

ESFRI
LANDMARK
MONITORING
Panel Monitoring Report
IAGOS
June 2024

TABLE OF CONTENTS

PART A – SUMMARY AND RESULT OF THE ANALYSIS	3
PART B – SCIENTIFIC PART	5
1. SCIENTIFIC EXCELLENCE.....	5
2. PAN-EUROPEAN RELEVANCE.....	7
3. SOCIO-ECONOMIC IMPACT	8
4. USER STRATEGY & ACCESS POLICY	9
5. e-NEEDS	10
PART C – IMPLEMENTATION PART	11
6. STAKEHOLDER COMMITMENT	11
7. CURRENT STATUS AND PLANNING.....	12
8. GOVERNANCE, MANAGEMENT & HUMAN RESOURCES POLICY.....	14
9. FINANCES.....	15
10. RISKS MANAGEMENT	17
11. ENVIRONMENTAL / ENERGY POLICY	18
PART D: KPI	20
KEY PERFORMANCE INDICATORS (KPI)	20
PART E: ADDITIONAL INFORMATION	21
ADDITIONAL QUESTIONS, DOCUMENTS, HEARINGS, ON-SITE VISITS.....	21
FURTHER COMMENTS.....	22

PART A – SUMMARY AND RESULT OF THE ANALYSIS

IAGOS (In-service Aircraft for a Global Observing System) is a European research infrastructure that conducts global observations of atmospheric composition using sensors installed on commercial aircraft. Building upon the successful research programme MOZAIC, which operated from 1994 to 2014, and CARIBIC, which operated from 1997 until 2014. IAGOS has continued and expanded this legacy, leveraging commercial aviation to collect invaluable atmospheric data. IAGOS operates a unique research infrastructure that utilizes commercial aircraft to conduct worldwide in-situ atmospheric measurements. This innovative approach allows IAGOS to collect high-quality data on atmospheric composition and air quality across different global regions. The data gathered are crucial for advancing scientific understanding of atmospheric processes, improving climate models, and informing environmental policies.

IAGOS's contributions extend beyond scientific research. The infrastructure supports research into environmental policies, contributes to the knowledge on climate change impacts, and enhances public awareness about air quality issues. The data collected by IAGOS are essential for validating and refining climate models, which are used to predict future climate scenarios and to develop strategies for mitigating climate change. By providing detailed and accurate measurements of atmospheric composition, IAGOS helps to identify trends and anomalies in air quality, contributing to public health initiatives and policy decisions aimed at reducing pollution and its associated health risks. IAGOS data have been and will be in the future, pivotal for the validation of products of past, ongoing and future satellite missions. Through its integration with commercial flights, IAGOS efficiently maximizes data collection opportunities while minimizing additional emissions, exemplifying a sustainable model for scientific research. This approach allows IAGOS to leverage existing flight operations, reducing the need for dedicated research flights and thus minimizing the environmental footprint of its data collection activities. The cooperation with airlines is pivotal, as it involves the transportation of IAGOS instruments free of charge, highlighting the commitment of the aviation industry to support scientific research.

IAGOS stands out as a landmark Research Infrastructure (RI) with a commendable track record in effective operations. It has established a significant role within the European research infrastructure landscape through continuous development and active engagement with the scientific community. This engagement has not only fostered advancements in atmospheric science but has also cemented IAGOS's scientific and socio-economic value. The performance of IAGOS largely meets the ESFRI (European Strategy Forum on Research Infrastructures) requirements, owing to its robust operational framework and the strong support from the hosting Research Performing Organizations (RPOs). These organizations play a pivotal role in ensuring the stability and growth of IAGOS, highlighting the mutual benefits derived from this partnership, recognized both nationally and internationally. The collaborative efforts with research institutes, universities, and national weather services in countries like Germany, France, and the UK have enabled IAGOS to maintain a stable operational framework and secure funding through various channels, including national and European projects. This support is

crucial for the continuous innovation and technological advancements necessary for adapting to new aircraft models and integrating state-of-the-art instruments. IAGOS's success is also reflected in its extensive international collaborations, involving partnerships with major institutions such as the National Oceanic and Atmospheric Administration (NOAA) in the USA, the National Institute for Environmental Studies (NIES) in Japan, and the National Central University in Taiwan. These collaborations enhance IAGOS's global impact and contribute to its comprehensive atmospheric monitoring capabilities. Furthermore, IAGOS's leadership in coordinating significant European projects such as ENVRI-FAIR and participating in Horizon inter-RI projects such as ATMO-ACCESS, as well as its role in the Board of European Environmental Research Infrastructures (BEERI), underscores its commitment to advancing environmental research and fostering international cooperation. In conclusion, IAGOS exemplifies a model of sustainable and impactful research infrastructure that not only advances scientific understanding but also supports policy-making and public awareness efforts. Its integration with commercial aviation, robust governance, and international collaborations position it as a key player in the global effort to monitor and mitigate atmospheric and climate changes.

General Recommendations

To maintain and enhance its esteemed position, it is crucial for IAGOS to continue receiving unwavering support from its members and the hosting RPOs. This support is essential for the ongoing operations and further scientific advancements of IAGOS. Additionally, attention should be given to addressing any emerging challenges proactively to uphold the high standards of data quality and operational efficiency. The collaborative efforts should focus on leveraging IAGOS's capabilities to contribute more profoundly to global climate research and policy-making, thereby increasing its impact on societal challenges. As IAGOS prepares for the next monitoring round, it should consider strategic initiatives that encourage broader participation and deeper collaboration across the research community. These efforts will ensure that IAGOS not only continues to meet the ESFRI requirements but also adapts to the evolving scientific landscape, thereby enriching its contributions to understanding and mitigating global environmental changes.

PART B – SCIENTIFIC PART

1. SCIENTIFIC EXCELLENCE

Keep scientific and technical leadership and impact visible at European and global level

Summary of performance:

IAGOS is an excellent and unique Research Infrastructure with the objective of monitoring atmospheric trace gases, aerosols, and clouds. IAGOS's objectives are carried out by implementing state-of-the-art in-situ instrumentation in commercial airplanes. Such infrastructure permits gaining knowledge in monitoring the state of the atmosphere and defining long-term strategies for addressing atmospheric changes and their causes. By far, this has huge socio-economic impacts. IAGOS continues with the previous developments in the field of implementing instrumentations for atmospheric research from MOZAIC and CARIBIC initiatives going further by establishing quality criteria and standardizations that make all these measurements available for the scientific community. This is a unique infrastructure of this type.

IAGOS, established as a distributed RI, has been on the ESFRI Roadmap since 2006 and operational since 2014. The central legal entity, IAGOS-AISBL, is based in Belgium with eight members from Germany, France, and the UK. Funding sources include annual membership fees, cash and in-kind contributions from members, voluntary contributions, and participation in European projects. Membership fees, totaling 130 kEUR/year, cover central activities and the Executive Secretary's salary, while operational costs are estimated at 7 MEUR annually. Current challenges in atmospheric and air-quality studies are having long-term measurements in remote areas. In spite of satellite measurements, limitations still persist due to the low-temporal resolution of satellites and the limitations of space platforms for studying many processes because these space instruments rely on remote sensing instrumentation. For example, satellites face limitations in having profiles of greenhouse gases or detailed aerosol properties. Advancing in these knowledge-gaps requires the use of complex in-situ instrumentation typically set up in research aircraft.

IAGOS is contributing to cutting-edge atmospheric research with more than 450 publications until 2023, with studies of climatologies, extreme weather events, aerosol studies in the upper troposphere-lower stratosphere, measurements of ice properties at supersaturation conditions, high altitude clouds, and even atmospheric mercury measurements. Validations of CAMS models, and of past (SCIAMACHY), ongoing (OMI, IASI, MOPITT, TROPOMI) as well as of future (GOSAT, EarthCARE) satellite missions are possible using IAGOS data. All of this has been possible thanks to fulfilling the Open and FAIR principles for data access and distribution, with a strong data quality control applied in IAGOS.

To quantify the performance, IAGOS uses 10 generic KPIs from the list of 21 KPIs proposed by ESFRI, implemented since 2020 and expanded in subsequent years. These indicators fulfill RACER criteria and are easily monitored over time, providing a detailed picture of scientific performance, with data

collection extending back to 1997 through predecessor projects. This long-term data collection supports comprehensive performance monitoring.

Recommendation: Consider developing a 5-year scientific strategy and renew it once during the strategy/financial period. All the plans and material already exist; they just need to be compiled. Think to further expand in terms of platforms and instruments. The systems have been greatly miniaturized with new instrumentation, expanding to remote sensing instruments. CubeSats, such as the HARP system from UMBC, are small and consume little energy, demonstrating interaction with the space sector.

2. PAN-EUROPEAN RELEVANCE

Clear position in the EU RIs landscape and cooperation/synergies with other RIs

Geographical distribution consolidated/expanding (if relevant)

Summary of performance:

IAGOS is a unique Infrastructure in the Environment/Atmosphere domain by providing 8/10 essential climate variables for atmospheric composition from the ground up to 12 km altitude thanks to the use of in-situ instrumentation in passenger aircraft platforms. This claim is supported and it is evident that IAGOS is strengthening the European Environmental Research Infrastructure Landscape. The complementarity of IAGOS with other European Infrastructures such as ACTRIS and ICOS (both referred to ground-based stations) is making possible a complete monitoring of the atmosphere, which positions Europe at the forefront of climate change studies and policy development. IAGOS is based in Europe, but it has demonstrated a global impact through partnerships with international airlines and cooperations with international institutions overseas. For example, the collaboration with the National Central University of Taipei is permitting the implementation of IAGOS capabilities in two China Airlines aircraft. There are also collaborations with the National Oceanic and Atmospheric Administration of the USA and the National Institute for Environmental Studies in Tsukuba, Japan. These cooperations with such important institutions are permitting IAGOS to have a global impact, and the implementation of IAGOS Infrastructure in the USA and Japan will expand the position of the Landmark European Research & Innovation ecosystem. However, the initiative's pan-European relevance could be further strengthened by engaging additional partners, expanding collaborations, and streamlining the certification process for new instruments to facilitate timely implementation and broader data coverage.

3. SOCIO-ECONOMIC IMPACT

Social and/or economic impact and how this is measured

Summary of performance:

IAGOS demonstrates a very relevant socio-economic impact. It contributes significantly to several United Nations Sustainability and Development goals, including:

Climate Action (Goal 13) by providing an impressive and unique database of climate variables.

Good Health and Well-being (Goal 3) through an extensive database of measurements of ozone and other trace gases.

Industry, Innovation, and Infrastructure (Goal 9) through links with the aviation industry and new instrumentation and innovation developments.

Sustainable Cities and Communities (Goal 11) by providing air-quality measurements over cities.

Quality Education (Goal 4) by enabling PhD and Master's theses through IAGOS data and research innovation instrumentation.

IAGOS's publications reach diverse sectors, including climate action, public health, and industry, showcasing its versatility and impact. Adaptation of instrumentation to aircraft is also pushing further technological advances. For the future, it is recommended to explore the implementation of the latest passive remote sensing technology and expand complementarities with the space sector. This could include adapting small systems for aircraft operations at minimal energy consumption, offering data for satellite validations and synergies.

Recommendation: The panel suggests further expanding the analysis to consider additional potential impacts. These include the broader economic benefits of improved climate models for various sectors, the potential for job creation in technology and data analysis, and the enhanced resilience of societies to climate-related challenges through better-informed policies. Moreover, the analysis could benefit from quantifying the potential cost savings associated with accurate environmental data that can inform more effective policies and strategies in tackling climate change.

4. USER STRATEGY & ACCESS POLICY

Solid access management system including:

- solid mechanism of exchange with users (e.g. operational single entry point for access, assistance to users; established catalogue of services for users),
- IPR policies fully established,
- dissemination programmes in place.

Summary of performance:

IAGOS operates a well-developed Data Centre (IAGOS-DC) responsible for managing and publishing all IAGOS data products. The user-friendly Data Portal (<https://doi.org/10.25326/20>) provides access to observational and added-value products, adhering to FAIR principles to ensure data is findable, accessible, interoperable, and reusable. Data is available to all users upon registration, with policies clearly outlined on the portal. IAGOS's data dissemination plan includes interoperability with other European Research Infrastructures (ERIs) like ACTRIS and ICOS, contributions to the Global Atmosphere Watch (GAW) of the World Meteorological Organization (WMO), and participation in major projects such as ATMO-ACCESS and RI-URBANS. These efforts enhance the reach and impact of IAGOS data. IAGOS actively engages with users through conferences, training programs, and collaborations, maintaining a steady increase in its user base. Future efforts should focus on expanding communication activities, such as social media outreach and visits to schools, to raise awareness and encourage more airlines and stakeholders to join the IAGOS program. Additionally, developing a more elaborate training program, including organizing Summer Schools, would further support user engagement and capacity building.

Recommendation: IAGOS could formulate and document its user strategy, ensuring it includes detailed guidelines for data access, user support services, and training programs tailored to various user groups such as researchers, policymakers, and industry stakeholders. This strategy could also include mechanisms for regular user feedback to continuously improve the services provided. By developing a clear and comprehensive user strategy, IAGOS will be able to enhance user satisfaction and engagement, ensuring that its data and tools are effectively utilized by a wide range of stakeholders. Additionally, IAGOS should consider developing online tutorials, workshops, and webinars to help users understand and make the most of its data and tools.

5. E-NEEDS

Data Management Plan (DMP) implemented and security policy deployed

Operational application of FAIR principles

Summary of performance:

IAGOS has implemented a comprehensive Data Management Plan (DMP) and adheres to FAIR principles, ensuring high-quality and accessible data. The Data Centre handles data from over 68,000 flights since 1994, providing validated data to a wide user base. IAGOS's data management strategy is well-aligned with European policies and standards, supporting interoperability and sustainability. The infrastructure's mature e-needs framework supports continuous development and integration with major projects like ENVRI-Hub NEXT and IRISCC, enhancing its data management capabilities and scientific impact. The DMP, a living document, outlines the technical solutions and strategies for data collection, processing, and dissemination, ensuring alignment with broader European and international standards. IAGOS's commitment to continuous improvement in data management and adherence to FAIR principles demonstrates its leadership in environmental data infrastructure.

The Landmark is well integrated into the European e-infrastructure landscape, including networks, data, and computing services, and aligns itself with the European Open Science Cloud (EOSC). IAGOS actively participates in the ENVRI community, where it plays a significant role in building a common data hub for environmental Research Infrastructures (RIs). The Landmark leverages and contributes to general data and computing standards, including persistent identifiers, to maintain interoperability across diverse systems.

To further improve interoperability, IAGOS could consider converting its specific standards or formats into more general ones, enhancing compatibility with a broader range of platforms and users. Additionally, unmet e-needs may include ensuring the availability of sufficient e-infrastructure resources, particularly in data storage and high-performance computing, to accommodate the growing data volumes and the increasing complexity of analysis. Overall, IAGOS's approach to data management is effective, and continued focus on interoperability and infrastructure will further enhance its impact.

PART C – IMPLEMENTATION PART

6. STAKEHOLDER COMMITMENT

Sustainable budget, including the budget for national nodes

Summary of implementation state:

IAGOS has eight members from three countries, with financial commitments through annual membership fees totaling 130 kEUR/year. The infrastructure relies heavily on in-kind contributions from airlines, which transport IAGOS instruments free of charge. This cooperation is essential for IAGOS's operations, as the costs of transporting instruments (25 kEUR/year/aircraft) are not covered by membership fees alone. The infrastructure plans to expand by inviting new airlines and developing new data products and services. To ensure long-term sustainability, IAGOS should focus on expanding its membership base and securing diverse funding sources. Engaging additional countries and universities could bring new ideas and enhance interactions with students and the general public, further strengthening IAGOS's impact and reach.

While the existing commitments provide a solid foundation, there is room to increase the number of involved entities and countries, which could bring fresh perspectives, ideas, and additional resources. The current financial plan is adequate for short-term operations. However, for long-term sustainability, it is imperative to broaden the stakeholder base. A more diverse network would introduce new funding opportunities and reduce the financial risks associated with relying heavily on a limited group of stakeholders.

IAGOS should strategically plan to diversify its funding sources by engaging with a broader range of governments, research institutions, and industry partners. Such diversification would enhance the organization's resilience and ensure that its research infrastructure continues to thrive even amidst changing financial landscapes. A robust long-term sustainability plan should include strategies for increasing international collaboration, expanding industrial partnerships, and identifying alternative funding sources, such as grants and private-sector collaborations. These initiatives will ensure that IAGOS remains a leading and sustainable research infrastructure in atmospheric science, with the ability to grow and adapt to future challenges.

7. CURRENT STATUS AND PLANNING

Core construction effectively completed or underway and any upgrade plans approved

Procedures for appropriate termination established

Summary of implementation state:

IAGOS is currently in the operational phase of its research infrastructure life cycle. The organization is praised for its continuous fine-tuning and development of technology, software, and services to meet scientific and societal needs. However, it faces significant challenges in adapting to new aircraft and technologies, necessitating ongoing innovation and adaptation to maintain sustainability.

Technological adaptation is crucial, particularly as the commercial aviation sector undergoes a significant shift from Airbus A330 to A350 models. The existing IAGOS instrumentation is not directly transferable to the A350, which requires the upgrade of both the IAGOS-CORE and IAGOS-CARIBIC platforms. These upgrades represent major development efforts, demanding substantial investment and a decade-long work plan. It's essential for IAGOS to secure strong financial support from its members for these upgrades.

Moreover, the organization actively works on new sensors, methodologies, SOPs, and data products to ensure constant renewal. This necessitates continuous innovation in instrument design and adaptation to remain compatible with the evolving technology in the aviation industry. IAGOS should explore compact, energy-efficient instruments that align with new technological trends such as passive remote sensing used in CubeSats.

IAGOS has been operational since 2011 or 2014, with components including IAGOS-CORE, IAGOS-CARIBIC, and the IAGOS Data Centre. The infrastructure faces challenges in adapting to new aircraft models and technologies, necessitating ongoing innovation and adaptation. Planning for upgrades and maintenance is in place, with cycles of 3 or 12 months for IAGOS-CORE. The re-launch of IAGOS-CARIBIC is expected in autumn 2024 after the phase-out of the previous aircraft due to the COVID-19 pandemic. IAGOS is continuously fine-tuning and developing technology, software, and services to meet scientific and societal needs. Future plans include exploring the implementation of the latest passive remote sensing technology and expanding complementarities with the space sector, which would enhance IAGOS's capabilities and impact.

Recommendations:

1. Conceptualize and internalize the different co-existing phases (operational phase and preparation phase with major upgrades) and develop operational and development plans for each. This will ensure a strategic approach to managing the operational life cycle and the associated upgrades.
2. Clearly identify the service portfolio to distinguish between operational "base" data products and tailored services. Developing a service portfolio for aviation partners can help anticipate user needs and adjust service offerings accordingly.
3. Consider the potential for joint projects with commercial entities and determine a suitable model for offering tailored services.

4. Leverage IAGOS's extensive knowledge of technology and innovation to develop Research Infrastructure (RI) services that can be utilized commercially.

8. GOVERNANCE, MANAGEMENT & HUMAN RESOURCES POLICY

Mechanisms in place for annual planning and reporting

All human resources policies and instruments established, including training

Summary of implementation state:

The governance structure includes an Executive Board, General Assembly, and Advisory Board, with mechanisms for annual planning and reporting. The Executive Board prepares a 5-year Activity Plan and corresponding Financial Plan, which are approved by the General Assembly. IAGOS-AISBL has one employee (Executive Secretary), with other staff employed by member organizations. Human resources are a key risk, with many staff on short-term contracts.

IAGOS boasts a well-established governance structure that effectively supports efficient management and operational excellence. The organization recognizes the crucial role of its human resources in achieving its mission, emphasizing the importance of training and retaining highly qualified personnel to sustain research and innovation efforts.

Human Resources and Talent Retention: A significant challenge highlighted in the report is the retention of skilled personnel, which is essential for ongoing research and technological innovation. IAGOS can address this challenge by developing strategies that offer attractive long-term contracts, competitive salaries, and continuous training opportunities. This will help secure the talent required for its future success. To address this, IAGOS should develop strategies that offer attractive long-term contracts, competitive salaries, and continuous training opportunities. This will help secure the talent required for its future success. The infrastructure's governance and management practices ensure transparency, accountability, and effective decision-making, supporting its long-term sustainability and success.

IAGOS also benefits from offering attractive subjects for researchers to work on, a supportive working environment, and stimulating projects that attract top PhDs and postdocs. Providing robust training programs is critical to maintaining this appeal, as they can motivate the technical and software operations teams and foster the dedication needed for success.

To ensure the effective operation of its services, maintenance centers require skilled technical personnel, software developers, and scientists. IAGOS recognizes that finding talented individuals is not the primary challenge; rather, the challenge lies in retaining them by providing the necessary resources to ensure their motivation and well-being. A combination of long-term contracts for permanent staff and fixed-term contracts for scientists can offer a balanced mix.

The panel is confident in IAGOS's recruitment strategy because it can rely on research centers like Julich, recognizing that securing the right talent and maintaining a supportive environment are critical to the infrastructure's continued growth and success.

9. FINANCES

Long-term financial plan and budget (including an estimation of decommissioning costs if relevant)

Auditing of accounting and budget systems in place

Summary of implementation state:

Financial stability is crucial for IAGOS's continued operations, and expanding funding sources is essential to support technological upgrades and expansion.

IAGOS AISBL operates as a non-profit association under Belgian law, with members paying annual fees and contributing in cash and in-kind. The total budget for operations is approximately 7 MEUR annually. Financial planning includes securing funding from national and European sources. The infrastructure needs to expand its funding base to support technological upgrades and ensure long-term sustainability. Auditing is performed by an independent external auditor as required by the statutes. Diversifying funding sources, including European Commission grants, private-sector partnerships, and international collaborations, will provide more stable financial support for operations and upgrades, enhancing IAGOS's resilience in a dynamic funding environment.

Financial Sustainability and Funding Diversification: While IAGOS maintains a stable financial status, its reliance on member contributions and project-specific funding poses some limitations. To ensure more diversified and stable financial support for operations and upgrades, it's critical to identify additional funding sources. Potential sources include European Commission grants, private-sector partnerships, and other international collaborations. This will enable IAGOS to secure sustainable resources for the long term and remain resilient in a dynamic funding environment.

A significant portion of IAGOS's sustainable resources comes from member Research Performing Organizations (RPOs) and their long-term commitments, which include maintaining staff in permanent positions. However, base funding is typically linked to 5-7 year strategic evaluations conducted by the RPOs, making these evaluations critical moments for IAGOS's future planning.

Recommendations:

Diversify Funding Sources: To reduce dependence on member contributions and project-specific funding, IAGOS should actively pursue alternative funding avenues. This includes engaging with the European Commission, forming private sector partnerships, and exploring other international funding opportunities.

Explore New Business Models: Given the limited resources and the ambition for expansion, IAGOS should seek complementary business models that can sustain economic growth. Wider service provision and diversified service offerings could open up additional revenue streams.

Widen Membership and Partnerships: Attracting new members to the IAGOS AISBL and collaborating with initiatives like CAMS/Copernicus will be essential in supporting the in-situ component and ensuring the sustainability of new services.

Plan for Upgrades and Renewal: Recognizing that upgrades require substantial investment, IAGOS should develop a dedicated funding scheme specifically for these purposes. This includes identifying possible funding models and sources to facilitate renewal.

Increase Visibility and Recognition: Improving recognition and visibility is key to attracting more partnerships and funding opportunities. By enhancing its profile, IAGOS can better communicate its value proposition to potential investors and stakeholders.

10. RISKS MANAGEMENT

Appropriate operational risk management and mitigation policies established

Summary of implementation state:

IAGOS has identified and is actively managing several operational risks, focusing on maintaining airline partnerships and adapting to technological and geopolitical changes. The risk management strategy emphasises maintaining strong relationships with airline partners, acknowledging that sudden changes in fleet composition or airline policies can pose significant challenges to the program.

Risk Management with Airline Partnerships: The dependence on airline partners for the transportation of instruments is a notable risk, particularly given the potential for unexpected fleet changes or shifts in airline policy. Moreover, geopolitical issues and events like the COVID-19 pandemic have highlighted the importance of robust contingency planning. Building strong strategic partnerships with airlines, such as Lufthansa, which has shown significant trust and support, is crucial. IAGOS could consider offering incentives or compensations to airlines to further solidify these relationships.

Mitigation Strategies:

Close Collaboration with Airbus: Engaging closely with Airbus and their testing systems can help mitigate risks related to sudden fleet changes. This collaboration ensures that IAGOS is well-prepared for shifts in aircraft technology or fleet composition.

Diversified Partnerships: To reduce dependence on a single airline, IAGOS should continue to diversify its partnerships. Working with multiple airlines helps distribute the risk and offers more flexibility in operations.

Scenario Planning and Contingency Measures: Developing detailed scenarios for various geopolitical events and health crises can help IAGOS anticipate and react to disruptions more effectively. This includes ensuring that there are backup plans in place to maintain data collection and operations.

Financial Risk Mitigation: Establishing financial buffers or insurance policies could help mitigate risks associated with sudden fleet changes or operational interruptions.

Benefit Enhancement for Partners: Enhancing the benefits for participating airlines by offering valuable data, recognition, or financial incentives could help maintain strong partnerships even during challenging times.

11. ENVIRONMENTAL / ENERGY POLICY

Green Deal

Summary of implementation state:

IAGOS minimizes its environmental impact by integrating instruments into existing commercial flights and implementing energy-efficient technologies. The largest negative impact is the additional fuel consumption due to the weight of the instruments. IAGOS is part of the CICONIA project, working to reduce aviation's non-CO₂ impact. The Data Centre is the biggest consumer of power within IAGOS, and the infrastructure is sensitive to power supply issues and geopolitical factors. The environmental policy includes minimizing non-essential travel, promoting vegetarian food, and using reusable consumables. IAGOS's commitment to environmental sustainability is reflected in its efforts to continuously improve the efficiency of its operations and reduce its carbon footprint. By adopting innovative technologies and practices, IAGOS aims to minimize its environmental impact while maintaining high standards of data collection and quality. The infrastructure's proactive approach to environmental management ensures that it remains aligned with broader sustainability goals and contributes positively to global environmental efforts. By engaging with stakeholders and continuously evaluating its environmental policies, IAGOS can ensure that its operations are sustainable and environmentally responsible.

IAGOS has demonstrated a strong commitment to environmental planning, primarily through its ongoing efforts to minimize its carbon footprint. The initiative's reliance on commercial aircraft for atmospheric measurements allows it to integrate seamlessly into existing flight operations, thus minimizing additional emissions. This strategy exemplifies efficient resource utilization, enabling comprehensive atmospheric data collection while maintaining a minimal environmental impact.

Technological Innovation and Operational Efficiencies: IAGOS continually explores innovative technologies to reduce its environmental footprint further. By developing more energy-efficient instruments and refining operational workflows, the organization seeks to enhance its sustainability. The aim is to not only maintain but also improve the efficiency of its data collection activities, reducing waste and emissions in the process.

Resilience to Power Supply Issues:

Data Collection Continuity: IAGOS's data collection is designed to be resilient to power supply disruptions. By leveraging aircraft power systems, data gathering is robust and can continue even during partial infrastructure outages.

System Redundancy and Backup Plans: To ensure continuous operations, IAGOS has implemented redundancies within its systems. Backup power and contingency plans ensure that critical data collection is maintained, even during unforeseen circumstances.

Adaptability to Technological Advancements: The organization is adaptable, frequently assessing and incorporating new technologies that offer greater energy efficiency and resilience. This adaptability further ensures that IAGOS can withstand shifts in the technological landscape that might otherwise pose risks.

Recommendations for Further Improvement:

Further Technology Integration: Continually assess and integrate emerging technologies that improve energy efficiency and reduce environmental impact. By adopting cutting-edge tools and processes, IAGOS can maintain its leadership in sustainable data collection.

Enhanced Renewable Energy Utilization: Where applicable, explore the use of renewable energy sources to support ground operations and data processing activities.

Sustainability Audits: Regularly conduct sustainability audits to identify potential areas for improvement in energy consumption and waste management.

Overall, IAGOS demonstrates a solid approach to environmental planning and energy policy. Its resilience is evident in the thoughtful integration of technology and resource efficiency, ensuring that the research infrastructure can withstand challenges related to power supply while minimizing its environmental impact.

PART D: KPI

KEY PERFORMANCE INDICATORS (KPI)

Summary:

IAGOS has established and is tracking a comprehensive set of KPIs that demonstrate its scientific impact, outreach, operational efficiency, and contribution to global atmospheric science.

PART E: ADDITIONAL INFORMATION

ADDITIONAL QUESTIONS, DOCUMENTS, HEARINGS, ON-SITE VISITS

Summary:

The comprehensive monitoring analysis confirms that IAGOS continues to be a landmark Research Infrastructure (RI), demonstrating significant leadership and impact in atmospheric research. It has consistently met the objectives set out by ESFRI and its own high standards of excellence. Its unique in-situ measurement techniques via commercial aircraft highlight the innovative approach IAGOS employs, making a substantial contribution to global atmospheric studies.

The scientific excellence, pan-European relevance, and socio-economic impact of IAGOS are underscored by its strong partnerships, sophisticated technology, and robust data management. However, to further strengthen its role and secure long-term sustainability, IAGOS requires increased support from its member countries and stakeholders. This support will enable the expansion of its activities, the adoption of new technologies, and the development of innovative solutions that address emerging challenges in atmospheric science.

Recommendation to Local Governments or Institutes (RPOs)

Given IAGOS's strategic importance and contribution to global environmental research, local governments are strongly encouraged to allocate additional funding. This financial backing will support IAGOS's ambitious technological upgrades, enhance operational resilience, and enable the diversification of its data services. With sustained investment, IAGOS can continue to push the boundaries of atmospheric research, providing invaluable insights that are crucial for shaping environmental policy and fostering innovation in commercial aviation.

FURTHER COMMENTS

Additional comments on the monitoring process as such:

*The Monitoring Panel may add here feedback on the monitoring process in this first round.
Any suggestions, on how to improve the procedure?*