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ASTRONAUT SELECTION AND POTENTIAL RISK MANAGEMENT: PSYCHOLOGICAL TRAUMA AND RESILIENCE FOR MARS SPACE MISSION

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Abstract. The first human orbited the Earth for less than two hours in 1961. The twelve Apollo astronauts experienced up to 22 hours of walking on the Moon (Apollo 17). Beginning in 2000, the International Space Station (ISS) hosted 279 individuals from 22 countries who stayed in space for six to 12 months. Among them, Oleg Kononeko holds the record for the longest mission, exceeding two years. The astronaut selection programme has evolved over time in accordance with the objectives and duration of spaceflight. Questions arise about the criteria for astronaut candidature, the selection process used in the past, and the psychological issues that warrant increased consideration for future deep space travel. Moreover, how can we mitigate potential risk factors and improve astronaut safety and well-being? This paper explores the historical narratives of the astronaut selection process for short-term missions. Considering major hazards such as confinement (isolation), distance from Earth (travel time), and hostile environments, this paper proposes a hypothetical human policy for a Mars return mission (2.5–3 years). It focuses on enhancing the astronauts' psychiatric resilience through a selection protocol that takes into account family traumas (bereavement, divorce, and abuse), addictions (drug, alcohol, smoking, internet gambling (games), and sex), and personality traits associated with possible emergency situations (threat, stubbornness, aggression, hostility, or violence) in the context of space community security.

Keywords: Mars, astronaut selection, trauma, risk management, resilience

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1. Introduction

As human spaceflight became a reality, Yuri Gagarin of the Soviet Union and Alan Shepard of the USA became the first astronauts in the early 1960s (Burgess 2016). Once the scientists and engineers had developed the necessary launch facilities, the questions of *who should fly* and *how do we know* arose. In the early stages of space exploration, there were numerous risks associated with manned spaceflight, such as equipment malfunction, turbulence, impact forces during launch and re-entry, physiological impact of microgravity, psychological effects of isolation and confinement, fire and explosions, radiation exposure, temperature fluctuations, rapid and/or explosive decompression of spacecraft, emergency egress, and crashes due to pilot error (Seedhouse 2010: 3). For the Mercury project, many experienced pilots under 40 with excellent physical condition and shorter than 180 cm were considered (Burgess 2016: 50-57). They were required to have at least a bachelor's degree or equivalent, a test pilot school graduation, and 1,500 hours of total flying time. Moreover, jet pilot qualifications were also necessary (Seedhouse 2010: 5). Thirteen female pilots passed the tests but were only enrolled in an 'unofficial' astronaut training programme (Seedhouse 2010: 7).

The criteria and qualifications for Project Gemini astronaut candidates were slightly modified. The minimum flight time was reduced to 1,000 hours, the age limit to less than 35, and the maximum height raised to 6 feet (182.88 cm). Unlike the Mercury programme, which involved only one astronaut, Gemini accommodated two astronauts, and the Apollo programme was designed to carry three astronauts. Out of 400 candidates, 14 were finally selected (Seedhouse 2010: 8). Under increasing criticism, the selection process shifted towards including 'scientist astronauts', with 6 selected in 1965 and 11 in 1967. They were required to have a doctorate degree in medicine, engineering, or natural sciences or possess equivalent experiences, with the minimum flight time criterion waived. After a ten-year hiatus in astronaut recruitment between 1969 and 1978 (Figure 1), the new space shuttle programme sought a fresh crop of 35 astronaut candidates. This marked the first instance of appointing females, African-Americans, Asian-Pacific Islanders, and Hispanic candidates. The training and evaluation programme included orbiter systems training, science and enrichment briefings, and T-38 flight training (Ross and Gomez 2003).

NASA shuttle astronauts were divided into three categories: pilot astronauts, mission specialists, and payload specialists. Pilot astronauts were trained to serve commanders and pilots of the space shuttle. They were required to hold a bachelor's degree in engineering, biological science, physical science, or mathematics with a minimum of 1,000 hours of pilot-in-command flight time and flight test experience. In addition, they had to "pass a NASA Class 1 space physical, including a minimum 20/50 uncorrected vision, correctable to 20/20, and a maximum blood pressure of 140/90 mmHg in the sitting position" (Seedhouse 2010: 11). Mission specialists required at least three years of relevant professional experience in addition to their degree. They had to pass a NASA Class II space physical similar to the requirements for pilot astronauts. The age limit was no longer enforced due to federal regulations.

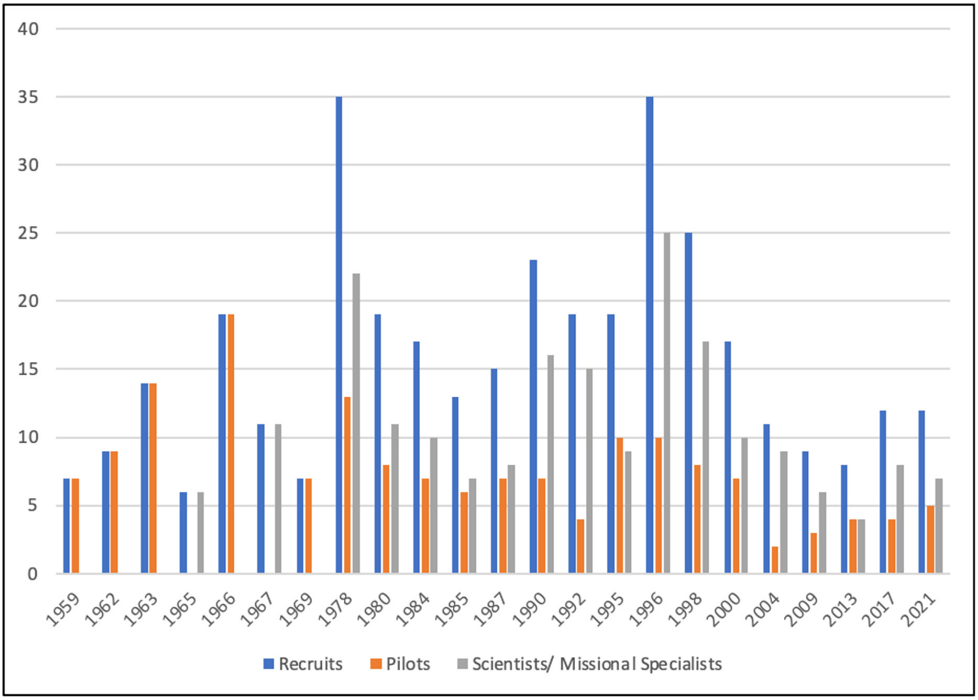

Figure 1. NASA astronaut recruitment 1959–2021 (Steimle and Norberg 2015: 258).

Payload specialists were required to "possess knowledge and expertise unique to particular payload and train along with an assigned crew for each mission" (Seedhouse 2010: 12). Notably, except for the 1995 recruitment, more mission specialists and scientists were chosen than military test pilots. During the 1990's, NASA's human space programme typically selected between 15 and 25 non-pilot candidates in each round of recruitment (in 1990, 1992, 1996, and 1998), resulting in about 150 active astronauts by the year 2000 (Cox et al. 2017: 30-32).[1]

During NASA's 2009 selection process, 120 out of 3,535 applicants were invited to the Johnson Space Center (the Behavioural Health and Performance Group: BHP) for assessment. The process comprised written psychological exams assessing sociability and teamwork (Stuster 2016: 22-23), interviews, and medical tests. The medical examination covered medical history, physical examination, cardiopulmonary evaluation, ENT (ear, nose, and throat) evaluation, dental examination, neurological examination, psychiatric/psychological evaluation, radiographic evaluation, and laboratory investigation (Seedhouse 2010: 27-30). Their backgrounds in 2013, 2017, and 2021 included test pilots, medical doctors, engineers, physicists, biologists, geologists, and chemists. In addition, desirable traits included good communication skills and bilingual proficiency (Spotlight 2024). The ability to multi-tasking

[1] The psychiatric evaluation system, which used to be conducted with different methods and styles, was standardised in 1989, including measures of personality, intelligence, and psychopathology.

capacities was also highly valued, considering the demands of a complex operational environment (Steimle and Norberg 2015: 256). The ideal candidates were expected to be intelligent, charismatic, likeable, agreeable, team players, and good speakers. Candidates with peculiar habits, behaviours, characteristics, or contentious political viewpoints faced reduced chances of selection (Steimle and Norberg 2015: 256). So far, NASA has selected about 360 astronaut candidates, with women comprising only 20 % (61), despite increasingly diverse backgrounds, such as military (212), pilots (191), non-pilots (159), and civilians (138) (NASA 2024). The 2024 astronaut selection programme emphasises choosing women with either a master's degree in a STEM discipline or a doctorate in medicine, with the goal of having the first woman for the Artemis III Moon mission in 2026.[2]

The selection of Russian cosmonauts was primarily managed by the Air Force (1960–2010), RSC Energia (for civilian cosmonauts: 1966–2010), and the Institute for Medical and Biological Problems (for medical doctors: 1972–2003). In particular, the Interkosmos programme, with other Eastern bloc countries, oversaw cosmonaut selection and training of cosmonauts for Soyuz missions as well as those up to Salyut 6 (1978–1981) (Faulconbridge and Kelly 2024). The Yuri Gagarin Training Center in Moscow was responsible for training Russian cosmonauts, having trained 422 cosmonauts since 1961. In 2009, the management authority was transferred from the Air Force (military) to the Russian Space Agency (civilian control). The Cosmonaut Space Agency subsequently oversaw all active cosmonauts participating in Soyuz TMA (2002–2012), Soyuz TMA-M (2010–2016), and Soyuz MS (2016–2024) missions for the ISS projects (Steimle and Norberg 2015: 263-64). Meanwhile, the European Space Agency (ESA) launched its first astronaut (Ulf Merbold, Italian) selection in the late 1970s to provide a Spacelab expertise for the Space Shuttle. In the 1980s, European nations ran their own national recruitment programmes for either the US Shuttle or the Russian Soyuz (Fassbender and Goeters 1992: 131-38). As a result, the European Astronaut Center (EAC) was established in Cologne, Germany, in 1990 to manage European astronauts' training (Steimle and Norberg 2015: 264). While each nation could propose up to five candidates, the ESA had the final say over the selection of new astronauts for the Shuttle and Mir missions. In 1998, the EAC took over the responsibility for selecting ESA astronauts. For the 2008/2009 ESA astronaut selection, applicants were required to hold a university degree in engineering, natural science, or medicine, along with pilot experience or at least three years of relevant postgraduate experience. The preferred age range was 27 to 37 years old (Steimle and Norberg 2015: 267). In addition to the high English language proficiency level, the applicants had to disclose their medical and psychological health conditions (Maschke et al. 2011: 38-44).

For instance, they must display an average range of motion and functionality across all joints. The visual acuity in both eyes should 20/20 vision at a distance of 20 feet, either corrected or uncorrected with lenses or contacts lenses. Moreover,

[2] "Want to be an astronaut? Step one: fill out this form". *Vox* (*Science*), 6 March 2024. Available online at https://www.vox.com/science/2024/3/6/24091622/nasa-astronaut-application-2024-requirements-form-salary. Accessed on 25 April 2024.

applicants were required to demonstrate mental, cognitive, and personality capabilities for working in an intellectually and socially demanding environment. The selection of ESA astronauts was unique in that it included two psychological and psychiatric evaluations on top of typical medical tests. The psychological evaluation focused on identifying candidates best suited for collaborative work in space, while the psychiatric evaluation intended to identify those who “possess qualities that indicate an increased risk for developing mental or behavioural illness” (Maschke et al. 2011: 38). Being free from any diseases or psychiatric disorders, as well as any dependencies on drugs, alcohol, or tobacco, were also key considerations (Steimle and Norberg 2015: 267). The ESA astronaut selection for 2021/2022 aimed to choose final five astronauts and twelve reserves from a pool of 23,000 applicants. This selection process was open to pregnant women (if married) and individuals with disabilities (parastronauts) (Wiedmann et al. 2023: 2267-2280).[3] The medical tests were administrated by the Institute for Space Medicine and Physiology (MEDES) in Toulouse, while the psychological tests were conducted by the DLR Institute for Aviation and Space Psychology in Hamburg.

2. Psychological traumas and resilience in potential risk management

The astronaut candidates selected by NASA’s Johnson Space Centre, the Russian Yuri Gagarin Training Centre, and the European Astronaut Centre typically undergo a three-stage (3.5–5 years) ISS astronaut training programme in Houston and Star City (Russia).[4] The basic training takes one to one and a half years, followed by one year of advanced training, and finally, increment-specific training lasting at least one and a half to two and a half years (Steimle and Norberg 2015: 278-281). However, as space exploration advances towards more challenging missions, such as the return travel to Mars in the 2030s, questions surface about the adequacy of current evaluation standards. These missions require crew members to work with greater autonomy and responsibility, with limited Earth-based control. Therefore, during the selection process, what psychological elements should be assessed more to mitigate potential impediments faced by astronauts? During a prolonged and lonely journey lasting 2.5–3 years, how can they ensure a safe and supportive environment for the crews of the space community? How can they be empowered to secure their own well-being on these missions? While scientists and engineers focus on developing advanced facilities, the field of space medicine continues to progress, improving our understating of the biophysical condition of the human body. This paper proposes a hypothetical countermeasure to address the psycho-physiological hazards of space travel, such as confinement (isolation), distance from Earth (travel time), and hostile environments. It suggests that analysing personal traumas related to family affairs (bereavement, divorce, and abuse), addiction (drug, alcohol, smoking, gambling

[3] The first Australian astronaut (Katherine Bennell-Pegg) passed through the basic training with ESA in April 2024 (European Space Agency, 2024).

[4] As well as the Canadian Space Agency (CAS) and the Tsukuba Space Center (Japan).

(internet games), and sex), and personality traits indicative of potential conflict (threat, stubbornness, aggression, hostility, or violence) can significantly improve astronauts' inner resilience, thereby ensuring space community security (Anania et al. 2017).

The future Mars astronauts will inevitably face the challenge of living and cooperating for a couple of years "with varying levels of taskload and incessant risk of vehicle malfunctions and failures" (Anania et al. 2017: 1). As "living and working in extreme environments can be psychologically stressful," the habitat section of NASA's Deep Space Transport (DST), designed for up to 1,000 days, remains limited "with functional areas of sleep/private quarters, dining, and communal activities, work space, exercise, hygiene, passthroughs, and stowage" (Landon et al. 2017: 36). The feelings of isolation from family and friends, with each astronaut allowed about 25 cubic meters of personal space, can profoundly affect astronaut health and performance (Alexander et al. 2021: 382-395). The following testimonies of a past astronaut illustrate the emotional difficulty: "I do crave my family. I'd love to give my children a big bear-hug. … I watched the family on my video camera installed in my living room. It was nice to see them and difficult at the same time" (Stuster 2016: 17). By 2024, 19 people have died in five in-flight accidents, including the collision of the Progress M34 cargo ship collided with the MIR station complex in June 1997 and an incident involving a critical water leak experienced by an ESA astronaut aboard the ISS in 2013, as well as an air leak (a 2 mm hole) in the Soyuz (2018) (Ewald 2019: 370-372). In this regard, Alessandro Arone, Tea Ivaldi, Konstantin Loganovsky, Stefania Palermo, Elisabetta Parra, Walter Flamini, and Donatella Marazziti have reported "symptoms of emotional dysregulation, cognitive dysfunction, disruption of sleep-wake rhythms, visual phenomena and significant changes in body weight, along with morphological brain changes" often occurring during space missions (Arone et al. 2021: 237-246).

The NASA Mars Design Reference Architecture 2009 outlines two possible mission types. The short-stay mission, also known as the 'opposition class mission' involves sending astronauts to Mars for a 30-day stay with a round-trip duration of about 640 days (Anania et al. 2017: 2). In contrast, a long-stay mission called a 'conjunction-class mission' takes a total return-trip travel time of 916 days in the case where the mission encounters no technical issues or compromises to the psycho-physical well-being of astronauts (Williams 2015). While the scientists continue to enhance the spacecraft environment such as SpaceX Starship, with work and personal spaces for astronauts (sleeping, resting, communicating, and personal time), the astronaut selection process for deep space missions must prioritise innovative research into human health, especially in the private realm. It is emphasised that the "prevention of mental health of space travellers should be carefully considered" (Arone et al. 2021: 237). As the ESA's astronaut selection process (2008/2009 and 2021/2022) demonstrates, psychological and psychiatric evaluations should be systematically incorporated into the Mars mission. Studying the human mind, including aspects like mental stability, confidence, anxiety, uncertainty, or fear, often goes beyond quantifiable metrics (Mezzacappa 2019: 195-206). The emotional state of astronauts confronting emergent situations or maladaptive group behaviours (schisms, friction, withdrawal, competitiveness, and scapegoating) may not be accurately predicted by even AI human monitoring systems until manifested in actions or external behaviours (threat, stubbornness, aggression, hostility, or violence) (Ball and Evans Jr. 2001). John R. Ball and Charles H. Evans Jr. also emphasise the importance of "the analysis of complex individual and group habitability interactions that critically influence behavioural health and performance effectiveness in the course of long-duration missions" (Ball and Evans Jr. 2001: 167). Thus, evaluating astronauts' resilience directly relates to their safety and the success of their long-term missions.

3. Traumas of family affairs

The personal experiences within family relationships may not be readily visible scientific or physical issues during the selection process, which warrants careful consideration for candidates who have experienced catastrophic family events in the previous year, such as bereavement, divorce, or abuse. The grieving process may last from six months to several years, depending on a person's sense of loss or agony. The resulting emotional trauma, along with behavioural changes, can not only be difficult to overcome but can also affect others around them. Traumatic experiences are often linked to chronic pain through conditions like post-traumatic stress disorder (PTSD), a mental condition triggered by terrifying events (DeCosmo 2023). Symptoms such as nightmares, flashbacks (with a racing heart or sweating), recurring dreams or memories, physical stress, distressing thoughts, severe anxiety, and uncontrollable thoughts about the event could significantly impact deep space astronauts (Kalin 2021: 103-105). Additionally, people with personal traumas may experience increased arousal and reactivity conditions, such as feeling tense, on edge (or on guard), easily startled, and struggling with concentration and sleep. Feelings of irritability, anger, and aggressive outbursts are also frequent, often leading to engaging in risky or reckless behaviours, which can create potentially destructive environments (National Institute of Mental Health (2024)). The Trauma Resiliency Model (TRM), developed by Linda Grabbe and Elaine Miller-Karas, uses sensory awareness for emotion regulation and integration, offering a rationale for body-based therapy grounded in the neuroscience of trauma and resilience (Grabbe and Miller-Karas 2017: 1-25). However, chronic distress from the trauma remains a potential concern, especially as space travel duration increases, leading to prolonged periods of solitary confinement and heightened stress levels (Kalin 2021: 103-105):

> I am not writing as much in the journal because there is not much to talk about. Most everything is the same up here. In general, I am to the point where I would be happy to go home and call it a mission. I am still fine with being here. I think today is the 1/3 point of my increment; X weeks down and Y weeks to go. I will be fine but 6 months is a long time to be here and I cannot see why anyone would want to be here for a full year (Stuster 2016: 19-20).

3.1. Bereavement

During the COVID-19 pandemic, many individuals not only experienced isolation (2 weeks or more away from family) as a result of legal restrictions but also lost family members. Even those who lost their loved ones due to expected biomedical complications may continue to grapple with unhealed mental trauma. Therefore, future astronauts must undergo assessments for any personal experiences with family death. The deceased family members could be the father, mother, grandparents, husband, wife, brother, sister, son, daughter, and other close relatives (Milligan et al. 2016: 103-111). While the manner of death may vary, including natural causes, accidents, suicides, homicides, or cases classified as undetermined (Snohomish County 2024), natural death is solely caused by diseases, such as ischemic heart disease, cancer, stroke, and chronic obstructive pulmonary disease (Yamaguchi et al. 2022: 774-778). Accidents, injuries, or industrial deaths often occur unexpectedly without allowing for mental preparation. The suicide of a family member can have profoundly adverse effects on the mental well-being of the surviving family members, while homicide involves violent deaths from deliberate or purposeful action (Fallah et al. 2024: e134130).[5] Undetermined cases may include deaths due to fire, drowning, and natural disasters (tsunami, earthquake, storms, and flooding) (Beer et al. 2022: 590-517).

Experiencing traumatic bereavement can lead to significant distress and difficulties for individuals. Physical reactions, as outlined by the Substance Abuse and Mental Health Services Administration (SANHSH), are a common human response to death and can manifest as muscle weakness, shakiness, difficulty breathing, dry mouth, and irregular sleeping (Yamaguchi et al. 2022: 774-778, Substance Abuse and Mental Health Services Administration 2024). The American Psychiatric Association (APA) recommends meditation, breathing exercises, soothing music, and engaging in enjoyable and recreational activities (American Psychiatric Association 2024). Furthermore, the death of a family member can profoundly cause the psychological and physiological functions of the surviving family members, manifesting as difficulties with concentration, restlessness or hyperactivity, loss of appetite, and difficulty in decision-making (GVS-RPB 2024). If any astronaut candidate has experienced the trauma of losing a family member, the negative effects of grief can appear in various mental disorders, including shock, anguish, anger, guilt, regret, anxiety, loneliness, unhappiness, depression, intrusive images, depersonalisation, and the feeling of being overwhelmed (Vig et al. 2021: 136). According to Cayetano Fernández-Sola, Marcos Camacho-Ávila, and José Manuel Hernández-Padilla, experiencing a perinatal death, particularly for female or male astronauts in their 30s or 40s, can significantly tackle family dynamics as well as their social and work environments (Fernández-Sola et al. 2020: 3421). The memory of such a significant lose can render individuals vulnerable to displaying their worst behaviour, even during a space mission. Christopher W. T. Miller describes a neural disability in the brain, stating that "during grief, stress hormone levels increase, and brain activation

[5] Divorced women have higher chance of suicide.

patterns can change. … the 'basal ganglia' – groups of neurons located deep within the lower portions of the brain – can become more activated" (Miller 2024).

3.2. Divorce

As another deeply impactful event in life, the personal experience of divorce typically remains two years, with the highest levels of emotional turmoil occurring within the first six months of separation (Morgan and Coleman 1997, Oklahoma State University 2017). For young adults with children, the situation can be even more complex and stressful, extending beyond the initial period of sorrow (Crawford et al. 2014). Following divorce, the dynamics of a couple's relationship often undergo a significant shift, causing considerable stress for all the individuals involved (Plunkett et al. 1997: 17-37). Feeling of rejection, loneliness, shame, guilt, and lack of love are common for divorcing individuals (Lagarde et al. 2004: 762-766). The physiological symptoms of this turmoil can include unstable sleep patterns, substance abuse (alcohol, drugs, and/or tobacco), changes in appetite (either overeating or loss of appetite), mood swings (sadness, anger, or depression), and even suicidal thoughts (Morgan and Coleman 1997). The stage of feeling numbness may disrupt daily routines and result in a pervasive sense of unsatisfaction. Ann Gold Buscho suggests that divorced men may bear a heavier burden as they often receive less social support (Buscho 2022, Kalmijn 2015: 921-938). Long-term health problems such as diabetes, heart disease, digestion or metabolic problems, cancer, or other chronic health issues are commonly observed among individuals who struggle to cope with the emotional strain of separation (Chicago News 2009). Emmanuel Lagarde, Jean-François Chastang, and Alice Gueguen highlight the impact of divorce on daily life, suggesting that the stressful experience of separation is associated with an increased risk of serious traffic accidents, comparable to the effects of alcohol consumption (Lagarde et al. 2004: 762-766). This increased risk of stressful accidents can potentially extend to deep space operations if an astronaut has not fully recovered from the trauma of divorce.

3.3. Abuse

The effect of abuse represents another critical consideration in assessing potential mental risks. Despite individuals overcoming internal anguish, their past experiences continue to be a sensitive aspect of their personal lives (Krill 2015). There are six major types of abuse: physical, verbal, mental, financial, cultural, and sexual (Dinis-Oliveira and Magalhães 2013: 113-132). Physical abuse involves actions such as punching, slapping, hitting, strangling, kicking, or physically restraining a partner against their will. Verbal and mental abuse occurs when offenders, often in an isolation environment, use hurtful words or intimidating actions over an extended period of time, leading the victim to hesitate to share their experiences and doubt their own sanity (Annerbäck et al. 2012: 585-595). While the financial and cultural abuses centre on controlling finances (credit cards and debts) and discriminating against different religions, races, and customs (including LGBT culture), the traumas resulting from sexual abuse, child abuse, or rape have both physical and non-physical components of power and control. Sexual abuse is associated with risk-taking behaviours and poor health, frequently coupled with intimate partner violence, bullying, and coercion (Annerbäck et al. 2012: 585-595). While the physical pain may subside in a couple years, the mental trauma can disrupt regular sleeping patterns, lead to alcohol or drug consumption, evoke feelings of emptiness, lower self-esteem, provoke self-hated, incite sexual or physical violence, pervade fear of people, and hinder the formation of new relationships (Kalfoglou 2012, Alaggia et al. 2019: 260-283). In particular, the experience of child sexual abuse (CSA) typically leads to depression, behavioural changes, nightmares, anxiety, traumatic memories, self-harm, and suicide attempts (Mathews and Collin-Vézina 2019: 131-148, McLean Hospital Boston 2024). Ateret Gewirtz-Meydan and Yael Lahav remind other side effects such as risky sexual behaviours, sexual dysfunctions, negative emotions, fear of sex, and sexual guilt (Gewirtz-Meydan and Lahav 2021: 1151-1160). Thus, it is essential to include formal assessments of any traumatic history of family bereavement, divorce, and abuse in the Mars astronaut's selection process to eliminate potential negative factors related to family affairs.

4. Experience of addictions

To enhance astronauts' inner resilience during the mental challenges of long space travel, counter-social behaviours associated with addiction, previously overlooked, should be carefully considered. While physically healthy candidates may appear suitable, identifying those with previous addition experiences is less evident (Stoll and Anderson 2015: 60-62). However, the psychiatric trauma stemming from past addiction may become apparent when astronauts encounter the extreme conditions of space travel for extended periods, including isolation, distance from Earth, and hostile environments. The personal struggles with addiction can impact an astronaut's ability to engage in 'social networking' with their colleagues (Carrillo et al. 2023: 7-14), potentially jeopardising the space mission if left unaddressed (Shamsaei et al. 2019: 130-132, Colpaert et al. 2012: 173-183). Kevin D. Shield and Jürgen Rehm raised the relationship between social well-being and addictions, emphasising that addictive behaviours and substance use disorders significantly affect physical and mental health, contributing to mortality and morbidity burdens (Shamsaei et al. 2019: 129-134, Shield and Rehm 2015: 79-105). The use of drugs, alcohol, tobacco, computer gambling (gaming), and sex, whether engaged in individually or as a group for various reasons (celebration, loneliness, longing, remembrance, or psychedelics), can lead to behavioural changes, suicidal tendencies, and stress.

4.1. Drugs

Individuals often turn to addictive drugs to experience feelings of pleasure, alleviate distress, or escape from current circumstances. Nevertheless, drug addiction indicates a physical, emotional, and psychological dependence on substances

(Rehman et al. 2022: 311-325). Past experiences of drug addiction can be detrimental to the long-term sustainability of astronauts. According to Kevin D. Shield and Jürgen Rehm, "exposure to addictive substances and behaviours increases the risk of the incidence or mortality from a disease, condition, or injury" (Shield and Rehm 2015: 89). Prior use of illicit and non-medical drugs broadly includes experiences with "opioids, cocaine, hallucinogen, inhalants, and other stimulant, sedative, hypnotic, or anxiolytic drugs" (Shield and Rehm 2015: 90). The World Health Organisation (WHO)'s ICD-10 Version 2010 confirms substance-related disorders in the forms of F11, F12, and F14 (World Health Organisation 2024). *Acute* drug use can result in accidents, drug-induced psychotic symptoms, myocardial infarction, and various forms of injuries. Furthermore, chronic drug use is related to liver disease, cancers, cardiovascular diseases, pulmonary diseases, psychotic disorders, common mental disorders, and neurotoxic effects (Chang et al. Huang 2023: 1044-1050). Drug abuse is also a significant risk factor for human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV), with the latter two giving "rise to chronic hepatitis and cirrhosis" (Jiang et al. 1995: 55-60). The increased risk of suicide is a major concern for individuals with a history of regular drug use (Shield and Rehm 2015: 91). It is "a silent killer that not only harms the addict but also their … communities" (Rehman et al. 2022: 313).

4.2. Alcohol

Past experiences of alcohol addiction have a profound negative impact on an astronaut's health. Although alcohol may offer certain benefits in some diseases, its consumption has been linked to adverse effects, especially on liver health (Van Thiel 1996: 261-265). Persistent alcohol consumption can cause various conditions, such as infectious and parasitic diseases, diabetes mellitus, malignant neoplasms, respiratory infections, neuropsychiatric conditions, and digestive diseases (Shield and Rehm 2015: 82-84). The personal secrecy surrounding drinking behaviours increases the risk of stroke, ischaemic heart disease, and diabetes, as well as intentional and unintentional injuries, whether self-inflicted or involving colleagues. The risk of unintentional injuries stems from impaired cognitive processing, reaction time, vigilance, and coordination. Alcohol consumption also alters the brains' biological receptors involved in neurotransmission, leading to increased aggression and self-inflicted injuries. One of the major concerns relates to "serotonin and gamma-aminobutyric acid receptors of the brain, which could lead to a reduction in fear and anxiety responses to the physical, social, or legal consequences of one's actions" (Shield and Rehm 2015: 90, see Ciranna 2006: 101-114). This increased tendency towards violence can escalate through fighting and intoxication in society. Moreover, the influence of alcohol, like opioids, "increases the risk for suicidal ideation, attempts, and death" (Rizk et al. 2021: 197 and see 194-207). Unstable consciousness resulting from alcohol consumption can severely disrupt the plan and goal of the (space) community. Therefore, Kelley J. Slack, Al Holland, and Walter Sipes, in *Selecting Astronauts: The Role of Psychologists*, advocate for a strict policy of alcohol and drug screening in the selection process (Slack et al. 2014).

4.3. Smoking

In the selection process for the inaugural long Mars mission, candidates' history of smoking, including exposure to second-hand smoke, should be analysed. While smoking habits may not be a critical issue in ordinary circumstances, they could pose significant risks during crises or conflicts among crew members. We also should consider the question, can a smoker completely quit smoking during the entire mission? The following testimony of a past astronaut illustrate the strict policy of smoking regulation in spaceflight: "Another smoke detector alarm today. I was exercising but made sure I checked out the [ISS community] situation. It is good training to react as if it is a real emergency. False alarms … I started a scoreboard in the lab of these false alarms" (Stuster 2016: 68). Emotional responses such as insecurity, anxiety, and uncertainty can impair communication and decision-making in operational settings. Engaging in smoking increases the likelihood of developing various health issues, including "cancer, stroke, lung diseases, heart disease, diabetes, and chronic obstructive pulmonary disease (COPD), which includes emphysema and chronic bronchitis" (Centers for Disease Control and Prevention 2024). Moreover, smoking raises the risk for certain eye diseases, tuberculosis, and immune system problems, like rheumatoid arthritis. These health concerns, coupled with the effects of space radiation, zero or low gravity, space adaptation syndrome (motion sickness), and bone loss, highlight the potential risks connected with tobacco use during extended space missions (NASA 2024b).

4.4. Gambling

Among various kinds of addictions, the issue of (internet/computer) gambling disorder may not seem immediately relevant, but it could pose a serious challenge for astronauts embarking on prolonged missions lasting 2.5–3 years. In the absence of any major personal activities or family connections, past experiences of gambling behaviours should be scrutinized as a preventive measure against potential conflicts or aggressive behaviours. Kevin D. Shield and Jürgen Rehm indicate that repetitive engagement in gambling not only impairs functioning in other areas of activity but also share similarities with substance use disorders such as those involving drugs, alcohol, and tobacco (Shield and Rehm 2015: 95). Gambling disorder is associated with adverse effects on mental and physical health, especially in terms of jeopardising crucial relationships with crew members, family, and friends. Its psychological allure is connected to other morbidities, such as depression, substance use disorders, anxiety disorders, and personality disorders (Shield and Rehm 2015: 96). Internet gambling, as outlined by the American Psychiatric Association in 2013, is linked to suicidal behaviour disorder (Shield and Rehm 2015: 96), particularly when coupled with the additive internet gaming (video game addiction) with other internet gamers. Both additive activities increase the risk of Internet Addiction (IA) and cause to bring negative outcomes such as bad-tempered, impaired self-control and dissatisfaction (Shabina et al. 2023: e36957, Macur 2018: 221-235).

4.5. Sex

Could the personal history of sexual addiction (SA) be readily apparent? Is compulsive sexual behaviour (CSB) a potential risk during extended space travel? While NASA no longer imposes an age limit, astronaut candidates typically fall between the ages of 26 and 46, with an average age of 34. Russian cosmonauts have an age limit of up to 35 years, where ESA has a maximum age limit of 50 years. Considering that the prime age for sexual activity generally falls within one's 30s and 40s, past experiences of SA and CSB, recognised as familial diseases, present problematic concerns. These experiences can lead to symptoms such as loss of control, increased sexual attraction, and psycho-social impairments. In an environment with a limited social space for an extended period, such as a Mars travel community scenario, both single and married individuals may experience increased desires with opposite or same sex colleague (Aghamiri et al. 2022: 1-37). According to Fakri Seyed Aghamiri, Johannes M. Luetz, and Karenne Hills, compared with males, females can endure a variety of negative emotional, relational, physical, and sexual effects, resulting in consequences for both individuals and society in terms of interpersonal, relational, and overall well-being (Aghamiri et al. 2022: 2-3). Additionally, research on SA and CSB has indicated associations with suicidal and parasuicidal behaviours (Orsolini et al. 2022: 56-67). Therefore, during the astronaut section process, it is important to exam any history of addictive behaviours, including drugs, alcohol, tobacco, computer gambling/gaming, and sex, as a precautionary measure, even when space medicine can partly manage these issues.

5. Resilience and personality traits

What personality traits are beneficial for astronauts on long-duration missions (LDMs)? Beyond fulfilling the fundamental (physiological and professional) requirements, attention should be given to candidates' cognitive attitudes, such as endurance, perseverance, patience, cooperation, discernment, self-sacrifice, leadership, positiveness, and optimism. Gro M. Sandal, Dave Musson, and Robert L Helmreich mentioned the importance of personality assessment in the context of 'social desirability' for confident performance during spaceflight (Sandal et al. 2005: 634-641). While not scientifically quantifiable, the resilience of personality serves as a subconscious metaphysical foundation that enhances their cognitive abilities and skills. This applies not only to typical isolated space scenarios but also to unexpected technological failures where a resilient spirit is required for crisis management. Especially in instances where astronauts must make logical decisions without external advice or help, fearless or responsible behaviour becomes paramount. A 2014 NASA psychologists' report acknowledges the difficulty of maintaining the astronauts' mental resilience, citing the most challenging aspect of astronaut selection as "predicting behaviour in the future" (Slack 2014). Personality disorders can impair cognitive functions (Sanatinia et al. 2016: 244-250), with R. M. Rose, L. F. Fogg, and R. L. Helmreich identifying negative attitudes as a primary psychological predictor among astronauts. The five non-linear personality subscales include low impatience and irritability, high negative expressivity and negative communion (subordinate and gullible), low negative instrumentality (egoism), low openness (to new ideas and experiences), and high agreeableness (Rose et al. 1994: 910-915). These personality attributes are considered metrics in the selection process.

Thus, there has been a gradual refinement in personality assessment methods for astronaut selection. As "higher levels of coping under conditions of isolation and confinement" correlate with different personality traits, the Personality Characteristic Inventory (PCI) and the NEO Personality Inventory (NEO-PI) are useful tools for final-stage astronaut selection (Musson et al. 2004: 342). The PCI evaluates both positive and negative aspects of two core personality dimensions: expressivity, linked to interpersonal sensitivity and concerns, and instrumentality, while pertains to task focus and achievement (Sandal et al. 2005: 634-641, Musson et al. 2004: 343-349). The NEO-PI measures the Big Five personality factors: Openness to new experiences, Conscientiousness, Extraversion, Agreeableness, and Neuroticism (also known as adjustment or emotional stability) (OCEAN) (Mittelstädt et al. 2016: 933-939, Aren and Hamamci 2020: 2651-2682). During the 1980s and 1990s, the OCEAN model was used as a predictor of astronaut performance in organisational employment settings and confined environments, including among Antarctic personnel (Musson 2011, Musson et al. 2004: 343-349). Furthermore, cognitive tests (attention, memory, decision-making, and problem-solving), behavioural assessments (teamwork abilities, stress management, and conflict resolution) (Stuster 2016: 35-36), psychiatric evaluations (psychiatric disorders, coping strategies, and stress reactions), and neuropsychological tests (brain function) are also employed in the selection process (Cen et al. 2023: e110203).

Meanwhile, the *Astronaut Aptitude Test* comprises questions based on NASA astronaut candidates' basic knowledge requirements and real-life psychological tests for intergalactic exploration (Astronaut Aptitude Test 2024). The questions are categorised into six sections: physicality, spatial visualisation, knowledge, education level, IQ/abstract reasoning, and personality. The test includes assessing responses to stress, as NASA expects "high emotional stability and moderate openness to experience" (ibid.). Gradually, NASA launched a behavioural health plan for long-term longitudinal surveillance in late 2018. The plan analysed the psychological conditions of former astronauts, including depression, anxiety, dementia, traumatic stress disorders, and substance use, using the Centre for Epidemiologic Studies Depression (CES-D), Symptom Checklist 90 (SCL-90R) scale, Beck Anxiety Scale, AUDIT (Alcohol Use Disorders Identification Test), Dementia Rating Scale-2, and Geriatric Depression Scale (Beven et al. 2018).

However, is the current short-term mission policy suitable for deep space travel conditions? If not, how can it be improved to ensure the safety of the space community? While no single method can perfectly monitor astronauts' psychological well-being, the Myers-Briggs Type Indicator (MBTI) assessment holds promise for predicting individual personality types, strengths, and preferences (Fetvadjiev and van de Vijver 2015: 752-776). This self-report inventory of internal consistency consists of four dichotomous scales: Introversion/Extroversion (IE), Thinking/Feeling (TF), Sensing/Intuition (SN), and Judgment/Perception (JP). While the MBTI, in conjunction with Carl Jung's four temperaments,[6] may not be considered a strictly scientific theory, it efficiently identifies "individuals 16 personality characteristics not only to professionals, but also to the individuals themselves" (Coulacoglou and Saklofske 2017: 267). Although the TF dimension has been criticised as "not sufficiently pure", L. Bastiaansen, G. Rossi, and C. Schotte suggest that the MBTI aligns with NEO-PI's Big Five personality traits, which are linked to personality disorders (Bastiaansen et al. 2011: 378-396, Samuel and Widiger 2008: 1326-1342). David S. Janowsky, Shirley Morter, and Liyi Hong further assert that the MBTI's profiles can also encompass dark-side traits (Janowsky et al. 2002: 33-39).

The NASA Office of the Chief Engineer applied the principle to system engineers to comprehend their personality and psychological type (Figure 2). The IE type focuses on natural energy orientation, while the SN type relates to how individuals perceive, understand, and absorb information. The TF type pertains to how judgements are formed, and choices and decision are made. The JF type concerns action orientation towards the outside world (Williams and Derro 2008). The resulting

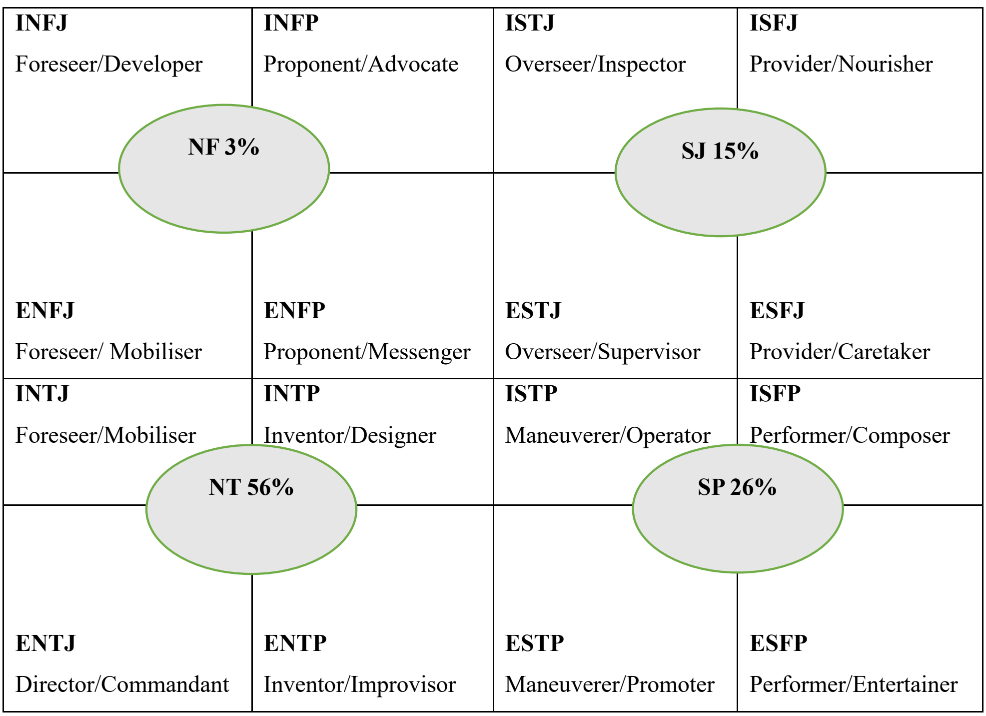

Figure 2. A brief form of MBTI psychological personality measure (Williams and Derro 2008).

[6] Jung's four temperaments are Sanguine (outgoing), Choleric (success-oriented), Melancholic (loyal), and Phlegmatic (intuitive).

basic behaviours were predominately NT (observable and measurable), indicating that these characteristics can be developed and learned (Williams and Derro 2008).

The environment faced by deep space astronauts would be challenging and demanding, with various risk levels. Selim Aren and Hatice Nayman Hamamci define this as 'risk aversion behaviour' (Aren and Hamamci 2020: 2651). The way an individual interacts, reacts, and behaves with their colleagues is something that can be ambiguous to measure, especially in emergencies. For example, *Psychometric Personality Differences Between Candidates in Astronaut Selection* (a research paper) shows that "the candidates who failed in basic aptitude testing showed higher levels of neuroticism than those who passed that phrase" (Mittelstädt et al. 2016: 933). Therefore, risk-taking behaviour should be considered a key factor in the astronaut selection process for a successful Mars mission. The effectiveness of management and decision-making processes (Zimmerman 2008: 309-348) is also significant, incorporating factors such as professional knowledge, practical experiences, personality, communication skills, and leadership (Tovmasyan 2022: 5-13).

In cases where future astronaut teams are composed of three or four types – mission commanders, pilots, payload specialists, and mission specialists – they should generally be investigative, inquisitive, and curious individuals. Despite often spending time in solitude, they are inclined towards proposing creative and original solutions, reflecting self-expression within a structured framework. Within such a picture, the mission commander oversees the safety of crew members and the spaceship, as well as the success of the return mission. The pilot assists the leader in operating the vehicle and deploying and retrieving satellites or other space utilities. While not definite, this paper proposes that ENTJ and INTJ personality types, along with ESTJ or ISTJ, are suitable for the roles of mission commanders/pilots due to their problem-solving skills and familiarity with complex systems. Collaborating with other crew members, they can motivate and inspire the space community with their intellectual traits of extroversion, intuitive, thinking, and judging. A charismatic and ambitious personality is crucial for strong leadership and responsibility, which is characteristic of INTJs who are goal-oriented and capable of foreseeing potential outcomes and scheduling accordingly: "I don't think the crew morale and mutual respect could be any better. I am very satisfied that I'm able to help and do my part as commander to run a happy and satisfied [space]ship. All is in good order" (Stuster 2016: 35-36). Figures such as Neil Armstrong (INTJ), General Douglas MacArthur (ENTJ), Admiral Chester Nimitz (ESTJ: US Navy leaders) and Senior ED medical staff in Tasmania and South Australia exhibited such distinct internal personalities, enabling them to overcome technological obstacles for mission's success (Boyd and Brown 2005: 200-203, Moraski 2001).

Payload specialists responsible for managing payload activities and conducting various experiments are generally exempt from certain NASA requirements. While they collaborate with the mission commander in operation and maintaining cargo and other equipment, they are selected and nominated by NASA, foreign sponsors, or commercial and research organisations for mission flights involving specific payloads (Gaskill 2024). Possessing technical skills in commercial/ scientific operations or specific experiments, they receive "a couple of hundred hours of training over four or five weeks" (Stevens 1981: A1). However, for the Mars mission, what personality traits beyond professionalism would be advantageous for ensuring smooth and productive communication during dangerous or challenging operations in space? Given the need for meticulous proficiency in operating complex systems, individuals with ENFP, ISTP, and ISFJ personality types are recommended, characterised by a strong sense of dedication, practical problem-solving skills, and responsibility (Robertson and Putnam 2018: 111-124). ENFP individuals are known for their observational skills and a strong commitment to the safety of others, being "friendly, creative, energetic, and innovative with the ability to connect with colleagues on a deep level" (Booth J. 2023). Dan Pan, Yijing Zhang, and Zhizhong Li, in their teleoperation performance experiment involving a space robotic arm, observed that individuals with skills in mobilising and manoeuvring benefited from the remote robotic arm, as they possessed familiarity with "high spatial cognitive ability, imagery and who list cognitive style, low neuroticism, and high agreeableness" (Pan et al. 2016: 772).

Mission specialists, who can be engineers, scientists, or physicians, traditionally maintain spacecraft and equipment and conduct experiments (Arnaldi et al. 2015). With NASA's focus on technical solutions for oxygen, food, water, power, spacesuits, communications, and shelter, the upcoming Mars mission requires additional experts, including planetary geologists, chemists, miners, botanists, microbiologists, mental health professionals, meteorologists, agriculturists, medical specialists, and habitat specialists (National Aeronautics and Space Administration (NASA) 2024). Individual personalities may vary between I (introversion) and E (extroversion), but future mission specialist candidates who demonstrate community-centred traits such as T (thinking), N (intuition), J (judgment), and P (perception), are deemed effective and self-reliant in the resilient context of the scientific manned space expedition (Sandal et al. 2005). J. M. Mittelstädt, Y. Pecena, V. Oubaid, and P. Maschke similarly applied the NEO Personality Inventory Revised (NEO-PI-R) for ESA 2008/2009 astronaut candidates not only to evaluate if personality traits could contribute positively to mission success, but also to understand the difference between unsuccessful and successful ones. It was observed that those eliminated during the basic aptitude testing showed higher levels of 'neuroticism' and lower levels of 'agreeableness' (Mittelstädt et al. 2016).

6. Conclusion

The scientific and technological advancements of NASA, the Russian and the Chinese space agencies have progressed to the point where human missions beyond Earth's orbits and the moon are feasible by the 2030s. Accompanying this process, space medicine management has progressed to a point where the physiological conditions of astronauts can be maintained in a challenging environment. However, this paper raised a critical question regarding the psychological dimension of human mental health. While the major focus of deep space travel projects has been on data-based spheres of space engineering and medicine, the question arises: Has the astronaut selection criteria been adequately updated to address the major hazards of confinement (isolation), distance from Earth (travel time), and hostile environments? The psychiatric well-being of each astronaut, less quantifiable aspect of human health, could pose serious risks during a Mars return mission. According to M. Bonati, R. Campi, and G. Segre, the two-week COVID-19 quarantine resulted in fear, depression, distress, and post-traumatic symptoms, highlighting how pandemic situations can become risk factors for individual's well-being, especially for females and unmarried young people (Bonati et al. 2022). They recommend not only minimising the risk of negative mental consequences but also enhancing the well-being of these vulnerable groups. Drawing parallels with the pandemic's lockdown experience, it becomes evident that psychological disorders during a Mars space mission lasting 2.5–3 years could be mitigated to a certain degree by addressing critical factors such as depression, transient anxiety, and/or psychosomatic reactions.

This paper argued a hypothetical theory suggesting that the non-scientific sphere of the human mind can display high levels of resilience if space policy selection criteria consider the gravity of mental traumas in the context of risk management and space community safety. It advocates for a thorough re-evaluation of candidates during the astronaut selection procedure, emphasising the importance of taking into account past mental traumas, even among physically qualitied individuals with suitable education, experiences, and backgrounds. Specifically, candidates who have experienced family-related traumas such as bereavement (loss of father, mother, grandparents, husband, wife, brother, sister, son, daughter, and other close relatives), divorce, or instances of abuse (including sexual abuse) within the past year should undergo careful scrutiny. Additionally, experiences with addiction, such as drugs, alcohol, smoking, internet gambling (games), and sex, should be subject to thorough examination. While there are many adverse effects, the risk of suicide, coupled with potential conflicts with colleagues, could be heightened due to past traumas and additions, excluding smoking. To assess future astronaut's resilience, the paper proposes using the MBTI psychological assessment method to evaluate their personality traits, including those of mission commanders/pilots, payload specialists, and mission specialists. While MBTI does not provide precise mathematical or scientific data, it offers valuable insights into each candidate's invisible character trait, which are crucial not only for routine operations but also for navigating unexpected crises. This approach is valuable for verifying the long-term suitability of individuals for space mission sustainability in terms of leadership, abilities, potential, and responsibility. Thus, whether for a short-duration (570 days) or long-duration (950 days) mission to Mars in the 2030s, it will not be without challenges. While the astronaut selection procedure cannot guarantee perfection, it at least mitigates predicted risk factors related to human resilience and well-being, directly impacting the mission's security and success.

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