EUROPEAN COMMISSION

Community Research

SEVENTH FRAMEWORK PROGRAMME

TEMPLATE FOR THE TECHNICAL REVIEW REPORT

The template hereafter provides the structure for the technical review report that needs to be prepared by the expert(s) after the review.

For the projects managed by DG RTD and DG ENTR and the Research Executive Agency (REA), technical review reports have to be completed and submitted only via the specific IT reporting tool system (so-called SESAM). A "quick guide" explaining how the users can use this specific IT reporting tool is available at the following address: http://webgate.ec.europa.eu/sesam.

If the expert feels that he/she does not have the competence or the information to answer a question, he/she must declare it in the corresponding sections.

TECHNICAL REVIEW REPORT

Grant Agreement number:	**606740**
Project Acronym:	**GENIUS**
Project title:	**Gaia European Network for Improved data User Services**
Funding Scheme:	**Collaborative Project**
Project starting date:	**01/10/2013**
Project duration:	**42 months**

Name of the scientific representative of the project's coordinator and organisation: **Dr. Xavier Luri**, **Universitat de Barcelona, xluri@am.ub.es**

Project web site: **http://genius-euproject.eu/** **http://gaiaverse.eu/**

Type of technical review:

☑ Periodic regular/foreseen technical review

☐ Unforeseen Technical Review

Period covered by the review report: from **01/10/2015** to **31/03/2017**

Date, place of review meeting: **19/04/2017**, **REA HQ Brussels**

Name of expert: **Dr Patrick Moriarty**

Expert drafting the report: **Dr Patrick Moriarty**

☑ Individual report

☐ Consolidated report

Name of the Project Officer: **Dr Giuseppe G. Daquino**

1. OVERALL ASSESSMENT

a. Executive summary

Comments, in particular highlighting the scientific/technical achievements of the project, its contribution to the state of the art, and its impact:

The GENIUS project is not a stand-alone effort, and its level of success must be viewed in the context of the endeavour it was designed to support, namely ESA's Gaia mission. Gaia is one of Europe's most significant space missions ever. Its goal of obtaining precise astrometric and photometric characterisation of more than a billion celestial objects is hugely ambitious, but it is essential that the data obtained are readily accessible to the widest possible audience, otherwise the mission legacy is just a vast accumulation of numbers. The task of processing and analysing the Gaia data was undertaken by a pan-European group, the Data Processing and Analysis Consortium (DPAC) comprising almost five hundred members, with a specific subgroup, Coordination Unit 9 (CU9), devoted to designing, implementing and operating the Gaia data archive. The GENIUS project was conceived within this framework with the aim of delivering the infrastructure and tools to provide external users with easy and comprehensive access to the archived data, thereby providing the crucial link that facilitates the transformation of Gaia data into scientific results.

In this context, the GENIUS project as a whole has been extremely successful, delivering effective visualisation and analysis tools built on a solid infrastructure transparent to the external user. The system has already demonstrated its value in dealing with the first official Gaia data release (GDR1), and the project leaves a legacy which will allow future Gaia data releases to be fully exploited.

GENIUS contributed to the design and implementation of the archive infrastructure. Archive design was predicated on the real needs of users as established by a comprehensive requirements-gathering exercise conducted as part of the project. The physical Gaia archive is located at ESA's European Space Astronomy Centre (ESAC), and particular effort has gone into ensuring that the GENIUS implementation is compatible with ESAC protocols.

An obvious impact of GENIUS can be seen in the data-access tools provided for the external user. The volume and complexity of the Gaia data mean that a visual exploration facility is essential, and GENIUS has delivered an effective user-friendly interface for this. Standard access methods (query forms, command line, TopCat) are also provided. The interface is fully Virtual Observatory (VO) compliant, and GENIUS has provided new VO tools as well as enhanced existing ones. Some progress was made in the development of data-mining tools.

GENIUS made a crucial contribution to validation of archive data, delivering a suite of methods and tools which have already been employed to validate the GDR1 data, and which are also being used for scientific analysis. The validation

procedures are now an integral part of CU9 and will form the basis for validation of future data releases. Part of the validation process involves comparison of the observed data with expectations derived from simulations. The GENIUS project has provided appropriate simulated catalogues, which are incorporated into the main archive and are also available at other sites.

GENIUS was also responsible for developing interfaces to connect real-time classification of events with the main Gaia data products, forming the basis for the very effective Gaia Science Alerts programme.

In addition, the project contributed substantially to the archive documentation and to dissemination of information regarding the Gaia mission. In particular, the gaiaverse.eu web portal is fully operational, delivering relevant content in thirteen different languages.

From an overall perspective, the work carried out was largely in line with the original proposed 'Description of Work' (DoW) and progress for the most part was excellent. A small number of aspects which were not completely satisfactory are discussed in Section 2, but it must be stressed that none of these impacts significantly on the core objectives of the project. All project milestones were successfully reached. Most deliverables were submitted in timely fashion, and where delays did occur, these were all made good before the end of the project. The final project report constitutes an accurate and balanced description of the status and achievements of GENIUS.

The project was well managed and coordinated throughout. The Consortium performed very effectively and displayed an admirable level of cohesion. Cooperation between the GENIUS Consortium and the wider Gaia Consortium, especially the coordination with DPAC CU9, was excellent. The project also interacted well with the various national Gaia communities, the Japanese teams involved in the JASMINE series of missions, and the External Advisory Board.

☐ Excellent progress (the project has fully achieved its objectives and technical goals for the period or has even exceeded expectations).

☑ Good progress (the project has achieved most of its objectives and technical goals for the period with relatively minor deviations).

☐ Acceptable progress (the project has achieved some of its objectives; however, corrective action will be required)

☐ Unsatisfactory progress (the project has failed to achieve critical objectives and/or is not at all on schedule).

b. Overall evaluation

The project has achieved all of its major objectives and technical goals, with only relatively minor deviations.

2. OBJECTIVES and WORKPLAN

a. Progress towards project objectives: Have the project objectives been achieved? In particular, has the project as a whole made satisfactory progress in relation to the Description of Work (Annex I to the grant agreement)?

✔		
Yes	Partially	No

Comments

The project objectives have been largely achieved. In the context of the original *Description of Work*, the progress made by the project as a whole has been excellent, with all of the core aims achieved very satisfactorily.

b. Progress in individual work packages: Has each work package (WP) made satisfactory progress in relation to the Description of Work (Annex I of the grant agreement)?

✔		
Yes	Partially	No

Comments

In general, the progress in the individual work packages within the project was excellent. All essential tasks were completed, and there are only a few minor issues which are detailed in the discussion below.

- **WP1** – *Management*: See Section 4 below.
- **WP2** – *Tailoring to the end-user community*

  The requirements-gathering exercise led to consolidated list of user requirements for the Gaia archive. Most of the desirable features were already implemented for GDR1, and the beta-test infrastructure is firmly in place for GDR2 and beyond.

  The aim of providing for interaction with the Gaia data in sophisticated ways in order to allow for testing of complex models is one area where progress was not entirely satisfactory. However, valuable lessons have been learnt from what was a very ambitious undertaking, and the limited progress does not significantly detract from the success of the project as a whole.

  Progress in providing for seamless data retrieval across archives and wavelength domains was excellent, delivering state-of-the-art cross-match algorithms and precomputed cross-matches with large astronomical catalogues, a feature that was well received by the community for Gaia DR1.

  The requirements for incorporating "living archive" features were investigated and documented, but it was decided not to pursue this initiative for the current Gaia archive.

  The issue of preserving raw or intermediate data and relevant documentation to allow for future reprocessing was investigated; the resulting analysis provides a good starting point for discussions concerning long-term preservation of Gaia data and ancillary software.

- **WP3** – *Archive system design*

  The work carried out in this WP was excellent, even though not all of the objectives were fully achieved. The aim of the WP was to develop aspects of the archive infrastructure required for effective scientific exploitation of Gaia data. Design features were dictated by user requirements, constraints arising from the need to interface with the ESAC archive system, and a core philosophy of adhering to Virtual Observatory (VO) standards.

  A key element in the definition of the Gaia data model is the DPAC Database Dictionary Tool. An enhanced version of this tool was developed which greatly facilitates information flow using VO protocols. The GENIUS team also implemented features such as TAP/ADQL autocompletion and enhancements to the ADQL parser implementation, and has laid the foundation for implementation of the next version of the ADQL standard. The formal VO-compliance document reports excellent VO compliance of the Gaia archive.

  GENIUS designed and implemented a prototype DQP subsystem that can be deployed securely at any data centre. The GENIUS prototype demonstrator, a test suite for beta and stress testing TAP resources, was developed and tested, with the aim of presenting it for inclusion on the Gaia Archive Server.

  One of the more ambitious objectives of the GENIUS proposal was to develop in the European context a CANFAR-style environment for cloud-based research and data mining. In the event, this avenue was not pursued. Instead, the GENIUS effort was devoted to investigating operating system level virtualisation, specifically the Docker containerisation system, as a vehicle for deployment of astronomical software, demonstrating its use by successfully containerising several deliverables. The detailed report on this investigation should prove very useful for future work in this area.

- **WP4** – *Tools for data exploitation*

  The objective of this WP was to provide visualisation, data-mining and VO tools, and the progress in most respects has been excellent.

  This WP is responsible for the iconic image of the Galaxy based on GDR1. A web-based interface allows the user to explore this image, plot various histograms and 2D graphs characterising the data, generate ADQL queries, and use Aladin Lite and js9 plug-ins. The range of options currently available is rather limited, and while it is planned to expand the options in preparation for Gaia DR2, such enhancements are beyond the scope of this report.

  An upgraded data-mining testbed system, which allows for large-scale testing, was deployed at CSUC. The VO SED analyser, VOSA, has been substantially upgraded and adapted to access Gaia photometry data.

- **WP5**: *Validation*

  The objective of this WP was to develop appropriate methods and tools for testing archive data to ensure suitability for publication. Based on actual needs and on the characteristics of the archive, a comprehensive battery of tests was developed to validate the internal consistency of the data, to compare them with external catalogues and with model predictions, and to identify outliers, artefacts and selection effects. All high-priority tests (and some lower-priority ones) were applied to the data from GDR1, and test reports and filtering recommendations were generated as a result. This was a

very successful exercise, with results already published. The validation procedures are now part of CU9 and will form the basis for validation of future data releases. The methods and tools developed are also being used to generate scientific results from the data. In addition, comparisons between the Gaia validation experience and the requirements for the data from the nano-JASMINE/Small-JASMINE/JASMINE missions will be of mutual benefit.

- **WP6**: *Simulations, Science Alerts*

  Part of the validation process involves comparison of the observed data distributions with expectations derived from simulations based on a realistic model of the Galaxy. The GENIUS project generated appropriate simulations of the Gaia catalogue, and these have been incorporated into the main archive as well as being available at other sites.

  Testbed work for the Gaia Science Alerts system was carried out as part of the GENIUS project, developing the interfaces required to connect real-time event classification with the main Gaia data products. The GENIUS alerts prototype began releasing photometric alerts in early 2016, representing the first public data from the Gaia mission.

- **WP7**: *Dissemination*

  The dissemination policy adopted by the Consortium is generally appropriate and involves a range of initiatives. Details are given in Section 5c below.

c. Milestones and deliverables: Have planned milestones and deliverables been achieved?

✔		
Yes	Partially	No

Comments

Milestones: All milestones specified for the project were reached satisfactorily, albeit with delays in a few cases as noted below.
During the first year of the project, the first seven milestones MS1-MS7 were passed successfully. MS8-MS12 were scheduled for the second year. MS10 and MS11 were reached satisfactorily. MS8, which corresponds to Deliverable 1.5, was delayed by four months – see note in Deliverables table below. MS9 (user prototype archive review) and MS12 (prototype archive tools open to the community) were originally set for October 2015 but were postponed to take account of the delayed issue of GDR1; both of these milestones were achieved in January 2017 without any adverse effect on the satisfactory completion of the project. The remaining five milestones, MS13 (stress test), MS14 (loading of actual Gaia data), MS15 (completion meeting and final external review), MS16 (GENIUS products available) and MS17 (GENIUS portal handed over to the Gaia community), were all reached before the formal end of the project.

Deliverables: The proposed deliverables were generally made available in a timely manner. During the course of the project, there were delays in a number of cases, but none of these was critical and all were made good before the end of the project. Ultimately, all deliverables were in place before the project formally ended and can be recommended for approval.

DELIVERABLES LIST STATUS Shaded entries have already been approved; remarks in those cases are from previous technical review reports.			
No.	**Title**	**Suggested Actions (Approve/Reject)**	**Remarks**
1.1	Kick-off meeting (plenary)	Approved	
1.2	Semestral Report 1	Approved	
1.3	Semestral Report 2	Approved	
1.4	Semestral Report 3	Approved	
1.5	Midterm meeting (plenary)	Approved	Delay to 20/11/2015 agreed at first-year review; approved 27/04/2016.
1.6	Semestral report 4	Approved	Delivered 28/10/2015; delay due to confusion re need for separate semestral report.
1.7	Semestral Report 5	**Approve**	Delivered 04/05/2016
1.8	Semestral Report 6	**Approve**	Delivered 20/01/2017
1.9	Completion meeting (plenary)	**Approve**	Meeting agenda and report provided.
1.10	External Advisory Board report	**Approve**	Sound endorsement of the project by EA board.
1.11	Gender balance report	**Approve**	Detailed analysis of status.
2.1	Requirements specification for catalogue and archive	Approved	
2.2	Requirements specification for outreach within archive	Approved	In same document as D2.1.
2.3	Requirements specification for generic projection module	Approved	Delivered 06/10/2015 instead of 01/04/2015.
2.4	Requirements specification for data retrieval across archives	Approved	Delivered 01/10/2015 instead of 01/04/2015.
2.5	Conclusion of requirements update gathering exercise	Approved	Deliverable status satisfactory as of 05/11/2015.
2.6	Requirements specification for incorporating new information into archive	**Approve**	Document detailing essential requirements for building a “living archive”.
2.7	Requirements specification for archiving of raw and intermediate data	**Approve**	Delivered 20/01/2017; late but non-critical.
2.8	Requirements specification for archiving of software	**Approve**	Delivered 20/01/2017; late but non-critical.
2.9	Requirements specification for model comparison and optimisation tools	**Approve**	Implementation not as comprehensive as planned. Delivered 02/03/2017

3.1	GENIUS/ESAC-SAT CIC document	Approved	No mention of GENIUS.
3.2	Web2.0 user interface demonstration prototype deployment	Approved	
3.3	Gaia data IVOA compliance document	**Approve**	Excellent VO compliance of Gaia archive.
3.4	Web services deployed, code and documentation	**Approve**	Satisfactory deployment of services, excellent report.
3.5	Data centre report and analysis document	**Approve**	Very good documentation.
3.6	TAP+ code and documentation	**Approve**	TAP over Firethorn implemented; associated documentation delivered.
3.7	VM environment deployed, reports and documentation	**Approve**	Approach not as originally planned, but very valuable exercise.
4.1	Requirements specification for exploitation tools	Approved	
4.2	First prototype of exploitation tools	Approved	Sketchy, but deliverable is prototype rather than text.
4.3	Second prototype of exploitation tools	Approved	No mention of GENIUS in deliverable documentation.
4.4	Third prototype of exploitation tools	**Approve**	Visualisation tools and GDAF data-mining platform.
4.5	Exploitation tools manuals and documentation	**Approve**	Very thorough manuals and documentation.
4.6	Deployment of exploitation tools on actual Gaia archive	**Approve**	Final tools effectively delivered on time.
5.1	Prototype of internal checking tools	Approved	Delayed 2 months due to personnel change.
5.2	Prototype of statistical tools	Approved	Delayed to 04/05/2016, but no knock-on effect on D5.4.
5.3	Delivery of internal consistency checking tools	Approved	Task completed on schedule; documentation submitted 28/10/15.
5.4	Delivery of statistical tools	**Approve**	Statistical tests applied on GDR1, validation test report (VTR) presented.
5.5	Delivery of model-based validation tools	**Approve**	Model-based tests applied on GDR1, VTR presented.
5.6	Delivery of prototype external validation tools	Approved	
5.7	Delivery of external validation tools	**Approve**	GDR1 validated against TGAS, IGSL, Hipparcos; VTR presented.
5.8	Delivery of special object tools	**Approve**	Validation of GDR1 using variables, multiples, clusters. Excellent documentation submitted 20/01/2017.

5.9	Deployment of validation tools on the Gaia archive	**Approve**	Includes A&A publication on GDR1 validation tests. Delivered on time.
6.1	First simulated catalogue data	Approved	No mention of GENIUS.
6.2	Public science alerts, first prototype	Approved	
6.3	Second simulated catalogue data	**Approve now**	Delayed to 2016; delivery to be notified. Catalogue issued April 2016.
6.4	Public science alerts, second prototype	Approved	
6.5	Third simulated catalogue data	**Approve**	Delayed because of agreed delay to D6.3; delivered to coincide with Gaia DR1.
6.6	Public science alerts, third prototype	**Approve**	Basis of excellent Gaia Science Alerts system.
7.1	Community portal internally available	Approved	
7.2	First public version of community portal	Approved	
7.3	Upgraded public version of the community portal	Approved	Delivered ahead of schedule.
7.4	Final version of community portal and handover to Gaia community	**Approve**	Excellent facility, delivered on time.

3. RESOURCES

a. Assessment of the use of resources : To the best of your estimate, have resources used, i.e. personnel resources and other major cost items, been (i) utilised for achieving the progress, (ii) in a manner consistent with the principle of economy, efficiency and effectiveness[1]. Note that both aspects (i) and (ii) have to be covered in the answer.

i

✔ Yes	Partially	No

ii

✔ Yes	Partially	No

Comments

In the light of the information provided via the project reports and presented during the final review meeting, and taking into consideration the procedures followed and the progress achieved, I am confident that

(i) the resources provided to the project (personnel and other major cost items) have been used wholly and exclusively to effect the progress reported in achieving the project objectives.

(ii) the resources have been managed effectively, distributed efficiently and used with the due concern for economy; there is no evidence of any unjustified or excessive expense.

A final financial report was not yet available at the time of writing this report. However, on the basis of the provisional numbers presented at the final review meeting, it is clear that, overall, the resources have been deployed appropriately to support the work performed. The progress and results achieved have been outstanding and represent excellent value for the funding invested.

The principles of economy, efficiency and effectiveness: refers to the standard of "good housekeeping" in spending public money effectively. Economy can be understood as minimising the costs of resources used for an activity (input), having regard to the appropriate quality and can be linked to efficiency, which is the relationship between the outputs and the resources used to produce them. Effectiveness is concerned with measuring the extent to which the objectives have been achieved and the relationship between the intended impact and the actual impact of an activity. Cost effectiveness means the relationship between project costs and outcomes, expressed as costs per unit of outcome achieved. Guide to Financial Issues, Version 30/06/2010p.37.

b. Deviations: If applicable, please comment on large deviations with respect to the planned resources.

Comments

No significant deviations are evident compared with the original plans, though there were a number of minor adjustments in the allocation of resources.

- A small amount of funding not required for software licences was reallocated to allow for two initiatives: upgrading of the data-mining testbed at CSUC, and development of the archive documentation system to ensure that adequate documentation was in place ahead of GDR1. Both of these adjustments are entirely appropriate and represent a very sensible use of the available resources.

- With the withdrawal of CSIC from the Consortium, the outstanding funds for this beneficiary were reallocated to University of Barcelona (see detailed discussion in Section 4a below).

- Some resources were redeployed from WP3 to WP5 because of the unavailability in GDR1 of data for solar system objects, and some of the effort (and associated resources) for VO tools was moved from WP3 to WP4.

4. IMPLEMENTATION OF THE PROJECT

a. Management: Has the project management been performed as required?

✔		
Yes	Partially	No

Comments

The project, which involved thirteen partners in nine different countries, was coordinated very competently, and the overall management operation was excellent due to the efforts of the coordinator and dedicated project manager. The team structure was mostly stable (but see note below re CSIC/INTA) for the duration of the project, and no critical management issues arose. Smooth operation of the project was facilitated by a system of monthly teleconferences (enhanced by using Webex), a Twiki for internal information exchange, and regular reports.

Given the nature of the GENIUS project, effective cooperation with the Gaia Data Processing and Analysis Consortium (DPAC), and particularly DPAC Coordination Unit 9 (CU9), was a crucial requirement for successful execution of the project. This cooperation was greatly facilitated by the fact that the coordinator of GENIUS also leads CU9, and was maintained through joint teleconferences and joint plenary meetings. The project also benefited from input from its External Advisory Board.

The only issue noted is an administrative one involving one of the beneficiaries, which led to some difficulties in the financial management in the early stages of the project. The project was initiated as a collaboration effort between thirteen entities, one of them the Agencia Estatal Consejo Superior de Investigaciones Cientificas (CSIC). CSIC itself is an umbrella organisation for multidisciplinary research, encompassing 135 institutes/centres throughout Spain, including the Centro de Astrobiologia (CAB) in Madrid. CSIC joined the GENIUS Consortium on the basis of the contribution to be made by Dr. E. Solana at CAB. However, CAB is actually a joint venture between CSIC and the Instituto Nacional de Tecnica Aerospacial (INTA). It subsequently transpired that Dr. Solano's employment at CAB was in fact with INTA so that his work could not be funded through CSIC, a fact that became apparent only after he had already invested considerable effort in GENIUS in line with the project DoW. To resolve this issue, it was agreed that CSIC would resign from the Consortium while INTA would be installed as a beneficiary as of the commencement of the project, so that work already done by Dr. Solano could be duly funded. In addition, the outstanding CSIC budget was reallocated for administration by the University of Barcelona in order to expedite contracts required for subsequent INTA work. These changes do not in any way affect either the nature or quality of the work for which Dr. Solano was responsible, or the resources allocated to that work.

b. Collaboration between beneficiaries: Has the collaboration between the beneficiaries been effective?

✔		
Yes	Partially	No

Comments

This project developed from an existing collaboration between dedicated and like-minded researchers and was based on an acknowledged need. The participants who formed the Consortium were therefore of necessity those with the appropriate expertise and a clear imperative to work effectively together, resulting in a highly cohesive Consortium, with excellent cooperation between its members. There is no doubt that the beneficiaries have collaborated very effectively; the level of success of the project is ample confirmation of this.

c. Beneficiaries' roles: Do you identify evidence of underperforming beneficiaries, lack of commitment or change of interest of any beneficiaries?

		✔
Yes	Partially	No

Comments

There is no evidence of that any of beneficiaries underperformed, lacked commitment or lost interest in the project (notwithstanding the CSIC/INTA issue outlined in Section 4a above). On the contrary, all of the eventual beneficiaries were fully and enthusiastically committed, and contributed appropriately to the overall project effort. Indeed, most of the beneficiaries intend to continue working on aspects of the project which will be of benefit in the context of future Gaia data releases, and are already actively exploring funding opportunities to support this work.

5. USE AND DISSEMINATION OF FOREGROUND

a. Impact: Is there evidence that the project has/will produce significant scientific, technical, commercial, social, or environmental impacts (where applicable)?

✔			
Yes	Partially	No	Not applicable

Comments

GENIUS may be a relatively small part of the overall Gaia endeavour in terms of resources, but there can be no doubt that the project represents an essential contribution to the work of the broader DPAC Consortium, in particular that of CU9. GENIUS has addressed the challenge of unlocking the full potential of the Gaia mission data archive and catalogue, by contributing to the development of crucial aspects of archive design and implementation and by delivering powerful tools for the exploration, visualisation and analysis of Gaia data. The project has delivered in timely fashion a functional system which is a clear and substantial added-value supplement to the mission.

- GENIUS made possible the development and implementation of tools and methods which were crucial for validation of Gaia data in preparation for the first public release (GDR1). This work will also have an important impact on preparations for future data releases.
- GENIUS has developed and made public a range of tools for data access that open up the riches of the Gaia data archive to all users. The effective visualisation tools in particular extend the impact beyond the scientific community, bringing appreciation of the project results within reach of the general public. These tools, together with IVOA initiatives, TopCat enhancement and data-mining tools, will have substantial impact beyond the Gaia archive itself. The sky panorama image based on GDR1 and made possible by the GENIUS project represents in a sense the epiphany of Gaia, and its global impact is inestimable.
- The importance of adequate documentation is often overlooked. GENIUS has played a significant role in providing clear documentation for the Gaia archive and its resources, and this contribution will have a major impact on the effective use of the data.
- The scientific impact made possible by GENIUS is already being manifested in many publications exploiting Gaia data, access to which has been greatly facilitated by this project. Although Gaia's predecessor, Hipparcos, measured a much smaller sample (2.5 million entries in the Tycho-2 catalogue), several thousand papers making use of its results and covering a very broad range of astronomical research have been published since its launch in 1997. Extrapolating from the experience of Hipparcos, the ultimate impact of the Gaia archive and catalogue is set to be enormous, and the contribution of GENIUS to that impact cannot be overemphasised.

- The science alerts system prototyped by GENIUS has become an integral part of the planning of astronomical observations, as evidenced by the regular (typically 2 to 3 per week) Astronomers Telegrams reporting ground-based follow-up of Gaia event alerts; just to give one example: ATel #10338 (01/05/2017) reported follow-up observations with the ESO NTT telescope of six Gaia alerts, five of them being identified as supernovae. The alerts system is certain to have a major impact in relation to observations of solar system objects, including potentially hazardous near-Earth objects.
- The gaiaverse internet portal and other outreach initiatives undertaken by the project have had a significant impact on public awareness of GENIUS and of the Gaia mission in general. It is to be hoped that the initiative of providing multiple language content will be emulated by other European project websites.
- Another important impact of the project will result from the formulation of requirements for the various aspects of archive design and implementation carried out by GENIUS. The comprehensive documentation of these requirements will provide a sound basis for work on other archives, including those deriving from the JASMINE series of missions.
- The cooperation among the project beneficiaries and their interactions with the wider Gaia community have contributed to enhancing the European research effort and are a clear representation of the need for, and the benefits of, pan-European collaboration. Other potential impacts include IT development, cooperation between research and higher education institutions, enhancement of astronomy courses, contributions to the Virtual Observatory, and more.

The Gaia mission, the wealth of data it delivers, and the right to convenient access to those data belong to every citizen of the European Union. The GENIUS project has lived up to the promise of providing that access.

a.1. Is there an impact on participating Small and Medium Enterprises (SMEs)?

☐	☐	☐	✔
Yes	Partially	No	Not applicable

Comments

No direct involvement of SMEs in the project.

a.2. Is there an exploitation potential for the participating SMEs?

☐	☐	☐	✔
Yes	Partially	No	Not applicable

Comments

No direct involvement of SMEs in the project.

b. Use of results: Is the plan for the use of foreground, including any update, appropriate? Namely, please comment on the plan for the exploitation and use of foreground for the consortium as a whole, or for individual beneficiary or groups of beneficiaries and its progress to date.

✔	☐	☐
Yes	Partially	No

Comments

The primary outputs of GENIUS are the tools developed for access to and effective exploitation of the Gaia catalogue. These tools will benefit the European astronomical community as a whole, the beneficiaries themselves, and potentially the wider public. The plans for making the project outputs available, and for maintaining and updating the tools as required, are appropriate and have progressed broadly as scheduled.

In the course of developing the infrastructure required to access and exploit the Gaia data, a number of advances have already been made which have proved useful to the members of the Consortium, and which will also benefit other projects and missions, particularly where massive datasets are involved (for example, enhancements to VO tools and protocols, visualisation techniques, virtual machines, models of the Galaxy, simulations, statistical analysis, etc.).

c. Dissemination: Have the beneficiaries disseminated project results and information adequately (publications, conferences…)?

✔		
Yes	Partially	No

Comments

The GENIUS project *per se* was not designed to produce scientific results directly, but rather to facilitate the exploitation of the Gaia catalogue, which will of course lead to many important discoveries. Consequently, the main thrust of dissemination efforts for the project centred on development of the gaiaverse portal, coordinated with other Gaia-related websites.

Nevertheless, in terms of publications, the validation of the information provided in Gaia DR1 is the basis for a comprehensive paper in Astronomy & Astrophysics, and a number of other papers have benefited from (and have acknowledged the funding provided by) the GENIUS project. The work of GENIUS has also been highlighted in several conference proceedings.

The gaiaverse portal has been operational for some time, providing the public with a window on the Gaia mission and an insight into the role played by GENIUS in making convenient access to the data possible. A unique feature is the availability of entries in thirteen different languages, providing scope for dissemination of local Gaia-related information, although one might question the viability of adequately maintaining such diverse content. The project has also been promoted through a range of outreach activities, including public presentations, talks for students and press releases. These activities benefit from national and ESA outreach efforts.

An interesting feature is the provision by the project of short courses in scientific communication for members of GENIUS and for Gaia community personnel, with a view to improving the communication of the Gaia mission to the public. This is an example which could be followed by other projects.

Social media outlets have been exploited, and appear to have been quite successful in communicating information about Gaia in general and about GENIUS in particular, though it is difficult to calibrate the associated metrics.

The Consortium has contributed to the production of excellent images, including the iconic all-sky map representing the first Gaia data release, and these can be used to promote public awareness both of this project and of the general excellence of European-funded space research.

The delivery of real-time Gaia Science Alerts keeps the astronomical community and the interested public continually aware of Gaia, and is a constant reminder of the importance of the GENIUS project to the successful exploitation of the scientific potential of this outstanding mission.

d. Please identify potential information that should be disseminated to:

- Policy makers

The project highlights the importance of providing resources to exploit fully the results of Europe's prestigious space missions. The work carried out on this project has enhanced immeasurably the value of the data acquired by the instruments on board ESA's Gaia satellite. Policy makers should be made aware of the progress made, and of the need to maintain (and even increase) support for such endeavours. Consideration should also be given to providing some formal mechanism for supporting further development of the more successful aspects of the project.

- The scientific community

It is important that the scientific community be made fully aware of the legacy that GENIUS leaves, both in terms of access and exploitation tools for the Gaia archive and in terms of the documentation provided. While the tools developed within the GENIUS project were designed for application to the Gaia data archive, many of them can be used for other purposes, and some have not actually been deployed on the archive. Researchers should be encouraged to make the widest possible use of the entire GENIUS legacy. In particular, every effort should be made to publicise the developments made in relation to Virtual Observatory tools.

- The general public

Through high-profile release of the iconic image showing Gaia'a view of the Galaxy based on DR1, GENIUS has already made a significant contribution both to public perception of the universe and to public appreciation of European research excellence. Even before that, general information about the project and the way it complements the Gaia mission was being provided the on gaiaverse portal. The existence of the portal, and especially the multilingual aspect, could be publicised more, perhaps by making more even greater use of social media. In addition, efforts should be made to highlight the fact that the Gaia data are available to everyone, not just astronomers, and that anyone can gain insights into the universe by making use of the visualisation tools provided.

- A specific group of end users

Teachers and students in schools and colleges can benefit enormously from the access to Gaia data enabled by GENIUS; these data can provide the basis for a wide range of project work, which would be greatly enhanced by suggestions and advice on project choice and efficient application of GENIUS tools.

Amateur astronomers are an obvious target as end users of Gaia data. Contacts were already established with amateur astronomers as part of the initiative to determine the user requirements for archive structure and functionality. Such users are likely to be particularly interested in the Science Alerts system, and the alerts app could perhaps be used to promote broader exploration of the Gaia data via the GENIUS-provided interfaces.

e. Involvement of potential users and stakeholders: Are potential users and other stakeholders (outside the consortium) suitably involved (if applicable)?

✓			
Yes	Partially	No	Not applicable

Comments

Potential users of the Gaia archive include the astronomical community, amateur astronomers, teachers, students, and the general public (see Section 5d above). The GENIUS project explicitly incorporated input from professional and amateur astronomers in establishing the requirements that guided both the design of the catalogue interface and the development of the underlying infrastructure, and in testing the prototype systems as they were developed.
The GENIUS project was developed to address crucial aspects of the work of the Gaia DPAC, aspects which were not otherwise funded. As such, the DPAC Consortium has a great interest in the project, and DPAC members have been kept fully informed of the progress and developments within GENIUS. Most of the personnel in the GENIUS Consortium are also members of DPAC CU9, and joint GENIUS-DPAC meetings and teleconferences ensured that the DPAC Consortium was involved appropriately during the course of the project.
Another group with a stake in the success of GENIUS is the ESAC SAT. Effective interaction between GENIUS members and SAT was essential to the deployment at ESAC of the infrastructure and tools developed by the project, and the success of these efforts is a testament to the level of cooperation achieved.
The Japanese nanoJASMINE team has also been appropriately involved with GENIUS through the participation of Kyoto University in the Consortium.

f. Links with other projects and/or programmes: Is the consortium interacting in a satisfactory manner with other related Framework Programme projects and/or other R&D national/international programmes, standardisation bodies (if relevant), existing relevant networks?

✔		
Yes	Partially	No

Comments

GENIUS has no formal links with other FP projects. However, as already noted, it is not an independent project but is embedded in the overall effort devoted to the Gaia mission. In that respect, interaction between the Consortium and other groups within the Gaia community has been excellent. In particular, GENIUS is very closely aligned with the Gaia DPAC, particularly DPAC CU9. GENIUS members are part of DPAC, and DPAC CU9 is led by the coordinator of GENIUS. Joint meetings and teleconferences involving participants from GENIUS and CU9 have contributed greatly to efficient coordination. GENIUS has also interacted well with the teams involved in the only other astrometric space ventures currently planned, the Japanese missions nano-JASMINE, Small-JASMINE and JASMINE, with the GENIUS beneficiary Kyoto University deeply involved in those projects. The participation by GENIUS partners in VO projects has contributed significantly to progress in development of the data exploitation framework, and has led to a number of enhancements to VO tools.

6. OTHER ISSUES

If applicable comment on whether other relevant issues (e.g., ethical, policy-related/regulatory, safety and gender issues) have been handled appropriately.

✔		
Yes	Partially	No

Comments

There were no ethical, regulatory or safety issues associated with this project.

In relation to gender balance, a serious effort was made when hiring new members for the team to improve the overall gender balance within the Consortium, and a modest degree of success was achieved.

Measures were also taken to help promote a good work-like balance, limiting the amount of travel required by using teleconferencing where possible in preference to physical meetings and by favouring shorter collaborative trips. The approach represents a good template which could reasonably be adopted by other projects.

At the end of the project, the Consortium compiled a comprehensive report covering the composition of the participant teams and the employment destinations of the staff recruited for the project. While this report suggests that the Consortium generally performed above average on gender balance relative to comparable areas of scientific and technical employment, and contains some interesting observations about post-project personnel mobility, the sample is unfortunately too small from a statistical point of view to draw any definitive conclusions. However, combination of these results with the corresponding information from other comparable projects may ultimately provide valuable insights.

7. FLAG THE PROJECT

☐ Highlight as a success/case story

☒ High visibility/media attractive project

☐ Substantial R&D breakthrough character

☒ Project linked to R&D national/international programmes

☐ Project with an impact on EU policies (click on which EU policy: http://ec.europa.eu/policies/index_fr.htm)

☐ Project with an impact on promoting Joint Programming (especially for ERA-NET)

☐ Outstanding Use/Exploitation of results

☐ Significant R&D participation from outside EU

☐ Involvement of non-RTD actors in the field (economic, policy makers, civil society, end-users, standardisation bodies…)

☒ Good innovation potential

☐ No Flag

☐ Other

Comments

The Gaia mission is a key European space mission that will have a profound impact on our understanding of stars, the Galaxy, and the Solar System. It will also influence the definition of the fundamental coordinate system that forms the basis for positional information both in space and on Earth. As such, the role of GENIUS both in facilitating access to the wealth of Gaia data and in promoting awareness of the mission itself ensures the visibility and status of the project. The project itself has been very successful, and the members of the Consortium are to be commended for their excellent work. It is a privilege to have been associated with this project.

Names of the expert: Patrick Moriarty

Date: 19 May 2017

Signature: