EUROPEAN SPACE AGENCY CONTRACT REPORT

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ARFIDAAS

Abstract

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1. Introduction

This document is derived from the document *NAVISP3-ESR-SINTEF-EL3-004_1.1_Executive Summary Report* and will serve as a very concise summary of the findings of the ESA contract number 4000126274, hereafter referred to as 'ARFIDAAS', 'ARFIDAAS project' or 'the project'. The ARFIDAAS project was executed in accordance with the Norwegian commitment to the protection of GNSS (Galileo) spectrum.

1.1. Objectives

The purpose of the ARFIDAAS project was to design and deploy a set of monitoring stations tailored to the specific task of detecting the presence of harmful Radio Frequency Interference (RFI) that may disrupt use of the very low power GNSS signals including those broadcast by Galileo and GPS.

In addition to basic detection activities, the project was focused on the attendant activities of alerting and analysis. In the case of alerting, here this means that the system should within a short time of an RFI event starting notify the facility operator, host or other operator of the system of the presence of the event so that they may make an informed decision about whether the detected RFI poses an immediate threat to their GNSS dependent needs. The term analysis here refers to the desire to provide initial characterization of the event in a human readable format to the user along with the notification to facilitate their decision-making process.

1.1. System design

The ARFIDAAS system comprises three components. The first is a custom design signal capture device called a 'Front-End' which is responsible for streaming 240 MHz of L-band spectrum containing all known GNSS signals in real time along with important metadata such as the amount of power present in the signals and other parameters. The data is streamed to and through the second component which is software running on a compact processor system where custom software monitors for events based on user configurable detection criteria. When these criteria are met, the software automatically captures and analyses the RFI event before notifying a list of relevant individuals via email of the event occurrence and providing them with a report file and a PDF document visually expressing the extent of the RFI event and which GNSS signals are impacted. At this point the system software interfaces to the 3rd system component which is cloud based centralized collection and storage of the data which allows all distributed ARFIDAAS systems to store their analysis products and the raw spectral data in one location automatically to permit further use and exploitation of the captured events by 1st and 3rd parties at a later time.

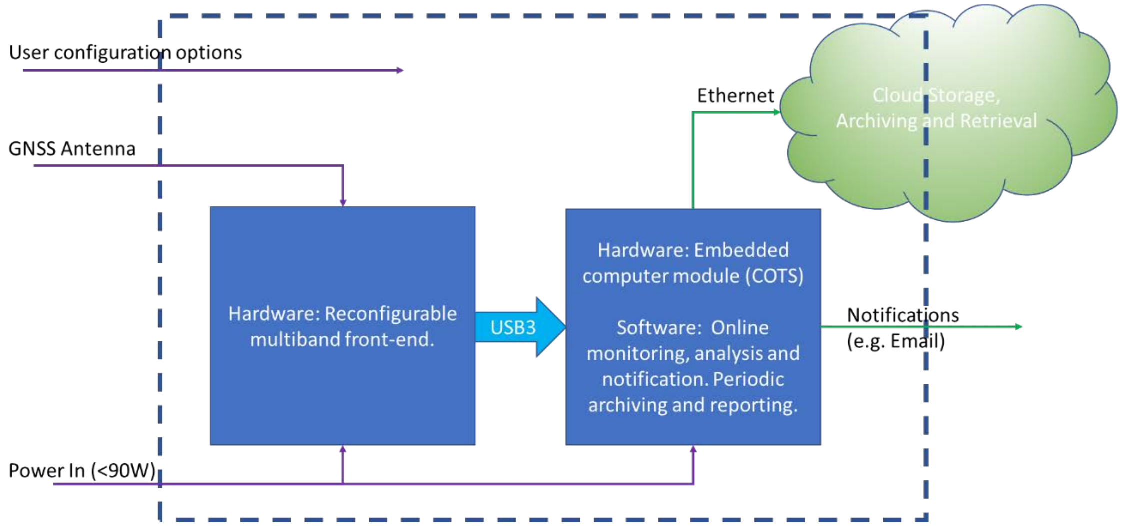

Figure 1: ARFIDAAS system block diagram

System hardware design

The system custom Front-End is designed to be compact and low cost while also allowing monitor and capture of all presently transmitted GNSS signals with a resolution sufficient to limit distortion even during exposure to typical RFI events.

While the system was originally envisioned to make use of a custom designed embedded compute solution, it was determined during the course of the project that it was less expensive and more robust to use a low cost off the shelf compute solution embodied in a NUC6CAYH 'NUC' PC with an SSD installed.

Figure 2: ARFIDAAS NUC PC on left connected to eclosed Front-end on right.

The system software running on each instance of the ARFIDAAS computers contains two distinct components. The first is web-based user interface which allows the hosting user to connect to and customize myriad options to tailor the system to their specific site, and to store these configuration options to a database file which is used by the second component. The second component is the detection, analysis, alerting and storage software comprising sub-modules each responsible for one step in the event detection and handling pipeline. The first stage is responsible for characterizing the local environment and determining based on the user settings in the database if measured deviation constitutes an event at any given moment. The second stage performs initial analysis and report formulation based on any detected events while the third propagates the summary information to the indicated stakeholders defined in the database via email before transmitting the raw and summary data to cloud storage. An additional sub-module is dedicated to diagnostic logging, daily reporting, and adherence to system 'speed limits' in terms of instantaneous and monthly data usage allowances set by the host in the database file, which is a critical consideration in light of the ability of an ARFIDAAS front-end to produce hundreds of Petabytes of data per month if configured to log continuously.

1.2. System deployment

Six instances of the ARFIDAAS system were deployed nationally within Norway and internationally to cooperating research institutes and organizations through November and December of 2019.

Figure 3: ARFIDAAS deployment locations (map image from creative commons)

The first deployment location was the SINTEF lab facilities in Trondheim where test and development work could proceed in parallel and the system could be closely monitored during initial operation. At a later point a second Trondheim location was added as a practical test of the process for deploying systems at remote locations. Once the process for remote system deployment was finalized, units were sent to ESTEC facilities in Leiden, NLR offices in Amsterdam, the campus of the University of Helsinki and to the lab of Indra Navia in Asker (Oslo).

1.3. Data products

When an ARFIDAAS system detects the presence of RFI two reporting documents are created. The first is a report file which summarizes in text the presence and perceived properties of the event as well as the baseline characteristics of the environment noted during system initialization. This latter data is useful when considering the relative severity of a detected RFI event, and whether there are persistent unintentional RFI signals or co-authorized spectrum users present in the vicinity of the ARFIDAAS station. The second reporting document expresses the information contained in the report file visually, and is suitable for rapid assessment by stakeholders of the severity of the detected event.