ESBO DS

Stratospheric Observatory

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LIST OF ABBREVIATIONS AND DEFINITIONS

Abbreviation	Definition
CAHA	Centro Astronómico Hispano en Andalucía
CNES	Centre national d’études spatiales
CSA	Canadian Space Agency
CSIC	Consejo Superior de Investigaciones Científicas
DLR	Deutsches Zentrum für Luft- und Raumfahrt
EMBL	European Molecular Biology Laboratory
ESA	European Space Agency
ESBO	European Stratospheric Balloon Observatory
ESFRI	European Strategy Forum on Research Infrastructures
ESO	European Southern Observatory
FIR	Far Infrared
IAA	Instituto de Astrofísica de Andalucía
IGO	Inter-governmental Organisation
IR	Infrared
LDB	Long Duration Ballooning
MPG	Max Planck Society
MPIA	Max Planck Institute for Astronomy
MoU	Memorandum of Understanding
NASA	National Aeronautics and Space Administration
NIR	Near Infrared
PI	Principal Investigator
RI	Research Infrastructure
ROM	Rough Order of Magnitude
SOFIA	Stratospheric Observatory for Infrared Astronomy
SPB	Super Pressure Balloon
SSC	Swedish Space Corporation
STUDIO	Stratospheric Ultraviolet Demonstrator of an Imaging Observatory
ULDB	Ultra-Long Duration Ballooning

USRA	Universities Space Research Association
UV	Ultraviolet
Vis.	Visible
WP	Work Package

REFERENCE DOCUMENTS

[RD1]	ESBO *DS*. Deliverable D2.1-3: Requirements Baseline – Common Operational Needs. Version 1.0. 31 May 2018.
[RD2]	ESBO *DS*. Deliverable D3.2: Preliminary Technical Specifications. Version 1.0. 30 April 2019.
[RD3]	ESBO *DS*. Deliverable D4.1: Design Justification File. Version 1.0. 30 April 2019.
[RD4]	German Brainstorming Meeting presentation on Balloon-Borne Astronomy
[RD5]	ESBO *DS* Project Proposal
[RD6]	ESFRI Roadmap 2018: Strategy report on research infrastructures. December 2018.
[RD7]	ESBO DS. Deliverable D3.1 Concept presentation to scientific audience. https:/esbo-ds.irs.uni-stuttgart.de/wordpress. ESBO DS 2019.
[RD8]	Pineda J. et al. (2019). The Far-Infrared Astronomy Stratospheric Balloon Facility. http://surveygizmoresponseuploads.s3.amazonaws.com/fileuploads/623127/5043187/66-8548c04bcb9700458f1272fa60e9250b_PinedaJorgeL.pdf
[RD9]	Strategy Report on Research Infrastructures ROADMAP 2021, Public Guide. 25th September 2019. https://www.esfri.eu/sites/default/files/ESFRI_Roadmap2021_Public_Guide_Public.pdf
[RD10]	ESFRI Roadmap 2021. https://www.esfri.eu/esfri-roadmap-2021

1. INTRODUCTION

ESBO *DS* stands for **E**uropean **S**tratospheric **B**alloon **O**bservatory - ***D**esign **S**tudy*. It is a Research Infrastructure project funded under the European Union's Horizon 2020 programme that paves the way for an astronomical observatory infrastructure based on stratospheric balloons - ESBO.

ESBO *DS* is an important step towards the development of a European research infrastructure to fly ballooning-based telescopes to altitudes of 30 to 40 km with regular flights, exchangeable instruments, and open access to observation time.

Within the three-year pilot project ESBO *DS* (2018-2021), two main steps are being taken:

1. The development and construction of a prototype gondola and telescope, which will perform technology tests as well as deliver first scientific results during its maiden flight with a newly developed UV-instrument provided by the Institute for Astronomy and Astrophysics at the University of Tübingen, Germany. This Stratospheric Ultraviolet Demonstrator of an Imaging Observatory (STUDIO) is ongoing with successful PDR and CDR meetings in December 2018 and October 2019, respectively.
2. The development of a strategy for the long-term establishment and operation of the observatory, including the study of the technical feasibility of balloon flights with larger telescopes, particularly of the 5 m aperture class for far infrared observations.

Some of the critical aspects of the long-term success of ESBO *DS* (and later on ESBO) are the development of feasible operation scenarios and the establishment of working governance concepts, together with the possible funding resources. These aspects are addressed in *WP6 "Observatory Operations and Governance Concept"*.

2. SCOPE

This deliverable *D6.1 Operations and Governance Report* (public report) summarizes the outcome of the work conducted within *WP6, Observatory Operations and Governance Concept"*. The WP6 work was split into several tasks:

Task 6.1 Analysis of different operations and governance structures

Within this task, different possible operations and governance structures were exaamined and they are described in Section 5. The following considerations were included:

- General organisational form of the infrastructure operator
- Governance structure of the infrastructure operator
- Potential funding structures
- Considerations of services and elements held within the infrastructure operator versus services and elements to be procured

- Consideration of services, including proposal/observer tools and science pipeline/data processing to be offered by the infrastructure operator
- Integration of the infrastructure into the network of existing infrastructures, coherence of services

The requirements and specifications regarding operations and services provided studied in Task 3.3 (Definition of functional requirements for proposal tools and science pipeline) and Task 3.7 (Preliminary concepts specification) of the *WP3 (Infrastructure Analysis*) were inputs for this task in addition to the technical infrastructure concept. These inputs were documented via the corresponding deliverables D3.1 "*Concept presentation to scientific audience*" at https://esbo-ds.irs.uni-stuttgart.de and D3.2 "*Preliminary Technical Specification*" (confidential report for members of the consortium).

Task 6.2 Definition of services based on operations options. Analysis of impact of different options

Within this task, the services that the infrastructure would offer to the scientific community under the operations and governance options identified under Task 6.1 are described in detail. The impacts on scientific, technological, and societal advancement expected with each option were analysed.

Task 6.3 Cost estimate of operation and construction under preferred options

This task was dedicated to performing rough order of magnitude (ROM) cost estimates for the operation and construction of the infrastructure under the preferred options for the operations and governance structure as identified in Task 6.1.

Task 6.4 Definition of site requirements and criteria

This task was dedicated to defining requirements and criteria for the selection of infrastructure sites. Considerations include both launch/landing sites based upon the technical specification and requirements, as well as an administration/ science services site based on the operations and governance structure options.

Content: The document *"D6.1 Operations and Governance Conceptual Design Report"* describes the considered operations and governance structures, along with the estimated ROM cost estimates of operation under each structure, the services offered, and impacts expected. It also contains the process for site selection along with site criteria and requirements and an identified recommendation regarding the operations and governance infrastructure.

The overarching goal of *WP6 Observatory Operations and Governance Concept* is to develop feasible operation scenarios, to establish working governance concepts, together with the possible funding resources, for ESBO *DS*, and also for ESBO in the mid- to long-term future.

Aiming for reaching the following Milestones (MS): WP6 and D6.1 are the baseline for reaching *MS6 Operations and Governance Recommendation Review* (foreseen for month 33 in the end of 2020) and *MS8 Infrastructure Conceptual Design Completed* (foreseen for month 36, i.e., within the final review meeting in spring 2021).

In Section 3 we define the basic terms, in Section 4 we describe the scope of the ESBO infrastructure. In Section 5 we describe the possible governance and operation structures. In Sections 6 & 7 we focus on the site requirements and criteria, and the costs estimated. Sections 8 & 9 describe the technical operations and structure options, and finally, in Section 10 we describe the possible offered services.

3. DEFINITIONS

3.1. SCOPE OF "INFRASTRUCTURE"

The term "**infrastructure**" in the context of ESBO and ESBO *DS* does not only refer to the flight infrastructure / flight systems carrying telescopes and instruments. It rather refers to the entire observatory infrastructure including everything required to operate ESBO as a stratospheric balloon observatory and to provide the foreseen services, as is illustrated in the general schematics of Fig.1. This includes the flight systems (dark blue), the ground systems (light blue), proposal and other observer tools as well as data pipelines and processing tools (red) and the governance structure / organisation (orange).

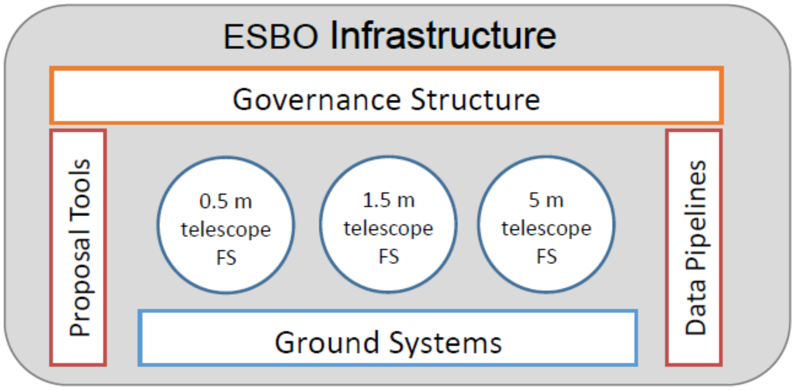

Fig. 1. General schematics of ESBO infrastructure.

The **ESBO concept** foresees different kinds of users with different degrees of involvement in the infrastructure, namely scientific users / groups that provide an own instrument ("Principal Investigator (PI) instrument") and users / groups that use observation time on instruments provided by the observatory operators ("Facility instruments"), or on PI instruments via open time access. Which type of instruments (and users) will be used (or dominate) at a certain implementation phase of ESBO will be highly dependent upon the eventual governance structure, the financing, and the backers of each specific phase.

It appears likely, however, that the implementation of ESBO firstly will be dominated by PI-instruments, before facility instruments are deployed on a larger scale. In order to also duly take into account the prototype phase, which will have particular constraints on operations, the following potential development phases are used to indicate which operational needs and requirements will be relevant for which operational setup (these phases should not be misunderstood as a hard plan for the sequential development of ESBO, but rather as a likely scenario with different operational setups).

The envisioned general strategy, reflected in the phases, is to, during the early development of ESBO, have the data calibration, processing, and related tools be taken care of by the instrument teams. Centralized processing tools, calibration procedures, observation modes, etc. may be defined and developed during the further process of including instruments into the ESBO facility itself.

Prototype Phase (within ESBO *DS*) refers to the development and the first flights of the prototype platform with one UV instrument, which is being designed and manufactured within ESBO *DS* and one supportive visible light instrument.

All responsibility for planning with the instruments: calibration, commissioning, science, data processing, etc., resides with the respective PI. Whereas the responsibilities for housekeeping, technical data, general performance, etc. reside with the observatory operator (in this case the ESBO *DS* consortium).

PI-driven Phase. The subsequent development and operation of ESBO after the prototype flight(s) will likely be dominated by scientific groups with an interest to fly their own instruments. While this does not exclude the option of providing observation time to other groups, operations in this phase would be driven by the interests of the PI which has the responsibility for data processing, calibration plans, instrument operations, etc.

Open Observatory Phase. Within this phase, ESBO operates own facility instruments with open access to observation time, or PI instruments with a large portion of observation time open to the community. In this case, likely a large part of the responsibility for data processing, calibration, archiving, data delivery, but also for proposal selection and time allocation will need to be taken care of by the observatory operator.

3.2 FUNDING ELEMENTS

The long-term goal of ESBO *DS* is to establish a European Research Infrastructure: the "European Stratospheric Balloon Observatory (ESBO)". There are several different estimated and real costs involved to fully implement a Research Infrastructure from the beginning of a Design Phase until the Operations Phase. There are very likely investments needed at national level to enable the establishment of a European Research Infrastructure, possibly also for the Operation Phase. For the definition of the funding elements we follow the concepts presented in the "Strategy Report on Research Infrastructures Roadmap 2021", Public Guide, from 25-Sep-2019, published by the European Strategy Forum on Research Infrastructures (ESFRI), see [RD9].

Preparation Costs. This includes the costs for the conceptual design, technical design and feasibility study (like the ORISON project), as well as the costs for drafting the Roadmap proposal. Budgets obtained to develop the project from institutional, national, European and international funds belong to the design costs, as well as labour of scientific, technical and managerial personnel dedicated to the project, prototype design and development (like the ESBO *DS* project), or the coordination of potential users. In addition, they cover all costs following a Preparatory Phase project, either under the Framework Programmes or via other in-kind and cash third-party contributions, up to the Implementation Phase.

Implementation Costs. The Implementation includes hiring personnel, acquiring the site and goods, construction costs, legal costs, coordination of user communities, data management infrastructure costs, commissioning as well as pre-operation and start-up costs. For an astronomical balloon-borne facility, some of the implementation costs (like for different telescopes, instruments, gondolas) will occur more than once, also during the Operations phase. Major upgrades (as already envisioned in the ESBO *DS* long-term plan) are also included in the implementation costs.

Termination Costs. Termination costs usually refer to the decommissioning and/or environmental mitigation costs that may be necessary at the end of the lifecycle of a research infrastructure. In case of a balloon facility this would refer to the termination of a given launch site.

Average Annual Operation Costs. The costs for running a balloon-borne facility on a yearly basis include the handling of proposals and data (call for proposals/instruments, time-allocation activities, scientific and calibration programme implementation, data reduction, calibration, storage, software development, interfaces, etc.), provision of user access, delivering scientific products to the users/community. This includes personnel, power, rents/mortgages, taxes, maintenance, continuous upgrade and replacement costs, user support, in-house scientific programme, cost of flights (balloon hardware, launch, flight operation, recovery, refurbishment) etc.

Total Investment Costs. This includes all above-mentioned costs, necessary to fully implement a Research Infrastructure from the beginning of a Design Phase until the Operations Phase, and including the Termination costs.

4. THE ESBO INFRASTRUCTURE

4.1 SCOPE OF THE ESBO INFRASTRUCTURE

ESBO *DS* is an important step towards the development of a European research infrastructure to fly balloon-based telescopes to altitudes of 30 to 40 km with regular flights, exchangeable instruments, and open access to astronomical observation time.

Some of the critical aspects of the long-term success of ESBO *DS* (and later on ESBO) are the development of feasible operation scenarios and the establishment of working governance concepts, together with the possible funding resources. These aspects are addressed in *WP6*, which is dedicated to the assessment of alternative operations and governance concepts of the ESBO infrastructure. To achieve this, we have drafted a baseline organigram of the ESBO infrastructure which particularly includes the infrastructure elements that we consider necessary to depict the required / inherent changes that each governance option would entail.

This organigram that schematically describes a baseline version of the full ESBO infrastructure is show in Fig. 4. Here, we have considered two scenarios: a) ESBO's operations as a separate legal entity, and b) Inclusion of ESBO in external institutions.

In both cases, we foresee an operation of ESBO by an internal staff sub-structure, composed of scientific and engineering committees. These will be in charge of the assessment of scientific and technological proposals, for observing time, as well as for testing new instruments and technological experiments. The computer group would be in charge of recovering and processing all acquired data to be provided to the researchers; whereas the public relations staff would be in charge of managing the academic and public services as well as everything concerning outreach.

Public and academic services, among other things, include the facilitation of flight opportunities for "add-on payloads", i.e. for testing small technologies and small experiments at stratospheric conditions. Proposals for these add-on payloads could come from academic institutions and/or private companies. The payloads shall be independent of the main payload of ESBO, and we currently foresee to support payloads with a mass of at least 4 kg for each experiment. Public Relations also shall be in charge of promoting these services at low-cost to institutions and companies from developing countries.

The launch management may include one of two cases: a) inclusion or procurement / rental of services and facilities from Space Agencies, or b) procurement / rental of services and facilities from a private company. In both cases, such facilities shall be in charge of everything concerning launching and (balloon) flight operations from ground systems up to recovery of the payload.

Up to now, the smallest foreseen flight platform of ESBO, carrying a 0.5 m telescope equipped with a UV and a visible light instrument, is being built as a prototype. This platform is planned to be in operation during 3-5 years. This period with one flight per year will provide enough expertise in both scientific and technical operations of the observatory.

The governance and operations infrastructure considerations also take into account the foreseen future development and implementation of flight platforms for 1.5 m and 5 m telescopes for NIR/Vis and FIR observations, respectively.

The eventual ESBO consortium will not necessarily coincide with the current ESBO *DS* consortium, but this will also be taken into consideration for the different governance options.

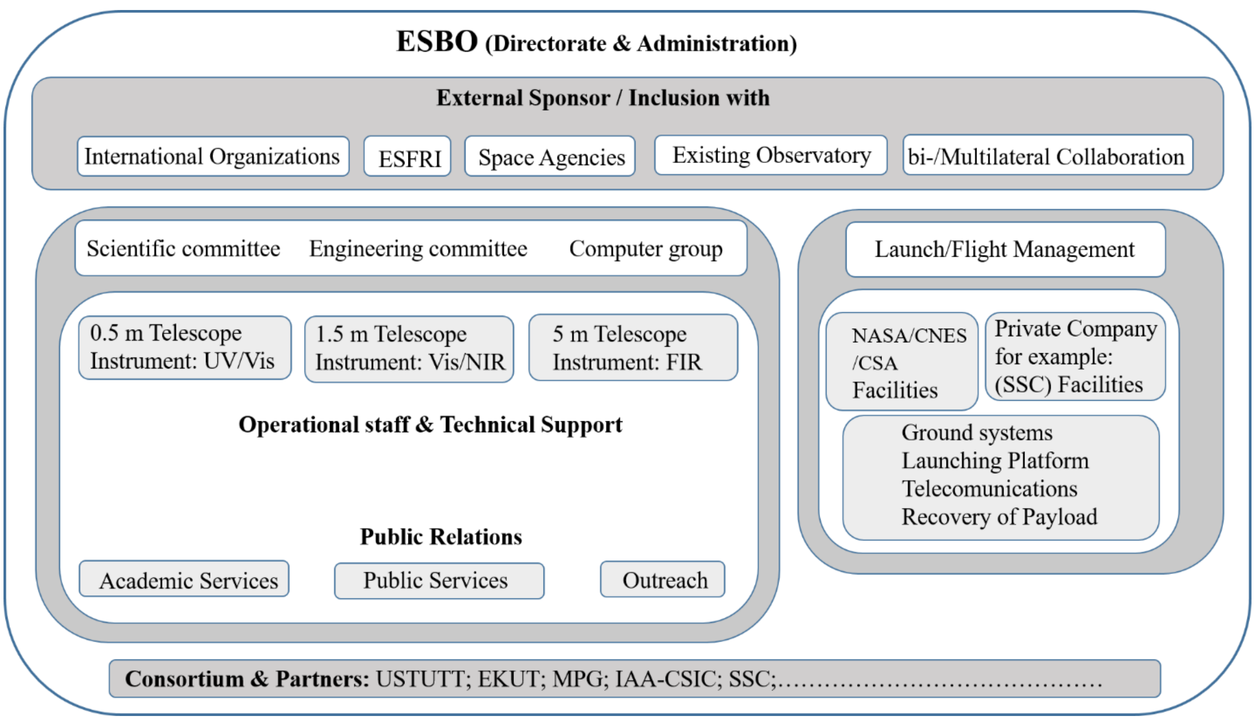

Fig. 2. Schematic organigram of the ESBO infrastructure.

4.2 POSSIBLE PERSPECTIVE / DEVELOPMENT SEQUENCE

As we said before, the long-term goal of ESBO *DS* is to establish it as a European Research Infrastructure. One promising strategy would be to aim for an inclusion in the European Research Infrastructure Roadmap [RD9]. New Research Infrastructures in progress towards implementation can be included in the Roadmap after a thorough evaluation and selection procedure, and for cases where a significant community supports such an infrastructure. For ESBO this would mean to follow the models and methods of ESFRI, which are described as “Lifecycle Approach” and schematized in Fig. 3.

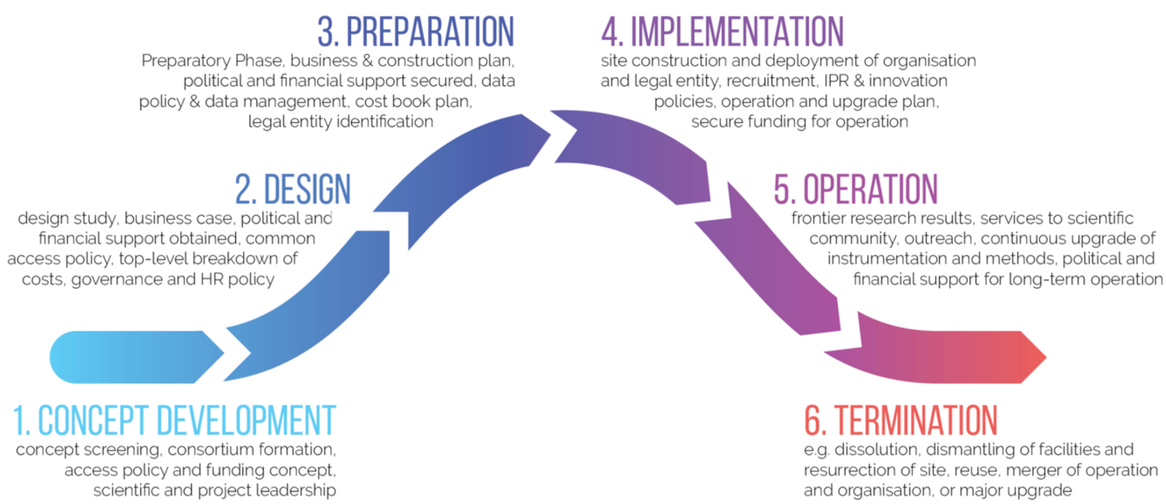

Fig. 3. Lifecycle approach. Taken from Roadmap 2021, public guide of [RD9].

Step 1: The concept development

The concept of a “European Stratospheric Balloon Observatory” requires a strong and large scientific community, together with clearly identified scientific needs and goals. A balloon-borne facility is placed somewhere between state-of-the-art major multi-purpose ground-based observatories and often very specialized and expensive space observatories/projects (see ORISON results, especially the public deliverables D3.2 – Feasibility Report and D4.1 – Strategy Report). From the scientific point-of-view, a balloon campaign will typically focus on a specific science field (and wavelength regime) which is not possible via current ground, airplane, or space facilities.

For establishing an Astronomical Balloon Research Infrastructure, several science cases/fields have to be identified. These fields have to be attractive to larger science communities and the science cases should not be doable by existing facilities. It is also clear that after an initial PI-driven (sub-) project phase, the facility and the observing possibilities have to be opened to a European or worldwide community to move towards a truly European Research Infrastructure. The step to identify first driving science fields has been performed under ORISON and under the first part of ESBO *DS*, narrowing them down to primarily certain applications in the middle and near ultraviolet, spectroscopic and photometric applications in the near infrared, and general applications in the far infrared.

Following up from the ORISON results, the concept development was addressed under ESBO *DS* in different WPs. The “WP2 Detailed Science Case Analysis” reviewed the user requirements for each of the platform-associated science cases, to establish the baseline requirements for the design and infrastructure analysis (see also D2.1 - Requirement Baseline). The various infrastructure options were evaluated in "WP3 Infrastructure Analysis" (see D3.2 - Preliminary Technical Specifications).

Part of "WP6 Observatory Operations and Governance Concept" can also be considered as a concept study to assess which elements of proposal/observer tools and science pipeline/data processing shall be provided by the infrastructure, and how these elements will be integrated into the infrastructure.

In addition to the more formal aspects of the ESBO concept development, the outreach, networking and communication activities are crucial: (i) to identify new and attractive science cases; (ii) to enlarge the potential ESBO science community; (iii) to gather support from national funding agencies and decision makers and to identify potential funding options; (iv) to demonstrate the existing possibilities (and limitations) of balloon experiments; and (v) to combine different efforts within Europe. ESBO *DS* has established a driving force in preparation for a future European Research Infrastructure.

Funding for this phase came from EU's Horizon 2020 research and innovation programme (ORISON via call H2020-INFRASUPP-2015-2, under grant agreement No 690013 & ESBO *DS* via call H2020-INFRADEV-2017-1, under grant agreement No 777516).

In the context of the "Concept Phase" also the HEMERA project (H2020 EU project) should be mentioned, although it is not explicitly related to astronomical observations. The project also deals with balloon launch sites, infrastructures, high-altitude conditions, enlarging the balloon-related science community or contacts to industry for balloon-related hardware, software or communication systems. Close contacts between ESBO *DS* and HEMERA have been established and will lead to robust concepts for a future astronomical balloon infrastructure.

Step 2: Design

ESBO *DS* is the Design Phase of a general astronomical Research Infrastructure based on stratospheric balloons (ESBO). The "WP4 Preliminary Infrastructure Concept" specifies the basis for the design of the infrastructure elements, and more specifically the design and definition for the prototype. The "WP5 Conceptual Design" develops the conceptual designs of the flight and ground elements of the infrastructure, together with the sound assessment of different operations and governance concepts (see upcoming deliverables D5.1 - Conceptual Design Report (flight platforms) and D5.2 - Conceptual Design Report (ground system)). Also "WP6 Observatory Operations and Governance Concept" is partly related to design aspects since the operations and governance structures have severe impacts on the final costs, on the offered services, and the expected impacts (see also "WP7 Development Roadmap" with the deliverable D7.1 - Design of Infrastructure Development Roadmap).

ESBO *DS* provides additional key elements for a proper Research Infrastructure Design Phase: the development and construction of a prototype gondola and telescope (50 cm), the assembly, integration and testing of a UV instrument, and the preparations towards the first flights (Stratospheric Ultraviolet Demonstrator of an Imaging Observatory – STUDIO). In parallel, the strategy for a long-term operation of a balloon observatory is developed and options to launch 5-m class telescopes are studied.

In preparation for a long-term balloon facility it will be necessary to conduct further design work, particularly including further technical design of platforms for different science cases and aiming for a larger telescope. A suitable frame for such work might be another design study, focusing on a new instrument with a larger and differently optimized telescope and platform to serve an additional science area. This would furthermore help to consolidate the design aspects, to test the scalability of costs, to verify potential governance concepts, and to enlarge the involved science community. EU funding could play an important role in this further development for example the ESFRI Roadmap 2021 for emerging projects.

The ROADMAP 2021 Public Guide [RD9] explains the procedure for new proposals:

- A strong science case is needed.
- It has to be shown that the implementation phase can be reached with high probability within ten years.
- A proof of political support by the lead Member State, and at least two additional Members.
- A funding commitment by the lead Member State.
- Signed inter-institutional and multi-lateral agreements by all core consortium partners.

For the transition from ESBO *DS* to an ESBO Research Infrastructure, several "minimal key requirements" have to be fulfilled: **Scientific excellence:** (i) long term science programme defined; (ii) scientific community well-established; (iii) scientific leadership described; (iv) cutting edge science and technology outlined. **Pan-European Relevance:** (i) pan-European approach for scientific area outlined; (ii) targeted user community is pan-European; **Socio-Economic Impact:** (i) relevance to societal challenges identified and potential economic impact predicted, including innovation aspects. **User Strategy & access policy:** (i) vision about user community; (ii) access modes described. **E-Needs:** (i) vision on e-infrastructure requirements, including access policy and security measures ready; (ii) interfacing with communication networks or distributed calculation or HPC/HTC. **Stakeholder commitment:** (i) institutional letters of Intent (LoI) signed; (ii) formal agreement amongst partners for design study agreed upon (e.g. Consortium Agreement). **Preparatory work & planning:** (i) concept screening successfully complemented and described in a conceptual design; **Governance, management & human resources:** (i) project organization approved; (ii) scientific leadership, project manager and required staff identified. **Finances:** (i) funding concept and potential partner contributions outlined;. **Risks:** (i) conceptual ideas about scientific, technological, political and financial risks.

Design costs (taken from [RD9] :

At the time of submission of a proposal for the Roadmap the design costs cover all costs (in-kind and cash) invested in the conceptual design, technical design and feasibility study, including the costs for drafting the proposal. They include specific budgets obtained to develop the project from institutional, national, European and international funds (such as Design Studies and Integration Actions of the EU Framework Programmes for Research and Innovation); labour of scientific, technical and managerial personnel dedicated to the project; prototype design and development; coordination of potential users, etc.

Step 3: Preparation

ESBO *DS* works towards phase "3. Preparation", but details depend on decisions about the legal entity for a future European Stratospheric Balloon Observatory. It also requires large and strong science communities supporting the project, and the willingness of national funding agencies to finance instruments or flights. If a stratospheric balloon observatory would make it to an updated EU Roadmap, then funding for the Preparatory Phase would also be possible with the European Research Infrastructure Work Programme:

- INFRADEV-02-2019-2020: Preparatory Phase of new ESFRI projects and early phase support to ESFRI high strategic potential areas.
- INFRADEV-04-2019: Fast track to the implementation of an ESFRI research infrastructure.
- INFRASUPP-01-2018-2019: Policy and international cooperation measures for research infrastructures
- INFRASUPP-02-2020: Strengthening the human capital of research infrastructures

Step 4: Implementation

Implementation phase is foreseen for ESBO afterwards ESBO *DS* conclude its first operation flight and its establishment by inclusion in an existing observatory, by inclusion in an international organisation, or by establishment as an own legal entity.

Step 5: Operation

Operation phase is foreseen up to ESBO act as one of the establishments mentioned above. It concerns all operations of a stratospheric observatory with regular flights, observation campaigns, implementation of new instruments, etc.

Step 6: Termination:

Termination phase may be applicable for both ESBO *DS* and ESBO, once the operations conclude, e.g. dissolution, dismantling of facilities or end of the funding's project.

The following EU H2020 funding elements might be interesting for the next steps towards ESBO and/or towards an inclusion in the Roadmap:

- INFRAIA-01-2018-2019: Integrating Activities for Advanced Communities (RIA).
- INFRAIA-02-2020: Integrating Activities for Starting Communities (RIA) – Deadline: Mar 17, 2020.

In the area of INFRASUPP there are the following option:

- INFRASUPP-01-2018-2019: Policy and international cooperation measures for research infrastructures (RIA, CSA) – Deadline: Mar 20, 2020.
- INFRASUPP-02-2020: Strengthening the human capital of research infrastructures (CSA) – Deadline: Mar 17, 2020.

The detailed work programme related to Infrastructures "Horizon 2020, Work Programme 2018-2020, 4. European research infrastructures (including e-Infrastructures)", European Commission Decision C(2019)4575 of 2 July 2019).

5. POSSIBLE GOVERNANCE AND OPERATIONS STRUCTURES

For establishing a system of operations and governance, our methodology takes into account that the operations and governance of ESBO shall be more similar to that of a ground-based observatory structure than of a space mission. This is due to the particular differences in between them, such as limitation in operating lifetime, the recovery and re-flight of the gondola with its payload and also budgetary differences (for example shown in different, less costly risk-management and testing approaches that can be used for balloons). The operations concept will need to enable ESBO to maintain continuous operations over the long-term. Furthermore, it will need to support the opportunity to change new instruments according to the state-of-the-art technologies.

Departing from this, we surveyed the functionality of some existing international entities in Europe, such as observatories, international organizations, and research agencies. Regarding its main principles of governance, we took them as a reference for establishing ours.

ESBO foresees to study the possibility for interacting with one of these entities, for instance, by inclusion as part of their infrastructure. Informal first contact has been established with representatives of such international entities to obtain information and gauge the general conceivableness of a collaboration with ESBO / operation of balloon-based telescopes.

So far, relevant international entities have been identified, their financing and funding structures as well as their organizational forms and governance structures have been studied as references for the ESBO structure concept, and informal discussions with representatives have been started. The following diagram in Fig 4 schematically summarizes our methodology.

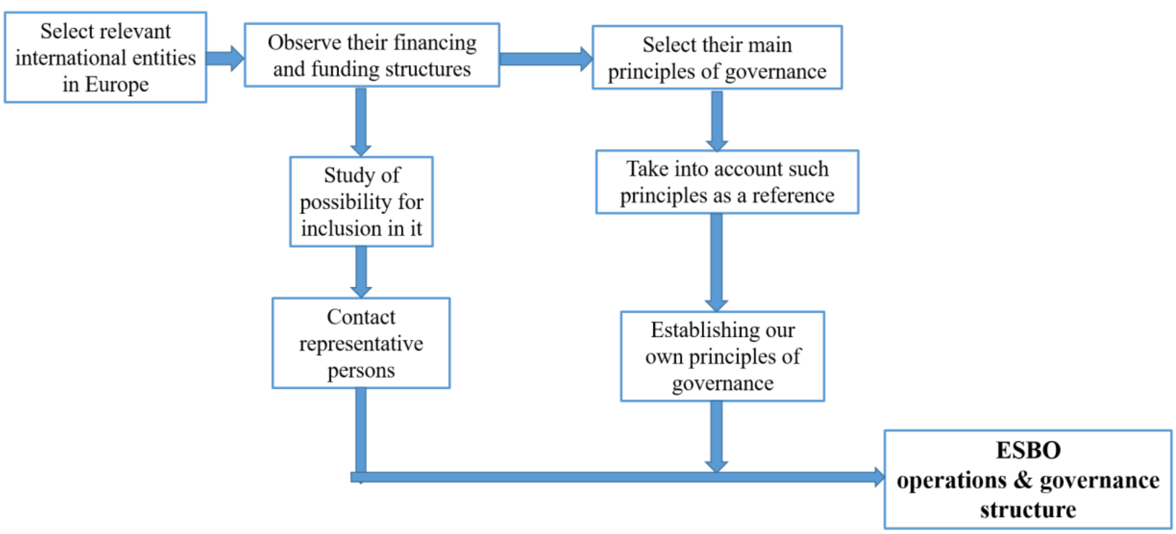

Fig. 4. Schematic diagram for achieving operation & governance structure of ESBO.

The different governance options that we have considered so far, along with their implications, advantages & disadvantages, as well as the possible funding structures via the European Commission or others, are explained in the next sub-sections.

5.1 OWN LEGAL INTERNATIONAL ENTITY

In general terms, a legal entity shall be capable to enter into agreement or contracts, assuming obligations, incur and pay debts, sue and be sued in its own right, and to be held responsible for its actions. Regarding to this, ESBO could be established as an own legal international entity, quite similar to an Intergovernmental Organization (IGO) set up by national governments with some degree of permanence, but following rules of multilateral mechanisms through the collective governments for a specific policy purpose, which is in this case: research, astronomy science, technology development (astronomical instruments), education, and so on.

Currently, a consortium of public and private European institutions is working towards ESBO, whose partnership is expected to be growing up in the next future. For now, its operability depends upon a European program funded to develop a pilot prototype, STUDIO. In the case that ESBO be established as a legal international entity, its permanence in the astronomical community will depend upon the annual incoming contributions provided by each partner or external sponsors. This shall provide sustainability for the long-term.

<u>Advantages for ESBO as an own legal entity</u>

- The creation of ESBO as an own legal international entity could provide the entire operation's independence from external international organizations (in case funding is obtained entirely from the partners). This independence includes the administration of its own incoming funding.
- The possible creation of a headquarters for ESBO, which could be placed at any country of the partners.
- The possibility of building an own launch and operations platform in the future.

<u>Disadvantages for ESBO as an own legal entity</u>

- Most of the scientists and engineers that currently participate in the prototype of ESBO *DS*, are permanent employees from public and private institutions. The establishment of ESBO as an own legal entity would require 100 % positions of personnel.
- The achievement as a well consolidated own international entity might takes many years.

5.2 ESFRI-RELATED INTERNATIONAL ENTITY

The European Strategy Forum on Research Infrastructures (ESFRI), was created by the European Council to support the emerging and existing research infrastructures in Europe. It supports coherent strategies to approach policy making, facilitate multilateral initiatives leading to the better use and development of such infrastructures at European Union and international level. It also establishes a European Roadmap for the next 10-20 years and follows-up on the implementation of the ongoing ESFRI projects after a comprehensive assessment.

The methodology of ESFRI is well described in [RD6], it engages in well-defined roadmapping processes with publicly available rules and procedures. Its dynamic is understood within an overall lifecycle approach summarized in 6 steps as follows:

1. **Concept development**: The concept of a new Research Infrastructure (RI), typically emerges bottom-up from scientific communities clustering around well-identified scientific needs and goals, which include consortium formation, access policy and funding concept, scientific and project leadership.
2. **Design**: The design covers the proof of the scientific concept and technical feasibility of the RI, the analysis of the potential user community, both science and innovation orientation, business case, political and financial support obtained, top-level breakdown of costs, governance and RI policy. The feasibility study can be carried out with institutional, national, or international support.
3. **Preparation**: The preparation carried out at institutional, national, European or international level, is directed towards developing the RI as a fully-fledged organisation. It includes its preparatory phase, business and construction plan, political and financial support secured, data policy and data management, cost book plan, and legal entity identification.
4. **Implementation**: The implementation is different for single-sited and distributed RIs. In the first case it corresponds to an intense investment period of several years for construction engaging human and financial resources with big impact on the market-suppliers of goods and technologies. It also should include the site construction and deployment of organisation and legal entity, recruitment, IPR & Innovation policies, operation and upgrade plane, secure funding for operation.
5. **Operation**: During their operation, RIs produce frontier research and deliver advanced services for excellent science satisfying the users' demand, boosting brain circulation of early career scientists and trainees, therefore improving the ranking of their academic and research institutions. RIs can create spin-offs and start-ups and attract corporate partners generating a high potential for innovation. It should provide frontier research results, services to scientific community, outreach, continuous upgrade of instrumentation and methods, political and financial support for long-term operation.
6. **Termination**: The termination may encompass dissolution of the organisation, dismantling of facilities and related safety aspects and resurrection of the original site but it does not apply in these identical terms in all research domains. The termination phase could also result in a new infrastructure development as part of the evolution of the field, as well as to be reused, to merge of operation and organisation or to achieve a major upgrade.

Advantages for ESBO as potential candidate for applying to the ESFRI calls

- ESBO could also be converted in a Landmark, once it reaches the top level of its implementation under the ESFRI roadmap.
- The achievement of landmark level for ESBO might generate optimal management for returning the investment.

Further suggestions:

- The ESFRI lifecycle approach provides a clear process towards the implementation and operation of ESBO as a European Research Infrastructure
- Being part of the ESFRI roadmap provides access to dedicated funding opportunities within the European Union's research and innovation programmes.
- The demonstrated relevance of the initiative supported by an inclusion in the Research Infrastructures Roadmap will support funding efforts.

5.3 INCLUSION IN AN EXISTING INTERNATIONAL ORGANISATION

The European Space Agency (ESA) and the European Southern Observatory (ESO) are two of the strongest consolidated organizations in Europe for managing, design, and development of space borne and ground-based telescopes respectively.

Both ESA and ESO are pre-eminent intergovernmental science and technology organizations in astronomy. They carry out many ambitious programs to build observing facilities for astronomy, and play an important leading role in promoting and organizing cooperation in astronomy research around all the world.

On the other hand, the National Aeronautics and Space Administration (NASA) already has several balloon programs for astronomy, including a launch platform facility placed in the southern hemisphere in Antarctica.

Advantages for ESBO by inclusion in an existing international organization

- Funding would be provided through the same mechanisms as for other programmes of the organization (member state contributions)
- ESBO could profit from existing structures of the organisation, including administrative structures, office and lab facilities, IT and facility support
- ESBO could profit from technical expertise existing in these observations. Technical project support could be obtained from experts in the organisations, potentially making it unnecessary to hire dedicated personnel for each technical area of expertise.
- ESBO would be subject to existing, established, and proven processes, e.g. for quality assurance and testing.
- Most technical development work (design, implementation, construction) would need to be subcontracted.

Disadvantages for ESBO by inclusion in an existing international organization

- ESBO would be subject to create dependence in several aspects such as administration and scientific programs of observation.
- ESBO would be subject to the existing decision structure of a large organization, which may not be optimally suited for a balloon observatory
- ESBO would be subject to existing processes, e.g. for quality assurance and testing, which may not be optimally suitable for a balloon observatory and which may be difficult to adapt
- Funding under the ESFRI-related calls within the EU’s research and innovation programme would likely not be possible.
- Most technical development work (design, implementation, construction) would need to be subcontracted.

5.4 INCLUSION IN AN EXISTING OBSERVATORY

An alternative to including ESBO in a large International Organization could be including it in a smaller and existing observatory. We study this possibility by considering the Calar Alto Observatory as an example.

The Calar Alto Observatory, recently renamed Centro Astronómico Hispano en Andalucía (CAHA), was funded by the Max Planck Society (MPG) and officially opened in 1975. It was operated entirely by MPG up to 2005. Then, it shared its management at 50 % up to middle of 2019 with the Spanish National Research Council (CSIC) through the Instituto de Astrofìsica de Andalucía (IAA). Since the end of 2019, Spain took over the German partner to conduct the overall operations at 100 %, sharing the management with CSIC/IAA and the Junta de Andalucía, respectively. The site is located in the Almeria province, in Spain, at 2,168 m altitude above sea level. Currently, there are four main telescopes of 3.5 m, 2.2 m, 1.3 m, and 0.8 m, respectively. All of them operating continuously for a broad range of astronomical observations.

The inclusion of ESBO as part of an existing observatory such as CAHA could open new perspectives since it addresses the missing availability of repeatedly flying balloon-based telescopes with open time access to researchers.

In such a case, all flights and operations of ESBO would be coordinated under the full program of activities of the host observatory, thus following their main statutes.

<u>Advantages of inclusion in an existing observatory for ESBO</u>

- The inclusion of ESBO in an existing observatory could provide opportunities for getting funding at different national and European programs to achieve joint projects.
- Participation and/or collaboration of the ESBO's staff to the new development of instruments for the CAHA's telescopes.
- Establishing new proposals for campaign observations that combine ground based and balloon borne telescopes, thus resulting of high interest for researchers.
- Possibility to use existing expertise and infrastructure of the existing observatory
- Proximity to existing technical and scientific expertise for the development of instruments
- Less formal practices as compared to large international organizations.

<u>Disadvantages of inclusion in an existing observatory for ESBO</u>

- Depending upon European or fluctuating national funding, some flights of ESBO could be limited, delayed, or cancelled.
- Potentially small number of funding sources that may (such as national funding) be prone to fluctuations.

5.5 BI-/MULTILATERAL COOPERATION

Another option that would not necessarily require the establishment of a new legal entity would be operating ESBO as a collaborative project between two or more institutions. Such a cooperation could in itself be implemented in different ways, in line with specific needs and boundary conditions. Two different examples of such a setup would be the operation of the Stratospheric Observatory for Infrared Astronomy (SOFIA) by the German Aerospace Center (DLR) and NASA, and the past joint operation of the Calar Alto Observatory by the German Max Planck Society (MPG) / Max Planck Institute for Astronomy (MPIA) and the Spanish Consejo Superior de Investigaciones Científicas (CSIC) / Instituto de Astrofísica de Andalucía (IAA).

In case of SOFIA, no dedicated legal entity exists, since SOFIA purely exists as a project on both sides of the cooperation. In the case of Calar Alto, CAHA acts as a separate legal entity.

A look at the (simplified) organizational structures of both collaborations in **Fig. 5** illustrates some of the possibilities.

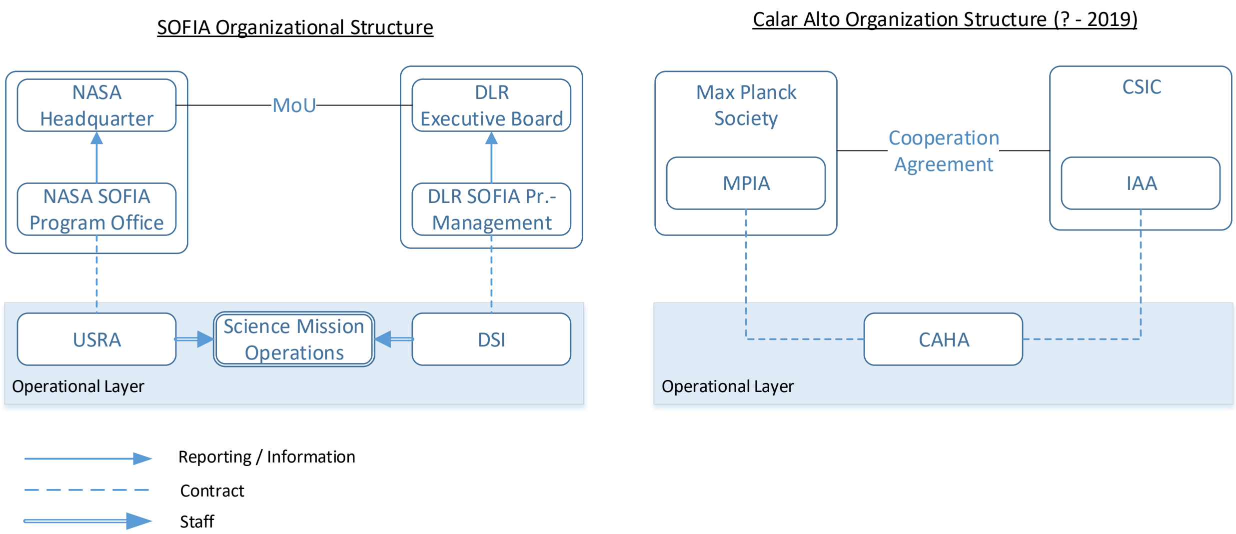

Fig. 5: Organizational structures of SOFIA and the Calar Alto Observatory (until 2019) as two examples for observatory operation under bilateral cooperation's

Note that in the case of SOFIA, no separate legal entity was created. The operation and maintenance of the observatory aircraft is carried out by the NASA Armstrong Flight Research Center and NASA contracts the U.S. part of the scientific operation to the Universities Space Research Association (USRA), where SOFIA operations is handled as a project among others. DLR contracts the German part of the science operations as well as telescope maintenance & improvement to the German SOFIA Institute (DSI), which itself is a project at the University of Stuttgart, without an own legal personality. Both USRA and DSI/the University of Stuttgart furthermore send personnel to jointly coordinate the SOFIA Science Mission Operations.

In case of CAHA, the operation of the observatory is contracted directly to it, which is a separate legal entity.

The comparison also shows that the cooperating organizations can be of quite different nature. In case of SOFIA, the main cooperating organizations (bound together by a Memorandum of Understanding (MoU) are space agencies, in the case of CAHA, they are research organizations.

In case of a cooperation of research organizations, or observatories, it is also conceivable that the subcontracting is avoided and that an observatory is just run jointly by staff of the two (or more) cooperating organizations (in principle, this would also be possible for agencies, but seems unlikely).

Advantages of a bi-/multilateral cooperation for ESBO

Establishing ESBO as a bilateral cooperation would have several advantages:

- Effort of setting up an observatory would be comparatively small, particularly if staff of the cooperating organizations was used at first, without creating an additional legal entity.
- No additional legal entity would be required. If a legal personality is required (such as to qualify for funding under some of the ESFRI-related H2020/Horizon Europe calls), a separate legal entity still could be created, such as CAHA. It might also be an option that one of the cooperating organizations lends its legal status to the project, such as the European Molecular Biology Laboratory (EMBL) does for the ESFRI project "ELIXIR".
- ESBO could (depending on the setup) easily make use of existing service infrastructure of the cooperating organizations, such as IT infrastructure, administrative and legal infrastructure, laboratories…
- ESBO could easily make use of existing expertise in cooperating organizations, particularly technical and scientific expertise.
- Depending on the cooperating organizations, synergies with other projects could be used, e.g. if the cooperating organizations are observatories.

Disadvantages of a bi-/multilateral cooperation for ESBO

- While not mandatory, the most natural assumption would be that in case of a bi-/multilateral cooperation, funding would come from (or through) the participating organizations. Particularly if only few organizations are involved, this may make the observatory dependent on the potentially volatile funding situations of each of the participating organizations (see e.g. SOFIA, or the German retreat from CAHA).

5.6. COMPARISON OF DIFFERENT GOVERNANCE OPTIONS

Regarding the five options described above as possible governance and operations structures, we have summarised in Table 1 a comparison to each other in order to know the feasibility to achieve the consolidation of ESBO. It should be taken into account that the qualitative adjective used in the first column do not have the literal meaning but the grade of easy, difficulty or convenience to achieve such consolidation.

Table 1. Comparison of different Governance Options

Governance Option / Feasibility	Own Legal International Entity	ESFRI-Related International Entity	Inclusion in an Existing International Organisation	Inclusion in an Existing Observatory	Bi-/Multi Lateral Cooperation
Very good		✓			
Good			✓		✓
Neutral				✓	
Bad	✓				
Very bad					

6. SITE REQUIREMENTS AND CRITERIA

The site requirements described here are related to the payload or the gondola. It is foreseen that the launch and flight of the balloon including the recovery operation is handled by external providers. In case of a large program with many yearly flights it can be preferable to incorporate the balloon launch and flight organization within ESBO.

As the basic requirement is long total observation periods over the total year it will be necessary to use different sites at different locations to achieve this. This also gives access to different latitude observations.

For the preparation of the gondola and the onboard instrument an assembly hall is required that can handle the complete gondola including crane for lifting the gondola inside the hall. The environment shall be room temperature. It shall include working space and be able to accommodate up to 10 people for the assembly and testing of the gondola. It shall be able to accommodate a small operation center for operation of the gondola during tests and flight.

It shall be able to accommodate one coordinator for coordinating within the science team and with the balloon flight provider.

The assembly hall will be used for integrating and testing the gondola before flight but also for refurbishment of the gondola in the case of a re-flight after recovery.

For testing the pointing system, a possibility to hang the gondola freely with free view of the sky shall be available. It is also preferable that the gondola is protected from winds to avoid interference from the wind.

General accessibility to the site concerning transports and infrastructures such as hotels, restaurants, stores etc. is a large advantage concerning costs but also for shorter turnaround times for flights.

Clean room facilities might probably not be necessary as the telescope probably have to be operated outside in an uncontrolled environment for ground tests. It will probably necessary to have a procedure for cleaning the telescope at the site.

7. COST ESTIMATE FOR PREFERRED OPTIONS

Many different scenarios could be foreseen for different launch locations and different flight paths. In this estimation two different established locations have been selected considering possibility for longer flight periods. The two different sites, Esrange and Antarctica can also represent the lower and higher spectrum of foreseen costs for different launch sites. With Esrange representing the lower end of the cost spectrum. Due to easy access, existing and well-developed infrastructure etc. Antarctica at the other end of the cost spectrum due to its remoteness, lack of infrastructure and harsh environment etc. Other sites and flight paths will probably be placed somewhere in between these two options concerning costs.

For comparison it is also important to compare the cost per observation hour for different sites. If using the figures below for overall costs and flight hours the cost per observation hour is similar.

Flight hardware:

- Complete gondola with subsystems excluding telescope and instrument; 3
- Complete balloon flight systems; 3
- Spare parts on subsystem level for critical systems
- Telescopes and instruments

Baseline flight schedule:

3 summer flights from Esrange to Canada;	430 h	(3 x 6 days)
3 winter flights from Antarctica;	1400 h	(3 x 20 days)
Total estimated observation time:	**1830 h**	

The selection of the flight paths and duration are based on existing practice for long duration flights with existing zero pressure balloons. There could of course be other options concerning other locations to achieve long duration flights (> 6 days) such as circumpolar arctic flights, New Zeeland flights, flights over Sahara from the Arabic peninsula to Morocco, etc. None of these flight paths have been established on a regular basis. Some have been tested and some are only speculative. The major issues to establish regular flights are different for different places but includes the following; overflight and landing permissions (political and safety related), unfavorable and unpredictable weather conditions and wind patterns, landing and recovery possibilities. When or if new flight paths are established, they can of course be used in the future within ESBO. The cost for these flights will most probably not exceed the present flights at Antarctica, which might be used as an upper cost limit.

The second issue for long duration flights is the flight limitation of the zero-pressure balloon. Due to the day night variation in the environment the zero-pressure balloon loses the lift gas and ballast must be used (limited resource) during the flight. This sets limitation for flight duration. This is partly compensated by flying close to the pole during winter/summer when the day night variations are small. The flights are either performed in almost 24 hours of light or almost 24 hours of darkness. With the disadvantages of either disturbing sun radiations for the observations or lack of sun radiation for power. This can be compensated with super-pressure balloons that will not lose lifting gas and will not use any ballast. Resulting in much longer flights under alternating conditions. This makes this option much more flexible both from an observation point of view and flight location point of view. The super-pressure balloon has been under development for some time and has also been tested and used in some missions. It is not a well-established technique yet but will probably be in the future. One disadvantage is a higher price for the balloons that could be partly "compensated" by longer flights with the same balloons.

Below, Table 2 summarises rough cost estimation for an ESBO program including investments and running costs.

Table 2. Cost estimation for ESBO

Systems, support etc.	**units**	**Cost, k€**	**comments**
Gondola including pointing system and all subsystems	3	3 000	one time investment, 1 000 k€ per unit
Telescope	3	9 000	One time investment, 3 000 k€ average per unit
First light instruments	3	9 000	One time investment, 3 000 k€ per unit
Subsequent instruments	TBD	3 000	3 000 k€ per unit

Balloon flight systems	3	1 500	one time investment, 500 k€ per unit
Flight and recovery Esrange-Canada	3 per year	4 500 per year	3 balloon flights at the same campaign
Flight and recovery Antarctica	3 per year	12 000 per year	3 balloon flights at the same campaign
Support, refurbishment, maintenance etc. of gondolas		980 per year	4 persons + 300 k€ for direct costs
Support, refurbishment, maintenance etc. of balloon flight systems		540 per year	2 persons + 100 k€ for direct costs
Science operations		3 000 per year	
Science support		4 000 per year	

The cost sheet above does not include any investment in required infrastructure at Antarctica. Either existing NASA infrastructure is used or investment in new infrastructure is required.

The lifetime of the gondolas including subsystems and the balloon flight systems is not trivial to estimate but with a 10-year program the equipment will log a maximum of 20 flights each over the program. This might be possible considering the dedicated team and budget for repairs, refurbishment and updates.

A facility for storage and performing refurbishment, repair updates etc. with the hardware is also required and has not been included in the cost estimation. To reduce cost, it will of course be good to implement this facility at an already existing organization that is used to handle this type of tasks.

8. SUMMARY OF TECHNICAL OPERATIONS CONCEPT

The technical operations were described in section 4 of Deliverable D2.1. In summary, we described an operations concept establish to conduct regular flights (1+ per year), which include the recovery and exchange of instruments. This implies the possibility of flights from different existing locations. The access to those sites and technologies operated by external entities may become easier or harder depending on the governance setup. As an example, the Antarctic route, where an infrastructure exists in McMurdo, run by the United States Antarctic Programme / NASA. The location of McMurdo is perfect for balloon flights, since the inland location in the bay leads to little overflight over the ocean during a stable vortex. Whereas circumpolar flights around the North Pole require overflight rights over Russia. These are at the moment not granted to European teams. In such case, the inclusion of Russia as a partner of ESBO could be a chance for the access to this area.

On the other hand, we also described the possibility of transatlantic flights, from Kiruna to Canada, currently operated by the Swedish Space Corporation (SSC) and NASA. In the same way, we described the possibility of turnaround fights over Kiruna, operated by SSC; over Timmins in a base owned by the Canadian Space Agency (CSA) operated by the Centre national d'études spatiales (CNES), and circumglobal flights over Wanaka in New Zealand.

It should be taken into account that, for each of these long-distance flights and long-duration flights, the use of a large super pressure balloon (SPB) is required. The operations of these SPBs seems to be more complex than operations of zero pressure balloons (ZPB). Currently, only NASA is driving the development of heavy-lift SPBs via Raven Aerostar Co. Neither SSC nor CNES, which drive the European stratospheric balloon development, have plans to develop and operate large SPBs for the current projects.

9. OFFERED SERVICES BASED ON OPERATIONS OPTIONS

ESBO foresees different kinds of users with different degrees of involvement in the infrastructure, namely scientific users / groups that provide an own instrument ("PI instrument"), and users / groups that use observation time on instruments provided by the observatory operators ("Facility instruments"), or on PI instruments via open time access.

In order to facilitate the deployment of PI instruments, ESBO will provide support to the developing scientific groups. This concerns technical topics related to the connection of instruments to the gondola and telescope, including support systems, but also support for the development of hardware to operate under stratospheric conditions.

On the other hand, ESBO will offer support systems for instruments, including the observatory control computer, telemetry and telecommand (TM/TC), and data downlink through the service system, but also thermal control to a certain degree. Besides providing these systems themselves in a way in which they can support different instruments, the observatory organization will also need to provide support to the teams developing instruments on interfacing with the gondola, telescope, and support systems. This may include the need to provide adjustments to the support systems based on the particular needs of instruments.

Public and academic services are also foreseen for ESBO. This includes the provision of an extra load assigned for testing small technologies and small experiments proposed from academic institutions and/or private companies. This extra load will be independent of the main payload, offering around 4 kg for each experiment. The users of these extra services will not be limited to institutions from European member states, but it is particularly also foreseen to invite users from institutions and companies from developing countries.

All flight planning will be considered depending upon the science case: a) long duration flights, using conventional ZPBs, or b) ultra-long duration flights, using SPBs.

Given the aspired long flight times and comparably low, but non-negligible launch and flight costs, ESBO will aspire to operate with a high reliability. This holds true for the flight platforms, but also for the instruments. As most groups that may provide instruments will likely not have experience with building hardware for the high stratosphere, ESBO will provide support on designing for reliability under flight conditions in the high stratosphere. Providing good design guidelines will not only be important in order to ensure reliability, but also to avoid significant increases in development effort due to over-engineering, e.g. for space conditions. One way to provide these guidelines and to ensure reliability may be to offer flight worthiness certification from the side of ESBO.

Table 3 describes several services that can be provided directly by ESBO, or indirectly by a subcontractor, depending on whether it is included in an existing observatory, in an Agency, or in an international organization. Table 4 assumes all services described in Table 3, adding new services foreseen for the long term.

Table 3. Short-term services foreseen for ESBO, PI-driven phase and STUDIO flight.

Services	**Site**	**Description**	**Supplier**
General services: • Operation of balloon launch and flight • Operation of balloon gondola, including service systems, and telescope during flight • Operation of the main instrument during flight.	Artic	Circumpolar flights around the North pole	Private company such as SSC in Europe;
Tools and services for observers: • Provision of data during flight to the observer • Provision of calibration procedures and tools • Provision of validated data processing tools • Maintenance of a data archive • Provision of visibility calculation and observation preparation tools. • Provision of instrument-specific observation preparation tools, such as exposure time calculators.	ESBO Headquarters	Technical management	ESBO
Public and academic services: • Provision of flight opportunities for add-on payloads • Conduction of public outreach activities.	ESBO Headquarters	Outreach and testing of small technologies	ESBO; Public/private institution

Table 4. Long-term services foreseen for ESBO and PI-driven phase.

Services	Site	Description	Supplier
Flight facility services: • Operation of ground station(s) for balloon flights • Operation of a launch site • Operation of payload recovery.	Antarctica	Circumpolar flights around the South pole	NASA
Development and technical services: • Development and manufacture of gondola bus subsystems • Development and manufacture of payload subsystems (excluding instruments) • Provision of integration facilities • Provision of testing facilities	Europe	Research, development and Innovation of state of the art technologies.	Existing observatory or Agency with such facilities; Private company such as SSC
Tools and services for observers: • Provision of open observation-time access to the full community • Provision of validated data pipeline • Provision of validated data processing tools	ESBO's Headquarters	Technical management	ESBO
Extended services for observers / the community: • Development and construction of facility instruments	Europe	Research and development	Existing observatory or Agency with such facilities.
Services for Instrument PIs/Developers: • Design guidelines /requirements for instruments • Practical flight worthiness certification for instruments • Provision and operation of instrument, support systems, thermal mana- -gement, power, communication channel	Europe	Research and development	ESBO; PI Developer

10. CURRENT PREFERRED GOVERNANCE/OPERATION AND STRUCTURE OPTION

The operations of balloon launch facilities for the current ESBO *DS* and towards ESBO, may be established ideally for a period of ten years, as is depicted in Fig. 6. As we can see, ESBO *DS* started in 2018 and is planned to have a flight in 2021. Once the analysis of the first results and update of the recovered payload are done, the platform might assume continuous operation with one flight per year. It should be taken into account that at least two flight more should be good enough for getting expertise in both scientific and technical operations, which turn to be essential for building and increasing the capabilities of the ESBO's team to run a balloon-based observatory. After that, ESBO may provide opportunities for observation calls to the astronomical community, even more, ESBO may provide opportunities to change new instruments every two years. The inclusion of balloon flights operation within the ESBO organization tends to procure this services from external companies that include launch facilities.

Whereas the ESBO program advance with a small telescope of 0.5 m, a new design for the 1.5 m telescope could be started around 2021. Thus assuming the inclusion of ESBO in one of the options mentioned above, such as an existing international organization, agencies, observatories or even better by selection into the programs of the ESFRI Roadmap 2021. This last option might provide an opportunity for starting the development of a new European Research Infrastructure. According to this scheme, the first flight for the 1.5 m telescope could be in 2025. At that time, ESBO could start designing the 5 m telescope, whose first flight could be in 2030. In this way, after ten years ESBO might turn to a Landmark, as expected for the ESFRI programmes.

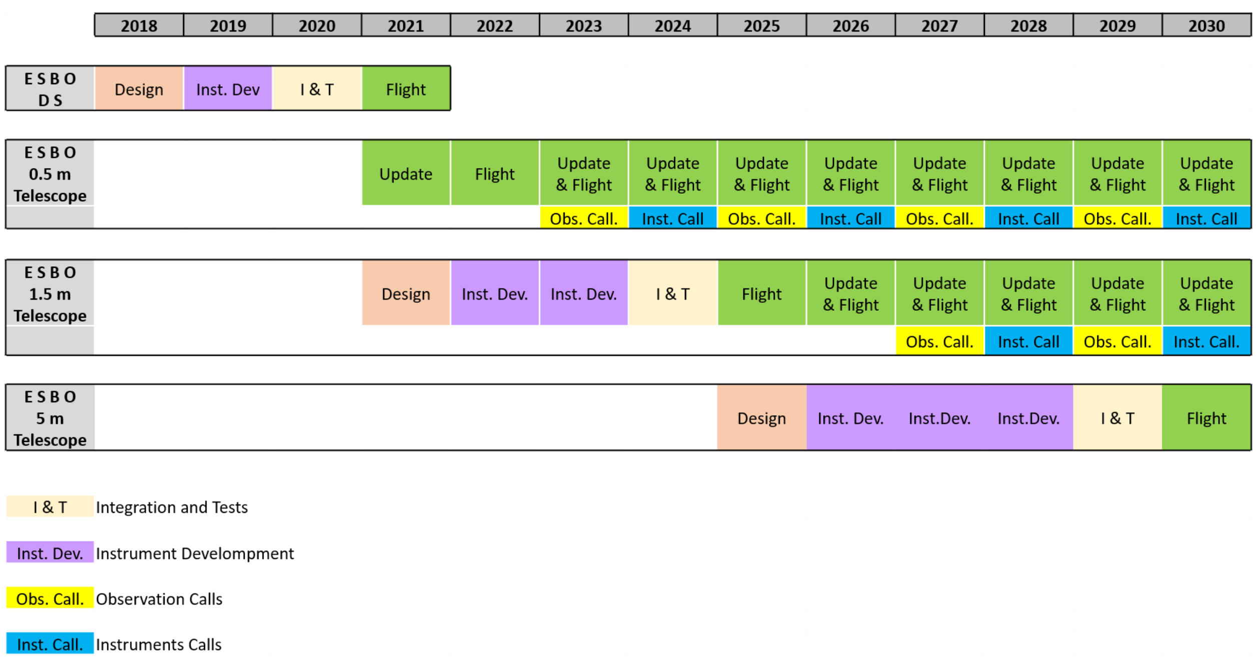

Fig. 6. Schematics for the ESBO`s flight program.

11. CONCLUSIONS

Several governance and operation structures concepts and options were described in this document. For our purposes, the consolidation of ESBO as International Research Infrastructure could be estimated to achieve it in around ten years. We have considered both, advantages and disadvantages for each option, from the establishment of ESBO as an own legal entity up to its inclusion in an international organization. We have taken into account the difficulties to obtain funding, especially for conducting regular flights annually. One of the most convenient ways to achieve our goals, might be by acceptance into the ESFRI Roadmap Programmes, since it establishes a coordinated planning of the lifecycle approach for each project from the development concept up to its termination in a period of ten years, thus converting such project as a landmark infrastructure.

ESBO could be considered in the state-of-the-art as one of the next generation of European astronomical infrastructures designed for long term research from the high stratosphere. This could provide large scientific and technological impact, not only for the astronomical community but also for multidisciplinary areas including technologists and outreach for all kind of societies. It also procure services for academics and particular enterprises from developing countries for testing small technologies.

The development of European super pressure balloons capabilities could turn to open new opportunities not only for European community members but for all countries that require this kind of services. In addition, it also could open new collaborations and strengthening of scientific ties with Russia for planning circumpolar flight routes for astronomical observations, and even more to maintain potential collaborations with the European FIR community.