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Issues of Information Exchange Efficiency in Long-Term Space Flights

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1. Introduction

A human being can live in outer space only in the artificially created environment of a spacecraft. Space vacuum, galactic space radiation, meteorite currents, super-low temperatures outboard give rise in space crew members to a natural feeling of threat to their health and survival. In this connection a high level of psychic tension persists even in a trouble-free space flight due to a natural worry about one's safety which is not relieved even during sleep.

As the time of a space flight increases, a cosmonaut's emotional sphere comes to be affected predominantly by uniformity (monotony) of the closed environment and by limitation of social contacts. The impact of these factors enhanced by zero gravity leads on to the appearance of dysfunctional changes. Their incrementing intensity manifests itself in cumulative weariness and central nervous system asthenisation due to an inadequate reaction of the nervous system to stimuli. Asthenisation, a condition experienced following space flights (as well as after serious illnesses, traumas, and mental overstrain), manifests itself after 1-2 months of long-term space flights due to sensory deprivation existing in space flight condition (Myasnikov, Zamaletdinov, 1997). In asthenisation, strong extrinsic stimuli may evoke a poor response, while on the other hand slight stimuli may produce a positive reaction (Myasnikov, Stepanova et al., 2000). A sign of deterioration in cosmonauts' psychic condition is a frequent appearance of frankly negative emotional responses especially if they leave a lasting negative track behind themselves in the form of low mood. Normally emotional responses (defined as the emotional component of responses to various external and internal stimuli) are transitory, clearly oriented and extremely diverse, and, most important, are not very strong. If however negative emotions predominate and become stagnant, establishing a steadily negative mood background together with irritability, aggressiveness, constant complaints of feeling unwell, of fatigue, headache etc., and if at the same time we observe paradoxical forms of emotional reactions with inadequate outbursts of irritation in response to insignificant stimuli, then this should be regarded as evidence of intense psychological trouble. In such condition a person often manifests speech peculiarities which are not normally characteristic of him or her, such as swearwords, expletives, sounds and words filling pauses, unusually loud or, on the contrary, unusually low speech with increased/decreased tonality and speed (Myasnikov et al., 1982). So individual speech style changes. It should also be pointed out that asthenisation of

cosmonauts' nervous and psychic sphere which mostly affects controlling systems, may have a negative impact on the interpersonal relationships in a space crew and on the crew-ground interaction, as well as affect performance of each crew member.

The influence of the social isolation factor in sealed cabin is displayed in the form of compulsory socializing of cosmonauts (obligatory contacts during communication with a limited circle of people in Mission Control). These limited social contacts are at the same time excessive because one has to socialize too closely with a limited circle of people. This specific situation makes it a necessity to reconsider many conventional rules and role orientations and results in an impossibility to satisfy a number of social and mental needs. (Novikov, 1981). Limitation of social contacts can induce negative emotional reactions, which have an influence on professional activities, and can for instance hamper communication of crew members with the ground services and become a source of conflict.

The analysis of space crew's communication with the Mission Control Center (MCC) is a standard operational procedure of the psychological support group in the Institute for Biomedical problems, Russia. For more than 20 years it has been used for monitoring the behavioral health of Russian crewmembers in space and long-term space simulations. Since 1992, we apply speech content analysis to reveal relationship dynamics within the group and between crew and MC. Since 2000, we apply the content analysis method to study communication of International Space Station (ISS) crews with MC.

The main reason for using content analysis for space crews communication is the necessity of non-invasive methods in crews' routine. ISS audiocommunication channels include those which are private and those which are open and automatically recorded. Crewmembers sign an informed consent thus agreeing with publicity of information surpassing this channel.

Daily work on ISS includes a considerable number of work tasks. An additional intervention in crew's schedule with one more methods concerning relationship dynamics, may lead to collection of biased data.

2. Space crew communication as a type of professional activity

The object of psychology in studying any type of professional activity is always psychological factors and processes which induce, program and regulate a person's professional activity as well as expression of personality traits through which this activity is implemented (Shadrikov, 1983). As the experience of psychological analysis of cosmonauts professional activity confirms, such processes manifest it selves in large-scale communication of a crew with various ground services (launching plant, technical and landing complexes, Mission Control etc.) and with other space objects included in the circuit of the automated system of the space flight control. First of all, part of this communication is the verbal communication of space crew members with Mission Control transferred through an open communication channel accessible for everybody of the Mission Control personnel (as distinguished from private communication channels used for special tasks of flight support, and among other things for medico-psychological purposes). In the course of such communication, cosmonauts provide Mission Control with a detailed and regular information about technological operations performed onboard, about space vehicle status, their health state, and appearing problems. In response an operators group of Mission

Control which usually includes experienced cosmonauts who have flown in space provide the crew with recommendations, instructions, directing and controlling the crew's work. Earlier such communication was limited to communication sessions, but now a space crew can communicate with Mission Control at any time during a space flight.

From the psychological point of view such cooperation ensures for a space crew information which is important for the crew members both professionally and for their personal relationships. It allows them to know better their way in the current situation, to make timely and appropriate decisions on the space ship control and its technical systems maintenance, to stay informed about life on Earth (Myasnikov et al, 2001). On their part, Mission Control operators need communication with the crew in order to get current information about the mission plan performance by the crew, which is used for the strategic and the short-time planning of the cosmonauts' activity, technical and medical support of the crew, timely consultation on various issues etc.

Therefore, information exchange is an intrinsic part of the professional activity of cosmonauts and Mission Control, and the communication efficiency directly determines the appropriateness of flight control decisions taken by the communication parties. A good personal and intergroup contact, a mutual understanding and cooperation in decision making ensures the mission plan realization and satisfies the crew's need for new informational challenges and socialization in a wider circle of persons. Adequate, open and friendly contact between the ground and the space professional groups determines, on the one hand, emotional tonus and performance of the cosmonauts and, on the other hand, precludes the development of so called deprivation effects caused by the impact of factors of a prolonged space flight. Combining engineering and technological and medical and psychological aspects of this professional activity makes communication of the crew and Mission Control an important source of unbiased current information from the engineering and technological and medical and psychological points of view. Due to this, a record and a later detailed analysis of communication of a space crew and Mission Control have been an intrinsic part of the Russian mission support system starting from the years 70 of the past century.

3. Methodology of space crew psychological status control

Psycho-diagnostics in the medical support system of manned space missions aim at the identification of various forms of adaptive behavior of people in special working conditions. In other words, psycho-diagnostics of cosmonauts' health status is are a synthesis of clinical, psychological and professional evaluations made conjointly by an expert-doctor and an expert-psychologist using accepted procedures, evaluation scales and terminology. In a space flight unlike clinical conditions, expert evaluation and diagnostics are performed on the basis of a remote observation (no direct contact with a 'patient'), with a scarcity of diagnostic data and impossibility in certain cases to make some necessary additional studies (Orbitalnaya stanciya Mir, 2002).

Psychological control and support of cosmonauts and astronauts at 'Mir" Space Station performed by Moscow Medico-Biological Problems Institute led the Institute's specialists to the development of a method which allows to remotely control and evaluate the personnel's psycho-emotional status basing on the expert evaluation of the content of their

communication with external parties and on the device-aided analysis of the time spans of such communication. The principal sources of psychological data derived from a monitoring of interpersonal interaction in a space crew are the crew's communication with Mission Control, video communication sessions, and also direct communication of the psychological support group with the cosmonauts (Gazenko et al, 1976; Kelly, Kanas, 1993; Gushin, 1995; Caldwell, 2000). The main advantage of the usage of the crew's wireless communication for the evaluation of the cosmonauts' psycho-physiological status is its psychological 'noninvasiveness', since the board-ground wireless communication is a regular procedure in a space flight. Diagnostic criteria developed by psychologists of Russian Public Scientific Center of Moscow Medico-Biological Problems Institute allow to objectively and quantitatively evaluate the psychological climate in a space crew without compelling the cosmonauts to undergo additional test procedures which would demand extra time and without installing additional equipment at the space station (Myasnikov, Stepanova, 2000). On the basis of these criteria Mission Control psycho-neurologists can provide flight directors with their professional opinions on the psycho-physiological status of space crew members for the purpose of correcting the work-and-sleep schedule.

How expert diagnostic assesment is organized during a space flight is represented on Figure 1. As we can see, information is transmitted from the board of a space vehicle through wireless and video telecommunication channels, biotelemetry channels to the experts (doctors and psychologists) being part of the medical support group. The experts analyzing the incoming information make partial expert judgments on the crew members behavior and group interaction. The chief psycho-neurologist summarizes these data and makes a diagnosis of the state of health within a day, within a week or other time periods, and also before the cosmonauts should perform especially difficult types of work, for instance, extravehicular activity. At the same time the experts decide whether the flight should continue along the regular plan or some required preventive (curative) measures should be taken.

We have to hardly mention that the efficiency of preventive care is determined for a great deal by the experts' general medical and clinical psychology knowledge of the phenomenology of a certain psycho-neurological state, of the underlying psycho-physiological mechanisms, as well as of the influencing factors. The basic premise for the analysis of information coming from onboard is that space flight conditions induce a certain psychological or neurological effect indirectly, which means that the same flight condition effect (e.g., constant noise on the ISS) does not result to the same psychological disturbances. The psychological effect depends on the initial and the current functional status of a crew member and his or her adaptive capabilities.

Until recently such analysis was a descriptive qualitative analysis. In order to make it more illustrative, a scale of expert evaluations has been developed which helps to render the work-rest distribution in quantitative characteristics ranged by number of points. After many years of making expert opinions (Orbitalnaya stanciya Mir, 2002), the specialists drew up a list of individual and group-related indicators of the psycho-neurological status of crew members (Myasnikov at al., 2002) which up till now have been monitored in the study of information coming from onboard (Chart 1). Myasnikov and Zamaletdinov who have been practicing this approach distinguished 14 individual and 5 group-related indicators used in the dynamic evaluation of the cosmonauts' mental state. These indicators were formulated

on the ground of expert assessments. The individual indicators are: dominant interests, proposals (complaints), deprivation phenomena, emotional response, mood, volitional actions, general behavior, health, sensorial sphere, motor performance, speech, sleep, psycho-physiological tension and professional activity. A special cluster of scales describes efficiency of group interaction thus allowing to judge about the small group's structure (formal and informal leaders, outcastes) and about the presence or absence of frictions in the space crew. An indicator of leadership is in the first place the fact of dominating in communication and the issues raised during it. Signs of a wrapped conflict in crew members are: the narrowing of the contacts circle and the exclusion of the unwelcome partner from it, or limiting the verbal interaction with such partner down to the minimum determined by the need to participate in a common activity, that is the formalization of the relationships with such partner.

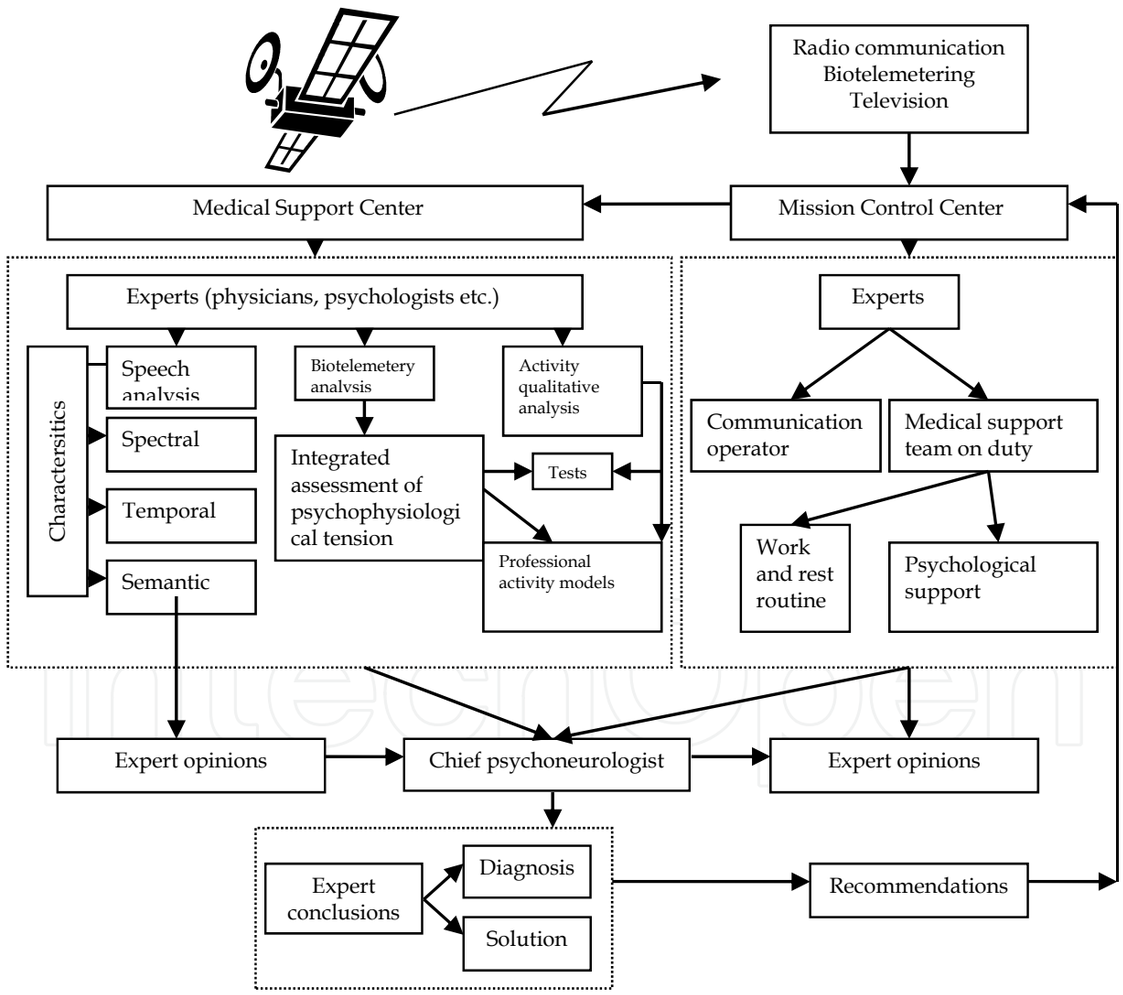


Fig. 1. Expert diagnostics organization during a space flight (Myasnikov, Zamaletdinov, 1997).

In their daily psycho-neurological opinions (which is a regular standard procedure in prolonged space flights) the experts describe unfavorable group dynamics phenomena registered in the course of observation (conflicts, formation of coalitions, mutual estrangement etc.). Besides, the degree of the mental ill-being in the group is assessed quantitatively through the method of expert evaluation on the basis of scales (such scales as "difficulties of group dynamics" in the space crew, "conflicts within the space crew and between the crew and the ground control").

As a novelty, the approach by Myasnikov and Zamaletdinov introduced 7 degrees of intensity for each diagnostic indicator. The diagnostic zones were subdivided into relative zones: optimal (from the 1st to the 3rd degree of the qualitative evaluation), transitional (from the 4th to the 5th degree) and unfavorable (from the 6th to the 7th degree). Once again, these intensity degrees were formulated by experts on the ground of their experience. A precondition for a correct assessment of an indicator is the fact that this indicator has appeared in at least two successive communication sessions. So, quantitative values representing qualitative changes along all or the majority of indicators make up quite an informative system of a dynamical remote evaluation. Research conducted during space flights (Gazenko et al, 1976; Grigorev, 1986) revealed that various parameters of verbal activity (length of communication session, content of voice messages (speech semantics), thematic variety of speech, emotional expressiveness of voice messages, character related properties of voice and speech etc.) are relatively stable indicators of the individual verbal behavior of a cosmonaut.

Individual indicators	Complaints Deprivation phenomena Emotional response Mood State of motivation and volition sphere Various aspect of general behavior Health State of sensorial sphere Motor performance Speech Sleep Psycho-physiological tension Dominant and associate interests Performance Operator activity Initiative Professional proposals and actions
Group-related indicators	Mutual understanding Group cohesion In-group control Group operation Nature of contacts with ground services

Chart 1. Basic Indicators Used in the Study of Information Coming from Onboard of a Spacecraft for Making Expert Opinions (according to "Mir" Space Station, 2002).

Until very recently, the remote psychological monitoring system was quite efficient in monitoring and progress forecast of the space crew activity. However, the experience of expert and diagnostic tasks solutions accumulated by space psychology and medicine revealed certain methodological difficulties. They are determined by the absence of a reliable conceptual model and objectively established criteria of the work of an expert dealing with remote control and information scarcity. As a result, such work of an expert has more to do with art than science, demands years of preparation, and such expert evaluations are to a certain degree subjective, determined by the expert's personal style and experience. Besides that, a problem was the ethic aspect of the method and a disfavor with which cosmonauts treated the studies of their psychological compatibility and mental health set against the background of the social acknowledgement of their achievements as those of national heroes. The fact of having assessment results which were not quite perfect could influence the possibility of cosmonaut's future flights. These factors hindered to a certain degree the development of psychological aspects of expert and diagnostic work.

4. Methods

Commencing our research of communication in actual long-duration space flights we have developed our analysis method based on the data of the space analogue experiment called SFINCSS-99 involving long-term isolation (Yusupova et al, 2006). The system of categories we developed worked sufficiently in the situation of long term isolation; however, when continuing our research in actual space flights, we had to face the fact that our analysis categories were not universal. The categories which we had used in the space analogue turned out to be too general for the analysis of the speech of space crews in long-duration space flights, that is they did not possess sufficient resolution capability and, in our view, differentiated the utterances inadequately. This inadequacy was quite expectable. According to T.G. Vinokur (Vinokur, 2007), variants of communicative verbal behavior, that is communicative styles absorb a practically 'open range' of individual interplays between the speaker and the listener, and the types of communicative styles can be defined in the terms *adequate to the components of the given heterogeneous segment of verbal behavior*. Therefore, the terms (categories) should be modified each time when the situation in which communication changes takes place.

The communication structure in space flights on ISS differed both from the communication in the above simulation experiments and from the communication of the Mir Space Station as well. At the stage of ISS development, the major share of communication was devoted to solving specific operational issues, and non-operational issues were seldom discussed. A special factor was that communication was effected simultaneously by two national Mission Control Centers (the Russian and the US MCC) and according to the regulations, the astronauts and cosmonauts could address each of them.

In order to upgrade our content analysis categories, we repeatedly listened to the records a space crew's communication for one week evaluated by the Mission Control specialists as 'normal': during this week there had been no contingency events and no large-scale innovations which would have changed the work schedule of the crew established on ISS. We registered standard phrases and dialogues trying to find textual differences related to changes in the ways of information conveyance, interpersonal interaction regulation and

feelings expression (in accordance with the three communicative functions which we were looking for in the text). We also took note of terms and phrases which occurred rarely but were typical of the communicators.

The result of this preliminary research was a modified categories chart (see Chart 2). The categories were arranged in three groups according to the Bales' (1950) communication analysis scheme and communicative functions established by B.F. Lomov (Lomov, 1981).

Modified Categories as Adapted to Space Analogue	**Modified Categories as Adapted to Real Space Flight**	**Category Functions**
Demands for information	Primary demands for information	Informative function of communication
	Clarifying (secondary) demands for information	
Information sharing (orientation) / Opinion	Informing after a demand	
	Informing without a demand	
	Ignoring a demand	
	Professional jargon, use of acronyms	
Demands for action	Requests	
Compliments, gratitude, approval, consent	Emotional consent	Emotional function of communication
Disapproval, discontent, discord	Emotional discord	
Warm-hearted humor, jokes, phatic expressions	Humor and jokes (tension release)	
Satire, acidity	Satire, acidity	
Complaints, laments/ antagonism	Operational complaint	
	Socially directed complaint	
Compliments, gratitude, approval, consent	Rational consent	Socio-regulatory function of communication
Disapproval, discontent, discord	Rational discord	
Request / intention of joint activity, solidarity, offers	Encouragement, sympathy, gratitude	
	Calls by name	
Justification, defense	Self-justification	
Refusal of joint activity, refusal of help, refusal of offers	Refusal to cooperate	

Chart 2. Bales' method categories modified to capture special features of communication on ISS.

We paid special attention to drawing up the codebook which should have reflected the basic provisions of our research method. A codebook is a manual used by an expert-encoder who collects empirical data and encodes the predetermined units of analysis (Neuendorf, 2002). Therefore, the codebook together with the coding form (chart of categories used to record the number of these categories in speech) are the principal documents of content analysis. Since we used the quantitative content analysis (Krippendorf, 1980), once the codebook and the coding form had been adopted, they did not change in the course of the four missions data collection in order to ensure the research data consistency.

One more relevant feature of the space flight communication analysis is how often such communication can be listened to. In our case, the choice of the days of the week was determined by the access to the encrypted communication channel which we gained. It was Tuesdays in case of the crews I, III, IV and Tuesdays plus Thursdays in case of the crew II.

5. Certain results and discussion

Certain issues we faced were connected to communicative styles of the two MCs, and their efficiency. It is ordinary that every nation has its specific style of communication that lay down implicit communication rules. However, in a situation where people work in extreme environments, the communication procedure should be built to be as effective as possible, if we think about communication efficiency as of its level of information transmission. Comparing styles of communication typical for American and Russian MCs, we found a significant difference between them. Certain sorts of utterances used by MC may raise or reduce the effectiveness of communication between MC and space crew.

5.1 Separation of communication channels

The analysis of the national MCCs' communication with ISS shows that the most striking feature of this communication is the division of communication channels between the Russian MCC and the USA MCC (Yusupova, Gushin, 2006). The Russian cosmonauts communicated with the Russian Mission Control, and the US astronauts communicated with the US Mission Control (see Figure 2). Each of the national MCCs preferred to communicate with their own crewmembers in terms of giving and receiving information. On average, the national MCCs spoke with their own crewmembers 98% of the communication time and with the other nationality crewmembers 2% of the communication time. There was very little international communication, and this was true of all communication components: informative, socio-regulatory and emotional.

The phenomena of what we called the contours of informational exchange was recognized during our ISS communication studies. It was clear that there were steady preferences in choosing the interlocutor between crewmembers and MC operators. The design of communication connections became more complex since ISS crews include members of two countries as a minimum, and are being controlled by two MCs – an American and a Russian one. The interlocutor is chosen not only by his psychological features that would go well with the crewmember, but also by preferred (native) language. This creates a certain disproportion in information receipt, which may lead to various misunderstandings between the two MCs.

Therefore, the onboard – Earth communication had two communicative channels: one channel was the Russians to Russians communication and the other channel was the Americans to Americans communication. In connection with this, a danger emerges that the Mission Control Centers may have two independent opinions each of which conditioned by insufficient information. Thus, we can speak about three visions of the situation onboard of ISS:

1. The vision achieved by the Russian MCC.
2. The vision achieved by the US MCC.
3. The vision achieved by the crewmembers.

Certainly, not all informational exchange of ISS and Earth goes through the audio communication. For instance, there is also an exchange of electronic messages and of control charts and work results. In our opinion, the separation of communication channels may lead to a loss of some information and affect the joint performance of the MCCs and the crews.

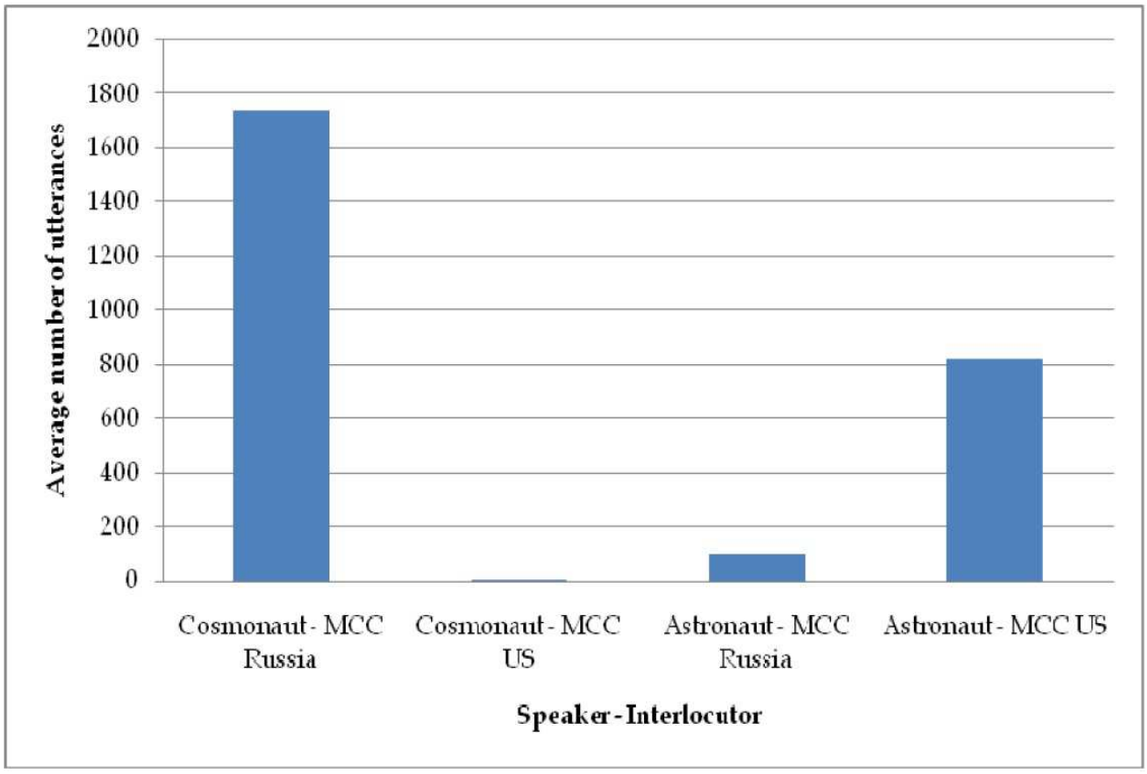


Fig. 2. Average numbers of utterances in space crewmembers – MCC communication.

5.2 Informing without a demand or after a demand

Clarifying the issue why the Russian cosmonauts were the communicative leaders in the majority of cases cannot go without an analysis of the distribution of informative function utterances. The existence of two almost completely independent communication channels as shown above allows to make such analysis.

Analyzing the special features of the usage of primary demands for information, we can see the following characteristics of the cosmonauts' communication with Mission Control. For instance, we see one and a half times more questions made by the Russian MCC than by the cosmonaut in the first mission. In an audio communication session this sounds like that: *"ISS, answer MCC! – In contact? – What is the pressure onboard? What are the oxygen values? Have you done the full work today? Have you done sports?"* or like that: *"Have you turned off the taps? What is the pressure? What about oxygen? Have you cleaned out the sacks or are they still lying there in a heap? Have you moved the fire extinguisher? Is cryogen on? Have you ridden the exercise bike? Is that lamp burning?"*. In case of the US astronauts' communication with the national Mission Control, such things are almost always reported by the astronauts without questions having been asked by Mission Control.

When we analyzed the first crew's data, we presumed that such predominance of questions on the part of the Russian Mission Control compared to the US Mission Control was due to the fact that the Russian cosmonaut was the crew commander, as the most of information is usually expected from crew commanders. Our analysis of the second and the fourth crews confirmed this idea, for the US Mission Control indeed addressed more questions to the astronauts – crew commanders than the astronauts to Mission Control. However, the correlation of the questions in the Russian communication channel remained the same.

Unfortunately, this "questions shower" phenomenon can hardly encourage cosmonauts' performance. The Russian cosmonauts often had to spend their time looking for the information being requested in that particular moment, which distracted them from working and increased the communication time. To support this view, we can cite some more of the audio communication (of the second crew):

MCC*: Have you ridden the exercise bike?*
Cosmonaut*: No, I haven't. We are going to ride it in the night.*
MCC *(calmly): Are you joking.*
Cosmonaut*: I am quite serious, I've given you an example of this fussing – an hour for this, an hour for that, forty minutes for this, forty minutes for that. That's why nothing is done. Yes, I've finished with the cargo ship [the logistics module] – but the other things – just in snatches. This is like, you know, in your garage – you fetched potatoes, then onions, then you ran somewhere else, sorted out your things, then fetched water, then gas – and here you've been running all day and what have you done? Nothing. And here it is like that.*

This feature of communication of the Russian MCC with the cosmonauts manifested itself also in the requests distribution. So, the Russian Mission Control addressed to the first crew's cosmonaut 3,3-times more requests than the cosmonaut to Mission Control (so the correlation was 3,3:1); in the second crew this correlation was 7:1; in the third crew – 18:1; in the fourth crew – 11:1. In our opinion, this feature is especially characteristic of the Russian MCC's communicative style which aims at extracting information from cosmonauts, at constantly controlling cosmonauts' actions. *"I am answering all your questions like a schoolboy at the blackboard"* – said the Russian crew commander when he was once again poured with questions for which he had no time to answer. The Mission Control's strategy of 'extracting information' was also from time to time opposed by the Russian cosmonaut of the second crew.

MCC: *Let's sum up today's results. Have you done your sports in full?*
Cosmonaut: *In full.*
MCC: *Say a few words about the plants which are growing. [Referring to the experiment of growing vegetables on ISS]*
Cosmonaut: *They are growing.*
MCC: *Growing? … Fine.*

The US MCC and the astronauts communication, though seemingly relaxed, turns out to be more efficient: information is reported by the astronauts without questions being asked, when they have collected and prepared all the data which need to be reported to Mission Control. The astronauts begin their information sharing like: *"I want to report that…"* Therefore, the informational exchange takes much less time (see Figure 3).

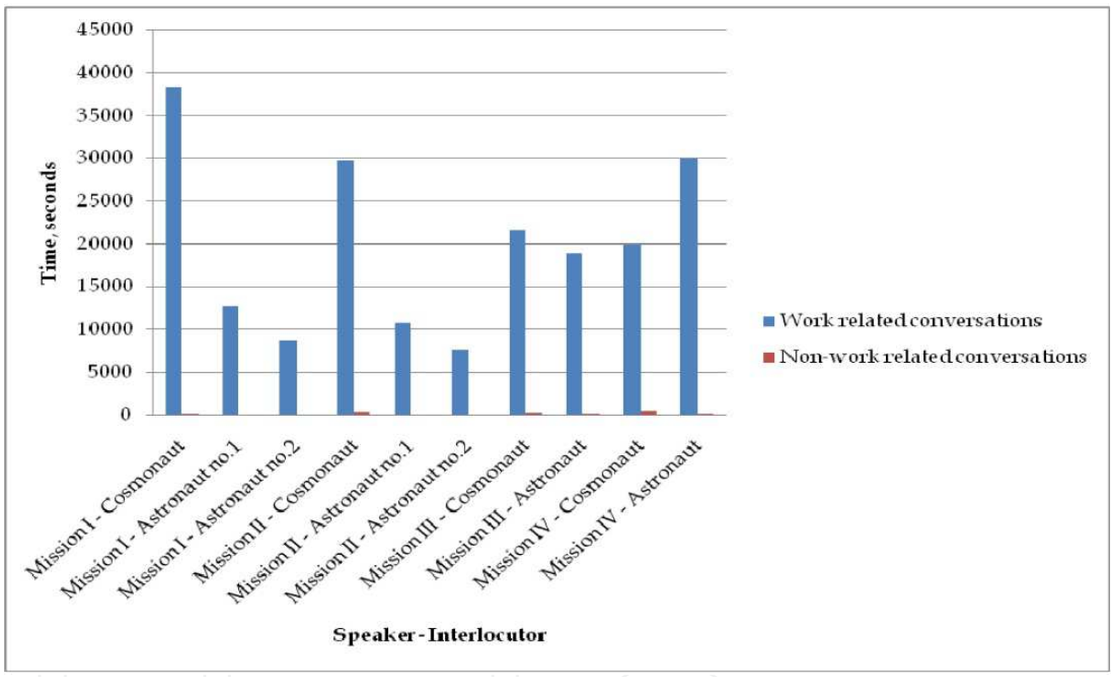


Fig. 3. Time spent by the crewmembers on work related and non work related communication with the Mission Control Centers at similar mission stages.

5.3 Informing and phatic component

We have to point at the high figures of the 'Informing after a demand' category in the Russian cosmonauts' speech which, however, is quite natural due to the fact that they are often asked questions. On the contrary, it was typical for the MCCs to inform the cosmonauts without a demand; the figure of this category was 1,8-times bigger than the figure of the 'Informing after a demand' category. Mainly the Russian communicators ask repeated questions, and the Russian Mission Control staff ask repeated questions more often than the Russian cosmonauts do. Most probably, this is related to the factors of the communication irregularity and of the pouring the cosmonaut with questions. These differences may be conditioned by the communicative style developed in a certain

culture, and so may be the differences in the phatic component of communication described below.

Despite the smaller total volume of communication, the number of utterances in the 'Encouragements, sympathy, gratitude' category in the first three crews was the same in case of the US and the Russian crewmembers, while in the fourth crew, the US astronaut used more utterances of this category than the Russian cosmonaut. Positive phatic (small talk) utterances were used in the speech of the astronauts and the US MCC as a natural thing in the course of communication, between this and then: *"I appreciate you folks for letting us know!", "Thanks for the heads up!"*. On the contrary, in the majority of cases, the Russian MCC provides phatic elements as a separate communication block, clearly separating the phatic and the informative components:

MCC *(wearily): Congratulations with the first of April, dear [crewmembers]. Today is the first of April and you should laugh well.*
Cosmonaut *(wearily): I began laughing already yesterday when I got your radiogram.*

Space crewmembers, being excellent specialists but also different personalities, form their own communication styles with MCs as well. These styles may include highly effective examples as well as neglecting styles leading to poor effectiveness level. As the communication between MCs and space crews is under control of psychological services, certain changes in training of the both communication sides should lead to enhancement of informational exchange efficiency.

5.4 Consents and discords

In the first mission, we noticed a predominance of utterances which contained the cosmonaut's consents with the interlocutor's position. The number of utterances of this type clearly prevailed over disapprovals, arguments, expressions of negative emotions, self-justifications, refusals to cooperate. At the same time, we noticed the tendency of the communicative leader – the Russian crew commander to avoid discussing sensitive issues. On the contrary, in the second mission, the number of discords, self-justifications and refusals to cooperate was 1,7-times bigger than the number of rational and emotional consents. We should point out that this ratio emerged owing to the cosmonaut – flight engineer who was the communicative leader. In the third and the fourth missions, the Russian cosmonauts were less dominating in communication with Mission Control and expressed what they thought of information which they received more seldom compared to the first two missions.

In the second mission, encouragements were a reaction of the Russian Mission Control Center to the increasing number of emotional discords of the cosmonaut and might be regarded as a kind of coping strategy (see Figure 4).

A considerable quantity of emotional discords and satire of the Russian cosmonaut in the second mission can be accounted for by several external stress generating reasons known in the mass media. But it is sure that the cosmonaut's negative utterances were often a reaction to the Mission Control actions. For example, *"We have written to Earth in what way we dispose of waste, and if Earth don't know this, then it's their problem"*. After another series of repeated questions: *"Do you at least take notes when I report?"* or *"Well again, you write with your one hand and strike out with your other hand, do you?"*.

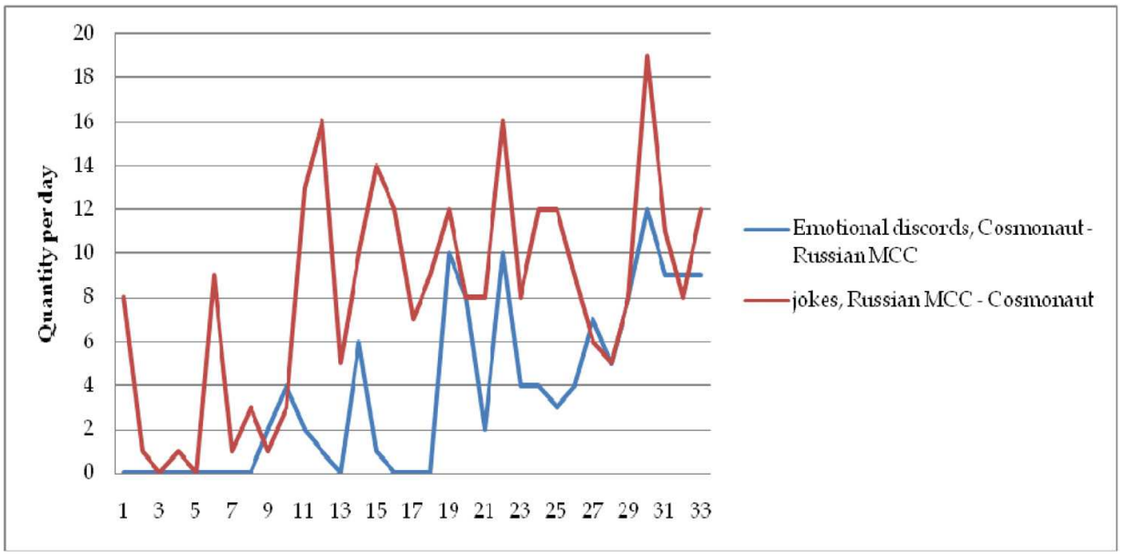


Fig. 4. Emotional discords addressed by the cosmonaut to the Russian MCC and jokes addressed by MCC to the cosmonaut.

6. Phenomena identified by the analysis of isolated small groups communication

The results of the previous part of the present chapter show the existing communication difficulties we detected in several space missions. These difficulties are to overcome with help of communication trainings of crews as well as ground personnel. During 20 years that we were collecting data in different isolated crews, we found out that there is a number of repeating communication phenomena that is typical for isolated small groups.

The phenomenon of isolated small group remote communication with the outside world takes place when due to their professional activity, a group of people are isolated from the usual socio-psychological contacts, have a restricted freedom of movement, no usual comfort, experience sensorial deprivation (there is no usual informational flow coming from the environment), and constantly face danger. Categories of personnel which communicate remotely in extreme environments are ocean-going ship crews, polar winterers, staff on oil platforms and distant mineral deposits, weather stations staff, prolonged expeditions personnel, cosmonauts and astronauts etc.

We should pay attention to the fact that isolated crewmembers experience difficulty in satisfying their need to reduce the ambiguity of how their behavior is perceived in a given situation. Firstly, the range of available standards of behavior is considerably restricted due to a small number of communication partners and a decreased informational flow, since communication in isolation is restricted. Describing communication of isolated subjects with the external world, specialists emphasized several times the involuntary nature of such communication because a person may not speak as much as he or she would want to and when and with whom he or she would want to.

We should bear in mind that isolated people communicate in an environment extremely poor in information, distinguished by monotony and sensorial deprivation. Undoubtedly,

on certain adaptation stages, this gives rise to an increased need, on the one hand, to compensate for the usual informational flows (in particular, the yearning of speaking with family and friends, the social inclusion in the life of people far away) and, on the other hand, to receive diverse new information.

However, special research has demonstrated that a mere increase of informational flows is not a fully adequate compensatory mean of psychological support in isolation. Adapting to sensorial deprivation and monotony in isolation, a person starts to communicate both with the crewmates and the distant society at a lower level of informational exchange (Gushin, 1997). So, the general volume of communication decreases, the range of topics and the circle of interlocutors narrow down – the 'psychological closing' phenomenon emerges. That is why the external group's attempts to communicate with the isolated crew with the same intensity as before isolation are often opposed by the crew. The isolated crew claims that contacts distract them from work and attempt to avoid communication.

Secondly, in space flight, the reflecting process itself is distorted when a group of people larger than the one the subject is accustomed to, pay their attention to him or her and consequently the subject may reassess his or her personal value and conceive himself or herself as a 'star'. An important aspect of communication in such conditions is that contacts take place against the 'public privacy' background (Leonov, Lebedev, 1975) when the isolated person feels to be carefully observed. Due to an almost total absence of communication privacy, cosmonauts' communication with Earth loses its freedom and confidence, becomes more formal and at the same time self-presenting, dramatic, since a cosmonaut has to constantly comply with a certain social role associated with a high social status. The feeling that one is being constantly evaluated leads on to the appearing signs of social facilitation as it is currently understood – that is, an increased social agitation occurring in the presence of other people and aggravated by the lack of personal space (crowding). So, the general increase of psycho-physiological agitation complicates the crew's performance in the new and little-studied conditions.

People are naturally attracted to the ones they like and want to speak to and they prefer to keep distance from the ones they dislike and have no wish to communicate with. We can suggest that the opposite is also true – an increasing distance between communication parties makes the interlocutor less attractive and reduces the person's wish to communicate. Consequently, it is no wonder that the isolated person, being at a significant distance from the support group, being highly motivated to perform and worrying about how he or she is evaluated by strangers whom he or she hardly can influence, wants to avoid such strangers by hiding from video monitoring and by reducing audio contacts.

So, remote communication of isolated small groups is restricted, involuntary andpublic. The functions of the isolated small group's communication are not only informational exchange, but also a compensation for sensorial deprivation, monotony, for a lack of openness and confidence in contacts. Finally, when speaking with the outside world, each communicator reflects not only his or her opinion but that of their group.

6.1 Influence of isolated small group's evolution on communication

At the initial stages of its formation, a small group, in particular, a space crew, is quite open towards the influence of society. In a real or simulated social isolation, a crew which has

participated in a full-fledged group training grows gradually cohesive and becomes a 'cooperation group' having a well developed internal structure and a high degree of member interaction (Umansky, 1980).

However, together with cohesion, the isolated small group experiences a sharp decrease of the influence of society due to the limited contacts. In fact, for the isolated crew, society means support group and group of confidants (family and friends), and they communicate with these groups by different information channels – mainly, audio communication channels in case of the support group and computer messages in case of the confidants. Consequently, the small group's communication turns from the full-fledged single-circuit communication into the limited two-circuit communication (Chart 3).

Further on (according to our information, in 4 to 6 weeks), the crew evolves as 'autonomy group' which is distinguished (according to Umansky, 1980) by the development of group identity, the construction of group rules, the rise of group cohesion and at the same time of separation. Potentialities of the group as a holistic entity increase, new tasks and goals appear which have evolved inside the group and might contradict those set up by society. In particular, Tuckman's research (Tuckman, 1965) points to such group evolution stages when group behavior which was originally generated by the need to resolve the problems of society generates a new type of behavior which is not induced directly by environment and is oriented to the group's own problems. This stage is certainly a higher stage of group evolution which enables the group to cope with emerging problems by themselves and it is a very important condition helping to cope with unfavorable environment in an expedition, space flight etc. On the other hand, owning to isolation and a decreased social control, there is a danger that the autonomy group may evolve into an unfavorable group form – 'corporation group' (Novikov, 1981, Umansky, 1980) which is distinguished by group egoism and aggressive behavior.

The problem is that specific living conditions in isolation, sensorial deprivation, monotony, involuntary communication, decrease of social control, public privacy speed up the coming of this stage of group evolution and aggravate its course. Describing communication of a group which have been acting autonomously for a long time, with an external group (a visiting crew), Novikov says that the autonomous group members experienced the feeling of being invaded and intruded on. No doubt, communication with the support group is experienced by the isolated small group less acutely, but sometimes the support group's attempts to make a closer contact might be regarded by the isolated group as intrusion.

The isolated crew perceives communication with the support group as imposed and tries to minimize it along with the general decrease of informational flows. On the other hand, they need to compensate for sensorial deprivation and monotony which they achieve through making informal contacts with the confidants more active. So, the need for socialization gradually specializes: the isolated group emphasizes not the quantity of communication, which gets smaller in connection with the general decrease of informational exchange in an environment poor in information, but the quality. In this sense, we can compare a group which has reached a high level of internal development to how a mature person who is getting older limits his or her interpersonal contacts and simultaneously makes models of his or her contacts more complex. At the group level, this is manifested in the emergence of the 'divided communication' phenomenon that we discovered: which means a decrease of communication with the support group, clear preferences with respect to communicator

choice, filtration of information which the isolated group communicates outwards and at the same time intensification of contacts with the confidants.

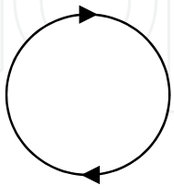
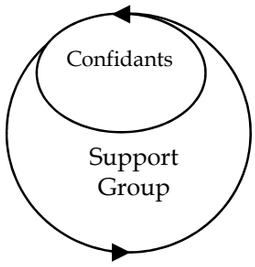
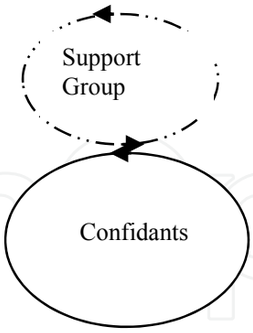
	Stages of Group Evolution (according to L.I. Umansky, 1984)	*Communication Type*	*Kind of Interaction with Society*
Ground Group Training	1) Conglomerate Group 2) Nominal Group 3) Association Group	single-circuit communication 	Open interaction with society
Orbital Flight	4) Cooperation Group (a well developed structure, a high level of cooperation – emerging in 4 to 6 weeks)	two-circuit communication 	1. Isolation from the larger community. 2. The larger community disintegrates into the support group and the group of confidants. 3. Communication decreases.
	5) Autonomy Group (group identification, separation, joint effort)	two-circuit, divided communication 	1. Decrease of social control. 2. Involuntary nature of communication.
Mission to Mars (a possible variant)	6) Corporation Group (group egoism, opposition, aggressivity)	No-circuit, monoreferential communication 	1. Delays in communication with Earth. 2. Absence of direct help of Earth.

Chart 3. Communication of isolated small group: ground training, flight on orbital space station, mission to Mars.

6.2 Remote communication as intergroup interaction

According to Tajfel (1978), the identification of oneself as a group member leads to the comparison of one's group and its members with other groups – and a further discrimination of other groups by the way of in-group favoritism and out-group hostility. This phenomenon emerges even if there are no objective contradictions or conflicting interests among the groups. In Ageev's view, this is related to the fact that the structure itself of intergroup activity contains factors reducing the adequacy of intergroup perception, which is the basis for in-group favoritism and out-group hostility. Adequacy of intergroup perception depends on the goals and values of joint intergroup activity, on criteria of evaluation of groups' achievements in such joint activity and, finally, on a group's success in an intergroup situations (Ageev, 1990).

The isolated group's interaction with the group of confidants is much simpler because this group is nominal or associated, that is to say that it is not so rigid, which facilitates communication. Moreover, in this communication circuit, a cosmonaut behaves as a group member to a much lesser degree and acts more like an individual. In communication with the confidants, a cosmonaut not only compensates for monotony, involuntary nature of contacts in space flight but also resolves the conflict between the growing aspiration to self-realization and self-assertion and the intensifying tendencies towards a person's involvement into the group structure and his or her integration into the group.

Extreme manifestations of intergroup problems may lead on to the development of group egoism, the aggravation of the small group's isolation from society, accompanied by a complete loss of mutual trust by the relevant groups against the background of the small group's monoreference, that is the isolated crew's orientation only to their own egocentric and eccentric (sometimes even delusive) ideas (Tuckman, 1965). A vicious circle occurs: autonomisation means that the isolated group orients itself not to the external but to the internal rules and ideas and try to get their own way in their communication with the outside world. They often do not find consent or understanding and therefore limit their external contacts, stop giving to the external communication parties information about what happens in isolation. Furthermore, the isolated group's contacts with the support group (and the correcting feedback) are limited by that the isolated group do not want to and have no need to speak with strangers which have different rules and ideas, while communication with the confidants is restricted due to rigorous operational limits.

In their turn, the support group which represent society do not have complete information about what happens onboard and have no possibility to give the crew really efficient recommendations to purposefully correct the crew's behavior. Therefore at the stage of the isolated group's autonomisation, due to the general decrease of the group's informational exchange with society, the limitedness of society's representation in communication circuit and the emergence of 'allotted communication', society forms an extreme difficulty in correcting the group's directedness so as this happens in usual conditions when social environment can constantly and efficiently optimize the functioning of a group which is open to the influence of society.

In this case, from an open exchange of relevant interpretations (Tuckman, 1965) which allows to gain an insight into the groups' intentions and to propose an alternative,

communication turns into no-circuit, monoreferent when having no feedback, and each party communicates to the other some information which the other party cannot completely understand and therefore cannot respectively correct its behavior. In such situation, each group overtly demonstrates that their intentions and requirements do not meet the tasks set up by the other group in front of them, and an inevitable an intergroup conflict emerges.

6.3 Influence of adaptation to isolation and conformism

In case of the normal course of isolation (no accidents, illnesses etc.), the level of the crew's adaptation to difficult conditions rises. In this case, changes in communication, such as the increasing autonomisation should in our opinion be interpreted from the point of view of that the isolated group's judgments are influenced by judgments of the social majority (in this case represented by the Mission Control group). This is reflected by the socio-psychological phenomenon of conformity to group norms as defined by Homans and Asch (Homans, 1961, Asch, 1955). Social psychologists regard conformity not simply as a negative phenomenon, for it is often an expedient form of behavior facilitating the interaction process by providing an individual with behavioral standards acceptable to the group. Moreover, we think that the abidance by the group's behavioral standards is especially important for performing in extreme environment and is a condition for the conservation and survival of the isolated small group (Jetten, Postmes, McAuliffe, 2002).

In the period of acute adaptation to new extreme environment of isolation or space flight, there increases an uncertainty in evaluation of the actual situation. The objective criteria of such evaluation are vague due to an inadequately formed flight model. There emerges the state of internal uncertainty which makes a person more amenable to influences from outside. Experiencing a need to reduce this uncertainty, the crew actively communicates with Mission Control. Simultaneously, a person's amenability to opinions of the support group which help him or her to cope with hard conditions rises steeply.

However, the isolated group's competence grows in the course of flight, and with the lapse of time, they start to consider themselves to be not less and even more competent than the external majority with respect to a large part of situations onboard. They accumulated judgments stemming from their own experience and not learnt from other people. Such judgments are more stable and less exposed to change in case of being attacked. In the course of mastering the unfavorable environment, a person's self-esteem grows, and, as it is known that people with a high self-esteem prefer to keep to their opinions and do not easily yield to persuasion. Due to this, the need for recommendations from outside decreases as well as the original amenability to Mission Control opinions. Thus, the opposition to opinions from outside (the inconformity with respect to the external group) grows parallel to the growth of the small group's capabilities during group cohesion and adaptation to difficult conditions.

The degree of the small group's conformity depends on the size of the majority group (Asch, 1955). However, as we already mentioned, for the isolated group, society 'shrinks' to two rather small groups: the Mission Control group and the confidants group. With the decrease of the degree of the majority's pressure, the level of 'obedience' also decreases. Another

factor fostering autonomization is a group heterogeneity. It is well known that homogeneous groups are more conform than heterogeneous ones. We can presume that the International Space Station crew that are heterogeneous in terms of nationality, gender and profession, will be less exposed to pressure of society than national crews of the past generation of space stations.

Therefore, as we pointed out, in isolation, the pressure both of physical and regulatory social information on isolated small group decreases due to a restricted number of communicators and of a restricted volume and diversity of communication. In this case, the opposition to the external pressure originally related to some operational aspects due to a higher competence of the isolated group in this respect may turn into the opposition to behavioral norms imposed by society. This opposition can be disguised as the so called public conformity, a demonstration of a socially acceptable reaction stereotype of the type "we are all right", while this attitude changes in private contacts with the confidants. In case of a further evolution of a group's inconformity, anti-social behavior can appear (such a degraded hygiene status) all the way to an open protest.

6.4 Unfavorable manifestations of remote communication

The 'psychological closing' and 'autonomy in communication' phenomena identified by us reflect the combined influence of isolation and intra-group and intergroup dynamics on communication. A high degree of 'psychological closing' in communication may lead on to decreased informational flows coming from the isolated group, to the filtering of outgoing information by the group especially with respect to problematic situations and also to a reduction of the number of external communicators with whom the isolated group wants to interact. Extreme manifestations of 'autonomy in communication' mean that the isolated group constantly defends their point of view, tries to impose the in-group beliefs (and even prejudices) onto the external communicators, and confronts them. Under such conditions, the outside group's attempts to regulate the isolated small group's behavior will be regarded by the isolated small group as invasion, aggression which should be immediately fended off.

An extreme evolution of the above phenomena is dangerous because as a result, the support group will not have enough information to take adequate decisions and help the isolated small group. And even the confidants trusted by the isolated crew and thus obliged to be less critical, will have more information but still this information will be distorted by the crew's prejudices. Therefore, some operational proposals and decisions of Earth (Mission Control) based on such insufficient or distorted information, might be inefficient and can aggravate a difficult situation, making the support group's authority seem even lower in the eyes of the crewmembers. More than that, the support group's attempts to interfere with the crew's affairs, being inadequate due to the lack of knowledge of the situation onboard, might aggravate the confrontation and as a consequence, the crew might refuse to fulfill Mission Control's instructions, ignore Mission Control's opinions as this has already happened in long-term space flights (e.g, the 'Skylab' strike).

The USSR practice of space crews communication was organized in the way that principal Mission Control operators communicating with space crews were themselves members of

cosmonaut corps. Therefore, space crews mainly communicated with people well known to them who had similar experience in life and profession. This approach ensured a greater confidence and mutual understanding of communicators. However, more complex flight programs expanded the circle of contacts with which space crew had to communicate. Cosmonauts have to speak to scientists and specialists little known to them or completely unfamiliar. So the role of cosmonaut corps members as mediators between space crews and Earth substantially reduced. The problem of ensuring confidence in space crew communication arose again and space crews' refusals to speak to certain interlocutors became more frequent.

Communication through a closed confidential channel has always been an important operational factor in space flight. Private psychological conferences began to be also used in flights on ISS. So cosmonauts and astronauts gained an opportunity to speak about their problems and drain their negative energy outwards without being afraid that this might harm their reputations and carriers. However, like in the above case, the problem of ensuring the full-fledged communication has been resolved only partially. The confidants are bound by written confidentiality obligations to keep secret information received through the closed channel. This does not allow to use such private information to improve a space crew's activity and state and resolve their problems.

At present, the problem of intergroup communication of space crews on ISS is aggravated by the presence of two national Mission Control Centers each of which speak mainly with their national astronauts and cosmonauts onboard. As a result, each MCC has only a part of information and only a partial notion of the whole picture of what happens on ISS, distorted by the national and culture-bound prejudices of their national crewmember. In the long run, such practice cannot but lead on to a confrontation of MCCs since their opinions on one or another issue might be based on somewhat different input data.

6.5 Problem of remote communication in mission to Mars

The problems mentioned above will be especially significant during preparation and implementation of a manned mission to Mars – the most promising of space projects existing now, which attracts public attention worldwide. The key feature of a mission to Mars is the space crew autonomy. It means in the first place that the crew will not receive help from Earth, including an immediate evacuation of a crew member in case of emergency, a resupply of resources (water, oxygen, food, devices etc.). They will have to use only resources available onboard (including informational resources) and fall back on their own strengths and ability to make their own decisions in extreme conditions. The autonomous nature of such mission combined with the well known features of space crews' communication may quite complicate the 'onboard – Earth' contacts.

We think that this together with delays in communication may lead on to a reduction of the Earth's controlling role in the course of the flight. MCC should switch from the function of controlling the crew to the function of consulting the crew. That is to say that in the past 40 years, the dominating strategy of ground services was to daily instruct space crews and set up tasks for them. Now ground services should provide space crews with informational support based on requests coming from onboard and do this in the maximally friendly and unobtrusive manner. The big Mission Control Center and the small crew should find new

common goals and try to achieve them on the basis of a full-fledged partnership and not of subordination as this happens now.

Stylistic features of MCCs' communication will be very important for the establishment of equality and cooperation in interaction of MCCs and space crews. First of all, such communication should be based on mutual confidence established before flight and maintained during the whole expedition. Besides that, the Earth's communicative style should be concordant and meet the actual needs of the isolated crew in terms of communication volume and content. All this will require a significant modification of the current concept of the 'onboard – Earth' communication as well as a principally new communication training of Mission Control operators. Operators should be involved in the process of the ground psychological preparation of the crew, participate together with the crew in group trainings of communication, conflict settlement, they should establish solid confidential relationships with the crew.

7. Conclusion

We regard communication as a certain sort of professional activity. During space flights, crewmembers have to be in contact with ground personnel, as well as they have to do their job. Communication is one of the main channels of information from the crew. Still, there are certain regulations of verbal behaviour and professional vocabulary, elaborated for fast information transmission.

Since communication is regarded as a professional activity, we can admit, that its analysis would let us make estimates about its effectiveness - indirectly, without going deeper into operational aspects. Then, it becomes possible to manage informational exchange by means of personnel and crewmembers' communication trainings. Choosing the right staff, from one side, and reducing conflict tension from the other side leads to rise and support of trust and openness in informational exchange. This point is especially important in interplanetary missions, as an effective informational exchange would result in adequate and correct decisions on Earth as well as in the space crews.

Communication process in space flights does not come to pure informational exchange. It is a psychosocial process and a source of information about personality and its mood. Psychological support in the present case is to ensure the psychological comfort through communication process and to obtain data about crewmembers' psychological state.

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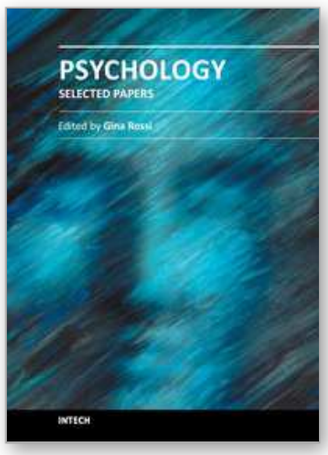

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