

## European Space University for Earth and Humanity

*UNIVERSEH is an alliance of five European universities established to develop a new way of collaboration in the field of Space, within the "European Universities" initiative.*

*The alliance aims to create new higher education interactive experiences for the university community, teachers and students, and for the benefit of society as a whole. Such initiatives will enable broadminded, informed and conscientious European citizens to capture and create new knowledge and become smart actors of European innovation, valorisation and societal dissemination within the Space sector, from science, engineering, liberal arts to culture.*

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# 1 General presentation

## 1.1 IREAL

IREAL [REF], which stands for "Interactive Remote Experimentation for Active Learning", is an innovative techno-pedagogical project whose objective is to reinforce and facilitate the implementation of scientific laboratory experiments in an educational context. It develops the IREAL platform dedicated to this objective, within which the "Labs" or scientific laboratory experiments carried out in real experimental conditions are integrated, then digitized\* using multimodal acquisition, resynchronization, and implementation, according to a specific development protocol guaranteeing the scientific and educational quality.

The IREAL device is thus offered as a complement to classic experimentation protocols, carried out in laboratories or to other possible virtualized practices (virtual, augmented, or mixed reality) according to the teachers' pedagogical intentions.

It enables the complexities of implementation encountered in educational contexts to be addressed.

- Limited temporal or geographical accessibility to the experiment, Scaling of the number of students, with the possibility of conducting experiments with a very large number of learners,
- Fragility or cost of the experimental set-up, Duration of manipulations,
- Risk factors hazardous area devices (e.g., ATEX).
- Responsibility for ecological impact
- Environmental constraints (pandemic context, degraded weather events)
- Consideration of ethical parameters of the practice (experiments on living organisms)

The device allows for the variation and enrichment of learning modalities and pedagogical support within the experimental work and practices, such as

- Group work, face-to-face work, bi-modal work (both face-to-face and remote in real time) or co-modal work (allowing in addition a work modality in deferred time),
- Putting into situation and apprehension of phenomena prior to the study of theoretical notions,
- Preparation of experimental protocols linked to practical work,
- Resource to support the elaboration of reports or summaries of practical work,
- Resources for the teacher for illustration in class (decontextualised, reusable experiments),
- Resources accessible at a distance allowing inclusive work for students in particular situations (illness, distance),
- Resources to support students' independent revision or personal enrichment at any time.

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IREAL also contributes to the dissemination and valorisation of the work carried out in the laboratory by teacher-researchers, who are authors of their experiments published within the platform under a Creative Commons licence<sup>1</sup>.

## 1.2 Abstract

The purpose of this document is to establish the necessary prerequisites for the integration of a new experiment within the IREAL platform by describing an appropriate methodology.

It defines the actors and tasks throughout the process, as well as the elements that make up the creation request file. It also defines how the platform will be used.

Technical support for the platform is provided by the IDEA team at ISAE-SUPAERO.

## 2 Process of experiment digitalisation

The process of digitising a scientific experiment takes place in several stages, aimed at meeting both pedagogical objectives (based on a pedagogical and experimental scenario) and strict compliance with the scientific protocol designed and validated by the test owner and business expert. Finally, it meets quality requirements for which the pedagogical scenario, the acquisition scenario and the implementation will consider the observability parameters and the ergonomics of the device, especially for the interactivity parameters. These steps, described in paragraph 2.3, ensure that the construction respects these different points of attention, and that the experimenter has regular visibility on the progress of the creation throughout this process.

### 2.1 Actors in the experiment creation process

The integration of a new experience into the IREAL platform involves different steps that may be dependent on each other.

During the creation process, different actors come into play.

#### 2.1.1 Test owner

- Guarantor of the test procedure
- Guarantor of the pedagogical\* potential of the experiment and the tests chosen (=> contribution to the scripting)
- => Defines the experiment.

#### 2.1.2 Test designer

- In charge of the technical implementation of the experience capture

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- ⇒ Produces/develops the capitation system

### 2.1.3 Test operator

- Carries out the tests
- Produces test data
- ⇒ Uses the capitation system

### 2.1.4 Integrator

- Integrates data into IREAL using the Scan Development Kit (SDK)
- Creates the plugins necessary for data acquisition in IREAL
- Produces the presentation of the experiment
- Platform support
- In charge of the platform
- MOC (Maintenance in Operational Condition) / Evolutions
- Technical support

### 2.1.5 Learner

- Enter experimental parameters
- Visualises and understands the experiments

### 2.1.6 Teacher

- Builds a teaching sequence that integrates one or more experiments from the IREAL platform (eg. DNA in LMS)

### 2.1.7 School coordinator

- Ensures that the pedagogical objectives of the experiment can be integrated into the digital teaching modules.
- He/she is also responsible for the communication established through the platform in favour of his/her home institution. He/she acts as a link between the various contacts at his/her home institution and the IDEA support (in charge of the platform).

## 2.2 Identification of actors

During the different phases of designing and creating a new experience, each actor will oversee tasks that are specific to their functions.

It is specified that the same person can take on one or more roles throughout the process. In parallel, a role can be assigned to one or more people.

The assignment of people to the above-mentioned roles will be established before the start of the design of the experiment.

The assignment is established through the following table (model available in Annex 1):

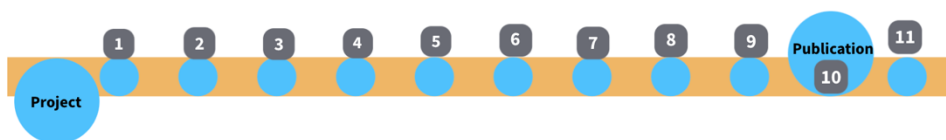
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Role	Lastname	Firstname	University	Email
Test Owner				
Test Designer				
Test operator				
Integrator				
IDEA Support				
Teacher				
Learner				
Coordinator				

### 2.3 Process of creating the experimental lab

The process of creating the experiments is illustrated in the following diagram:



- 1) Meeting, observation of the test bed and determination of the feasibility and implementation parameters.
- 2) Validation of the creation of the Lab
- 3) Elaboration and validation of Templates related to the pedagogical scenario, acquisition scenario
- 4) Scheduling - Acquisitions
- 5) Processing the acquired elements and preparing the implementation
- 6) Implementation of all the elements in pre-production, and communication of an observable version for confirmation to the Test Owner
- 7) Conducting user tests
- 8) Possible corrections following the tests
- 9) Go/No Go for publication
- 10) Publication within the IREAL platform
- 11) Feedbacks

An experiment is defined as being simple or complex:

- A simple experiment is one that does not use any other technologies than those already deployed within the IREAL platform. It can therefore be designed and deployed using the built-in components, e.g., user interface components.

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- A complex experience is defined by the need to create a new component or install a new plugin or even a new technology to run it according to its specifications.

The assignment of the level of the experiment ("simple" or "complex") leads to a different distribution of man-days.

It is therefore essential to define the experience that is to be digitised in advance and in a precise manner, in order to follow the resulting creation process.

### 2.3.1 Design process for a simple experiment

The different phases and tasks are distributed as follows (indicative assignment):

stage	task	Simple Experiment											
		role	m.d.	role	m.d.	role	m.d.	role	m.d.	role	m.d.	role	m.d.
		test owner		test designer		test operator		integrator		IDEA support		Learner	
Design	Meeting presentation of the experiment		0,5		0,5		0,5		0,5		0,5		0,5
	Definition of input variables		0,5		0,5								
	Selection format of input variables				0,5								
	Label of input variables				0,1								
	Contextual help text for input variables		1		0,1								
	Selection of output components		0,5		0,5								
	Label of output variables				0,1								
	Contextual help text for output variables				0,1								
	Selection of data to be displayed		0,5		0,5								
	Label of legend		0,1		0,1								
	colour and display		0,5		0,5								
	values of customisable control components		0,5		0,5								
Captation	Acquisition scenario		1				1		0,5				0,5
	List of possible combinations		0,5				0,5		0,1		0,5		
	Scenography		0,5		0,5		0,5		0,5				0,5
	Booking of experimental sites and materials				0,1		0,5						
	Booking audiovisual equipment				0,1		0,5						
	Audiovisual staging				1		1						
	Recording of sequences						2						
	Provision of recordings						0,5		0,1				
	Quality control of records								1				
	Correction records						1		0,1				
	Provision of corrected recordings						0,5		0,1				
	Audiovisual post-production								0,5				
	Sequence naming								0,5				
	Provision of data						0,5		1				
Implementation	Implementation of data in IREAL								1				
	Data reading scheme (notice)		0,5				0,5						
UX Design	Arrangement of components				1								
	Size of the components				0,5								
	Poster and illustrations				0,1								
Validation	Validation of the UX Design template		0,1		0,1					0,1			0,1
	Validation of the experiment on a test sample		0,5		0,5					0,5			0,5
	Data read validation		0,1		0,1		0,1						
	Validation of textual elements		0,1		0,1								
	Validation of selection modes		0,1		0,1								
	Validation of experiment		1		1								
	GO/ NO GO production start-up		0,1		0,1		0,1			0,1			0,1
			8,6		9,3		9,7		5,9		1,7		0
												0	2,2

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## 2.3.2 Design process for a complex experiment

The different phases and tasks are distributed as follows (indicative assignment):

stage	task	Complex Experiment													
		role	m.d.	role	m.d.	role	m.d.	role	m.d.	role	m.d.	role	m.d.	role	m.d.
		test owner		test designer		test operator		integrator		IDEA support		Learner		Teacher	Coordinator
Design	Meeting presentation of the experiment		0,5		0,5		0,5		0,5		0,5				0,5
	Definition of input variables		0,5		0,5										
	Selection format of input variables				0,5										
	Label of input variables				0,1										
	Contextual help text for input variables		1		0,1										
	Selection of output components		0,5		0,5										
	Label of output variables				0,1										
	Contextual help text for output variables				0,1										
	Selection of data to be displayed		0,5		0,5										
	Label of legend		0,1		0,1										
Development	colour and display		0,5		0,5										
	values of customisable control components		0,5		0,5										
	Selection of the web technology associated with the new component				0,1				0,1						
	Integration of the constituent parts of the new component				0,1				0,5						
	Synchronisation of components with the controller								0,5						
Captation	Integration testing								1						
	Integration of the component into the platform								1						
	Acquisition scenario		1				1		0,5						0,5
	List of possible combinations		0,5				0,5		0,1		0,5				
	Scenography		0,5		0,5		0,5		0,5						0,5
	Booking of experimental sites and materials				0,1		0,5								
	Booking audiovisual equipment				0,1		0,5								
	Audiovisual staging				1		1								
	Recording of sequences						2								
	Provision of recordings						0,5		0,1						
	Quality control of records								1						
	Correction records						1		0,1						
	Provision of corrected recordings						0,5		0,1						
	Audiovisual post-production								0,5						
	Sequence naming								0,5						
Implementation	Provision of data						0,5		1						
	Implementation of data in IREAL								1						
UX Design	Data reading scheme (notice)		0,5				0,5								
	Arrangement of components				1										
Validation	Size of the components				0,5										
	Poster and illustrations				0,1										
	Validation of the UX Design template		0,1		0,1						0,1				0,1
	Validation of the experiment on a test sample		0,5		0,5						0,5				0,5
	Data read validation		0,1		0,1		0,1								
	Validation of textual elements		0,1		0,1										
	Validation of selection modes		0,1		0,1										
	Validation of experiment		1		1										
	GO/ NO GO production start-up		0,1		0,1		0,1				0,1				0,1
			8,6		9,5		9,7		9		1,7		0		2,2

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### 3 Design of experiment

#### 3.1 Meeting presentation of the experiment

A meeting prior to any digitisation project is organised between the team carrying out the experiment and the IREAL team around the experimental device. This meeting is a major step in the project.

It allows:

- An observation of the experiment in question and its progress, as well as its environment; the aim is to understand the experiment, its educational interest and to ensure the feasibility of the digitisation envisaged according to the IREAL protocol.
- Careful determination of all the elements that will be necessary for the integration of the experiment within the IREAL platform (linked to the educational scenario implemented).
- Taking into account the multimodal observability parameters (i.e. visual, auditory, measurements) for the users (parameters of reading, acceleration, pause, eventual slowing down relevant to the targeted experimentation).
- The interactive elements and the modalities of implementation of these interactive functionalities allowing the effective experimentation via the platform: formats, accessibility, temporality, etc.
- The determination of the informational elements linked to the experiment (presentation of the experiment, legends, units of value, indications linked to the manipulations on the device, possible addition of graphs, curves, etc.).
- The possibility of extracting data (during the experiment, or afterwards, the formats of these data)
- Preferences related to the representation of the information and different elements presented
- Finally, this meeting allows the different interlocutors linked to the experiment and its uses to be brought together in the same pedagogical direction.
- Based on all of this information and the observation of the experiment, the IREAL team will be able to develop a complete acquisition scenario for the experiment, and will propose a first version of an experimental device:
- Quality (observation, functionality, strict respect of the scientific experimental protocol).
- Pedagogically efficient (the experimental parameters will be of a wider range (in compliance with the conditions supported by the device), integrating in particular values that are not considered critical in the experiment, so as to propose a truly experimental practice device).
- Decontextualised, in order to favour its usability by the community of practitioners of the scientific field concerned, and within various learning or teaching situations.
- This meeting must therefore be approached with all the information needed to present both the content and the form of the experimental principles of the test bench to be digitised.

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of the European Union



The distribution of expected contributions in this major phase of preparation for production by the various project actors can be summarised as follows:

- On the part of the Test Owner and the teachers: to present the experiment as it is carried out in practical sessions to the students.
- From the Test Designer: to present the tools needed to manage the experiment (software, hardware, output and input files)
- From the Coordinator: the people who can be assigned to the roles defined in the process.
- From IDEA Support and the Integrator: to check the eligibility of the experiment in relation to the prerequisites for digitising and controlling an experiment.
- To take into account the data formats, it is recommended that the test bench expert team has an example of a test in real conditions (remote meeting in the laboratory, test video, images, etc.)
- During the meeting, the integrator may request sample test files (data files at the output of the experiment) in order to check the viability of the data and to test the configuration within the platform.

### 3.2 Definition of input variables

An IREAL experiment is defined as an experiment with multiple observations depending on different input variables.

These input variables must be established according to the manipulative procedures submitted to the learning audience.

The objective of this task is therefore to list all the parameters that the learners will have to select before launching their observation.

In order to determine the completeness of the selection values, it is necessary to take stock of all the actions carried out during the actual experimental protocol.

Based on this inventory, the actions are grouped according to their category (e.g. value input, installation action, switch on, switch off, value from observation, etc.).

The categories [value input] are automatically included in the input components. The installation, start-up or shutdown actions are integrated into the experimental circuit according to their pedagogical interest and necessity.

See table to be completed in Annex 2

#### 3.2.1 Format for selecting input variables

The Test Designer should pay particular attention to the format in which the input variables are selected. The format should be as close as possible to the appearance of the input blocks offered to learners in real life.

Some parameters are difficult to represent in a web interface (e.g. a gearstick lever) but the aim is to choose components that come as close as possible to the selection manoeuvre.

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In order to determine the types of components to implement to select these variables, it is necessary to answer the following questions:

- Selection method: value entry, drag and drop, tuner system, tick system, etc.
- Selection dependency: Are some parameters (only) displayed when other parameters are present?
- Are there minimum and maximum values?
- Are there value steps?
- How does the learner access these parameters ( $\Rightarrow$  / representation)

See table to be completed in Annex 2

### 3.2.2 Label of input variables

The wording, as well as any other textual elements, must be delivered in English.

The name should correspond to the generic names used in the subject area in which the experience is carried out. For these reasons, the wording should be established in a collegial manner between the Test Owner, the Test Designer and the Teachers concerned.

See table to be completed in Annex 2

### 3.2.3 Context sensitive help text for input variables

The wording, as well as any other textual elements, must be delivered in English.

Context-sensitive help offers the platform's users the possibility to benefit from an explanation of the usefulness of each component and parameter. It has a pedagogical objective but also reinforces the accessibility of the experience to the learning public.

See table to be completed in Annex 2

## 3.3 Selection of output components (results of the experiment)

The test designer should pay particular attention to the choice of format for selecting the output components. The format should be as close as possible to the appearance of the result blocks offered to learners in real life.

In order to determine the types of components to be implemented, it is necessary to answer the following questions:

- In what form do the results appear?
- Are the results immediate or do they require a delay?
- Do the results appear dynamically?
- Do the results follow a well-defined colour scheme?
- Are the results retrievable? If so, in which format?
- Do learners have to post-process the results?

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See table to be completed in Annex 3

### 3.3.1 Label of each output component

The wording, as well as any other textual elements, must be delivered in English.

The wording should be consistent with the standard terms used in the subject area in which the experience is carried out. For these reasons, the wording should be established in a collegial manner between the Test Owner, the Test Designer and the Teachers concerned. (=> consultation)

The labels of the output components include:

- Component titles
- Scale values
- Graph data axes
- Table row and column names
- Indexes
- Legends

See table to be completed in Annex 3

### 3.3.2 Context sensitive help (optional) for output component

The wording, as well as any other textual elements, must be delivered in English.

The output components may require contextual help to read the data according to the educational requirements.

Contextual help may be in the form of text or image.

See table to be completed in Annex 3

### 3.3.3 For data display components: selection of data to be displayed

The question here is to determine what graphs, tables or other types of output are needed for observation. It is necessary to analyse how the test rig provides output. Is the experimental setup instrumented? If so, in what format do the values appear?

Any files that can be extracted can be implemented in IREAL and represented as a graph, table or other output component.

If the test bed output data is time coded, it can be synchronised in IREAL with the video observation.

Data export is an option available on the IREAL platform. Some values from the graphical representations can be used by the learners through the post-processing of the observation via this export option.

See table to be completed in Annex 4

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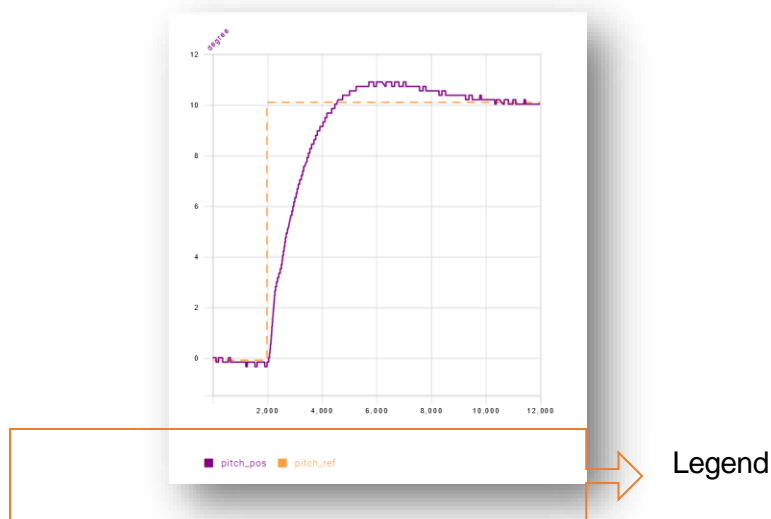


### 3.3.4 For graphic components: captioning

The role of the graphs is to display data from the result of the observed experiment. The user must be able to grasp the meaning attributed to each indicator.

To do so, he is helped by a legend that indicates the belonging of a graphic flow to a type of data.

The following figure shows, by way of example, the expectations for the legend:



The legend is positioned below the graph and indicates the name of each flow represented.

The unit of measurement of the y-axis is also indicated.

The abscissa axis has, by default, the unit of measurement as time. If another unit of measurement is to be used, the Test Designer must indicate the units of measurement of the data graph. An example of a graph, in the form of an image or screenshot, is recommended.

### 3.3.5 For graphical components: color selection and appearance for each parameter

It should be determined whether the appearance of the data should follow a specific graphic chart known to the scientific community. If this is the case, this charter must be respected (colour code, type of curve, etc.). In the absence of a well-defined charter, the appearance will be determined by the test designer in collaboration with the IREAL team. The Test Designer must provide the colour code assigned to each data stream to respect the colour mapping of the data and improve the accessibility of the experience for the platform's users.

Similarly, to improve the readability of the data for the public with dyschromatopsia problems, it is recommended to distinguish the graphic data streams on their form: linear, dotted letter, dashed.

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### 3.4 For the control component (experiment reading controller): Determining the read advance/return interval

The duration of an observation may vary from one experiment to another.

The IREAL platform is designed to respect the observations as they are carried out in laboratories, in principle in real time. Nevertheless, in order to optimize the waiting time of the participants in a long experiment, these temporal manipulation possibilities are proposed with the observation control component.

The observation control component is a basic core component offered by the IREAL platform.

All experiments have such an observation controller which has the following options by default:



From left to right, the control options are:

- A replay button
- A stop button
- A pause button
- A rewind button (default: 5 seconds)
- A forward button (default: 5 seconds)
- A speed button (default: double speed [x2])

If an observation requires the user to go forward or backward for more than 5 seconds, the Test Designer must indicate this to the integrator via the form (see table to be completed in Annex 5).

## 4 Captation/recording

### 4.1 Setting up the acquisition scenario

**Special attention is given to this operation. It is a critical operation.** Indeed, a poorly defined acquisition scenario forces the actors to redo the acquisitions and start the whole digitisation process again. The acquisition scenario marks the key steps to be respected to capture all possible observations that will be implemented in the IREAL platform and how they will be recorded.

The acquisition scenario is dependent on the steps related to the design of the experiment.

For each observation, the acquisition scenario must be identical.

At this stage, the Test Owner, the Test Designer and the Integrator will define each step necessary for an observation to take place and define the marker between each observation.

The scenario lists each action, whether performed by man or machine, throughout an observation.

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The scenario ends with the identity sheet of the separating marker (except in case of absence of a specific marker). The acquisition scenario logbook is present during acquisitions. It serves as a guideline and allows any element to be considered by the Postproduction Manager. If an observation fails, the Operator must indicate this on the logbook so that the Integrator can integrate it in "failure" mode or delete it from the data to be implemented. The same applies to observations that are made several times. Each observation with the same input parameters must be numbered in the logbook.

## 4.2 Definition of possible combinations

The definition of the possible combinations comes directly from the list of input variables.

This is the sum of the possible values for each input variable.

This set will be listed and sorted according to the acquisition scenario.

The observation output files will be adapted to this list for naming.

As an example: Take an experiment containing 2 variables A and B. Variable A contains 3 possible values and variable B contains 2 possible values. The observation results in a file in CSV format as output.

Ordered list of possible combinations:

Variable A	Variable B	Nom du fichier en sortie
1	1	VarA_1_VarB_1.csv
1	2	VarA_1_VarB_2.csv
2	1	VarA_2_VarB_1.csv
2	2	VarA_2_VarB_2.csv
3	1	VarA_3_VarB_1.csv
3	2	VarA_3_VarB_2.csv

## 4.3 Choice of staging (scenography) for audio-visual recording

Staging thus refers to the multiple choices of image and sound composition. It is based on choices to be made in the following areas:

- Framing, space: what angle to set to faithfully observe the experience as it is lived during the practical sessions in the classroom.
- The graphic charter: concerns the lighting and the sets. Here, mention should be made of the scenery not related to the observation, which should be removed during the recording

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to obtain a refined audio-visual rendering. The lighting is important, as it must be adjusted to highlight the experiment and its equipment, and to reduce extraneous shadows as much as possible.

- Sound: adjust the sound to avoid crackling or to reduce extraneous noise not related to the experiment itself.
- Speakers: in the presence of manual action, each person's dress and intervention should be identical from one observation to the next, as far as possible.

The choice of staging will be the subject of a test sample which will be submitted to the Integrator and IDEA support, who will be able to provide, if necessary, answers to staging problems.

#### **4.4 Booking of slots for audio-visual recording**

The places where the recording is to be carried out must be reserved.

The recording requires an audio-visual quality that must not be altered by the occupation of the premises by persons other than those who are conducting the recording.

##### **4.4.1 Reserving of audiovisual equipment and staging accessories**

It is advisable to reserve (or acquire) the necessary equipment for the recording.

The equipment should be tested beforehand.

##### **4.4.2 Setting up the scene**

The set-up is carried out according to the staging scenario developed earlier in this stage.

##### **4.4.3 Recording sequences**

This stage is the audiovisual capture stage.

Attention should be paid to the memory available on the different cameras and the level of battery.

The video recording format should also be checked and set to high definition.

The default orientation of the cameras is landscape unless the experiment requires a different orientation.

##### **4.4.4 Provision of records**

The records will be made available to the Integrator on a shared directory, or by secure electronic means (e.g. Renater's Filesender service).

##### **4.4.5 Quality check of records**

The Integrator will check the audio and video quality upon receipt of the recording files. In case of audio-visual failure, he will inform the Operator in order to carry out the tests again. Only the corrupted observations will have to be redone and sent back.

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#### 4.4.6 Correction of records following the audits check

The Operator performs a new recording of the corrupted sequences that have been listed by the Integrator. These recordings are made under the same conditions as the original recordings.

#### 4.4.7 Provision of corrective records

The recordings will be made available to the Integrator on a shared directory, or by secure electronic means

#### 4.4.8 Sequence splitting

The cutting of the sequences can be automated in the presence of a specific marker present on the videos and with software processing. In the absence of a specific marker, the cutting is done manually by the Operator. The cutting time is directly linked to the presence of this marker and to the total duration of the videos transmitted.

#### 4.4.9 Sequence naming (depending on the acquisition scenario)

The name of each video sequence follows the hierarchy of the acquisition scenario and the resulting ordered list of possible combinations.

#### 4.4.10 Provision of sequences

At the request of the Operator and/or other actors, the Integrator may make available a sample of video sequences on a shared directory, or by secure electronic means.

#### 4.4.11 Hosting of video sequences

The videos are hosted by the Integrator through the IREAL platform's hosting contracts.

The videos are hosted in private mode and are only open to the public via the IREAL platform.

#### 4.4.12 Provision of data

The results data files are made available to the Integrator on a shared directory, or by secure electronic means.

## 5 Implementation

### 5.1 Data reading scheme (notice)

The Test Owner and the Operator draw up a manual for reading the output files so that the Integrator can correctly implement the data and read them according to the established manual.

These instructions can be formalized with a document and supplied with illustrative diagrams.

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### 5.1.1 Implementation of data in IREAL

Once the Integrator has retrieved the data (e.g. videos, data files, images), it proceeds to integrate them into the BETA version of the experiment on the pre-production instance of the IREAL platform.

The integration is carried out in two stages:

- Integration of a test sample to validate the implementation according to the de-sign phase
- Total integration to validate the experiment as a whole and to de-deploy it in the platform.

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## 6 UX Design

### 6.1 For the overall UX Design: layout of components

The Test Designer creates a mock-up of the experiment page by specifying the layout of each component block on the page.

### 6.2 Selection of components

The Test Designer defines the types of components to be included on the IREAL experiment page in relation to the experiment as it is performed in the laboratory.

If a user has to select parameters by means of a cursor in the laboratory, it is important that he/she can perform the same action in IREAL.

The various components must be as close as possible to the actions carried out in the classroom.

### 6.3 Size of each component

Through the experience page model, the test designer also defines the ratio of each component block.

The grid references used by the IREAL platform are based on the Bootstrap Framework documentation [REF]. Columns are defined by a ratio of 12.

### 6.4 Poster of video component (before playback)

Before playing back the videos related to the observation, the video component displays a poster illustrating the expected video result and/or the material that is to be used in the experiment.

The Test Designer is responsible for choosing which poster will appear by default on the video component before playback and whether the poster should change according to certain selection parameters.

## 7 Validation

### 7.1 Validation of the UX Design Template

Following the mock-up of the experience page by the Test Designer, the following roles are required to validate the established Template:

- Test Owner (as scientific business expert)
- IDEA Support (as platform administrator)
- School Coordinator (in the capacity of pedagogical follow-up and respect of the rules in force within the school)

### 7.2 Validation of the experiment on a test sample

Generation of a test sample by the Integrator in the platform.

This test sample will serve as a validation support for the principle of operation and processing of the experiment within IREAL.

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This test will be implemented within the BETA version of the IREAL platform (IREAL pre-production platform).

The aim here is to implement a test observation on the Template, previously validated, in order to confirm the various actors on the integration choice made during the previous stages.

The validations are to be pronounced by:

- Test owner
- Test designer.
- IDEA support
- School coordinator

### **7.3 Data read validation**

Through the sample test implemented in the BETA version of IREAL, a validation is needed on how the data is retrieved and translated to the output components.

Validations are to be performed by the following roles:

- Test Owner
- Test Designer.
- Test Operator

### **7.4 Validation of textual elements**

Validation of compliance with the instructions concerning the textual elements indicated in the de-sign phase.

Validations are to be given by:

- Test Owner
- Test Designer.

### **7.5 Validation of selection modes**

Validation of the compliance with the guidelines for the selection components according to the guidelines specified in the design phase.

The validations are to be made by:

- Test Owner
- Test Designer.

### **7.6 Validation of experiment**

Validation of the experiment as a whole (appearance, functioning).

Validations are to be pronounced by:

- Test Owner
- Test Designer.

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### **7.7 Release to production: business expert**

Validation for putting the experiment into production on the IREAL platform.

Validations are to be pronounced by:

- Test Owner
- Test Designer
- Test Operator

### **7.8 Validation for production: educational expert**

Validation for putting the experiment into production on the IREAL platform.

Validations are to be pronounced by:

- School coordinator

### **7.9 Validation for production : IDEA**

Validation for putting the experiment into production on the IREAL platform.

Validations are to be pronounced by:

- IDEA Support

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## 8 Using the IREAL Platform

### 8.1 Home page

The URL of the platform is: <https://ireal.isae-supaero.fr>

The homepage describes the purpose of the platform and the benefits it brings.

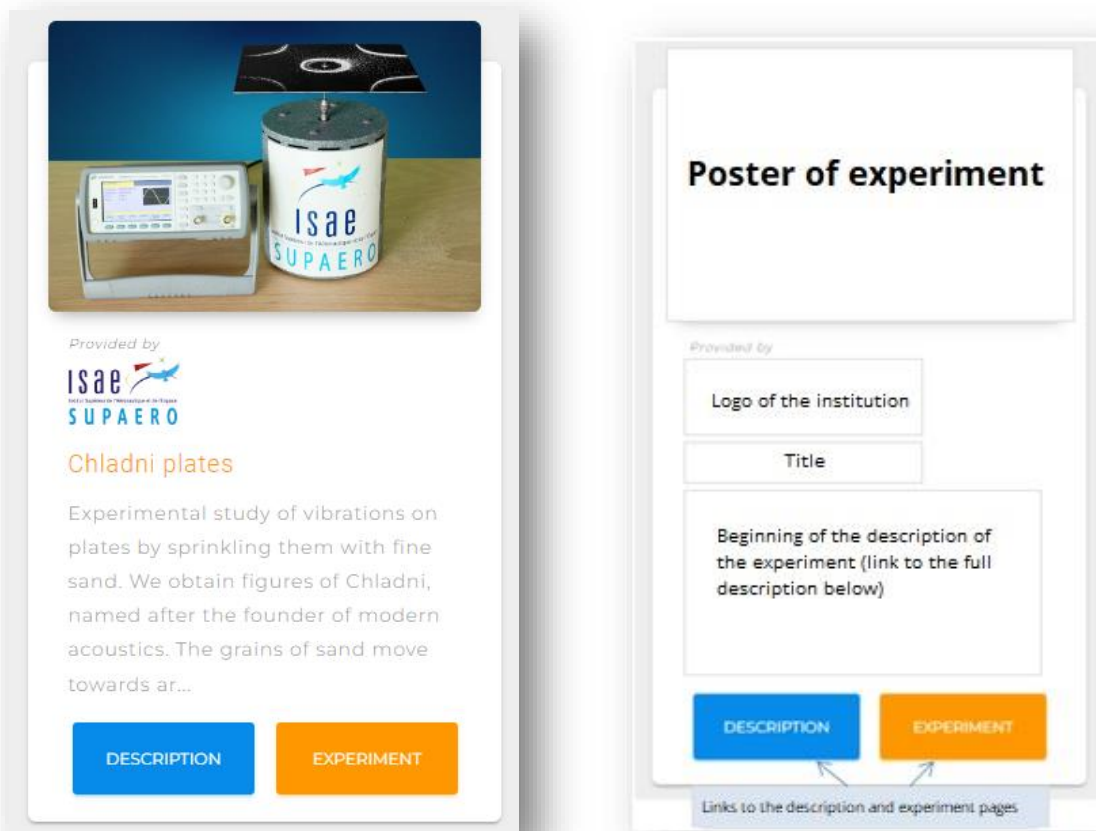
It also mentions the various partners who have contributed to its development.

A link to the list of experiments is available via a button on the navigation banner:



### 8.2 List of experiments

Each experiment is represented on a map as follows:



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### 8.3 Experiment descriptions page

This page describes the experiment as it is performed and its scientific interest. It provides a technical explanation of the experimental process.

Various presentation materials can be included (e.g. videos, diagrams, text, poster).

### 8.4 Experiment page

This page gives access to the experiment itself.

The input blocks are orange, and the output blocks are blue.

#### 8.4.1 Launching the observation

The user selects his parameters to access a specific observation.

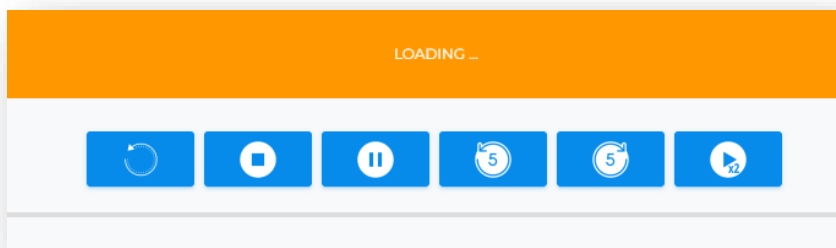
When the input values are defined, the user triggers the observation with the button:



START THE OBSERVATION

#### 8.4.2 Monitoring observation

At the start of the observation, a control block appears in order to optimize the user's experience of the result. This block offers the following options:



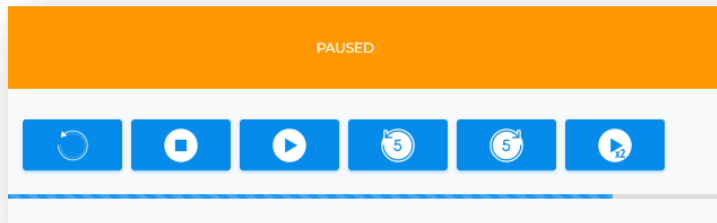
- Replay of the observation
- Stopping the observation
- Pause
- Rewind by 5 seconds
- Advance 5 seconds
- Increase speed

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A progress bar appears at the bottom of the control block. It gives a view on the duration of the observation. Depending on the experiment, the elapsed time may be indicated.

Progress bar (in blue):



### 8.4.3 Downloading results

The user can export the results obtained in order to analyse them and/or work on them from another angle.

If the option is available, an export button is proposed above the output components that are eligible for data export.

This button appears like this:

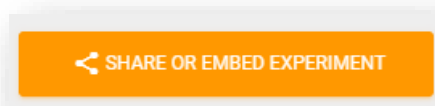


The browser will open a dialog box that will offer the user to save the file(s) or to open them.

## 8.5 Integrating an experiment into educational content

An experiment can be carried out on the IREAL platform directly but it can also be integrated into educational content (LMS, ADN, etc.).

To do this, at the top right of each experience page, a sharing and integration button is accessible:

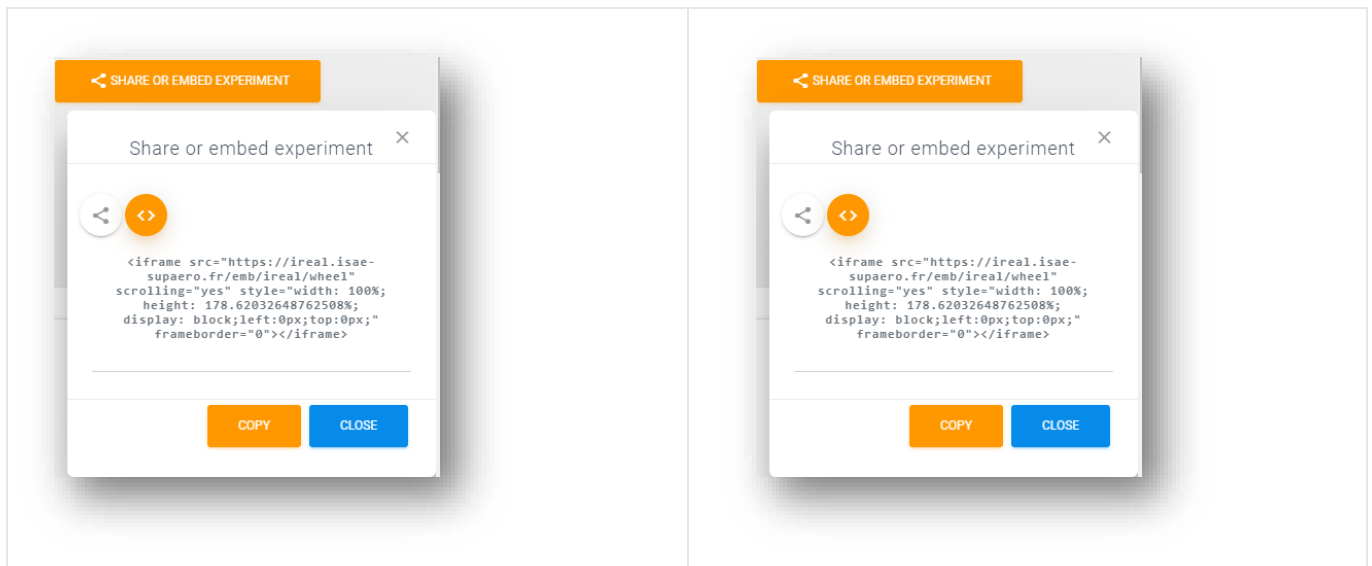


Two tabs are available:

Tab for the share link :	Tab for the integration link (embedded) :
--------------------------	---

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## Example of integration into an “ADN”:

### Experiment lab

The objective is to learn how PID (Proportional Integral Derivative) regulation works and how the tuning of the controller gains affect the closed loop performances, here the basic concepts of system control are illustrated through the stabilization of a “helicopter” platform with one degree of freedom (pitch angle). In this experiment the control scheme is provided and the user sets up the 3 gains of the PID controller whose responses will be observed and analyzed.

More precisely, in order to get a fast, stable and accurate control of a 10 degrees commanded pitch angle, the performance specifications are:

- Rise time less than 0.5s
- Settling time less than 1s
- Overshoot less than 5% (and no oscillations)
- No steady state error

Find the best combination of  $K_p$ ,  $K_i$  and  $K_d$  in order to reach these performance specifications.

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The integration of an experiment within the educational content allows the learner to be directly involved in the experimental process in order to appropriate the concepts described and explained in the theoretical content. It puts the learner in a position of active learning. It can confirm or invalidate their hypotheses, subject them to learning by error and activate their visual learning of scientific laws and theories.

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## 9 Example: LUNA LAB experiment – Velocity of a Rover

### 9.1 Selection of the experiment

The University of Luxembourg has an experimental laboratory that reconstructs the lunar soil. This laboratory is called LUNA LAB.

Several experiments are carried out there.

Within the framework of the UNIVERSEH project, it is interesting to be able to make certain experiments accessible in order to illustrate the courses that are offered but also to be able to give a practical case to the learners on the notions approached.

The LUNA LAB experts were asked to select experiments that could be implemented on the IREAL platform.

Three experiments emerged from the study:

- **Proposal 1:** observe the image lunar delay effect from different locations (onboard, lunar gateway, earth), it can give an idea of the telerobotic issues on the moon. It can be combined with different illuminations (Equatorial-90 degrees, intermediate-45, south pole-6).
- **Proposal 2:** observe the perspective of different cameras (e.g., 360 cameras, stereo camera) with different illuminations (Equatorial-90 degrees, intermediate-45, south pole-6) and different environment configurations (flat, flat+rocks, craters, craters+rocks)
- **Proposal 3:** observe different speeds on the lunar rover (e.g., five speeds) with varying environment configurations (flat, craters, hills).

It was decided to start with the third proposal. The latter is simpler in terms of data capture and recovery. During a first collaboration between an institution and the IREAL team, this allows the institution to take possession of the protocol for implementing the experiment on the platform.

### 9.2 Actors

Following discussions with the laboratory's expert team, the actors are listed:

Role	Person n°1			Person n°2		
	Surname	Firstname	Institute	Surname	Firstname	Institute

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<b>Test Owner</b>	OLIVARES MENDEZ	Miguel An- gel	Uni.lu			
<b>Test Designer</b>	OLIVARES MENDEZ	Miguel An- gel	Uni.lu	COLOMA CHACON	Sofia	Uni.lu
<b>Test operator</b>	COLOMA CHACON	Sofia	Uni.lu			
<b>Integrator</b>	COLOMA CHACON	Sofia	Uni.lu			
<b>IDEA Support</b>	IDEA Team		ISAE- SUPAERO	BERNARD	Sophie	ISAE- SUPAERO
<b>Teacher</b>	OLIVARES MENDEZ	Miguel An- gel	Uni.lu			
<b>Learner</b>						
<b>Coordinator</b>						

Thus, the description and ownership of the experiment belongs to Miguel Angel OLIVARES MENDEZ. He will manage the final rendering and the final validation of the experiment before its publication on the IREAL platform.

Sofia COLOMA CHACON will manage the acquisitions. She will also oversee guiding and validating the final Template to make it operational from a functional, experimental and educational point of view.

All technical exchanges will be handled by the IDEA team (ISAE-SUPAERO, Toulouse (FRANCE)) with Sophie BERNARD as contact person.

### 9.3 Acquisition parameters and scenario

From the synthesis of the experiment, the following variables are highlighted:

- The soil typology (flat, crater, hill)
- The speed of the rover

As far as the first parameter is concerned, the user will be asked to select it by a "radio button":

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Choose configuration

☒ Flat

☐ Crater

☐ Hill

For the second parameter, when it is a numerical value, it is necessary to know the possibilities of selectable values.

Thus, in order to guide the test designer on this definition, three questions are asked:

- What is the minimum value?
- What is the maximum value?
- Are the values separated by regular steps, or are they already predefined?

The answers provided by the test designer are as follows:

- minimum value => 0.01 m/s
- maximum value => 0.21 m/s
- step between each value => 0.04

For a better user experience, these speeds will be selectable by means of a slider:

Choose velocity (m/s)

0.09

0.01 0.05 0.09 0.13 0.17 0.21

From these different values, we can establish an acquisition scenario.

This involves defining the different possibilities by combinatorial analysis.

Here, with 18 possible observations, the result is as follows:

N°observation	Floor typology	Speed	Output file naming
1	Flat	0.01	uni-verseh.YYMM DD.0p1.flat-robot-imu-data

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2	Flat	0.05	uni- verseh.YYMM DD.0p5.flat- robot-imu-data
3	Flat	0.09	uni- verseh.YYMM DD.0p9.flat- robot-imu-data
...	...	...	...
18	Hill	0.21	uni- verseh.YYMM DD.0p21.hill- robot-imu-data

In this acquisition scenario, we assume that only one observation will be made per value set. However, if possible, the operator is advised to perform an observation resulting from the same value set several times in order to provide a real experience for the learner and to ensure that the random effects that may come into play during an experiential process are offered. If this is the case, each output file will have an additional flag indicating the number of the repeated observation (e.g. universeh.YYMMDD.0p1.flat-robot-imu-data\_a, uni-verseh.YYMMDD.0p1.flat-robot-imu-data\_b, etc.)

#### 9.4 Output data for observation

We have defined the input values. Here, it is a question of defining the modes and the output results.

In essence, IREAL experiments include at least a visual output in video format.

Here, the LUNA LAB is equipped with several cameras at different angles and heights.

In total, the video outputs of 4 cameras will be retrieved and implemented.

For the instrumented data, the test designer provided a test sample (csv file) to the technical support team.

This file will be implemented, in a raw manner, on a graphical component in order to ensure that the rules for reading the file by the IREAL platform are correct. It also serves as a first visualization on a test template that allows the test designer to adjust the specifications according to the rendu.

Please note that this sample must have the same format as the output files during acquisition. Indeed, when the implementation script by IREAL is validated, this same script will be used for the final files.

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## 9.5 Template

A first Template is created on the test platform. The associated link will be the same throughout the IREAL experience creation process.

Sujet **Re: UNIVERSEH - Luna Lab/IREAL**

Pour Sofia COLOMA CHACON <sofia.coloma@uni.lu> ★

Dear Sofia,

Thank you for your reply

I give you the link of a first very simple template so that you can see how it could look like:

<https://ireal-preprod.isae.fr/lab/ireal/lunalab>

This link is on the test platform of IREAL

The test designer is asked to list the changes, deletions and/or additions to be made to this first Template in order to validate the final Template.

This first Template integrating the sampled test data is also used to revise the acquisition scenario if a major observation element is noted.

For example, here, the first Template retained several video components for each camera. However, this takes up a lot of space on the interface while the added value of having all the angles of view on a separate component is not present.

Following this observation, the video files will be concatenated in order to produce a single video showing the different angles of the rover's behaviour on the surface.

As for the data from the rover's instrumentation, there is a lot of it. Indeed, each wheel of the rover is equipped with velocity and effort sensors.

If we integrate the associated curves into a single graph, it quickly becomes unreadable.

The choice was therefore made to put one graph per wheel (so four graphs), one graph for the total values and one last graph for the IMU (pitch and roll). That is six graphs in total.

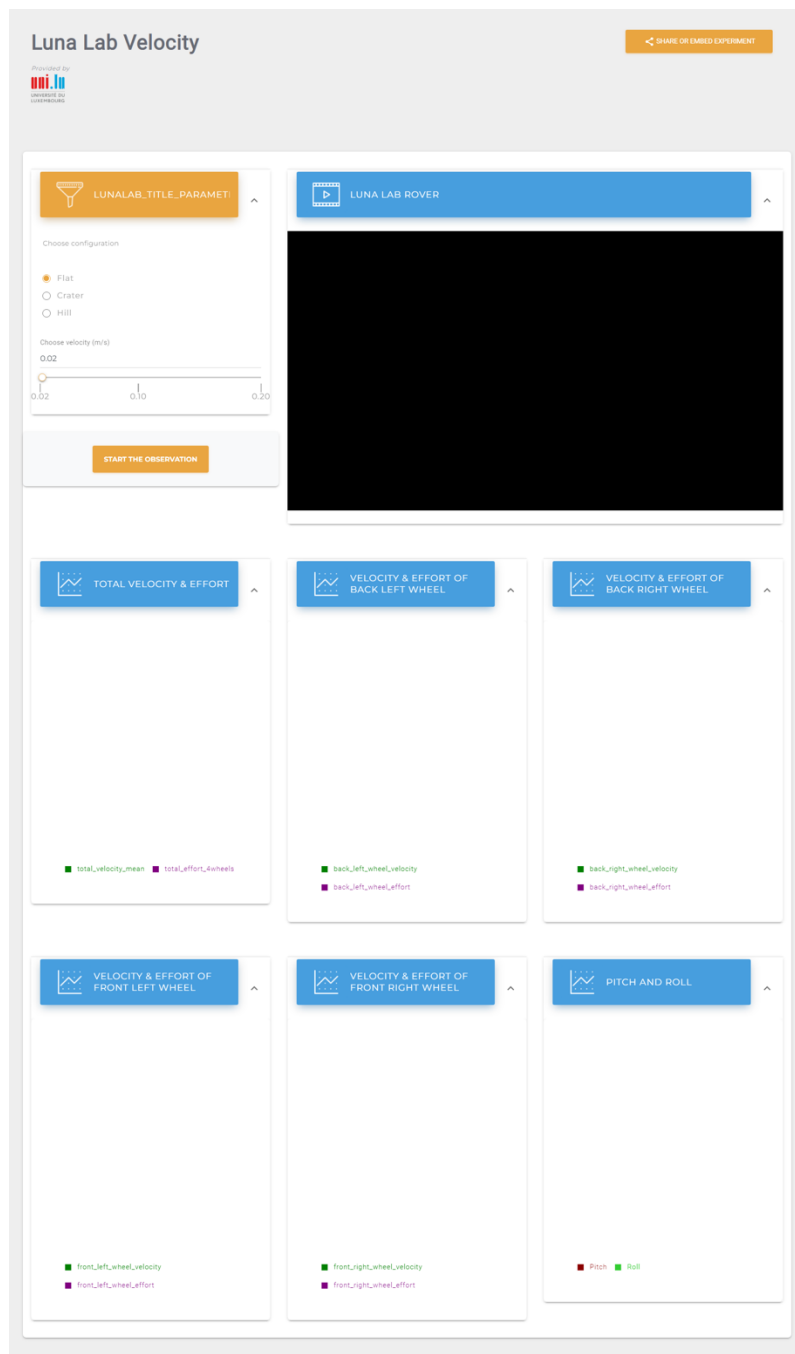
From the criteria, previously defined, a first Template is returned:

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## 9.6 Acquisition of observations

Sofia COLOMA CHACON, as operator, played the different observations listed.

The final acquisition could not respect the scenario initially defined.

Technical problems were encountered.

In the end, 3 speeds could be played: 0.02 m/s, 0.1 m/s, 0.2 m/s

This necessitated modifying the template accordingly.

The additional acquisitions can be integrated later. Indeed, the IREAL experiments are said to be living. Throughout their life, they can receive other possible observations, either on the same values or on new values, which respect the defined skeleton.

The various actors in this IREAL experiment work remotely (actors in Luxembourg and actors in France). Files are exchanged via a drive server.

## 9.7 Data implementation

The next step is for the technical support team. This involves incorporating the various files (videos, data) into the IREAL database.

When the integration is complete, information is sent to the test designer and the operator (in this case, Sofia COLOMA CHACON) in order to check the result and carry out user tests.

## 9.8 Review and corrections

### 9.8.1 Adding

Following the test designer's verification, a first need was identified:

- To facilitate the reading of the graphs by guiding the user through more ergonomic location

The test designer states the need to add an interactive image of the rover that allows, by clicking on a specific wheel, to highlight the corresponding graph.

Here, this option is not integrated in the platform's component library.

The technical team, IDEA, therefore proceeded to develop this interactive option.

The development is on schedule. The decision to wait until the end of the development or to keep the set dates is then up to the test designer and the test owner.

In this case, there was no opposition to extending the deadlines.

The technical team therefore proceeded with the development while waiting for the release.

The design of a new option is submitted to the IDEA team (ISAE-SUPAERO) so that it can be reused for other IREAL experiments and so that it can respect the standards and structures recommended in terms of UX Design.

### 9.8.2 Corrections

The main corrections are made by the test designer who re-specifies the correct wording for the various titles and scientific indications.

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Indeed, the syntactic approach is the sole responsibility of the test designer who has the scientific expertise of the test bench and the reading mode.

As far as the graphs are concerned, the difference between the effort and velocity curves on the same ordinate scale makes reading difficult.

A correction by differentiating the ordinate scale will be made.



9.9 Tests following corrections

Following the evolutions and corrections made, a second set of tests is entrusted to the test designer and the operator.

The aim is to test all possible scenarios to ensure that they are consistent with the experiment and its real-life observations in the laboratory.

9.10 Validation and publication

As a result of the reviews, a new feature to be developed has emerged: to allow zooming in on a part of a graph (in particular, here, for velocity curves whose fluctuations are not clearly apparent).

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This new functionality does not prevent the publication of the experiment as such. Nevertheless, the need has been raised in the technical team's features. When its development is finalized and completed, it will be added to the published experience.

The decision to publish is mainly the responsibility of the test owner (in advised cooperation with the test designer and the IDEA team of ISAE-SUPAERO)

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## 10 ANNEXES

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## Annex 1 -- Assignment of contact persons

Role	Person n°1			Person n°2			Person n°3		
	Sur-name	Firstname	Institute	Sur-name	Firstname	Institute.	Sur-name	Firstname	Institute.
<b>Test Owner</b>									
<b>Test Designer</b>									
<b>Test operator</b>									
<b>Integrator</b>									
<b>IDEA Support</b>									
<b>Teacher</b>									
<b>Learner</b>									
<b>Coordinator</b>									

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## Annex 2 – IREAL Convention – Input parameters

Name of variable	Label in English	Context sensitive help	Unit of measurement	Possible values	Minimum and maximum values	Interval

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Note: attach files (images, text, other ...) if necessary

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### Annex 3 – IREAL Convention – Output components

Name of component	Type of display (video, curve graph, gauge, table, other ...)	Label of component (in English)	Context sensitive help	List of data to be displayed

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--	--	--	--	--

Note: attach files (images, text, screenshots, other ...) if necessary

#### Annex 4 –IREAL Convention – Data display components

Name of component	List of data integrated in the component	Stream source file	Label of data (in English)	Legend of data (in English)

Name of component	List of data integrated in the component	Stream source file	Label of data (in English)	Legend of data (in English)

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Note: attach files (images, text, screenshots, other ...) if necessary

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## Annex 5 – IREAL Convention – Observation control component

Function	Default model	Customised model	Customised value
<b>REPLAY</b>	<input type="checkbox"/>	<i>Not available</i>	<i>Not available</i>
<b>STOP</b>	<input type="checkbox"/>	<i>Not available</i>	<i>Not available</i>
<b>PAUSE</b>	<input type="checkbox"/>	<i>Not available</i>	<i>Not available</i>
<b>BACKWARD</b>	<input type="checkbox"/>	<input type="checkbox"/>	
<b>FORWARD</b>	<input type="checkbox"/>	<input type="checkbox"/>	
<b>SPEED</b>	<input type="checkbox"/>	<input type="checkbox"/>	

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