



**EUROPEAN COMMISSION**  
**DIRECTORATE-GENERAL FOR COMMUNICATIONS NETWORKS, CONTENT AND TECHNOLOGY**

Digital Excellence and Science Infrastructure  
**Infrastructure and Science Cloud**

Brussels,

**REVIEW REPORT**

<b>Grant Agreement (GA) number:</b>	676541
<b>Project<sup>1</sup> Acronym:</b>	OpenDreamKit
<b>Project title:</b>	Open Digital Research Environment Toolkit for the Advancement of Mathematics
<b>Type of Action:</b>	RIA
<b>Start date of the project:</b>	01/09/2015
<b>Duration of the project:</b>	48
<b>Name of the primary coordinator contact and organisation:</b>	Nicolas THIÉRY (UPSud)
<b>Period covered by the report:</b>	from 01/09/2018 to 31/08/2019
<b>Periodic report:</b>	Final
<b>Date of first submission of the periodic report (if applicable):</b>	22/10/2019
<b>Date of latest version of Annex 1 to the GA (Description of the Action - DoA) against which the assessment is performed</b>	01/08/2018
<b>Date of meeting with consortium (if applicable):</b>	30/10/2019
<b>Name(s) of monitors assisting in the project assessment (if applicable)</b>	PEREZ MARIA S. Peter DZWIG Wil SCHILDERS
<b>Name of Project Officer drafting the report:</b>	Christophe DOIN

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<sup>1</sup> The term ‘project’ used in this template equates to an ‘action’ in certain other Horizon 2020 documentation

## 1. Overall assessment

<b>Overall assessment</b>
Project has achieved most of its objectives and milestones for the period with relatively minor deviations.
<b>Significant results linked to dissemination, exploitation and impact potential</b>
<p>Project has delivered exceptional results with significant immediate or potential impact (even if not all objectives mentioned in the Annex 1 to the GA were achieved).</p> <p>The project has delivered exceptional results with significant immediate or potential impact. The project has contributed to provide customized Virtual Research Environments (VREs), which are very helpful for researchers, SMEs, companies and users in general. The project has achieved most of its objectives and in some areas gone beyond what was anticipated. This is to be commended. Some minor corrective and administrative actions have had to be taken during the course of the project. These have been satisfactorily carried through in the view of the reviewers. Worth mentioning also is the success of the consortium in disseminating the ODK products to a wider community of users. It is believed that the impact of the project will be quite high, also after the project has officially ended. The actions taken by the consortium beyond those originally envisaged, particularly those involving Women in Mathematics and the extension of outreach beyond that originally considered, particularly to developing countries has been exemplary.</p>
<b>General comments</b>
<p>The project has been very successful with regard to achieving the main objective. Besides this main objective, the proposal lists also a number of additional objectives:</p> <ol style="list-style-type: none"><li>1. Virtual Research Environment Kit (this is the main objective): The project has provided major JupyterHub and JupyterLab developments, enabling the use of Jupyter as interface for the computational components. It has also enhanced other elements that facilitate collaboration.</li><li>2. Core components – development of core new tools: Key components of which sets of tools. OpenSage etc – definitely. Most of the required components and extensions have been deployed. In the last period report, the partners have concentrated on mathematical data sets.</li><li>3. Community Building across Disciplines – get developers of SAGE, SINGULAR and GAP on board, for example using IPYTHON and JUPYTER: Achieved – good to excellent. This objective has been achieved by means of the development of workshops, enabling Jupyter as uniform interface for the computations components, sharing best practices, working on interfaces between systems, etc.</li><li>4. Updates to Mathematical Software Components – updating existing software systems to interoperate seamlessly and comply with best practice for portability and platform integration: Achieved – excellent. This objective has been achieved, thanks to the work performed in the development, release and integration within SAGEMATH of different libraries, the PARI library for computational number theory, the GAP software for computational group theory, the FLINT and Singular software for commutative algebra, etc.</li><li>5. A Sustainable Ecosystem of Software Components – factoring out joint needs, outsourcing components to larger communities, better collaboration processes: Achieved – good (but ties in closely with 2). The project has contributed to the interoperability and sustainability of the ecosystem.</li><li>6. Engineering Social Interactions in Open Source VRE – investigate optimal ways to allocate reputation scores to developers and users of open source VRE, to facilitate the “mutual crowdsourcing” that is taking place as the VRE toolkit evolves, using OpenDreamKit as a testing ground: This objective was removed, as a result of one of the reviews.</li><li>7. Next Generation Mathematical Databases – build infrastructure, enable mathematicians to collaboratively build this common resource: Achieved. This objective has been achieved by developing the Math-in-the-Middle ontology, and instantiating the FAIR principles for mathematics.</li><li>8. Collaborative Research Environments that Transcend Domains – create a repository of notebooks and books across a range of application domains: Achieved. Very strong results in the present area, some broader demonstration. See below. This objective has been demonstrated by using the demonstrators and use cases Ubermag and interactive executable textbooks.</li><li>9. Training and Dissemination: Achieved. Excellent. 29 events have been organized in the third reporting period. This area has been a resounding success and is one of the major achievements of the project. There have been a very large number of dissemination and education events which have undoubtedly achieved the aims of the project in this area.</li></ol>
<b>Recommendations concerning the period covered by the report</b>

All deliverables are accepted as well as the work done during the period. D2.16 had not been delivered at the time of the final review, but only because the Consortium wished to make a joint Press Release. This is acceptable and was agreed with the Commission's representatives. During the course of the proposal two deliverables were provided late, although the reasons why are well understood and accepted by reviewers and Commission. The reasons need to be more clearly set out in the Final Report and the PI has agreed that this will be done.

There is no need for resubmission of deliverables

The Dissemination and Communication Activities are to be highly commended, especially the Women in Mathematics activities and the outreach to developing countries. This has gone far further than was originally envisaged

Exploitation plans for this project, such as they are, are accepted

The reviewers would like to encourage the Consortium to find ways to exploit this work further.

### **Recommendations concerning future work, if applicable**

Not applicable

## 2. Objectives and Workplan

<b>Is the progress reported in line with objectives and work plan as specified in the DoA? If there are significant deviations, please comment.</b>	Yes
<p>As previously stated, all aspects and objectives of the WP have been achieved and in many cases substantially exceeded. Further all the work undertaken during the current reporting period relevant to WPs 1-6 has enabled the project to achieve its overall goals, except the one related to the former WP7, whose resources were reallocated. With regards to the remaining WPs, the progress made in them have been:</p> <p>WP1: Project Management The management has been performed in a very professional manner. No major deviations.</p> <p>WP2: Community Building, Training, Dissemination, Exploitation, and Outreach Around 30 events were organized in the last year. It is noticeable the organization of Women in Sage events and the creation of comics, which can help to understand the approach.</p> <p>WP3: Component Architecture The OpenDreamKit components are available in the major Linux distributions (Debian, Ubuntu, Fedora,...) and also in Windows and MacOS.</p> <p>WP4: User Interfaces All deliverables of this WP were successfully delivered in previous reporting periods. In this period, partners have worked in tasks for improving and maintaining the results of the WP4.</p> <p>WP5: High Performance Mathematical Computing In the context of this WP, the following results have been delivered:</p> <ul style="list-style-type: none"> <li>• An MPI based distributed rational linear system solver based on Chinese remainder algorithm in LINBOX.</li> <li>• A new hybrid algorithm for rational linear system solving based on p-adic lifting and Chinese remainder algorithm, and its parallel implementation in LINBOX for multi-core servers.</li> <li>• A full-featured parallelisation engine, supporting POSIX threads and MPI, for PARI/GP in production release of the software.</li> <li>• The release of GAP-4.9 allowing compilation in HPC-GAP compatibility mode.</li> <li>• A major redesign of the polynomial arithmetic used in Singular.</li> <li>• The exploitation of parallelism when combining computational software</li> </ul> <p>WP6: Data/Knowledge/Software-Bases In this last period, this WP was focused on the representation and curation of mathematical data, defining narration (papers and textbooks), computation (algorithms and software), inference (theorems and proofs), and tabulation (database schemas and datasets). In addition, they have adapted the FAIR principles to mathematical research data.</p>	
<b>Are the objectives of the project still scientifically and /or technologically relevant?</b>	Yes
Virtual Research Environments such as the one(s) delivered by this project are very much still relevant and we can expect to see their growing adoption.	
<b>Are the critical implementation risks and mitigation actions described in the DoA still relevant?</b>	Yes
Not applicable	
<b>Have the pilots/case studies started to showcase innovative results as described in the DoA?</b>	Yes
Different demos and applications of the results of the project have been shown in the review meeting, demonstrating their innovative benefits.	
<b>Have the ethics related deliverables and/or requirements due for the current period been adequately addressed and approved?</b>	Not applicable
Not applicable	
<b>Have the comments and recommendations from previous assessments been taken into account?</b>	Yes
Regarding the follow-up of recommendations, all of them have been addressed. Particularly:	

- Recommendation 1. "A minor aspect: In the deliverable D5.11, authors have to clarify the reason why the speedup with the use of cores is not so high when you increment the number of cores. The presentation has also to be improved."

This recommendation has been done in the context of the deliverable 5.11.

- Recommendation 2. "To include the KPIs in a centralized way in the technical report (KPI table)"

This recommendation has been done, including in the Technical report a centralized presentation of the KPIs (pages 40-49).

- Recommendation 3. "Demonstration of capabilities due to project results is crucial, especially for test cases/show cases. Often, such demonstrations are extremely technical. A higher level approach to such demonstrations is needed, so that potential users are not taken aback by the many actions they need to undertake. It would be good if the project team discusses this, and takes action to make demonstrations more attractive and appealing. This is also vital for the sustainability of the project results."

This has been done.

- Recommendation 4. "Financial statements must be made available to reviewers no later than 15 days before Review Meeting in final form and to the Commission much earlier."

This information has been submitted on time (except for the press release, as previously mentioned).

- Recommendation 5. "It is to be hoped that spend can be accelerated in the next year to make best advantage of the funds available and to ensure maximum benefit to the communities."

Most of the resources of Leeds were redistributed to the other partners, increasing the number of dissemination events and adding a new case study exploring the MitM. This was formalized in the 5th grant agreement amendment. A total of 7.6 million€ was spent (accelerated in RP3).

- Recommendation 6. "Greater attention must be paid to acknowledgement of EU funding in all areas. For example, include the name of the project in Software Carpentry: Related projects:<https://software-carpentry.org/join/projects/>" As for the Software Carpentry, the web page is about to disappear. For the rest of projects and publications, partner have been an effort for double checking that the acknowledgement of EU funding has been included.

- Recommendation 7. "To develop a comic explaining the MitM approach."

This has been properly done.

- Recommendation 8: "To disseminate the Adoption by Logipedia of the MitM principle of integrating (logical) systems by aligning concepts."

They have made a blog post about this.

- Recommendation 9. "Some guidelines (set of recommendations) for using the different tools provided by OpenDreamKit would be recommendable."

This has been properly done.

- Recommendation 10. "Some guidelines (set of recommendations) for using the different hardware architectures would be recommendable."

These guidelines have been uploaded in the web page recently. However, they are not visual either depicted as a comic. This would contribute to make them more appealing and attractive.

### 3. Impact

<b>Does the work carried out contribute to the expected impacts detailed in the DoA?</b>	Yes
The project has had (and will have) impact on different communities (not only in Maths) and for different deployments, namely, cocalc.com, notebooks.egi.eu, jupyter.math.cnrs.fr, mybinder.org, etc. The use of Jupyter has contributed to increase the impact.	
<b>Does the work carried out follow the plan detailed in the DoA to enhance innovation capacity, create new markets opportunities, strengthen competitiveness and growth of companies, address issues related to climate change or the environment, address industrial and/or societal needs at regional level or bring other important benefits for society? Give information on the relevant innovation activities carried out (prototypes, testing activities, standards, clinical trials) and/or new product, service, reference materials, process or method (to be) launched to the market, if any.</b>	Partially
Partially, because it is unclear whether new market opportunities will be generated. However,, this can probably not be expected from a project like this one, such opportunities will always be secondary results. It would be good if the ODK team considers this question, and writes a short report on how new opportunities as indicated above, can be generated. This would make the work even more valuable.	
<b>Does the work carried out contribute towards European policy objectives and strategies and have an impact on policy making?</b>	Yes
The work carried out demonstrates an innovative way to create flexible networks of collaboration between researchers at a global level, thereby enhancing productivity. ODK demonstrates this in the context of Mathematics research. OpenDreamKit contributes to the EOSC through the tools that it has developed and the work on Jupyter which is widely used throughout the EOSC community. As a result it will influence policy making.	
<b>Does (or will) the work carried out have an impact on SMEs?</b>	Yes
The work carried out in ODK has been demonstrated as a framework for SMEs and other small-scale operations to collaborate in research projects and will undoubtedly bring benefit.	
<b>Have the beneficiaries aimed at a gender balance at all levels of personnel assigned to the action? If beneficiaries could not achieve the balanced participation of women and men in their teams despite active recruitment efforts, have the reasons been explained in the periodic report?</b>	Yes
Gender issues were addressed in a successful way. The recruitment of women (4 in the last reporting period) and the organization of Women in Sage events are very good actions taken by the project.	

#### 4. Implementation

<b>Has the project been efficiently and effectively managed?</b>	Yes
Excellent management work for a difficult project, with many changes and issues to be addressed.	
<b>Is the management of the project in line with the obligations of beneficiaries (including ethics and security requirements, risk and innovation management if applicable)?</b>	Yes
<p>The foreseen risks have been mitigated or have not appeared. Specifically:</p> <ul style="list-style-type: none"> <li>- Recruitment of highly qualified staff: Mitigated</li> <li>- Different groups not forming effective team: Mitigated</li> <li>- Implementing infrastructure that does not match the needs of end-users: Mitigated</li> <li>- Lack of predictability for tasks that are pursued jointly with the community: Mitigated</li> <li>- Reliance on external software components: N/A</li> </ul> <p>The mitigation measures have been feasible, mainly due to a flexible work plan.</p>	
<b>Is the contribution of each beneficiary in line with the work committed in the DoA? (applicable only to multibeneficiary projects)</b>	Yes
The contribution of each beneficiary has been properly justified, and is in line with the work committed in the DOA (except for the partners leaving the consortium, whose efforts have been reallocated).	
<b>Have the beneficiaries disseminated project results (foreground) in scientific publications as planned in the DoA, including the deposition of publications in open access repositories? Has the dissemination plan been updated? Do they include a reference to EU funding?</b>	Partially
<p>In the continuous reporting of the portal, only 17 publications are reported. However, there are more publications than that, see website and deliverables.</p> <p>Some of these references have not the reference to EU funding. Namely:</p> <ul style="list-style-type: none"> <li>• The “Linear Time Interactive Certificates for the Minimal Polynomial and the Determinant of a Sparse Matrix” paper does not have a reference to EU funding in the arxiv repository (<a href="https://arxiv.org/pdf/1602.00810.pdf">https://arxiv.org/pdf/1602.00810.pdf</a>), although it does in the HAL system: <a href="https://hal.archives-ouvertes.fr/hal-01266041v2/document">https://hal.archives-ouvertes.fr/hal-01266041v2/document</a> URL</li> <li>The “The logarithmic class group package in PARI/GP” paper does not have a reference to EU funding, at least in the places where I found it: <a href="https://www.math.u-bordeaux.fr/~kbelabas/research/bnflog-2016.pdf">https://www.math.u-bordeaux.fr/~kbelabas/research/bnflog-2016.pdf</a> and <a href="https://hal.archives-ouvertes.fr/hal-01419870/document">https://hal.archives-ouvertes.fr/hal-01419870/document</a></li> </ul>	
<b>Have the beneficiaries disseminated and communicated project activities and results by other means than scientific publications (social media, press-release, the project web site, video/film...) as planned in the DoA? Do they include a reference to EU funding?</b>	Yes
The dissemination and communication activities are very relevant and they contribute to increase the impact of the results of the project. It is difficult to know if all of them include a reference to EU funding, but those that I have found include that reference.	
<b>Has the plan for exploitation of results, in particular as regards intellectual property rights, been appropriately planned and executed, as described in the DoA?</b>	Yes
As mentioned elsewhere the exploitation and dissemination is in line with the DoA. Almost all results and documentation are Open Access.	
<b>Has the dissemination and exploitation plan been appropriately executed and updated? Give details if an update of the D&amp;E plan is needed.</b>	Yes
As mentioned elsewhere the exploitation and dissemination is in line with the DoA. Almost all results and documentation are Open Access.	

<b>Has the Data Management Plan (DMP) been appropriately drafted and, if applicable, executed? Give details if an update of the DMP is needed.</b>	Yes
The latest version of the DMP (D1.6: “Data Management Plan V2”) remains adequate for this last reporting period.	
<b>Have the proposed institutional changes been appropriately promoted?</b>	Not applicable
Not applicable	



## 5. Resources

<b>Were the resources used as described in the DoA and were they necessary to achieve its objectives? If there are deviations from planned budget, have they been satisfactorily explained? Have they been used in a manner consistent with the principle of sound financial management, in particular regarding economy, efficiency and effectiveness?</b>	Yes
<p>There have been minor deviations over the courses of the project due to recruitment and other issues but these have been satisfactorily resolved. Financial reporting on the part of some institutions could have been better. Some comments on detail and presentation were made in the course of the Final Review by the Financial Reviewer. These will be addressed by the PI in his Final Report.</p>	

## **Annex 1 - Expert's opinion on deliverables**

<b>Del. no.</b>	<b>Deliverable name</b>	<b>Status</b>	<b>Comments</b>
D2.16	Ending press release	Accepted	At the final review, it was explained why no press release was issued yet. The reviewers are confident that the press release will be issued soon after the final review.

## **Annex 2 - Expert's opinion on milestones**

<b>Miles. no.</b>	<b>Milestone title</b>	<b>Achieved</b>	<b>Comments</b>
MS1	Startup	Yes	Project has started timely
MS2	Implementations	Yes	Achieved
MS4	Evaluation	Yes	Evaluation was of informal character
MS5	ODK's computational components available on major platforms	Yes	Components are available on major platforms
MS6	Prototype VRE for mathematical researcher	Yes	This has been achieved by means of VREs based on JUPYTER
MS7	Collaborative VRE for mathematical researchers and beyond	Yes	Achieved and well done
MS8	Seamless use of parallel computing architecture in the VRE (proof of concept)	Yes	Parallel computing has been addressed, although the results are sometimes somewhat disappointing
MS9	First Math-In-The-Middle-based interoperability prototype	Yes	This prototype was released
MS10	Second Math-In-The-Middle-based interoperability prototype	Yes	Released