Inter- and intragroup interaction in MARS-500 Project

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MILESTONES IN RUSSIAN SPACE SIMULATION

1967 - 3 Russian men (2 engineers and medical doctor) spent 1 year in the chamber, simulating interplanetary Mission.

1999 - 12 people (11 men and 1 woman) from Russia, Japan, Germany, Austria and Canada spent from 110 to 270 days in the chamber, simulating the orbital flight of the international crew – SFINCSS-99.

2010-2011 - 6 men from Russia (3 subjects), France, Italy and China spend 520 days in the chamber, simulating Manned Mars Mission – MARS-500.

2036 – Manned Mars Mission?
FACILITY FOR SPACE FLIGHT SIMULATION
“MARS-500” SIMULATION OF FLIGHT TO ANOTHER PLANET

Experiment objective – to study medical and biological aspects of an autonomous manned flight to Mars.

CREW COMPOSITION: international crew of three Russians, two representatives of ESA from France and Italy, and Chinese Space Agency representative, age 25-40

Isolation duration: 520 days.

Specific features

1. The conditions of autonomous existence were created by limiting the amount of resources available to the crew and stopping the re-supplies on the 36-th day of the experiment.

2. The project was the first to simulate an increasing communication delay between the Mission Control Center (MCC) and the interplanetary mission crew, which reached 12 minutes. Moreover, communication with the crew was stopped completely on days 320–327. During the period of high autonomy, the crew used e-mails and video messages to communicate with the MCC.

3. It was the first time that scientists studied not only an extremely long 520-day isolation imitating an interplanetary flight but also simulated a landing on the surface of Mars with the execution of the key research operations planned under the scenario developed by Roscosmos and RAS.
CREW SELECTION AND TRAINING

Survival training

Crew compatibility assessment

Training and final selection
ASTRONAUTS PARTICIPATION
WORK- REST SCHEDULE

8 hours of work - 8 hours of leisure time - 8 hours of sleep (with night duties of one crewmember)

Skill maintenance and learning (i.e. training of piloting skills)

Research (more than 70 experiments from Russia, Europe, China and US)
Resources consumption control and management

LSS management

LSS repair
COMMUNICATION WITH DELAY

Mission Control

Communication channels:

a. **Audio communication via phone** in accordance with the space schedule (30 minutes each 90 minutes)

b. **Text communication** via computer (Radiograms, Commander’s reports, private E-mail)

c. **Video messages** via Web camera (new!!!)
AUTONOMOUS MEDICAL SUPPORT

Medical and psychological control

Medical and psychological countermeasures

Medical and psychological care. Telemedicine
• Wearing space suit under Earth gravity after 200 days hypokinesia

• Picture transmission to TCOUP

• Sampling on Martian surface
“MARS-500” RESULTS
GROUP DYNAMICS OBSERVATION

Study objective was to find correlations between popularity in the isolated autonomous group and individual behavior

1. Classic approach
   - Sociometric questionnaire to assess group status (popularity) of the crewmembers (monthly)
   - Preferable color choice test to assess the level of frustration and anxiety (twice a month).

2. Etho-psychological approach was supplied with a computerized tool, Observer XT®, designed to collect and process video data.

   The non-verbal behavior during breakfast time (video only) was coded (divided in categories): “visual interactions”, “object interactions”, “body interactions”, “personal actions”, “facial expressions” and “collateral acts” (data from C. Tafforin, Ethospace, France). The verbal behavior was analysed during group discussion (video + audio).
“MARS-500” RESULTS

POPULARITY AND ANXIETY LEVEL

Two subgroups were defined in the crew:

The first one consisted of the subjects A, B, D with high group status (popularity) and lower level of frustration (less anxious).

The second one consisted of less popular subjects, having respectively higher anxiety level.

Feeling frustration under extended isolation and monotony, subjects were mostly attracted by those who felt more self-confidence and less tension.

That’s why the group perceived the last (subjects A, B and D) as sociometric leaders.
**“MARS-500” RESULTS**

**POPULARITY, ANXIETY AND FACIAL EXPRESSION**

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<thead>
<tr>
<th></th>
<th>Anxiety</th>
<th>Sociometry Question 1</th>
<th>Sociometry Question 2</th>
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<tbody>
<tr>
<td><strong>Interpersonal communications</strong></td>
<td>R</td>
<td>-0.928**</td>
<td>0.841*</td>
</tr>
<tr>
<td></td>
<td>Sign. (2-tailed)</td>
<td>0.008</td>
<td>0.036</td>
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<tr>
<td><strong>Collateral acts</strong></td>
<td>R</td>
<td></td>
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<tr>
<td></td>
<td>Sign. (2-tailed)</td>
<td></td>
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<tr>
<td><strong>Facial expressions</strong></td>
<td>R</td>
<td>-0.771</td>
<td>0.829*</td>
</tr>
<tr>
<td></td>
<td>Sign. (2-tailed)</td>
<td>0.072</td>
<td>0.042</td>
</tr>
<tr>
<td><strong>Anxiety</strong></td>
<td>R</td>
<td>-0.771</td>
<td>-0.943**</td>
</tr>
<tr>
<td></td>
<td>Sign. (2-tailed)</td>
<td>0.072</td>
<td>0.005</td>
</tr>
</tbody>
</table>

(*) – Significance level is p<0.05;  
(**) – Significance level is p<0.01;  
Bold – quasi-significant correlations 0.05<p<0.1.

Crewmembers with higher sociometric popularity were less anxious and demonstrated facial expressions more frequently. They were also more frequently involved into interpersonal communication, with more pronounced facial expressions vs. collateral acts.
The video analysis showed twice more manifestations of facial expressions and interpersonal communications in the subgroup of popular subjects (A, B, D).

High sensitivity, self-disclosure and expressiveness helps leaders demonstrate empathy to the other subjects, which they need so much under social isolation.

For all of the subjects, the amount of non-verbal behavior categories was higher than the amount of verbal behavior categories. It means that crewmembers were more frequently involved in interpersonal actions than in interpersonal communications. Body language seems to dominate in communication during extremely long sensory deprivation and monotony.
With the help of linguistic software (NooJ) we calculate the frequencies of certain statements (semantic units), that we attribute to the psychologically relevant content analysis categories:

- **Needs** — statements, containing adverbs and verbs, expressing the area of motivation and necessities e.g. “we need, it’s necessary, it will be helpful, we demand, we require”, etc.

- **Interaction** — statements, containing mentioning by name or by the status (PI, Mission controller, Coordinator, etc.) or using the pronouns “Me”, “We” (separately about the crew and MCC), “They” (separately about the crew and MCC).

- **Time** — statements related to time perception, e.g. “hour, day, always, never, constantly”, etc.

- **Negativism** — statements, containing critique of the crew’s life and work under isolation in the chambers, e.g. “mistakes, shortages, deficit, faults”, etc.

Only ‘official’ messages, sent via non-confidential communication channel, are used for the content analysis.
In the course of the Mission the number of crew’s needs expressed to the Mission Control was decreasing.

The more autonomous the crew was, the less the crewmembers needed any support from MC.

Average relative frequency of ‘Needs’ statements in written messages of the MARS-500 crew (%).
The written messages became considerably less formal and more personal in “special” periods of MARS-500 (increase of interactions), and considerably less personal in some other periods.

The first of three main peaks clearly corresponds to the beginning of high autonomy period (08.2010), the second - to the Mars landing simulation and preparation period, (01-02.2011), and the third - to the period of awaiting and preparation for the end of the experiment (for the life outside the chamber afterwards).

Average relative frequency of ‘Interaction’ statements in written messages of the MARS-500 crew (%).
The state of waiting and expectation of something significant and important can be rather stressful, and a crewmember needs to perform many tasks in given time during an important (‘key’) period. The perception of time can significantly change in such conditions. “When the life inside is monotonous, the time stops and all the days look the one long day, when the key event is approaching it starts running”. Thus the messages before and during significant periods and events contained a relatively frequent mentioning of ‘Time’ category.

Average relative frequency of ‘Time’ statements in written messages of the MARS-500 crew (%).
The content of the crew’s messages was relatively more negative in the periods of serious changes in experimental conditions. The radiograms contained complaints, blame, and sharp criticism. The crewmembers, like in real space Missions, obviously tended to ‘drain out’ (“displacement”: according to N. Kanas) their negative emotions outside, to maintain psychological climate inside the chambers in equilibrium state, preventing disintegration of the crew.

Average relative frequency of ‘Negativism’ statements in written messages of the MARS-500 crew (%).
One of the extreme cases modeled in Mars-500 was a situation with complete loss of communication with MC. All the communication logistics were disabled (except for emergency communication).

In average the crew displayed a tendency to write significantly less messages after the event. The individual communication patterns restored only after a period of same length as the period with communication loss (about one week).
“MARS-500” RESULTS
ECOPSYCHOLOGICAL ASPECTS OF GROWING PLANTS UNDER EXTENDED ISOLATION

METHODS

A. Specially developed (together with Utah University) **Greenhouse-related questionnaire** – monthly during the isolation

B. Analysis of **photo** and **video** from the chambers

C. Individual **interviews** - during debriefing

D. **Eysenck Personality Questionnaire** – during debriefing

E. **WLGS sensors (DLR, Germany)**, allowing to calculate physical **distances** from the **Aerogarden** to the subjects. – once in 2 weeks
ECOPSYCHOLOGICAL ASPECTS OF GROWING PLANTS UNDER EXTENDED ISOLATION IN “MARS-500”

Fig 1. **Personality traits** of subjects, **working** and **non-working** with plants

Group 1 – subjects, **actively working** with plants
Group 2 – subjects, **rarely working** with plants
Fig 2. Estimation of the positive (A) and negative (B) impact of growing plants on mood

- **Group 1** – subjects, actively working with plants
- **Group 2** – subjects, non-working with plants

Subjects from **Group 2** paid attention mainly on **negative events** in the Greenhouse: problems with growing, plants’ diseases and death, etc.

Negative psychological impact in **Group 2** was caused by combination mostly of **negative events, lack of knowledge about plants** (according to the questionnaire there were few discussions about plants. That was not a surprise, taking into account the introversion of Group 1)
ECOPSYCHOLOGICAL ASPECTS OF GROWING PLANTS UNDER EXTENDED ISOLATION IN “MARS-500”

PLANTS AS A FOOD SOURCE

1. All the subjects regarded the presence of fresh food in their ratio as a positive factor.

2. Subjects paid special attention to smell, taste and the presence of vitamins in the plants, not to the amount of calories containing. This data corresponds with the interviews of Russian cosmonauts.

3. Smell and taste of plants were especially important for the subjects, representing cultures with well-developed food requirements (non-Russian).
Fig 3. **Greenhouses’ significance** as ...

1 – an additional source of **FOOD**;
2 – a source of **RECREATION and RELAXATION** (psychological support);
3 – something that is **CHANGEABLE AND CONTROLLED** by them

**Group 1** – subjects, **actively working** with plants
**Group 2** – subjects, **non-working** with plants
1. Psychological selection criteria for the interplanetary Mission were clarified. Candidates with dominant motivation for success gaining, high resilience and readiness for risk in unpredictable environment should have the priority.

2. Experiment results confirmed N. Kanas and D. Manzey’s (2003) hypothesis about the possibility of developing of the psychological separation from Earth and groupthink phenomena during an autonomous interplanetary mission. This phenomenon manifested in decreasing dependence of the crew on the MCC decisions and recommendations and the increasing number of independent decisions based on the knowledge, values, and goals of the isolated small group.

3. “Mars-500” participants declared that it was not the length of communication delays, but the very fact of its presence that decreases effectiveness of data exchange with MC. Complete communication brake with MC could significantly decrease re-established communication volume, restoration of full-scale communication takes time.
4. Key-events during the interplanetary Mission (landing, communication break) could significantly influence (both, negatively and positively) behavior, performance and psychophysiological status of the crewmembers. «Mars landing» divided the Mission into two parts, that are unequal from the psychological point of view. During the first period the crew demonstrated higher motivation, vigor and crew morale. Second period (after landing) was marked by the vigor decrease, more vivid symptoms of sensory deprivation and monotony.

5. Extremely long isolation and autonomy factors demonstrated the importance of taking into account the culture-based needs of the international crew. These needs can be related to the food habits, as well as aesthetic preferences of the crewmembers. Psychological support should consider this as well as the increasing need of the communication support from friends and relatives.

6. The main organizational principals (know how) for the simulation of the key medico-psychological aspects of the manned interplanetary Mission were established.