

PHD THESIS POSITION
Synchronization and security techniques for
Faster-than-Nyquist signals



Context and expected outcomes

In the race for spectral efficiency, the idea of overriding the Nyquist criterion has been proposed in [Maz75] leading to “faster-than-Nyquist” (FTN) systems (*i.e.*, symbol rate greater than the occupied bandwidth). Consequently, interpulse interference cannot be avoided at the output of any linear receiver. Several authors proposed efficient techniques to mitigate this interference and yield spectacular spectral efficiency gains (from 30% to 60 % over Nyquist systems) [RA09, BFC09, PA12, MRSS17].

However, **synchronization techniques** (mainly timing, but also frequency and phase) **should be studied in the case of FTN signals** to result in feasible transmission systems. A scarce literature on the topic confirms the need to lead more investigations [FGZ⁺17].

For example, in the case of non-data-aided (*i.e.*, blind) synchronization, it should be noted that usual algorithms based on second order cyclostationarity cannot be used within FTN signals. However, **higher-order statistics** may be used to reveal cyclic features [IN96, ARF18].

More generally, **various estimation techniques** (*e.g.*, deterministic, Bayesian, neural networks...) will be used to derive suitable synchronization algorithms either in data-aided and non-data-aided cases [Kay93, Kri07]. **Open-loop and closed-loop** architectures will be studied and their performance will be compared to those of usual Nyquist rate systems [Men97].

FTN signals may also be used to **enhance physical layer security** by adding randomness to the synchronization parameters (to decoy eavesdroppers) or using those parameters to carry information (with low-probability of detection).

Fields of application of this work includes primarily **satellite and aeronautical communications**. For example, safety/security critical systems requiring very high data rate services are at stake: UAVs, intelligent transportation systems, airliners, military aircraft... As a first step, we will assume a single carrier transmission over additive white Gaussian noise channels. An extension to multipath mobile channels and multicarrier modulations may also be considered...

Host institution and place of work

Located in **Toulouse** (France), **ISAE-SUPAERO** is a public higher education and research institute focused on aerospace applications. More particularly, the department of electronics, optronics and signal processing (DEOS) has an extensive expertise in electrical engineering applied to aerospace systems. Activities in the field of telecommunications are focused on secured high throughput transmission techniques for satellite and aeronautical systems. To this extent, commonly used tools are related to information theory, estimation and detection, optimization, time-frequency analysis and much more signal processing building blocks.

Candidate profile and application

Applicants should be last-year master (or engineer) students or hold a master degree. A strong background in **signal processing and statistics** is required since the PhD is focused on esti-

mation theory. Good communication skills in English are necessary (written and oral), as well as good development skills (Matlab, Python...). Applications from candidates familiar with digital communications and estimation/detection techniques are particularly encouraged.

⇒ Applications (resume, motivation letter and current academic record, in English or in French) and informal inquiries are to be emailed to damien.roque@isae-supaero.fr.

Useful information...

- **Application as soon as possible:** the PhD student will be appointed as soon as we'll have enough suitable application files (final deadline: 30-Jun-2018).
- Field of study: digital communications (signal processing, estimation/detection).
- Start of contract **before December 2018** (36 month fixed-term contract).
- Various opportunities during the PhD: teaching, international mobility, supervision experience (internships, teaching projects...), relations with defense and aerospace industry.
- EU citizenship is required by the funding agency.

References

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