

BRAINMARK

Enhance Cognitive Performance

Cognitive Performance in Air Traffic Controllers

QEEG Evidence and Neurofeedback-Based Strategies for Sustainable Performance

Prepared for aviation stakeholders, IFATCA audiences, and aviation authorities
Based on Brainmark Health field data collected during the IFATCA Annual Congress in Romania

Executive Insight

Across 50 Air Traffic Controllers from different countries, ages, ethnicities, and genders, more than 85% showed the same pattern: strong operational cognitive capacity, but poor regeneration, reduced calmness, and low adaptive flexibility. The data suggest that controllers are maintaining high performance while operating on a depleted system.

1. Study Context

Air Traffic Controllers operate in one of the most demanding professional environments in the world. Their daily role requires sustained attention, rapid information processing, high sensory integration, and precise decision-making under pressure. Shift work, high responsibility, constant vigilance, and limited recovery windows can gradually affect the brain's ability to regenerate and self-regulate.

To better understand these effects, Brainmark Health collected QEEG data from 50 active controllers during the IFATCA Annual Congress in Romania. The goal was to identify objective brain-based patterns linked to performance, stress, and recovery, and to evaluate the potential of neurofeedback as a practical solution.

Study Population

- 50 active Air Traffic Controllers
- International sample

Assessment Focus

- Operational brain efficiency
- Stress and calmness regulation

- Diverse ages, ethnicities, and genders
- Field setting: IFATCA Annual Congress, Romania

- Recovery and regeneration capacity
- Cognitive flexibility and adaptive decision-making



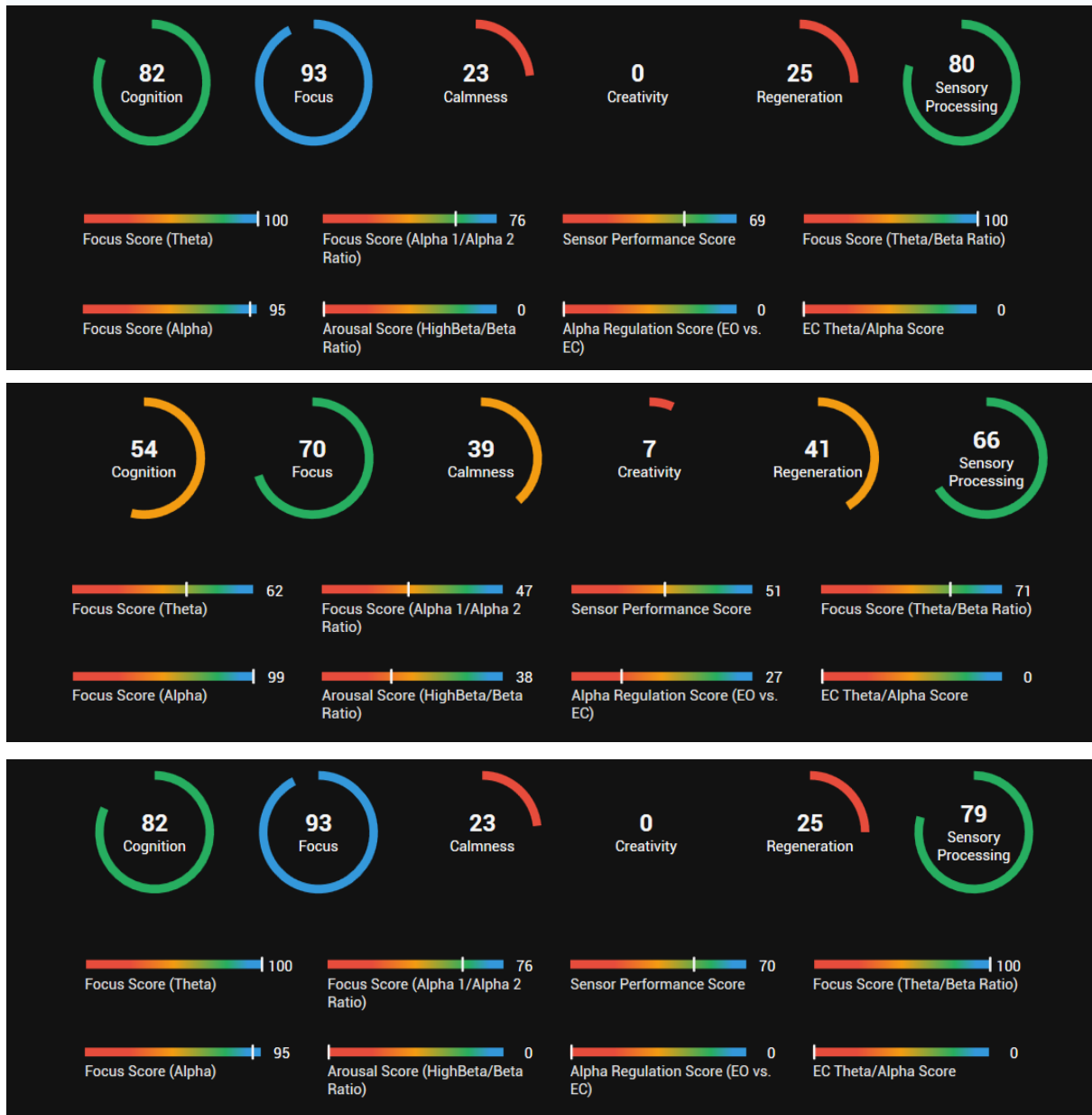
2. Functional Biomarkers Measured

Rather than presenting EEG values only in technical language, the study focused on six functional biomarkers that are directly understandable in operational terms.

Biomarker	Operational Meaning	General Result	Interpretation
Cognition	Ability to use the cognitive brain for analysis, reasoning, and structured decision-making	High	Controllers demonstrate strong analytical and executive capability
Focus	Sustained attention and ability to remain engaged with the task over time	High	Consistent attention capacity supports operational performance
Sensory Processing	Ability to handle auditory and visual information efficiently	High	Supports tower and radar environment demands
Regeneration	Brain's capacity to recover, reset, and maintain sustainable performance	< 40%	Clear deficit in recovery capacity and restoration
Calmness	Stress regulation and ability to remain physiologically and mentally settled	Low	Suggests chronic internal activation or hyperarousal
Creativity	Cognitive flexibility, improvisation, and adaptive decision-making in unusual situations	< 20%	Reduced flexibility may affect resilience in non-routine events

Figure 2 — Biomarker Dashboard

A few common example of Six-pillar dashboard for Cognition, Focus, Sensory Processing, Regeneration, Calmness, and Creativity.



3. Key Findings

The strongest conclusion from the study is the consistency of the pattern. In more than 85% of cases, controllers displayed the same general profile:

- **High Cognition**
- **High Focus**
- **High Sensory Processing**
- **Low Regeneration**
- **Low Calmness**
- **Very Low Creativity**

ATCs are not underperforming. They are overperforming on a system that is not recovering enough.

What Is Working Well

- High attention under operational load
- Strong cognitive processing capacity
- Excellent sensory integration for communication and situational awareness

What Is Under Strain

- Low neurological regeneration
- Reduced calmness under chronic pressure
- Lower ability to improvise and adapt when situations become difficult

Operationally, this means controllers are functioning, but often at the expense of recovery and adaptive reserve. This may not always be visible in routine conditions, but it can become more relevant over time, during cumulative fatigue, or in high-pressure and non-standard events.



4. Discussion

The observed profile is consistent with the realities of air traffic control: chronic stress exposure, shift work, circadian disruption, and the need to sustain precision over long periods. The results do not suggest that ATCs lack capability. On the contrary, they show remarkable adaptation. However, that adaptation appears to come at a biological cost.

The most important issue is not whether controllers can still perform. It is whether the brain is recovering enough to keep performance sustainable, safe, and resilient over time. A deficit in calmness and regeneration, combined with reduced cognitive flexibility, suggests a system that remains highly capable but less balanced.

5. Neurofeedback as a Targeted Cognitive Enhancement Tool

5.1 What is Neurofeedback?

Neurofeedback is a non-invasive brain training method that enables individuals to regulate their own brain activity in real time. It is based on electroencephalography (EEG) and the principle of neuroplasticity, meaning the brain can reorganize and form more efficient pathways through feedback and repetition.

During a session, brain activity is continuously measured and translated into visual or auditory feedback. This allows the brain to recognize its own patterns and naturally adjust toward better functioning.

5.2 Brainmark Health Neurofeedback Approach

Brainmark Health uses an advanced platform that allows the programming of targeted protocols based on the QEEG findings of each individual. Depending on the needs identified, the training may focus on calmness, regeneration, memory consolidation, focus optimization when required, and SMR training for stability and resilience.

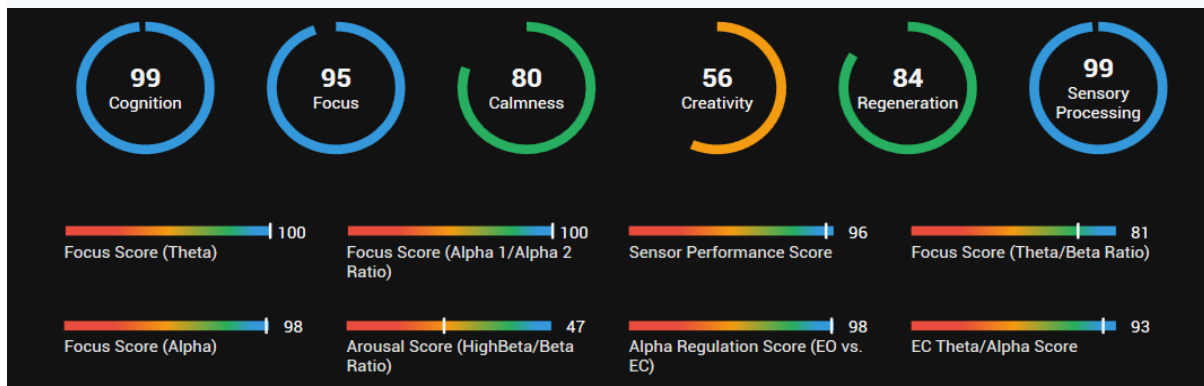
This means the intervention is not generic. It is designed to match the brain profile of the controller and directly address the areas that are underperforming.

5.3 Interactive Training Through Modified Video Games

The training experience is designed to be intuitive and engaging. Controllers use specially modified video games that can be controlled only through live brain activity. The EEG signal is filtered through the selected neurofeedback protocol, and only the desired brain patterns allow the game to move or perform well.

This creates a direct learning loop: the subject can see, in real time, when the brain is not functioning optimally, and the brain begins to adapt naturally through repeated feedback. The process does not depend on conscious effort alone; it relies on implicit learning and neuroplasticity.

Figure 4 — Neurofeedback Training Journey - Example of stabilized performance improvement after Neurofeedback training



5.4 Neuroplasticity and Lasting Change

Over approximately 20 to 30 sessions, repeated reinforcement can create durable neural pathways. As the brain repeatedly experiences more optimal states, those pathways become stronger and more stable. The goal is not a temporary boost, but a lasting change in how the brain regulates stress, recovery, and performance.

When new neural pathways are established, subjects often report feeling clearer, calmer, and more capable, while also accessing abilities they may not have felt for a long time. This can improve both their professional performance and their quality of life.

5.5 Why This Matters for Aviation

Neurofeedback is particularly relevant for aviation because it is short, efficient, non-invasive, drug-free, and engaging. It can be personalized, objectively monitored, and integrated into performance and well-being strategies without disrupting operational identity.



6. Brainmark's recommendations for Aviation Authorities

Recommendation	Rationale
Introduce cognitive monitoring	Objective tools such as QEEG can help detect early signs of fatigue, poor recovery, and chronic stress before these become more significant.
Support targeted neurofeedback programs	Personalized brain training can improve calmness, recovery, and flexibility while preserving strong operational performance.
Recognize regeneration as a safety factor	Recovery should be treated not only as a well-being issue, but as a direct contributor to sustainable performance and operational resilience.
Expand research and operational pilots	Larger studies and structured pilots can correlate brain-based data with fatigue, decision-making quality, and operational outcomes.

7. Conclusion

This report identifies a clear and repeated pattern in Air Traffic Controllers: strong operational brain function coupled with reduced recovery, lower calmness, and poor adaptive flexibility. The profession appears to create highly capable performers, but often at the cost of long-term balance and regeneration.

Neurofeedback offers a practical and scientifically grounded response. By using real-time brain data, personalized protocols, and engaging training tools, it becomes possible to help controllers recover more effectively, feel better, and sustain higher-quality performance over time.

Final Message

The objective is not simply to help controllers perform better. It is to help them live a healthier, more resilient, and more sustainable life with fully recovered brain abilities.

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