



# SPARK

D3.4

SPARK PLATFORM –

V.3

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## I EXECUTIVE SUMMARY

The SPARK platform is a responsive and intuitive ICT tool that exploits the potential of Spatial Augmented Reality (SAR) to foster the collaboration among designers and stakeholders (e.g. clients, end-users) during the conception of new ideas, especially in the fields of product interface and packaging design.

This deliverable proposes an overview of the functionalities provided by the third and last release of the SPARK platform implemented during the tasks of WP3. Further details, also related to the technical implementations, are included in the deliverables 3.2 and 3.3.

The document has been structured as a user guide following the workflow required to install, calibrate and run each component of the platform. After a brief description of the components constituting the SPARK platform, the preparation of the session has been described in detail by defining all the elements needed to start a design session. Then, all functionalities are illustrated through a series of explicative images.



## 2 INTRODUCTION

The SPARK platform is mainly composed of two modules:

- the Spatial Augmented Reality (SAR) module – is a system used during the collaborative creative session (i.e. the co-design session) where all the users have the possibility to interact with the digital contents (i.e. images, textures, fonts and 3D models) projected onto the surface of a white physical object (mixed prototype).
- the Information System (IS) module – is a management tool based on web technologies used for the preparation of the co-design session where the digital contents are stored and all the modifications performed during the session activities are recorded in real time and shared online or for a post-session review.

The aim of this deliverable is to provide a brief and effective user's manual for the correct installation and use of the SPARK platform. No technical descriptions related to the implementation and functioning are added. Conversely, the document includes significant images<sup>1</sup> that help also non-expert users to follow the workflow needed to start a co-design session with the SPARK platform. The document is organised as described in the following:

- Section 3 describes the main components of the SPARK platform.
- Section 4 illustrates how to install and calibrate the components of the SAR module (projectors, tracking system, interaction system and SAR software).
- Section 5 illustrates how to prepare the digital contents (images, textures and 3D models), the physical prototype and administrate a co-design session with SPARK.
- Section 6 illustrates how to use and interact with the two modules of the SPARK platform (IS and SAR) before and during the co-design session.
- Section 7 illustrates the reporting tool integrated into the SPARK platform.

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<sup>1</sup> Some of the pictures have been post processed to better display the results of the projection.



### 3 SPARK PLATFORM

The SPARK platform is composed of several components, which can vary according to the devices installed in the room where the session is taking place. This section describes the different components that contribute to the execution of a co-design session.

Figure 1 shows the architecture of all the components that interact during a co-design session.

The design session is prepared using a web application running on the IS Server, where all the related resources are uploaded. Inside the room of the co-design session, a PC controls the projection, the tracking system and the interaction device. The number of the projectors can vary, even if a single projector is sufficient to run a session. The tracker allows monitoring the position of the mixed prototype, which can be handled by the user during the design session. Finally, the interaction device, (i.e. tablet, wide touch screen or mouse with monitor) enables the user to modify in real time the information projected on the mixed prototype.

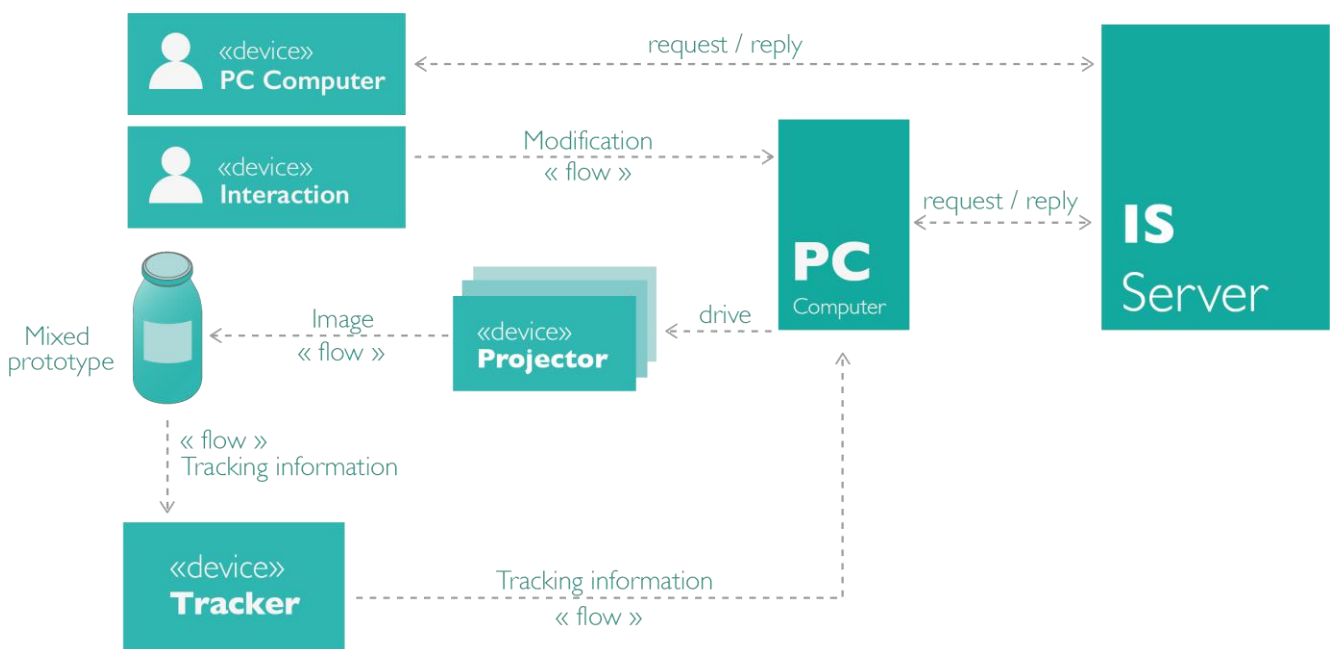


Figure 1: SPARK platform architecture



## 4 SAR MODULE PREPARATION

The main devices of the SAR module are projectors and tracking system, which should be calibrated once the setup of the room has been defined. Although this initial procedure is time-consuming, it is required only for the first setup or if one of these devices is moved. Since it has a great impact on the output in terms of rendering quality and overlay precision, it is fundamental to obtain adequate results in each step of the calibration procedure. Some “checkpoints” have been introduced to help the user within the calibration workflow. However, at the end of the procedure, the user can perform some manual adjustments for the final fine-tuning.

### 4.1 ROOM SETUP

One of the main advantages of the SPARK platform is its adaptability to different use conditions. All the components of the SAR module (projection, tracking and interaction) can be scaled or modified. This means that:

- Number of projectors can be customised from one to N;
- Position and orientation of the projectors can be adapted in order to have a complete or partial overlap of the working area. The first case allows increasing the surface area of the mixed prototype covered by projection, while the second extends the projection area and therefore the working volume;
- The tracking device can be scaled from an array of independent cameras to a single bar with pre-calibrated and fixed-attached cameras;
- The tracking system can be deactivated to reduce the complexity of the platform and therefore the time required for the preparation of the SAR session;
- Interaction metaphor can be changed from multi-touch gestures to a traditional mouse;
- The interface can be scaled to different devices, resolutions and aspect ratios; it is possible to move from a small and efficient tablet to a wider and more collaborative touchscreen.



This section describes some configurations of the SPARK platform installed at the partners' premises during the development activities. Figure 2 shows two similar setups installed at Politecnico di Milano (POLIMI) and at Grenoble Institute of Technology (GINP). Multi-projection includes two projectors



Figure 2: SPARK platform installed in controlled environment: Politecnico di Milano (PoliMi, top), Grenoble Institute of Technology (GINP, bottom)



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Figure 3: SPARK platform installed real operational environment: Artefice (Milano, left), Stimulo (Barcelona, right)

that point at the interaction area of the meeting table. The participants of the session can interact with the mixed prototype thanks to an array of IR cameras installed directly on the structure and can modify the digital projected contents by means of a tablet.

Slightly different is the SPARK installation at the premises of the design agencies (Figure 3): with the aim of simplifying the calibration process, a single tracking bar with three cameras substitutes the array of IR cameras. Two different devices have been integrated for the interaction: a wide touch screen for Artefice and a standard monitor-mouse for Stimulo. This choice has a relevant impact also on the disposition and engagement of the participants of the collaborative session, which are more focused on the interface in the first scenario and on the augmented prototypes in the second one.

## 4.2 PROJECTOR CALIBRATION

In a SAR system, projectors are used to wrap the external surface of the prototype with images that reproduce the exterior finishing of the real product. Their importance is strictly related to the quality of the visualization and the type of projector depends on the setup of the platform. During the development of the SPARK platform, several types of projectors have been tested in order to



Figure 4: Comparison of different projectors used: Epson EB-5530U (left), Hitachi CP-WU8600 (middle), Barco F50- WQXGA (right).

(Source of the images [www.epson.it](http://www.epson.it), <http://www.hitachidigitalmedia.com>, [www.barco.com](http://www.barco.com))

understand the impact of each projector parameter on the final projection. In Figure 4, the three projectors used for the installation of the SPARK platforms are presented in ascending order according to the cost and therefore the quality of the projected image. The aspects, which should be taken into consideration to choose the right projector, are:

- Sensor technology – DLP projector ensures a low visibility of the pixels borders and a higher contrast; LCD projector has a richer colour dynamic in ambient light and avoids any “rainbow effect” on the projected images. To increase the colour rendering, a colour calibration procedure has been developed. This procedure is able to calculate a compensated input signal to obtain a projection that is the closest to the real reference colour.
- Lens throw distance – it measures the ratio of the distance from the lens to the screen (throw) and the screen width; it is important to have a lens that, depending on the position of the projector inside the platform, ensures a projection area of 1x1 meters at least. Increasing this space means increasing the dimension of the pixels projected onto the physical prototype (lower resolution of the images).
- Brightness (Lumens) – it measures the intensity of the projection light. Due to the limited area of projection, it is not required a very high value of brightness and often projectors are used in eco mode for those setups with a reduced ambient lighting.
- Resolution – It measures the number of pixels of the projected images and for this reason the greater the resolution the higher is the picture quality. A good rendering of the augmented prototype is ensured with projectors with a resolution equal to or higher than 1920x1080 pixels.

To calibrate the projectors used inside the SPARK platform, standard RGB cameras (webcam), which are mounted in a fixed position directly onto the external case of the projectors, are used. This task is

required for each projector and needs to be repeated only if some modifications of the projector cone occur (e.g. position of the projector, in/out zooming, lens shifting, etc.).

The algorithm adopted is based on structured light and it allows extracting the intrinsic and extrinsic parameters of the projector (i.e. the shape of the projection cone and its position/orientation). The software<sup>2</sup> automatically projects and captures a set of patterns, whose number depends on the resolution of the projector, on a pre-printed chessboard (Figure 5). At least three sets of images are necessary in order to obtain the results with a sufficient accuracy. It is important to change the position of the chessboard between the three sets by taking in consideration that: the projected image should cover the entire printed target, the camera should recognise easily the corner of the target, the camera settings should allow capturing high and low-brightness conditions.

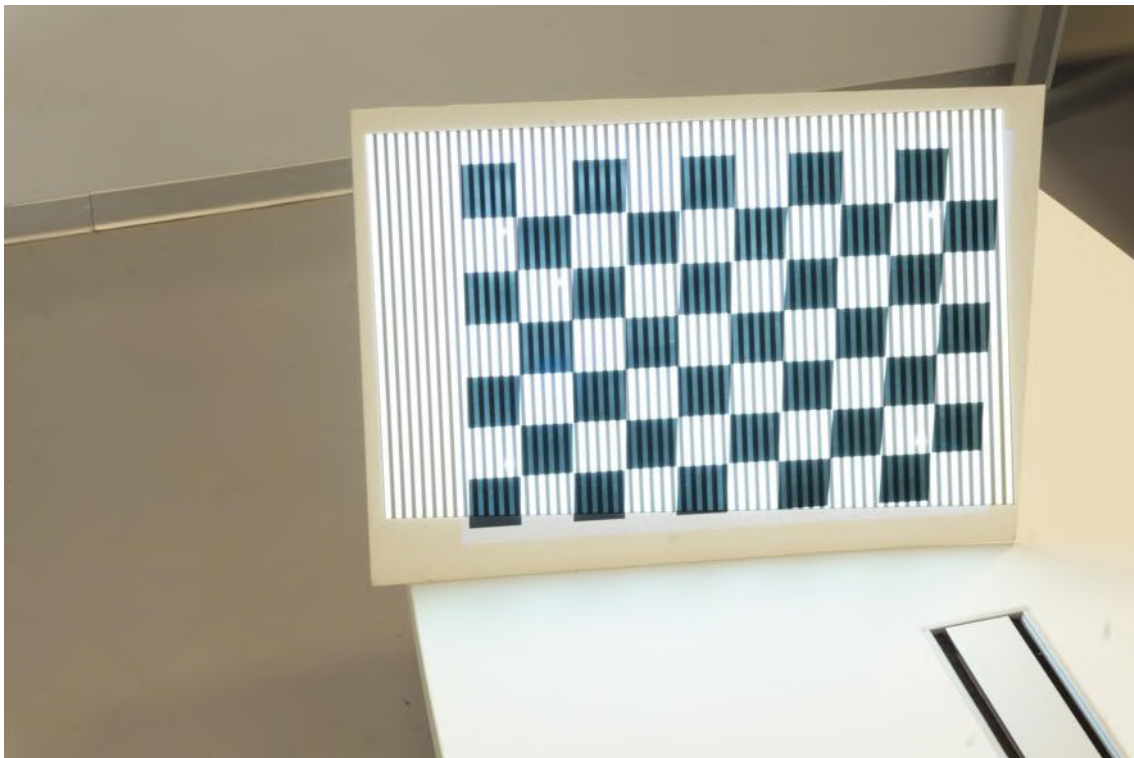


Figure 5: Image taken during the calibration of a camera-projector system by means of the structured light algorithm

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<sup>2</sup> D. Moreno and G. Taubin, "Simple, Accurate, and Robust Projector-Camera Calibration" in *Proceedings of Second International Conference on 3D Imaging, Modeling, Processing, Visualization & Transmission*, 2012, pp. 464-471

At the end of the process it is possible to check the results thanks to an additional software tool developed within the project. This tool (Figure 6) dynamically projects a red rectangle on the target, which corners should match with the internal corners of the chessboard. The user has to check that the projected red rectangle follows the position and orientation of the target.

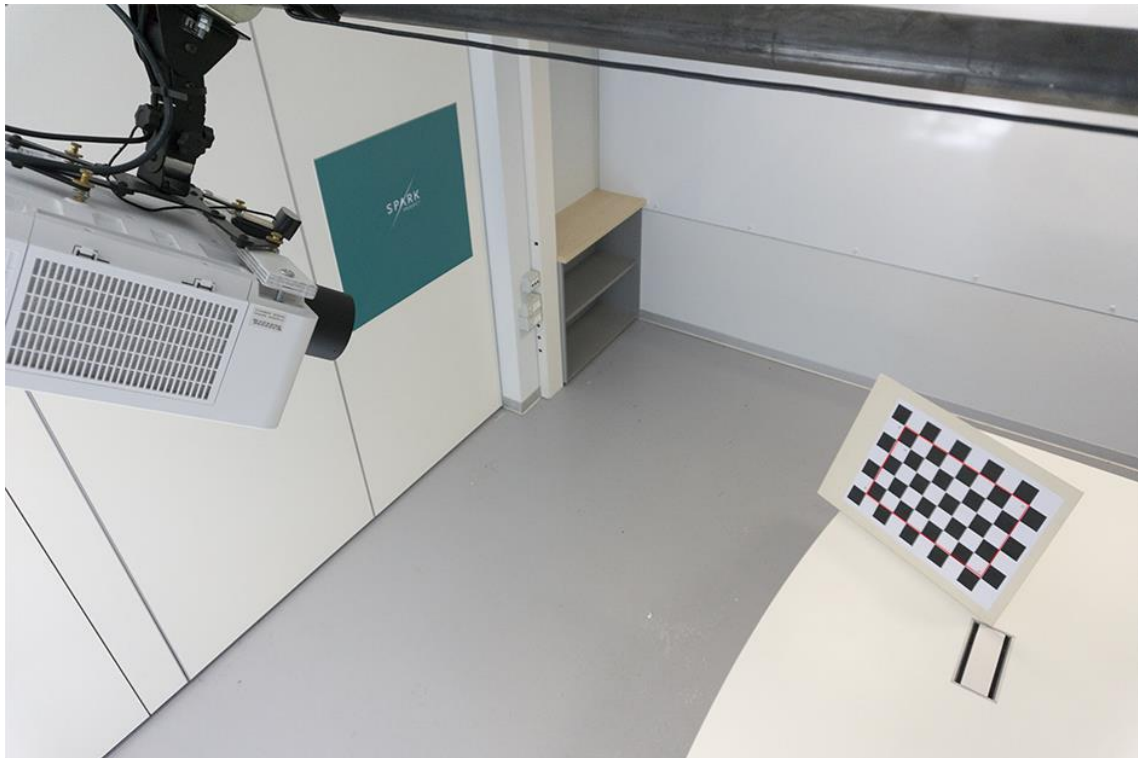


Figure 6: Calibration result control for a single camera-projector system

### 4.3 TRACKING SYSTEM CALIBRATION

The calibration of the tracking system depends on the chosen device. During the development of the platform, two different OptiTrack devices (Figure 7):



Figure 7: The two different tracking devices: array of individual IR cameras (left) and single bar of three IR cameras (right). (Source of the images <http://www.optitrack.com/hardware>)



- An array of Flex 3 IR cameras;
- The VI20:Trio device (3 fixed IR cameras on a bar).

The former solution is more complex to be installed since each camera should be fixed individually and serially connected with the others. In addition, they require an initial calibration, which is performed with the software managing the cameras. The main advantage of this option, which strictly depends on the number and the disposition of the cameras, is the larger tracking volume, the increased precision and stability of the tracking and the reduced risk of occlusions. The latter solution, instead, ensures a better portability of the system and a faster installation procedure. On the other hand, it has stricter limitations on the tracking volume and on the manipulation of the mixed prototype.

Once the tracking system has been arranged with the desired configuration, it is necessary to define a common reference system with the camera-projector pairs. This is done by using the same chessboard described in Section 4.2 where 5 IR reflective markers are attached at specific positions. In Figure 8 this last step, performed using the Motive (proprietary software of OptiTrack), is visible with the final digital reconstruction of 6 IR cameras with respect to the local reference system (centred with the corners of the chessboard).

A second software tool has been developed within the SPARK project to automatically transform the reference system of each projector (centred on the camera) with the one adopted in Motive (centred on the chessboard).

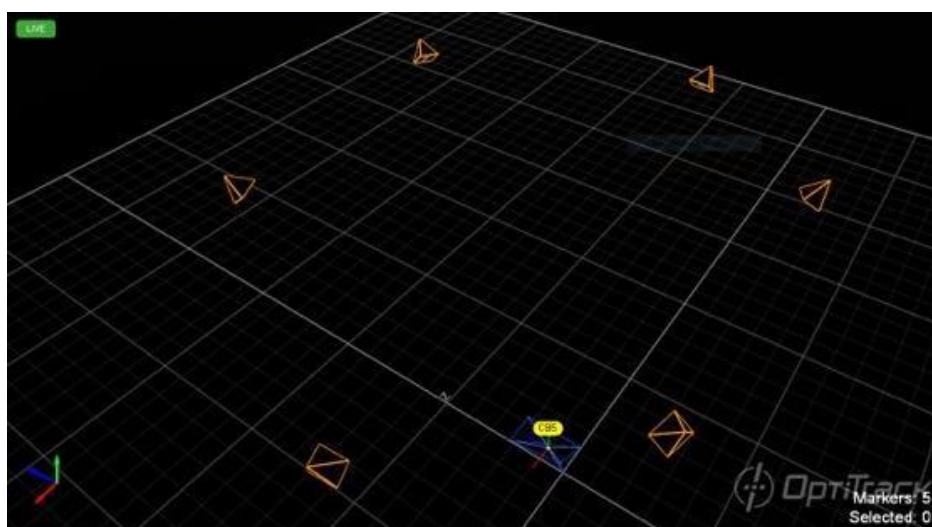


Figure 8: Screenshot of Motive (OptiTrack) with the view of the results after the calibration of 6 single IR cameras and the definition of the ground plane



## 4.4 MULTI-PROJECTION CALIBRATION

Once all the projectors used inside the SPARK platform are calibrated, two files, with the intrinsic and extrinsic parameters of the projectors, are obtained. The user can now open the SPARK application and set the multi-projectors parameters by using the projector panel (Figure 9 left). First, he has to choose the number of projectors and then he has to choose, for each of them, the relative calibration information from a list of pre-loaded data. In case of a new setup, the user can use a secondary panel (Figure 9 right) in order to link the files by means of the location path or simply by copying and pasting their contents. Thanks to this approach, all the data, as well as the selections, are saved inside the configuration file of the application and therefore they are always available at the beginning of the session.



Figure 9: Definition of the multi-projection setup (left) and creation of a new calibrated projector (right)

## 5 SESSION PREPARATION

In order to run a design session with the SPARK platform, digital and physical contents need to be prepared in advance. Digital contents, called 'assets', include 3D models of the objects for the design session, images, textures and fonts. These contents are visualized on the physical prototype and they can be modified in real time. In this section, both the preparation of the digital and physical contents are described in detail.

### 5.1 ASSETS

The 3D models used in the SPARK platform are meshes in the standard OBJ format. The shape of the 3D model should be as much as possible consistent with the shape of the physical prototype to ensure

a good alignment between the two versions of the prototype. The 3D models can be generated with any 3D or CAD software, which supports the OBJ file format. The level of detail of the 3D model should be limited to its surface; the internal technical details of the product are not necessary to run a SPARK design session. In addition, some elements characterizing the external finishing of the prototype can be simulated with textures or images. The last step, before importing the 3D model in the SPARK platform, is to generate its UV map.

This operation, which has been widely illustrated in the Deliverable 3.2, is necessary to display and modify each asset applied to the 3D model surface.

Images and textures can be created by using standard software, such as Adobe Illustrator and Photoshop, and, subsequently, they have to be converted in PNG format. Images usually include photos, brand logos and illustrations while textures are special images to simulate different types of finishes.

## 5.2 PROTOTYPE PREPARATION

The physical prototype is the tangible representation of the 3D model previously generated. Its shape should be coincident with the 3D model and it can be produced with different techniques and materials. Objects with soft and deformable shapes are currently not suitable for the SPARK platform. Starting from the 3D file, the prototype can be 3D printed or alternatively built with traditional prototyping procedures. In some cases (i.e. packaging design), existing products can be directly used as prototypes. In all cases, the external appearance of the prototype should be matte white painted to ensure a correct visualization of the projection. The surface of the prototype should be as smooth as possible to ensure a good visualization of the projected images and to avoid any visible defects. The physical prototype together with the projection creates the so-called ‘mixed prototype’.

The mixed prototype during the design session can be handled by the participants and thanks to the tracking system described in section 4.3 the projected view follows the movement of the prototype. To enable the tracking, the prototype has to be equipped with a set of spherical or hemispherical markers. Figure 10 shows some example of prototypes, fully prepared for design sessions. Markers should be placed arbitrarily on the most visible surface of the prototype and should be arranged in order to ensure a good recognisability by the tracking system. Their size can vary; small markers can be placed on the top surface of the object without interfering with the projection on the mixed prototype, while bigger markers need a dedicated structure to hold them together.



Figure 10: Physical prototypes prepared for the SPARK platform

### 5.3 ARTEFACT CALIBRATION

The calibration of the artefact is required each time a new prototype is added or when the shape of the 3D model is modified. This procedure allows aligning the virtual model with the physical one, which is tracked according to the constellation of the IR markers attached to it.

Once the prototype is ready, according to the recommendations of section 5.2, it should be placed inside the working volume of the tracking system to make all the markers visible. In addition, it is important aligning the physical prototype with the chessboard in order to have the same orientation of the reference system of the 3D model. After that, a new rigid body can be created inside Motive (Figure 11) by selecting all the points that correspond to a single constellation. Each rigid body must have a different identifier, especially if they should be used together in a single session.

To export the artefact calibration parameters is used an external tool that is able to read the data streaming from Motive. This software automatically extracts the rotational matrix to compute the orientation of artefact with respect to the projectors.

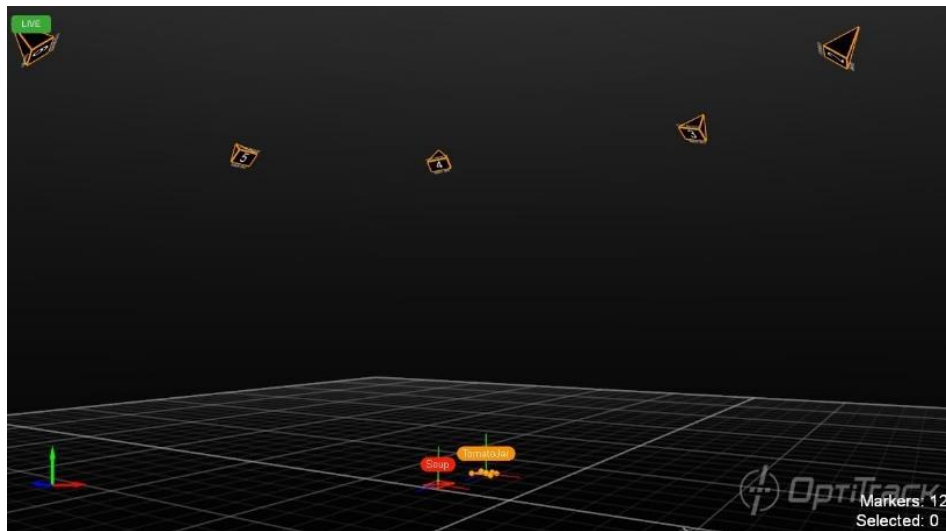


Figure 11: Generation of a rigid body for the prototype tracking inside Motive (OptiTrack)

At this point, it is possible to upload the obtained information inside the SPARK application. As for the multi-projection, the user has to link each prototype downloaded from the selected session to the relative calibration data (Figure 12 left). In case of a new artefact, a secondary panel (Figure 12 right) can be used to link the path of the calibration file, set the translational vector (only if the pivot in Motive does not correspond with the pivot of the 3D model) and specify the identifier of the rigid body. All these data, which are saved within the configuration file of the application, are necessary only if the tracking system is activated. A collaborative session, in fact, can be performed even without the possibility of manipulating the physical prototype. In this situation, it is required a manual adjustment of the projection to make it aligned with the static position of the prototype. Calibration of projectors and tracking system is not required too.



Figure 12: Definition of the artefact properties (left) and creation of a new calibrated artefact (right)

## 5.4 BLENDING TREATMENT

Having a perfect multi-projection alignment is difficult and the overlap region of two projectors turns out to be over lighted. For this reason, blending tools have been integrated to have a homogeneous surface rendering in a multi-projection configuration.



Figure 13: Standard blending with two projectors: A – right projector, B – left projector, C – Blending result

Two different approaches have been developed to correct this undesired effect:

- Standard Blending (Figure 13) – it reduces the intensity of the projection in the blending zone according to the weighted sum of each projector. By using two projectors, the blending zone will be reduced approximatively by 50% in each projector.
- Sharp Edge (Figure 14) – the projection is split on the two projectors; each projector displays part of the object without blending with the other one.

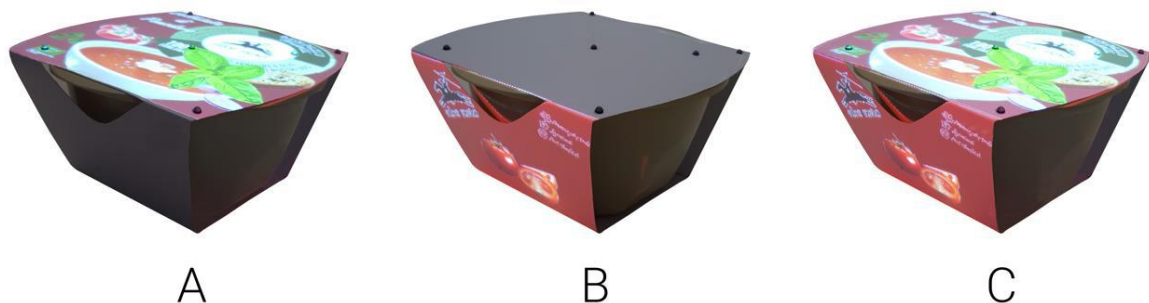


Figure 14: Sharp Edge with two projectors: A – right projector, B – left projector, C – Sharp edge result

Generally, it is recommended to select the Standard Blending mode with circular or cylindrical surfaces, and the Sharp Edge mode with shapes characterized by well-defined edges.

Two adjustment tools have been developed in order to control better the results of standard blending and sharp edge (Figure 15). The blending smoothing tool will reduce the defects in the background texture by using a slider to change a set point that filters colour heterogeneity. The blending exposition tool, instead, is an optional tool to control the exposition of the blending area.

The sharp edge tool is used to correct projectors conflict in sharp edge mode.

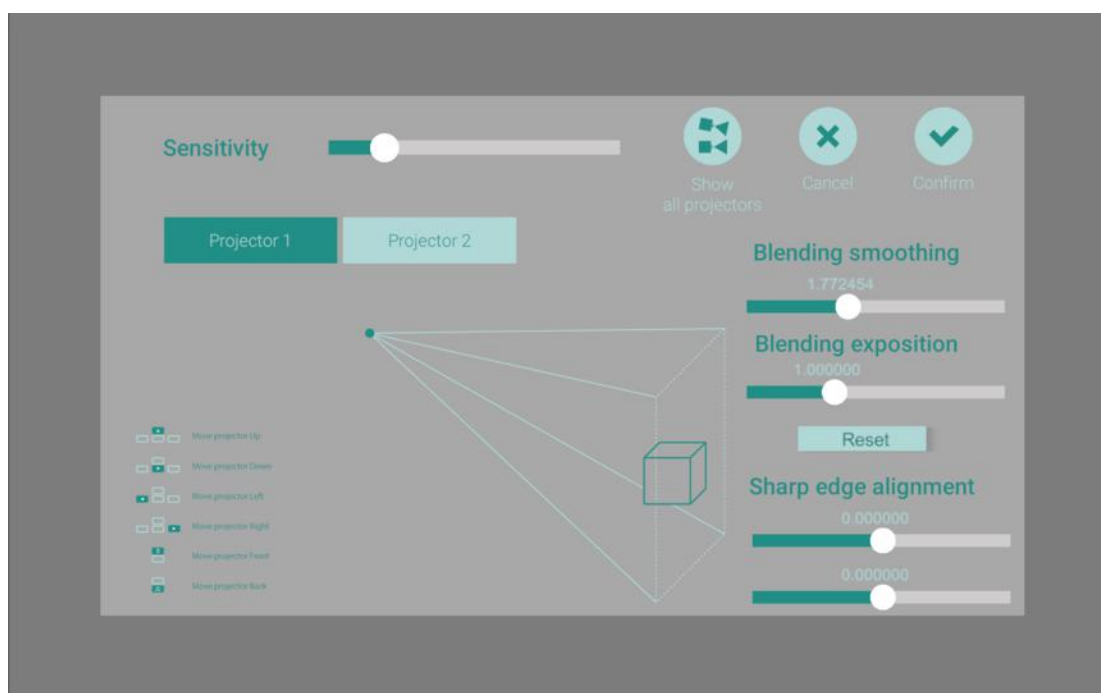


Figure 15: Interface showing the controls of blending smoothing and sharp edge alignment.

## 5.5 SESSION ADMINISTRATION

The creation of clients and products is essential to initialize a co-design session. A client can have different products and each product can include multiple sessions (Figure 16). A new session can be created on the IS in two different modalities:

- 1) Before starting the session from the product administration page: when a product is selected, a detailed view of the product is displayed showing the possibility to create a new session.
- 2) After the session from the prototype history page: by selecting a specific version of the prototype, which is used as a starting point to pursue different design ideas.



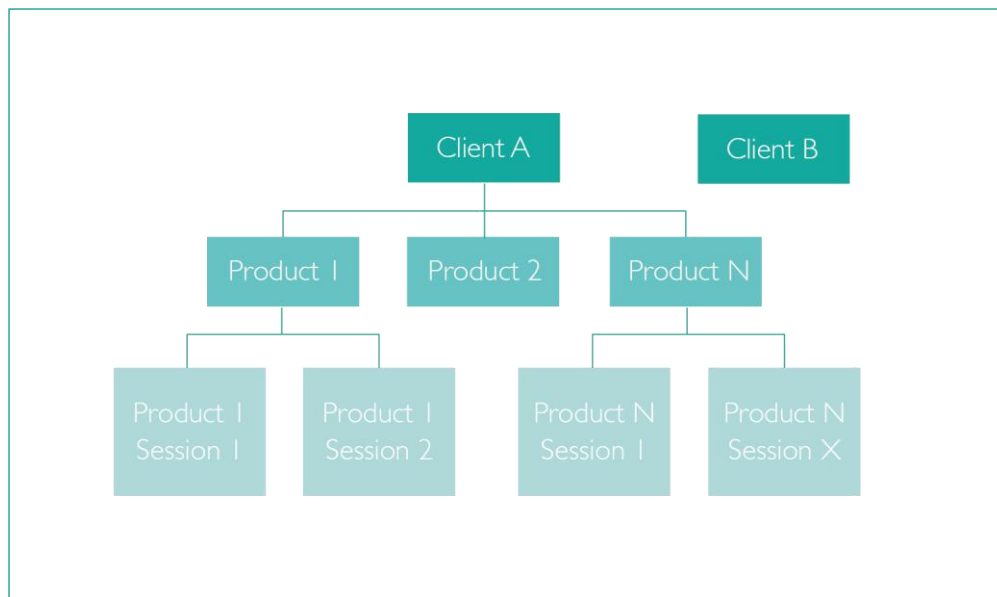


Figure 16: Hierarchical organisation of the co-design session

### 5.5.1 Session dashboard

Six panels compose the session dashboard (Figure 17):

- 1) *General Information*: contains information about the product and the client involved in the session, the planned date and time of the session, the location of the design session and a description of the session.
- 2) *Participants*: a list of the users linked to the session and their profile (*Leader, designer, attendee*). By default, the user creating the session is assigned the *Leader* profile.
- 3) *Tasks*: allows the user to create/edit new tasks and keep track of the number of tasks that should be done, in progress and done.
- 4) *Whiteboard*: allows the users to add posts, documents or notes to the session whiteboard.
- 5) *Assets*: allows the user to link assets, previously uploaded/added to the *asset library*, to the session.
- 6) *Prototypes*: allows the user to add 3D models of the products, which can be used during the session.

A user can navigate within the different panels by pressing the corresponding button. The user can also interact with the left menu of the dashboard to perform the same actions.

In the following, we will explain the steps needed to launch a session where all the participants of the co-design session can work.

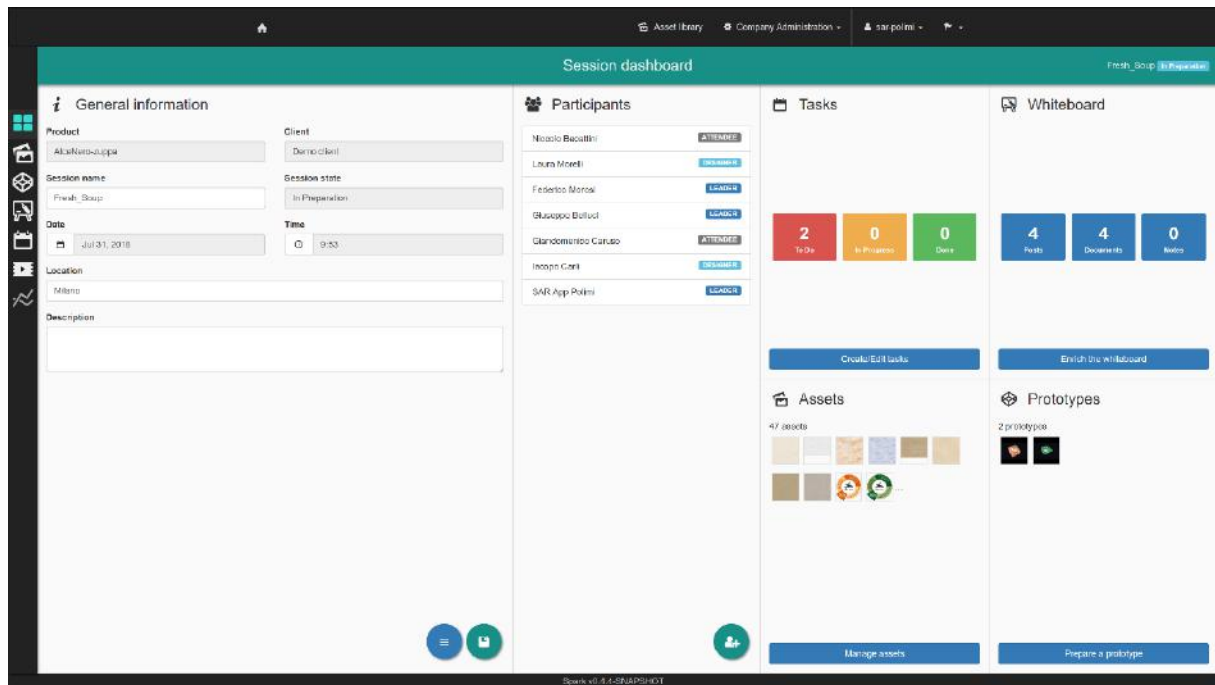


Figure 17: Session dashboard

### 5.5.2 Asset library

The asset library is the space where all the assets used across all co-design sessions, within the same company, are stored. It can be accessed, using the menu bar under the *Asset library* tab. Assets are organized in a structure that reproduces the hierarchical organization of the co-design sessions. Finally, for each product, assets are arranged in pre-defined types like images (.png format), 3D models (.obj format), textures (images used as background), animated objects (.gif format) and fonts (.ttf, .woff and .eot format). For each of these elements, there is a specific folder inside the asset library, which allows a better organization of the assets linked to the session.



Within each asset type, the user can upload new assets by clicking or dragging a new asset onto the drop zone, as shown in Figure 18. If the user drops in a new file, or a URL of a file, the file will be uploaded, and a new asset will be added to the library (under the corresponding client, product and asset type). If the user clicks on the drop zone, a window will open to allow the user to navigate within the file system of the computer.

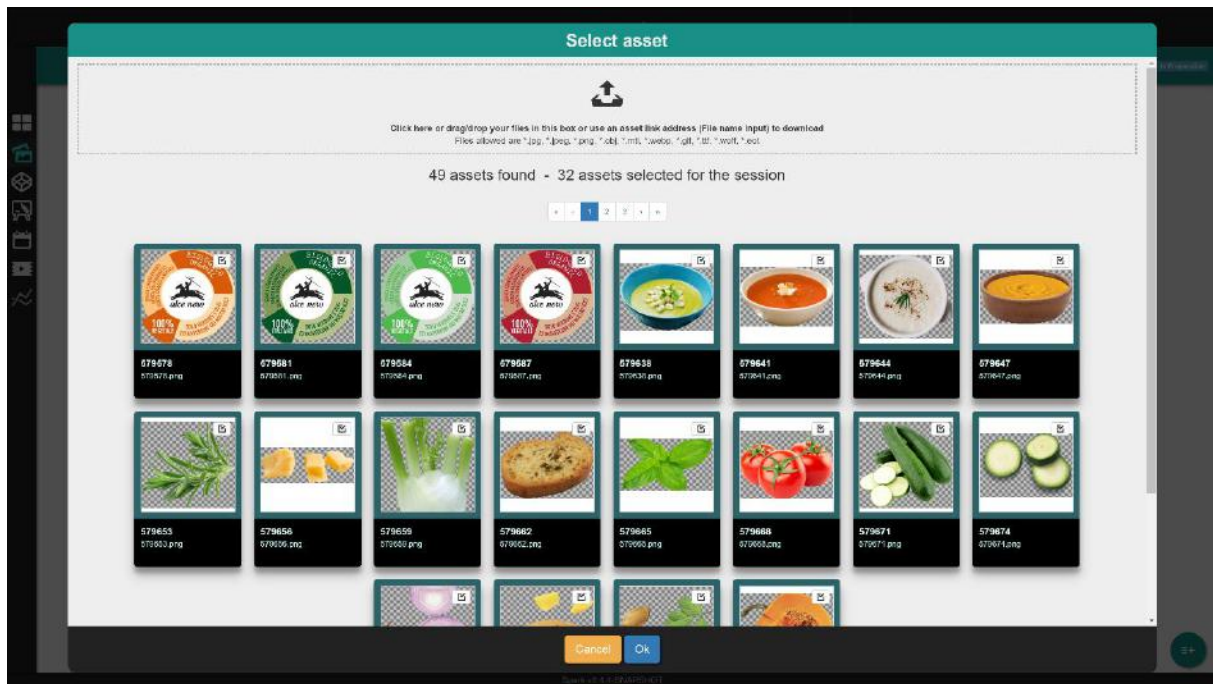


Figure 18: Assets (images) linked to the session

### 5.5.3 Prototypes of the session

Accessing the prototypes related to the session from the dashboard can be done by pressing the *Prepare a prototype* button (Figure 17). The user will be directed to the virtual prototypes related to the session (Figure 19).

To create a new prototype, the user has two options:

- 1) Click on the *Create a new prototype* thumbnail;
- 2) Click on the *plus* button on the bottom right side of the window.

After the selection, a window appears, enabling the user to select one of the 3D models, previously uploaded. For each added prototype, a thumbnail showing a preview of the prototype will be displayed. On each prototype thumbnail, a list of buttons can be pressed to allow the user to perform different actions: delete the added prototype, edit the prototype before starting the session, enable or disable the participants, who can make modifications on the prototype.

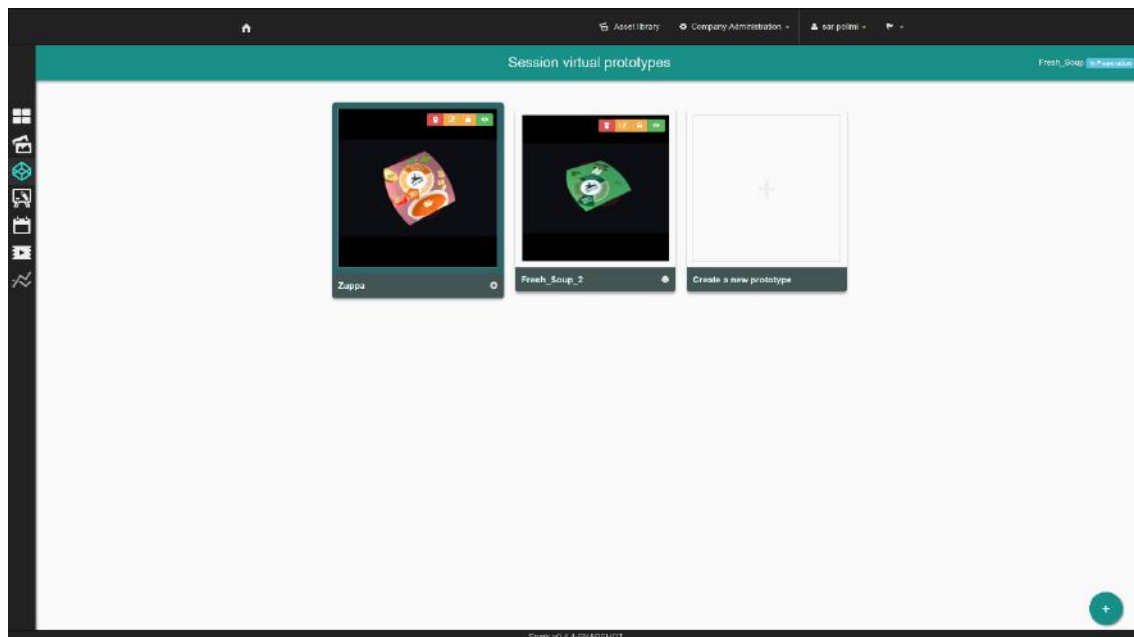


Figure 19: Virtual prototypes created for the current session

From the virtual prototype viewer (Figure 20) the user can do the following:

- 1) Enlarge the window for a better view;
- 2) Center the prototype model;
- 3) Save an image snapshot of the view;
- 4) Download a zip folder containing the object file and its texture.

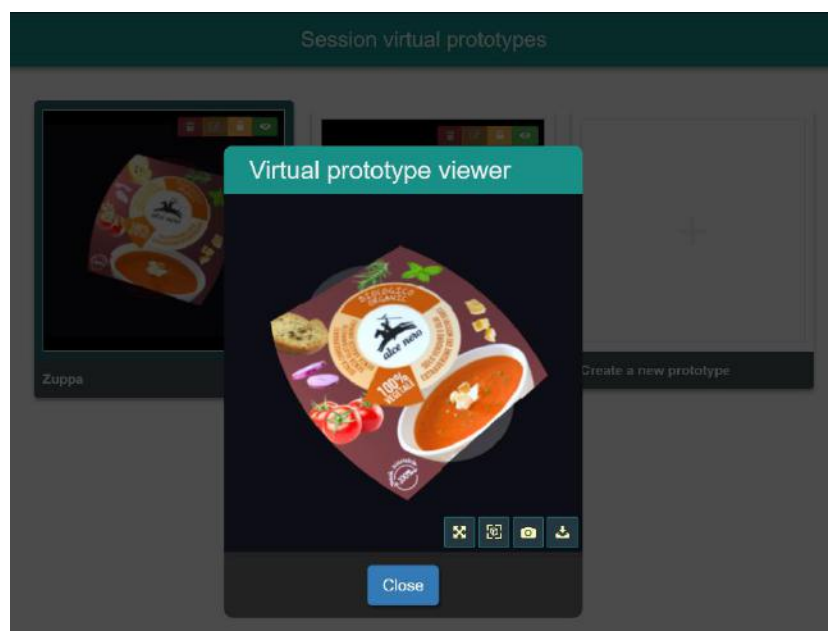


Figure 20: Virtual prototype viewer

### 5.5.4 Taskboard and Whiteboard

The IS includes also two areas, taskboard and whiteboard, to schedule tasks and to collect notes, posts and document generated during the co-design session.

Accessing the task board, from the dashboard of the session, can be done by pressing the *Create/Edit tasks* button (Figure 21 - left). Tasks are arranged by status: *To Do*, *In Progress* and *Done*. To create a new task the user can select the button that appears on the bottom right corner of the tasks board. By pressing the button, a window will be displayed. The form contained in the window has to be filled with the new task and related details. Once a new task is created, its status is turned on “*To Do*”.

Accessing the session whiteboard from the dashboard can be done by pressing the *Enrich the whiteboard* button. The user will be directed to the whiteboard view. On the whiteboard the user can do the following:

- 1) Add a note;
- 2) Add an asset post;
- 3) Add a prototype post;
- 4) Upload a document.

Similarly, to the tasks, items of the whiteboard can be viewed or deleted by pressing the corresponding button on the right side of each item. In addition, items of document, asset post and prototype post can be downloaded.

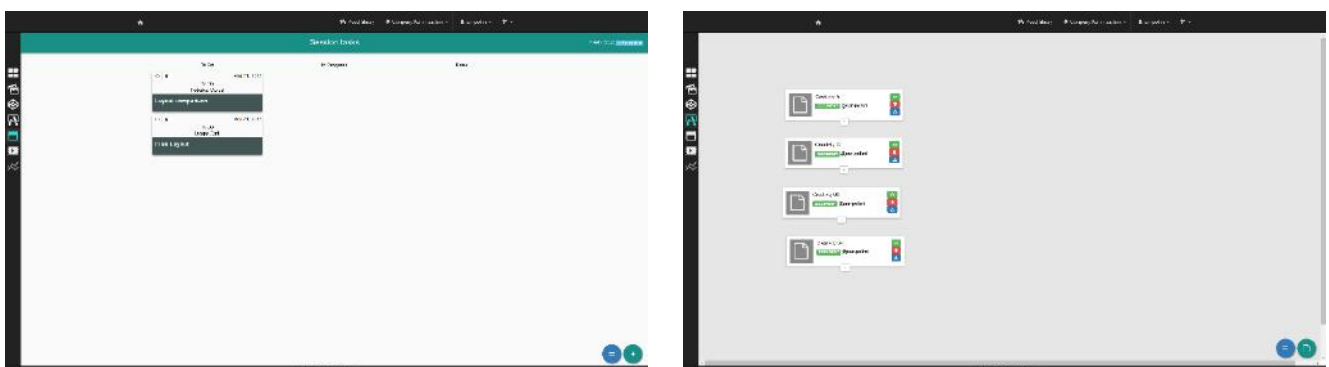


Figure 21: Panel for the management of the tasks (left) and the documents (right) of the session

## 6 SPARK PLATFORM AT WORK

Once the user has completed the upload of the assets and has prepared the prototypes, to be used within the session (they can be white or with an initial configuration), he has to change the state of the session in live mode. This is the only way to allow the SAR system to retrieve all the information related to a specific session.

### 6.1 INFORMATION SYSTEM: PROTOTYPE EDITING

The prototype editor view (Figure 22) is composed of a stage (centred in the middle of the page), which shows the 3D model of the prototype currently selected, and a floating left side action bar, which can be used to interact with the 3D object.

Two different panels are placed on the side of the screen from which the user can perform the following actions:



Figure 22: Interface for the editing of the virtual prototype (3D view) with the edition and prototype panel

- 1) Under the edition tab (left side of Figure 22), parts of the mesh can be selected. When a mesh is selected, the user can change its colour. In addition, the user can open a 2D canvas viewer by clicking on the 'Show 2D texture editor'. Using the canvas, the user can select images already present on the prototype mesh and perform all the transformations on them.



- 2) Under the images tab (left side of Figure 23), the user can choose from a list of assets linked to the session of type 'Images'. The user drags one image at a time, then while holding the selection maintained (by clicking on the left mouse button), he drops the selected image onto the 3D model of the prototype to apply it to its mesh. Under this tab, the user has also the possibility to link new assets to the session and even upload new assets to the asset library. This can be done by clicking on the 'Select or Upload more assets' button. On button click, a window similar to the one displayed on the session assets page will open and allow the user to upload and/or choose new assets. The same actions can be performed under the textures tab but for 'Textures' assets type.
- 3) Under the prototype tab (right side of Figure 22), the user accesses to a list of all versions that the 3D model generated during the design process. In addition, the user can switch to one of the other prototypes currently linked to the session.
- 4) Under the session tab (right side of Figure 23), the user accesses to all the information related to the session like any switch of the prototype, the completion of the task, the changes of the state of the session, etc.

All the actions involved in the manipulation of the 3D object mesh and of the assets applied on it can be mainly performed using the floating action bar appearing on the left-hand side of the 3D model. The possible actions can be grouped into three categories:

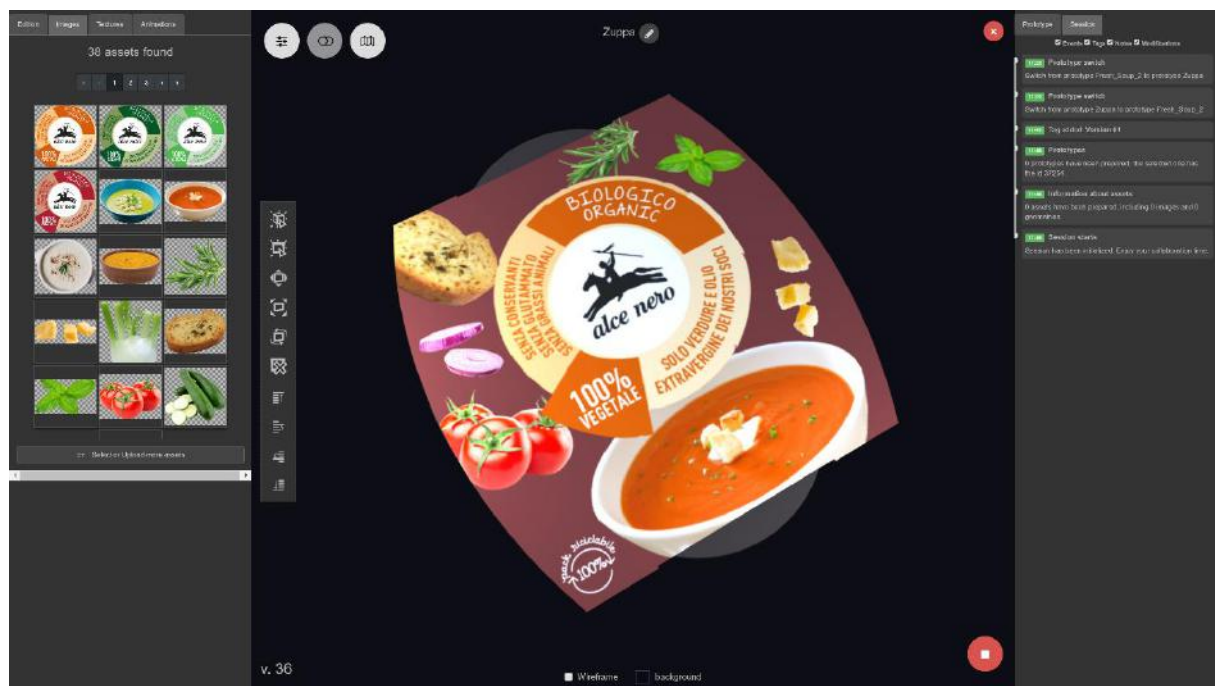


Figure 23: Interface for the editing of the virtual prototype (3D view) with the asset and session panels



1. Select and delete actions: the user can select a mesh, select an image placed on the 3D model or delete an image currently selected and present on the 3D model;
2. Interact with the images placed on the 3D model mesh: while an image on the mesh is selected, the user can apply multiple transformations on that image. The image can be translated over the 3D model mesh, the image can be rotated, and the image can be scaled. To apply a transformation on a different image, the user has to intentionally go into the 'select an image' mode to select a different image, then, once toggled, the user can apply transformations on the image;
3. Change the depth order on the image layer: while an image is selected, the user can change its depth by moving it to the foreground or push it to the background. The user can also place the image in front of another image on the mesh (forwards) or behind another image (backwards).

All the actions described above can be performed also by using the keyboard shortcuts available on the prototype editor view.

On the main panel, the user has also the possibility to switch onto the 2D view (Figure 24), which allows manipulating easily pictures without the toolbox. The user can click on an image, to select it, and can carry out the following manipulations: resize, rotate, translate, delete, change layer order.



Figure 24: Interface for the editing of the virtual prototype (2D view)

## 6.2 SAR MODULE: USER INTERACTION

This section illustrates in detail the functionalities of the user interaction with the mixed prototype. The interaction modality consists of multi-touch gestures on a touch screen device and in the manipulation of the mixed prototype. The Graphical User Interface (GUI) of the SAR module is adjustable and it can be used with different type of devices such as handheld tablet and wide touch screen, as shown in Figure 25. The usability of the tablet device has been tested within controlled design tasks and the results can be explored in Deliverable 5.2.

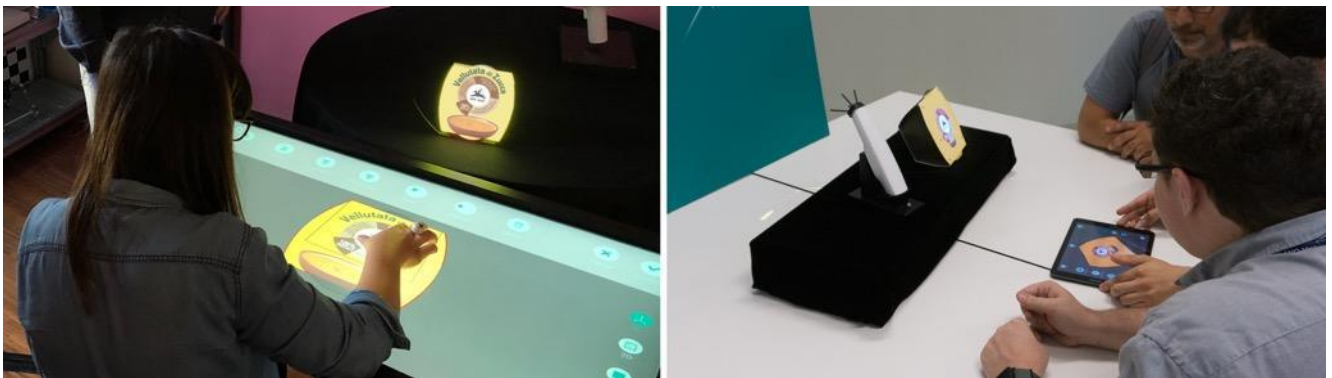


Figure 25: Interaction devices used in the SPARK platform. On the left the wide touch screen, on the right the tablet

At the beginning of design activities, the session, previously prepared on the Information System, is selected (Figure 26) and all the related assets are retrieved (i.e. 3D models, textures).

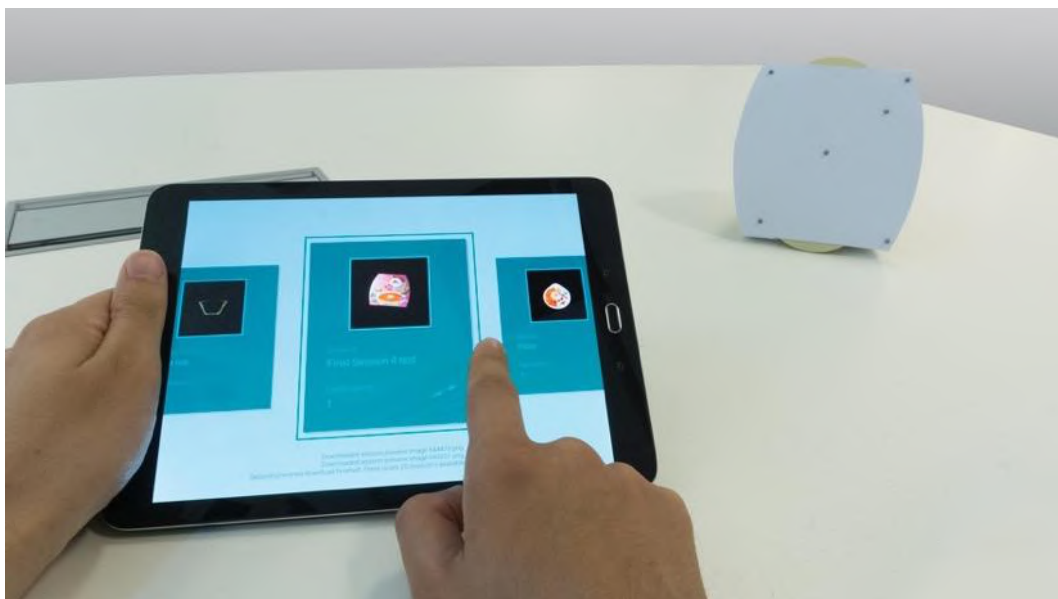


Figure 26: Selection of the session at the beginning of the design activities



The first prototype layout is displayed on the physical prototype, which is augmented thanks to the projection (Figure 27). The GUI displayed on the tablet, is composed by three main areas: the main functions menu, the contextual menu and the visualization menu.

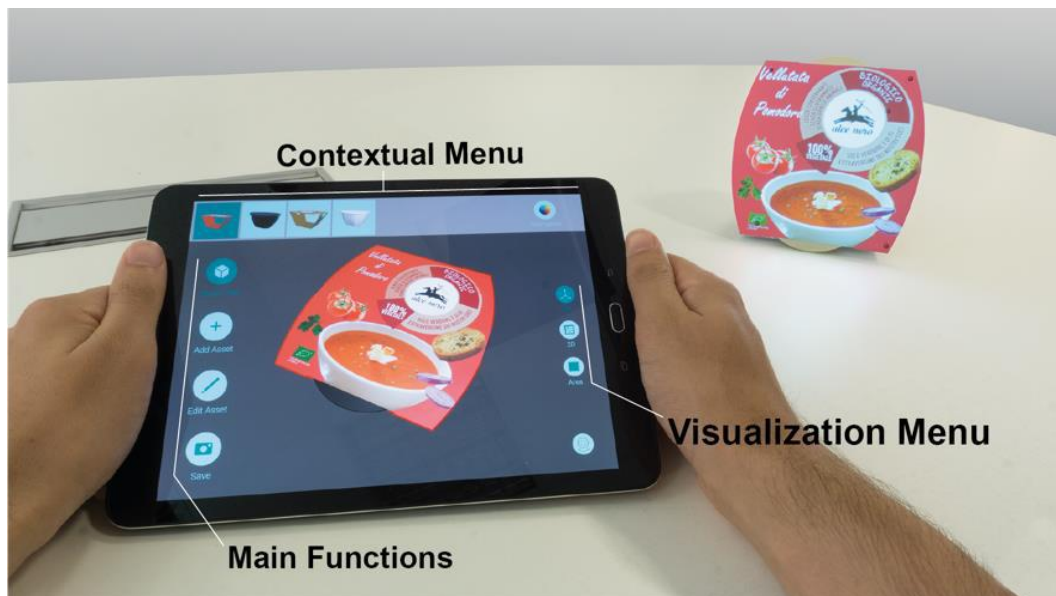


Figure 27: Tablet user interface and visualization on the mixed prototype

The main functions are listed on the left side of the screen: select a part of the prototype, add assets, edit assets and tag the current version of the mixed prototype on the Information System (Save). 'Select part' opens the top contextual menu and it enables the selection of a single part of the prototype and the switching between variants of the same prototype (Figure 28). In the same menu,

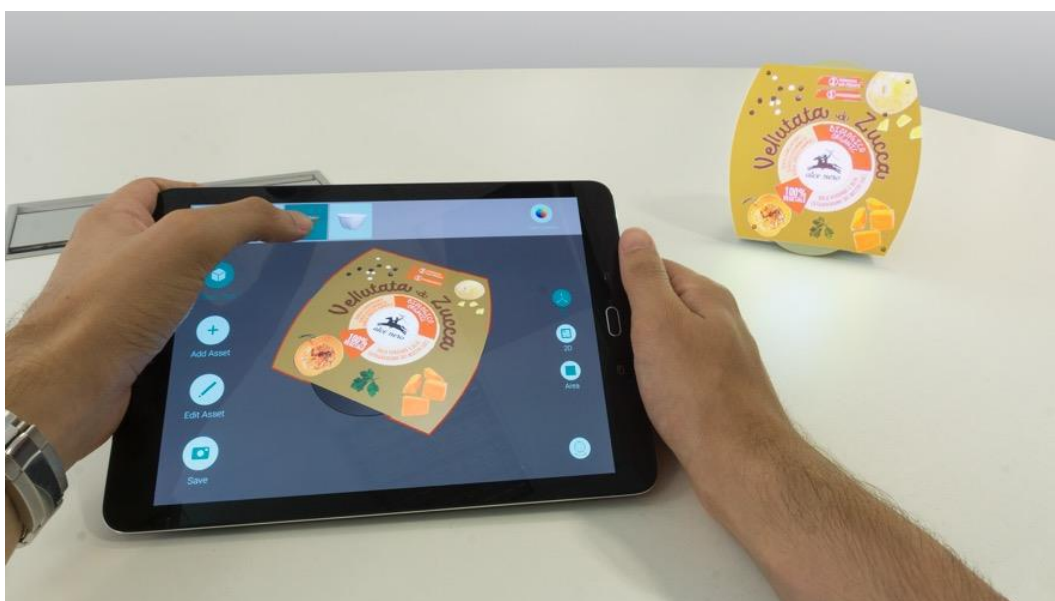


Figure 28: Selection of different part composing the prototype and between different version of the same prototype



different prototypes are visible, if expected for the selected design session. Once a part is selected, its colour can be modified and displayed in real time on the tablet and on the mixed prototype by opening the colour palette on the top right side of the screen (Figure 29).

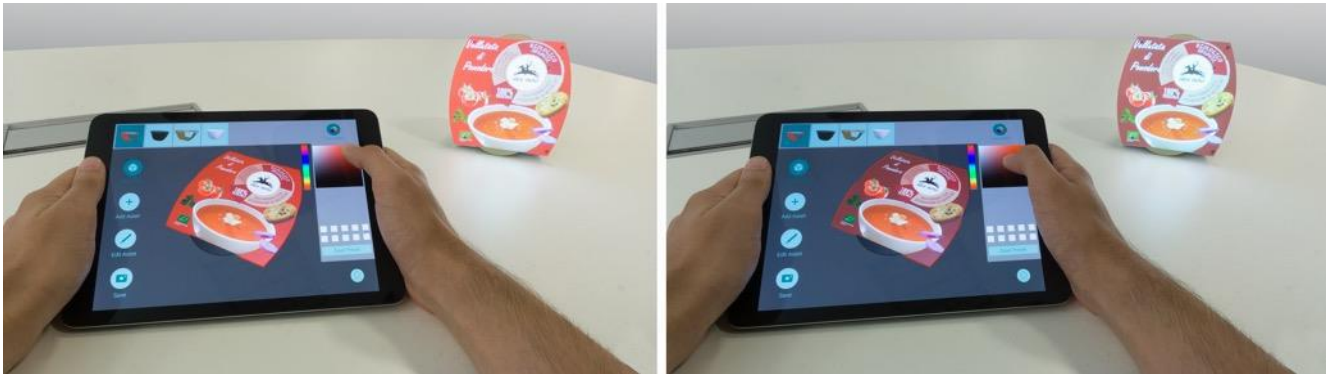


Figure 29: Modification of the mixed prototype colour. On the left before and on the right after the change

'Add asset' opens the library on the top contextual menu (Figure 30). All the assets, which are available in the session, can be explored by scrolling horizontally with a single finger. To add an asset, first the user taps on the image in the library, a selection feedback shows the successful selection, and second, he touches a point on the 3D visualisation of the prototype.

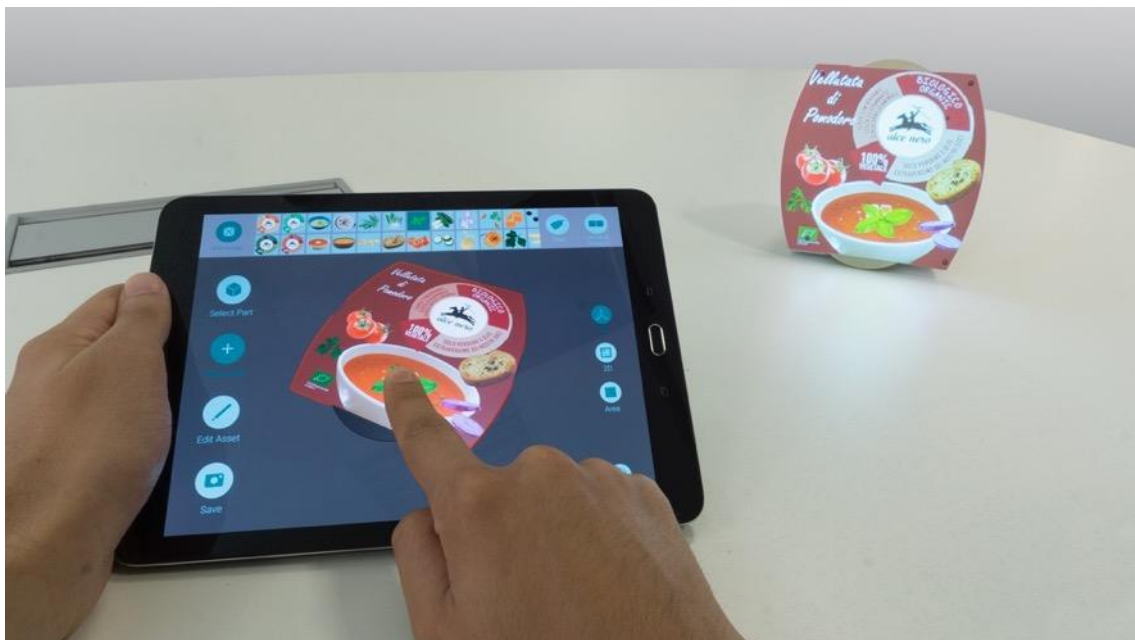


Figure 30: Add an asset. The user touch on the 3D model on the tablet and the asset is added on the mixed prototype

The asset is now displayed on the tablet 3D view and at the same time on the mixed prototype, by dragging a single finger it can be shifted around (Figure 31 - left), by pinching two fingers it can be scaled and by rotating them its orientation can be modified (Figure 31 - right).

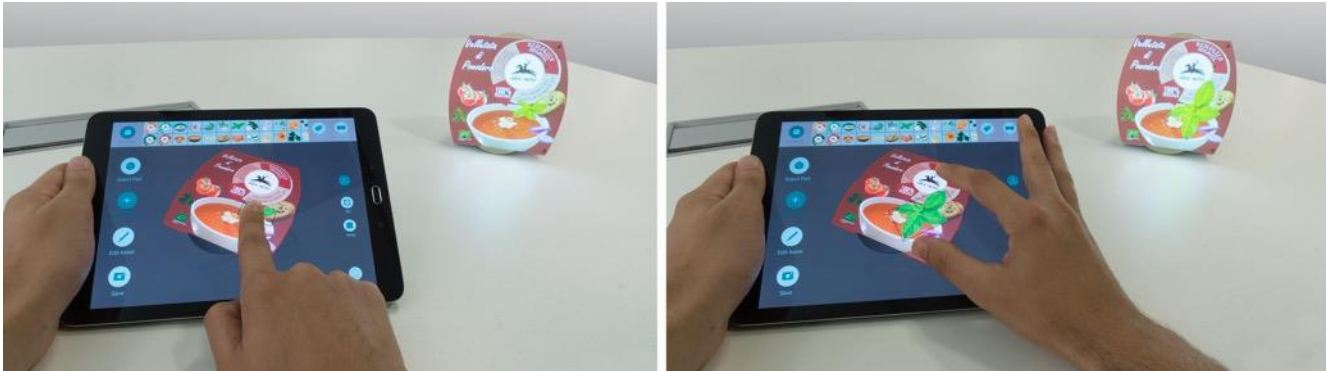


Figure 31: On the left, the asset position is changed by dragging a single finger. On the right, the orientation and scale of the assets is changed by using two fingers

It is also possible to select and edit other assets that are already present in the layout. If multiple assets are layered on the top of each other, a pop-up window shows their preview (Figure 32).

'Edit asset' opens on the top contextual menu a scrolling panel with the preview of all the assets already

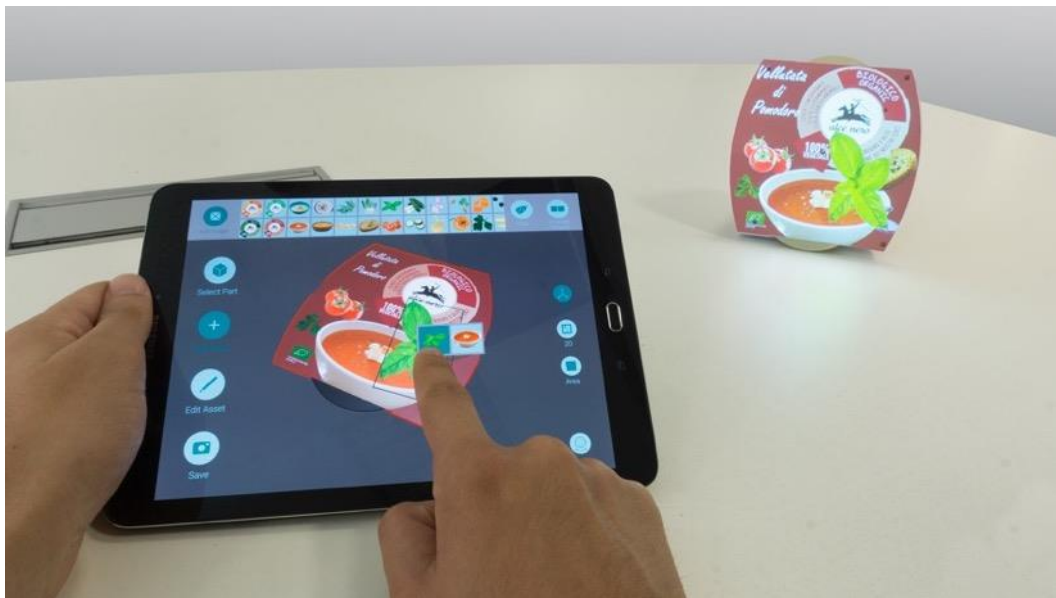


Figure 32: Selection of layered assets

placed on the selected part of the prototype. To modify an asset the user needs to select it by touching its preview in the top panel or by tapping directly on it in the 3D view (Figure 33). After the asset has been selected, it can be modified using multi-touch gestures as previously illustrated in Figure 31.

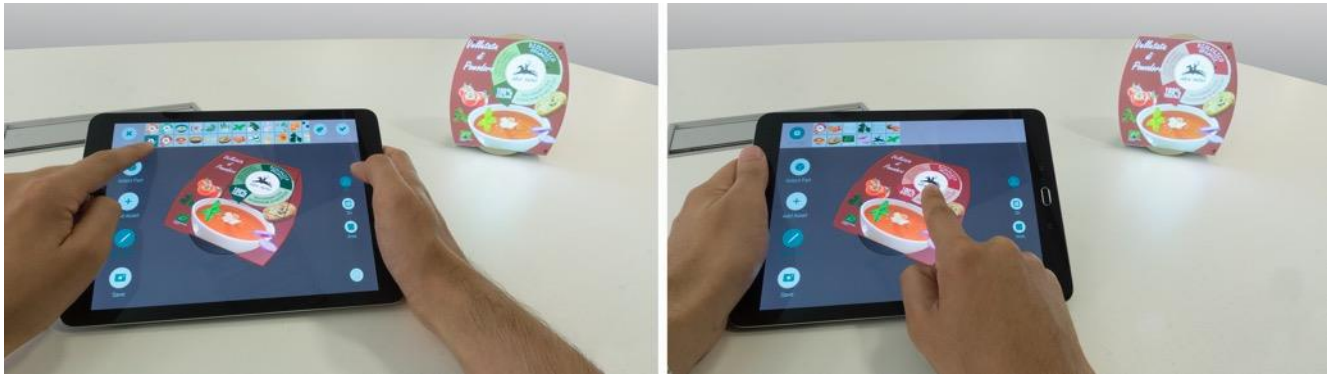


Figure 33: Selection of the asset to edit: from the top menu (left), directly from the 3D view (right)

Other modifications (i.e. change of layer, asset replacement, delete) can be performed by activating them in the top contextual menu, which appears after the asset selection (Figure 34).

Three different interaction modalities are available, and they can be enabled by the user at any phase of the design activities. The visualization menu on the right side of the GUI shows three buttons, one for each modality. The first one is called '3D View' (Figure 34), it displays the 3D model of the prototype. This can be oriented and explored from different point of views by dragging a single finger or zoomed by pinching two fingers; the user makes all the modifications interacting directly with the 3D model surfaces.

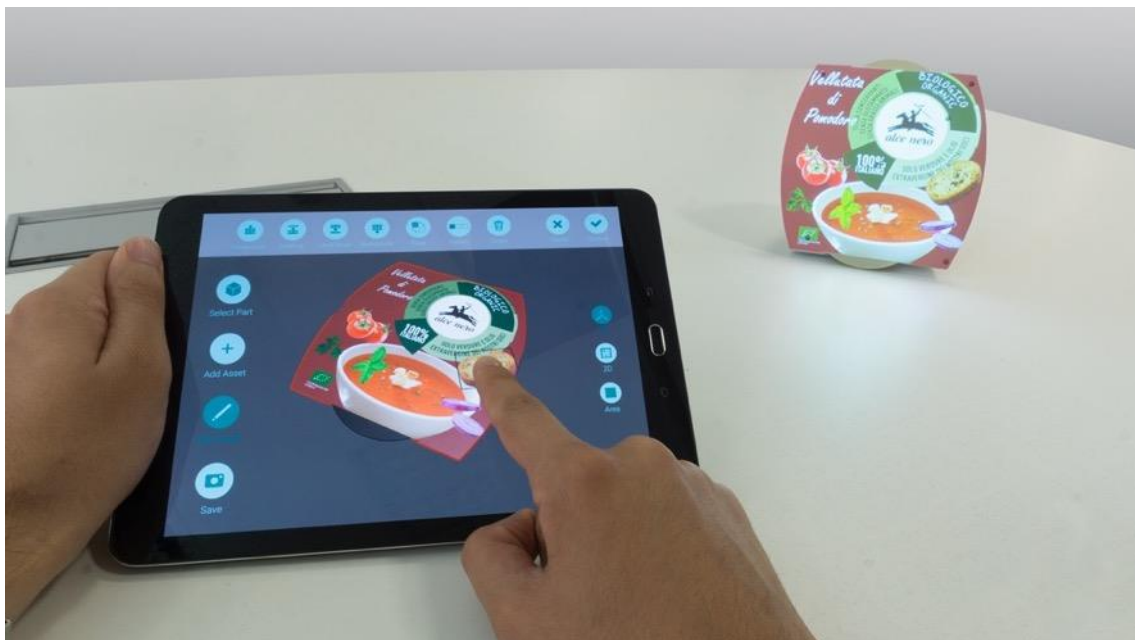


Figure 34: 3D View interaction modality



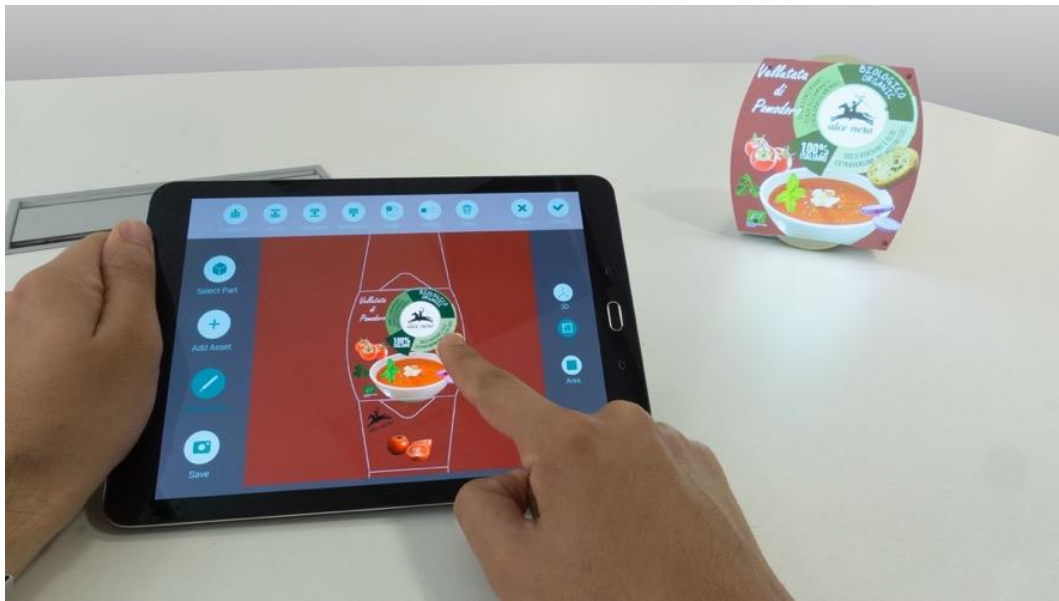


Figure 35: 2D View interaction modality

The second interaction modality is called '2D View', it consists of the 2D outline of the selected part (Figure 36). All the sides of the 3D model part are flattened on a plane and the part borders are made visible through a black and white outline. This modality is giving to the user a general overview of the product layout showing more clearly the relation and hierarchy between assets in the layout. The third interaction modality is called 'Touch Area' (Figure 36). The GUI doesn't show any 3D model or 2D visualization but only a blank area where the user can perform multi-touch gestures to apply modifications on the previously selected asset.

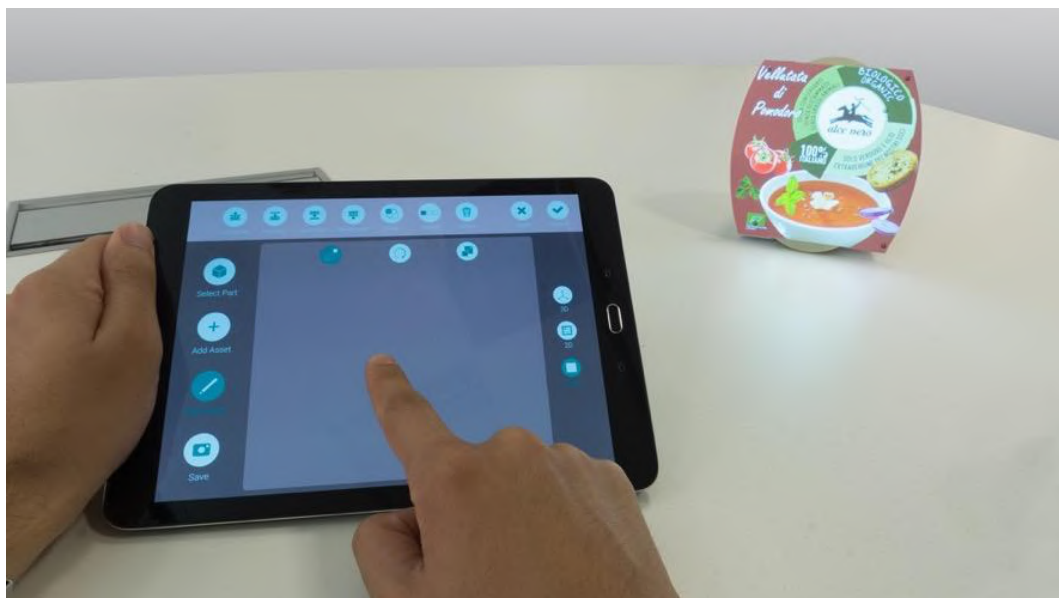


Figure 36: Touch Area interaction modality



While with the '3D View' and '2D View' the user can see and work on the tablet and then look at the output on the mixed prototype, with the 'Touch Area' the only visualisation feedback is the mixed prototype, the user looks only at it while performing any modification.

The multi-touch gestures performed with the '3D View' can be performed equally with the '2D View' and the 'Touch Area' (Figure 37). These interaction modalities have been tested and compared in depth in Deliverable 5.2.

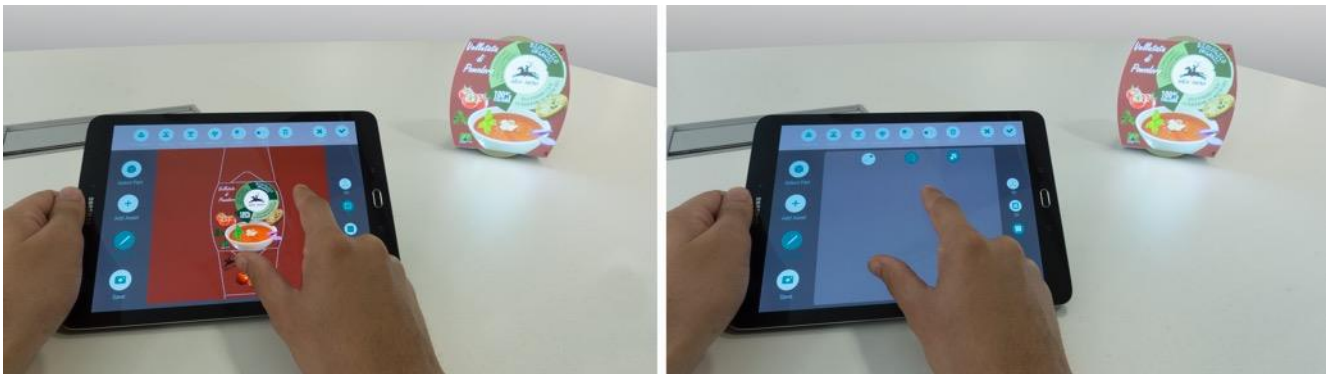


Figure 37: Multi Touch gestures performed with the 3D View and Touch Area interaction modalities

The mixed prototype can be handled by the users participating in the design session, as shown in Figure 38, since it is tracked, and the projection is updated in real time. The manipulation area of the prototype is dependent on the initial setup of the projection system and has been set at 1x1m.

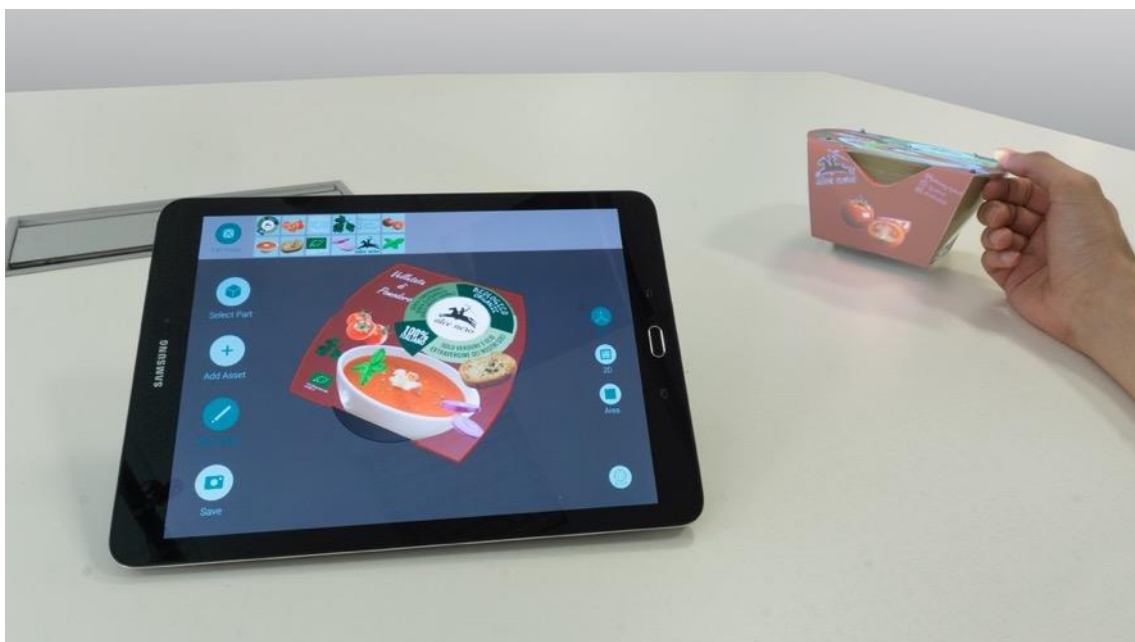


Figure 38: Manipulation of the mixed prototype

## 7 REPORTING

From the prototype editor, the user can reach the reporting page (Figure 39) by switching the state of the session to *Done*. From the reporting page, the user can:

- 1) Select the prototype to review its timeline and history;
- 2) Replay the sequence of the prototype modifications;
- 3) Create a new co-design session from a version in the prototype history;
- 4) Review the session timeline.

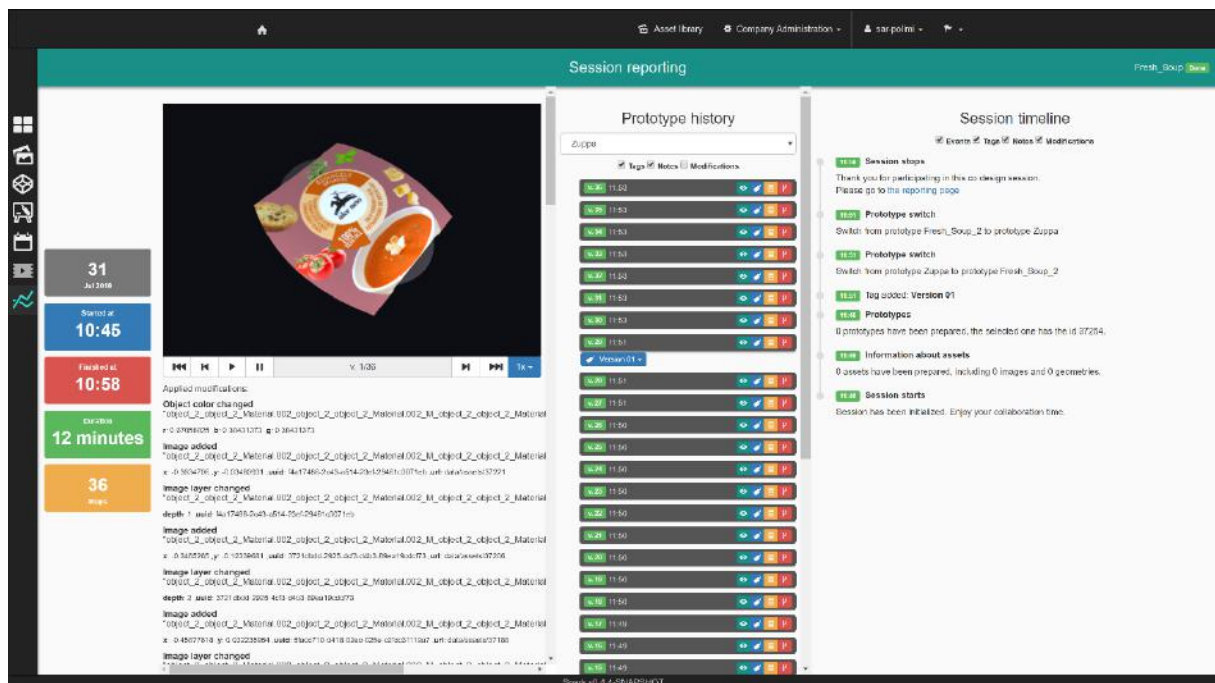


Figure 39: Reporting tool panel of the concluded session



## 8 CONCLUSIONS

The document provided a detailed user guide for the SPARK platform third release, describing its main components and the general process for their setup and use.

The preparation of the session has been described in detail by defining all the elements needed to start a design session, showing as examples, some of the physical prototypes used in the tests carried out during the project activities.

The SAR module preparation phases, which include the setups of the room at the different premises of project partners, show the flexibility of the platform components (tracking system and multi-projection) according to the context and the conditions of use. The new GUI developed for the SAR module simplifies the configuration of multiple projectors and the calibration of multiple prototypes by saving all configuration data imported by the user.

Finally, the features of the IS and user's interaction with the mixed prototype in the SAR environment have been illustrated in their working context. The IS has been updated including functionalities to switch the editing window from the 3D view and the 2D view of the selected part, managing different assets types as textures and text.

The GUI of the SAR module has been updated enabling the possibility to use multi-touch screens with different resolutions to increase the flexibility of the setup.

