



Ph.D. position  
2024-2027  
Call for applications



## Distributed wideband beamforming for satellite communication swarms

### Context and main goal

Access to broadband services is often taken for granted, but to this date there are still many underserved regions, such as rural areas, that lack connectivity, thus creating a digital divide. High costs hinder remote broadband infrastructure. *NewSpace*-related satellite broadband may be an alternative for offering cost-effective extensive coverage. Satellite communications have the potential to provide diverse services universally, including mobile broadband in underserved regions. To make this come true is challenging due to several factors; one such a factor is dealing with small handheld devices, which require the deployment of expensive large satellite antennas. A proposed solution is to use multiple nanosatellites to create a large virtual antenna array. *This Ph.D. work aims to investigate computationally efficient distributed beamformers over satellite swarms for wideband signaling.* The work will focus on fundamental research (equivalent to TRLs 1/2), while keeping in mind future practical applications, including broadband coverage for civil aviation, autonomous cars in underserved areas, and mobile broadband Internet in rural areas.

In terms of related works, the work in [Tuzi et al., 2023] focuses on 6G networks, proposing direct satellite-to-UE connectivity in L/S frequency bands using satellite swarms. It highlights gains in beamforming gain, beamwidth, and cost-effectiveness, exploring optimized antenna array designs and tethered swarms. The work in [Bacci et al., 2023] integrates terrestrial and nonterrestrial segments using “formation of arrays” in wireless networks, employing smaller sub-antennas on individual small satellites. Our paper in [Duncan et al., 2023] addresses challenges in delivering broadband services to user terminals with miniature antennas, proposing distributed beamforming and modeling wideband signal behavior in swarm nodes.

### Host institution

The host institution is **ISAE-SUPAERO**, member of the University of Toulouse, France. **ISAE-SUPAERO** is a public higher education and research institute focused on aerospace applications. In particular, the “Communications and Information Theory” (ComIT) research group conducts activities in digital communications, radar, channel access techniques. Applications include space systems and commercial/military aviation. Webpage: <http://isae.fr/deos/comit>. The Ph.D. supervisor will be Prof. Wallace Martins.

The recruited Ph.D. candidate will be offered various opportunities during her/his work: international mobility, teaching, supervision experience (internships, teaching projects, etc.), and relations with the defense and aerospace industry.

### Candidate profile

Applicants should be last-year master’s students or hold a master’s degree. A strong background in **signal processing** and **digital communications** is required, along with good programming skills, including in Matlab. Good communication skills in English are necessary (written and oral). Prior experience in satellite communications and machine learning/adaptive filtering, while optional, would be particularly appreciated.

## Application procedure

Applications (résumé, motivation letter, name and contact of up to 3 references, and official transcripts in English or in French or in Portuguese) and informal inquiries are to be emailed to

- wallace.martins@isae-superaero.fr

### Application deadline

- 15-June-2024 or else once the position is filled

## Ph.D. period

Three years, starting between September-December/2024

## References

- [Bacci et al., 2023] Bacci, G., Gaudenzi, R. D., Luise, M., Sanguinetti, L., and Sebastiani, E. (2023). Formation-of-arrays antenna technology for high-throughput mobile nonterrestrial networks. *IEEE Transactions on Aerospace and Electronic Systems*, 59(5):4919–4935.
- [Duncan et al., 2023] Duncan, J. C. M., Ha, V. N., Krivochiza, J., Palisetty, R., Eappen, G., Vasquez, J. A., Martins, W. A., Chatzinotas, S., and Ottersten, B. (2023). Harnessing the power of swarm satellite networks with wideband distributed beamforming. In *2023 IEEE 34th Annual International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC)*, pages 1–6.
- [Tuzi et al., 2023] Tuzi, D., Delamotte, T., and Knopp, A. (2023). Satellite swarm-based antenna arrays for 6G direct-to-cell connectivity. *IEEE Access*, 11:36907–36928.