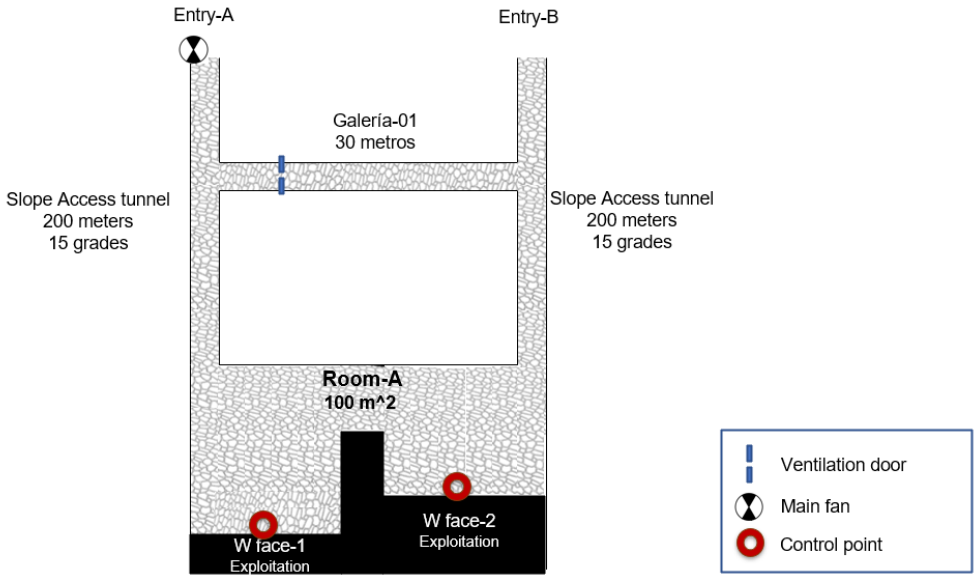
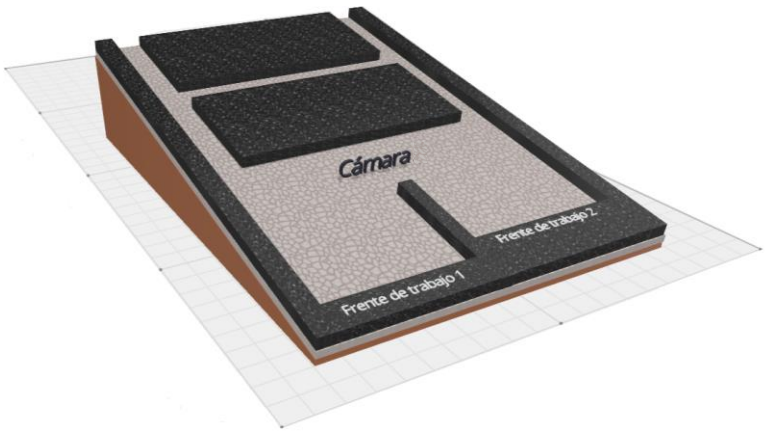
Exercise 1. Modeling of the mine structure, control points, sensors, and actuators.

Mine ***El Diamante***

The ***El Diamante*** underground coal mine has a structure as shown in Figure 1. An IoT system will be deployed inside the mine for continuous atmospheric monitoring and ventilation control. The mine has two control points with a group of sensors to monitor gases and an alarm in case workers need to be alerted. There is also a main fan in ***Bocamina A*** and a ventilation control door in Gallery 01.



a) Mine structure

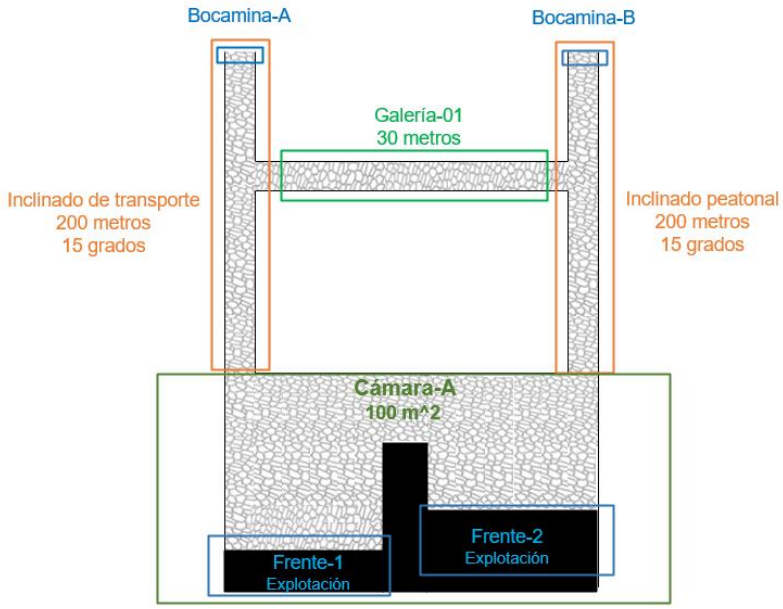


b) 3d Design

Fig. 1. ***El Diamante*** underground mine structure and design

Task

1. 1. Use the DSL to model the mine structure. In the following image you can find the distribution of the regions.



2. Use the DSL to model the control points including their sensors and actuators. Note that each control point has the following sensors and actuators.

Device	Type	Unit	Threshold	Brand	Communication
Sensor	Methane gas (CH4)	%	1	Winsen	Zigbee
Sensor	Carbon dioxide (CO2)	ppm	5000	ST	Zigbee
Sensor	Carbon monoxide (CO)	ppm	25	Winsen	Z-Wave
Actuator	Alarm	--	--	Digi	WiFi

3. Use the DSL to model the two actuators that do not belong to any control point.

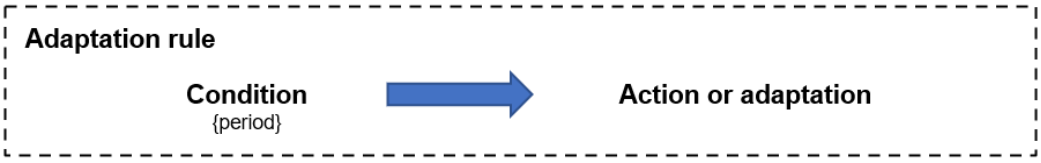
Device	Type	Unit	Threshold	Brand	Communication
Actuator	Fan	--	--	MetalWorks	Ethernet
Actuator	Ventilation door	--	--	Allen	Serial

Concepts for mine structure modeling.

Icon	Concept	Atributes
	Underground coal mine	Name
	Carbon seam	Name Thickness
	Working face	Name Type: • Development • Exploitation
	Room	Name Area
	Internal tunnel	Name Longitude
	Drift access tunnel	Name Longitude
	Slope access tunnel	Name Longitude Inclination
	Shaft access tunnel	Name Longitude
	Entry	Name
	Other region	Name

Exercise 2. Adaptation rules modeling

The DSL allows modeling several types of adaptation rules. Recall that an adaptation rule is composed of a condition and one or more adaptations.



The conditions can be modeled using various combinations:

Left side	*Mathematical operator*	*Right side*
Sensor_id {Region} {Sensor Type} {Control Point} {Sensor Type}	>, <, =, >=, <=	*{Numerical value}* {unit} *{Threshold value}*

To model an ***operate actuator*** type adaptation, you must specify the actuator ID and the message or action you want to send to it.

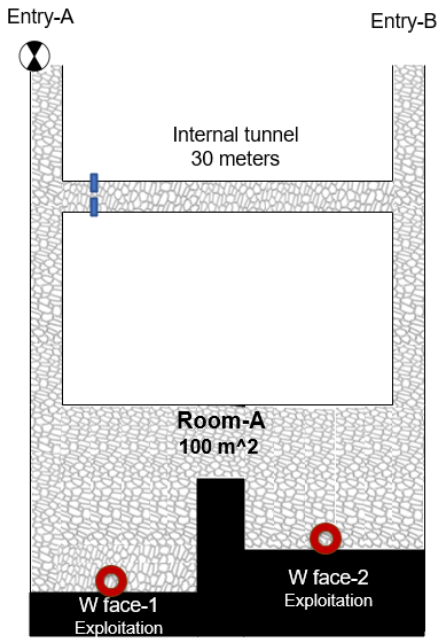
Examples of adaptation rules:

```
Regla Ejemplo 1
  Condition: ( pc02-co2 ) = ( Threshold value )
  Period: 10 m
  Actions
   Perform all actions
    * Operate Actuator -> Actuator: Puerta
                          message: abrir

Regla Ejemplo 2
  Condition: ( Cámara-A -> CO ) < ( 4000 ppm )
  Period: 1 s
  Actions
   Perform all actions
    * Operate Actuator -> Actuator: Puerta
                          message: cerrar
    * Operate Actuator -> Actuator: pc01-alarma
                          message: activar
```

Task

1. Use the DSL to model the following adaptation rules.



#	Condition	Action
1	If the sensor called **pc01-co** detects a concentration higher than 30000 ppm for 10 minutes	Turn on the work front alarm 1.
2	If in **Room A**, the concentration of CH4 gas exceeds 1%, for 10 seconds.	Activate alarms for work front 1 and 2.
3	If in the whole mine, any of the methane gas (CH4) type sensors exceeds the permissible limits (***Threshold value***) for 5 seconds.	Turn on the main fan, activate all mine alarms, and close the ventilation door.