NEWS RELEASE

Singapore, 20 October 2020

NTU spin-off Zero Error Systems launches new radiation-protection chips for satellites and autonomous vehicles

The Singapore tech firm also raised S$2.5 million seed funding

A “smart chip” capable of protecting satellites from radiation damage could enable fut ure satellites to carry more sophisticated equipment and yet be less costly to build, th anks to an innovation developed by **Nanyang Technological University, Singapore (NTU Singapore)** researchers.

Built by a team led by **Professor Joseph Chang from the School of Electrical and Electronic Engineering,** the NTU-developed smart chip can detect incoming heavy-ion radiation with the potential to cause serious damage to electronics.

When the effects of radiation (known as a Single Event Latchup) are detected, the smart chip shuts down other electronics in the satellite safely and turns them back on once the danger has passed. The chip itself is hardened and protected against heavy-ion radiation and can stay ‘awake’ throughout the event.

Known as the **Latchup Detection and Protection (LDAP) chip**, it is now commercialised by **Zero-Error Systems (ZES),** a start-up incubated by NTUitive, NTU’s innovation and enterprise company. The technology for the LDAP has recently been awarded two patents and has been verified under heavy-ion tests in a cyclotron, a type of particle accelerator that generates radiation particles.

The chip has been installed as part of the radiation-protection circuitry in three pico-satellites built by the Kyushu Institute of Technology, Japan, for Japan, Paraguay and the Philippines, and is expected to be first launched into space in 2021.

Prof Chang explained that their new method of protecting satellites from radiation damage is unlike conventional methods, which use radiation-hardened space-grade electronics for each component of a satellite. This is costly, makes the satellite heavier and reduces choice to an older generation of ‘tried and tested’ components.

“By using our LDAP chip, satellite manufacturers are now able to employ the latest

consumer-grade electronics, such as those used in mobile phones, to build satellites," said Prof Chang, who is a founder and Technical Advisor at ZES.

ZES Chief Technology Officer and co-founder Dr Shu Wei, said: "Consumer-grade electronics are lighter, more compact, cost only a fraction of the price, and are significantly more sophisticated than radiation-hardened components."

"Pairing ZES technology together with advanced consumer-grade electronics will help to make it more cost-effective to launch satellites and constellations of satellites into space," said Dr Shu, who did both his Bachelor of Engineering and his PhD at NTU, after which he worked as a research scientist at the university for a decade before joining ZES.

Dr Alex Lin, Interim CEO of NTUitive, said: "We are heartened to be a part of ZES' journey in building this critical component for future space-faring instruments and vessels. What ZES did will contribute significantly to our ability to explore space – the next frontier."

ZES receives S$2.5 million boost to scale up

ZES is also announcing today that it has successfully raised S$2.5 million in seed funding, comprising investments from **Airbus Ventures**, **SEEDS Capital**, **Silicon Solution Ventures**, NTU's Strategic Research Innovation Fund, private investors and ZES founders.

Dr Tang Pen San, Co-Founder and Managing Director of ZES said the new funding will enable the start-up to quickly scale up its operations and to work with international customers to deploy their portfolio of products into space and other applications, including self-driving vehicles with high levels of autonomy.

"Being able to use consumer-grade electronics is a game changer for the New Space industry," Dr Tang said. "Besides reducing the cost substantially, state-of-the-art consumer-grade devices like AI chips and high-performance Field Programmable Gate Arrays – an integrated circuit that can be reprogrammed for different applications after manufacturing – will also enhance the functionalities and performances of these new satellites."

Mr Mathieu Costes, Airbus Ventures Partner adds: "At Airbus Ventures we're proud to add ZES to our global portfolio of innovative space systems. We're pleased to entrust ZES founding team, bringing impressive new technologies to the challenges of electronics for space and autonomous vehicles at large, to represent our second deal in Singapore. Together with our syndicate of investors, we're pleased to help draw together the ecosystems of new space excellence."

Mr Geoffrey Yeo, General Manager of SEEDS Capital adds: "ZES enables satellite

manufacturers to build in cutting edge functionality at a fraction of the cost today. We see ZES as a promising addition to Singapore's vibrant space-tech ecosystem and look forward to supporting the company's growth as it continues to scale its operations."

Mr David Ng, Founding Partner and CEO of Silicon Solution Partners (SSP) said: "ZES's product roadmap focus in the space electronics arena will certainly value add to speed up more complex Digital Signal Processing (DSP) electronics chipset deployment. This will further enhance our Singapore deep-tech technical talent in the space electronics sector."

Upcoming ZES-NTU satellite innovations

In ZES's product line-up, there are two new innovations from NTU which are under development.

The first innovation is a **radiation-hardened power management integrated circuit** for small satellite components that is compact, reliable, and more efficient than conventional point-of-load modules. This would allow electronic components to operate optimally without interruption to the power supply from heavy-ion radiation.

The second product is a unique **radiation-hardened 'building block' for silicon chip makers**, which would eliminate almost all errors in electronic circuits caused by random heavy-ions.

Known as the rad-hard standard cell library, this could be valuable in fully autonomous vehicles where safety-critical functions cannot be compromised by soft errors and where semiconductor reliability is of utmost importance.

More than 50 per cent of soft errors occur due to stored memory values in electronics being altered by high-energy particles from cosmic rays, which break the silicon nuclei in electronics and thus leads to computing errors.

Such soft errors have been known to cause internet server outages, network router resets and could cause unpredictable quirks in vehicles equipped with modern-day electronics.

Current mission-critical systems such as aircraft electronics have triple or quadruple redundancy to reduce and mitigate the effects of soft errors, but that is not feasible in autonomous vehicles with constraints on space, energy consumption and cost.

With technology development spearheaded by Dr Shu and co-founders **Dr Juanda** and **Dr Chong Kwen Siong**, ZES is now scaling up their operations and is working with partners to design technologies for the "New Space" industry.

The NTU technology to build the new radiation-hardened power management

integrated circuit is also applicable to the personal mobility device market where reducing the size and improving the reliability of electronic circuits is important.

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Note to editors:

Recent publications by Prof Joseph Chang and the NTU team:

K.-S. Chong, N. K. Z. Lwin, W. Shu, and J. S. Chang, "Radiation-Hardened-By-Design (RHBD) Digital Design Approaches: A Case Study on an 8051 Microcontroller," in Proc. IEEE Int. Sym. Circuits & Systems (ISCAS), 2020, Spain.

Jize Jiang, Wei Shu and Joseph Chang, "A 5.6 ppm/°C Temperature Coefficient, 87-dB PSRR, Sub-1-V Voltage Reference in 65-nm CMOS Exploiting the Zero-Temperature-Coefficient Point", IEEE Journal of Solid-State Circuits, March 2017.
Jize Jiang, Wei Shu and Joseph S. Chang, "Design and Test of an RHBD CMOS-only Voltage Reference", IEEE Nuclear and Space Radiation Effects Conference, July 2018, Hawaii, US.

Patents Granted:

"Electronic Circuit for Single-Event Latch-Up Detection And Protection", US Patent No. 10,566,780, Feb 18, 2020.

"A Method For Providing A Voltage Reference At A Present Operating Temperature In A Circuit", US Patent No. 10,423,175B2, Sept 24, 2019.

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About Nanyang Technological University, Singapore

A research-intensive public university, Nanyang Technological University, Singapore (NTU Singapore) has 33,000 undergraduate and postgraduate students in the Engineering, Business, Science, Humanities, Arts, & Social Sciences, and Graduate

colleges. It also has a medical school, the Lee Kong Chian School of Medicine, established jointly with Imperial College London.

NTU is also home to world-renowned autonomous institutes – the National Institute of Education, S Rajaratnam School of International Studies, Earth Observatory of Singapore, and Singapore Centre for Environmental Life Sciences Engineering – and various leading research centres such as the Nanyang Environment & Water Research Institute (NEWRI) and Energy Research Institute @ NTU (ERI@N).

Ranked amongst the world's top universities by QS, NTU has also been named the world's top young university for the past seven years. The University's main campus is frequently listed among the Top 15 most beautiful university campuses in the world and it has 57 Green Mark-certified (equivalent to LEED-certified) building projects, of which 95% are certified Green Mark Platinum. Apart from its main campus, NTU also has a campus in Singapore's healthcare district.

Under the NTU Smart Campus vision, the University harnesses the power of digital technology and tech-enabled solutions to support better learning and living experiences, the discovery of new knowledge, and the sustainability of resources.

For more information, visit www.ntu.edu.sg