

COVER PAGE

Title of Proposal: **XX: Collaborative ecosystems for mathematical research and software development**

Date of preparation: **November 20, 2014**

Participant no	Participant organisation name	Country
1 (Coordinator)	Université Paris Sud	FR
2	University of St Andrews	UK
3	Logilab	FR
4	Université Bordeaux	FR
5	University of Kaiserslautern	DE
6	University of Oxford	UK
7	University of Warwick	UK
8	University of Silesia	PL
9	University of Washington at Seattle	US

Contents

1	Excellence	2
1.1	Objectives	2
1.2	Relation to the Work Programme	4
1.3	Concept and Approach	6
1.4	Ambition	8
2	Impact	9
2.1	Expected Impacts	9
2.2	Measures to Maximise Impact	10
3	Implementation	13
3.1	Work Plan — Work packages, deliverables and milestones	13
3.2	Management Structure and Procedures	32
3.3	Consortium as a Whole	33
3.4	Resources to be Committed	34
4	Members of the Consortium	35
4.1	Participants	35
4.2	Third Parties Involved in the Project (including use of third party resources)	40
5	Ethics and Security	41
5.1	Ethics	41
5.2	Security	41
	References	42

♠**EC Commentary:** *Please follow the structure of this template when preparing your proposal. It has been designed to ensure that the important aspects of your planned work are presented in a way that will enable the experts to make an effective assessment against the evaluation criteria. Sections 1, 2 and 3 each correspond to an evaluation criterion for a full proposal.*

Please be aware that proposals will be evaluated as they were submitted, rather than on their potential if certain changes were to be made. This means that only proposals that successfully address all the required aspects will have a chance of being funded. There will be no possibility for significant changes to content, budget and consortium composition during grant preparation.

Page limit: The cover page, and sections 1, 2 and 3, together should not be longer than 70 pages. All tables in these sections must be included within this limit. The minimum font size allowed is 11 points. The page size is A4, and all

margins (top, bottom, left, right) should be at least 15 mm (not including any footers or headers). If you attempt to upload a proposal longer than the specified limit, before the deadline you will receive an automatic warning, and will be advised to shorten and re-upload the proposal. After the deadline, any excess pages will be overprinted with a 'watermark', indicating to evaluators that these pages must be disregarded.

Please do not consider the page limit as a target! It is in your interest to keep your text as concise as possible, since experts rarely view unnecessarily long proposals in a positive light.♣

Outline of Project (for Proposers)

♠**TO DO:** *This is the place for various READMEs not included in the final submission*♠

Mission statement for the grant

Our mission is to promote the next generation of community-developed open source software, databases, and services adapted to the needs of collaborative research in pure mathematics and applications.

Our research will cover a wide variety of aspects, ranging from software development models, user interfaces ♠**TO DO:** *virtual environments?*♠, deployment frameworks and novel collaborative tools, component architecture, design, and standardization of software ♠**TO DO:** *system?*♠ and databases, to links to publication, data archival and reproducibility of experiments, development models and tools, and social aspects.

It will consolidate Europe's leading position in computational mathematics and build on the remarkable success of the ecosystem of projects GAP, Python/Sage, Pari, Singular, LMFDB.

♠**TO DO:** *What do we mean by "new generation"*♠.

1 Excellence

1.1 Objectives

♣**EC Commentary:** 1-2 pages♣ ♣**EC Commentary:** Describe the specific objectives for the project, which should be clear, measurable, realistic and achievable within the duration of the project. Objectives should be consistent with the expected exploitation and impact of the project (see section 2).♣

Aim 1: Build collaborative open source tools that support the entire life-cycle of computational work in mathematical research, from initial exploration to publication and teaching.

Aim 2:

♣**TO DO:** *The pieces of material below need to be recombined in a flowing story.*♣

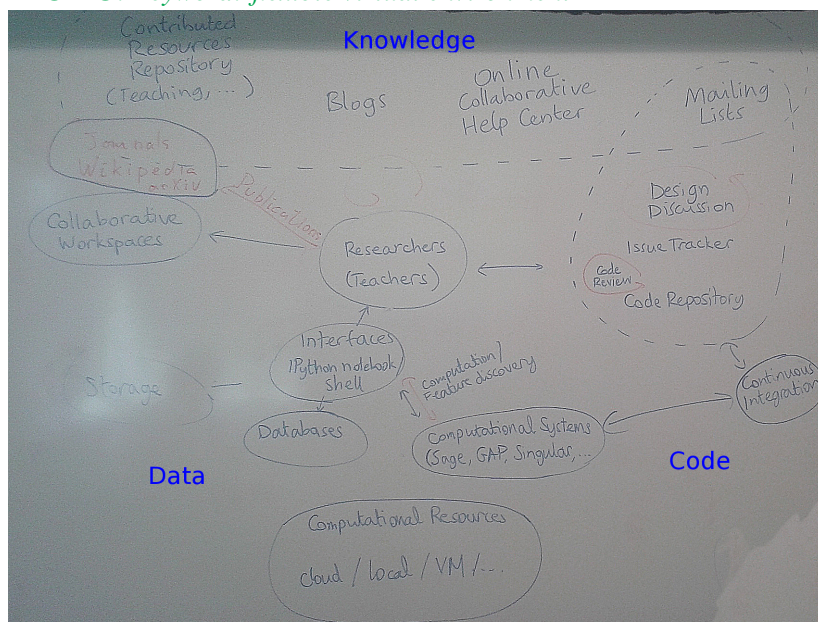
1.1.1 Key ideas

:

- Experimental maths has become a core asset for research in pure mathematics and its applications.
- Over the last decades, mathematicians have gained strong experience in collaborative software development, with pioneering work and continuing leadership of Europe.
- Mathematicians have a strong tradition of sharing knowledge openly (arxiv, Wikipedia, ...).
- Mathematicians have been building and sharing databases for a long while; the needs for such is growing tremendously, and the process needs to be streamlined.

This project gathers European core developers of leading mathematical software (GAP, Pari, Sage, Singular, ...), databases (LMFDB, ...), and critical components (IPython stack), together with researchers in computer and social sciences, with mission to promote a new generation of community-developed open source software ♣**TO DO:** *more precisely what's new is the combination thereof!*♣, databases, and services, adapted to the needs of collaborative research in pure mathematics and its applications.

♣**TO DO:** *Keyword: flexible virtual environment*♣



Our research will cover a wide variety of aspects, ranging from software development models, user interfaces ♣**TO DO:** *virtual environments?*♣ deployment frameworks and novel collaborative tools, component architecture, design, and standardization of software components and databases, to links to publication, data archival and reproducibility of experiments, development models and tools, and social aspects. It will build on the remarkable success of the open source ecosystem and consolidate Europe's leading position in computational mathematics.

Following the call specifications, all software, data, and publications resulting from this proposal will be open.

1.1.2 Why collaborative development of open source software?

From their early days, computers have been used in pure mathematics, either to prove theorems or, like the telescope for astronomers, to explore new theories. Major achievements include the proof of the four color theorem or **♠TO DO: Nice flashy example?♠**. Usage has grown to the point that certain areas of mathematics now completely depend on experimental methods, with major efforts spent on software development. As the sophistication of the required computations increased, supported by the boom of the available computational power, it became vital to share those efforts at the scale of large research communities. European mathematicians have been pioneers and have grown a steady tradition of collaborative open source software development, with systems like GAP, Singular, or Pari/GP playing a major role for decades.

1.1.3 Importance of experimental tools in maths

The field of computer algebra allows us to compute in and with a multitude of mathematical structures. It is interdisciplinary in nature, with links to quite a number of areas in mathematics, with applications in mathematics and other branches of science and engineering, and with constantly new and often surprising developments. Quite a number of these developments, in fact the creation of whole subareas of the field, have been initiated by European researchers who made crucial contributions at all levels. These include the design of fundamental algorithms, the development of major computer algebra systems, applications of the computational methods in various fields, and the creation of widely used databases.

Particular fruitful interactions unfold between computer algebra and algebraic geometry, number theory, and group theory. Algebraic algorithms open up new ways of accessing subareas of these key disciplines of mathematics, and they are fundamental to practical applications of the disciplines. Conversely, challenges arising in algebraic geometry, number theory, and group theory quite often lead to algorithmic breakthroughs which, in turn, open the door for new theoretical and practical applications of computer algebra.

Based on exact computer aided calculations, the experimental method has now been added to the toolbox of the pure mathematician. Experiments lead to new conjectures which may have a deep impact on the future development of mathematics. An outstanding example is the Birch and Swinnerton-Dyer conjecture which is one of the Clay Millennium Problems. Databases relying on computer calculations such as the Small Groups Library or the Modular Atlas in group and representation theory provide indispensable tools for researchers. A constructive way of understanding proofs of deep theorems yields algorithmic tools to deal with highly abstract concepts. These tools make the concepts available to a broader class of researchers, with many potential applications. A prominent example from algebraic geometry is the desingularization theorem of Hironaka, for which Hironaka won the Fields Medal, and its algorithmization by Villamayor.

Spectacular theoretical breakthroughs such as Wiles' proof of Fermat's last theorem are based on interdisciplinary approaches. Current developments on the algorithmic side allow one to conquer crossconnections between different areas of mathematics also computationally and, thus, to arrive at cutting-edge applications which previously were inconceivable.

1.2 Relation to the Work Programme

♠EC Commentary: 1-2 pages; Eugenia will help there♠

♠EC Commentary: *Indicate the work programme topic to which your proposal relates, and explain how your proposal addresses the specific challenge and scope of that topic, as set out in the work programme.*♠

♠EC Commentary:

This is a synthesis of Antonios Barbas' slides describing the Call 3
Topic 9-2015 EINFRA-9: e-Infrastructure for Virtual Research Environment

See file:../Documentation/VirtualEnvironmentsWorkProgramme2014-2015.ppt

** Suggested EU contribution per proposal: 2 to 8 M euros ; Total budget: 42 Meuros

** Dates: 14/01/2015

- H2020-EINFRA-2014-1 15/04/2014
- H2020-EINFRA-2014-2 02/09/2014
- H2020-EINFRA-2015-1 14/01/2015(tbc)

** European contacts: Antonios Barbas
See file:Documentation/Contacts.docx

** Definition:

- Groups of researchers, typically widely dispersed, who are working together
- through ubiquitous, trusted and easy access to services for scientific data, computing and networking
- in a collaborative, virtual environment:
 - > the e-Infrastructures

** Characteristics:

- Address the needs of specific scientific communities { in support of e-Science;
- Have users from both academia and industry;
- Involve bottom-up research and develop user-oriented services;
- Are based on e-infrastructures

** Specific challenge:

- Capacity building in interdisciplinary research
- through community-led development and deployment of service-driven digital environments
- for large-scale cross-disciplinary research collaboration and data interoperability

** Expected impact:

- More effective collaboration between researchers and increased take-up of collaborative research by new disciplines;
- Easier discovery, access and re-use of data, resulting in higher productivity of researchers;
- Accelerate innovation via access to integrated digital research resources across disciplines;

*** Scope: Proposals are expected to

Notations: [X]: easy to argue; [?]: we have some lead, but that will take some arguing

- [?] Integrate resources across all layers of the e-infrastructure (networking, computing, data, software, user interfaces) to foster cross-disciplinary data interoperability
- [?] Build on requirements from real use cases, i.e. integrate heterogeneous data from multiple sources and re-use tools and services from existing infrastructures
- [X] Target any area of Science and Technology, especially

- interdisciplinary ones, including ICT, mathematics, web science and social sciences and humanities
- [X] Use standardised building blocks and workflows, well-documented interfaces and interoperable components;
- [?] Define semantics, ontologies and metadata to enable data citation and promote data sharing, as to ensure interoperability;
- [X] Target easy-to-use functionalities; and indicate the number of researchers they target as potential users;
- ** Specific conditions for the Call on e-Infrastructures:
 - [X?] Proposals should be structured around Networking, Service and Joint Research Activities
 - [X] The Software to be developed needs to be open source
 - [] A Data Management Plan to be developed enabling data preservation, on-line discoverability, authorisation and re-use of data
 - [X] Clear Metrics (KPIs) to be proposed and used;
 - [?] Open Access to Publications resulting from the project;
 - [X] Usefulness of services to the end user community and financial sustainability to be ensured;
- ** Where should the emphasis be?
 - [?] Services
 - [X] Thinking innovation
 - With both suppliers or users
 - [X] Mainstreaming skills development
 - [] Integration between data and computing
 - [X] Business plans for financial sustainability
 - ...and partnerships with the private sector
 - [] Supporting policies
 - [X] open data and software
 - [X] Sharing basic operations services and building blocks
 - [X] Monitoring performance (KPIs)
- ** Simplified funding model
 - Up to 100% for Research and Innovation
 - Flat 25% rate for indirect costs (overhead?)

♠

1.3 Concept and Approach

♣**EC Commentary:** 5-8 pages ♣ **EC Commentary:** – Describe and explain the overall concept underpinning the project. Describe the main ideas, models or assumptions involved. Identify any trans-disciplinary considerations; – Describe and explain the overall approach and methodology, distinguishing, as appropriate, activities indicated in the relevant section of the work programme, e.g. Networking Activities, Service Activities and Joint Research Activities, as detailed in the Part E of the Specific features for Research Infrastructures of the Horizon 2020 European Research Infrastructures (including e-Infrastructures) Work Programme 2014- 2015; – Describe how the Networking Activities will foster a culture of co-operation between the participants and other relevant stakeholders. – Describe how the Service activities will offer access to state-of-the-art infrastructures, high quality services, and will enable users to conduct excellent research. – Describe how the Joint Research Activities will contribute to quantitative and qualitative improvements of the services provided by the infrastructures. – As per Part E of the Work Programme, where relevant, describe how the project will share and use existing basic operations services (e.g. authorisation and accounting systems, service registry, etc.) with other e-infrastructure providers and justify why such services should be (re)developed if they already exist in other e-infrastructures. Describe how the developed services will be discoverable on-line. – Where relevant, describe how sex and/or gender analysis is taken into account in the project's content. ♣

1.3.1 Linked research and innovation activities

♣**EC Commentary:** Describe any national or international research and innovation activities which will be linked with the project, especially where the outputs from these will feed into the project; ♣

♣**TO DO:** For each item below, write a paragraph describing the project and one describing how it connects with this proposal ♣

DFG Priority Project SPP 1489 `computeralgebra.de`

♣**WD [WRITE HERE:** Summarize this into a paragraph] ♣

The field of computer algebra allows one to compute in and with a multitude of mathematical structures. It is interdisciplinary in nature, with links to quite a number of areas in mathematics, with applications in mathematics and other branches of science, and with constantly new and often surprising developments.

Particular fruitful interactions unfold between computer algebra and algebraic geometry, number theory, and group theory. Algebraic algorithms open up new ways of accessing subareas of these key disciplines of mathematics, and they are fundamental to practical applications of the disciplines. Conversely, challenges arising in algebraic geometry, number theory, and group theory quite often lead to algorithmic breakthroughs which, in turn, open the door for new theoretical and practical applications of computer algebra.

The goal of the DFG Priority Program SPP 1489 is to considerably further the algorithmic and experimental methods in the afore mentioned disciplines, to combine the different methods where needed, and to apply them to central questions in theory and praxis. Moreover, the programme is meant to support the further development of free computer algebra systems which are (co-)based in Germany, and which in the framework of different projects, may require crosslinking on different levels.

Of particular interest are interactions with application areas inside and outside of mathematics such as system- and control theory, coding theory, cryptography, CAD, algebraic combinatorics, and algebraic statistics as well as hybrid methods which combine numerical and symbolic approaches.

♣**WD [WRITE HERE:** Link to the project] ♣

IPython/Jupyter grant from the Alfred P. Sloan foundation ♣**FP [WRITE HERE:** Proofread] ♣

The IPython project received a \$1.15M grant from the Alfred P. Sloan foundation that is supporting IPython development for two years (1/1/2013-12/31/2014), in particular at the University of California, Berkeley and California Polytechnic State University, San Luis Obispo. This grant enabled the project to focus on developing the IPython Notebook as a general tool for scientific and technical computing that is open, collaborative and reproducible. This goes a long way toward Aim ♣**TO DO:** ... and ... ♣ of **XX**, especially given the current rapid evolution of IPython

toward its language agnostic avatar Jupyter.

XX will build on the outcome of the Sloan grant, and further develop the critical IPython/Jupyter component in close collaboration with the IPython/Jupyter team. In particular, we plan to hire some of the European developers that are currently funded by the Sloan grant to work in California and wish to later return to Europe.

Sage-Combinat grant ♠NT [WRITE HERE: ...]♠

Logilab: simulagora, cubicweb, ...

Sage Math Cloud

FLINT grant?

LMFDB grant ♠JC [WRITE HERE: One paragraph description of the grant]♠

1.4 Ambition

♠EC Commentary: 1-2 pages♠

♠EC Commentary: – Describe the advance your proposal would provide beyond the state-of-the-art, and the extent the proposed work is ambitious. Your answer could refer to the ground-breaking nature of the objectives, concepts involved, issues and problems to be addressed, and approaches and methods to be used.

– Describe the innovation potential which the proposal represents. Where relevant, refer to products and services already available, e.g. in existing e-Infrastructures.♠

2 Impact

♠**TO DO:** Orsay's grant services will help here in December♠

2.1 Expected Impacts

♠**EC Commentary:** *Please be specific, and provide only information that applies to the proposal and its objectives. Wherever possible, use quantified indicators and targets.*

Describe how your project will contribute to:

- the expected impacts set out in the work programme, under the relevant topic (including key performance indicators/metrics for monitoring results and impacts);*
- improving innovation capacity and the integration of new knowledge (strengthening the competitiveness and growth of companies by developing innovations meeting the needs of European and global markets; and, where relevant, by delivering such innovations to the markets;*
- any other environmental and socially important impacts (if not already covered above).*

Describe any barriers/obstacles, and any framework conditions (such as regulation and standards), that may determine whether and to what extent the expected impacts will be achieved. (This should not include any risk factors concerning implementation, as covered in section 3.2.)♠

2.2 Measures to Maximise Impact

2.2.1 Dissemination and Exploitation of Results

♠**EC Commentary:** – *Provide a draft 'plan for the dissemination and exploitation of the project's results'. The plan, which should be proportionate to the scale of the project, should contain measures to be implemented both during and after the project.*

Dissemination and exploitation measures should address the full range of potential users and uses including research, commercial, investment, social, environmental, policy making, setting standards, skills and educational training.

The approach to innovation should be as comprehensive as possible, and must be tailored to the specific technical, market and organisational issues to be addressed

– *Explain how the proposed measures will help to achieve the expected impact of the project . Provide a draft business plan for financial sustainability as stated in the Part E of the Specific features for Research Infrastructures of the Horizon 2020 European Research Infrastructures (including e-Infrastructures) Work Programme 2014-2015.*

– *Where relevant, include information on how the participants will manage the research data generated and/or collected during the project, in particular addressing the following issues: What types of data will the project generate/collect? What standards will be used? How will this data be exploited and/or shared/made accessible for verification and re-use (If data cannot be made available, explain why)? How will this data be curated and preserved?*

– *Include information about any open source software used or developed by the project.*

You will need an appropriate consortium agreement to manage (amongst other things) the ownership and access to key knowledge (IPR, data etc.). Where relevant, these will allow you, collectively and individually, to pursue market opportunities arising from the project's results.

The appropriate structure of the consortium to support exploitation is addressed in section 3.3.

– *Outline the strategy for knowledge management and protection. Include measures to provide open access (free on-line access, such as the “green” or “gold” model) to peer-reviewed scientific publications which might result from the project.*

Open access publishing (also called 'gold' open access) means that an article is immediately provided in open access mode by the scientific publisher. The associated costs are usually shifted away from readers, and instead (for example) to the university or research institute to which the researcher is affiliated, or to the funding agency supporting the research.

Self-archiving (also called “green” open access) means that the published article or the final peer-reviewed manuscript is archived by the researcher - or a representative - in an online repository before, after or alongside its publication. Access to this article is often - but not necessarily - delayed (“embargo period”), as some scientific publishers may wish to recoup their investment by selling subscriptions and charging pay-per-download/view fees during an exclusivity period.♠

Long term sustainability The success of large specialized software like Pari, Singular or GAP in the last decades has shown the viability of the academic open source development model for such. For a long time, it was bitterly debated whether this model would have any chance to scale to general purpose systems for pure mathematics. The rapid take off of Sage in the last 10 years has proven the viability of the “developed by users for users” model: despite its large community of 300 developers, it's running on a tiny specific budget, with most activities being funded indirectly by research grants that require specific development.

This was made possible by reusing existing components whenever possible (e.g. hundreds of specialized open source math libraries, or the Python programming language with its developers tools and huge library), and outsourcing software development (e.g. the Cython compiler) to larger communities whenever possible.

♠**TO DO:** *This piece of argument is tricky to setup!!!♠*

Yet, long term critical non mathematical features like portability, modularization, packaging, user interfaces, large data, parallelism, or outreach toward related software, have been lagging behind. Indeed they can hardly be implemented as a side product of research projects, and **need to be assigned to full time developers**. Regular funding is also needed to better structure the computational mathematics community in Europe and support its upcoming major widening through training, development workshops, exchanges, ...

The purpose of this grant is to initiate this process. The principle is that, with the growth of the user base, a tiny

number of institutions or companies will hire a single full-time developer, and this will be sufficient because they critically need it to support their research.

The number of such required full time developers will be made even tinier because most of the efforts now will be focused toward outsourcing more components to reduce the recurrent needs.

For example, this project will save much recurrent efforts to the mathematics community by outsourcing the development of the user interface to IPython. This grant will provide the required temporary boost to make IPython stand to the stringent needs of the community. Later on, thanks to its large user base, both in academia and industry, IPython will continue to strive without specific funding or major contributions from the mathematics community.

Another big focus of this project will be on the study of open source development models for mathematical software and how they can be made more productive, in particular by better processes and collaboration between components, which will also reduce the number of required full time developers.

2.2.2 Communication activities

♠**EC Commentary:** *Describe the proposed communication measures for promoting the project and its findings during the period of the grant. Where appropriate these measures should include social media and public events with user participation. Measures should be proportionate to the scale of the project, with clear objectives. They should be tailored to the needs of various audiences, including groups beyond the project's own community. Where relevant, include measures for public/societal engagement on issues related to the project.*♠

3 Implementation

♠**TO DO:** *Typical granularity: 5-8 work packages with 3-5 tasks and one deliverable per task; 10 milestones*♠

3.1 Work Plan — Work packages, deliverables and milestones

♠**EC Commentary:** *Please provide the following:*

- *brief presentation of the overall structure of the work plan;*
- *timing of the different work packages and their components (Gantt chart or similar);*
- *detailed work description, i.e.:*
 - *a description of each work package (table 3.1a);*
 - *a list of work packages (table 3.1b);*
 - *a list of major deliverables (table 3.1c);*
- *graphical presentation of the components showing how they inter-relate (Pert chart or similar).*

♠

Overall Structure of the Work Plan

The work plan is broken down into XX workpackages as shown in Figure ??: WP2 deals with ... In addition, there is one management work package (WP1) and one general dissemination work package (??). The Gantt chart on Page 14 illustrates the timeline for the various tasks for these work packages, including inter-task dependencies.

How the Work Packages will Achieve the Project Objectives

♠**ALL [WRITE HERE:** *This needs to explain that we're actually going to meet the objectives. Needs to be done after objectives and WPs.]*♠

The project objectives (Section 1.1, page 2) and the corresponding work packages that contribute to achieving those objectives are:

Objective	Purpose	WPs
Objective 1	XX	WPX

Work Programme for Objective 1: Objective 1 is covered by WPX, which will ...

Work package list

Work package No	Work package title	Lead partic. no.	Lead short name	Person months	Start month	End month
WP1	Project Management	1	UPS		1	60
WP2	Community Building and Engagement	1	UPS			
WP3	Component Architecture	1	UPS			
WP4	User Interfaces	1	UPS			
WP5	HPC and massively parallel components	1	UPS			
WP6	Next generation Mathematical Databases	2	USTAN			
WP7	Development Models for an Academic Free Software Ecosystem					
WP8	Social Aspects	6	UO			
WP9	Dissemination, Exploitation and Communication	2	USTAN			
Total				XXX		

List of Deliverables

Del. no.	Deliverable name	WP no.	Lead	Type	Dissemi- nation level	Delivery date
D8.1	Requirements Analysis	WP?		R	CO	??

List of milestones

Milestone number	Milestone name	Related work package(s)	Estimated date	Means of verification (deliverables shown here + success criteria below)
MS1 MS3	Completed initial requirements analysis.	WPX WPX	1	??.

Milestone	Success Criteria	Contributes to Objective(s)
MS1 MS3	Completed requirements analysis (Deliverable ??). XX	1, 3. XX

♠**EC Commentary:** *KEY Estimated date Measured in months from the project start date (month 1) Means of verification Show how you will confirm that the milestone has been attained. Refer to indicators if appropriate. For example: a laboratory prototype that is 'up and running'; software released and validated by a user group; field survey complete and data quality validated. ♠*

Work package description (WP1)

Work package number	WP1		Start date or starting event:			Month 1	
Work package title	Project Management						
Participant number	2	1					
Participant short name	USTAN	UPS					
Person-months per participant:	48	48					

Objectives: The objective of WP1 is to undertake all project management activities, including setting up joint infrastructure, organizing meetings, and producing overview reports.

Description of work:

This workpackage will perform ...

Deliverables:

- D1.1 (Month 1): Internal and external mailing lists.
- D1.3 (Month 1): Internal software repository. ▲TO DO: Needed?▲
- D1.4 (Month 12): Project Periodic Report (first year).
- D1.5 (Month 24): Project Periodic Report (second year).
- D1.6 (Month 36): Project Periodic Report (third year).
- D1.7 (Month 48): Project Periodic Report (fourth year).
- D1.8 (Month 48): Project Final Report

Work package description (WP2)

Work package number	WP2	Start date or starting event:	Month 1
Work package title	Community Building and Engagement		
Participant number	2		
Participant short name	USTAN		
Person-months per participant:	1		

Objectives: The objective of WP2 is to further develop the community at the European scale, foster cross teams collaborations, spread the expertise, and engage the greater community to participate to the definition of the needs, and the implementation and use of the produced solutions.

Description of work:

We will organize regular open workshops (e.g. Sage Days, Pari Days, summer schools, etc.); some of them will be focused on development and coding sprints, and others on training.

This work package will also provide general travel budget to fund short to long term visits between the participants, to collaborate on specific features. A typical such visit would bring together an IPython developer with a GAP developer for a couple of days to implement a first prototype of notebook interface to GAP.

This work package will complement and lean on a parallel COST network whose role is to build and animate the greater community.

Deliverables:

- ?? (Month 12): Report on community needs
- Workshop 1 ...
- Workshop 2 ...
- Workshop 3 ...
- ♠**TO DO: make a list**♠

Work package description (WP3)

Work package number	WP3	Start date or starting event:					Month 1
Work package title	Component Architecture						
Participant number	2						
Participant short name	USTAN						
Person-months per participant:	1						

Objectives: The objective of this work package is to develop and demonstrate a set of API's enabling components such as database interfaces, computational modules, separate systems such as GAP or Sage to be flexibly combined and run smoothly across a wide range of environments (cloud, local, server, ...).

Description of work:

This work package includes work on:

- Portability:
 - Sharing experience and best practices.
 - Port to Windows (GAP, Sage, Singular).
 - Shared multiplatform test infrastructure.
- Interfaces between systems:
 - Self adaptation to the environment, better schemes for automatically selecting appropriate algorithms / components for a given task.
 - Semantic-enabled handles to objects stored in other systems (NT):

Handles are a popular design pattern for interfaces between two systems A and B; instead of exchanging objects back and forth, only handles to those objects are exchanged, letting e.g. A manipulate an object which actually resides in B. Typical features include remote method calls, introspection, or documentation queries. The next step would be for A to be aware of the semantic of the object, using an adapter infrastructure to propagate category/ontologies information. For example, we would want GAP's categories to be mapped to Sage's categories, so that a handle to a GAP group would automatically appear within Sage like a native Sage group.

- Modularization
 - common architecture for module maintenance and distribution (related to point 1 above)
 - Sharing experience and best practices
 - Modularization of Sage
 - Refactorization of GAP's package mechanism; namespaces?

- Deployment and distribution

- High Performance Computing and Parallelism:

As in all other areas of science, properly supporting of massively parallel architecture is a major challenge.

Many of the computational components have already gone a long way in this direction. For example, grant **♠TO DO: ...♠** founded the GAP-HPC project which adapted the GAP kernel to support HPC. The expertise gained there was then transferred to the ongoing Singular-HPC project.

Building on this, this project will:

- Foster further sharing of HPC expertise and best practices between computational components.
- Develop novel infrastructure for HPC in the context of combinatorics.
- Investigate and implement HPC-friendly ways of combining components together, so that calling components can benefit from the HPC features of called components, with self-adaptation to the environment and cooperative sharing of resources.
- Support work on HPC-enabling more components (Linbox)
- Investigate

Deliverables:

- ?? Make sure that Sage and therefore all the components it depends on (including GAP, Linbox, Pari, Singular, ...) have standard packages in the main Linux distributions: Debian/Ubuntu, Redhat, Gentoo, ...

♠**TO DO:** *Get feedback from our experts, and make this precise; what can we actually promise to achieve? how much work is this? Do we have personnel for this? There is strong expertise in Logilab with a Debian developer working there; he could advise someone on this. Logilab is interested in this because it's meeting similar issues with some of its clients software like Salomé.*♠

x

- ?? (Month 12): Creation, deployment, and distribution of preconfigured virtual machines for Pari, Sage, ... as a cloud service, in particular within the StratusLab infrastructure. This includes build bots and test bots for continuous integration over a variety of operating systems.
- ?? (Month 12, Month 24): Fully functional one-click install Sage distribution for Windows using a 32bits version of Cygwin.

This 32bits version would work right away on Windows 64 bits with Cygwin 32 bits; more work would be required for a version working on a 64 bits of Cygwin.

In both cases, this includes complete port of Singular, GAP, Pari, ... to cygwin.

- ?? Modularization of the Sage distribution
Separation of the different components of Sage (communication with third-party softwares, build system, Sage native code). This is a prerequisite for easier packaging and integration in standard Linux distributions and lmonade, native integration within the IPython notebook and other interfaces (larchenv, Spyder, ...) and collaboration with sister projects.
- ?? Add support for the SCSCP interface protocol to all relevant components (e.g. Sage, ...). ♠**SL/AK [WRITE HERE: Brief description of what SCSCP is, reference to previous grant, relevance to the goals of this grant; maybe this should go in the work package description]**♠
- Some IPython/Jupyter deliverables here. ♠**TO DO:** *review what it can already do in term of choice of computational resource and storage back-end.*♠
- Contribution by Kaiserslautern: libSingular, pySingular?, GAP-Singular, Singular-Sage.
Moving code from Sage into Singular when relevant
- ?? (Month ...) Configure the components of Sage's distribution (e.g. Atlas, Linbox, GAP, Singular, ...) to be systematically HPC-enabled, and make sure that Sage's calls to such components indeed enable HPC.
- ?? Develop HPC features in components
 - ♠**JGD [WRITE HERE: Linbox]**♠
 - ♠**WD [WRITE HERE: Singular]**♠
- Transparent integration of IPython capabilities for cluster computing.
- Implementation of a transparent abstraction over mpi.
- Develop or integrate existing solutions for MapReduce operations over big data.
- FLINT development (key component for several systems)?
- Some demonstrators of cross-disciplinary/cross-software calculations

Raw material:

Component Architecture

Recomputation connection belongs here?

Collaboration with unreliable (or restricted!) networking connections (peer-to-peer, opportunistic syncing, 3rd world). This is technically interesting, and gets in support for non-networked working. Not sure if it belongs here or not.

- Security concerns

Goal: Fostering collaborations/integration between components in an open source ecosystem

=====

- How to make systems "cooperate" rather than "predate each other".
- E.g. reduce the version issues
- Foster collaboration with upstream libraries by sharing the development and maintenance of the interfaces, typically as standalone upstream Python bindings (e.g. py-Singular).
- How to make it easy to develop simultaneously two interdependent components (e.g. Sage+Singular)
- Foster communication
- Social aspect:
 - Credit, Citations, Recognition, Funding

Documentation system

=====

In which package?

Improvements to Sphinx

Sage heavily customizes the Sphinx documentation system, hacking deep in it in some cases, with quite some duplication in some cases. Refactor the whole thing, generalizing and contributing back upstream as much as possible (e.g. parallel compilation).

Work package description (WP4)

Work package number	WP4	Start date or starting event:	Month 1
Work package title	User Interfaces		
Participant number	2		
Participant short name	USTAN		
Person-months per participant:	1		

Objectives: The objective of this work package is to provide a modern, robust, and flexible interface for computation, supporting real-time sharing, integration with collaborative problem-solving, multilingual documents, paper writing and publication, links to databases etc.

Description of work:

♠**TO DO:** *What is a notebook interface*♠

♠IPython people [**WRITE HERE:** improve this draft presentation of]♠

IPython is a leading notebook interface in the world of interactive computations, and use massively by biologists, physicists, ♠**TO DO:** *and outside academia!*♠. Originally tailored for Python, it has been language agnostic, and can communicate through a standardized interface to various computation kernels ♠**TO DO:** *cite a few*♠. It can transparently run kernels locally or remotely (e.g. on the cloud), and has built in support for parallel computing and HPC.

Task 4.1 Uniform notebook interface for all interactive components

In this task, we will implement Jupyter kernels for the interactive computation components of XX (GAP, Pari, Singular). A first release D 4.3 will focus on basic functionality, and a second release D 4.2 will cover advanced features like 3D graphics, transparent documentation browsing (as live worksheets whenever relevant).

Sage itself will require a specific treatment as it already has a notebook interface. Its development started about at the same time as the IPython notebook, with similar target features but a different agenda: the Sage notebook had to be available very quickly to solve pressing needs of the Sage community; instead the IPython notebook was to take its time and build robust foundations from the ground up. The two projects have exchanged a lot, and the IPython notebook, which benefits from a much larger user base and thus developer pool, has mostly caught up with the Sage notebook in terms of functionality. It's thus time for the Sage community to outsource this key but non disciplinary component and phase out the Sage notebook in favor of the IPython notebook.

The Sage and IPython convergence D. ?? will require:

- *Robust migration tools for Sage worksheets,*
- *Import (and export?) of ReST documents, with full support for Sage's specific roles (math, ...)*
- *Support for math, 2D, and interactive 3D output.*
- *Support for remote Sage kernel, typically on the cloud, or running with a different Python version (Sage as a library).*
- *A migration path for interactive widgets implemented with Sage's @interact functionality.*

Joint meetings and visits between the developers of Jupyter and of the computing components will be a key asset for this task.

.. TODO:: include here everything about this topic in Needs.rst

♠**TO DO:** *Wherever relevant, create tickets with details, and refer to them here.*♠

Deliverables:

Deliverable 4.1 *(Month 12) Basic IPython/Jupyter for GAP, Pari, Sage, Singular*

Deliverable 4.2 *(Month 12) Full featured IPython/Jupyter for GAP, Pari, Sage, Singular*

Deliverable 4.3 *(Month 12) Sage notebook / IPython notebook convergence*

- ?? (Month 24) IPython usability
 - Multilingual notebooks?
 - Improved 2D/3D graphics: maybe architecture for integrating VPython, vispy, ...? 3D visualization of algebraic surfaces (in collaboration with Singular)
- ?? Collaborative interactive tools: e.g. embedding live shared IPython sessions in voice-over-IP or teleconference calls or reciprocally.
- ?? (Month 36) Exploratory support for interactive widgets as demonstrated in the Larch Environment project (see demo vidéo on <http://www.larchenvironment.com/>)
- ?? (Month ???) Heavyweight (e.g. QT based and not web based) user interface with docking support in the style of Spyder <https://code.google.com/p/spyderlib/>. Can possibly be implemented by extending the QT IPython console, or by letting Spyder use the IPython protocol (♠**TO DO:** *If that's not yet the case*♠).
- ?? (Month ???) Dynamic documentation system: java API style documentation, allowing e.g. the exploration of the class hierarchy, generated on the fly by introspection. If possible this should be implemented generically for any computation kernel by extending the IPython protocol with introspection and documentation queries.
Rationale: in Sage, large parts of the class hierarchy is built dynamically, hence static documentation builders like Sphinx can't render all the available information.
- ?? (Month ???) Support for tested notebooks.
The writer specifies the expected outputs, e.g. in text format, and can check at any point that the full execution of the notebook yields exactly the expected output, as can be done with e.g. ReST files in Sage: `sage -t notebook.rst`
- ?? (Month ???) Support for writing interactive structured documents, and in particular papers, books, experimentation log books and reports, presentations, course notes, etc, with the following features:
 - Static printed/PDF/HTML version and interactive version.
Achieved by either importing or exporting document files in some standard format (LaTeX, ReST, Markdown, ...).
 - Tests (see above).
 - Native folding support for sections and the like, with mouse and keyboard commands.
 - Collaborative edition.
 - Version control.

Work package description (WP5)

Work package number	WP5	Start date or starting event:					Month 1
Work package title	HPC and massively parallel components						
Participant number	2						
Participant short name	USTAN						
Person-months per participant:	1						

Objectives: The objectives of WP5 is to design interfaces that can be used for a wide range of mathematical data, facilities for accepting contributions while tracking provenance and credit, standard metadata allowing database discovery, versioning allowing stable references, citability, recomputation without copying entire database into VM. Participants: Warwick, Paul Oliver Dehaye, Logilab (SME in Paris)

Description of work:

This workpackage ...

Deliverables:

- Databases
 - Polytopes in Polymake
 - Finite groups (Max)
 - Lattices
- ?? (Month X): Shared persistent memoization library for Python/Sage. Typical use case: A group of collaborators is using intensively a given function (in Sage, or in their private code). They want to memoize the results, as with e.g. Sage's `cached_method`, but across sessions. They further want to share the underlying growing database between themselves, and maybe eventually publish it.

Features:

- Use, further extend, and contribute back to some established (Python?) persistent memoization infrastructure. E.g.
 - * <https://pythonhosted.org/joblib/memory.html>
 - * github.com/vivekn/redis-simple-cache
 - * bitbucket.org/zzzeek/dogpile.cache
- Apply not only to user-level functions, but also to lower level functions, e.g. in the Sage library, so that indirect calls to the function also get memoized.
- Trivial to setup and configure for the end user: in a single line, the user selects an existing function, a backend (with a default value), maybe provide some semantic information, and voilà.
Typical interface: a decorator to be set on appropriate functions. ♠**TO DO:** *Mock code* ♠
- Trivial to setup and configure for groups of researchers, with a wide range of storage backends (e.g. shared dropbox folder, remote directory, database, git repository, ...).
- Easy to setup data-bot: e.g. launching a virtual machine that systematically fills up the shared database.
- Versioning and provenance tracking (user, algorithm, software version, ...), for quality certification, credit, ...
- Recomputation?
- Ease of publishing, importing, ...
- Usual database properties: atomicity, merging (easy since the results are supposed to be immutable: just need to merge the tracking info), alerts in case of divergence.

Work package description (WP6)

Work package number	WP6	Start date or starting event:					Month 1
Work package title	Next generation Mathematical Databases						
Participant number	2						
Participant short name	USTAN						
Person-months per participant:	1						

Objectives: The objectives of WP6 are to:

-
-
-
-
-

Description of work:

This workpackage ...

Deliverables:

- ?? (Month X): X.

♠UM,DP [WRITE HERE: ...]♠

Work package description (WP7)

Work package number	WP7	Start date or starting event:	Month 1
Work package title	Development Models for an Academic Free Software Ecosystem		
Participant number	6		
Participant short name	UO		
Person-months per participant:	1		

Objectives: The objectives of WP7 are to:

-
-
-
-
- Supporting the Mathematical Process

Description of work:

This workpackage ...

Deliverables:

- ?? (Month X): X.

Work package description (WP8)

Work package number	WP8	Start date or starting event:	Month 1
Work package title	Social Aspects		
Participant number	2		
Participant short name	USTAN		
Person-months per participant:	1		

Objectives: The objective of this work package is to organize and optimize the communication with the larger community. This includes:

- Reviewing emerging technologies
- Advertising the project (press, web, ...).
- Disseminating results and deliverables.

Description of work:

The first task of WP8 is to produce periodic reviews of emerging technologies and relevant developments elsewhere, and implications for our plans. This include the review of standard components and service for storage and sharing, computational resources, authentication, package management, etc. This may further include negotiating access or shared development when appropriate. This information will be fed to the other work packages, in particular **TO DO**: *ref: Component Architecture*.

Dissemination: software, APIs, technologies, research results, ...

Deliverables:

- ?? (Month 12): Year 1 report.
- ?? (Month 24): Year 2 report.
- ?? (Month 36): Year 3 report.
- ?? (Month 48): Year 4 report.

Raw material:

- Documentation improvements: overview, cross links, overview of recent improvements
- Thematic tutorials
- Collections of pedagogical documents
E.g. a complete collection of interactive class notes with computer lab projects for the “Algèbre et Calcul formel” option of the French math aggregation (starting from 2014-2015, only open-source systems will be supported, and Sage is a major player).
- Localization of the Sage user interface and key documents in various European languages.
- Distribution of the documents either in the main distribution of Sage or through the online repository (see collaborative tools).

- Massive online introduction course to Sage, drawing on the sage tutorial/notebooks. Could be "First year Sage course in a box".
- Taking the opportunity of Python courses to propose Sage as a natural extension for mathematics; an example is French's "Classes préparatoires"¹, where Python has been recently selected as the language to learn programming².

♠**TO DO:** *Milestones need to be discussed and then described here.* ♠

¹http://en.wikipedia.org/wiki/Classe_prparatoire_aux_grandes_coles

²See the "Annexe" at http://www.education.gouv.fr/pid25535/bulletin_officiel.html?cid_bo=71586

♠**TO DO:** *Check this for any necessary changes.*♠

3.2 Management Structure and Procedures

♠**EC Commentary:** *Will get help from Orsay's grant services*♠

♠**EC Commentary:** *Describe the organisational structure and the decision-making (including a list of milestones (table 3.2a)).*

Explain why the organisational structure and decision-making mechanisms are appropriate to the complexity and scale of the project.

Describe, where relevant, how effective innovation management will be addressed in the management structure and work plan.

Describe any critical risks, relating to project implementation, that the stated project's objectives may not be achieved. Detail any risk mitigation measures. Please provide a table with critical risks identified and mitigating actions (table 3.2b).♠

3.3 Consortium as a Whole

♠EC Commentary:

- *Describe the consortium. How will it match the project's objectives? How do the members complement one another (and cover the value chain, where appropriate)? In what way does each of them contribute to the project? How will they be able to work effectively together?*
- *If applicable, describe the industrial/commercial involvement in the project to ensure exploitation of the results and explain why this is consistent with and will help to achieve the specific measures which are proposed for exploitation of the results of the project (see section 2.3).*
- *Other countries: If one or more of the participants requesting EU funding is based in a country that is not automatically eligible for such funding (entities from Member States of the EU, from Associated Countries and from one of the countries in the exhaustive list included in General Annex A of the work programme are automatically eligible for EU funding), explain why the participation of the entity in question is essential to carrying out the project*



♠TO DO: *Select some events from the list on computer.algebra.de to highlight the existing tight collaborations between the members.*♠

♠TO DO: *Explanation of why we want to include Seattle (sage-math cloud, is a key component; access to IP).*♠

3.4 Resources to be Committed

♠EC Commentary: Will get help from Orsay's grant services♠

♠EC Commentary: Please provide the following:

- a table showing number of person/months required (table 3.4a)
- a table showing 'other direct costs' (table 3.4b) for participants where those costs exceed 15% of the personnel costs (according to the budget table in section 3 of the administrative proposal forms)

♠

Summary of staff effort

♠EC Commentary: Please indicate the number of person/months over the whole duration of the planned work, for each work package, for each participant. Identify the work-package leader for each WP by showing the relevant person-month figure in bold.♠

♠TO DO: Update this once the list of parthers and the WPs are finalised.♠

Partic. no.	Partic. short name	Work package									Total PMs
		WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	
1	UPS										
2	USTAN										
3	Logilab										
4	UB										
5	UK										
6	UO										
7	UW										
Total PM											

♠EC Commentary: Please complete the table below for each participant if the sum of the costs for 'travel', 'equipment', and 'goods and services' exceeds 15% of the budget table in section 3 of the proposal administrative forms).♠

Other direct cost items

	Cost (€)	Justification
Travel		
Equipment		
Other goods and services		
Total		

Management Level Description of Resources and Budget

♠TO DO: This needs to be updated in line with the rest of the project.♠

The project will employ XX person-months of effort over YY years, comprising ...

♠**EC Commentary:** *This section is not covered by the page limit.
The information provided here will be used to judge the operational capacity.*♠

4 Members of the Consortium

4.1 Participants

♠**EC Commentary:** *Please provide, for each participant, the following (if available):*

- *a description of the legal entity and its main tasks, with an explanation of how its profile matches the tasks in the proposal;*
- *a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities;*
- *a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content;*
- *a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal;*
- *a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;*
- *any other supporting documents specified in the work programme for this call.*

♠

♠**TO DO:** *Write a Participant template*♠ ♠**TO DO:** *Write a CV template*♠

♠**SL [WRITE HERE:** Saint Andrews]♠

Université Paris Saclay

University Paris-Sud is among the 40 top universities worldwide in the 2013 Shanghai ranking, and is one of the two best French research universities. With about 27000 students, 1800 permanent teaching staff and 1300 permanent research scientists from national research organisations (CNRS, Inserm, INRA), it is the largest campus in France. Since 2006, scientists from the University were awarded two Fields medals, one Nobel Prize and a number of other international (European Inventor Award 2013, Wolf Prize 2010, Holweck Prize 2009, Japan prize 2007) and national prizes. The Université Paris-Sud has a complete array of competences, ranging from the purest of exact sciences to clinical practices in medicine, covering life and health sciences, legal sciences and economics. Research at the Université Paris-Sud, an essential part of academic understanding, is complemented by research activities with a high valorisation potential. Research contracts and partnership with companies make the Université Paris-Sud a key actor and a major player in French research. The University is located close to the Plateau de Saclay, the largest cluster of public and private R&D institutions in France (with ca. 16000 research staff), and is one of the core members of the University Paris Saclay – a world class university and a world-renowned research and innovation hub.

In the context of this project, the Université Paris Saclay is the home of one of the largest group of Sage developers worldwide. It's a member of the Open Source Thematic Group of the Systematic Paris Region Systems and ICT Cluster. The University also hosts a major research group working on proof assistants (Coq), which naturally opens the door for reaching toward this neighbor community.

Curriculum vitae of the investigators

Florent Hivert Professor at the Laboratoire de Recherche en Informatique, Florent Hivert is a senior researcher in Algebraic Combinatorics with 29 papers in international journals and 15 communications in international conferences. With 100 tickets (co)authored and as many refereed, Hivert is himself a core Sage developer, with contributions including key components of the Sage infrastructure (documentation, automated test, combinatorics infrastructure, parallelism, ...), specialized research libraries.

Publications, achievements

♠**TO DO:** *Il faut être plus formel dans la description des projets antérieurs : Acronyme, titre, agence de financement, durée. Pareil pour les publi - auteurs, titre exact, année etc.* ♠

1. Lead of the Sage-Combinat software project.
2. Coauthoring of the open source book “Calcul Mathématique avec Sage”, the first of its kind comprehensive introduction to computational mathematics in Sage for education.
3. XXX tickets contributed to Sage.

Previous projects or activities

1. Home of six one week-long Sage Days workshops.
2. Co-Organizer of ♠**TO DO:** XXX ♠ Sage Days.
3. Founder and regular organizer of a bimonthly Sage User Group meeting in the greater Paris area.
4. Expertise exchanges with Logilab
5. ♠**TO DO:** XXX ♠

Significant infrastructure

The Université Paris Sud hosts the lead developers of the open source cloud infrastructure Stratuslab and its reference infrastructure (♠**TO DO:** XXX cores ♠). The participants are regular users of this infrastructure, and in close contact with the developers.

4.1.1 University of Kaiserslautern

Principal investigator Prof. Dr. Wolfram Decker

Personal Data

Gender: male
Nationality: German
Address: Department of Mathematics
Technical University of Kaiserslautern
P.O. Box 3049
Germany
Phone: +49 631 205 2253
Email: decker@mathematik.uni-kl.de
URL: www.mathematik.uni-kl.de/agag/mitglieder/professoren/prof-dr-wolfram-decker/
Status: Professor

Scientific Qualification

PhD 1984 University of Kaiserslautern
Habilitation 1989 University of Kaiserslautern

Academic Career

1984 – 1990 Assistant Professor, University of Kaiserslautern
1990 – 2009 C3 Professor, University of the Saarland
2009 – present W3 Professor, Technical University (TU) Kaiserslautern

Synergistic Activities

PhD students

Hirotachi Abo, Holger Crüi, Hiep Dang, Hanieh Keneshlou, Dereje Kifle, Michael Messollen, Ngoc Anh Pham, Sorin Popescu, Andreas Steenpaß, Isabel Stenger, I. Made Sulandra, Shrawan Tiwari

University Service

1994–1996 Dean, Dep. of Math., University of the Saarland
2014–present Dean, Dep. of Math., TU Kaiserslautern

Scientific Service

1996–1999 Coordinator of EuroProj (a European algebraic geometry network)
2000–2004 Chair of the programme management committee of EAGER
(a European algebraic geometry network)
2010–present Coordinator of the DFG Priority Programme SPP1489
‘Algorithmic and experimental methods
in algebra, geometry, and number theory’

Conferences (co)organized

1997– 2004 About 30 conferences, summer schools, and workshops
in the framework of EuroProj and EAGER.
1992–present More than 20 coding sprints, conferences, summer schools,
and workshops outside EuroProj and EAGER,
including 3 conferences at Dagstuhl and 1 at Banff.
2000 Chair of the Minisymposium on computer algebra, third ECM.

Selected Grants

1986–1987	NATO-Grant of the DAAD (visit UC Berkeley)
1987–1994	In: DFG Priority Programme ‘Complex manifolds’
1993	Grant: Japanese Society for the Promotion of Science (visit Kyoto)
1992–1997	In: DFG Priority Programme ‘Algorithmic number theory and algebra’
2002–2006	In: DFG Priority Programme ‘Global methods in complex geometry’
2010–present	In: DFG Priority Programme SPP1489 (two grants)
1997–2004	Seven grants for EU Highlevel Scientific Conferences

Selected Publications

1. On the uniqueness of the Horrocks-Mumford-bundle (with F.-O. Schreyer). *Math. Ann.* **273** (1986), 415–443. (MR0824431)
2. Stable rank 2 vector bundles with Chern-classes $c_1 = -1$, $c_2 = 4$. *Math. Ann.* **275** (1986), 481–500. (MR0858291)
3. Construction of Surfaces in \mathbb{P}_4 (with L. Ein, F.-O. Schreyer). *J. Algebraic Geometry* **2** (1993), 185–237. (MR0858291)
4. Computational algebraic geometry today. In: *Applications of algebraic geometry to coding theory, physics and computation (Eilat, 2001)*, 65–119, NATO Sci. Ser. II Math. Phys. Chem., 36, Kluwer Acad. Publ., Dordrecht, 2001. (MR1866896)
5. Computing in Algebraic Geometry. A Quick Start using SINGULAR (with C. Lossen). *Algorithms and Computation in Mathematics*, 16. Springer, Berlin, 2006. xvi+327 pp. (MR2220403)
6. Parallel algorithms for normalization (with J.Böhm, S. Laplagne, G. Pfister, A. Steenpaß, S. Steidel). *J. Symbolic Comput.* **51** (2013), 99–114. (MR3005784)
7. A first course in computational algebraic geometry (with G. Pfister). *African Institute of Mathematics (AIMS) Library Series*. Cambridge University Press, Cambridge, 2013. viii+118 pp. (MR3052757)
8. Local analysis of Grauert-Remmert-type normalization algorithms (with J.Böhm, M. Schulze). *Internat. J. Algebra Comput.* **24** (2014), 69–94. (MR3189667)

Selected Mathematical Software

- | | |
|--------------|---|
| 1997–present | Coauthor of SINGULAR libraries for adjoint ideals, absolute factorization, integral bases, invariant theory, parametrization of rational curves, primary decomposition, normalization, and sheaf cohomology |
| 2009–present | Head of the SINGULAR developers group |

Publications, products, achievements

1. ♠WD [WRITE HERE: ...]♠

Previous projects or activities

1. ♠WD [WRITE HERE: ...]♠

Significant infrastructure ♠WD [WRITE HERE: ...]♠

University of Oxford

♠DP/UM [WRITE HERE: Oxford]♠

Curriculum vitae

Publications, products, achievements

1. ♠DP/UM [WRITE HERE: ...]♠

Previous projects or activities

1. ♠DP/UM [WRITE HERE: ...]♠

Significant infrastructure

♠WD [WRITE HERE: ...]♠

Université de Bordeaux

♠VD [WRITE HERE: Bordeaux]♠

Curriculum vitae

Publications, products, achievements

1. ♠VD [WRITE HERE: ...]♠

Previous projects or activities

1. ♠VD [WRITE HERE: ...]♠

Significant infrastructure

♠VD [WRITE HERE: ...]♠ ♠NT/FC [WRITE HERE: Logilab]♠ ♠MK [WRITE HERE: University of Silesia]♠
♠SL/WS [WRITE HERE: Seattle]♠ ♠JC [WRITE HERE: Warwick]♠
[?]

4.2 Third Parties Involved in the Project (including use of third party resources)

♠EC Commentary: *Please complete, for each participant, the table (see page 27 of "VRETemplate.PDF"), or simply state "No third parties involved", if applicable.*♠

No third parties involved.

♠TO DO: *Or Seattle?*♠

5 Ethics and Security

♣**EC Commentary:** *This section is not covered by the page limit.*♣

5.1 Ethics

♣**EC Commentary:** *If you have entered any ethics issues in the ethical issue table in the administrative proposal forms, you must:*

- *submit an ethics self-assessment, which:*

- *describes how the proposal meets the national legal and ethical requirements of the country or countries where the tasks raising ethical issues are to be carried out;*

- *explains in detail how you intend to address the issues in the ethical issues table, in particular as regards: research objectives (e.g. study of vulnerable populations, dual use, etc.), research methodology (e.g. clinical trials, involvement of children and related consent procedures, protection of any data collected, etc.), the potential impact of the research (e.g. dual use issues, environmental damage, stigmatisation of particular social groups, political or financial retaliation, benefit-sharing, malevolent use , etc.)*

- *provide the documents that you need under national law(if you already have them), e.g.:*

- *an ethics committee opinion;*

- *the document notifying activities raising ethical issues or authorising such activities*

If these documents are not in English, you must also submit an English summary of them (containing, if available, the conclusions of the committee or authority concerned).

If you plan to request these documents specifically for the project you are proposing, your request must contain an explicit reference to the project title♣

5.2 Security

Please indicate if your proposal will involve:

- activities or results raising security issues: NO
- 'EU-classified information' as background or results: NO

References