Deliverable 3.4: ACTRIS strategy on scientific added value, impact, attractiveness and relevance

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Work package no	WP3
Deliverable no.	D3.4
Lead beneficiary	UHEL
Deliverable type	X R (Document, report) ☐ DEC (Websites, patent filings, videos, etc.) ☐ OTHER: please specify .....
Dissemination level	X PU (public) ☐ CO (confidential, only for members of the Consortium, incl. Commission)
Estimated delivery date	M42
Actual delivery date	28/06/2023
Version	Final
Reviewed by	Elena Saltikoff. Valerie Thouret
Accepted by	Eija Juurola
Comments	

ACTRIS IMP (www.actris.eu) is supported by the European Commission under the Horizon 2020 – Research and Innovation Framework Programme, H2020-INFRADEV-2019-2, Grant Agreement number: 871115

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1. Background

The Aerosol, Clouds and Trace Gases Research Infrastructure (ACTRIS) is the pan-European research infrastructure (RI) producing high-quality data and information on short-lived atmospheric constituents and on the processes leading to the variability of these constituents in natural and controlled atmospheres. On April 28, 2023, the European Commission took a long-anticipated decision to establish the ACTRIS as a European Research Infrastructure Consortium, ERIC.

ACTRIS ERIC provides access to a large variety of high-quality services to a wide range of users and needs, for scientific, technological, and innovation-oriented usage through its internationally recognized National Facilities. ACTRIS National Facilities operated by Research Performing Organizations (RPOs) are distributed across ACTRIS ERIC's 17 countries: Austria, Belgium, Bulgaria, Cyprus, Czechia, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Poland, Romania, Spain, Sweden, and Switzerland. Some NFs are located outside continental Europe, such as Cabo Verde, Antarctica, French overseas territories and Tajikistan. Greece and the UK expressed interest in joining at later stages. With their commitment, the members demonstrate atmospheric and air quality research as a national priority, thereby supporting scientific excellence across Europe. Being a member country of ACTRIS ERIC means that a country's representative can help shape the strategy, participate in mission-based research, and join ACTRIS's unified voice at the forefront of European science and education landscape of atmospheric research focused on aerosol, clouds, and trace gases. ACTRIS facilities make up the largest, multi-site atmospheric research infrastructure in the world and offer its users open access to instruments, expertise, training opportunities, and data management services. Typically all users, regardless of their affiliation, area of expertise, or field of activity, can benefit from ACTRIS services. However, in May 2022, The European Commission stated that "no access to Research Infrastructures shall be provided to Russian researchers included in the sanctions list or to the researchers affiliated to Russian public entities" (http://aquaexcel.eu/european-commission-suspends-cooperation-with-russia-in-research-and-innovation). We need to pay attention the development in this regard in the coming years. Nevertheless, ACTRIS aims at increasing the excellence in Earth system observation and research by providing information and knowledge for developing sustainable solutions to societal needs.

This document briefly summarises the steps of ACTRIS ERIC to enhance scientific added value, impact, attractiveness and relevance from a strategic point of view. We will provide a synthesis on the strategy towards scientific added value, impact, attractiveness and relevance of ACTRIS as well as update the strategy of ACTRIS on selected topics that have emerged during the last years.

While compiling the Roadmap of ACTRIS in 2016, we estimated that ACTRIS should be established as an ERIC by 2026, but as stated earlier, ACTRIS received ERIC status already in spring 2023. We note that the development of ACTRIS has been expedited and faster than expected. To develop steps towards the future, we will take ACTRIS Technical and Scientific Description (TSD) as the starting point. It was approved by the Interim ACTRIS Council in its 15th meeting on 1 March, 2021.

TSD states that "ACTRIS is fundamentally at the heart of grand challenges facing society: climate change and human health. Establishing ACTRIS as a sustainable RI will enable the expansion of the capacity to

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provide the science-based information necessary to face grand societal challenges." This statement is fully valid and clearly describes the societal need for the ACTRIS as a whole. To continue, the vision statement in the TSD reads: "ACTRIS is the fundamental European Research Infrastructure for short-lived atmospheric constituents increasing the excellence in Earth system observation and research and providing information and knowledge for developing sustainable solutions to societal needs."

In 2021 we formulated the mission of ACTRIS as follows:

"ACTRIS shall establish, operate, and develop a pan-European distributed research infrastructure for short-lived atmospheric constituents. ACTRIS shall provide effective access for a wide user community to its resources and services, in order to facilitate high-quality Earth system research."

The ACTRIS ERIC was established in April 2023. Followed by the anticipated steps towards operationalizing ACTRIS ERIC by 2026, this mission will be completed. Thus, these statements will be revisited as a community effort in near future.

At this time, we need to develop a strategy for the operational ACTRIS. The key elements in the ACTRIS strategy in the future are 1) to expand the ACTRIS towards an infrastructure with global relevance, 2) to further develop the ACTRIS services and facilitation of innovation 3) in order to remain state-of-the-art and that will allow us 4) to enhance the ACTRIS scientific impact. We will summarise these elements in the document at hand.

2. Strategy towards an infrastructure with a global relevance

It is not foreseeable nor meaningful that the European member states would be capable of establishing or operating a truly global research infrastructure. Therefore, the ACTRIS needs to actively seek for partnerships and co-operation with regional and global organizations which are active on other continents. Interaction with other large operators is critical and with this kind of interactive mode a global coverage can be reached taking care that the observation setups and methodologies are harmonised across the operators.

For example, connecting the new ACTRIS NFs to World Meteorological Organization Global Atmospheric Watch (WMO-GAW) has clear strategic benefits. This collaborative effort is supported by the fact that ACTRIS Central Facilities provide harmonisation services as global calibration centres for the WMO-GAW already. This ensures harmonisation across the networks. By default, ACTRIS work leads to harmonised observations on aerosol particles, trace gases and clouds with in-situ and ground-based remote sensing techniques. The geographical focus of ACTRIS is pan-European and therefore European-centric. However, there is a need to expand the observational capacity to a global scale as global data is required to provide science-based evidence towards solving grand environmental challenges the society is facing in the coming decades. ACTRIS delivers the European contribution to the global networks.

The ACTRIS strategy towards the global infrastructure relies on existing ACTRIS structures and procedures. A natural starting point for this development comes through the observational platforms. The ACTRIS data

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is provided by National Facilities (NFs) operated by the Research Performing Organizations (RPOs). Some of the NFs are already operational outside Europe. To expedite the inclusion of new sites into ACTRIS, we need to explore possibilities to collaborate and co-fund the observation sites as multinational joint activities. In terms of science, the expanded observational coverage would allow a more thorough analysis of processes governing atmospheric composition of aerosol particles, trace gases and clouds. Jointly operated sites would allow a tighter scientific collaboration within the RPOs of ACTRIS and relying on the complementary expertises of the RPOs. In a long term, this might also reduce the cost for individual member countries and RPOs while enabling the site to contribute to multiple ACTRIS components. Overall, supporting the development of these sites as well as including new observational facilities into the ACTRIS network will scale the work up from Europe towards a global impact.

The work in the network development within and beyond Europe can be enhanced by adopting Regional Partner Facilities (RPFs) in ACTRIS. These facilities are not NFs but provide ACTRIS quality data distributed through ACTRIS Data Centre. Although full membership in ACTRIS is aimed for, this concept allows new sites, institutes and eventually countries to join the ACTRIS work even before an often long and bureaucratic process of the country formally joining ACTRIS ERIC.

In the United States, ACTRIS has already established collaboration with Atmospheric Radiation Measurement (ARM), which is financially supported by the United States Department of Energy. They operate long-term aerosol, trace gas and cloud observation sites in the USA at several observation sites on a continuous basis as well as perform science-driven short-term campaigns. Recently the National Science Foundation (NSF) granted Mid-Scale Research Infrastructure program to provide high time-resolution, long-term measurements of aerosol particles at 12 observation sites around the United States forming Atmospheric Science and mEasurement NeTwork (ASCENT). In practice this will deploy Aerosol Chemical Speciation Monitors (ACSM) at the sites. The instrument is the same as deployed at many ACTRIS aerosol in-situ sites. The strategic aim for ACTRIS is to collaborate with ARM and ASCENT to ensure data and methodology harmonisation across the networks and develop integrated near real time data products covering different environments across the USA and Europe.

Similarly in other continents, ACTRIS needs to leverage the existing collaborative actions through the RPOs and bring the key long-term collaborative observation sites to ACTRIS. Joint efforts through ENVRI and collaborative work in European projects such as Knowledge and Climate Services from an African Observation and Data Research Infrastructure (KADI) should be utilized in order to collaborate in Africa towards improved atmospheric observations in the African continent. The possibilities should be explored with counterparts in other continents.

In the network expansion within Europe, co-location with other European Research Infrastructures, such as Integrated Carbon Observation System (ICOS), Integrated European Long-Term Ecosystem, critical zone and socio-ecological Research (eLTER) and European Plate Observing System (EPOS) is a strategic goal of ACTRIS. A joint strategy in observation development of the Environmental Research infrastructures is needed for understanding versatile interactions in the environment and for the scaling towards global impact. The co-located observation sites allow cost-sharing, cost-saving and integrated data development towards the global, complex environmental challenges.

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The strategic goal of expanding the harmonised observations within ACTRIS requires sustainable investments of the member countries to support the new observation sites. It also requires enhanced capacities to support the ACTRIS data centre to digest and process the data from the new sites and scaled-up capacity of the ACTRIS calibration facilities to perform the technical evaluation of the sites and their instrumentation.

The strategic aim in the infrastructure development is to enhance the European contribution to the global observations in the ACTRIS relevant fields.

3. Strategy towards improved services and tools

The mission of ACTRIS is to contribute towards science-based solutions to the grand challenges we are facing. This implies that ACTRIS is a trust-worthy partner for the multidisciplinary scientific community and other collaborators. This is achieved by producing open-accessed, harmonised, high-quality, long-term observations globally. Comparable observations are the key to the understanding of the complex processes in the atmosphere. The strength of ACTRIS is in collaboration between different RPOs and experts with multidisciplinary backgrounds. It ensures that the tools and services are accessible for our collaborators but additionally continuously developed to respond to the needs of the community and keep up with the latest breakthroughs in measurement principles.

First, the harmonised and expanded observation capacity allows improved services and tools by providing a wide view of the atmospheric composition. Hand-in-hand with global network development, network development within Europe is needed. For example, provision of ACTRIS data from urban environments needs to be further expanded and improved. This is particularly important for the air quality services. This work should be performed in close coordination and collaboration with local, city and regional level authorities responsible for air quality monitoring. The added value from ACTRIS originates from state-of-the art observations and from the capacity to contrast the urban observations against the regional background data.

As presented in the previous section, the expansion needs to be done in coordination with WMO, GEO as well as other global observation initiatives with interoperable data services that allow cross-platform development of new services and tools. Taking the full advantage of the open and accessible observational data requires fast and reliable near-real time data delivery. This is connected to the ACTRIS strategy towards global observations.

Second, we need to ensure the pathway for the novel observational techniques to be incorporated into ACTRIS. This includes both implementing new ACTRIS components and observations as well as continual development of the measurement technologies already included in the ACTRIS network. A key component for the development is active participation of ACTRIS and RPOs in Horizon Europe Research projects and COST-actions that provide additional networking with partners developing novel techniques.

Third, we need to continue development of ACTRIS services in close collaboration with Copernicus, EUMETSAT and other key stakeholders. ACTRIS needs to continue to develop data services towards

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calibration and validation of satellite remote sensing. This can be supported by targeted access programs to ACTRIS observation sites tailored for the validation activities. The work together with Copernicus and other stakeholders allows a clear pathway for the ACTRIS data towards large scientific and societal data users. We need to ensure traceability of ACTRIS data from the data providers to the data users in the full cycle of data provision.

Fourth, integrative data services taking the advantage of the ENVRI infrastructure observations and capacities need to be developed. ACTRIS drives collaboration with other environmental RIs, which helps with cost-efficiency and cost-sharing but also with awareness of ACTRIS observations to users from other fields of science which is needed to solve the global grand challenges. Additionally, collaborative development towards interoperable data centres leads to user-friendly access to the data, maximising the utilisation of the data. As an example, collaborative work with solid earth observations in volcanology and local and regional air quality networks allow development of early warning systems. This approach is most logical within the ENVRI framework but can also extend to other domains.

The strategic aim for the service development is to enhance comprehensive utilisation of ACTRIS data and to expand the user base of the ACTRIS data and tools. In order to progress here, we need to develop ACTRIS stakeholder analysis and then explore the key contributions in the data delivery value chain.

4. Strategy towards technology development and innovation

ACTRIS brings together a versatile scientific community with leading experts from its core topics. Expertise and the continuous collaboration with RPOs leads to an efficient channel to share knowledge and develop metrology needed for cutting-edge research on short-lived atmospheric constituents.

ACTRIS CFs are reliable metrology partners in EU-projects and in standardisation processes. The methodology harmonisation work in ACTRIS needs to be connected with the latest developments in EMPIR and EURAMET standardisation procedures. The innovative observation capabilities need to be transferred into global perspective through technique harmonisation globally.

The technology development needs to be performed in cooperation and a close interaction with instrument developers, both at ACTRIS RPOs and in the private sector. The pathway of the new techniques and instruments towards ACTRIS network need to be coordinated by ACTRIS Central Facilities as it ensures network-wide compatibility and harmonisation. Also the new techniques should deliver near-real time data as it will allow novel data services.

We need to establish ACTRIS as a platform to support innovation at different levels. Practical work requires continuing the network-wide organisation of innovation workshops. ACTRIS needs to interact with the private sector in technology development and perform technology benchmarking at the observation sites, exploratory platforms and chamber facilities with controlled environments.

We need to establish an innovation pipeline that allows coordinated development of technologies within ACTRIS CFs as well as in participating RPOs. The innovation pipeline needs to allow onboarding the new

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technologies as part of ACTRIS observational capacities, either by implementing improved observations of the ACTRIS variables or initiating completely new ACTRIS variables. We need to develop and implement relevant structures to deal with intellectual property rights, technology harmonisation steps and internal processes related to on-boarding new technologies, including possible new ACTRIS observables and CFs, when deemed necessary.

The strategic aim is to remain at the state-of-the-art in 4D atmospheric aerosol, trace gas and cloud measurements while keeping the compatibility between the new and earlier data sets.

5. Strategy towards increased scientific impacts

Overall, ACTRIS provides expertise and long-term, high quality observations on short-lived atmospheric constituents. They have an impact on the radiative balance of the Earth, air quality, environment and human health. The observations allow us to monitor changes in these constituents and their distributions, and also help in understanding for example how the reductions in trace gas emissions is affecting observed atmospheric composition. Collaboration with other ENVRIs ensures world-class knowledge on monitoring environmental conditions, which creates synergy in developing services and metrology used at the observation sites.

The increased ACTRIS impacts towards scientific impacts is founded on the expanded observational capacity, new data and service tools, implementing the novel technologies and integrating the scientific results from the ACTRIS components and techniques.

The strategy towards increased scientific impact requires ACTRIS as whole to be an active entity that coordinates and participates in European projects. On a national level, ACTRIS RPOs should be actively involved in their research communities. The ACTRIS participation in the EU-projects can vary case-by-case, from contributions through the ACTRIS ERIC, through a combination of ACTRIS CFs or through individual RPOs. The participation is discussed and coordinated by ACTRIS structures, including ACTRIS Director General, Head Office and ACTRIS Research Infrastructure Committee. As a governing guideline, the projects that are envisioned to develop services, tools or structures that would later be implemented by ACTRIS, participation of the ACTRIS ERIC and relevant CFs is required. In science-driven projects, ACTRIS contribution can be reached via RPO participation, but ACTRIS should be recognized as an infrastructure that facilitates and supports scientific work.

Internally, ACTRIS scientific contributions can be improved by integrating the data, services and expertise of different ACTRIS components and particularly by supporting new generations of scientists and engaging them in the ACTRIS activities.

Externally, ACTRIS scientific impact can be increased via infrastructure driven development projects. Here the collaboration within the ENVRI domain is preferred for maximising interoperability and integration, but also work with other domains will be important such as with Environmental Exposure Assessment Research Infrastructure (EIRENE) in the health domain.

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The strategic aim is to contribute to scientific breakthroughs via ACTRIS observations, services, tools and integrative analyses in the field of atmospheric sciences. Particularly the focus remains in aerosol particles, trace gases and clouds with contributions to advances in air quality, atmospheric composition and climate change.

6. Summary

ACTRIS ERIC is now officially established as an European Research Infrastructure. In this document we summarised and elaborated ACTRIS strategies in network development, in novel services, technologies and innovation and in scientific relevance. The strategic development builds upon existing, on-going and planned strategic partnerships within Europe and beyond.

The overall ACTRIS strategy including the scientific strategy will be finalised in next one-two years, by engaging the ACTRIS community and which will be discussed and approved in the ACTRIS ERIC General Assembly. To support the process, we need to define relevant Key Performance Indicators (KPIs) and Key Impact Indicators (KII).

At this stage, we have identified several strategic aims for ACTRIS as whole:

1. The strategic aim in the infrastructure development is to provide the European contribution to the global observations in the ACTRIS relevant fields. Within Europe, the network development should include improved integration of ACTRIS components and co-location with other European RI observation sites. Regionally the observation network should include observation sites both at remote and urban sites.
2. The strategic aim for the service development is to enhance comprehensive utilisation of ACTRIS data and to expand the user base of the ACTRIS data and tools. A focus should be placed upon interoperability across ENVRI domains.
3. As a whole, the strategic aim is to remain at the state-of-the-art in 4D long-term atmospheric aerosol, trace gas and cloud measurements via innovation actions in collaboration with the private sector, ACTRIS CFs and RPOs. We should develop and implement an innovation pipeline that allows on-boarding of novel instrumentation and technologies.
4. The strategic aim is to contribute to scientific breakthroughs via ACTRIS observations, services, tools and integrative analyses in the field of atmospheric sciences. Particularly the focus remains in aerosol particles, trace gases and clouds with contributions to advances in air quality, atmospheric composition and climate change.

References

ACTRIS Technical and Scientific Description (TSD), 2021

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