# O'BELLX 1.8: A MODULAR AND REMOVABLE GAS SYSTEM FOR AVALANCHE PREVENTIVE RELEASE

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ABSTRACT: The O'BellX range introduces a modular, helicopter-portable gas system for avalanche preventive release, designed for remote or environmentally sensitive areas. This system uses removable, compact gas module that can be deployed, retrieved, and maintained via helicopter without ground personnel. Key features include a patented automatic hook for single-rotation installation/removal, synchronized triggering ("Multisynch") for coordinated explosions across 2–10 systems, and an eco-friendly design with zero chemical residues and minimal visual impact. Technical specifications highlight 55–65 m effective range (25 mbar isobar at ground level) and 40–60 shots autonomy. The system's modularity, mobility, and synchronization make it ideal for isolated paths or protected natural areas, ensuring both safety and environmental compliance.

KEYWORDS: Avalanche prevention, modular gas system, helicopter-portable, synchronized triggering, eco-friendly, removable infrastructure.

## 1. INTRODUCTION

Gas-based avalanche release systems have been used operationally for nearly four decades and are now widely deployed in avalanche-prone mountain environments. Over this period, the technology has progressively evolved from fixed installations, such as GAZEX systems introduced in the late 1980s, to helicopter-borne mobile systems such as DaisyBell in the 2000s, and later to removable fixed-position systems such as O'BellX in the 2010s.

This evolution reflects a broader effort to improve the operational flexibility of remote avalanche control systems while reducing the need for personnel to access exposed release areas. Removable systems in particular were developed to address several operational constraints. Installation, retrieval, and much of the maintenance can be conducted without requiring personnel to work directly in the release zone. Seasonal removal of the active unit can also reduce the amount of permanent infrastructure remaining on the mountain, including visible equipment, pipelines, and remote gas-storage installations. In addition, removing the active module during the summer helps protect the most sensitive components from rockfall, storms, and other forms of seasonal degradation.

Different gas-based architectures involve different operational trade-offs. Fixed GAZEX systems can provide very high shot autonomy and high pressure-wave output, whereas removable O'BellX systems place greater emphasis on ease of maintenance, seasonal retrieval, and the possibility of synchronized multi-unit firing to coordinate the pressure-wave effect on the snowpack.

These operational advantages, however, introduce additional engineering constraints. A removable system must combine sufficient gas storage, pressure-wave performance, energy autonomy, structural resistance, and communication capability within a compact unit that remains compatible with helicopter transport.

Against this background, the O'BellX 1.8 was developed to investigate whether the autonomy and pressure-wave performance of a removable gas-based system could be increased while preserving the principles of seasonal removal, helicopter deployment, and remote operation. This paper describes the main engineering choices associated with this development, including the change in gas mixture, the redesign of the combustion chamber, numerical pressure-wave analysis, structural assessment, and preliminary performance measurements.

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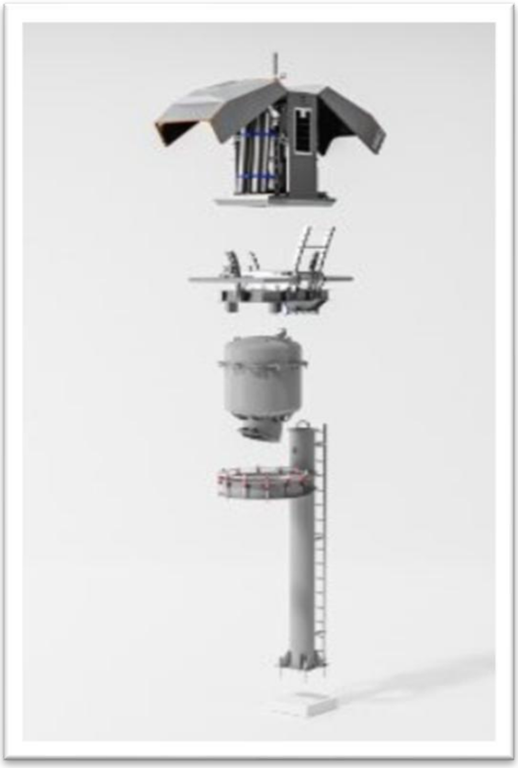

Figure 1: Exploded view of the O'BellX 1.8 modular system and mast assembly.

## 2. DESIGN REQUIREMENTS AND CONSTRAINTS

The development objective was to preserve the removable architecture of the existing O'BellX concept while increasing available shot autonomy, ease of maintenance, pressure-wave performance, and low environmental impact. The resulting design had to balance energetic performance with helicopter transport constraints, compact gas storage, structural resistance, remote operation, and seasonal removability.

The specific patented automatic hook, common to the entire OB range, has been incorporated into the OB 1.8 module to enable direct retrieval by helicopter, without requiring human presence on the ground.

| ***DESIGN REQUIREMENTS*** | ***ENGINEERING IMPLICATION*** |
|---|---|
| Removable architecture | The complete operating module must remain compatible with helicopter installation and retrieval. |
| Increased autonomy | Gas storage must be integrated in the removable unit without a remote cylinder shelter or permanent pipeline network. |
| Pressure-wave performance | Combustion-chamber geometry must generate a useful pressure footprint while remaining compact. |
| Structural integrity | Internal pressure loads must remain compatible with material strength and defined safety margins. |
| Remote operation | Energy supply and communications must support unattended operation from the valley. |
| Minimize site interaction | The integrated and removable architecture reduces the need for permanent infrastructure and on-site intervention, simplifying installation, maintenance, and seasonal removal. |

## 3. GAZ-MIXTURE SELECTION AND COMBUSTION CHAMBER REDESIGN

### 3.1 Transition from $H_2$–$O_2$ to $C_3H_8$–$O_2$

The previous O'BellX architecture utilized a hydrogen ($H_2$) and oxygen ($O_2$) mixture. In contrast, the O'BellX 1.8 employs propane ($C_3H_8$) and oxygen ($O_2$). This transition was made to enhance shot autonomy within an integrated, removable unit.

Propane enables more compact storage compared to hydrogen. However, as propane is denser than air, the combustion chamber design must be fundamentally different from that used for a hydrogen/oxygen mixture. Additionally, propane exhibits distinct combustion characteristics compared to hydrogen.

The chamber architecture was therefore redesigned from the earlier bell-shaped arrangement to a more enclosed geometry in which the outlet remains oriented toward the snowpack. The design intent was to promote rapid pressure-wave development within a limited volume while maintaining compactness and structural resistance.

This choice has enabled increased autonomy, achieving 40 shots at maximum power and up to 60 shots at standard power.

### *3.2 Presure-wave development*

This change in gas has led to substantial modifications to the entire system, particularly the explosion chamber.

Since propane is heavier than air, the entire system had to be rethought, especially the shape of the explosion chamber, which had to be redesigned from a bell shape to a container, while ensuring the outlet always points toward the snowpack.

The explosion of a propane-oxygen mixture in open air is relatively slow. However, confinement of this explosion makes it possible to achieve Chapman-Jouguet conditions, accelerating the explosion and enabling a transition from a deflagration regime to a detonation regime.

In a tube filled with explosive gas:

A spark triggers a deflagration.

The flame accelerates due to shock waves reflecting off the walls.

When its velocity reaches the Chapman-Jouguet (CJ) velocity, detonation initiates.

In a confined environment, the pressure generated by a CJ detonation is much higher than in free space, because:

Reflected shock waves combine.

Confinement prevents gas expansion, increasing pressure.

Whereas the length of a GAZEX tube enables this acceleration, it was necessary to find other solutions to accelerate the explosion while maintaining the system's compactness, without exceeding the structural strength limits of the materials, and meeting the weight constraints associated with high-altitude helicopter transport using a standard helicopter.

The positioning of the spark plugs within the explosion chamber is a key element for generating a self-constrained explosion and thus achieving maximum chamber output power.

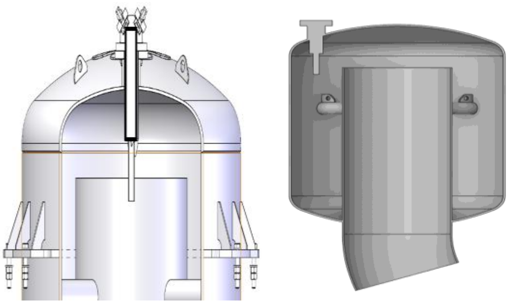

Figure 2: Combustion chamber cross-section design and spark plug configuration for self-constrained detonation.

## 4. NUMERICAL AND STRUCTURAL DESIGN METHOD

### *4.1 CFD pressure-wave analysis*

Computational Fluid Dynamics (CFD) was used to examine the evolution of pressure within the chamber and the propagation of the pressure-wave. Figure 3 shows time-resolved static-pressure fields and describes the wave front propagating from the inition region, separation near the cylinder inlet, and subsequently forming a more uniform front.

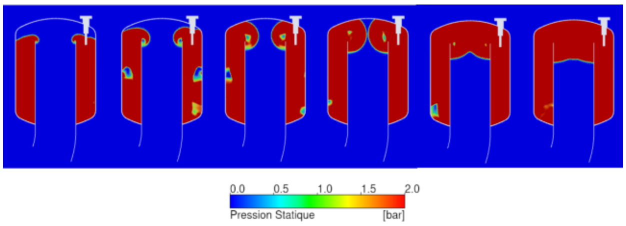


Figure 3: CFD simulation of static pressure wave propagation (0 to 2 bar) at the cylinder inlet over time.

### *4.2 Structural assessment*

Structural assessment was performed in conjunction with pressure measurements to evaluate the stresses acting on the explosion chamber, which is manufactured from 4 mm thick high-strength steel.

The pressure loads were then extracted from the CFD simulations, tabulated, and used to calculate the mechanical stresses exerted on the system.

The calculated stresses show that the pressure loads inside the chamber generate stress waves in the material. For the postulated maximum detonation scenario, the calculated maximum stresses never exceed the steel yield limit, and the safety factor is at least 2.

### *4.3 Pressure Wave Evolution at the Cylinder Inlet*

Starting from the spark, the pressure wave front travels up the chamber walls until it reaches the cylinder inlet.

A separation of this pressure wave is observed at the cylinder inlet.

The wave then propagates within the cylinder and forms a nearly uniform front.

## 5. FIELD TESTING AND PERFORMANCE

## CHARACTERIZATION

### 5.1 Pressure-footprint metric

Field measurements seem to confirm the simulations. The reference was a 25-mbar overpressure on the snowpack, equivalent to that produced by a skier passing by. The area subjected to a 25-mbar pressure extends to 65 meters.

It should not be interpreted as a direct measure of avalanche release effectiveness, which also depends on snowpack conditions, slope characteristics, and triggering location.

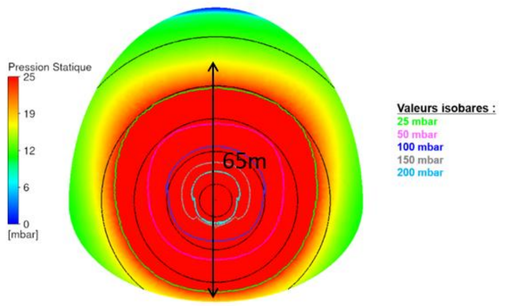


Figure 4: Ground-level static pressure isobar footprint showing the 25-mbar threshold extending to 65 m.

### 5.2 Preliminary field measurements

An O'BellX 1.8 was deployed under field conditions to assess its performance.

These measurements are consistent with the numerical simulations, but it does not describe the experimental configuration or provide a quantitative simulation-to-measurement comparison.

The height of the explosion optimizes its impact on the snowpack. To achieve this, a mast—allowing the addition of elements for heavily snow-covered areas—has been developed.

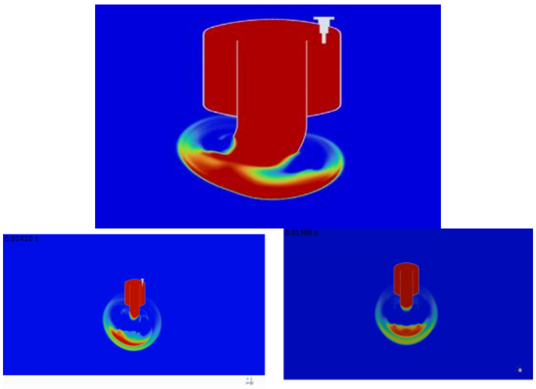

Figure 4: CFD simulation of blast wave dynamics and expansion from the exit nozzle during detonation.

## 6. OPERATIONAL ARCHITECTURE

### 6.1 Deployment, retrieval and maintenance

The O'BellX 1.8 is designed for seasonal installation and retrieval by helicopter using the patented automatic hook common to the O'BellX range. The system can therefore be installed or removed without requiring personnel to be present on the ground at the release point.

This architecture also allows the active module to be removed outside the operating season, protecting sensitive components from rockfall, storms, and other forms of summer degradation. Maintenance operations can consequently be performed mainly in the valley under controlled conditions before the unit is redeployed.

The modular design also allows the complete operating unit to be removed and, if required, reinstalled at another location. This provides additional flexibility when operational requirements or snow-avalanche patterns evolve over time.

### 6.2 Remote and synchronized operation

The O'BellX 1.8 combines a large integrated gas capacity with the pressure-wave characteristics generated by its redesigned combustion chamber. In addition to individual firing, the system supports synchronized operation of multiple units through the **Multisynch** function.

Between two and ten systems can be triggered in a coordinated sequence. This capability is compatible across the MND SAFETY range and is intended to provide operators with greater flexibility when managing several release points within the same avalanche path or sector.

The O'BellX 1.8 can be operated through the Safety-CS or GME control environment alongside other remote avalanche control systems. The control architecture enables individual shots, predefined firing sequences, and synchronized multi-unit firing. A firing command can be executed in less than 40 seconds under the defined operating configuration.

### 6.3 Energy supply and communication

The system is designed for autonomous operation in remote mountain environments. Four photovoltaic panels, distributed around the unit, provide additional energy to the onboard battery system. Battery capacity can be increased for installations exposed to particularly demanding conditions, including high-latitude environments with reduced solar availability (e.g., the Far North).

Communication is designed with a redundant radio + cellular system, enabling connection to the base or to other MND RACS systems, which can relay to the base.

This redundancy is intended to maintain communication capability across sites where terrain, distance, or network coverage may limit the reliability of a single communication channel.

### 6.4 *Regulation and environmental compliance*

The removable architecture was also developed to limit permanent interaction with the release site. Unlike configurations requiring remote gas-storage shelters and pipeline networks, the O'BellX 1.8 integrates its operating components within the removable module.

This approach reduces the amount of permanent infrastructure installed on the mountain, particularly gas pipelines and associated compressed-gas installations. Seasonal removal also limits the visual presence of the active equipment outside the avalanche-control period.

As a gas-based avalanche control system, the O'BellX 1.8 does not rely on solid explosive charges for each firing. The firing process therefore avoids residues associated with the use of conventional explosive charges at the release point.

The combination of removability and modularity enables the complete removal and reinstallation of the device at another site at a lower cost, providing flexibility over time to adapt to snowpack changes linked to climate change.

## 7. CONCLUSION

Building on the operational experience gained from previous gas-based avalanche control systems, including DaisyBell and the standard O'BellX architecture, the O'BellX 1.8 was developed to increase autonomy and pressure-wave performance while preserving the main advantages of a removable system: helicopter deployment, seasonal retrieval, integrated gas storage, and valley-based maintenance.

The transition from an $H_2$–$O_2$ mixture to a $C_3H_8$–$O_2$ mixture required a substantial redesign of the combustion chamber and a combined numerical and mechanical assessment of pressure-wave propagation and structural loading. The resulting design uses a 4 mm high-strength steel chamber, with calculated stresses remaining below the material yield limit and a minimum safety factor of 2. Numerical simulations indicate that the 25 mbar ground-level isobar extends to approximately 65 m along the reference axis, and preliminary field measurements have shown behavior consistent with these simulations.

Beyond pressure-wave performance, the removable architecture reduces the need for permanent infrastructure at the release point and allows sensitive components to be maintained in the valley and removed outside the operating season. This makes the O'BellX 1.8 a complementary solution within the broader range of remote avalanche control systems available for different mountain environments and operational constraints.

The diversity of avalanche paths, snowpack conditions, accessibility constraints, and operational requirements means that no single avalanche control technology can address all configurations. The O'BellX 1.8 therefore extends the range of available engineering options by combining autonomy, removability, remote operation, and pressure-wave performance within a compact gas-based syst

| ***Criteria*** | | ***GAZEX*** | | | ***O'BellX*** | | ***DaisyBell*** |
|---|---|---|---|---|---|---|---|
| ***Category*** | Sub-criteria | 0.8 m³ | 1.5 m³ | 3.0 m³ | 1.2 | 1.8 | - |
| ***Capacity to trigger avalanches*** | Power (25 mbar isobar at ground level) – Axial | 50 m | 60 m | 75 m | 55 m | 65 m | 25 m |
| | Autonomy (Number of shots at nominal power) | 80 | 80 | 80 | 24 | 60 | 50 |
| | Firing time | 8 sec | 11 sec | 18 sec | 21 sec | 40 sec | 7 sec |
| | Time between shots | 15 min | 15 min | 15 min | 21 sec | 5 min | 7 sec |
| | Shot synchronization | Yes | Yes | Yes | Yes | Yes | No |

Table 1: Comparison of Remote Avalanche Control Systems (RACS) characteristics and performance parameters across product models.

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