

	Programme ERA-NET Cofund QuantERA	Project acronym:	AZX
	Call for proposals QuantERA	Edition 2017	
	Administrative and financial document		

Project identity

Acronym:	AZX			
Project title: <i>in French</i>	A Flexible Intermediate Representation for Quantum Software			
Project title: <i>in English</i>	A Flexible Intermediate Representation for Quantum Software			
Duration of the project <i>(months):</i>	36			
Estimated amount of funding requested from ANR (k €) (In the pre-selection stage where applicable)	Not applicable	Amount of aid requested from ANR (€)	367 957.53	Total of aid requested for the project 1 312 177.13
Estimated amount of funding requested from foreign agencies (k €) (In the pre-selection stage where applicable)	Not applicable	Amount of aid requested from foreign agencies (€)	944 219.60	
		Total of own funds for the project (€)	0.00	
Funding instrument	Not applicable			
Year of thesis defence	0			
Primary societal challenge	Not applicable			
Secondary societal challenge	Not applicable			
Research theme	<i>Not applicable to this call for proposals</i>			
Sub-theme (and keywords):	<i>Not applicable to this call for proposals</i>			
R&D Categories:	<i>Not applicable to this call for proposals</i>		Platform:	<i>Not applicable to this call for proposals</i>
Transnational project:				

Project acronym: AZX

Main disciplines:	<i>Not applicable to this call for proposals</i>
Types of projects:	<i>Not applicable to this call for proposals</i>
Keywords:	quantum computation, quantum software, compilation, intermediate representation, semantics, categorical quantum mechanics, zxcalculus.

Time coordinator spent on project in one year:	<i>Not applicable to this call for proposals</i>
Has the proposal already been submitted in a previous edition?	
If yes, please enter the year:	Project acronym

Is the project a continuation a previous project funded by ANR?	No
Project acronym	
Is the project connected to the Investments for the Future Programme (PIA)?	

Summary: Partnership, budget and workforce

Partner's initials	Full cost (€)	Requested grant amount (€)	Permanent staff (persons/months)	Non-full time staff with funding requested (persons/months)	Non-permanent staff without funding requested (persons/months)	Research Funding Organisation
University of Strathclyde (Coordinateur)	365 621.60	365 621.60	0.00	0.00	0.00	EPSRC
University of Oxford	328 598.00	328 598.00	0.00	0.00	0.00	EPSRC
Laboratoire lorrain de recherche en informatique et ses applications	262 957.53	262 957.53	0.00	0.00	0.00	ANR
Bull SAS	420 000.00	105 000.00	30.00	0.00	0.00	ANR
Radboud Universiteit	250 000.00	250 000.00	0.00	0.00	0.00	NWO
Totals	1 627 177.13	1 312 177.13	30.00	0.00	0.00	

List of Research Funding Organisation

Name of the Research Funding Organisation	Associated to the project	Associated to the partner(s)/organisation(s)
EPSRC		University of Strathclyde University of Oxford
NWO		RU

Project acronym: AZX

Abstract (non-confidential) in French

Not applicable to this call for proposals

Abstract (non-confidential) in English

SUMMARY

High-level software descriptions of quantum algorithms must be translated to low-level control instructions for quantum hardware. However, whereas classical computers have had a roughly static concept of “low-level instructions” for decades, the analogous notion for quantum hardware is constantly changing and evolving to cope with the rapid progress in quantum technology. Extant quantum computers are not so much single devices, but instead patchworks of components which vary greatly between implementations such as ion traps, superconducting qubits, or quantum optical devices. Programming such devices requires intimate knowledge of the hardware, which is a significant barrier to the realisation of usable, scalable quantum computers, as programs must be rewritten for every new device. We face a situation where the ever-multiplying range of quantum computers has minimal software support.

This project introduces AZX, a flexible intermediate language for quantum computation, which removes this obstacle by providing a common interface between the software and the hardware. This intermediate language will be versatile enough to target a wide variety of hardware implementations, and simple enough to support any programming language. Further, AZX will expose a formal algebraic structure based on an existing graphical formalism called the zx-calculus. The latter enables provably-correct program transformations for automatically adding error correction and performing hardware-guided optimisations, e.g. by preferring certain quantum gates over others or enforcing topological constraints. This project will develop and standardise the AZX language for quantum computation, integrate it into an effective stack of tools for compiling quantum programs, and develop new techniques for automated transformations that make quantum computations run better and faster.

RELEVANCE

The project clearly has “potential to initiate or foster new lines of quantum technologies through collaborations exploring advanced multidisciplinary science and/or cutting-edge engineering”, which is the overall objective of QuantERA. We specifically address the Quantum Computation area of the call. The retargetable nature of the compiler supports new architectures for quantum computation, in particular technologically heterogeneous implementations. The optimising aspect of the compiler will allow the optimisation of error correction codes, both at the intermediate and machine level. The ability to compile multiple high-level languages will promote the development of novel quantum algorithms. More generally, this project is an enabling technology that multiplies the impact of all the target outcomes of QuantERA, and prepares the stage for the Quantum Technology Flagship.

Overall objectives, scientific/technical obstacles

Not applicable to this call for proposals

Work programme

Not applicable to this call for proposals

Scientific, technical, and economic benefits

Not applicable to this call for proposals

Note: all the above-listed information; except that relating to the last three fields, will be published if the project is selected for funding (subject to update if necessary). By submitting an application, partners consent to the publication of all of the above-mentioned information.

Partner1 identity and budget

Scientific and technical leader

project coordinator: Yes

Gender: Mr
Last name: Duncan
Phone: +44 141 548 3301
E-mail: dr.ross.duncan@gmail.com
Date of birth: 01/01/0001

Title: Researcher/Lecturer
First name: Ross
Mobile:

Partner identity:

Full name of partner: University of Strathclyde
Partner's initials:
Partner's RNSR:
Partner's category: Divers public
Partner's country : United Kingdom of Great Britain and Northern Ireland (the)
Research Funding Organisation : EPSRC
Base for calculating grant amount: Coût complet
Is the partner "Carnot Institute" labelled? No **If yes, which one?**
Siret number of the organisation:

For an institution or public research body:

Research unit type: Research unit number:

Funding management authorities:

Legal Nature of the management instance:

Control instances:

Other instances:

Siret number of the organisation:

For a company:

Workforce (if SME):

Project acronym: AZX

Address where scientific work is performed:	Street Number:	
	Address:	
	Additional address:	
	Postcode:	City:
	Cedex:	Country:

Person authorised to legally represent the managing establishment (for acts of award)

Gender:			
Last name:		First name:	
Position:			
Mailing Address	Street Number:		
	Address:		
	Additional address:		
	Postal code:		City:
	Country:		

Banking information:

Name of bank:	
IBAN account information (<i>Europe Area</i>) <i>in IBAN format :</i>	
Bank's BIC/SWIFT:	

Person in charge of administrative and financial follow-up

Title:		Last name:	
First name:		Phone:	
Fax:		E-mail:	
Mailing Address:	Street Number:		
	Address:		
	Additional address:		
	Postal code:		City:
	Country:		

Project acronym: AZX

Other financial support*

Name of funders	Nature and purpose of funding	Amount requested	Amount obtained
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* Please list here all requested or obtained grants by the beneficial owner for the same project (Cf. ANR grant Regulation n°ANR-RF-2015-03). This list is to be updated as necessary.

Financial data for partner's contribution (Net amount excluding taxes in €, including non-refundable VAT)

Full-time		Personnels Non-full-time WITH funding request		Non-full-time WITHOUT funding request		Instruments and equipments (€)	Buildings and grounds (€)	Contract research (€)	Overhead costs (€)	Total (€)
Cost (€)	Persons. months	Cost (€)	Persons. months	Cost (€)	Persons. months					
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	365 621.60	0.00	365 621.60

For information only : maximum amount of structure costs taken into account 25 593.51

Personnel costs (Max 68%) 0 % 0.00 €
 Other expenses (Max 7%) 0 % 0.00 €
Total expenses 0.00 €

Full cost (€) 365 621.60
 Funding base (€) 365 621.60
Grant rate requested (%) 100.00

Requested funding (€)	365 621.60
including	0.00 € for internal billing on the whole project
	0.00 € for billing between partners on the whole project

Partner2 identity and budget

Scientific and technical leader

project coordinator: No

Gender: Mr
Last name: Coecke
Phone: +44 7881 333990
E-mail: bob.coecke@cs.ox.ac.uk
Date of birth: 23/07/1968

Title: Researcher/Professor
First name: Bob
Mobile: +44 7881 333990

Partner identity:

Full name of partner: University of Oxford
Partner's initials: University of Oxford
Partner's RNSR:
Partner's category: Divers public
Partner's country : United Kingdom of Great Britain and Northern Ireland (the)
Research Funding Organisation : EPSRC
Base for calculating grant amount: Coût complet
Is the partner "Carnot Institute" labelled? No **If yes, which one?**
Siret number of the organisation:

For an institution or public research body:

Research unit type: Research unit number:

Funding management authorities:

Legal Nature of the management instance:

Control instances:

Other instances:

Siret number of the organisation:

For a company:

Workforce (if SME):

Project acronym: AZX

Address where scientific work is performed:	Street Number:	
	Address:	
	Additional address:	
	Postcode:	City:
	Cedex:	Country:

Person authorised to legally represent the managing establishment (for acts of award)

Gender:			
Last name:		First name:	
Position:			
Mailing Address	Street Number:		
	Address:		
	Additional address:		
	Postal code:		City:
	Country:		

Banking information:

Name of bank:	
IBAN account information (<i>Europe Area</i>) <i>in IBAN format :</i>	
Bank's BIC/SWIFT:	

Person in charge of administrative and financial follow-up

Title:		Last name:	
First name:		Phone:	
Fax:		E-mail:	
Mailing Address:	Street Number:		
	Address:		
	Additional address:		
	Postal code:		City:
	Country:		

Project acronym: AZX

Other financial support*

Name of funders	Nature and purpose of funding	Amount requested	Amount obtained
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* Please list here all requested or obtained grants by the beneficial owner for the same project (Cf. ANR grant Regulation n°ANR-RF-2015-03). This list is to be updated as necessary.

Financial data for partner's contribution (Net amount excluding taxes in €, including non-refundable VAT)

Full-time		Personnels Non-full-time WITH funding request		Non-full-time WITHOUT funding request		Instruments and equipments (€)	Buildings and grounds (€)	Contract research (€)	Overhead costs (€)	Total (€)
Cost (€)	Persons. months	Cost (€)	Persons. months	Cost (€)	Persons. months					
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	328 598.00	0.00	328 598.00

For information only : maximum amount of structure costs taken into account 23 001.86

Personnel costs (Max 68%) 0 % 0.00 €
 Other expenses (Max 7%) 0 % 0.00 €
Total expenses 0.00 €

Full cost (€) 328 598.00
 Funding base (€) 328 598.00
Grant rate requested (%) 100.00

Requested funding (€)	328 598.00
including	0.00 € for internal billing on the whole project
	0.00 € for billing between partners on the whole project

Partner3 identity and budget

Scientific and technical leader

project coordinator: No

Gender: Mr
Last name: JEANDEL
Phone:
E-mail: emmanuel.jeandel@loria.fr
Date of birth: 10/01/1980

Title: Researcher/Professor
First name: Emmanuel
Mobile:

Partner identity:

Full name of partner: Laboratoire lorrain de recherche en informatique et ses applications

Partner's initials: LORIA

Partner's RNSR: 198912571S

Partner's category: Laboratoire public

Partner's country : France

Research Funding Organisation : ANR

Base for calculating grant amount: Coût marginal

Is the partner "Carnot Institute" labelled? No **If yes, which one?**

Siret number of the organisation: 13001550600012

For an institution or public research body:

Research unit type: UMR **Research unit number:** 7503

Funding management authorities: Université de Lorraine

Legal Nature of the management instance: Etablissements publics à caractère scientifique, culturel et professionnel.
- EPSCP

Control instances: Université de Lorraine

Other instances:

Siret number of the organisation: 13001550600012

For a company:

Workforce (if SME):

Project acronym: AZX

Address where scientific work is performed:	Street Number:			
	Address:	Campus Scientifique, BP 70239		
	Additional address:			
	Postcode:	54506	City:	VANDOEUVRE LES NANCY
	Cedex:	CEDEX	Country:	

Person authorised to legally represent the managing establishment (for acts of award)

Gender:				
Last name:		First name:		
Position:				
Mailing Address	Street Number:			
	Address:			
	Additional address:			
	Postal code:		City:	
	Country:			

Banking information:

Name of bank:	
IBAN account information (<i>Europe Area</i>) <i>in IBAN format :</i>	
Bank's BIC/SWIFT:	

Person in charge of administrative and financial follow-up

Title:		Last name:		
First name:		Phone:		
Fax:		E-mail:		
Mailing Address:	Street Number:			
	Address:			
	Additional address:			
	Postal code:		City:	
	Country:			

Project acronym: AZX

Other financial support*

Name of funders	Nature and purpose of funding	Amount requested	Amount obtained
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* Please list here all requested or obtained grants by the beneficial owner for the same project (Cf. ANR grant Regulation n°ANR-RF-2015-03). This list is to be updated as necessary.

Project acronym: AZX

Financial data for partner's contribution (Net amount excluding taxes in €, including non-refundable VAT)

Full-time		Personnels				Instruments and equipments (€)	Buildings and grounds (€)	Contract research (€)	Overhead costs (€)	Total (€)
Cost (€)	Persons. months	Non-full-time WITH funding request		Non-full-time WITHOUT funding request						
Cost (€)	Persons. months	Cost (€)	Persons. months	Cost (€)	Persons. months					
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	262 957.53	0.00	262 957.53

For information only : maximum amount of environmental costs taken into account 21 036.60

Environmental costs (Max 8.00%) 0 % 0.00 €
Total expenses 0.00 €

Cost declared 262 957.53
 Funding base (€) 262 957.53
Grant rate requested (%) 100.00

Requested funding (€)	262 957.53
including	0.00 € for internal billing on the whole project
	0.00 € for billing between partners on the whole project

Partner4 identity and budget

Scientific and technical leader

project coordinator: No

Gender:	Mr	Title:	Directeur R&D
Last name:	Allouche	First name:	Cyril
Phone:	0130807000	Mobile:	0130807000
E-mail:	cyril.allouche@atos.net		
Date of birth:	10/11/1975		

Partner identity:

Full name of partner:	Bull SAS		
Partner's initials:	Bull		
Partner's RNSR:			
Partner's category:	Entreprise autre que TPE ou PME		
Partner's country :	France		
Research Funding Organisation :	ANR		
Base for calculating grant amount:	Coût complet		
Is the partner "Carnot Institute" labelled?	No	If yes, which one?	
Siret number of the organisation:			

For an institution or public research body:

Research unit type:	Research unit number:
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Funding management authorities:

Legal Nature of the management instance:

Control instances:

Other instances:

Siret number of the organisation:

For a company:

Workforce (if SME):

Project acronym: AZX

Address where scientific work is performed:	Street Number:	
	Address:	
	Additional address:	
	Postcode:	City:
	Cedex:	Country:

Person authorised to legally represent the managing establishment (for acts of award)

Gender:			
Last name:		First name:	
Position:			
Mailing Address	Street Number:		
	Address:		
	Additional address:		
	Postal code:		City:
	Country:		

Banking information:

Name of bank:	
IBAN account information (<i>Europe Area</i>) <i>in IBAN format :</i>	
Bank's BIC/SWIFT:	

Person in charge of administrative and financial follow-up

Title:		Last name:	
First name:		Phone:	
Fax:		E-mail:	
Mailing Address:	Street Number:		
	Address:		
	Additional address:		
	Postal code:		City:
	Country:		

Project acronym: AZX

Other financial support*

Name of funders	Nature and purpose of funding	Amount requested	Amount obtained
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* Please list here all requested or obtained grants by the beneficial owner for the same project (Cf. ANR grant Regulation n°ANR-RF-2015-03). This list is to be updated as necessary.

Financial data for partner's contribution (Net amount excluding taxes in €, including non-refundable VAT)

Full-time		Personnels				Instruments and equipments (€)	Buildings and grounds (€)	Contract research (€)	Overhead costs (€)	Total (€)
Cost (€)	Persons. months	Non-full-time WITH funding request		Non-full-time WITHOUT funding request						
Cost (€)	Persons. months	Cost (€)	Persons. months	Cost (€)	Persons. months					
365 000.00	30.00	0.00	0.00	0.00	0.00	50 000.00	0.00	0.00	5 000.00	420 000.00

For information only : maximum amount of structure costs taken into account 252 050.00

Personnel costs (Max 68%) 0 % 0.00 €
 Other expenses (Max 7%) 0 % 0.00 €
Total expenses 0.00 €

Full cost (€) 420 000.00
 Funding base (€) 420 000.00
Grant rate requested (%) 25.00

Requested funding (€)	105 000.00
including	0.00 € for internal billing on the whole project
	0.00 € for billing between partners on the whole project

Partner5 identity and budget

Scientific and technical leader

project coordinator: No

Gender:	Mr	Title:	Researcher/Lecturer
Last name:	Kissinger	First name:	Aleks
Phone:		Mobile:	0631340970
E-mail:	aleks@cs.ru.nl		
Date of birth:	03/04/1985		

Partner identity:

Full name of partner: Radboud Universiteit

Partner's initials: RU

Partner's RNSR:

Partner's category: Divers public

Partner's country : Netherlands (the)

Research Funding Organisation : NWO

Base for calculating grant amount: Coût complet

Is the partner "Carnot Institute" labelled? No **If yes, which one?**

Siret number of the organisation:

For an institution or public research body:

Research unit type:

Research unit number:

Funding management authorities:

Legal Nature of the management instance:

Control instances:

Other instances:

Siret number of the organisation:

For a company:

Workforce (if SME):

Project acronym: AZX

Address where scientific work is performed:	Street Number:	
	Address:	
	Additional address:	
	Postcode:	City:
	Cedex:	Country:

Person authorised to legally represent the managing establishment (for acts of award)

Gender:			
Last name:		First name:	
Position:			
Mailing Address	Street Number:		
	Address:		
	Additional address:		
	Postal code:		City:
	Country:		

Banking information:

Name of bank:	
IBAN account information (<i>Europe Area</i>) <i>in IBAN format :</i>	
Bank's BIC/SWIFT:	

Person in charge of administrative and financial follow-up

Title:		Last name:	
First name:		Phone:	
Fax:		E-mail:	
Mailing Address:	Street Number:		
	Address:		
	Additional address:		
	Postal code:		City:
	Country:		

Project acronym: AZX

Other financial support*

Name of funders	Nature and purpose of funding	Amount requested	Amount obtained
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* Please list here all requested or obtained grants by the beneficial owner for the same project (Cf. ANR grant Regulation n°ANR-RF-2015-03). This list is to be updated as necessary.

Financial data for partner's contribution (Net amount excluding taxes in €, including non-refundable VAT)

Full-time		Personnels Non-full-time WITH funding request		Non-full-time WITHOUT funding request		Instruments and equipments (€)	Buildings and grounds (€)	Contract research (€)	Overhead costs (€)	Total (€)
Cost (€)	Persons. months	Cost (€)	Persons. months	Cost (€)	Persons. months					
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	250 000.00	0.00	250 000.00

For information only : maximum amount of structure costs taken into account 17 500.00

Personnel costs (Max 68%) 0 % 0.00 €
 Other expenses (Max 7%) 0 % 0.00 €
Total expenses 0.00 €

Full cost (€) 250 000.00
 Funding base (€) 250 000.00
Grant rate requested (%) 100.00

Requested funding (€)	250 000.00
including	0.00 € for internal billing on the whole project
	0.00 € for billing between partners on the whole project

SUMMARY TABLES

Summary of partners' names

	Partner's abbreviated title	Full name of partner
Partner 1		University of Strathclyde
Partner 2	University of Oxford	University of Oxford
Partner 3	LORIA	Laboratoire lorrain de recherche en informatique et ses applications
Partner 4	Bull	Bull SAS
Partner 5	RU	Radboud Universiteit