CubeSat Opportunities For In-Flight Testing Of Quantum Technologies

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Introduction

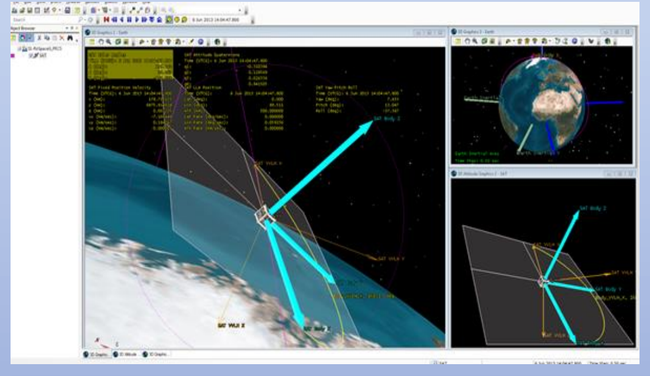
CubeSats are no longer an unproven tool and are now used even by national space agencies as means of fast-tracking technologies and affordable instruments for science. This role is perfectly aligned with demonstrating QKD using space assets. The maturity of those technologies is not yet seen as sufficient for dedicated large scale missions, which also limits the rate of advancement in the field.

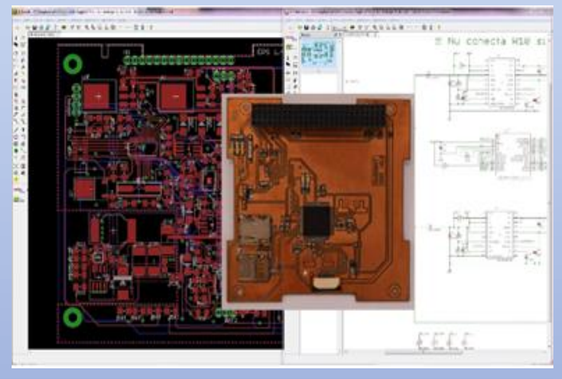
CubeSats at the Institute of Space Science (ISS)

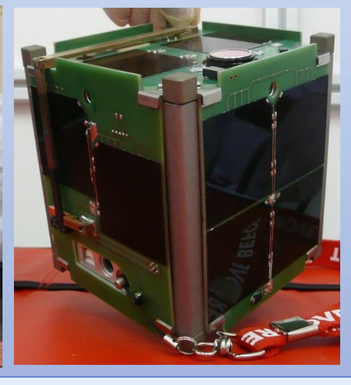
The Institute of Space Science has been the leader of Romanian research in space for more than half a century. Its activities are covering advanced scientific research on high energy physics, cosmic rays' physics and astrophysics. At the institute the CubeSats' potential for instruments in pursuing space activities was recognized early on and a team was formed by the students developing GOLIAT, the first Romanian nanosatellite. The 1U CubeSat developed in Romania was mostly designed and manufactured in Romania and involved national partners in developing specialized hardware for the small-scale spacecraft (e.g. custom optical mount for a high resolution camera, reaction wheels, radiation detector etc.).

ROmanian nanoSatellite Technology – Competence Center (ROST-CC within ISS)

- Mission planning and design (by means of the STK platform)
- CAD design for both mechanical and electrical (SolidWorks, Autodesk EAGLE)
- Rapid prototyping equipment (3D printing, CNC milling machine, PCB manufacturing: PCB milling, solder paste stencil, temperature control solder oven).
- Functional testing (fully equipped electronic test benches)
- Environmental testing (TV installation)
- Assembly and integration (class 8 clean room)
- New AIT Facility and mechanical test equipment to be commissioned in 2 years.







CubeSats for Quantum in space

The European initiative towards pursuing the new quantum revolution is a tentative to match the advancement in China (Gibney, 2016). The nanosatellite research team at ISS has been investigating possible scenarios for testing proposed quantum technologies on an accelerated schedule by using nanosatellite class spacecrafts. A phased approach is considered to be safer and more easily to integrate on such small spacecrafts:

1. Demonstration of modulated CCR as means of communication;
2. Demonstration of entangled photon sources on board a single spacecraft;
3. Demonstration of reception of ground emitted photons at satellite;
4. Demonstration of reception of satellite emitted photons at ground stations.

The simplest QKD experiment that validates the technology involves a black box with both the source and the receiver (Tang et al., 2016). Such an experiment has two goals: to validate the survivability during the shocks of launch and to assess the impact of the effects the in-orbit environment has on the functional parameters of the source (mainly the radiation environment). More challenging objectives in which the ground and space segment have different roles could also be achieved on CubeSats. The main restrictions for these types of missions are from the ADCS module embarkable on CubeSats. Particularly both knowledge and control of the spacecraft location and orientation are necessary for optical alignment. Traditionally these have been the most difficult subsystems to scale down to the CubeSat class and although improvements have been made, larger than 3U CubeSats may need to be employed for these demonstrator missions.

Gibney, E. (2016). Chinese satellite is one giant step for the quantum internet. Nature, 535, 478–479. https://doi.org/10.1038/535478a

Tang, Z., Chandrasekara, R., Tan, Y. C., Cheng, C., Sha, L., Hiang, G. C., … Ling, A. (2016). Generation and Analysis of Correlated Pairs of Photons aboard a Nanosatellite. Physical Review Applied, 5(5), 1–5. https://doi.org/10.1103/PhysRevApplied.5.054022

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