CEITEC CTLAB

BRNO UNIVERSITY OF TECHNOLOGY

Space satellite component inspection on page 2.

Source: TRL Space

NEWSLETTER SPRING 2025

It is a pleasure for me to present you with a new issue of the newsletter of our Laboratory of X-ray Micro and Nano-Computed Tomography at CEITEC BUT. You can read about some of our recent explorations, including inspection of a component of the Czech space satellite TROLL or measurement of the BUT student formula on a high-energy CT.
Enjoy reading!

Tomáš Zikmund
Head of the laboratory

CZECH SPACE SATELLITE TROLL COMPONENT INSPECTION

Last year, we tested a component called an "LLD assembly" in our tomography lab, manufactured using metal 3D printing by the company One3D. This is a part of the hyperspectral camera equipped on the TROLL satellite from the Brno Space Company. TRL Space launched into orbit on January 14th of this year atop a Falcon 9 company SpaceX. Images from this camera can, for example, help monitor pollution in the Czech Republic and abroad. For example, illegal landfills and constructions can be detected more easily and accurately, as well as deforestation or water pollution. In addition, these images can be used to accurately monitor the state of vegetation.

How the device works

A hyperspectral camera, unlike a conventional camera, can capture light in dozens of spectral bands at once, with each point of the image containing detailed information about the reflected light at different wavelengths. This allows us to "see" the properties of materials that are invisible to the naked eye or to conventional cameras – for example, the chemical composition, humidity, or temperature of objects.

The specific task of our laboratory was to test the printed aluminum component of the LLD assembly (see Fig. 2). More precisely, it was to detect defects in the sample material and their possible quantification using available software. When evaluating the entire part, no pore-type defects were found with the given resolution (36 μm/voxel). Only in the area of one of the threads (see Fig. 3), small inclusions (foreign material) of higher mass than the base material were identified.

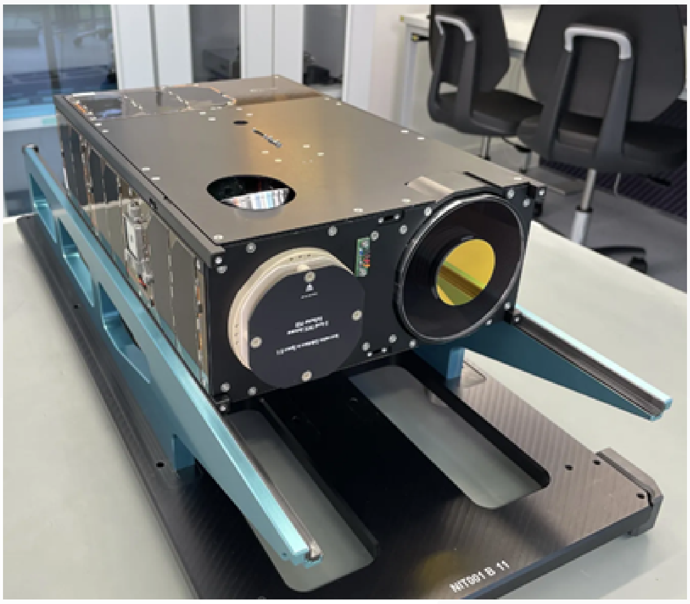

Fig. 1: TROLL Satellite. (Source: TRL Space)

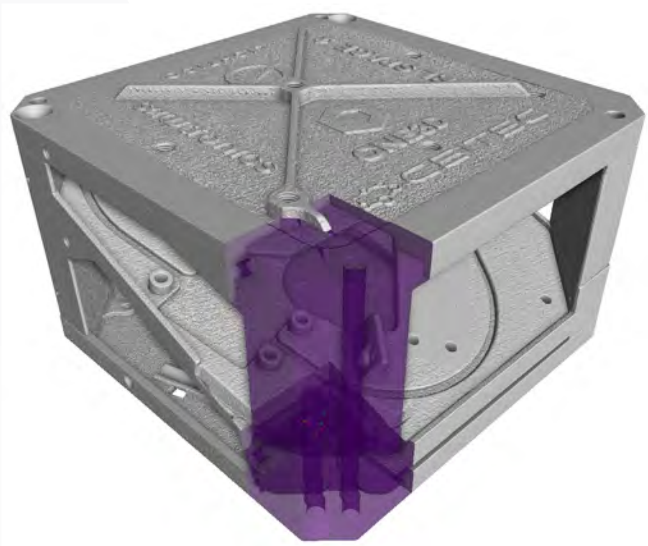

Fig. 2: 3D render of tomographic data of the LLD assembly.

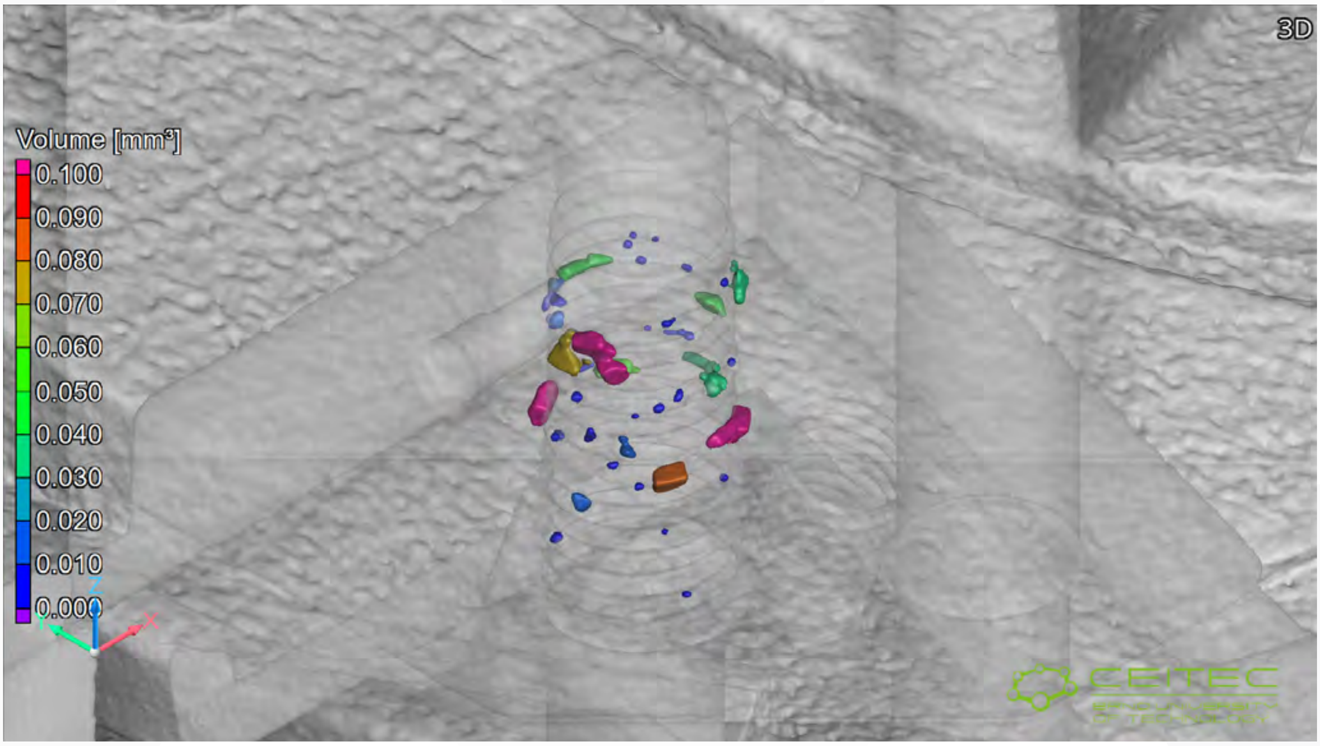

Fig. 3: 3D render of tomographic data of the LLD assembly with detail of inclusions in the thread area (colored according to volume size).

Author: Vojtěch Slovák

STUDENT FORMULA MEASUREMENT IN HIGH-ENERGY CT

We had the opportunity to perform CT measurements with a 450kV X-ray tube directly at the CT manufacturer Waygate Technologies in Germany. The measurement was carried out on the device **Phoenix v|tome|x L450**, which will be installed in our laboratory in the fall of 2025. As a test sample, we imported a student formula monocoque from the **TU Brno Racing** at BUT.

Fig. 4: Photo of the student formula TU Brno racing. Source: https://tubrnoracing.cz

The tested device has a unique tube with a voltage of 450 kV (so-called mezzo-focusing tube) and five selectable modes according to the power used, where the finest of them allows even at maximum voltage to achieve a resolution of tens of micrometers. Thanks to this, the system offers a relatively universal use for all samples made of heavier materials from small dimensions to complex assemblies. The monocoque we measured was about 2.5 m long, including clamping devices. The area of interest was the stressed parts around the suspension arms. The aim of the measurement was to detect any damage caused by year-round stress during the racing season.

The measurements lasted 6 and 8 hours and used the virtual extension of the detector by moving it to 3 positions in the horizontal axis and up to 6 positions in the vertical axis. Therefore, it is probably not surprising that the resulting CT data is about 200 GB in size per data set. Although we irradiated mainly the carbon monocoque with a relatively hard X-ray beam, all the honeycombs, foam adhesives and partial carbon layers can be seen in contrast in the resulting data, see Fig. 6.

You can watch a video with the measurement results at **this link**.

Fig. 5: Picture of the monocoque clamped inside the tomographic system

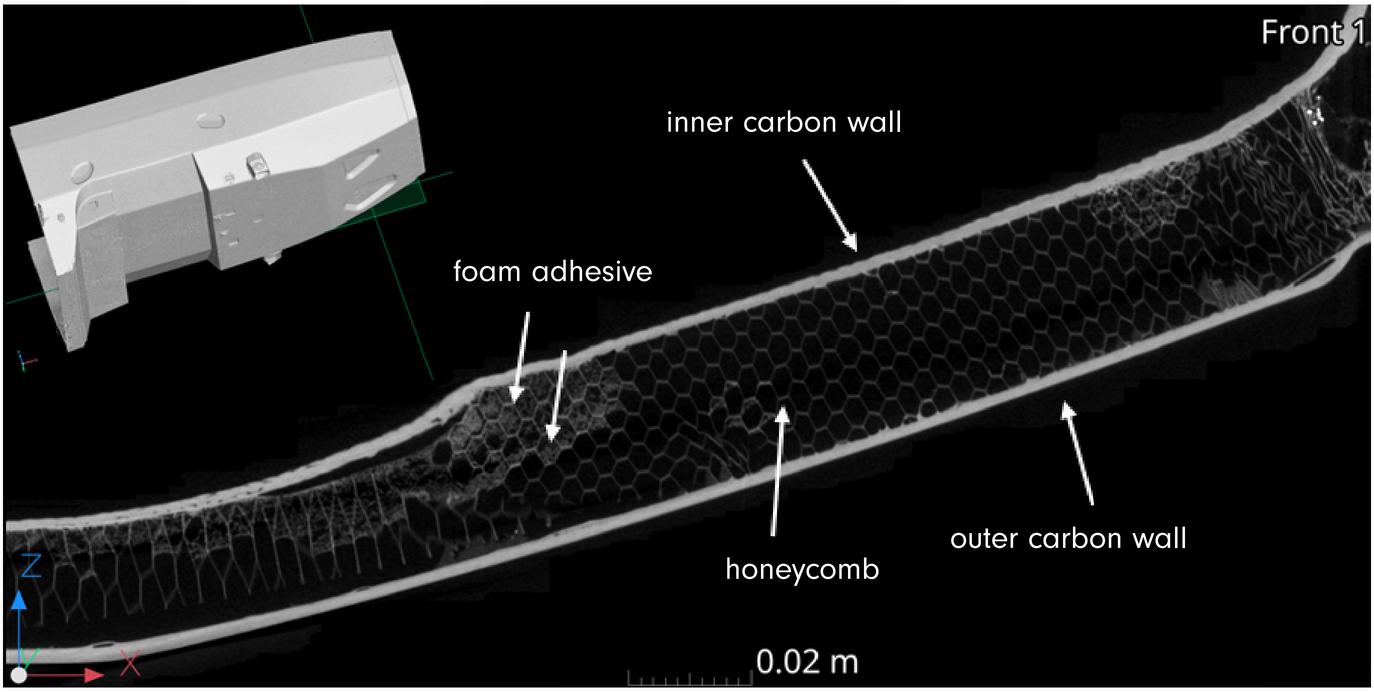

Fig. 6: Tomographic section through the monocoque wall. The position of the section is shown in the 3D render.

ANALYSIS OF COOLER CHANNELS PASSABILITY

Coolers are an integral part of modern cars. In the case of cars with an internal combustion engine, cooling removes 30 to 35% of the total heat supplied by the fuel. The waste heat removed in this way can be used, among other things, to heat the vehicle. Therefore, there is an effort to make cooler as efficient as possible. Their efficiency can be negatively affected by, for example, deformed fins or leaks in the cooling system, which will be manifested by the notorious leakage of liquid under the vehicle engine. Both are more or less detectable by sight without the need to intervene inside the cooler.

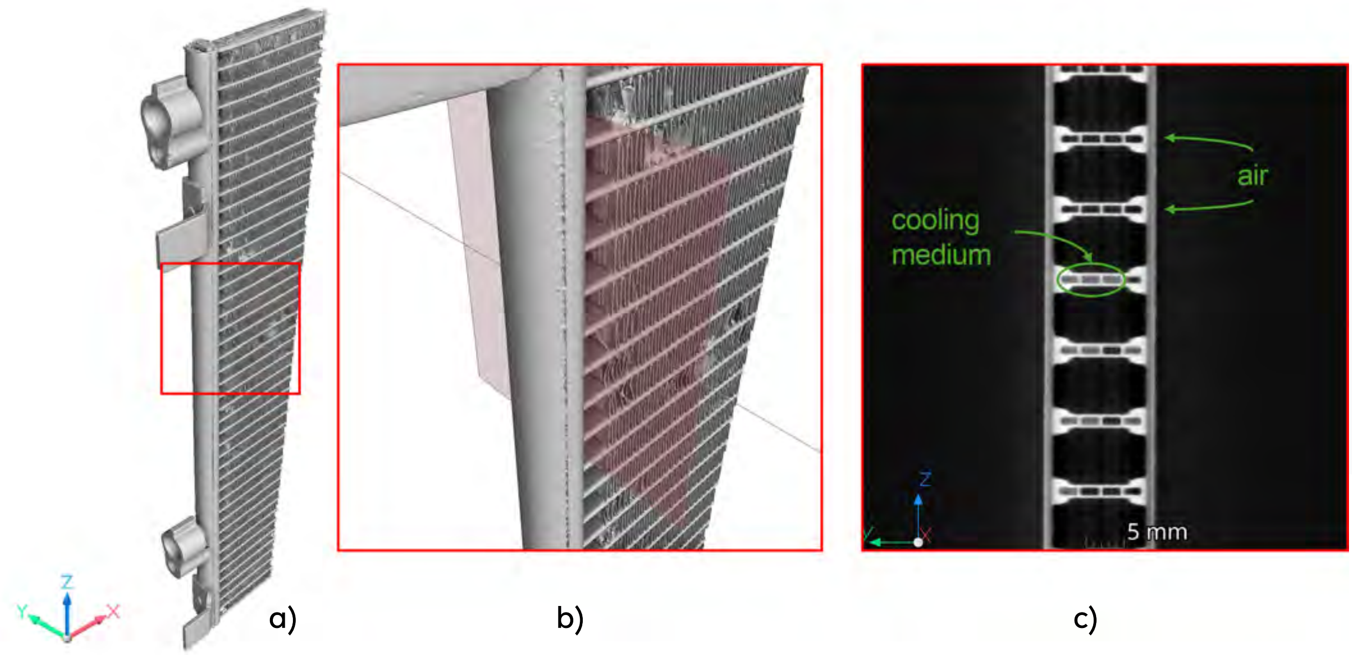

Fig. 7: Verification of patency at a specific location of the cooler: 3D render of CT data (a) with marked plane (b) corresponding to tomographic section guided by individual tubes that are soldered to the main tube (c).

What is even more difficult to check is the permeability of the channels in which the coolant flows. This should be checked both during the production process and after long-term loading. X-ray computed tomography is an ideal method that allows for non-destructive verification of the permeability of these channels (see Fig. 7). On the far right, you can see a cross-section of a mass-produced cooler, where there are four channels stacked on top of each other, some of which are filled with coolant. The size of one channel in this case is 2 x 0.8 mm.

Thanks to CT, it is possible to determine the proportion of through and clogged channels, and thus determine the decrease in the effective cross-section, which has a fundamental impact on the performance of the cooler. To properly evaluate the permeability of the channel, it is necessary to analyze it either along its entire length or at least at the point of connection to the main pipe, where blockages often occur due to soldering during production.

Author: Vít Holeňa

3D ATLAS OF A DEVELOPMENT XENOPUS LAEVIS

The European Water Frog (Xenopus Laevis) serves as a model organism in scientific research. Due to its ease of reproduction in laboratory conditions, rapid development, and egg size, this amphibian is one of the most important organisms for research, especially in developmental biology and genetics. Although this frog has been used in science for several decades, its development and sexual dimorphism have never been precisely documented based on real data.

Using microCT, it was possible to create a 3D atlas that maps the development of this frog in individual stages from the birth of a tadpole to an adult frog (Fig. 8). This atlas consists of created 3D models [1–3] where any structure can be examined in detail, both visually and quantitatively [4]. 3D models allow us to follow changes between individual stages and analyze differences, for example, between males and females, with males being about a third smaller than females.

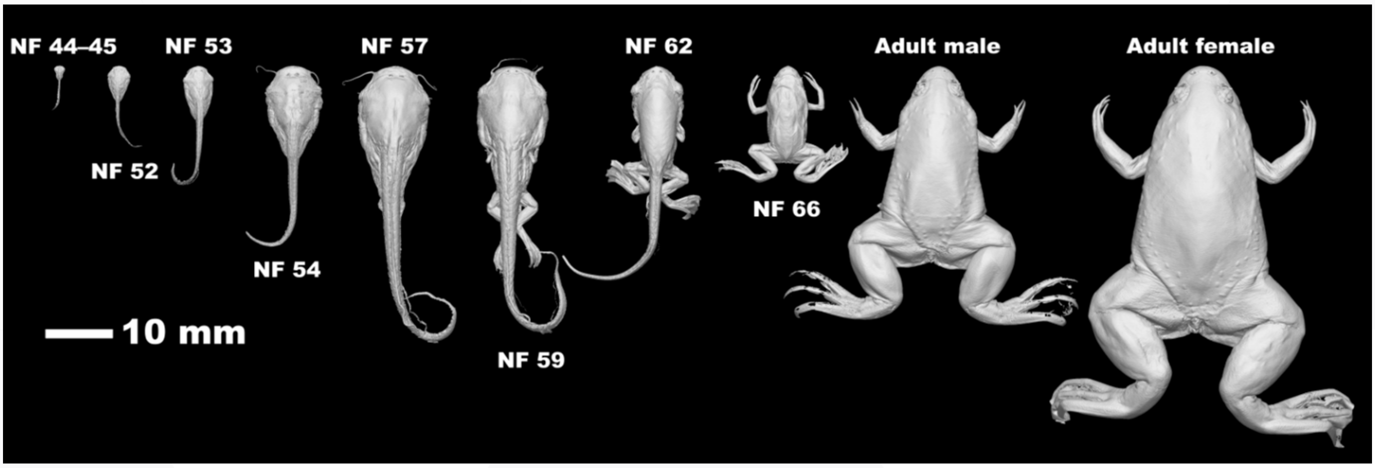

Fig. 8: 3D models of tomographic data of the water frog describing its development from tadpole to adult frog.

One of the most interesting periods in the development of the Frog is the metamorphosis phase, when fundamental changes occur in the structure and size of the body. Before metamorphosis, the tadpole gradually grows and accumulates body mass, which it will then use as a source of energy for the development of new organs. During this process, for example, the gills and tail disappear, while the lungs and limbs, which are crucial for the life of an adult frog, develop. MicroCT allows us to monitor changes in these structures already in the early stages of metamorphosis, when the total size of the tadpole is only a few millimeters.

Despite the high resolution and detail that microCT offers, the creation of the atlas poses certain challenges. One of the main limitations is the need for double scanning for the analysis of soft and hard tissues, as it is not possible to image both types of tissue simultaneously with sufficient contrast. Therefore, the hard tissues were scanned first, followed by chemical staining of the sample to highlight the soft tissues, and then a second measurement of the already stained tissues was performed. The next key step was the extraction of selected organs and structures from the samples using state-of-the-art software, and their quantitative analysis. More information about the creation of the atlas can be found in the reports [5,6].

[1] https://skfb.ly/p9GrU, [2] https://skfb.ly/p9GrV, [3] https://skfb.ly/p9GrW
[4] https://academic.oup.com/gigascience/article/doi/10.1093/gigascience/giae037/7714386?login=true
[5] https://www.irozhlas.cz/veda-technologie/veda/vedci-z-brna-zachytili-embryonalni-vyvoj-zab-ve-3d-modelech-dosud-existoval_2410081001_epo
[6] https://www.ceskatelevize.cz/porady/1181680258-tyden-v-regionech-brno/324281381891116/

Author: Jakub Lázňovský

MULTI-SCALE IMAGING WORKSHOP

The Multi-scale Imaging workshop, hosted by our laboratory, took place from April 1st to 3rd, 2025. With over 130 participants from industry and academia, we spent 3 dynamic days focusing on specialized techniques using state-of-the-art Earth and environmental sciences technologies. The aim of the meeting was to bring together manufacturers, scientists and professionals to share insights, showcase innovations and discuss evolving imaging needs across disciplines.

The first, an industrial day, was organized in collaboration with Waygate Technologies. We focused on real-world CT application cases, technological advances and listened to the valuable knowledge and experience of the speakers. This was followed by scientific days, organized in collaboration with the EXCITE network, which included practical training with Dragonfly and Avizo imaging software, as well as excursions to microscope manufacturers ThermoFisher Scientific, TESCAN and Delong Instruments, and guided tours of CTLAB a LIBSLAB.

Photo gallery is on this link.

Fig. 9: Picture of workshop participants.

Author: Michaela Škaroupková

MICROME|X MICROFOCUS MOVING

This year, another device was transferred from the Faculty of Mechanical Engineering of BUT to the laboratories at CEITEC BUT. **Microme|x microfocus X-ray inspection system**, is primarily designed for electronics inspection. It is designed primarily for the inspection of complex printed circuit boards and SMT (Surface Mount Technology) assemblies. More information about solder joint analysis can be found at this link.

Fig. 10: Photograph of a crane moving a Microme|x microfocus.

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