UNIVERSITÀ DEGLI STUDI DI GENOVA

ENDURANCE Project
FCH-JU Grant Agreement: 621207

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TO: Joao SERRANO GOMES

FCH-JU

Brussels

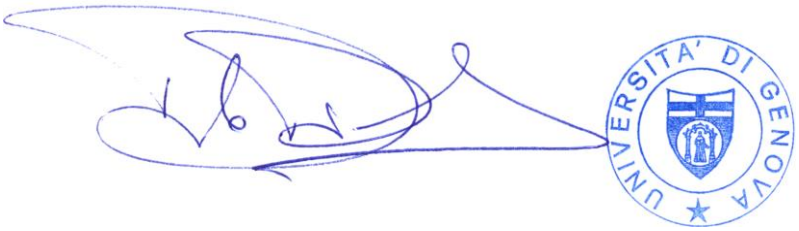
Subj.: Deliverable 8.2 - Interactive software-tool kit (Seriuos Game)

Please find here attached the report for D 8.2.

The whole document corresponds to the first version of D 8.2, further updated version will be uploaded until the final version of the serious game is available. The game is actually at its alpha version.

With best regards

Paolo Piccardo



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Deliverable *D8.2*:

Interactive software-tool kit (Seriuos Game)

WP8

Person in charge: Paolo Piccardo and Daria Vladikova

Expected delivery time: 31/03/2015
Delivery time: 09/04/2015

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1. Goal

To increase public awareness and public acceptance of hydrogen drive renewable power sources

2. Target Audience

Common people with teenagers as main target. The market can open only when the population is aware of the opportunities offered by the usage of renewable power sources related to hydrogen. The first goal is to create the awareness of safety of the system, then the advantages can be disclosed and the perspectives anticipated. The two ranges of age taken into account are 13-20 (teenagers) and 20-50. The age limits are only indicative.
Teenagers are the customers and developpers of the future. They will be the first living the Hydrogen Age and shall feel their involvement to build it.
The adults are the very first users, expressing their needs and expectations can better direct the message we want to pass to make the hydrogen power sources accepted, submitting their doubts they allow us to prepare the best matching answers and explanations.

3. The kit

The kit is composed of several parts:
1) Videoclip expressing the mainstream thoughts behind the goal of the kit and anticipating the main dissemination tool: the serious game "The Lost Colony: an Energy Game"
2) The serious game: an interactive game developed on an original plot written by two members of the Endurance Consortium and designed by the specialists of the UNIGE partner. This game is based on 90's graphic design in order to be more user-friendly for adults and is shaped around a modern science-fiction story in order to engage the teenagers. More details on the plot of the game are offered in the following pages. By playing the gamer is introduced to the concepts of renewable energy, cogeneration between renewable sources, fuel cells, electrolyser cells, stacking and combining more unites to achieve the desired power. Each level is a combination of instructions and tests (e.g puzzles, multiple questions) and allows the gamer to check the knowledge acquired. At the end of each level a step forward in the challenges is made. At the end of the game the gamer receives a certificate signed by the consortium and he/she is asked to write down in a sort of Laboratory journal one or more ideas in various categories (i.e. usage of fuel cells, usage of stacks, combination of components). The ideas are automatically transferred to the Scientific board of the consortium and evaluated. The best ideas, in a number to be established according to the sponsorship under negotiation, from individuals and from schools will be rewarded with an award composed by an official plate of distinction and a fuel cell or hydrogen related gadget. The awards will be given during an official event, possibly in Brussels, at the end of the project.
3) A questionnaire is distribute to the gamer at the begninning of the game and is directly sent to the Scientific board of the consortium in order to have an immdiated feedback on ideas, doubts and expectations. A second questionnaire is proposed to the gamer at the end of the game in order to check the impact of the serious game on the perception of the individual. The questionnaires are short (4 questions) and no limitations are imposed on the dimension of the answers. A statistical review is made on the base of the age of the individual filling the documents.
4) Social Network: a specific page is opened on Facebook and on Twitter, directly related with the official website of the project (www.durablepower.eu) in order to: have access to the questionnaires; submit open questions and comments (to which the Scientific board will answer in a maximum of 48hours), check the Hall of Fame of the players, download the clip, download the game or play online.
Strategy
The toolkit is distributed for free to high-schools in all countries involved in the consortium using the direct contacts each member of the consortium has. The language of the tool kit is English and a translation is made for each touched country. The teachers of the involved schools will distribute the indications on how to access to the toolkit to the parents in order to have access to the adults.
During public events as Festival of Science, University open doors, renewable energy events, open demonstrative events, planned around Europe the information on the toolkit and printed leaflets will be distributed while the serious game will be played. Subscriptions can be made on site at each event.

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4. The questionnaires

Introductive questionnaire

- Introduce yourself: age: profession:
- Why renewable energy
- What do you know about hydrogen power sources as fuel cells
- What do you think about the usage of fuel cells
- What is your perception about near future energy sources?

Final questionnaire

- Introduce yourself: age: profession:
- "Do you think that we need to evolve from traditional to renewable power sources?" "Why?"
- "Would you like to know more about fuel cells and hydrogen driven power sources?"
- "What do you think about the cogeneration of energy combining renewable power sources only?"
- "Would you like to use fuel cells powered tools in your daily life?"

5. The plot of the serious game

"The Lost Colony. An Energy Game"
Funded by FCH-JU EU Project ENDURANCE
Plot: Paolo Piccardo and Daria Vladikova
Game Design: Riccardo Berta, Francesco Bellotti, Alessandro De Gloria, Nicola Secco

Characters:

The Guides: Nikola Tesla and Jules Verne, Holographic Artificial Intelligence.
The Group: Konstant, Victor, Dawn, Eileen, teenagers of the first colony
The members of the colony: a selected number of people coming from Earth to found the first colony
The planet: Mars underground, after the discovery of an oxygen rich atmosphere in a deep network of caves naturally protected by the Sun radiations
The doctor: Dr. Xavier Simone (Savve), the first man on Mars, in charge of the very first mission and the only scientist remained on the planet. He had created the two guides and died 30 years before the story starts. This character is often quoted by the two HAIs.

Date

2114

Background

The Great Darkness represents the worldwide blackout lasted 1 month as a consequence the day the resources of the planet were consumed M1 of the year. This started the quest for the stars to search for a place to stay or from where obtained the resources we need. The last rover sent on planet Mars found a huge amount of breathable air, extremely rich in oxygen, in the underground Martian caves. The first colony is therefore settled in a large dome-cave to organize and prepare the settlement for the one million people expected to be part of it. The first colony is made of hundred people selected among workers, farmers, engineers, scientists and their families.
Technical solutions
The colony exists since 1 month and the breathable air for the dome is obtained by filtering the oxygen rich atmosphere of the caves network. This excess of oxygen is so far unexplained and in contrast with the external atmosphere typically rich in methane and CO2 with some water and nitrogen. The idea is to use plants, algae and bacteria to restore the breathable atmosphere of the planet. The excess of carbon can eventually be part of the cellulose based organisms. The lightning of the dome is obtained with a mirrors system inspired to pyramids and old mines solution. The innovation is

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that each mirror reflects the visible light-waves of the sunlight while the UV and highly radioactive rays are filtered and transferred to the photovoltaic layers. In this way the Dome receives light and energy at the same time.
The idea to use the methane and the oxygen to produce energy and warmth is rejected according to the experience made on Earth on the usage of fossil fuels.
The day and night intermittence of the sun energy is temporary solved by rechargeable zinc-air batteries. However the limited amount of zinc plates and the unresolved limited life span (5 years) of other batteries makes such solution as temporary. One of the goals is therefore to find a viable alternative solution to it.
The Dome is deep enough to guarantee a constant temperature 20°C and a reliable protection from the harmful sun radiations.

Levels

Level 0: Introduction
Level 1: The Laboratory
- Level 1.1: The Entrance
- Level 1.2: The Library
- Level 1.3: The Lab
- Level 1.4: The Control Room

Level 2: The Factory
Level 3: Back to the Colony

The Story with some hints and examples of the game

Level 0: Introduction

During the night the 4 main characters, teen agers, sons and daughters of colony members, are used to meet and tell each other stories. The night the game starts they've decided to tell dreadful stories and the memory immediately goes to the "Great Darkness" as the world wide black out was called. One month without electricity with dark nights and all electrical tools, facilities, equipments stopped. The GD was a consequence of the planet Earth renewable resources consumed at M1 of the year. All digital memories were lost and then people forgot of the first manned mission on planet Mars sent by ESA in 2014. The GD is the reason for they are on Mars with their families to create a new and better balanced future for humankind. They start talking about it finding out that "The adults" have for sure solutions but a lack of creativity and imagination. They are for example so lost in calculations of efficiency and viable solutions that they forgot to explore the Dome and therefore missed the Hidden Door.
Moved by curiosity and the spirit of adventure they decide then to start the exploration of the undiscovered part of the Dome passing through the Hidden Door.

Level 1: The Laboratory

Once the door is opened a pale semi transparent figure of an old man tall and slim with an elegant voice and dressed in a very old fashion way is greeting them: "Indeed you arrived, Earth people". The fear is keeping the group tight and frightened but the adventure has just started and cannot stop. "Who are you, sir?" says one of the group
"what a manner, it seems that Earth inhabitants lost a lot of education in the last century"
"are you a ghost? do you know in which century are we?"
"we're in the XXII century, according to the terrestrial way of counting time, and no, I'm not a ghost, why did you think that? Ah, by golly, it is my fault, I beg your pardon, not knowing when finally some of you might came I've set myself in safe energy mode."
"safe energy?"
"yes, just a second, … et voilà" the figure is now shining and real but still leaving a lot of doubts to the Group.
"well you know, after the first decade I've found myself waiting and wasting energy so I've decided to save energy and wait for you to come"
"waiting? for us? how did you know?"

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"I've waited for exactly 20 years since the time I've switched the safe energy mode, ten years after Savve left. And yes, it take to you too long than expected by Savve my colleague and creator told me that humankind is predictable and reliable when 'it has to save the skin'"
"we are Victor, Dawn, Ellen and I, Konstant, we like to call ourselves the group, sir, nice to meet you"
"finally an educated young man, let me introduce myself I am Nikola Tesla, HAI"
"HAI!!!!" yelled the group
"ehm, HAI means Holographic Artificial Intelligence"
"ups, sorry Nik"
"Nik? very nice, I like it"

After the first dialogue they can start exploring having NT as a guide. In the first room the plan of the site is described: a sequence of room with safety doors closed with a code of keywords (that shall be used to check the level of learning of the player). NT shall have time by time some XIX century expression and shall quote his books.
The Place is made of: the Entrance, the Library, the Lab, the storage room, the treasure room (control room). In the treasure room there is a beautiful sealed door. The keyword to open the door is the correct sequence to build a stack and once opened lead the group to LEVEL 2 "the factory" where Jules Verne is greeting them substituting NT.

The Entrance

"let me switch the light on" NT says. and the Entrance, nicely decorated with a steampunk taste is shining. The Group is astonished and asks from where the sunlight comes being in the middle of the dark Martian night. "By the stacks placed all around" is the short answer of NT.
"Stacks? what are they?"
"you don't know it? well, years before my physical existence on Earth, in the glorious XIX century of discoveries, a revolution, other than the industrial one, changed humankind destiny: Electricity. There was then a quest for the best source of electricity from the static one (electrostatic motor, Van De Graff Generator), to the chemical one (Volta and Galvanic Cells), from the electromagnetic one (ahh, my lovely passions and discoveries) to the fuel cells. Well, it is hard to admit but my invention, the dynamo, electromagnetic generator of alternate current, overwhelmed all the previous one. For sure batteries, chemical solution, survived dignity for a long time but the GigaWatts were made using my technology." (each of the cited power sources can open a short wiki describing it with some historical information)
The Group asks for more information and the talk is leaded to discover the origins of Fuel cells (the first patent and the advances will be described in the following room).
Combining hydrogen and oxygen, what a great idea, but I was so stupid, so tremendously genial and blinded by my passion for the power of the electrons (an image of NT surrounded by lightning shall appear).
The concepts to learn at this stage is Electrical Energy, power sources, pro and cons, importance and innovation of fuel cells.
The door shall open connecting the inventor with a power source and the power source with the year of invention.

The Library

Here the group can find more information about energy production with a special care on fuel cells principles and history.
An overview on the fluctuating interest of the scientific and political communities on the FC in time shall be given stressing the point that EU from FP5 (?) on believed and invested a lot on it allowing scientists and industries develop the FC technology.
The archive's images of the Apollo missions using Alkaline FC, fuel cell vehicles, stationary, domestic and portable solutions, and all positive and real examples shall be given.
The questions about the energy of the place they are discovering shall be more specific as: from where the fuel and the oxygen come.
"at the beginning the whole atmosphere was like the one of above, well when my colleague arrived and I was still lost in the electrical discharges of the Earth atmosphere"
We can say that NT, during the last experiment he made, transferred his personality and brain in electrical waves surrounding the planet Earth. He didn't know or realize it until when the A.I. created by doctor Xavier Simone, received and transcribed in the artificial brain such information travelling across the space as electromagnetic waves. "they made me destroy my beautiful tower (an image of the Tesla tower) and pretended me to play the fool in order to discredit my

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inventions and my ownership of them but I never stopped to be cleaver and I bought secretly a place where a tower was under construction. I've participated as simple engineer and introduced the correct network of metal and electric path to have an even largest and more powerful tower. I was capturing electric waves surrounding the planet and discovered that some of us dying are simply transforming their potential energy in electromagnetic waves. Ahhh that Albert Einstein what a brilliant mind. When I was writing my "how to increase humankind energy" I was aware only of the kinetic one ($E=1/2\ mv^2$) and made all my dissertation around it. My intuition was good "Matter is energy!" but how brilliant was to introduce the $E=mc^2$, and then with mister Plank the final beautiful $E=hc/\lambda$ so that finally our mass is $m=h/\lambda c$" (some images of this, like Einstein at the black board shall appear). "you see how beautiful it is, we are all made of waves and I've crossed Mark Twain waves in space during my experiments, talked to him, what a great writer. They pretended me to be crazy but they simply didn't know what I was talking about. And then during my experiments at the tower I eventually became wave myself, or a copy of me, and now I'm here, when the A.I. received me. You can't imagine the surprise of Xavier (Savve, as I was used to call him) when the A.I. introduced himself as myself."
The initial water came from the frozen soil using solar concentrators to transform it in water vapour. Then this vapour was passed through a metallic foam kept at high T still by the Solar concentrator. The Metal foam catalyzed the hydrolysis phenomenon. The hydrogen escaped rapidly to the atmosphere (this experiment design error shall be noticed by the player, in this case the score is increased) but the oxygen was collected and then the first fuel cell operated. Methane, being abundant on the planet, was the first fuel. The excess of CO2 produced as a waste was passed under vacuum, purified and became nanotubes (stimulated by the natural radiation of the sun), the main raw material used by the first team of scientist to build most of the tools and components "you can see here".
"But it looks like wood"
"and stronger than steel, simulated materials based on nanotubes".
Then most people from the first mission abandoned the planet to go back to Earth scared of the dramatic important political and economical crisis arose when the world resources were exhasted in may. They wanted to try to contribute to change this trend before it was too late. Unfortunately without success and the Great Darkness, as the Group revealed to NT, happened. Only Savve remained on Mars in order to continue the work supported by robots and the HAI he was working on.
The dome, discovered during Curiosity exploration on 2013 represented for them the best place to stay due to the natural protection from the sun radiations and the possibility to place a forced ventilation with a limited dispersion of breathable air. The Lab was then built placing stacks all around it. The absence of sulfur in the methane rich atmosphere made this stacks operating at high efficiency with a very limited degradation. They were then powering a number of SOEC meant to produce a reservoir of Hydrogen (this time not lost) stored in another cave with a safe and stable solution.
The solution is not explained but the Energy storage as Energy vector (Hydrogen) has to be explained and compared with Energy storage as batteries. Definition of Energy vector: a substance or mechanical solution that can give back the energy used to produce it: e.g. gazoline. It is an energy vector every kind of material that can give energy by a reaction, therefore wood, natural gas are energy vectors.
The battery has a limited lifetime even when not used, a safely stored Energy vector can keep its potential energy as long as it exists.
The knowledge to acquire is the history of fuel cells, the possibility to use methane and hydrogen in the same kind of SOFC, the possibility to reverse an SOFC to become an electrolyzer (SOEC) "inverting the pole from positive to negative and from negative to positive" (Young Frankenstein tribute), the hydrogen as an Energy Vector safe and long lasting.
The keywords to open the door shall take these information into account and test the player understanding.

The Lab

Here they enter in the experimental lab where materials are studied. Some equipments like electron microscopes, furnaces, test benches can be found and described.
We shall here talk mainly about the raw materials and their role in cells manufacturing. The decision to mainly work on SOFC is due to the highest efficiency and long lasting endurance.
The story continues and then it is explained the extremely high concentration of oxygen in the dome atmosphere. While the hydrogen was stored the oxygen was released in the cave in order to push the Martian atmosphere outside. The SOEC operated unstopped for the last decades without any SOFC working (until when they opened the hidden door and NT switched on the light of the first room).
The amount of stored hydrogen is so high that they can produce energy for more than 1000 years.

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"We're going to consume the whole water of the planet then! exhausting resources as we did on our poor Earth!"
"not really. the versatility of the SOFC can be used to consume CH4 and not only H2, however all is in balance once we know how to not waste energy and to work with highly efficient and low consuming electrical devices. How do you produce energy out there?" indicating vaguely the Dome colony behind the wall.
"We use the sun! and batteries to store the energy for the night!"
"but I've heard the adults saying that this won't last. I mean, not the sun, he shall last long enough, but the batteries"
"I'm an artificial intelligence, don't forget it, but I'm Nikola Tesla plus the things I've learned from Savve, my friend, and I think I have a solution. Would you like to explore it with me"
The solution NT and the Group have to formulate with a logical process is the cycle: external renewable power source, SOEC to produce hydrogen and oxygen (Stored), SOFC to produce energy on demand using the stored H2 and O2, the waste (by product of the SOFC) is highly pure water re-introduced in the SOEC. The losses are contained and the surplus of energy needed to compensate the efficiency losses is given by the Sun. The absence of clouds in the Martian sky is making sun power a reliable and renewable power source.
The correct material for one of the components (randomly selected by a sort of slot machine placed on the door) and the correct sequence of devices in the "Cycle" are the two tests the player shall pass to enter in the next room.

The Control Room

This shall be the place where the operators control the power plant but all is covered with a tissue and looks new and untouched.
"I take care to clean and switch these machines on once per week. Maybe you'll make it work, my friends."
An holographic computer screen is switched on and an exploded stack appear. All components are placed but not in the right order. An impedance curve as it is typical of a Fuel Cell is composed step by step with the correct positioning of the components in a cell.
NT answers to questions on the nature of each components: cathode, anode, electrolyte, interconnect, gas pipes (inlet outlet), structure, sealing.
The importance of stacking: how to increase the power? increasing the surface! How to increase the surface? widening the cells or placing once cell above the other.
To do this it is important to explain the definition of Current density (I=A/sqcm), of Voltage and of Power (W=V I). To improve the power one can increase the Voltage but a low current is not a viable solution for certain applications (examples). To improve the current passes through the increase of surface but needs as well the right Voltage.
The principles of parallel and serial circuits, the first keeping the Voltage and increasing the Current, the second keeping the current and increasing the voltage are explained.
In this way the Group (the player) will learn that a stack shall be made of cells stacked in serial in order to increase the voltage, while to achieve the needed current density one needs to connect the right number or stacks (equipotential) in parallel.
The doors open once the right circuit to achieve 500W. the door will be a touch screen where all layers have to be sequenced to make a cell (100W), then 5 cells are assembled to make a 500W stack.

LEVEL 2: The Factory

Tesla cannot exit from the Level 1 due to his nature as an hologram and greets the Group hoping to see them soon operating in the control room. Once entered in Level 2 a new Hologram welcome the Group and is the Jules Verne H.A.I.
"I am not a technologist, but I know how to combine the knowledge with the dreams"
"Good day Sir, we are the Group. Nikola Tesla brought us through the previous floor up to here"
"Good Lord, Nikola, I wondered why he wasn't coming to our daily talk yesterday. Now all is clear. My name is Jules Verne HAI"
"Glad to meet you Jules"
"Ehi, I've read plenty of novels from you!"
"those I wrote during my previous physical life. Since Nikola rescued me from the skies and together with dr. Xavier Simone (did you met him?) and gave me the opportunity to be again. I've got much many stories to tell you my young friends… but this is not the time"
"We're sorry to inform you that Savve died thirty years ago according to Nik's report"
"Dead, well he'll be hanging around the outer space since. He always wanted to be closer to the stars in is wave-like post-life. But we're losing time! I was keeping everything in order for you."

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Saying these words he touches a switch and nothing happens.
The group have to notice that the switch for the hydrogen is closed and without hydrogen the fuel cell cannot work.
Once this is done the operation is repeated and the factory shines in a beautiful image of cleanness and efficiency (idealized images from SOFCPower Factory shall be used here together with some images).
This level is meant to teach how to build an idealistic stack.
"The factory is ready to produce stacks that will be operated for the goodness of the Colony. There is a colony out there, isnt'it?"
"A pre-colony, actually sir, of a hundred people"
"Enough to have a huge fun and to need power"
"And we'll bring power to them, like Prometheus did with the fire against all gods"
"Good girl, I see the fire of freedom burning inside of you. This Energy is incredibly adaptable and suitable to so many applications indeed that I cannot see any error in your loudly spoken thought."
In this Level the players are going to see and contribute to examples of stacking and application. They will learn that using a stack suitably designed it is possible to run a car, an house, an office or a building.
Most of the images and possibly some short movies shall come from the real factory and on computer screen the player assemble.
The Group pass through the factory and finally reaches the entrance to the 3rd and last level. To pass through the door they have to answer some questions about the factory: need for clean locals; correct usage of structural components as the sealing, correct usage of a stack for a given application, and so on.

LEVEL 3: Back to the Colony

This part of the game is no longer for learning but is for triggering the creativity of the players. They have all stack size and have to suggest some original usage.
At the entrance they find no guide. Turning toward Jules Verne they ask why and the answer is
"This was the thinking room of Savve. He was coming up here time by time when he wanted to focus on something new. No HAI were needed here just the human and its creative brain. As HAI we are able to react and interact but we miss the essential fuel of all your inventions: the need. We are simply fine and existing but we do not suffer the cold, the hunger or the stress. Feel free to work here and come back to me each time you feel the need to. I'll be here at the door, ready to reply to your questions."

Once inside this last room, with a huge window giving to the deep space the Group looks around and find a journal, open to the last page with only the title "My Inventions, my applications". Beside a book, the Tesla's book "How to increase humankind energy" at the page of the predictions Nikola Tesla made about the applications in the near and far future of its discoveries and inventions. This shall stimulate the creativity of the players.
On the wall the sentence of Albert Einstein (to check if this is his sentence or not, and for the correct quotation) "Young people are able to think the impossible and some time capable to make it".
"The adults are going to be mad at us because we disappeared for a whole night. We shall be back with a good story but most of all with an original application able to show them what we learned here" said one of the Group. And suddenly they started to think and to write. "With a stack of the right power is possible to build up…." Then they will have to fill the page by writing one or more applications using the stacks (whatever size they might need). Once they have the idea they can come back to the Colony and expose it to the adults which will welcome it as a great solution (this corresponds to on the game to save and share on a social network the idea). At this point the players are demanded to stop the game or to continue by going back to level 3 in order to write down another idea.
To this level they can come each time they want and they can enter as many ideas as they might have. Moreover, if the game is connected to facebook, this ideas shall be published with the name of the player/s.

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Figure 1: images of the game The entrance

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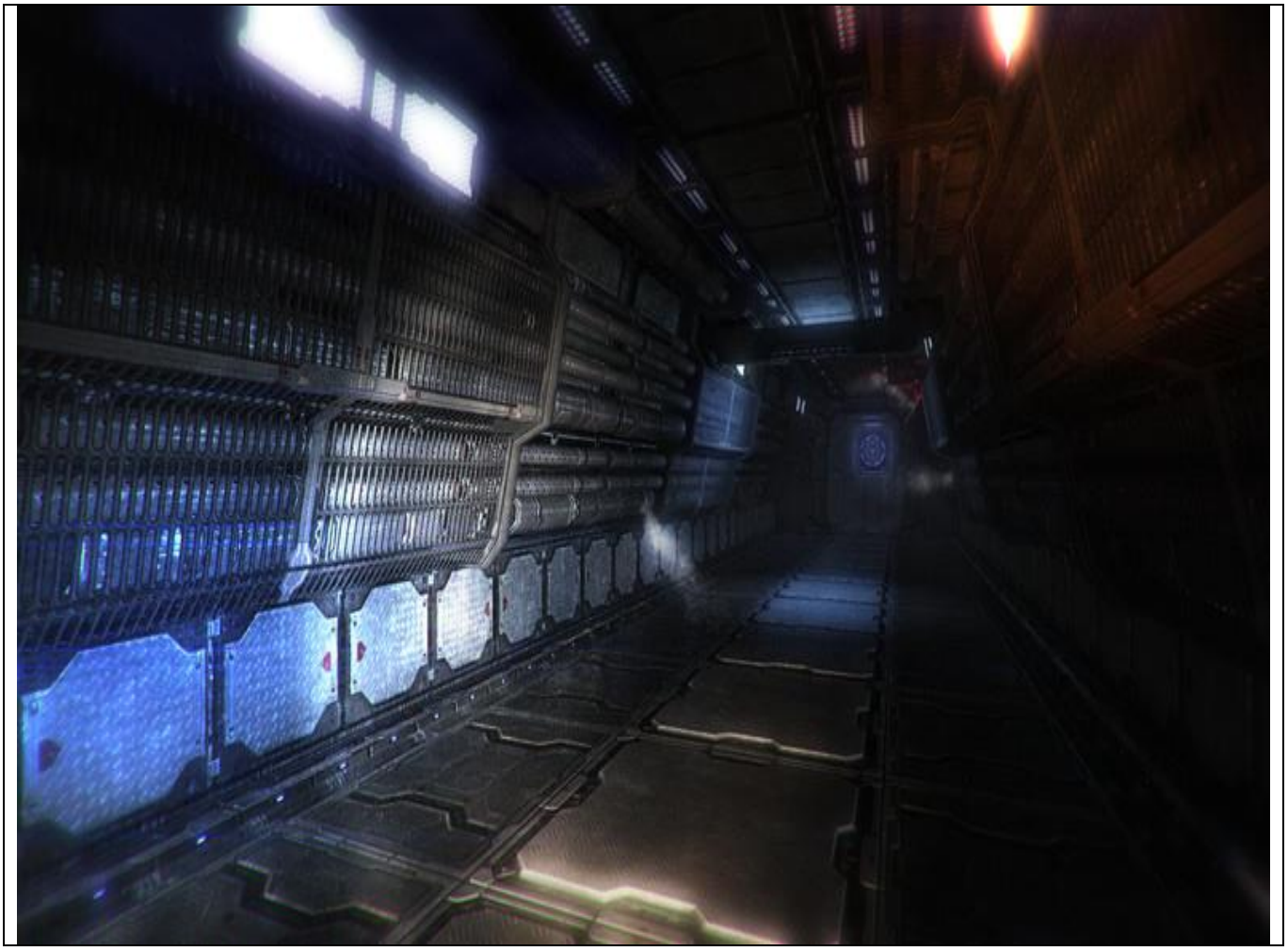

Figure 2: images of the game The Laboratory

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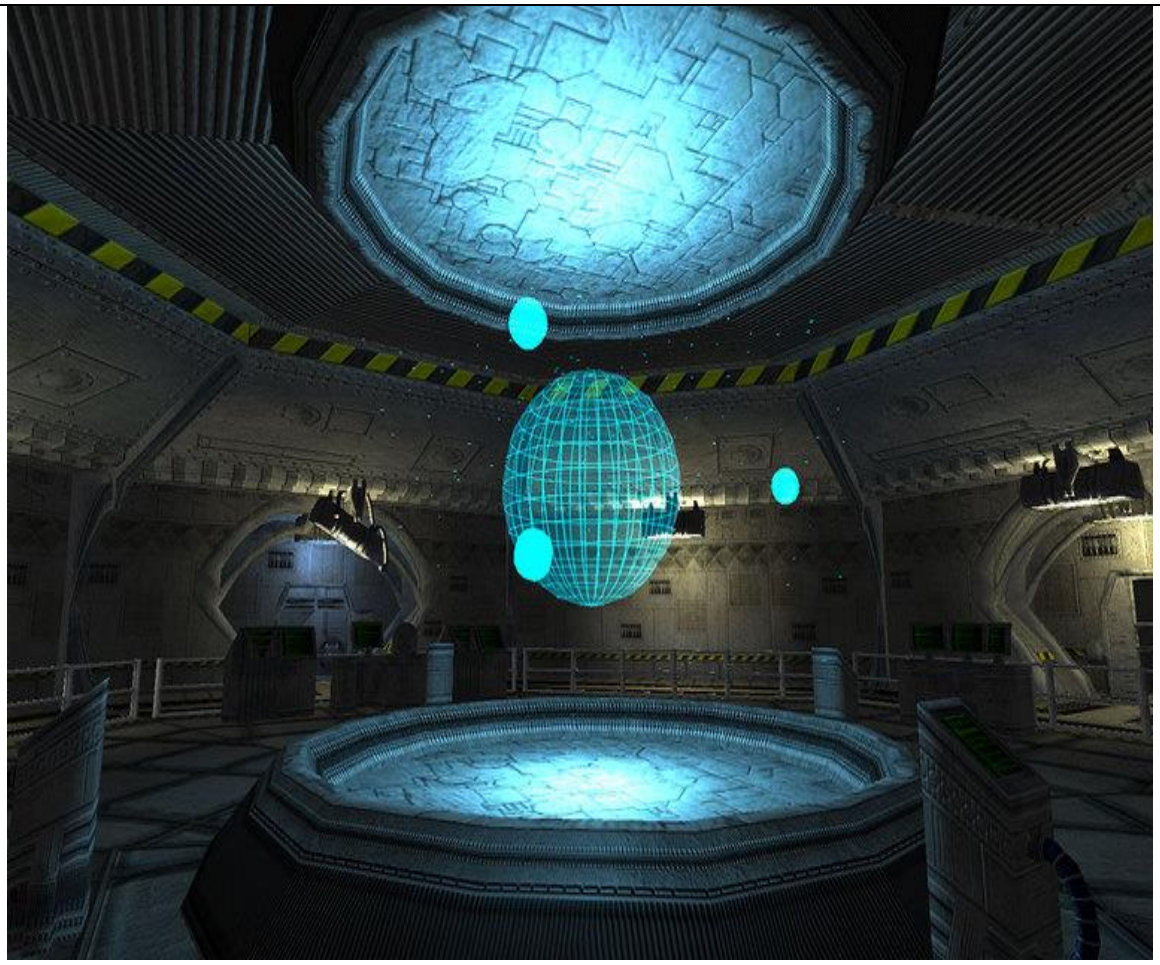

Figure 4: images of the game The final room