

MONITORING AVALANCHE ACTIVITIES INSIDE AN AVALANCHE PATH FOR RACS OPERATORS

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ABSTRACT: This fully automatized versatile system aims to provide RACS (Remote Avalanche Control Systems) safety operators accurate information of the situation inside the avalanche path, daily, on specific demand, or during critical phases of risk mitigation.

It helps decision-makers to anticipate and enhance their perception of avalanche dangers and finally know if they have to use - or not - the preventive triggering systems.

Installed directly inside the avalanche path downstream of a RACS, it is equipped with some weather sensors, including a snow height sensor and a seismic vibrations acquisition system (similar to MND's AvaWatch™ existing system) intended to be working fully automatically during the triggering phase.

After the shot, the system analyzes the operation thanks to the seismic sensor data and to the snow height evaluation, estimates the importance of the event, and is finally able to confirm the release of an avalanche.

With this equipment, the operator can then benefit in real time from an analysis of the results, which can be displayed by an extremely simplified and effective manner or even more detailed by offering a frequency analysis of the recorded data.

Thanks to these 3 phases monitoring "before-during-after", the operator always has a clear view of the evolution of the snowpack inside the avalanche path.

KEYWORDS: mast, snow, height, seismic, vibrations, automatic, monitoring.

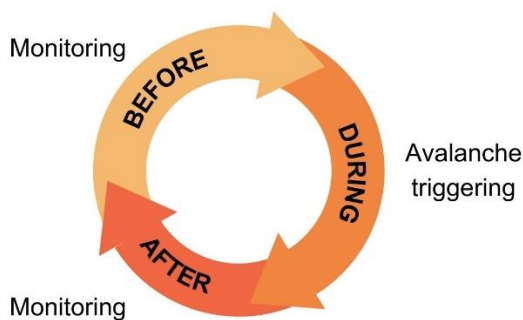
1. INTRODUCTION

As part of avalanche risk management, the PIDA ("French Avalanche Triggering Intervention Plan") is a document governed by a very precise procedure in France, which has been able to incorporate technological developments over time.

Indeed, the decisions makers about avalanches triggering on roads or ski resorts increasingly need to know better the conditions of the area where the risk is located. To be able to treat them preventively, they use remote-controlled automatic equipment (e.g., GAS or Explosive triggering technology).

To achieve this, those responsible for safety and avalanche risk mitigation use monitoring techniques. These monitoring techniques can provide precious information on the 3 steps - "BEFORE, DURING and AFTER" - that make up the treatment of an avalanche path.

2. MONITORING STEPS



BEFORE: Those responsible for risk reduction using RACS (Remote Avalanche Control System) devices and a PIDA need to know the situation. Therefore, they need general meteorological data (temperature, wind, solar radiation) that can be collected using standalone weather stations or remote avalanche control system device on site (GAZEX™ shelter or O'BELLX™ equipment).

One of the most important pieces of data is the current snow height in the avalanche path.

NivWatch™, the measuring mast presented here, automatically and regularly monitors the snow height accumulated at the precise location to be treated. Thanks to automated measurements or readings taken on specific request, and centralization in an international database via the cellular network, the decision makers can access easily in real time to the latest risk information on the avalanche zone, via an internet website or mobile application.



Figure 1: The NivWatch™ located in the avalanche path

DURING: The main objective of the safety operator is to apply the rules given by his PIDA and proceed when necessary. Nevertheless, most of the time, these rules are applied with relative emergency, and the operator's full attention is required for the triggering actions.

This is why the NivWatch™ measuring mast is fully and automatically synchronized with the operator's actions, without requiring any particular action on his part, allowing him to stay focused on more pragmatic and professional risk management.

This is how the NivWatch™ equipment, synchronized with the triggering actions, will be able to demonstrate its ability to inform the operator of the result obtained. Moreover, all this information is in real time and whatever the weather conditions.

Thanks to a highly accurate signal acquisition system, the NivWatch™ will record the seismic data corresponding to the actual start of a triggered avalanche.

This data is analyzed without any delay, and the effective result of the preventive fire action is directly indicated to the operator in a very simple way.

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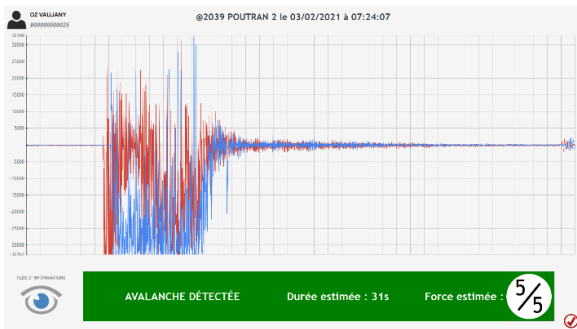


Figure 2: The simplified result report obtained in real time in SAFETY-cs (Green color = the result is positive)

To benefit from these features, it is necessary to use the SAFETY-cs software control system, which is an innovative web-based for data management of the triggering solution, firstly dedicated to MND gas equipment (GAZEX™ and O'BELLX™).

This control method also allows the operator to choose the level of complexity of the automatic real-time analysis. This can range from the simple GO-NOGO expression of the actual result, or else, allow a more in-depth representation resulting from the frequency processing of the signals recorded (real time analysis of the frequencies generated by the avalanche). The solution can also provide a representation of the magnitude as well as the actual duration of the avalanche.

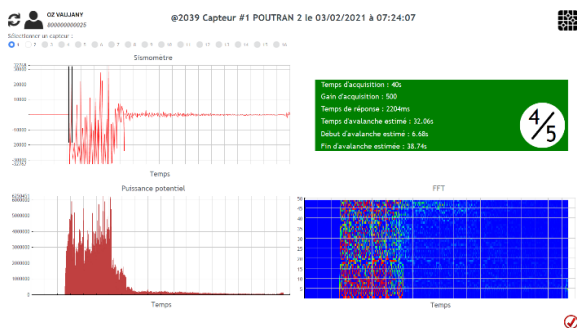


Figure 3: Frequency and immediate analysis of results

AFTER: Roads Safety Managers in charge of avalanche risk management need reliable information on the results of their preventive shooting. They need to be sure that the overhanging areas treated are safe and can be used without risk.

The NivWatch™ equipment presented here combined with the Safety-cs software offer several advantages for this phase:

- it allows the operator to obtain the residual quantity of snow in the path close to the mast without any manual action, thanks to a new automatic measurement of the snow height.

- it also allows the operator to consult the seismic analysis of his shot, which is permanently available in his database along-side the other archived preventive shots parameters.

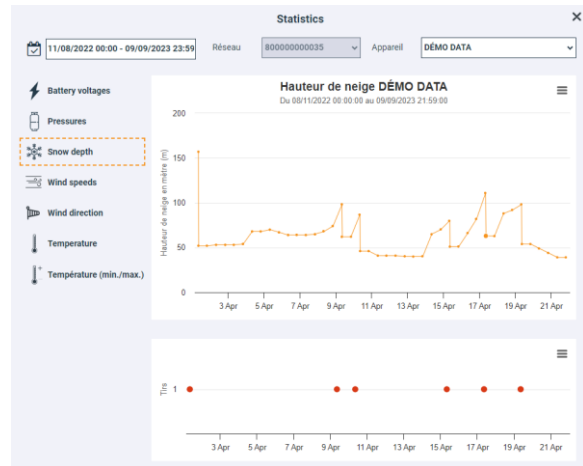


Figure 4: Shot synchronization

Shots

Current number of shots: 105

Network: 80000000035 MND SAFETY

Datation	System	Shot	before	Measurements	after
02/25/2025 07:59:59	GAZEX SHELTER - High	EXP1: 4 Duration: 6 Status: FAIT	Received a SHOT REPORT	171	OXYGEN (B)
04/23/2023 08:36:02	GAZEX SHELTER - High	EXP2: 0 Duration: 0 Mode: NORMAL	Received a SHOT REPORT	0	PROPANE
04/23/2023 08:36:02	GAZEX SHELTER - High	EXP1: 1 Duration: 11 Status: Done	Received a SHOT REPORT	0	OXYGEN (B)
04/23/2023 08:36:02	GAZEX SHELTER - High	EXP2: 0 Duration: 0 Mode: NORMAL (TAMS/SM)	Received a SHOT REPORT	0	HYDROGEN (B)
04/23/2023 08:36:02	GAZEX SHELTER - High	EXP1: 1 Duration: 11 Status: Fait	Un report de TIR a été reçu	0	OXYGEN (B)
04/23/2023 08:36:02	GAZEX SHELTER - High	EXP2: 0 Duration: 0 Mode: NORMAL (TAMS/SM)	Un report de TIR a été reçu	0	PROPANE
04/22/2023 14:22:24	GAZEX SHELTER - High	EXP1: 1 Duration: 3 Status: Fait	Un report de TIR a été reçu	125	OXYGEN (B)
04/22/2023 14:22:24	GAZEX SHELTER - High	EXP2: 0 Duration: 0 Mode: NORMAL (TAMS/SM)	Un report de TIR a été reçu	0	HYDROGEN (B)
04/22/2023 14:10:59	TEST BE KMK	EXP1: 1 Duration: 11 Status: Fait	Un report de TIR a été reçu	0	OXYGEN (B)
04/22/2023 14:10:59	TEST BE KMK	EXP2: 0 Duration: 0 Mode: NORMAL (TAMS/SM)	Un report de TIR a été reçu	0	PROPANE
04/22/2023 14:10:59	TEST BE KMK	EXP1: 1 Duration: 11 Status: Done	Received a SHOT REPORT	0	OXYGEN (B)
04/22/2023 14:10:59	TEST BE KMK	EXP2: 0 Duration: 0 Mode: NORMAL (TAMS/SM)	Received a SHOT REPORT	0	HYDROGEN (B)
04/20/2023 12:35:07	GAZEX SHELTER - High	EXP1: 1 Duration: 3 Status: Not verified	Cancelled	125	OXYGEN (B)
04/20/2023 12:35:07	GAZEX SHELTER - High	EXP2: 0 Duration: 0 Mode: NORMAL (TAMS/SM)	Cancelled	0	PROPANE

Figure 5: A centralized database with permanent access

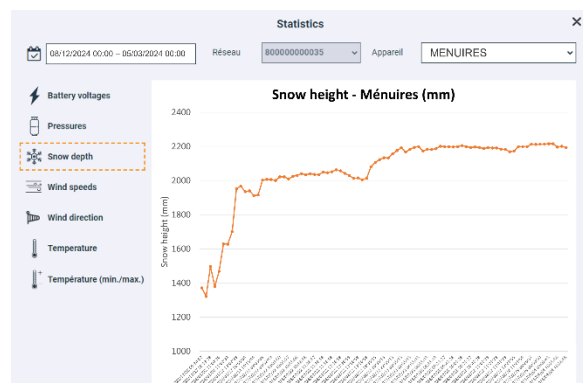


Figure 6: Seasonal Snow height variations monitored with the NivWatch™

3. A SCALABLE PRODUCT

The objective is to adapt the NivWatch™ solution to the needs of the safety operator: If the mast is equipped with the automatic image-taking option, a photo showing the real conditions of the avalanche path can also be available and displayed on Safety-cs, allowing the operators to take the right decisions and to better manage the situation (according to the real and actual snow conditions in the avalanche path to be treated).

On top of the automatic visual observation option, snow height and temperature sensors, human presence sensors and meteorological sensors are developed in order to meet the safety operator's needs expressed within the 3 steps decision-making process steps - "BEFORE, DURING and AFTER" - of the treatment of the avalanche path.

4. CONCLUSION

NivWatch™ is a fully automatic equipment which, thanks to the accessibility and clarity of its conclusions, points the way in a new direction for the monitoring of preventive avalanche triggering.

It must be used in conjunction with the SAFETY-cs (MND) website or application to have a perfect monitoring of snow accumulation and measure in real time the effects of avalanches triggered in a path.

It can also be used to evaluate the level of the residual risk after a preventive triggering. NivWatch™ is composed of a robust measuring mast equipment directly located in the avalanche path and its total autonomy (thanks to its solar panels) is a huge ally for the decision makers. Thus, this innovative solution is dedicated to equipping remote and not accessible sites which must be treated, in ski resorts, over transport infrastructures, and industrial production site such as mines or hydropower sites.

All these features combine effective analysis, accessible expression of results in real time and centralized data. Then, NivWatch™ provides operators the accurate traceability and rigorous monitoring of all the actions throughout the winter season.

5. ACKNOWLEDGMENT

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