explain in the comment section per dataset or data type where appropriate.

- Yes, Intellectual Property Rights

TID12LPP_DATA and TRCRISCV_DATA: Normalization of data needs to be performed before publication.

Where will the data be made available? If already known, please provide a repository per dataset or data type.

TIDTRCGEN: https://iiw.kuleuven.be/onderzoek/advise/datasets

When will the data be made available?

Upon publication of research results.

Which data usage licenses are you going to provide? If none, please explain why.

When possible share

- Designs and experiment datasets under Creative Commons Attribution-ShareAlike (CC-BY-SA) or Creative Commons Attribution-NonCommercial-ShareAlike (CC-BY-NC-SA)
- Software under GNU General Public License 3 (GPL-3.0)

Do you intend to add a PID/DOI/accession number to your dataset(s)? If already available, you have the option to provide it in the comment section.

- Yes

What are the expected costs for data sharing? How will these costs be covered?

Free

6. Responsibilities

Who will manage data documentation and metadata during the research project?

The researcher

Who will manage data storage and backup during the research project?

The researcher

Who will manage data preservation and sharing?

The supervisor

Who will update and implement this DMP?

The researcher