24th Humans in Space Symposium

(2026, Montecatini, Italy) SYNOPSIS

1. Overview

The 24th Humans in Space Symposium marks a transition from low Earth orbit operations toward deep-space, long-duration missions, requiring integrated, adaptive, and autonomous human support systems.

Across disciplines—physiology, neuroscience, AI, life support, and mission design—the symposium highlights a unified shift toward:

System-level integration

Personalized and predictive medicine

Operational autonomy

Strong Earth–space translational applications

2. Artificial Gravity: From Countermeasure to Rehabilitation Platform

Artificial gravity (AG) is no longer viewed solely as a countermeasure, but as a multi-system physiological regulator with direct clinical applications.

Space Physiology Role

Dose-dependent neuromuscular and cardiovascular activation

Improvement of orthostatic tolerance via autonomic conditioning

Integration with analogs, such as dry immersion, to model microgravity adaptation

NEW: Translational Rehabilitation Applications (Key Contribution)

Several studies demonstrate that:

Artificial gravity via short-arm human centrifugation (SAHC) can:

Restore neuromuscular activation patterns

Improve postural control and motor function

Enhance cardiovascular conditioning in deconditioned patients

Evidence from clinical and analog populations shows:

Significant increases in muscle activation

Functional recovery in neurological conditions (e.g., motor impairment, MS-like deconditioning)

Modulation of autonomic and circulatory responses

AG acts as a "gravitational exercise modality", combining:

mechanical loading

vestibular stimulation

cardiovascular stress

This positions AG as a unique therapeutic platform, especially for:

Neurological rehabilitation

Immobilized or deconditioned patients

Aging populations

Supporting Analog Findings

Increased muscle oxygenation and synchronized circulation in unloading conditions

Rapid spinal neuroplastic changes (hyperreflexia) under microgravity

Effectiveness of complementary countermeasures such as EMS

Conclusion:
Artificial gravity represents a paradigm shift:
From space countermeasure → to integrated space–clinical rehabilitation technology

3. Cardiovascular and Environmental Adaptation

The cardiovascular system remains a central regulator of adaptation:

Maintains functional efficiency despite structural remodeling

Enables continuous monitoring via wearable technologies

New factor: Hypomagnetic conditions

Increased arrhythmia and ischemia risk in deep space

Individual autonomic profiles determine resilience

Conclusion:
Future missions must address combined environmental stressors, including electromagnetic changes.

4. Brain, Behavior, and Neuro-Ocular Risks

Neurophysiological responses vary with individual psychological traits

Brain adaptation is nonlinear and dynamic

SANS (major risk)

Affects a large proportion of astronauts

Causes structural and functional visual changes

Conclusion:
Brain and visual systems are critical limiting factors for long-duration missions.

5. AI, Omics, and Predictive Space Medicine

A major transformation toward precision medicine:

AI + multi-omics → digital twins of astronauts

Early detection of physiological decline via machine learning

Continuous monitoring through wearable systems

Conclusion:
Healthcare becomes predictive, personalized, and real-time.

6. Systemic Health: Immunity and Reproduction

Immune system

Decreased immune function

Latent infection reactivation

Allergic responses

Reproductive biology

Subtle but significant physiological changes in astronauts

Limitations in mammalian embryogenesis

Successful multi-generational adaptation in biosatellite missions

Conclusion:
Long-term missions must address biological sustainability, not just survival.

7. Life Support Systems and Habitats

Closed-loop systems (BLSS) for air, water, and food

Advanced plant-based and hydroponic technologies

Emerging concept:

Biophilic habitats integrating plant systems for psychological support

Conclusion:
Habitats must function as living ecosystems.

8. Analog Environments and Mission Preparation

Long-duration isolation studies (e.g., SIRIUS) simulate mission conditions

Terrestrial analogs support:

operational testing

ISRU validation

Conclusion:
Analog environments are essential for risk reduction and system validation.

9. Mission Architecture, Radiation, and Operational Risk

Modular systems (Gateway, transit habitats) define future missions

Radiation monitoring and deep-space simulation platforms are advancing

Critical phase:

Post-flight readaptation (sensorimotor deficits)

Conclusion:
Mission success depends on integrated system design and operational readiness.

10. General Conclusions

The symposium converges on five principles:

1. Integration – physiology, AI, and environment
2. Autonomy – independence from Earth
3. Personalization – individual-based strategies
4. Prediction – AI-driven early detection
5. Sustainability – long-term biological viability

FINALLY

Artificial gravity is now both a space countermeasure AND a rehabilitation technology

Brain, immune, and reproductive systems are critical risks

AI and wearables enable predictive space medicine

Analog environments are essential mission testbeds

Future spaceflight will be integrated, autonomous, and human-centered