TELEOP: Impact of Confinement and Isolation on Crew Performances during Long-Duration Missions

Veronica Martin Estrana, Federica Vagnone, Raphaëlle N. Roy, Stéphanie Lizy-Destrez

TELEOP: Impact of Confinement and Isolation on Crew Performances during Long-Duration Missions

Veronica Martin Estrana[a], Federica Vagnone[b], Raphaëlle N. Roy[c], Stephanie Lizy-Destrez[d]

[a] *DCAS, ISAE-SUPAERO, 10 Avenue Edouard Belin, Toulouse, France 31400,* veronica.martin-estrana@student.isae-supaero.fr
[b] *DCAS, ISAE-SUPAERO, 10 Avenue Edouard Belin, Toulouse, France 31400,* federica.vagnone@student.isae-supaero.fr
[c] *DCAS, ISAE-SUPAERO, 10 Avenue Edouard Belin, Toulouse, France 31400,* raphaelle.roy@isae.fr
[d] *DCAS, ISAE-SUPAERO, 10 Avenue Edouard Belin, Toulouse, France 31400,* stephanie.lizy-destrez@isae.fr

Abstract

In the last decades, most space agencies have been focusing on manned flight missions. Therefore, to ensure the success of long-term space missions, new factors like confinement and isolation need to be studied. The TELEOP project investigates these effects on crew's performance during Human-Robot Interactions (HRI), such as cargo docking operations or remote control of a rover for surface exploration of the Moon or Mars. Confinement implies living in narrow spaces with limited privacy and isolation having very little contact with people from the outside; those conditions mostly characterize human space missions. In order to study its impact, several analog mission campaigns ave been run within the TELEOP project, such as: MDRS-189 (Mars Desert Research Station – Utah desert) and ARES III (in Lunares Research Base, Poland). The subsequent mission will soon be carried out in the Institute of Bio-Medical Problems of Moscow (IBMP) in Russia, during the SIRIUS-19 campaign (Scientific International Research In a Unique terrestrial Station), with the collaboration of NASA, and the next MDRS-206 expedition. In the following years, the aim is to run the experiment in more realistic and confined environments: the ISS and the Concordia station in Antarctica. In order to assess confinement and isolation and their impact on teleoperation performance, an innovative protocol has been designed. This enables us to have a complete overview on factors linked to teleoperation performance (execution time and accuracy), such as participants' personality traits, affective state and physiological state. Teleoperation performance was evaluated by the guidance of a rover, a task that was performed by each crewmember several times per mission. During the task, physiological activity was recorded using an electrocardiogram (ECG), whereas assessment of both psychological and personality aspects were performed using questionnaires. The latter two intended to assess the mood, motivation, confinement feeling and subjective effort. As a result of the analysis of the data gathered during both the MDRS-189 and ARES III missions, important results were uncovered. The main finding demonstrated a significant correlation between motivation and positive feelings or personality and confinement. Moreover, the outcomes showed a strict link of confinement and teleoperation performance. Thanks to this unique approach in studying the impact of confinement in such realistic environments, TELEOP allows us to learn more about this unexplored field and consequently to better prepare for future missions to Mars and to the Moon.

Keywords: Confinement, Isolation, Motivation and Performance.

Acronyms/Abbreviations

ANalysis Of VAriance(ANOVA)
Electrocardiogram (ECG)
European Space Agency (ESA)
Extra-Vehicular Activity (EVA)
Heart Rate (HR)
Human-Robot Interaction (HRI)
Institute of Bio-Medical Problems (IBMP)
Intrinsic Motivation Inventory (IMI)
International Personality Item Pool – Neuroticism Extraversion and Openness (IPIP-NEO)
International Space Statio (ISS)
Mars Desert Research Station (MDRS)
Negative Affect (NA)
National Aeronautics and Space Administrartion (NASA)
Nazemnyy Eksperimental'nyy Kompleks, in English Terrestrial Experimental Complex (NEK)
Positive Affect (PA)
Positive and Negative Affect Schedule (PANAS)
Remotely Operated Video Enhanced Receiver (ROVER)
Robot Operating System (ROS)
Rating Scale Mental Effort (RSME)
Scientific International Research In Unique terrestrial Station (SIRIUS)

1. Introduction

In the recent history of space missions, most agencies have centred part of their research on manned flight missions, more precisely on the possible effects of long-term experiences, such as confinement and isolation. In the majority of them, the success of the mission is directly linked to the outcome of certain activities, for example: docking, teleoperation of a rover, etc. Although microgravity negative impact on human-robot interaction performance has been well documented [1], confinement and isolation studies have mostly been focused either on general well-being including sleep quality or on interpersonal relationships [2,3,4] with no direct assessment of their impact on teleoperation performance.

Thus, the TELEOP project was designed to assess whether or not confinement and isolation affect human-robot interaction as well as the mental and physical state of the operator. In order to evaluate this effect, the concept TELEOP uses to link all the parameters is the level of engagement. In this paper, engagement refers to how much a person is mentally involved in a task. Thanks to that, it is able to study the different influences of the variables (see Figure 1).

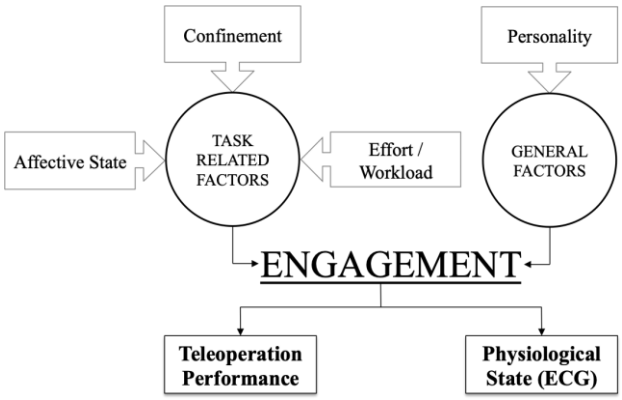

Fig. 1. Engagement diagram

1.1 Objectives

TELEOP aims, principally, to evaluate the impact of confinement and isolation on HRI performance. In addition, some psychological and physiological measurements were taken, in order to study them in comparison with the previous data.

1.2 Hypotheses

The hypotheses studied with the TELEOP project are the following ones [5,6]:

- Motivation evolves following a U-shaped curve as represented in Fig. 2.
- Confinement is inversely correlated with motivation.
- Motivation and confinement have an effect on the mental state.
- Personality has an impact on how confinement is felt.
- Teleoperation performance is directly linked to operator's engagement.
  Therefore all factors that impact engagement are likely to modulate operators' performance.
- Some external effects, such as learning effect and social relationships, may be more significant than confinement itself.

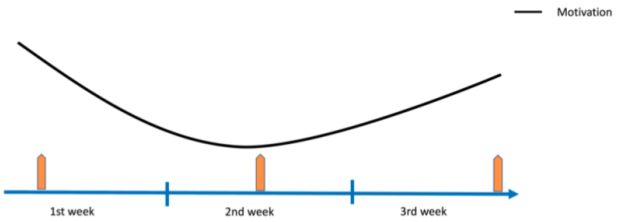

Fig. 2. Motivation curve

2. Materials and Method

The interest on long-term missions has highly increased in the recent years and, with it, the use of space analog facilities. These installations allow researchers to simulate very accurately space environments. The experimental protocol of the TELEOP project was implemented multiple times: once in the MDRS and another one in Lunares facility. This let the team test the protocol and obtain the firsts results. The protocol varied slightly between missions. But the basis of the methodology was kept the same: application of protocol, data processing and data analysis.

2.1 Analog missions

2.1.1. MDRS-189

MDRS-189 was the first analog mission TELEOP was executed in. This mission took place in the Mars Desert Research Station (MDRS) in the Utah Desert in early 2018 during 3 weeks. This facility is meant to simulate the environment that future astronauts may find in the surface of Mars. For this reason, it is specially focused on the extravehicular activities that the crew have to perform along the experience in the desert. For this reason, the main aspect that the MDRS analog reproduces is isolation (see structure of the habitat on Figure 3).

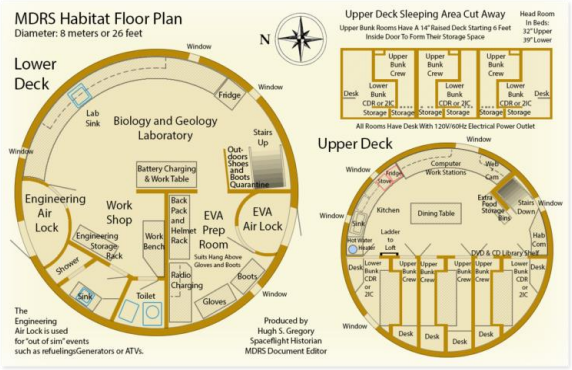

Fig. 3. Mars Desert Research Station habitat [7]

The crew was formed by 7 French students (1 female), between the ages of 19 and 23, from the ISAE-SUPAERO aeronautical engineering school.

2.1.2. ARES III Mission

This analog mission was the second in which TELEOP was performed. ARES III was carried out in the Lunares facility in Poland, during 2 weeks in August 2018. It is designed especially to simulate a Moon base [8]. Taking into account the enclosed facility and the little contact with the outside, it is considered that the crew was in an environment of confinement and isolation (see structure of the habitat in Figure 4).

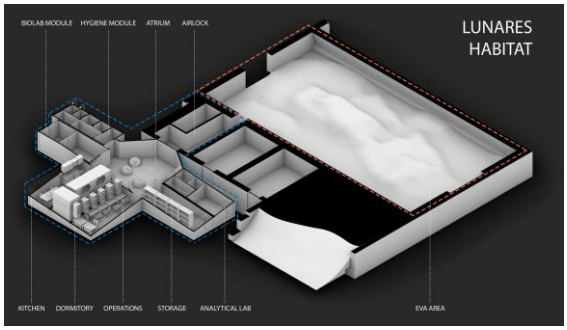

Fig. 4. Lunares habitat [4]

The crew of ARES III was formed by 6 members (3 females) of different origin, ages and nationalities.

2.2. Teleoperation task

The main objective of the TELEOP project is to study the impact of confinement and isolation on the performance of astronauts during long-term missions during common HRI activities, such as rendezvous and docking operations or teleoperation of exploration rovers on the surface of a celestial body. For this reason, special attention was given to the design of this task. Choice was made to reproduce the guidance of a rover along a predefined path.

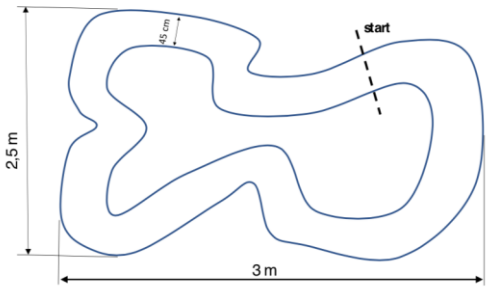

Fig. 5. Predefined track for the teleoperation task [5]

As it can be seen in the Figure 1, the path simulates sharp turns and narrow passages, typical situations that a rover may face in real missions. The overall goal of the teleoperation was for the subject to complete a whole turn, with a rover, along this path, by watching the trajectory through a camera installed on the rover (the user did not see directly the rover movements) [5].

The rover was designed and built using LEGO® pieces. The motors, to allow movement, and a camera, for real-time video, were mounted in a rectangular base using LEGO® MINDSTORMS® Education package. In order to allow connection from the rover to the main computer (which the user controls the rover from) and vice-versa, the rover ran on Raspberry Pi® 3. This allowed remote control and real-time video connection [5].

2.3. Experimental Protocol

Three main groups of data were considered: subjective, behavioural and physiological datasets. The first one is related to the mental state of the subject. To obtain this data, specific questionnaires were used (see section 2.4.). Regarding the behavioural data, they consist of performance metrics. They are acquired by evaluating task performance metrics of the teleoperation described in section 2.5. Lastly, physiological state was assessed through cardiac activity which was measured using an electrocardiogram during the teleoperation task.

To make sure the protocol was correctly followed and anticipating that some problems may arise during the analog missions, a member of the crew was chosen to be the supervisor. Her/his duty was: to set the experiment, measure the time-to-completion and errors of the teleoperation task, and make sure to check and store all the data. From the feedbacks of the first analog mission (MDRS-189), this protocol was improved. The details will be explained in the following sections.

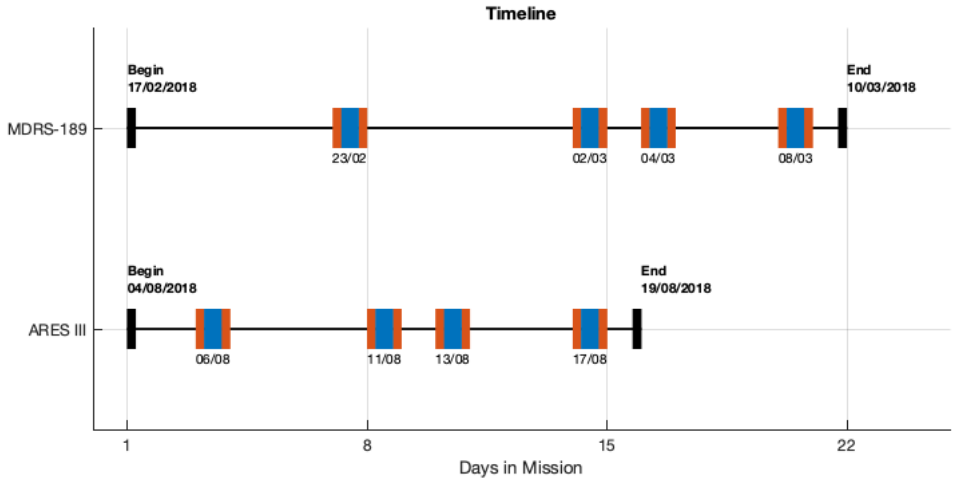

Fig. 6. Schedule of TELEOP during MDRS-189 and ARES III

Some assumptions that TELEOP wants to assess are the evolutions of certain feelings, as well as the teleoperation performance and the heart activity. In order to do that, the times that TELEOP is performed and, specially, in which moment of the mission play a great role on the results. Hence, the scheduling of TELEOP is very important to obtained reliable data. Homogenous measurements must be taken along the missions, putting exceptional attention in the beginning, middle and end phases.

As it can be seen in Fig. 6, TELEOP was performed 4 times in each mission. In the timeline, it can be clearly seen the position in time of the first session, the middle sessions (seconds and third sessions) and the last one. Due to the duration of the mission, TELEOP was not possible to be carried out more than 4 times. Despite that, the data obtained is enough to validate the protocol and approach the main scientific questions that TELEOP concentrates on. In the timeline figure, the orange areas represent the questionnaires while the blue areas represent the teleoperation task.

2.4. Subjective measures

The first step of the protocol was meant to measure the mental state of the subject. In particular we meant to measure the operators' personality, positive and negative affect, motivation, confinement and mental effort. This was done using the following questionnaires:

- IPIP-NEO [9]: This questionnaire was filled online and its goal was to evaluate the personality of the subjects within the Five Factor Model (extraversion, agreeableness, conscientiousness, neuroticism and openness to experience). It consisted in 300 questions that, later on, it is analysed and returns the score of each personality facet. This questionnaire was filled only once, at least 2 weeks before the mission.
- PANAS [10]: 1st questionnaire filled before every teleoperation task during the mission. It assessed the positive and negative affect and consisted in 20 items (10 positives and 10 negatives). The subjects had to answer how much they agreed with each item in a scale from 1 to 5.
- IMI [11]: This questionnaire was filled after the PANAS one. It aimed at calculating, as much as possible, the level of motivation using various subscales. Although motivation is linked to all of them, as indicated by the authors, in our sense the best subscale that represented it is Interest/ Enjoyment one. In MDRS-189 it consisted in 27 questions, evaluating Interest/Enjoyment (linked to motivation), Perceived Competence, Effort/ Importance, Pressure/Tension and Value/ Usefulness. All of them rated between from 1 to 7. From the feedback of MDRS-189 crew and the results obtained, it was decided to change this questionnaire for a shorter version and new questions assessing the social interactions were added. This way, the IMI questionnaire for ARES III consisted in 10 questions and it measured: Interest/Enjoyment, Pressure/ Tension and Relatedness (social relationships).
- Subjective Performance: This questionnaire was only applied in MDRS-189. Its goal was to estimate the perceived performance. It consisted in 3 questions asking about the time they think it took them to complete the task, the errors the think they made and their feelings. This questionnaire was created especially for this study.

The following questionnaires were answered after the teleoperation task.

- Confinement: This questionnaire tries to evaluate the level of confinement the subjects feel. In MDRS-189, it consisted in 8 questions about the private space, outdoors activities and other aspects. After some rephrasing, deleting of some questions and adding some new ones regarding the social aspect, the new confinement questionnaire implemented in ARES III consisted in 7 questions. This questionnaire was created especially for this study.
- RSME [12]: This was the last questionnaire that the subjects had to fill after the teleoperation task. This questionnaire consists, for the subjects themselves, to evaluate the amount of mental effort they put on into performing the teleoperation task.

Taking into account the feedback from the first mission, the team decided to put all the questions in each questionnaire in a random order for every TELEOP session in the ARES III mission in order to limit the boredom of the crew. In addition, some rephrasing and synonyms were used to make the questionnaire more dynamic.

2.5. Behavioural and physiological measures

The teleoperation task performance was evaluated through task effectiveness metrics [13]. The supervisor of TELEOP during the mission counted the number of times the rover stepped outside the track and measured the time-to-completion. With these values, it was possible to compute the evolution of the teleoperation performance along the mission.

The physiological measures that we used for these studies were cardiac ones. Cardiac activity was measured using electrocardiography recorded thanks to the Faros 360 system. Heart rate and heart rate variability (standard deviation of the RR interval) were extracted from this signal using the Kubios software [14].

2.6. Data Analysis

All results underwent statistical analysis using analyses of variance (ANOVAs) and Spearman correlation analyses. Questionnaires data had to be preprocessed. They can be divided in 5 groups: personality, PANAS, IMI and confinement, subjective performance and finally RSME.

Concerning the personality questionnaire, the online software analyses the data and sends it to the user. These results are mainly used in the statistical analysis to check if there is any correlation between the personality and the other parameters.

The analysis of the PANAS questionnaire follows the guidelines in the reference [10]. The results are split in two groups: PA and NA. The values of PA reflect how much a person feels enthusiastic, active and alert. On the other hand, the values of NA show the level of distress and unpleasurable engagement. The nominal values of PA and NA are 29.7±7.9 and 14.8±5.4, respectively.

Regarding the analysis for the IMI questionnaire, it was performed according to [11]. The mark of the negative items is reversed and for every subscale, the resulting scores are evaluated and averaged. The same basis was used to analyse the confinement questionnaire. For the subjective performance, it was compared with the actual teleoperation results measured by the supervisor. Lastly, the RSME was kept with its original values.

3. Results and Discussion

First, a global overview of the results is given in dedicated parts, next the statistical results are detailed.

3.1 Subjective Results Basic Description

Two of the main focuses of TELEOP were to assess the evolutions of motivation and confinement, and their impact on the teleoperation performance.

By analysing the IMI questionnaires, especially the questions related to Interest and Enjoyment, it was possible to obtain a curve representing the time dependency of motivation on the analog missions presented in section 2. For confinement, the results were taken from the according questionnaire. In Fig. 7, it can be seen the results for both experiences.

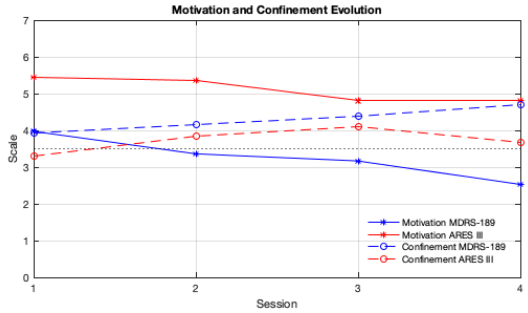

Fig. 7. Motivation and confinement evolution

Both missions have common tendencies of motivation and confinement reported feelings. In the above graph, it can be seen that motivation decreases and confinement increases, along the mission. Figure 8 represents the average scores of PA and NA in both missions. As it can be seen, the trend of PA and NA followed pretty close the curves of motivation and confinement, respectively (particularly for the MDRS-189 mission). This link was confirmed in the correlation analysis, in section 3.3. It needs to be noted that for

most of the time, all the values were inside the nominal margin.

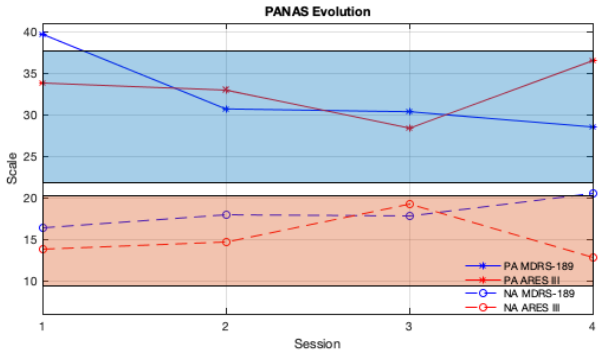

Fig. 8. PA and NA evolution

From the subjective results obtained through the PANAS, IMI and Confinement questionnaires, it can be seen that the mood and feelings, of both crews, deteriorated constantly along the mission. These results were not expected in the hypotheses. This may be due to the short duration of the missions and the problems the crews encountered during the enclosure.

3.2 Behavioural Results Basic Description

In this section, the teleoperation performance is studied. In both missions, the teleoperation was evaluated by measuring the time-to-completion of the task and the amount of times the rover went outside the track. In Fig. 9, the evolution of the average per crew of the time is compared to the confinement curve.

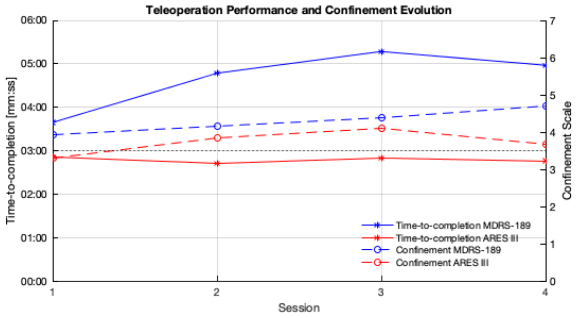

Fig. 9. Teleoperation performance evolution

The aim of the previous figure is to compare, side-by-side, both curves, time to complete the simulation and confinement, and to see whether there is a relationship between them or not. As it can be seen, no apparent link is noticeable from the graph.

From the figure 10, it can be observed that the errors have a constant decreasing tendency. This can be called a "learning effect". This curve represents clearly that along the mission, the subjects were getting more comfortable with the task and they were improving their performance.

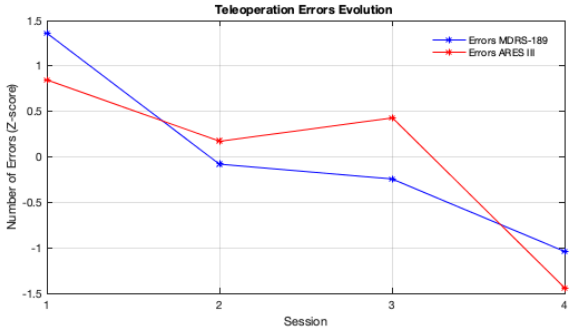

Fig. 10. Teleoperation errors evolution

For this reason, these results are not relevant, and it is not possible to extract any conclusion from them. In order to avoid this effect in future missions, a training program is currently designed so the subjects feel comfortable with the task before they start the mission.

3.3 Statistical Analysis Results

The following results reflect the findings obtained from the statistical analysis. This section is divided in two: the correlation analysis results and the ANOVA results.

3.3.1 Correlation analysis results

The correlation analysis shows if there is any connection between two chosen continuous variables. The tables, where the results are presented in, display values from -1 to 1 to indicate the strength of the connection (being -1 and 1 the strongest links and 0 the weakest one). The values highlighted in red represent those correlations that were found between the two parameters evaluated.

Table 1. Spearman correlation analysis results for MDRS-189 (red: significant, $p<0.05$)

	PA	NA	Motivation	Effort	Time-to-Completion	Errors	Confinement
PA	1.000	-0.035	0.529	0.440	-0.396	0.549	-0.159
NA	-0.035	1.000	-0.328	0.102	-0.067	-0.451	0.835
Motivation	0.529	-0.328	1.000	0.330	-0.511	0.543	-0.242
Effort	0.440	0.102	0.330	1.000	-0.349	-0.035	-0.026
Time-to-Completion	-0.396	-0.067	-0.511	-0.349	1.000	-0.006	-0.204
Errors	0.549	-0.451	0.543	-0.035	-0.006	1.000	-0.601
Confinement	-0.159	0.835	-0.242	-0.026	-0.204	-0.601	1.000

Table 2. Spearman correlation analysis results for ARES III (red: significant, p<0.05)

	PA	NA	Motivation	Effort	Time-to-Completion	Errors	Confinement	Relatedness
PA	1.000	-0.491	0.314	0.044	0.629	-0.222	-0.424	0.265
NA	-0.491	1.000	-0.354	-0.444	-0.274	0.140	0.418	-0.618
Motivation	0.314	-0.354	1.000	0.328	0.228	0.201	-0.150	0.214
Effort	0.044	-0.444	0.328	1.000	0.260	0.229	-0.134	0.178
Time-to-Completion	0.629	-0.274	0.228	0.260	1.000	0.028	-0.488	0.305
Errors	-0.222	0.140	0.201	0.229	0.028	1.000	0.314	-0.287
Confinement	-0.424	0.418	-0.150	-0.134	-0.488	0.314	1.000	-0.374
Relatedness	0.265	-0.618	0.214	0.178	0.305	-0.287	-0.374	1.000

Table 3. Spearman correlation analysis results for MDRS-189 and ARES III merged (red: significant, p<0.05)

	PA	NA	Motivation	Effort	Confinement
PA	1.000	-0.169	0.303	0.222	-0.227
NA	-0.169	1.000	-0.439	-0.170	0.690
Motivation	0.303	-0.439	1.000	0.391	-0.287
Effort	0.222	-0.170	0.391	1.000	-0.121
Confinement	-0.227	0.690	-0.287	-0.121	1.000

The first two tables (1 and 2) show the correlation between the studied parameters in each mission, while table 3 presents the correlations values measured for both missions at the same time.

From the first 2 tables no common behaviours can be seen. However, when the data is merged, the following statements can be made:

- Motivation is correlated to the affective state of the operator (PA and NA).
- The negative affect (NA) is strongly correlated to the feeling of confinement.
- Effort is correlated to motivation.

These results show that there is a very strong direct link between confinement and negative feelings, and motivation with positive feelings. Furthermore, some relation between the above parameters and effort are spotted. These results strengthen the purpose of the TELEOP experiment, since the scientific question about the impact of motivation and the mental state with confinement is confirmed.

In parallel, the teleoperation performance has been proved to have some relationships with some parameters in both missions.

- Time-to-completion may be related in some way with PA. (ARES III – negative link)
- Some relationships have been found between the teleoperation parameters and motivation (MDRS-189) and confinement (MDRS-189 and ARES III).

The fact that some correlations are found proves the importance to further study this topic. In addition, once the learning effect is reduced in future missions, TELEOP will have more reliable data and conclusions on this topic.

The last parameter to study, considered only in ARES III, is Relatedness. From the feedback of MDRS-189, it was assumed that the social relationships between the crewmembers are very important and have a great impact on the feelings of confinement and motivation. After the correlation analysis, it has been found that this aspect is strongly linked to negative feelings, and, indirectly, to motivation and confinement through the mental state of the operator. This shows the importance to keep evaluating this parameter in future missions.

3.3.2 ANOVA

Analysis of variance results are shown, for both analog missions, in Table 4. The values highlighted in red are the results that express a low enough p-value (less than 0.05). This way, it proves that the trend of the parameter is not a coincidental behaviour. Only the MDRS-189 data shows some significant results (PA, motivation and error).

Table 4. P-value results from ANOVA on several results according to time of confinement (red: significant, p<0.05)

	p-value	
	MDRS-189	ARES III
PA	0,013	0.2671
NA	0,341	0.2742
Motivation	0,029	0.5768
Effort	0,203	0.6551
Time-to-Completion	0,270	0,337
Errors	0,000	0,130
Confinement	0,345	0,461

3.4 Impact of confinement on physiological state

To obtain physiological data, an ECG was performed during the teleoperation simulation. This task was only carried out in ARES III because, due to unexpected technical issues, this was not possible in MDRS-189. Figure 11 shows the evolution of the heart rate (HR) and the heartrate variability (HRV; standard deviation between RR peaks) averaged across participants.

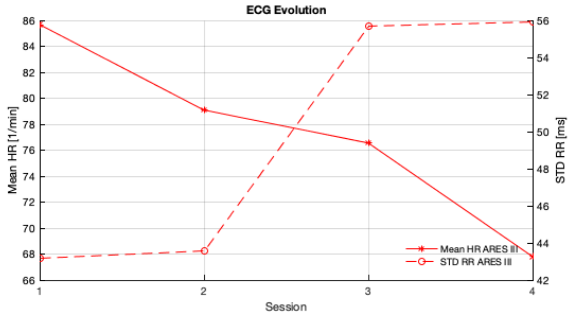

Fig. 11. ECG evolution

As it can be seen, the HR decreased while the HRV increased. This can be a consequence of the crew getting more used to the task and habitat and thus, getting more comfortable. No correlations were found between the ECG measurements and the other parameters. Further investigation on this topic must be done.

3.5 Personality and confinement

Personality has been known as a key factor to build a suitable crew. This study not only helps identifying possible good candidates to form the crew, but it also helps to anticipate how certain environments, activities and tasks may affect the person her/himself. TELEOP aims to see if there is any relationship between certain personality traits and confinement. In table 5, the correlation analysis between these parameters is shown.

Table 5. Correlation analysis between confinement and personality traits (red: significant correlation p<0.05)

	Confinement		
	MDRS-189	ARES III	Merged
Extraversion	-0.403	-0.346	-0.363
Agreeableness	-0.456	-0.510	-0.803
Conscientiousness	-0.257	0.435	-0.500
Neuroticism	0.846	0.899	0.685
Openness facets	-0.610	0.869	-0.707

As it can be seen, a strong link is found between neuroticism and confinement. According to the results, the more neurotic a person is, the more confined they will feel. This seems sensible if we think about the lack of privacy and space the crewmembers have during this kind of missions. Neuroticism refers to the tendency to experience negative feelings, these people respond emotionally to events that would not affect most people [9]. For this reason, it is coherent to think that they would be prone to be more affected by confinement.

On the other hand, confinement was shown to be inversely correlated to agreeableness and openness to experience. The first trait, agreeableness, represents the concern with cooperation and social harmony. The second trait, openness to experience, evaluates the how imaginative, creative people are in comparison with more conventional, down-to-earth people. The people that mark high in one or both traits are considered friendly and intellectual. Both of them appear to have a negative impact on confinement. This may be due to them being able to deal in an easier way with their feelings, and so not feeling as confined as someone that scores higher in neuroticism.

4. Future Work

TELEOP is a very ambitious project. Thanks to the analog missions analysed here and the feedbacks from the crewmembers, the improvements have been important. The future plan of TELEOP is, essentially, to be performed in more and longer analog missions and to keep improving the simulation. The previous missions (2-3 weeks long) allowed settling the protocol and acquiring the first batch of data. But from here on, TELEOP is focused on longer mission durations, where the effect of confinement and isolation is more noticeable.

4.1 Protocol Improvement

Given that TELEOP will be performed in multiple analog missions in the future, and some of them at the same time, it was decided that the protocol needed to be updated. The main changes are: the addition of training phases, the digitalization of the whole protocol and the design of software to simulate a new teleoperation task. These improvements reduce drastically the time

duration of the experiment and there is no need to train a supervisor, thus allowing having more subjects per mission.

Concerning the training, this phase prior to the mission will be added in order to minimise the learning effect of the teleoperation that could be observed in the analysed results. About the teleoperation simulation, its goal has changed slightly. This time, the operator will be controlling a digital rover through a virtual lunar landscape, as see in Figure 12. The objective is to collect a sample and bring it back to the starting point.

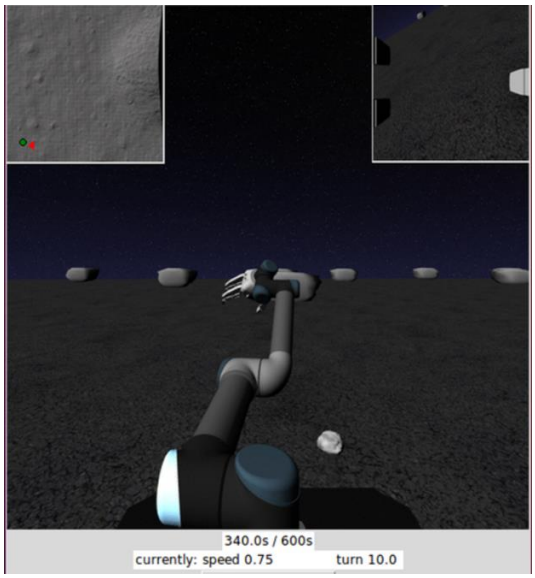

Fig. 12. Digital teleoperation simulation

4.2 MDRS-206 Mission

This mission is key for the future of TELEOP. MDRS-206 is performed in the same facilities as MDRS-189 and the team is formed by French students from ISAE-SUPAERO. The crew of MDRS-206 will be performing both protocols (the old one with the physical rover and the path, and the new one, with the digital rover). The plan is to compare them and see if there is any impact on the crew performance with the new improvements.

4.3 SIRIUS Campaign

In addition, TELEOP is interested in SIRIUS campaigns carried out in IBMP NEK facilities, in Moscow. SIRIUS is formed by 4 different duration analog missions. SIRIUS-19 will be the first long analog mission TELEOP will be performed in and the second of the entire campaign. This is a 4-months mission with a crew of 6 persons (3 male and 3 female), 2 American and 4 Russian. SIRIUS-19 is the first long mission that TELEOP will be carried out in. This will allow testing the new protocol as well as obtaining reliable data.

5. Conclusions

This project was based under the assumption that confinement and isolation have an effect on HRI. After the analysis of the data obtained from MDRS-189 and ARES III analog missions, some crucial relationships were observed. The link between confinement/isolation and engagement was ascertained. In addition, some effects could be seen on teleoperation performance too. In parallel, some external effects that weren't considered were found in the results, such as the learning effect on the teleoperation performance and the impact of social relationships on the crew's affective state. Future missions will be key in order to better understand the results to pave the way towards efficient operator's monitoring in long duration and confined missions.

References

[1] Weber, B., Riecke, C. & Stelzer, M. (2019). Disentangling the Enigmatic Slowing Effect of Microgravity on Sensorimotor Performance. In: *Proceedings of the HFES Europe Chapter 2019 Annual Conference*, Nantes, France.

[2] Palinkas, L. A., & Suedfeld, P. (2008). Psychological effects of polar expeditions. *The Lancet*, *371*(9607), 153-163.

[3] Sandal, G. M., Van De Vijver, F., & Smith, N. (2018). Psychological hibernation in Antarctica. *Frontiers in psychology*, *9*, 2235.

[4] Sandal, G. M., Bye, H. H., & van de Vijver, F. J. (2011). Personal values and crew compatibility: Results from a 105 days simulated space mission. *Acta Astronautica*, *69*(3-4), 141-149.

[5] A Ambrosio and F Reyna (2018) SIRIUS: Impact of confinement on Human-Robot performances. End of study report. Toulouse, France.

[6] V Martin-Estrana and F Vagnone (2019) TELEOP: Impact of Confinement and Isolation on Crew Performances during Long-Duration Missions. Toulouse, France.

[7] The Mars Society, http://mdrs.marssociety.org (accessed 27.06.19)

[8] Space is More Sp. z o.o. https://lunares.space (accessed 27.06.19)

[9] John A. Johnson, https://www.personal.psu.edu/~j5j/IPIP/ipipneo300.htm (accessed 27.06.19)

[10] D. Watson, L. A. Clark and A. Tellegen (1988) Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scale, J. Personality and Social Psychology, 54, N.6 1063-1070.

[11] Center of Self-Determination Theory, https://selfdeterminationtheory.org/intrinsic-motivation-inventory/ (accessed 27.06.19)

[12] Zijlstra, F. R. H., & Van Doorn, L. (1985). The construction of a scale to measure subjective effort. *Delft, Netherlands, 43*.
[13] Olsen, D. R., & Goodrich, M. A. (2003). Metrics for evaluating human-robot interactions. In *Proceedings of PERMIS* (Vol. 2003, p. 4).
[14] Tarvainen, M. P., Niskanen, J. P., Lipponen, J. A., Ranta-Aho, P. O., & Karjalainen, P. A. (2014). Kubios HRV–heart rate variability analysis software. *Computer methods and programs in biomedicine*, *113*(1), 210-220.