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From Human Behavior to Human Factor in Aerospace, Astronautics and Space Operations

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Editorial

On ground, in the air or in space, men and women are actively involved in tasks achievement for the success of allotted missions. Their actions and interactions for planning, conceiving, managing, designing, building, testing, controlling, regulating or adapting are expressed through human behavior and operated by considering human factor. To promote further advances on manned missions, fundamental researches and applied studies need continued sharpening in several areas and in interdisciplinary perspectives.

Ethology, science of behavior, is concerned with the knowledge of relationships between the human being and his environment. That can be sensorial, social, cultural or cognitive environment as well as technologic, logistic or engineering environment. This scientific discipline not only emphasizes the result of the behavior, i.e. human performance, but also the patterns leading to it, i.e. strategies. For more than three decades, it was applied to a wide panel of aerospace situations both real, such as in aerobatic flights, parabolic flights and orbital flights, and simulated such as isolation and confinement experiments. The method consists in observation, description and quantification of motor actions, spatial positions, facial expressions, collateral activities, non-verbal and verbal interactions as main behavioral expressions (Figure 1). The peculiarity of such an approach is to objectively encode the occurrence of these events according to a relevant list of descriptors in real time on-site or off-line from video recordings. Then data are processed using non-parametric statistical analyses. A software-based solution for research in space ethology [1] can be used as professional system for collection, analysis, statistic and presentation of behavioral results, i.e. The Observer XT®. In acrobatic flights for instance, qualitative observations were made in studies dealing with the role of visual vs. gravitational information in a mismatching sensorial environment. Onboard a Cap-10 cockpit constraining to body immobility with direction changes of the aircraft, visual information prevails. Ethological data collected in aerobatics showed that experienced pilots efficiently reorganized their motor actions with fixed head and trunk positions, frequent eye movements scanning alternately dials and sky cues for active and accurate piloting. Conversely, neophytes coped with disorientation and frequent head movements, impairing visual information, passive and inaccurate mobility, without anticipating aircraft movements [2]. A complementary study of the first minutes in microgravity experienced by neophytes during parabolic flights revealed significant sensori-motor disturbances. Aboard the 0-g Caravelle aircraft, quantitative descriptions of the subjects' behavior showed swimming reflexes, very slow movements, forelimb lateralization and mobility, predominant grasping and persisting upright position. Untrained subjects progressively freed themselves from vertical position with time and experience, optimizing their adjustment to the microgravity conditions and the three-dimensional space. They used new environmental information by assuming orthogonal positions between their body axis and cues duration [3]. Behavioral skills in the astronaut have improved their cognitive representation of the surrounding environment. In orbital flights, ethological analysis of video recordings aboard US shuttles provided qualitative and quantitative descriptions of astronauts' motor behavior adaptation over short-term missions. The results showed how humans in space build a new world of perceptions and actions through the diversification of body orientations and the appearance of floating strategies allowed by weightlessness. Modifications of sensorial environment and motor behavior accordingly induce new behavioral patterns such as sequences of hand grasping and body impulsion for moving while assuming slightly flexed postures and head-down orientations [4,5]. For future space exploration, in extended periods of time, the social and cultural environment will also have an impact on the crews' behavior and as a result on human performance with positive effects [6]. Confined and isolated experiments were conducted in that aim. However, in synergy with time effect, isolation generates stress because of danger while staying far from any rescue and evacuation possibilities, whereas

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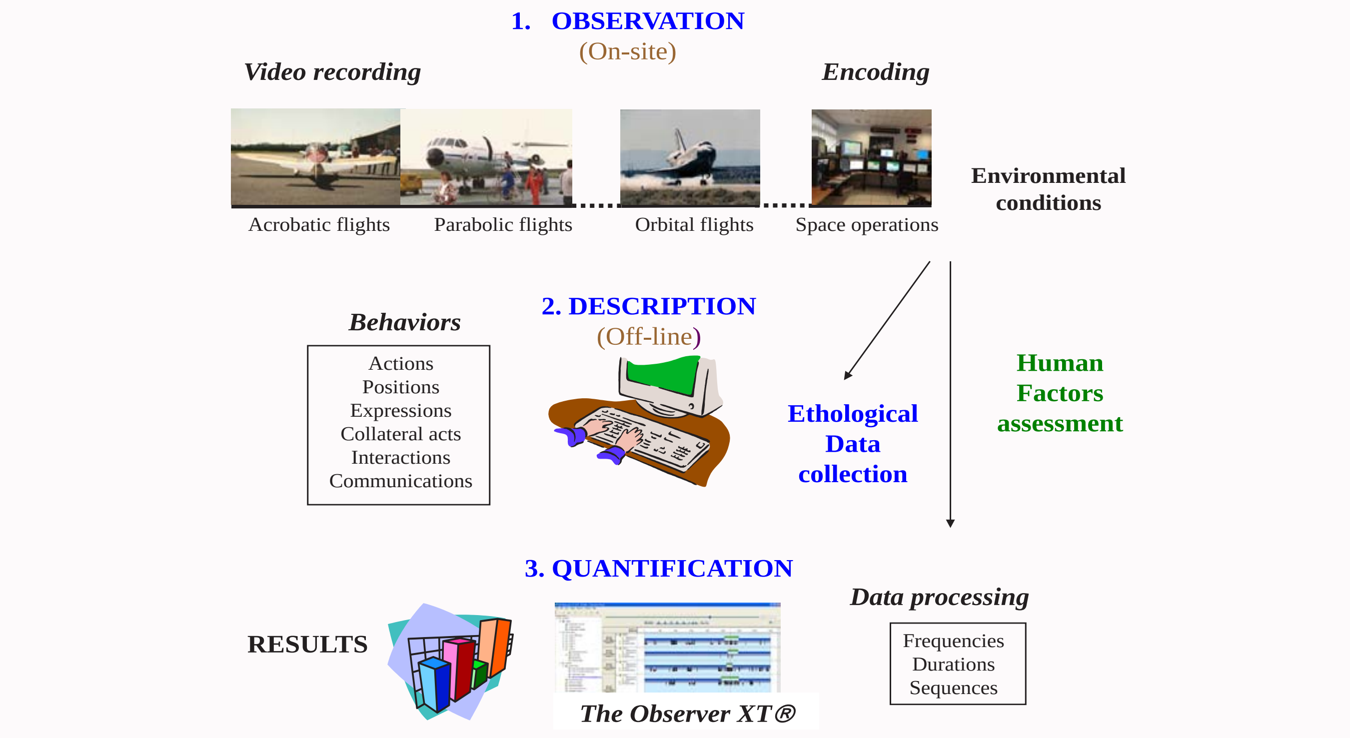

Figure 1: The ethological approach (images © Ethospace and NASA).

confinement generates monotony because of many deprivations and repetitive operations. All that can have negative effects on human behavior, like motivation to the mission goal, and consequently on human factor.

Ergonomy, regarding human factor, is concerned with the understanding of relationships between human being and operational environments for efficient missions. It is the scientific discipline that applies theory, principles, methods and experiments to design overall system performance and to enhance human performance. Common issues with Ethology are better comfort, well-being and good spirit of pilots, astronauts, operators in their area of competence, let it be in Aerospace, Astronautics, Space operations, or other fields. Some assumptions to newly be tested in interdisciplinary approaches are:

- Action reliability
- Human dependability
- Salutogenic response
- Individual adaptability
- Monotony vs. vigilance
- Cognitive capability
- Psycho-physiological merit
- Health and safety
- Simulation test
- Training procedure
- Control Routine
- Human/system optimization

The association between human behavior and human factor was pointed out by applying the ethological tools in interactive space operations [7] during a first experiment at the Network Operations Center (NOC) of the French Space Agency (CNES) [8]. The general goal was to propose an innovative method in this field. The emphasis was on daily live activities of operators who coped with routine tasks and unexpected events while anticipating human factor in the satellites control room. The operational goal was to objectively implement behavioral descriptors allowing to minimize risks and to optimize the relationships operator/system by considering human action as a positive factor. The ethological approach was adjusted on-site and addressed to routine operators controlling satellite passes on monitor screen and acting on the system if required. Adequate behavioral descriptors were on positions (in different areas), postures, actions and interactions (human/system, human/human, and human/environment). The ethologist was outside not involved in the operations but beside the operators for live observations of the spontaneous activity. First results showed that the operator's activity was to privilege interactions with the system. He frequently checked the control screen then communicated with the other operators more frequently inside than outside the control room. Whole quantitative description pointed out that changing of positions in the working area was more frequent than changing of posture, e.g. sitting or standing. It was also observed some ego-centered actions, e.g. writing and reading, few facial expressions, indicators of well-being, but high level of collateral acts, i.e. indicators of stress or fatigue. A comparative analysis between two operators allowed defining behavioral profiles. The results showed that one operator had more frequent interactions with the system and more frequent occurrences of collateral activities that were compensated by body moving. The other operator had an opposite tendency: less control at the screens, more communications with others leading to less collateral acts, highlighted the quality of individual differences in term of interactive strategies. There are no positive or negative profiles but human performances that underlie human factors. A longitudinal analysis, over different time slots, showed increasing behavioral indicators of fatigue, decreasing indicators of well-being and increasing mobility as to maintain levels of active vigilance, at the end of the routine operation day. To break up monotony, the operator more frequently looked outside or watched screen not assigned to the working task but as leisure time. In future applications, the level of occurrences, according to behavioral patterns, could be used as a warning, without generating false alarms but useful for the operator to act on the system. Ethological data collected during training procedures of satellite tests have supported such analyses.

Studies and researches from human behavior to human factor become salient when the emphasis has to be on comfortably living (in extreme conditions) and efficiently working (in stressful operations) in new, unusual or particular environments within the field of Aviation and Aeronautical science.

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