

# Way forward for the Athena mission: the definition of NewAthena

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## Introduction

On the occasion of the June 2022 SPC workshop Delegations unanimously stated not to support the adoption of the Athena mission in 2023 at the currently estimated CaC of 1.9 B€ (2022 e.c.). Much discussion took place at the workshop concerning “what next”, with many delegations expressing their clear wish to see a flagship-class “Large X-ray mission” capitalizing on the technologies developed by ESA and on the national investments performed in the context of Athena, to be a part of the Programme in the near future. Such mission is indicated for brevity in the rest of this White Paper as “NewAthena”.

It was clear to all Delegations that NewAthena will have to be significantly less expensive than Athena as currently defined (in June 2022). Following much discussion at the workshop, an indicative cost ceiling for such mission of 1.3 B€ was proposed by the Executive (with the same ceiling to be used for the LISA mission), and supported by all Delegations present for the definition of NewAthena.

The discussion that took place at the workshop showed that there’s no “obvious” mission that can meet such cost cap and still meet all the ambitious requirements of Athena and that the definition of this mission will need significant work by all stakeholders (i.e., the involved scientific community, the Executive, and the national funding agencies, together with the international partners), including engineering studies.

Delegations suggested a number of possible elements of a way forward that would lead to a NewAthena. While a number of different points of view were present at the workshop, the Executive felt that the common point among the different positions was that NewAthena should to a maximum possible extent capitalize on the significant investment made by all stakeholders in the preparation of Athena. Such mission is described in the following as the “minimum disruption mission” (MDM in brief), i.e., one that is closest to the current Athena configuration while satisfying the financial constraints and being scientifically “flagship class”. The present document spells out the planned steps and the action for the foreseeable future (i.e., approximately a one-year horizon), bearing in mind that most likely the steps herewith described might need to be adapted in light of discussions still to be held with stakeholders.

## Guiding principles

The goal of the NewAthena activity is the definition of a new X-ray observatory mission that

- 1) can be implemented within the target ESA CaC of 1.3 B€;
- 2) is considered by the Advisory Structure and by the SPC to be a “flagship-class” mission;
- 3) makes use insofar as possible of the technologies developed by the different stakeholders for the preparation of Athena.

Point 1) above spells out the affordability within a diverse Science Programme in view of the current and expected Programme income; it may be necessary to revisit point 1) in light of the CM22 settlement.

Point 2) is admittedly somewhat ill-defined and a matter of judgement, by the Advisory Structure first and by the SPC (who will have the last word) subsequently. Given the assessment of the Athena Independent Science Review (see below) it’s likely that, in spite of the unavoidably reduced mission performance, the science case can be “enriched” by taking stock of the recent exiting developments in the fields of astrophysics addressed by Athena.

Point 3) recognizes the significant investments all stakeholders have made in the preparation of Athena, and recognizes the wish to capitalize on them to explore the feasibility of a MDM

related as much as possible to Athena in its current configuration. Point 3) will have to be applied with some flexibility, to avoid to over-constraining the exercise, making it impossible to achieve a mission configuration that will satisfy the cost constraint (point 1).

While one could define a mission fitting the 1.3 B€ target relatively easily, the challenge is to do so while retaining the flagship-class science. As already mentioned in the White Paper and at the workshop the cost is largely driven by the X-IFU instrument, for which most of the cryogenic chain would need to be provided by ESA. The only likely path forward the Executive foresees is a mission with a significant simplification of its focal plane instrumentation, in particular with a much simpler cooling chain, and a likely reduced telescope aperture. Some simplification will likely need to be introduced also in the WFI instrument. Thus, while the “MDM exercise” will aim at retaining current investment, the reduction in ambition will need to be significant.

As a consequence, the science case of NewAthena will by necessity be different than Athena’s, both because of the different (less ambitious) mission configuration. In addition, this will be the appropriate time to evolve the science case of the mission in the light of the progress in astrophysics since the definition of the science case of Athena. The definition of NewAthena is likely to require some creative, “out of box” thinking, and over-constraining the process, by prescribing in advance the science case, is unlikely to help to converge to a mission that is both significantly less expensive and yet scientifically highly compelling, as mentioned above by also taking stock of the evolution of the fields of astrophysics addressed by Athena, and mentioned by the Athena Independent Science Review.

As a side line, the Executive is implementing in parallel a comparable exercise for LISA, aiming at bringing the ESA CaC back to same 1.3 B€ ceiling as Athena.

## **Partners in the definition of NewAthena**

The Executive sees the following partners in the process that will lead to the definition of NewAthena

- 1) The two extant instrument consortia;
- 2) A renewed “Science re-definition team”;
- 3) National funding agencies;
- 4) International partners;
- 5) The ESA study team.

### **The instrument consortia**

The two consortia (for WFI and for X-IFU) are key partners in the Athena mission, and their role is essential in the definition of the minimal disruption NewAthena. While the NewAthena mission will aim at preserving the instrumentation concepts of Athena, in the spirit of protection of the extant investment, the “newWFI” and “newX-IFU” concepts will have to be modified, possibly significantly, likely resulting in more modest performance. Their redefinition should and can only be carried out by the extant consortia, with the Executive available to support the process. The Executive will therefore interface for this purpose (exclusively) with the two instrument consortium leaders (D. Barret and K. Nandra), with both teams needing to perform the necessary engineering activities.

### **The science re-definition team**

The extant Athena Science Team is largely composed of scientists strongly linked to one of the two consortia. Following also a statement made by the SSAC, the Executive considers it

important to bring in fresh views to look at NewAthena. The Athena Independent Science Review ([AISR](#)) team chaired by M. Cruise led to very useful insights about the current state of the Athena science as well as recommendations for its further development, and the Executive plans to continue to rely on the advice and on the insight of a refreshed version of this team.

The first step will be to dissolve the extant Athena Science Team, that, with the SPC decision not to follow with the adoption of Athena in 2023, no longer has a function. To augment the science-redefinition team under the responsibility of M. Cruise the Executive will issue as soon as possible an open call, inviting interested scientists to apply for membership in this team. While the intention is to recruit insofar as possible younger, early-career scientists, applications will be fully open, with the only limitation of substantial independence from the extant instrument consortia (i.e., scientists who have a substantial, management-type role in the extant consortia won't be considered eligible, their inputs being channeled through the consortium leaders, see above).

NASA and JAXA will be invited to appoint one scientist each to this team.

### **National funding agencies**

The interface with national funding agencies will be a key element of the process, as the result of the NewAthena exercise must include a “proto-MLA” with clearly defined and costed nationally contributed elements, and explicit preliminary commitments by the Member States. The Executive will thus interface with the SPC delegates of the Member States that are currently involved in the funding of the current consortia, to ensure both interest and affordability for the nationally funded elements of NewAthena.

Member States not currently funding elements of Athena that might be interested in participating to NewAthena are invited to contact the Executive.

### **International partners**

The Executive has kept NASA and JAXA constantly informed of the developments around Athena. Both have expressed an interest in the being part of the NewAthena exercise, although neither can commit to a contribution prior to having seen what the configuration of NewAthena will be. Both agencies will be invited to appoint a contact point for the exercise, in addition to the discussion at higher management level through the customary SCI-C channels.

### **ESA study team**

The Executive will support the NewAthena exercise with a dedicated engineering team, largely composed of engineers with relevant expertise who have worked on the definition of Athena, augmented with additional expertise. The Athena study scientist will support the NewAthena exercise and will, together with the astronomy coordinator, support the interface with the scientific community through the science re-definition team.

### **The minimally disrupted mission**

The first iteration will see the attempt to define a minimally disrupted mission (MDM) that, while achieving flagship-class science and satisfying the cost constraint mentioned above, departs as little as possible from the current configuration of Athena. Such mission will be pursued through TBD reductions of the performance and complexity of the instrument and of the mirror, while retaining their basic technology insofar as possible. The science case for

the mission will need to be modified to reflect the new, less ambitious instrumental configuration. While this approach is the one more conducive to protecting the extant investments, the Executive is not in a position to guarantee at the current stage that such a mission exists (i.e., that a mission obtained by “shrinking” the current Athena to fit into the 1.3 B€ constraint will still achieve flagship-science – although this will also depend on the additional, new science that can possibly be addressed by the NewAthena mission).

## **Steps in the definition of NewAthena**

The definition of NewAthena will by necessity be an iterative process, with some of the steps taking place in parallel, and some of the later step currently only partially defined (as their execution will depend on the outcome of the earlier steps).

The currently foreseen steps are:

- 1) Analysis of possible reduced instrument configurations;
- 2) Assembly of the science re-definition team;
- 3) Consultation with international partners;
- 4) Consultation with national funding agencies;
- 5) Definition of a minimal disrupted mission;
- 6) Consultation of the Advisory Structure and of the SPC.

### **Analysis of possible reduced instrument configurations**

For this first step, that can and should take place immediately, the two consortium leads are invited to contact the Executive to discuss whether they see significant reduction in instrument performance (e.g., the instruments’ field of view, energy resolution, etc.) that can lead (obviously with a performance impact) to significant reductions in the ESA CaC, (to be assessed by the ESA engineering team). The Executive welcomes the discussion, and will analyze, insofar as possible, the proposed alternative configurations, with the aim of determining the cost impact at system level and in particular on the ESA CaC. While this step should start as soon as possible (the initiative resting with the consortium leads), the analysis may require some time and, depending on the proposed change, some internal analyses and possibly iterations following an assessment of the scientific performance. It is foreseen that this step may require 3 to 5 months (depending on the number of iterations needed). At this point, assuming a credible configuration emerges for NewAthena, the Executive foresees to consolidate the work with focused industrial studies, which may take typically another 6 months.

### **Assembly of the science re-definition team**

The Executive will soon issue an open “AO” for membership in the “science re-definition team”. The new team should be in place by September 2022.

### **Consultation with international partners**

The Executive will immediately start to discuss with NASA and JAXA their level of commitment in the NewAthena exercise, their possible contribution, etc. Possible evolution in the interests of the international partners may obviously affect the outcome of the exercise.

### **Consultation with national funding agencies**

The Executive will start a consultation with all currently involved funding agencies, to ascertain their continued commitment to the mission and what possible changes to their nationally provided elements would they be willing to entertain.

### **Definition of a minimal disrupted mission**

Armed with the outcome of the previous steps, and in consultation with all the stakeholders, the Executive will take it upon itself to attempt to define a viable MDM profile. Once more, there's no guarantee at the present time that such mission will exist, and the possibility that the first iteration of the exercise, based on the constraint of minimal disruption, may not converge is real. At the same time the answer to the question of whether such mission profile exists can only come from the exercise herewith described.

While the definition of the mission profile will be based on interaction with all the stakeholders, to ensure adherence to the CaC ceiling the configuration of the mission will remain under the responsibility of the Executive. The Executive will maintain all stakeholders informed, both through the regular reporting to the SPC and through ad hoc information sessions that may be organized as necessary.

The Executive assesses that the outcome of this first iteration of the exercise should be available towards the end of 2023. The SPC and the SSAC will be continuously informed of the progress status through the regular communication channels at the SPC meetings. Should the Executive consider at any time through the process that no viable minimal disrupted mission is likely to exist, the SPC and all stakeholders would be informed immediately, and the SPC consulted about the following steps.

### **Consultation of the Advisory Structure and of the SPC**

Once a minimal disruption mission has been defined by the Executive, the Advisory Structure would be requested to issue a statement concerning its scientific value and in particular whether the resulting mission is “flagship class” (and thus whether it could recommend its adoption to the SPC).

Following this step, the Executive will present the outcome of this activity to the SPC, possibly with a proposal for the way forward for the mission (i.e., the mission's possible adoption, etc.).

### **Possible outcomes and follow-on steps**

Given that the Executive is at the current time unable to assess whether the MDM definition exercise that is proposed in the present paper will converge on a viable, scientifically appealing mission, it is difficult to define the follow-on steps reliably, and the possible outcomes and follow-on steps have to remain somewhat speculative. Plan A is based on the MDM being identified and being scientifically compelling. Plan B would kick in in case Plan A were to prove not feasible.

#### **Plan A: A minimally disrupted mission profile is identified**

If the exercise described above results in a viable MDM NewAthena that the Advisory Structure considers of “flagship scientific quality” the Executive would present the SPC a description of the mission, together with a possible timeline for its implementation. The SPC would in this case have to discuss how to insert such mission in the Programme, also in relationship to LISA and to the need for the Programme, as stated during the June 2022 SPC workshop, to adopt a Large mission in 2023. The details will depend on the actual structure of the resulting mission, its technological readiness, and the detailed definition work to be done for enabling the mission adoption both by industry and the instrument consortia. The possibility of an accelerated phase A/B1, with a typical duration of 1-2 years, will be analyzed

in due time. The process would eventually result in an SPC vote about the adoption of NewAthena in the Programme.

**Plan B: No minimally disrupted mission identified**

It is possible that the first iteration of the MDM NewAthena exercise may not converge, either because no such mission can be identified within the cost ceiling, or because the resulting mission is not considered as sufficiently compelling for a flagship mission.

In such case the Executive would re-examine the situation with the SPC, in light of 1) the outcome of the exercise aiming at identifying a minimally disrupted mission, 2) the Programme's financial situation (in particular the outcome of CM22), 3) the interests of Member States.

The Executive considers it premature to discuss what the possible way forward might be in such case, given the many factors that would affect the decisions to be taken (including, e.g., the status and maturity of LISA for an adoption in 2023, that would be much clearer in about a year from now).