Statistical modeling of the railway electromagnetic environment for jamming detection.

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Abstract: These last years, GSM-R (global system for mobile communication - railway) was developed and widely implemented in Europe as a unique standard to exchange voice communication, signaling information and control data between trains and ground control centers. To effectively carry out this mission, it is vital to ensure the resilience of the GSM-R radio link against electromagnetic interferences coming from unintentional but also intentional sources. Considering this requirement, the European project "SECRET", SECurity of Railways against Electromagnetic aTtacks implements perturbation detection methods. One of the developed methods exploits a statistical modeling based on the electromagnetic (EM) spectrum evolution. It uses a supervised detection method to identify EM perturbations based on the knowledge of the EM environments and using the probabilistic density function (p.d.f). The goal is to use these methods to set up, on demand, adjusted countermeasures ensuring a better resilience of the railway system against external EM perturbations.

GSM-R and jamming devices:
In Europe, GSM-R is the system selected to ensure the whole set of radio communication required between trains and ground controls centers. Placed onboard the train, cab radio systems use GSM-like equipment delivering powers up to 8 W to train antennas. A dedicated Base Transceiver Station infrastructure is installed at ground, along the tracks. In the other side, jammers covering wide frequency range, including the GSM-R dedicated band, and delivering up to several W are considered.

Jamming detection methodology:
GSM-R operates on dedicated frequency bands. The uplink (876-880 MHz) and the downlink (921-925 MHz) are divided into channels of 200 kHz. A GMSK modulation and TDMA (time division multiple access) are used. Figure 1 represents the typical power spectral density (p.s.d) of the communication and the spectrum of two different commercial on the shelf jammers.

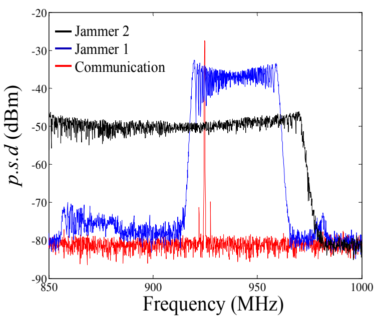

Figure 1. P.s.d representation of communication and jammers.

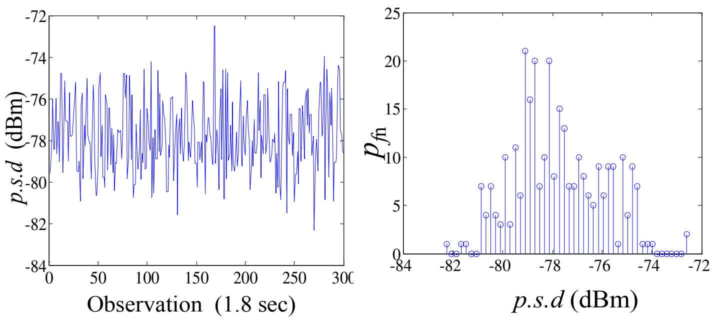

Figure 2. Time observation and histogram of the p.s.d at 912 MHz.

Based on the p.d.f of each frequency, we implement a statistical model of the received power spectral density (p.s.d) at train or at ground. As presented in figure 2, a multi Gaussian distribution was selected as a model for the p.s.d. It is based on a supervised method. Therefore, a learning phase is required. During this step, the different multi Gaussian models were learned for each of the three environments: communication, jammer1 and jammer2. Then, the detection process compares the distribution of the p.s.d from the learned one and detects jamming conditions using the Bayesian rules.

Conclusion and perspectives:
This paper studied a statistical method based on the power spectral density for the detection of EM jamming. Tested in laboratory controlled conditions it brings ideal results. On the other side, in railway environment, it presents some limitations. Consequently, the efficiency of the method can vary significantly according to the scenarios.