Virtual reality for safety, entertainment or education: the Mars mission test

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Abstract
A Virtual reality (VR) has many applications; the main ones are related to safety and performance, entertainment, and education. To increase safety and performance, VR may use, for example, simulation for training purposes or for improving the performance of the operator; in entertainment, it can be used to experience for fun new realities that are possible only virtually; and finally, in education, VR can be used to let the user learn in an immersive environment.
This paper wants to open a debate on how to increase the trustworthiness of virtual reality in order to increase the number of possible applications in the field of safety.

Keywords: Human Factors · Human-systems Integration · Virtual Reality · Space Mission.

1 Introduction: Safety and simulation

"The entertainment industry is one of the most enthusiastic advocates of virtual reality, most noticeably in games and virtual worlds. But other equally popular areas include:

- Virtual Museums, e.g. interactive exhibitions
- Galleries
- Theatre, e.g. interactive performances
- Virtual theme parks
- Discovery centres

Many of these areas fall into the category 'edutainment' in which the aim is to educate as well as entertain" (1). However, there are also many possible scientific and educational applications, in areas such as training, testing of procedures, medical devices, and rehabilitation (2, 3). One problem of scientific application of VR is that the

context of the application may be confused with that of entertainment, decreasing the trust of the user and, as a consequence, negatively affecting the results. For example, if a doctor performs remote surgery on a patient, virtual reality may be used to increase performance and reduce the risk of failure. In the same way, VR can also help the patient to train their motor performance during rehabilitation. In both cases, trust in the system is very important to achieve an increase in safety and performance. Deutsche Bank created a simulation environment in Second Life where the user was able to interact with the bank as an avatar to learn about new credit opportunities and get consulting. But how ready are we to make investments in Second Life? How much trust do we have in virtual reality systems? How much might it be perceived as an application used just for fun?

2 The case study

This problem has been shared by the Italian Mars Society, which has developed a virtual reality scenario to help test and develop technologies for a human Mars mission. The Italian Mars Society (4) states: "The international space community is contemplating long-duration crewed missions to Mars in the near future. In this regard, human space mission simulators play an important role in developing and testing hardware and software technologies required for such missions. Simulators also provide an ideal platform for conducting research in psychology, physiology, medicine, mission operations, human factors and habitability. These research areas are critical in ensuring crew well-being and performance for long term space missions."

A Mars surface and a Mars base mission have been reproduced virtually on the basis of the real Martian surface. "As operational test beds, the stations serve as a central element in support of parallel studies of the technologies, strategies, architectural design, and human factors involved in crewed missions to Mars. The facilities also feature field laboratories in which data analysis can begin before scientists leave the field site and return to their home institutions" (4).

The virtual interaction is done with immersive visual and audio environment using the Oculus Rift technology.

2.1 Test procedures and result

To verify the interaction and the trust in the system, the Mars scenario was proposed to 17 testers. The test was performed during the event "Bergamo Scienza" in Italy in 2015 and during a mission simulation in Madonna di Campiglio, Italy, in 2014.

2.2 Open access test

During the "Bergamo Scienza" event, to motivate the testers to use the virtual reality environment, a scenario was provided with several tasks within a questionnaire.

The scenario was a rescue mission: "**G1 Emergency Mission:** The Mars 2035 V-eras station is contaminated by a toxic Martian fungus. You're safe with your crew in a rescue module 2km from the station, but there remain only a few hours of oxygen available to live in the module.
There is a solution: in the greenhouse of the station, the presence of a substance that immunizes against the effect of the fungus has been identified. To save the mission, you have to enter the lab. The mission depends on your help. Fulfill the tasks and save the mission."

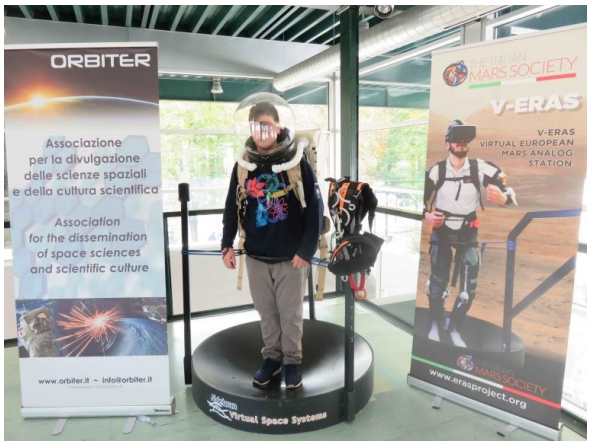

Fig.1 Italian Mars Society VR system at "Bergamo Scienza" (© Italian Mars Society 2015)

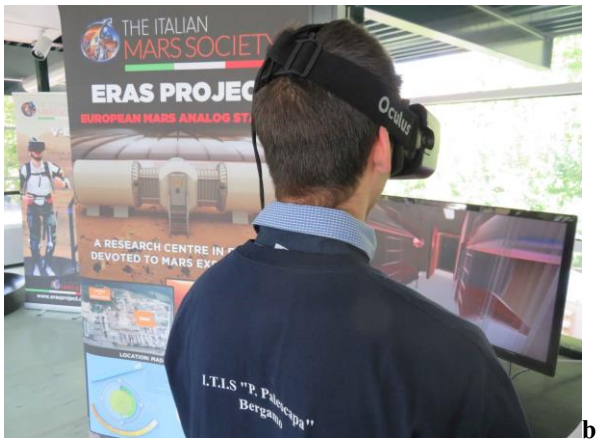

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Fig.2 Italian Mars Society VR system at "Bergamo Scienza" (© Italian Mars Society 2015)

Fig.3. The questionnaire, Italian Mars Society VR system at "Bergamo Scienza" (next page)

Bergamo Scienza
3-17 October 2015 The Italian Mars Society

THE ITALIAN MARS SOCIETY

Welcome to Mars! Please answer the following questions and begin the mission:
- If you participate in the mission, you agree that your answers will be used anonymously for the development of other missions. O I agree; O I do not agree
- You are aware that your contribution is voluntary and you can stop the simulation at any time. O yes O no
- Your age is 0-18 years: O 18-25; O 25-35; 35-50 O; O >50
- You are: O student; O professional O professional from the field

G1 Emergency Mission

The Mars 2035 V-eras station is contaminated by a toxic Martian fungus. You're safe with your crew in a rescue module 2km from the station, but there remain only a few hours of oxygen available to live in the module.
There is a solution: in the greenhouse of the station, the presence of a substance that immunize against the effect of the fungus has been identified. To save the mission, you have to enter the lab. The mission depends on your help. Fulfill the task and save the mission."

Task 1
Enter the station, try to orient yourself as quickly as possible to get to the greenhouse were the immunizing substance is located. Check how long it takes; if you can get there within 60 seconds, you will not get contaminated.
Time O <60 sec. O> 60 sec.
Level O difficult O ok O easy

Task 2
Now you have the immunizing substance and you have to reach the crew as soon as possible. Exit the station; the sand outside is contaminated by the fungus, so be careful not to stir it up! EXIT FROM THE STATION AND MOVE AWAY as quickly as possible to the emergency module.
Your rover is turned upside down O yes O no
Level O difficult O ok O easy

Task 3
The crew has caught up with you and is safe, but the mission is not finished; Earth awaits communication. Answer the 6 questions and end the mission. If you want to, you can also leave your suggestions.

1. Tasks 1 and 2 were completed successfully without stress. O yes O no Suggestions:
2. The mission is realistic and I identified myself with the context. O yes O no Suggestions:
3. The Martian terrain has a very realistic effect. O yes O no Suggestions:
4. The simulation is optimal. O yes O no Suggestions:
5. The mission is useful for increasing my knowledge and can be used in education. O yes O no
What field: Tips:

(Optional) Other suggestions are welcome:
Mission Support sends thanks from Earth if you want to leave the simulation team. Add your contact details to the mailing list of the Mars Society to get information about the next mission.
Mission Over.

In this paper, the most important observations from this test are reported. The persons who volunteered for the test were mostly younger, under 35 years of age. Of the 17 tests, only 2 were incomplete and not valid. The other 15 subjects completed the entire test.

The first task was described as follows: "Enter the station, try to orient yourself as quickly as possible to get to the greenhouse where the immunizing substance is located. Check how long it takes; if you can get there within 60 seconds, you will not get contaminated."

Only 1/5 of the testers found the task difficult; among the persons who found this difficult, only one was under the age of 35, which demonstrated that the first approach with the software was quite intuitive at least for persons under 35 years of age.

The second task was described as follows: "Now you have the immunizing substance and you have to reach the crew as soon as possible. Exit the station; the sand outside is contaminated by the fungus, so be careful not to stir it up! EXIT FROM THE STATION AND MOVE AWAY as quickly as possible to the emergency module."

A little more than ¼ found this task difficult; in this case, a decrease in performance was also seen among younger testers. However, the majority of the people still found the first and the second task easy, showing that the system may be intuitive for most people.

As a conclusion of the experiment, five questions were asked to understand how the system was perceived.

Of the 15 testers, two thirds reported the tasks as stressful, which also shows that these persons were actually involved in the tasks. Also, the majority reported that they had been able to identify themselves with the scenario, in particular, the subjects under the age of 35; on the other hand, of the 4 subjects over the age of 50, only 1 managed to identify himself with the virtual environment. The overall quality was evaluated positively by the majority of the testers. Regarding possible applications of the mission, such as with regard to learning features or educational application, the system was associated more with entertainment than with education or training like from the observations reported.

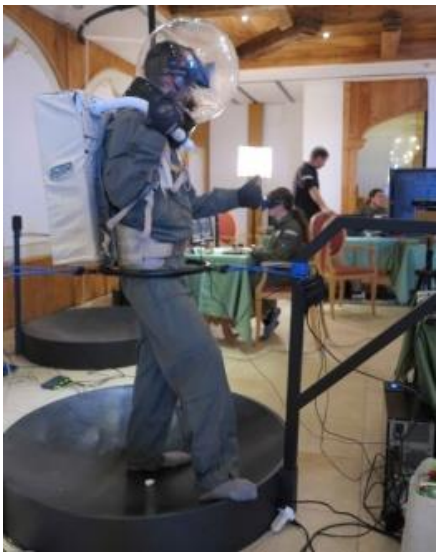
Tab. 1. OBSERVATIONS V-ERAS: MISSION G1 (Italian Mars Society, 17.10.2015, Bergamo Scienza)

Observations:
• Increase the graphics • 3 toilets needed inside the station • Plants will make it prettier • Need to be improved • Support audio • It is more for entertainment • Is just a game; make it more scientific and useful • Avoid having to close the door • The knowledge was increased by the tutorial • Graphical mistakes: door too small and wall that became transparent. • You can walk through the wall.

Tab. 2. RESULT V-ERAS: MISSION G1 (Italian Mars Society, 17.10.2015, Bergamo Scienza)

RESULT V-ERAS: MISSION G1 (Italian Mars Society, 17.10.2015, Bergamo Scienza) (Blue = subject from the field)																					
Age		0-18				18-25				25-35			35-50	50+				Total			
17 subjects, 2 tests not valid		A	B	C	D	E	F	G	H	I	L	M	-	N	O	P	Q	15			
Interaction Easy: V; Ok: 0; Difficult: X																		V	0	X	
T1	Station	V	0	0	0	X	0	0	0	V	V	V		X	V	V	X	6	6	3	
T2	Rover	X	X	0	V	V	0	X	V	0	V	0		V	0	V	X	6	5	4	
Tot																		12	11	7	
Qualities Yes: V; No: X																					
T3.1	Stress	X	V	X	X	V	V	X	X	V	V	V		V	V	V	V	10		5	
T3.2	Identification in the avatar	X	V	V	V	V	V	X	V	V	X	X		V	X	X	X	8		7	
T3.3	Terrain	V	V	X	V	V	V	-	V	X	X	X		V	X	X	X	7		7	
T3.4	Simulation	V	V	V	X	V	V	X	V	V	X	X		V	X	V	X	9		6	
T3.5	Application: knowledge and education	V	V	V	X	V	X	X	V	X	X	X		V	X	X	V	7		8	
Tot V		3	5	3	2	5	4	-	4	3	1	1		5	1	2	2	41		-	
Tot X		2	-	2	3	-	1	4	1	2	4	4		-	4	3	3	-		33	

2.3 Test with selected persons



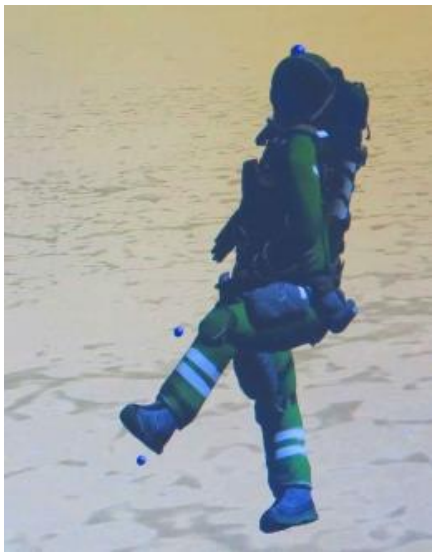


Fig.4 Simulation on the Motivity virtual dimension station. **Fig.5.** Visualization of the avatar on Mars (© Schlacht 2014)

During the mission in Madonna di Campiglio, a mission simulation was also performed with a more complex task over a period of one week. The team had some problems related to the low level of comfort of the equipment. However, there was no observation or comment or doubt about the main scientific purpose of the system with regard to scientifically testing procedures, equipment, and overall mission aspects. More information is reported in "Space Missions a safety model[5]".

3 Conclusion

The Italian Mars Society developed a VR system to test possible missions to Mars, including rescue procedures.

With 17 testers, we studied how people would react and how much the program may be trusted to act as training and testing facility. The VR system attracted mostly young people. The majority of the people did not see a strong purpose in terms of acquiring knowledge or using it as an educational application, leading us to conclude that the entertainment aspect is stronger. To increase the level of trust and improve scientific application, the persons involved need to be selected and trained as in the tests performed with selected persons. If the VR system is open to the public, it will attract mostly young people, who will emphasize the entertainment aspect. If the system is used in a restricted environment with selected and trained persons, the purpose and the results could be scientific.

Thanks

Thanks to all the person & institutions involved. For the images: Italian Mars Society.

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