The **French-German Research Institute of Saint-Louis (ISL)** situated in the border triangle of Germany, France and Switzerland is an internationally renowned research institute belonging to a global industrial and economic network.
The spectrum of our core activities comprises a variety of topics: aerodynamics, energetic and advanced materials, lasers and electromagnetic technologies, protection, security and situational awareness. Our activities are related to both basic and applied research.

ISL is offering a **PhD Position**

**Research field: Sensors, Telemetry and Communication**

# Development of a flexible target detection system based on Software-Defined Radio for embedding inside a gun-fired ammunition

## Context

This study is proposed by the French-German research Institute of Saint-Louis (ISL) and the Institute of Electronics and Digital Technologies (IETR) of Nantes with a possible co-funding by the Direction Générale de l'Armement (DGA).
The ISL works, among other things, on the design of future artillery ammunitions. Guided munitions allow to drastically improve accuracy, track non-ballistic trajectories or conceal one's position to the enemy and avoid retaliation. Technological challenges are centered on countermeasures nowadays. In an era where radio communications suffer ever more jamming, "GNSS-denied" solutions where the ammunition can position itself independently from a GPS reception are hence becoming crucial. It is proposed here to enable an artillery ammunition to localize its target using sensors in the RF domain, typically an antenna array and implementation of Direction Finding algorithms. The array is to be steered using Software-Defined Radio (SDR) technology.

## Research aspects

The proposed research work focuses on the development of a passive Direction Finder (c.f. Direction Of Arrival for literature) based on SDR to enable the localization of as many different signal sources as possible (e.g. a military radar or jammer, or communications using Low Probability of Interception techniques) with a single hardware designed for guided artillery ammunitions. Therefore, the research challenges reside in Direction Finding and waveform recognition, target classification, in environments with very high dynamics. The student will be trained to techniques and algorithms to localize and identify transmitters using signals from an antenna array embedded in an artillery shell flying at high speed (Mach1 or above). Experimental research will be a key part of the work as a functional demonstrator will be developed using commercial SDR and validated in an anechoic environment. Comparison between simulations and measurements will provide a first assessment of realistic performance in a context of artillery ammunitions.
Transmitter localization using antenna arrays is an active research domain. Some studies have used such techniques in drone surveillance applications using SDR. But detected waveforms are found within general telecommunications applications (mobile phone networks, car GPS navigation, etc.). However, an artillery shell flies at speeds several times that of sound and undergo huge constraints, can follow ballistic trajectories or can be guided, and can present spins of several hundreds of Hz.
Moreover, embedding of such a system inevitably brings constraints in terms of space, battery consumption, computational power or accuracy performance.

## Envisioned planning

In order to address these numerous challenges, we will first adapt Direction Finding techniques from State of the Art while respecting project constraints (needed computation power, processing time, angular resolution, etc.) and will validate the results using a numerical simulator (e.g. Matlab). Sampled IQ signals received by the array will be simulated depending on the target or evolution of the Channel State Information (CSI) such as the Doppler effect induced by the ammunition and target trajectories, Signal-to-Noise ratio, reflections, etc. For instance, pulses and wideband Continuous Wave signals will be considered. Techniques of spectrum analysis will also be implemented to create a more intelligent system capable of taking decisions.
The Direction Finder will also be implemented on commercial SDR hardware and performance will be measured during firing campaigns in real conditions. This study will first take place at the IETR of Nantes (FR-44), then at ISL (FR-68). Publications in international conferences and peer-reviewed journals will be encouraged and appreciation of the student's work by the scientific community will be his/her supervisor's priority.

## Profile of the candidate

We are looking for a candidate who will have a master degree or equivalent by October 2024, in electronics, signal processing, telecommunications or radar technology. The candidate will need skills in digital signal processing. Knowledge about Direction Finding techniques or SDR technology would be appreciated, but can be acquired during the PhD.

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## Informations

**Dates**: starting beginning of October 2024, for 3 years
**Places**: 1st half in the laboratories of IETR in Nantes (FR-44), 2nd half at ISL (FR-68)
**Contact**: by sending a cover letter and a resume to the supervising team

## Supervisors

**IETR, Nantes Université Polytech Nantes**
Pascal Chargé: pascal.charge@univ-nantes.fr
Jean-François Diouris: jean-francois.diouris@univ-nantes.fr
Guillaume Andrieux: guillaume.andrieux@univ-nantes.fr

**Institut franco-allemand de recherches de Saint-Louis (ISL)**
Clément Campo: clement.campo@isl.eu

## Laboratories

**Institut d'Electronique et des Technologies du numéRique**
IETR - Université de Nantes
Campus Chantrerie - rue Christian Pauc
CS 50609, 44306 Nantes Cedex 3
www.ietr.fr

**French-German Research Institute of Saint-Louis**
5 rue du Général Cassagnou
68301 Saint Louis Cedex, FRANCE
www.isl.eu