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IOT, Machine learning and Natural Language Processing for launch system exploitation

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Abstract
The examples and tests cases described in the article demonstrate the interesting possibilities to use the wireless IoT measurements locally on different isolated sites or even mobile ones as a complement to the wired measurements already deployed on the most critical sites. The possibilities of coupled analysis with machine learning and Natural Language Processing are exposed with respect to previous experiences in CNES and with industrial partners in the framework of SESAME H2020 project. The applications of Adaptive Operations Module (AOM) and Model Predictive Control (MPC) are presented.

1. Context

With the arrival of Newspace actors and new missions, many Launch Bases are becoming or are already spaceports with a complex organization and multi launcher services. Despite of that, the costs must remain low maintaining the necessary reliability for the exploitation service. In order to reach this objective, the technologies coming from the Industry 4.0 based on IoT and Artificial Intelligence could be used.

The launch system is characterized by three important pillars:

- The Product (the launcher operations with payloads)
- The Industry that produces the launcher (the production)
- The Launch base or Spaceport (the Ground exploitation service)

These three factors are strongly related each other, if we want to satisfy the customers (the satellites) et maintain the low costs. Each pillar contributes to the efficiency of the space transportation service.

This article concerns the application examples of those technologies for Guiana Space Center (GSC) in the French Guiana, where they have been introduced and tested in order to demonstrate the gains in terms of value for the space transportation in terms of efficiency, quality, safety, security and cost reduction. Some of them had been specifically treated in [1] and [2]. This study goes beyond those tests in the same logic.

An analytical expertise in different domains of the activities in the GSC allowed identifying a value chain with new technologies including IOT, smart monitoring, geolocalisation, machine learning and Natural Language Processing (NLP) with specific state of art algorithms. The sensors, and communication architectures were defined for a certain number of tests. The main technologies are SigFox, Lora, in the LPWAN (Low Power Wide Area Network) and BLE in short range. Each identified case had very distinct specifications, including transmission latency, geographical penetration and range, power consumption, costs, speed (uplink/downlink), etc.

2. Study objective

The main objective of the study was to demonstrate the feasibility of smart monitoring, geolocation, energy management and intelligent maintenance of the infrastructures located in the space base in French Guiana. In particular two aspects were tested:

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- The "Smart Building", i.e. the possible means of supervision and predictive maintenance of buildings, including energy consumption and air conditioning: inventories, preparations for dangerous operations, available technologies and feasibility, compatibility with existing means of utilities control,
- Geolocation and smart monitoring of people and equipment, including the characteristic of mobility and/or dispersed location.

Smart monitoring is an approach that allows, thanks to the implementation of appropriate sensors, to remotely monitor the state of health of the essential equipment of a site or an organization. Generally, Smart Monitoring implements wireless technologies with low energy consumption (Low Power)

- At the communications level: use of radio type transmissions.
- At the energy level: Use of batteries.

This objective was broken down into several secondary objectives:

- Identify state-of-the-art IoT technologies that meet the needs of test cases.
- Demonstrate and justify the technology best suited to the case study considered.
- Highlight the gains, constraints and characteristics and performance of these technologies through testing.

3. Tested solutions

A fundamental point of this study was to implement the test cases in quasi-real conditions on the Guiana Space Center. The two main data transmission technologies that have been targeted are SIGFOX and LoRaWAN. These two technologies were therefore implemented simultaneously at the CSG, by distributing them over the different test cases. However, other technologies (GPS location, satellite transmissions or Bluetooth Low Energy) have also been tested, when SIGFOX and LoRaWAN did not provide adequate solutions.

The solutions proposed for the implementation of the test cases aimed to cover them with a certain technological redundancy in order to bring more robustness to the conclusions of the study. These solutions covered the complete data processing chain, from the measurements taken by the sensors, through the transmission, collection and storage of data, to their restitution/presentation to the end user.
Finally, it is important to precise a few points outside the scope of this study:

- Geolocation is not focused on the definition and fine monitoring of routes, but only the identification of the position of people and goods at regular and infrequent intervals (every 10 minutes for example, or even more).
- The geolocation of people is safety oriented, in the event of an accident to people or an incident on the base. In any case, it is not made to manage their access to restricted access areas: There is a system already in place with which it was not intended to interfere.

The market for LPWAN technologies is evolving, due to the high market expectations related to IoT activities. It is difficult to predict which technologies will still be available and maintained in 5 to 10 years, for example we don’t know how the 5G technology will be adequate in terms of technical and economic needs and specifications. However, significant progress has been made in wireless transmission distance and power consumption, so the implementation of a low-power, wide-coverage wireless network is now made attractive.

LPWAN technologies are relevant if the following three points are present:

- Need for “long range” (several Km).
- Application data can be transmitted at very low speed (a few bytes, a few times a day).
- Need to implement sensors / sensors with low energy consumption (autonomy of several years).

If one of these points is not part of the fundamental needs of the application to be implemented, it is very likely that the LPWAN technologies are not the best suited to the case in hand, and that it is preferable to move towards other types of solutions.

The graph below positions LPWAN technologies vis-à-vis RF transmission technologies on the current market.

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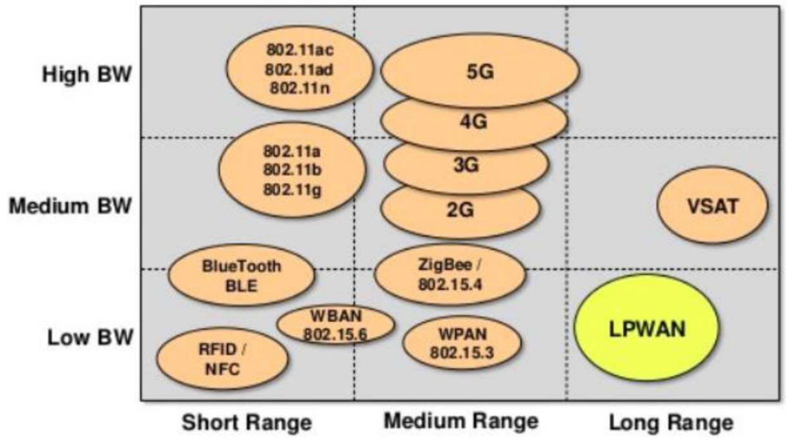

Figure 1: Relative positioning of RF technologies, in range vs frequency bands

SIGFOX is a world's leading IOT communication service provider and 0G network pioneer specializing in M2M data exchange (Machine to Machine) acquired recently this year by UnaBiz. It has developed a proprietary technology based on UNB (Ultra Narrow Band) technology which uses a public ISM (industrial, scientific and medical) frequency band (868 MHz in Europe and 902 MHz in the United States), access to which is regulated. This technology allows long distance transmissions (10 km or more) of small messages (12 bytes) while consuming little energy. It is essentially unidirectional (upward direction) but supports bidirectional, within certain limits.

LoRaWAN is a telecommunications protocol allowing low-speed communication, by radio, of objects with low power consumption communicating using LoRa technology and connected to the Internet via gateways, thus participating in the Internet of Things. This protocol is used in the context of smart cities, industrial monitoring or even agriculture. The modulation technology linked to LoRaWAN is LoRa, created in 2009 by the Grenoble start-up Cycléo and acquired by Semtech in 2012.

4. Tests description

Among performed tests the SigFox and LORA technologies were implemented for a monitoring of a Radar station that is far from the GSC but still in French Guiana, close to the border with Republic of Surinam in Saint Laurent de Maroni. The distance from the Launch Base is relevant and it takes about 3 hours by car (250km from Kourou) with important logistic and related costs. Another test was to instrument with specific sensors a pump of an iced water center responsible of air conditioning production necessary for the refrigerating circuit of one of the launch complex area. The main objective is not only to identify the best IOT and architecture solution but start with a machine learning study in order to identify the preventive decision for the main pump maintenance and to predict the anomalies and the life duration. Other tests concerned notably geolocation of ground equipment.

The following test cases were performed:

For Smart monitoring & geolocation objectives:

- Test case 1: Outdoor geolocation of a mobile power generator and monitoring of its operating status
- Test case 2: Indoor / outdoor geolocation of mobile tools and equipment in EPCUs (satellite preparation building facilities)
- Test case 3: Remote monitoring of equipment
- Test case 5: Geolocation of an isolated operator
- Test case 6: Geolocation of cars and trucks

The test cases that cover the topic of conditional/predictive maintenance are:

- Test case 7: Monitoring of the operation of the air conditioning of the BSE building
- Test case 8: Monitoring the operation of the chilled water production units of the Mollier plant
- Test case 9: Monitoring the electrical consumption of equipment

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Table 1: Summary of the solutions implemented for each test case

Test case	GSC (Kourou)	Saint Laurent de Maroni
Test case 1: Outdoor geolocation of a mobile power generator and monitoring of its operating status	Generator n°20 50KVA • State on/off • Fuel level • Alarm indicator LPWAN : SIGFOX	
Test case 2: Indoor / outdoor geolocation of mobile tools and equipment in EPCUs	EPCU S1 GPS outdoor BLE indoor LPWAN : LoRaWAN	
Test case 3: Remote monitoring of equipment	Gate barrier to “Fusée Sonde” site : simple contact sensor LPWAN : SIGFOX	Site Monitoring Fuel level Gate contact sensor Temperature / hygrometry SIGFOX et LoRaWAN
Test case 5: Geolocation of an isolated operator	Geolocation of isolated operator GPS Satellite	Geolocation of isolated operator GPS Satellite
Test case 6: Geolocation of cars and trucks	Geolocation of Generator & Vehicles GPS SIGFOX GPS LoRaWAN	Geolocation of Vehicle GPS Satellite
Test case 7: Monitoring of the operation of the air conditioning of the BSE building	Differential pressure LPWAN : SIGFOX	
Test case 8: Monitoring the operation of the chilled water production units of the Mollier plant	Solution PREDIKTAS Solution BK-VIBRO LPWAN : SIGFOX & LoRaWAN	
Test case 9: Monitoring the electrical consumption of equipment	Electricity consumption monitoring • Generator • BSE air conditioner LPWAN : LoRaWAN	Electricity consumption monitoring • Shelter air conditioner • Site LPWAN : SIGFOX & LoRaWAN

In the next chapters only the tests 7 to 9 were detailed with their respective results. The other tests demonstrated that wireless measurement chain using LPWAN was functioning correctly and that its measurements could be gathered for further analysis, despite of some aleas, such as internet blackout in French Guiana on the moment of the test. The redundancy of LPWAN solutions present the advantage to avoid that problem and guarantee the status availabilities of critical infrastructures during Launch base exploitation and in certain cases anticipate or avoid failures In the test case 1 it is relevant the gain from operational point of view because this item (mobile power generator) is a resource mutual mobile infrastructure used by more operators and industrial actors at the Launch base. The location and its status quo is linked to the operational planning of the launch campaigns.

4.1 Test 7 and 9 : BSE building air conditioner case study

The test case "Monitoring the health status of the air conditioner at the BSE" was designed to illustrate how connected objects of different types can help to understand the health status of an equipment or its part and make it possible to specify a diagnosis by cross-checking more data information

For this test case, the state of health of the Mollier building air conditioning system is determined by two types of measurements:

- The measurement of its electricity consumption: Installation of three amperometric clamps on each phase of the air conditioner fan power supply. These clamps, also connected to an LPWAN transmitter, are implemented in the electrical cabinet of the room.
- Assessment of air filter clogging by differential pressure measurement: Installation of a differential pressure sensor on either side of the air conditioner air filter. This sensor is itself connected to an LPWAN transmitter.

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The LPWAN networks covering the buildings where the test cases were set up were implemented using two indoor SIGFOX micro-stations and a LoraWAN gateway, also indoor, all three retransmitting the data by mobile telephone network:

- SIGFOX micro-stations were installed in the two opposite wings of the CDL3 building, to cover the BSE and Centrale Mollier buildings.
- The LoraWAN gateway was installed in the Mollier plant in order to cover specifically LoRa transmissions in this building.

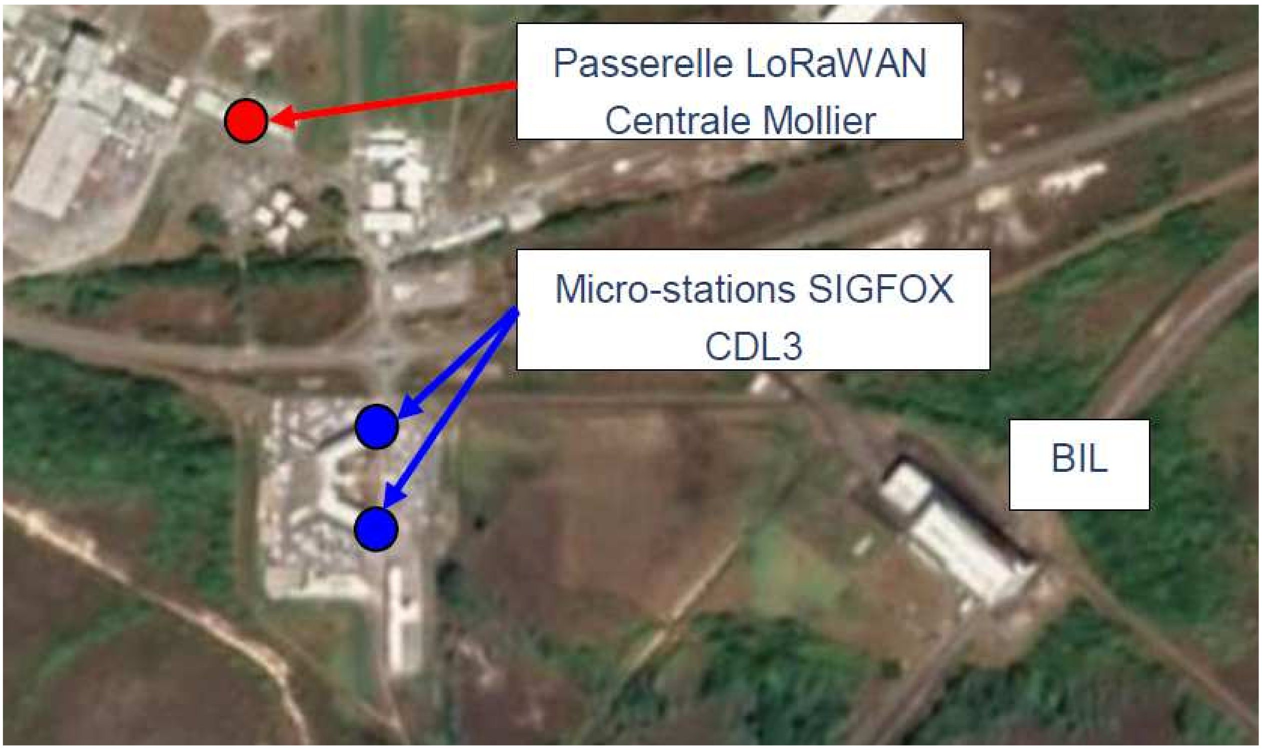

Figure 2 : Installation of micro-stations / LPWAN gateways

The fan power consumption is measured by installing an amperometric clamp on each phase of the fan power supply, in the electrical cabinet of the BSE technical room. The transducer provides an analog signal to the LPWAN transmitter which digitizes it and transmits it by radio signal to an LPWAN gateway located in the CSG outside the BSE.

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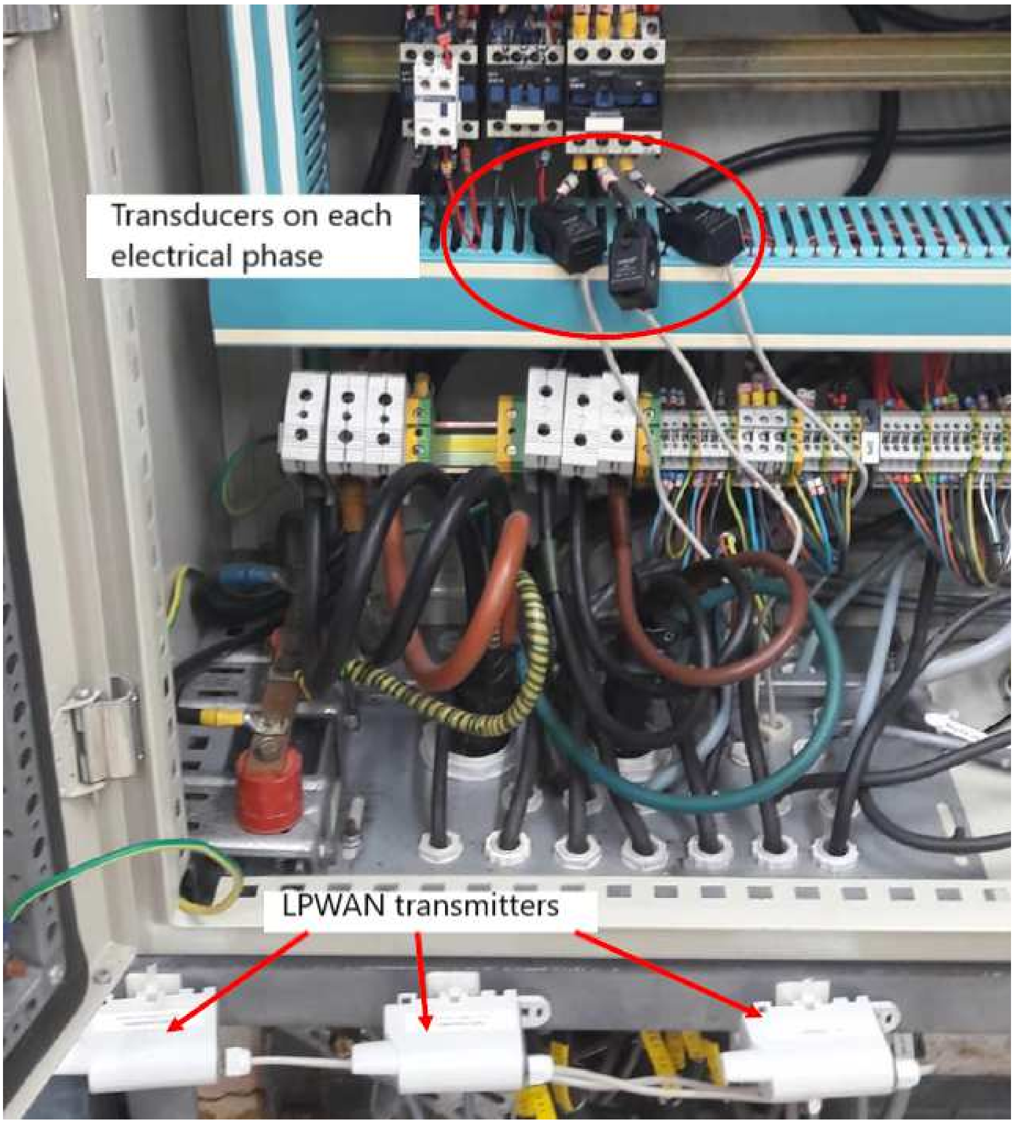

Figure 3 : BSE air conditioner power consumption measurements setup

The figure below shows the measurements of current consumed for the air conditioner at the BSE over a period of 4 months (one measurement every 6 hours).

Figure 4 : Dashboard of BSE air conditioner power consumption measurements

The current measurements show an uneven operating regime, after the 2nd month, between phase 1 (in green on the curve) and phases 2 (orange) and 3 (blue). It is appropriate here to question the event that triggered this change of regime and to carry out an inspection of the installation if necessary. It should also be noted that this change in regime may be attributable to the connected object itself (failure, interference, etc.) which should therefore be monitored.

For second test two pressure measurement nozzles currently exist upstream and downstream of the Air filter. They are used to carry out the measurement of the differential pressure by the sensor, which provides this measurement as an

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output through an electrical signal. This signal is picked up by the LPWAN Sigfox transmitter which digitizes it and transmits it by radio signal to a Sigfox gateway located in the CSG outside the Mollier building.

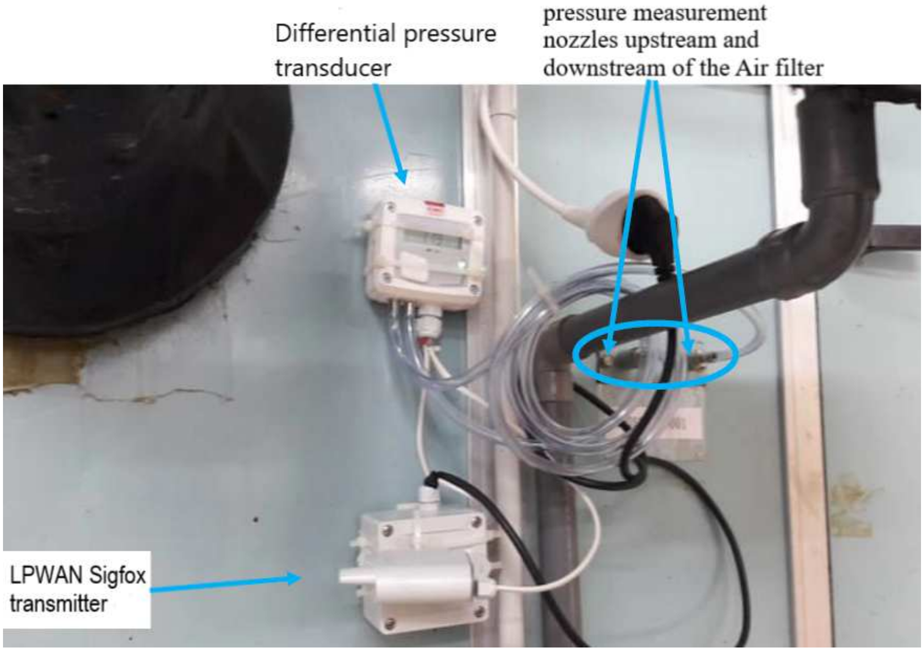

Figure 5 : BSE air conditioner differential pressure measurements setup

The figure below shows the differential pressure measurements on the air conditioner air filter at the BSE over a period of 4 months (one measurement every 6 hours).

Figure 6 : Dashboard of BSE air conditioner differential pressure measurements

Differential pressure measurements show a drift of 20 Pa (change from 115 Pa to 135 Pa) in 4 months. This indicates that:

- The clogging of the air filter is very slow (the Pa is a very small unit) but constant.
- Except for exceptional events, the replacement of the filter may wait for several years.
- The frequency of measurement could be reduced to once a day, or even less, in order to limit unnecessary transmissions.

This test case made it possible to demonstrate the relevance of the implementation of objects connected to the CSG for the purpose of conditional / predictive maintenance. LPWAN transmissions operate satisfactorily between objects placed inside the Mollier building and the SIGFOX micro-station located more than one kilometer, inside the CDL3 building.

4.2 Mollier Chilled Water plant pumps surveillance with IoT case study

Condition-based maintenance implicates characteristics measurements of the operation of equipment, mainly vibrations, but also temperature, sound level, noise, power consumption. The maintenance manager defines thresholds and the system raises alerts when the measurements exceed these thresholds. Generally, the measuring instruments transmit the values to a central system which allows remote equipment monitoring. The following test is demonstrating such capacity with IoT sensors.

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For this test the PREDIKTAS sensors are fixed by magnetization respectively on the master bearing of the motor and on the main bearing of the pump. The data transmission chain is implemented as follows:

- The sensors send the measured values in BLE (Bluetooth Low Energy) to the BLE/SIGFOX collection module.
- The collector transmits the data in SIGFOX to a SIGFOX micro-station.
- The micro-station transmits in GSM to a relay antenna.
- The relay antenna transmits the data in the CLOUD SIGFOX
- The PREDIKTAS WEB server collects the data in the CLOUD SIGFOX, processes it and arranges it in the PREDIKTAS Dashboard.
- Finally, the Maintenance Manager connects to the PREDIKTAS Dashboard and visualizes the results.

The data transmission chain of the PREDIKTAS solution for the Mollier power plant test case is presented below:

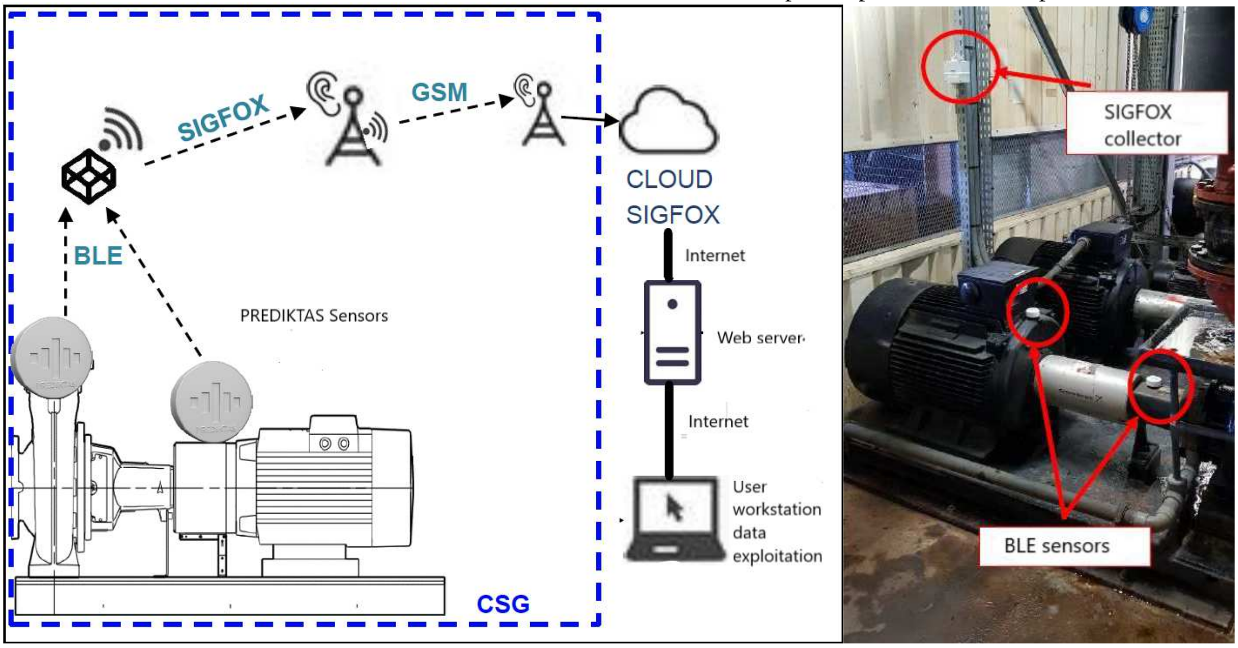

Figure 7 : Mollier Chilled Water pumps measurement test setup with PREDIKTAS sensors, BLE and SIGFOX

PREDIKTAS sensors measure several physical quantities:

- The RMS vibration along the X axis (axial direction)
- The RMS vibration along the Y axis (horizontal radial direction)
- The RMS vibration along the Z axis (vertical radial direction)
- The RMS ultrasound level
- The peak-to-peak ultrasound level
- Ambient temperature.
- Infrared temperature of the casing (IR radiation linked to the surface temperature of the casing).

Due to the operation of the Chilled Water distribution group in alternating redundancy with another group, the following curves show periods when the values displayed are significant, alternating with periods when the values correspond to measurements when the group is at rest. The alert thresholds were set in relation to the measurement values taken when the device was started. These thresholds can be modified at any time by the Maintenance Manager. For each sensor (front bearing, rear bearing), a summary table is first presented, then the time curves of the measurements of each physical quantity (see below). The colors indicated on the curves indicate the limit zones for the acceptance/normality of concerned characteristics (green, blue for normal status, yellow for limit values, red for anomalous situation).

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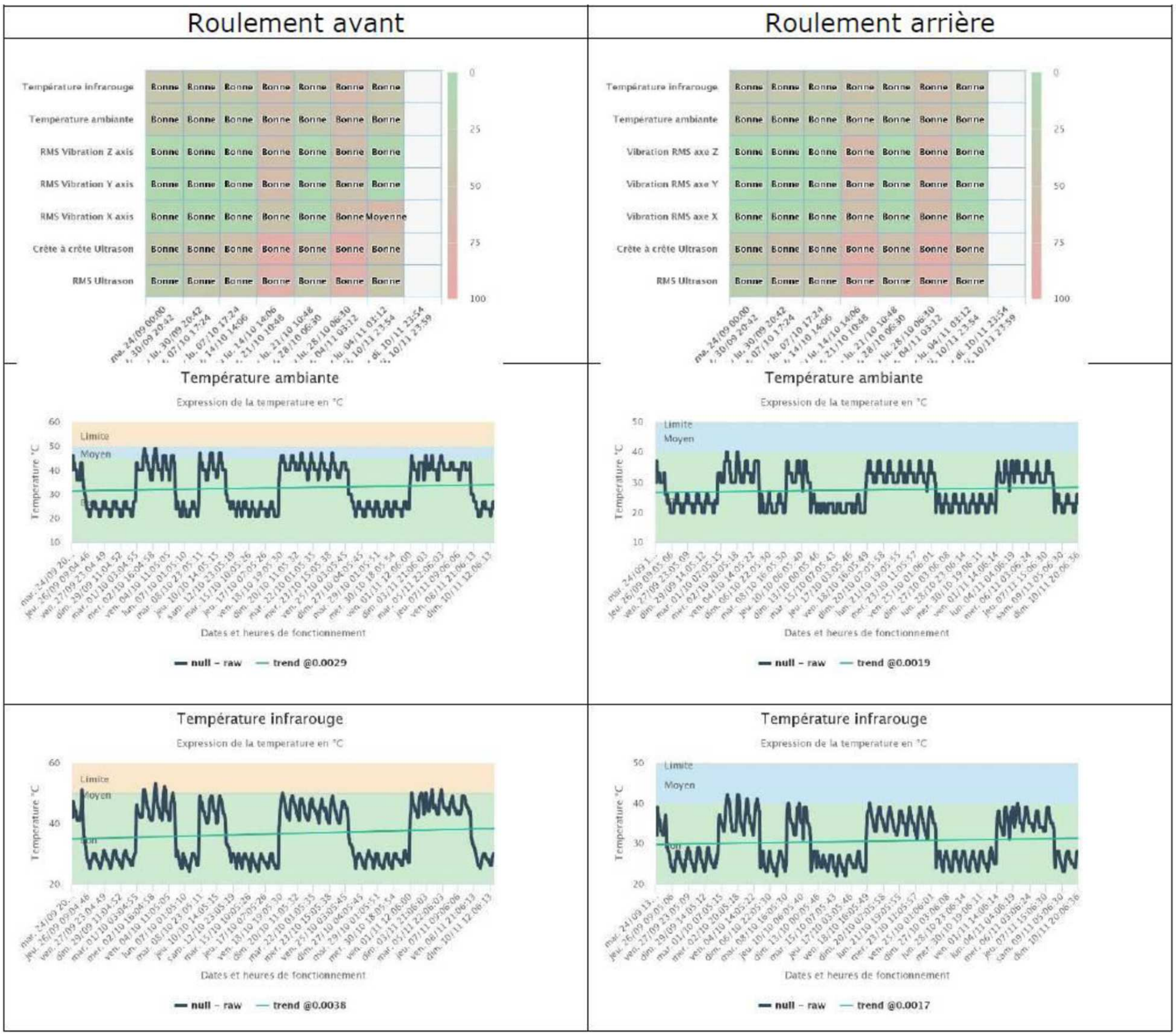
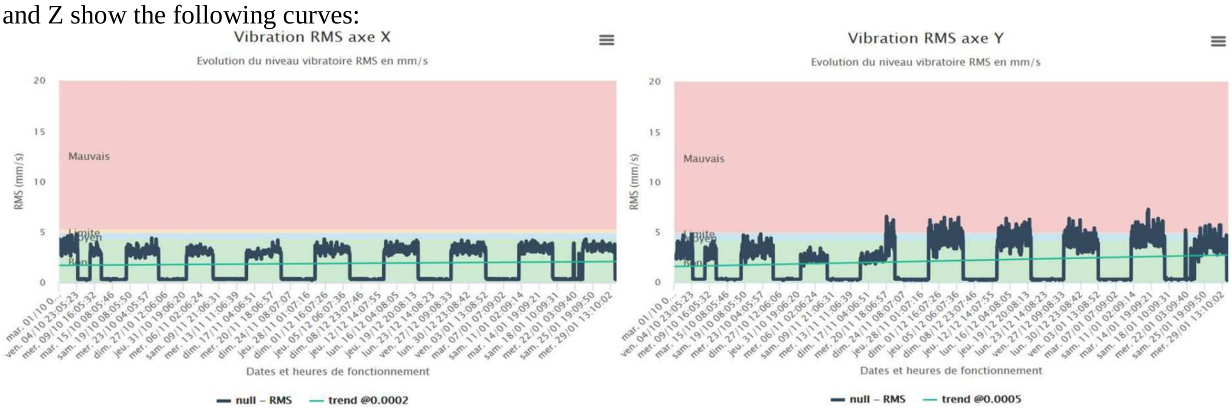


Figure 8 : Different measurements of the rear sensor, placed on the bearing on the pump side

This type of measuring device makes it possible to monitor a rotating machine with the aim of knowing and monitoring its state of health. It can also provide the Maintenance Manager with information on variations in the use of this machine. For example, we observed the following phenomenon on the measurements of the rear sensor, placed on the bearing on the pump side. Over a period of about 4 months, the RMS vibration measurements on the three axes X, Y and Z show the following curves:



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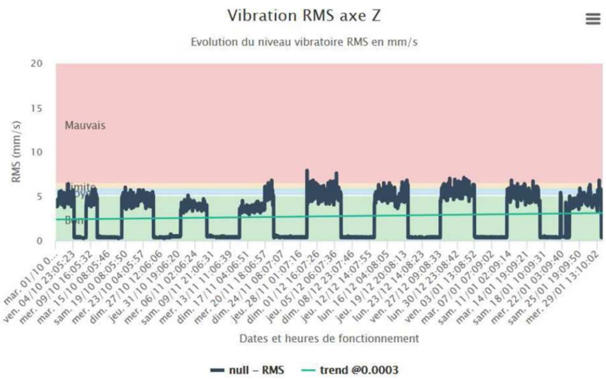

Figure 9 : Examples of vibration measurements on 3 axis of the rear sensor, placed on the bearing on the pump side

A change of regime on the date of 11/21 for the RMS vibrations on the Y and Z axes can be noted, while the X axis retains the same behavior. Otherwise, other temperature measurements and ultrasonic levels show no change.
This set of observations leads us to hypothesize that it is not a question of the beginning of degradation of the bearing on the pump side, but rather a slight but significant hydraulic instability in the Chilled Water circuit which is manifested by a change in the vibration axis of the bearing on the pump side. Given the absolute values of the measurements, varying between 3 and 7 mm/s, which are significant of a healthy system, the thresholds of the Y and Z axes can be increased in order to return to green indicators for these two axes.

The results obtained by this solution according to this approach are very positive:

- Simultaneous measurements of several physical quantities (temperatures, vibrations, ultrasonic levels) allow the Maintenance Manager to have significantly increased knowledge of the state of health of the rotating machine.
- Installing the solution on the rotating machine is extremely simple and quick: 15 minutes in all to place the magnetic sensors on the machine and fix the BLE/SIGFOX collector to the wall.
- This solution is relatively inexpensive (less than 1000 euro installation per machine)
- The interpretation of the results is intuitive and does not require any particular training.
- The implementation of LPWAN transmissions using an indoor GSM gateway is very relevant because it offers flexibility, efficiency and ease of implementation.

5. Coupling IoT with NLP and Machine Learning for GSC

The sensors study in Mollier HVAC facility has shown that heterogeneous data type and quantity can be gathered with relatively simple means. In literature (for example [4], [5]) we find a lot of examples of well implemented predictive maintenance using machine learning on the data in industrial application cases similar to those that can be found in GSC. The associated methodologies are increasing their maturity as a system and for each individual part of the process.

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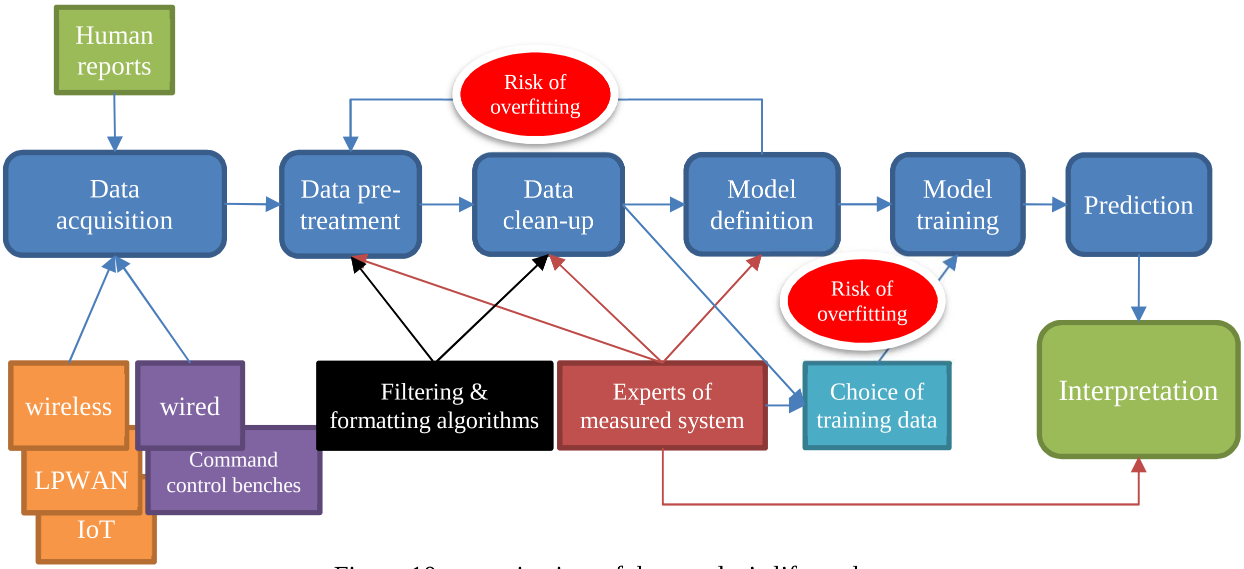

Figure 10 : generic view of data analysis life cycle

The follow up us of GSC gathered data would be a generation of wear models for specific failure modes. However it will require additional and careful pre-treatment of the measurement data to clean them up both for training data set and for data sets to be analyzed by the algorithms. The experts of measured systems should be implicated and in the center of the process.

Such kind of case study has been performed on the chill down of Ariane 5 ground segment LH2 cryogenic lines, where the measurements results were submitted to the supervised machine learning model (neural networks) in aim to create the model calculating the temperature and pressure of propellant by the function of mass flow acquired by the sensors on a small part of fluid circuit. While the first results were not encouraging (important standard deviation from real data), they have reminded the importance of mastering the technical context in the metadata associated with data set (typically the sampling rate of data, their compatibility in terms of time stamp, the data resolution compatible with dynamics of analyzed phenomena, etc.). In that activity executed mainly by the data scientists the technical experts were not implicated sufficiently in the process leading to the incorrect use of the input data.

However the previous CNES works via study [2] and [3] demonstrated good performance of Natural Language Processing coupled with different machine learning algorithms (both supervised and non-supervised) in detection of critical anomalies impacting launch vehicle exploitation and development in the texts describing the issues and technical facts that appeared during launch campaigns and in the development phase. The success was linked mainly with stringent control over input data: their correct clean-up from anomalous elements (for example non-significant texts, empty entries, entries in foreign languages, etc.) and customized pre-treatment, taking into account the context of data, such occurrence place, specificity of product life cycle, simplification of physical values contained in the treated text). The training data needed to be correctly labelled with coherent criterions and thus for supervised approach they needed to be carefully reviewed by the technical expert.

The similar methods can be used with data obtained from IoT exploitation taking into account the lessons learned mentioned before. The GSC installations use the quality process that is similar to the one applied on the launcher itself by treating the anomalies of "ground systems" in a similar manner: the full text reports are established describing the context of each anomaly by the technical responsible, who has detected such anomaly. They are associated with numerous metadata describing the context, such as operation type, the concerned team technical background (electrical, pyrotechnic, fluid, etc.). In addition the measurements are available for the most critical facilities (by wired connections) and they can be correlated with anomaly reports. In [2] the "ground segment" anomalies have been analyzed in the data base of 42k cases. Out of those there are roughly 1000 anomalies concerning different events linked to HVAC, thus linked to the installations similar to Mollier plant. Both measurements, that can be done by IoT and textual anomalies are dated and have defined place of appearance. Then both elements can be combined under time and place criterion to associate the anomalies described by text to the concurrent measurements in a goal to elaborate the potential criticity or predict the feared event on the basis of labelled lessons learned and their context:

$$\sum_k^1 T_n \ \& \ \sum_l^1 M_n \ \& \ \sum_m^1 D_n \xrightarrow{modelisation} C_n \qquad (1)$$

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The criticity “C” can be modelled by the global matrix concatenating “k” different columns containing full text T, “l” columns of metadata “M” and “m” columns of continuous or discrete quantitative data “D” (dates, measurements, etc.). Initial tests done with collection of texts and metadata had shown a promising results on the database used for [2], when the concerned data were correlated.

6. Machine learning for enhancing the operational performances of the Launch Base during the exploitation

Guiana Space Center is a launch base that is evolving towards a high rate launch manifest taking into account Ariane 6, Vega C as well as the future European Space launchers coming from the New Space. These new Launch Operators are preparing together with CNES the implementation of their Launch System in the new launch complex ELM (Ensemble de Lancement Multilanceurs). Moreover, it is foreseen to perform the demonstration test campaigns of Callisto and Themis on ELM, as referred in [6]. The resulting high launch rate per year puts in evidence the necessity of anticipating the dynamic management of yearly launch manifest well beyond current situation. For that new technologies and operational improvement methods are applied in order to maintain the high performance requested.
Among different solutions used to achieve this goal, the Machine Learning methods could provide the capacity to assure and maintain more launch campaigns in parallel and satisfy the time to market of the launch costumers and their planning.

In this context, CNES with other partners (in particular Ariane Group, Telespazio, CRAT and Capgemini) have developed an independent and secure platform “SecNumCloud”, where AI with specific algorithms can optimize the management of a maximum of assets in a secure environment in order to improve the logistic chain and the ground operational launch campaign. It strives to reduce the launch cost in the competitive landscape generated by the New Space, while dealing with several inevitable constraints such as respect of ground and flight safety requirements driven by compliance with French Space Operations Law (FSOA). This project named SESAME (Smart European Space Access through Modern Exploitation of data science) has been founded by European Commission in the program H2020 and will be officially finished at the end of September 2022 [7].

In this frame the partners CRAT and Telespazio have developed a first algorithm demonstrator applied to Vega launch campaign [8]. The proposed algorithm has been developed to aid spaceports operators during the launch campaign phase, but it can be extended to cover other operational phases which we can find in the spaceport operational life. The algorithm is implemented in a software module, referred to as Adaptive Operations Module (AOM), in charge of monitoring and controlling the state of the integration activities. The AOM receives in input both static data (e.g., planned scheduled, operational procedures and constraints, historical data) and dynamic data (i.e., real-time data from the field), and suggests in real-time an updated and optimized campaign planning to spaceport’s operators. The variables considered in the optimization process by the AOM are tasks, workstations and resources.

At first a Model Predictive Control (MPC) has been developed for the execution control in the launcher assembly phase. The first trial was concentrated on normal operations according to foreseen scheduling and then it was submitted to automated re-planning after an adverse event. The algorithm schedules the tasks in respect of the constraints on the working hours. Also, the algorithm handles the predefined tasks precedence constraints. The updated operational planning is reported and the algorithm successfully integrates the new tasks into the overall operational planning. The output of the algorithm also includes the schedule with the allocation of the resources to the tasks at any given time, compatible with the resource constraints. The problem to be solved by algorithm has about 1.5 million variables in the first iteration. The MPC framework integrate the information on past events, gathered via feedback from sensors or personnel, such as the event of a fault of a workstation (in assembly hall of the mobile gantry , for example) or a delay on a task. In semi-supervised learning approach it includes the forecasted data of events that are expected to happen in the future. The MPC can integrate, for example, the information acquired from predictive maintenance/predictive quality algorithms, about future events, like the maintenance interventions required in future, reworking of some tasks after checks, etc., which can then be introduced in the planning as additional tasks to be scheduled by the algorithm. Currently the demonstrator project is still ongoing with more complex trials with additional launch operations plannings. The objective is to extend these results and capabilities to a qualified version in order to support the operational decision makers in a future more dense operational management of the launch campaigns. In perspective such algorithm is expected to respond to the complex co-activity environment expected in the ELM exploitation.

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7. Conclusions

The examples and tests cases described in the article demonstrate the interesting possibilities to use the wireless measurements locally on different isolated sites or even mobile ones as a complement to the wired measurements already deployed on the most critical sites. These solutions can use a relatively simple architecture with the state of art telecommunication connections. The obtained measurements will allow to optimize the recurrent cost of the launch base as the personnel will be less obliged to verify the equipment by inspections and tests and it will be rather the measurement analysis and prediction that will give the indications for starting the maintenance actions. The gain in operations time duration is expected. In the same manner the availability of instrumented technical means could be increased as the information about their status will be easily available.

All these static data and dynamic data could be used in a more complex AI machine learning platform, as explained in the previous chapter. They will participate to enrich the algorithm of the Adaptive Operations Module (AOM), in charge of monitoring and controlling the operations and means of the system where it will be applied. AOM will also predict and suggest to operational decision makers the right decisions to manage and maintain the high level of reliability and guarantee the efficient operational work flow even in a future with high launch rate at Guiana Space Center.

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