EUROPEAN COMMISSION
Research Executive Agency
Director

AMENDMENT Reference No AMD-765374-13

Grant Agreement number: 765374 — Reduced Order Modelling, Simulation and Optimization of Coupled systems (ROMSOC)

The parties agree to amend the Grant Agreement as follows ('**Amendment**'):

1. Change of Annex 1 (description of the action)

Annex 1 is changed and replaced by the Annex 1 attached to this Amendment.

2. Change of the action's duration

The duration of the action in **Article 3** is changed to 60 months.

3. Change of the reporting periods

The reporting periods are changed.

This implies the **following changes** to the Grant Agreement:

- The reporting periods in **Article 20.2** are replaced by:

  - RP1: from month 1 to month 24
  - RP2: from month 25 to month 60

4 . Changes of Annex 2 (estimated budget)

Annex 2 is changed and replaced by the Annex 2 attached to this Amendment.

5. Change of the maximum grant amount (decrease)

The maximum grant amount set out in **Article 5.1** is changed to:

"**EUR 2 661 418.08** (two million six hundred and sixty one thousand four hundred and eighteen EURO and eight eurocents)".

6. Change of the estimated eligible costs

The estimated eligible costs of the action set out in **Article 5.2** are changed to:

> "**EUR 2 661 418.08** (two million six hundred and sixty one thousand four hundred and eighteen EURO and eight eurocents)".

All other provisions of the Grant Agreement and its Annexes remain unchanged.

This Amendment **enters into force** on the day of the last signature.

This Amendment **takes effect** on the date on which the amendment enters into force, except where a different date has been agreed by the parties (for one or more changes).

Please inform the other members of the consortium of the Amendment.

SIGNATURES

For the coordinator

For the Agency

Enclosures:

Annex 2
Annex 1

EUROPEAN COMMISSION
Research Executive Agency

The Director

ANNEX 1 (part A)

European Industrial Doctorates

NUMBER — 765374 — ROMSOC

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1.1. The project summary

Project Number [1]	765374	Project Acronym [2]	ROMSOC

One form per project

General information	
Project title [3]	Reduced Order Modelling, Simulation and Optimization of Coupled systems
Starting date [4]	01/09/2017
Duration in months [5]	60
Call (part) identifier [6]	H2020-MSCA-ITN-2017
Topic	MSCA-ITN-2017 Innovative Training Networks
Fixed EC Keywords	Transport engineering, intelligent transport systems, Control theory and optimization, Electronics, photonics, Numerical analysis and scientific computing, Medical engineering and technology
Free keywords	Model hierarchy, model coupling, model reduction, error estimation, adaptive optics, computational finance, pulsative blood pumps,industrial flow, power networks, transport network, blast furnaces.

Abstract [7]

The development of high quality products and processes is essential for the future competitiveness of the European economy. In most key technology areas product development is increasingly based on simulation and optimization via mathematical models that allow to optimize design and functionality using free design parameters. Best performance of modelling, simulation and optimization (MSO) techniques is obtained by using a model hierarchy ranging from very fine to very coarse models obtained by model order reduction (MOR) techniques and to adapt the model and the methods to the user-defined requirements in accuracy and computational speed.
ROMSOC will work towards this goal for high dimensional and coupled systems that describe different physical phenomena on different scales; it will derive a common framework for different industrial applications and train the next generation of researchers in this highly interdisciplinary field. It will focus on the three major methodologies: coupling methods, model reduction methods, and optimization methods, for industrial applications in well selected areas, such as optical and electronic systems, economic processes, and materials. ROMSOC will develop novel MSO techniques and associated software with adaptability to user-defined accuracy and efficiency needs in different scientific disciplines. It will transfer synergies between different industrial sectors, in particular for SMEs.
To lift this common framework to a new qualitative level, a joint training programme will be developed which builds on the strengths of the academic and industrial partners and their strong history of academic/industrial cooperation. By delivering early-career training embedded in a cutting-edge research programme, ROMSOC will educate highly skilled interdisciplinary researchers in mathematical MSO that will become facilitators in the transfer of innovative concepts to industry. It will thus enhance the capacity of European research and development.

1.2. List of Beneficiaries

Project Number [1]	765374	Project Acronym [2]	ROMSOC

List of Beneficiaries

No	Name	Short name	Country	Project entry date[8]	Project exit date
1	TECHNISCHE UNIVERSITAT BERLIN	MATHEON-TUB	Germany		
2	MATHCONSULT GMBH	MathConsult	Austria		
3	UNIVERSITAT LINZ	JKU	Austria		
4	MICROGATE SRL	MICROGATE	Italy		
5	CONSORCIO INSTITUTO TECNOLOXICO MATEMATICA INDUSTRIAL ITMATI	ITMATI	Spain		
6	INSTITUT NATIONAL DE RECHERCHE ENINFORMATIQUE ET AUTOMATIQUE	INRIA	France		
7	UNIVERSITAET BREMEN	U-HB	Germany		
8	BERGISCHE UNIVERSITAET WUPPERTAL	BUW	Germany		
9	STMICROELECTRONICS SRL	STM	Italy		
10	FRIEDRICH-ALEXANDER-UNIVERSITAET ERLANGEN-NUERNBERG	FAU	Germany		
11	POLITECNICO DI MILANO	MOX-PoliMi	Italy		
12	SCUOLA INTERNAZIONALE SUPERIORE DI STUDI AVANZATI DI TRIESTE	SISSA	Italy		
13	FORSCHUNGSVERBUND BERLIN EV	FVB-WIAS	Germany		

1.3. Workplan Tables - Detailed implementation

1.3.1. WT1 List of work packages

WP Number[9]	WP Title	Lead beneficiary[10]	Start month[12]	End month[13]
WP1	Training Programme	11 - MOX-PoliMi	7	60
WP2	Coupling Methods	8 - BUW	7	60
WP3	Reduction Methods	12 - SISSA	7	60
WP4	Optimization Methods	10 - FAU	7	60
WP5	Benchmarks for Model Hierarchies	5 - ITMATI	7	60
WP6	Dissemination	3 - JKU	1	60
WP7	Management	1 - MATHEON-TUB	1	60
WP8	Ethics requirements	1 - MATHEON-TUB	1	60
WP9	Open Research Data	1 - MATHEON-TUB	1	60

1.3.2. WT2 list of deliverables

Deliverable Number[14]	Deliverable Title	WP number[9]	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D1.1	Personal career development plans for all ESRs	WP1	11 - MOX-PoliMi	Report	Public	11
D1.2	Completed training programme on Mathematical Methodologies	WP1	11 - MOX-PoliMi	Other	Public	23
D1.3	All the ESRs pass their first-year Ph.D. evaluation at their respective institutions	WP1	11 - MOX-PoliMi	Other	Public	24
D1.4	Completed training programmes on transferable and- soft skills	WP1	11 - MOX-PoliMi	Other	Public	47
D1.5	Awarded PhD degrees for all ESRs	WP1	11 - MOX-PoliMi	Other	Public	60
D2.1	Report on common coupling framework, error and complexity measures	WP2	8 - BUW	Report	Public	23
D2.2	Reports on specific model hierarchies for different coupling applications and the corresponding error analyses	WP2	8 - BUW	Report	Public	24
D2.3	Reports and Software for parameterized coupling interface	WP2	8 - BUW	Other	Confidential, only for members of the consortium (including the Commission Services)	41
D3.1	Reports about new model order reduction techniques, error estimators and algorithms	WP3	12 - SISSA	Report	Public	24
D3.2	Reports on specific reduced order modelling techniques for different applications	WP3	12 - SISSA	Report	Public	24
D3.3	Reports and Software for new model reduction techniques in different industrial	WP3	12 - SISSA	Other	Confidential, only for members of the consortium (including the	38

Deliverable Number[14]	Deliverable Title	WP number[9]	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
	applications and the incorporation of reduced order models in model hierarchies				Commission Services)	
D4.1	Reports about error estimators and data-driven adaptations for modelling and optimization errors	WP4	10 - FAU	Report	Public	23
D4.2	Reports about new techniques for the integration of model hierarchies into optimization techniques	WP4	10 - FAU	Report	Public	44
D4.3	Reports and Software for new optimization methods in different industrial applications	WP4	10 - FAU	Other	Confidential, only for members of the consortium (including the Commission Services)	44
D5.1	Reports about 8 selected benchmark cases of model hierarchies	WP5	5 - ITMATI	Report	Public	12
D5.2	Software-based representation of selected benchmark hierarchies equipped with publically available data	WP5	5 - ITMATI	Other	Public	24
D5.3	Benchmark cases	WP5	5 - ITMATI	Report	Public	46
D5.4	Reports, data and web presentation of model hierarchies for the use in training courses	WP5	5 - ITMATI	Other	Public	54
D6.1	ROMSOC website	WP6	3 - JKU	Websites, patents filling, etc.	Public	12
D6.2	Invited session proposals at Conference on Reduced Order Modelling, Simulation and Optimization of Coupled Systems	WP6	3 - JKU	Other	Public	24
D6.3	Final workshop on future valorisation of the results and	WP6	3 - JKU	Other	Public	49

Deliverable Number[14]	Deliverable Title	WP number[9]	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
	industrial knowledge transfer					
D7.1	Organization of Kick-off, Supervisory Board, and project meetings	WP7	1 - MATHEON-TUB	Other	Confidential, only for members of the consortium (including the Commission Services)	1
D7.2	Consortium agreement	WP7	1 - MATHEON-TUB	Other	Confidential, only for members of the consortium (including the Commission Services)	2
D7.3	Supervisory Board of ROMSOC	WP7	1 - MATHEON-TUB	Other	Public	2
D7.4	Discussion platform	WP7	3 - JKU	Other	Confidential, only for members of the consortium (including the Commission Services)	12
D7.5	ESR recruitment final summary report	WP7	1 - MATHEON-TUB	Other	Public	12
D7.6	Progress report	WP7	1 - MATHEON-TUB	Report	Confidential, only for members of the consortium (including the Commission Services)	13
D7.7	Innovation Report	WP7	1 - MATHEON-TUB	Report	Public	59
D8.1	NEC - Requirement No. 1	WP8	1 - MATHEON-TUB	Ethics	Confidential, only for members of the consortium (including the Commission Services)	12
D8.2	DU - Requirement No. 2	WP8	1 - MATHEON-TUB	Ethics	Confidential, only for members of the consortium (including the Commission Services)	12
D8.3	M - Requirement No. 3	WP8	1 - MATHEON-TUB	Ethics	Confidential, only for members of the consortium (including the	12

Deliverable Number[14]	Deliverable Title	WP number[9]	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
					Commission Services)	
D9.1	Data Management Plan	WP9	1 - MATHEON-TUB	ORDP: Open Research Data Pilot	Public	6

1.3.3. WT3 Work package descriptions

Work package number [9]	WP1	**Lead beneficiary** [10]	11 - MOX-PoliMi
Work package title	Training Programme		
Start month	7	**End month**	60

Objectives

TO1, TO2, TO3, TO4, TO5, TO6 as described in detail in Section 1.2.2 of the DoA (pp. 10-11)

Description of work and role of partners

WP1 - Training Programme [Months: 7-60]
MOX-PoliMi
WP1 is constituted by the following tasks corresponding to the Training Objectives TO1-TO6 described in § 1.2.
Task 1.1: Hands-on research projects
Task 1.2: Advanced training courses
Task 1.3: Workshops
Task 1.4: Network meetings
Task 1.5: Project meetings
Task 1.6: Post Graduate and Staff Development courses
WP1 involves all participating teams and all ESRs; MOX-PoliMi is the leading partner.

Participation per Partner

Partner number and short name [10]
1 - MATHEON-TUB
2 - MathConsult
3 - JKU
4 - MICROGATE
5 - ITMATI
6 - INRIA
7 - U-HB
8 - BUW
9 - STM
10 - FAU
11 - MOX-PoliMi
12 - SISSA
13 - FVB-WIAS

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D1.1	Personal career development plans for all ESRs	11 - MOX-PoliMi	Report	Public	11
D1.2	Completed training programme on Mathematical Methodologies	11 - MOX-PoliMi	Other	Public	23
D1.3	All the ESRs pass their first-year Ph.D. evaluation at their respective institutions	11 - MOX-PoliMi	Other	Public	24
D1.4	Completed training programmes on transferable and- soft skills	11 - MOX-PoliMi	Other	Public	47
D1.5	Awarded PhD degrees for all ESRs	11 - MOX-PoliMi	Other	Public	60

Description of deliverables

D1.1: Personal career development plans for all ESRs (M11).
D1.2: Completed training programme on Mathematical Methodologies (M23).
D1.3: All the ESRs pass their first-year Ph.D. evaluation at their respective institutions (M24).
D1.4: Completed training programmes on transferable and- soft skills (M47).
D1.5: Awarded PhD degrees for all ESRs (M60).

D1.1 : Personal career development plans for all ESRs [11]

Personal career development plans for all ESRs (M11)

D1.2 : Completed training programme on Mathematical Methodologies [23]

Completed training programme on Mathematical Methodologies (M23)

D1.3 : All the ESRs pass their first-year Ph.D. evaluation at their respective institutions [24]

All the ESRs pass their first-year Ph.D. evaluation at their respective institutions (M24)

D1.4 : Completed training programmes on transferable and- soft skills [47]

Completed training programmes on transferable and- soft skills (M47)

D1.5 : Awarded PhD degrees for all ESRs [60]

Awarded PhD degrees for all ESRs (M54)

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS3	Personal career development plan ESRs	11 - MOX-PoliMi	8	Personal career development plan ESRs (verified by D1.1)

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS6	ESRs pass 1st-year Ph.D. evaluation	11 - MOX-PoliMi	18	ESRs pass 1st-year Ph.D. evaluation (verified by D1.3)
MS14	Ph.D. degrees ESRs awarded	11 - MOX-PoliMi	60	Ph.D. degrees ESRs awarded (verified by D1.5)

Work package number [9]	WP2	**Lead beneficiary** [10]	8 - BUW
Work package title	Coupling Methods		
Start month	7	**End month**	60

Objectives

Based on industrial applications from different sectors, an efficient coupling methodology will be developed, that allows coupling of different physical phenomena in a joined system of partial differential and algebraic equations. The coupling methodology will be constructed such that it can be directly mapped into model hierarchies, and that it can be used in combination with commercial and academic software, allowing compromises between user-defined accuracy and efficiency. Physical areas are thermal-mechanical, thermal-electrical, fluid-structure, fluid-optical and multi-rate models. Industrial applications will be the control of thermo-acoustic multi-layer flow velocity sensors, industrial production flows, thermo-mechanical behaviour of blast furnaces, and the development of pulsatile heart pumps.

Description of work and role of partners

WP2 - Coupling Methods [Months: 7-60]
BUW
WP2 is constituted by the following research tasks:
Task 2.1: Development of a common coupling framework for thermal-mechanical, thermal-electrical, fluid-structure, fluid-optical, thermo-acoustic systems and of multi-rate models, on the basis of appropriately chosen scales. (This task will involve all the partners in Figure 1 second column, and the ESRs 2, 5, 8, 9 and 10)
Task 2.2: Definition of appropriate error and complexity measures. (This task will involve all the partners in Figure 1 second column, and the ESRs 2, 5, 8, 9 and 10)
Task 2.3: Building of concrete model hierarchies and selection of appropriate basis representations and parameter sets for models in different coupling applications fields and industrial sectors, (individual subgroups of partners and ESRs as in the different boxes in Figure 1 second column).
Task 2.4: Error analysis for model hierarchy in specific application fields and industrial sectors (subgroups of partners and ESRs as in the different boxes in Figure 1 second column).
Task 2.5: Construction and implementation of a parameterized coupling interface
(This task will involve all the partners in Figure 1 second column, and the ESRs 2, 5, 8, 9 and 10)
WP2 involves the teams ITMATI, Microflown, BUW, STM, Danieli, MOX, CorWave, SISSA, AMIII, and the ESRs 2, 5, 8, 9 and 10; BUW is the leading partner.

Participation per Partner

Partner number and short name [10]
5 - ITMATI
8 - BUW
9 - STM
11 - MOX-PoliMi
12 - SISSA

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D2.1	Report on common coupling framework, error and complexity measures	8 - BUW	Report	Public	23
D2.2	Reports on specific model hierarchies for different coupling applications and the corresponding error analyses	8 - BUW	Report	Public	24
D2.3	Reports and Software for parameterized coupling interface	8 - BUW	Other	Confidential, only for members of the consortium (including the Commission Services)	41

Description of deliverables

D2.1: Report on common coupling framework, error and complexity measures (M23).
D2.2: Reports on specific model hierarchies for different coupling applications and the corresponding error analyses (M24)
D2.3: Reports and Software for parameterized coupling interface (M41)

D2.1 : Report on common coupling framework, error and complexity measures [23]

Report on common coupling framework, error and complexity measures (M23)

D2.2 : Reports on specific model hierarchies for different coupling applications and the corresponding error analyses [24]

Reports on specific model hierarchies for different coupling applications and the corresponding error analyses (M24)

D2.3 : Reports and Software for parameterized coupling interface [41]

Reports and Software for parameterized coupling interface (M41)

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS7	Specific model hierarchies for different coupling applications available	8 - BUW	19	Specific model hierarchies for different coupling applications available (verified by D2.2)
MS11	Software for parameterized coupling interface available	8 - BUW	42	Software for parameterized coupling interface available (verified by D2.3)

Work package number [9]	WP3	Lead beneficiary [10]	12 - SISSA
Work package title	Reduction Methods		
Start month	7	End month	60

Objectives

This WP aims the development of new efficient model order reduction algorithms and software with error control for (coupled) parameterized systems of partial differential and algebraic equations. These reduced models will form the coarsest level of the desired model hierarchy. The goal is to study reduced basis methods, proper orthogonal decomposition and modal truncation methods for the parameterized models for industrial applications arising in the control of high performance telescopes in adaptive optics, the valuation of financial products, and the thermo-mechanical behaviour of blast furnaces. Key factor in this work package is to use the challenges arising in the different industrial applications to extend the currently available MOR with error estimates and error control techniques.

Description of work and role of partners

WP3 - Reduction Methods [Months: 7-60]
SISSA
WP3 is constituted by the following research tasks:
Task 3.1: Development of a new parameterized model order reduction methods on the basis reduced basis techniques, proper orthogonal decomposition, as well as modal truncation methods. (This task will involve all the partners in Figure 1 third column, and the ESRs 1, 6, 8 and 10)
Task 3.2: Definition and computation of appropriate error estimates and methods for error estimation for reduced order models. (This task will involve all the partners in Figure 1 third column, and the ESRs 1, 6, 8 and 10)
Task 3.3: Reduced order modelling on the basis of appropriate basis representations and parameter sets for models in different coupling applications fields and industrial sectors. (This task will involve individual subgroups of partners and ESRs as in different boxes in Figure 1 third column).
Task 3.4: Implementation of model order reduction methods in different coupling applications fields and industrial sectors, (This task will involve individual subgroups of partners and ESRs as in different boxes in Figure 1 third column).
Task 3.5: Incorporation of reduced order models in model hierarchies generated in WP2. (This task will involve individual subgroups of partners and ESRs as in different boxes in Figure 1 third column).
WP3 involves the teams JKU, Microgate, MATHEON, Mathconsult, ITMATI, Danieli, SISSA, AMIII, and ESRs 1, 6, 8 and 10; SISSA is the leading partner.

Participation per Partner

Partner number and short name [10]
1 - MATHEON-TUB
2 - MathConsult
3 - JKU
4 - MICROGATE
5 - ITMATI
12 - SISSA

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D3.1	Reports about new model order reduction techniques, error estimators and algorithms	12 - SISSA	Report	Public	24
D3.2	Reports on specific reduced order modelling techniques for different applications	12 - SISSA	Report	Public	24
D3.3	Reports and Software for new model reduction techniques in different industrial applications and the incorporation of reduced order models in model hierarchies	12 - SISSA	Other	Confidential, only for members of the consortium (including the Commission Services)	38

Description of deliverables

D3.1: Reports about new model order reduction techniques, error estimators and algorithms (M24).
D3.2: Reports on specific reduced order modelling techniques for different applications (M24).
D3.3: Reports and Software for new model reduction techniques in different industrial applications and the incorporation of reduced order models in model hierarchies (M38).

D3.1 : Reports about new model order reduction techniques, error estimators and algorithms [24]

Reports about new model order reduction techniques, error estimators and algorithms (M24)

D3.2 : Reports on specific reduced order modelling techniques for different applications [24]

Reports on specific reduced order modelling techniques for different applications (M24).

D3.3 : Reports and Software for new model reduction techniques in different industrial applications and the incorporation of reduced order models in model hierarchies [38]

Reports and Software for new model reduction techniques in different industrial applications and the incorporation of reduced order models in model hierarchies (M38).

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS9	Specific reduced order modelling techniques for different applications available	12 - SISSA	22	Specific reduced order modelling techniques for different applications available (verified by D3.2)
MS12	Software for incorporation of reduced order models in model hierarchies available	12 - SISSA	39	Software for incorporation of reduced order models in model hierarchies available (verified by D3.3)

Work package number [9]	WP4	Lead beneficiary [10]	10 - FAU
Work package title	Optimization Methods		
Start month	7	End month	60

Objectives

In current industrial design or process planning, the optimization process typically consists in simulating several different parameter constellations and choosing the optimum is chosen from these possibilities. The new levels of optimization techniques that will be delivered in this WP are based on the choice of appropriate cost and the use model-based optimization to optimize this cost function by varying over whole parameter set. To be feasible and accurate enough for used needs model hierarchies including vastly reduced parameterized models will be employed as they are generated in WP2, WP3. Making use of such model hierarchies and integrating them into current efficient optimization methods is the innovation of this work package. This will be done on the basis of the individual industrial applications combined with state-of-the art optimization techniques.

Description of work and role of partners

WP4 - Optimization Methods [Months: 7-60]
FAU
Task 4.1: Combination of error estimates and bounds for modelling errors and optimization errors. (This task will involve all the partners in Figure 1 fourth column, and the ESRs 1, 3, 4, 7 and 11)
Task 4.2: Integration of model hierarchies and error estimators in state-of-the art optimization techniques for models in different applications fields and industrial sectors. (This task will involve all the partners in Figure 1 fourth column, and the ESRs 1, 3, 4, 7 and 11)
Task 4.3: Implementation of hierarchical models and error estimates in optimization methods for different applications fields and industrial sectors. (This task will involve all the partners in Figure 1 fourth column, and the ESRs 1, 3, 4, 7 and 11)
Task 4.4: Integration of data-driven model adaptations using basis/machine-learning approaches based on the error analysis done in Task 4.1. (This task will involve all the partners in Figure 1 fourth column, and the ESRs 1, 3, 4, 7 and 11).
WP4 involves the teams JKU, Microgate, INRIA, Signify, U-HB, SagivTech, FAU, DB, FVB-WIAS, MathTech and ESRs 1, 3, 4, 7 and 11; FAU is the leading partner.

Participation per Partner

Partner number and short name [10]
3 - JKU
4 - MICROGATE
6 - INRIA
7 - U-HB
10 - FAU
13 - FVB-WIAS

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D4.1	Reports about error estimators and data-driven adaptations for modelling and optimization errors	10 - FAU	Report	Public	23
D4.2	Reports about new techniques for the integration of model hierarchies into optimization techniques	10 - FAU	Report	Public	44
D4.3	Reports and Software for new optimization methods in different industrial applications	10 - FAU	Other	Confidential, only for members of the consortium (including the Commission Services)	44

Description of deliverables

D4.1: Reports about error estimators and data-driven adaptations for modelling and optimization errors (M23).
D4.2: Reports about new techniques for the integration of model hierarchies into optimization techniques (M44).
D4.3: Reports and Software for new optimization methods in different industrial applications (M44).

D4.1 : Reports about error estimators and data-driven adaptations for modelling and optimization errors [23]

Reports about error estimators and data-driven adaptations for modelling and optimization errors (M23)

D4.2 : Reports about new techniques for the integration of model hierarchies into optimization techniques [44]

Reports about new techniques for the integration of model hierarchies into optimization techniques (M44)

D4.3 : Reports and Software for new optimization methods in different industrial applications [44]

Reports and Software for new optimization methods in different industrial applications (M44)

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS10	New optimization methods in different industrial applications available	10 - FAU	45	New optimization methods in different industrial applications available (verified by D4.3)

Work package number [9]	WP5	Lead beneficiary [10]	5 - ITMATI
Work package title	Benchmarks for Model Hierarchies		
Start month	7	End month	60

Objectives

Development of benchmarks for model hierarchies that are based on industrial applications.

Description of work and role of partners

WP5 - Benchmarks for Model Hierarchies [Months: 7-60]
ITMATI
Task 5.1: Selection of appropriate benchmark models from industrial partners where concrete data can be made publically available.
Task 5.2: Implementation of the model hierarchy as open access models based on several of the industrial applications.
Task 5.3: Preparation of documents for dissemination that will be equipped with available data to be used for training in modelling, model testing, reduced order modelling, estimation errors, optimization efficiency in algorithmic approaches, and testing of generated MSO / MOR software.
Task 5.4: Preparation and testing of benchmarks as teaching material for training courses offered at the participating academic and industrial partners.
Task 5.5: Preparation of web-based versions of benchmarks for public use.
WP5 involves all partners of the network and all ESRs; the leader of this WP will be ITMATI.

Participation per Partner

Partner number and short name [10]
1 - MATHEON-TUB
2 - MathConsult
3 - JKU
4 - MICROGATE
5 - ITMATI
6 - INRIA
7 - U-HB
8 - BUW
9 - STM
10 - FAU
11 - MOX-PoliMi
12 - SISSA
13 - FVB-WIAS

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D5.1	Reports about 8 selected benchmark cases of model hierarchies	5 - ITMATI	Report	Public	12
D5.2	Software-based representation of selected benchmark hierarchies equipped with publically available data	5 - ITMATI	Other	Public	24
D5.3	Benchmark cases	5 - ITMATI	Report	Public	46
D5.4	Reports, data and web presentation of model hierarchies for the use in training courses	5 - ITMATI	Other	Public	54

Description of deliverables

D5.1: Reports about 8 selected benchmark cases of model hierarchies (M12)
D5.2: Software-based representation of selected benchmark hierarchies equipped with publically available data (M24).
D5.3: Benchmark cases (M46)
D5.4: Reports, data and web presentation of model hierarchies for the use in training courses (M54).

D5.1 : Reports about 8 selected benchmark cases of model hierarchies [12]

Reports about 8 selected benchmark cases of model hierarchies (M12)

D5.2 : Software-based representation of selected benchmark hierarchies equipped with publically available data [24]

Software-based representation of selected benchmark hierarchies equipped with publically available data (M24)

D5.3 : Benchmark cases [46]

Benchmark cases (M46)

D5.4 : Reports, data and web presentation of model hierarchies for the use in training courses [54]

Reports, data and web presentation of model hierarchies for the use in training courses (M54)

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS5	Selected benchmark cases of model hierarchies available	5 - ITMATI	12	Selected benchmark cases of model hierarchies available (verified by D5.1)
MS8	Software-based representation of selected benchmark hierarchies equipped with publically available data ready	5 - ITMATI	20	Software-based representation of selected benchmark hierarchies equipped with publically available data ready (verified by D5.2)
MS13	Benchmark cases	5 - ITMATI	47	Benchmark cases (verified by D5.3)

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS15	Benchmarks for model hierarchies available for the use in training courses	5 - ITMATI	53	Benchmarks for model hierarchies available for the use in training courses (verified by D5.4)

Work package number [9]	WP6	Lead beneficiary [10]	3 - JKU
Work package title	Dissemination		
Start month	1	End month	60

Objectives

Increase synergies between academia and industry in the field of MSO; initiate the transfer of results to the scientific community and to real-world (industrial) applications.

Description of work and role of partners

WP6 - Dissemination [Months: 1-60]
JKU
This WP involves:
Task 6.1: Set up ROMSOC website, organization of workshops, invited sessions at conferences and publications.
Task 6.2: Knowledge transfer to industry using industrial partner as pivotal points to translate cutting-edge research into software directly applicable to real-world industrial challenges.
WP6 involves all participants and all ESRs and will be led by JKU. It will strongly benefit from the EU-MATHS-IN network comprising 14 European countries and over 2,000 estimated stakeholders.

Participation per Partner

Partner number and short name [10]
1 - MATHEON-TUB
2 - MathConsult
3 - JKU
4 - MICROGATE
5 - ITMATI
6 - INRIA
7 - U-HB
8 - BUW
9 - STM
10 - FAU
11 - MOX-PoliMi
12 - SISSA
13 - FVB-WIAS

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D6.1	ROMSOC website	3 - JKU	Websites, patents filling, etc.	Public	12

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D6.2	Invited session proposals at Conference on Reduced Order Modelling, Simulation and Optimization of Coupled Systems	3 - JKU	Other	Public	24
D6.3	Final workshop on future valorisation of the results and industrial knowledge transfer	3 - JKU	Other	Public	49

Description of deliverables

D6.1: ROMSOC website (M12).
D6.2: Invited session proposals at conferences on: Challenges in Reduced Order Modelling, Simulation and Optimization of Coupled Systems (M24).
D6.3: Final workshop on valorisation of the results, industrial knowledge transfer and future challenges (M49).

D6.1 : ROMSOC website [12]

ROMSOC website (M12)

D6.2 : Invited session proposals at Conference on Reduced Order Modelling, Simulation and Optimization of Coupled Systems [24]

Invited session proposals at conferences on: Challenges in Reduced Order Modelling, Simulation and Optimization of Coupled Systems (M24)

D6.3 : Final workshop on future valorisation of the results and industrial knowledge transfer [49]

Final workshop on valorisation of the results, industrial knowledge transfer and future challenges (M49)

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS4	Project website online	3 - JKU	10	Project website online (verified by D6.1)

Work package number [9]	WP7	Lead beneficiary [10]	1 - MATHEON-TUB
Work package title	Management		
Start month	1	End month	60

Objectives

Monitoring and control of the progress of the project.

Description of work and role of partners

WP7 - Management [Months: 1-60]
MATHEON-TUB
The management tasks are divided as follows:
Task 7.1: Organisation of workshops along with 6-months meetings (MATHEON-TUB)
Task 7.2: Research Data Management (MATHEON-TUB)
Task 7.3: Discussion of progress regarding the PhD theses of the ESRs (Supervisory Board: all)
Task 7.4: Discussion of participation in external conferences, workshops and summer schools (MOX-PoliMi).
Task 7.5: Discussion platform (wiki) for keeping WP2-WP5 knowledge base up to date (JKU).
Task 7.6: Scientific aspects of intermediary and final reports (Training & Research Committee: WP-Leaders).

Participation per Partner

Partner number and short name [10]
1 - MATHEON-TUB
2 - MathConsult
3 - JKU
4 - MICROGATE
5 - ITMATI
6 - INRIA
7 - U-HB
8 - BUW
9 - STM
10 - FAU
11 - MOX-PoliMi
12 - SISSA
13 - FVB-WIAS

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D7.1	Organization of Kick-off, Supervisory Board, and project meetings	1 - MATHEON-TUB	Other	Confidential, only for members of the consortium (including	1

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
				the Commission Services)	
D7.2	Consortium agreement	1 - MATHEON-TUB	Other	Confidential, only for members of the consortium (including the Commission Services)	2
D7.3	Supervisory Board of ROMSOC	1 - MATHEON-TUB	Other	Public	2
D7.4	Discussion platform	3 - JKU	Other	Confidential, only for members of the consortium (including the Commission Services)	12
D7.5	ESR recruitment final summary report	1 - MATHEON-TUB	Other	Public	12
D7.6	Progress report	1 - MATHEON-TUB	Report	Confidential, only for members of the consortium (including the Commission Services)	13
D7.7	Innovation Report	1 - MATHEON-TUB	Report	Public	59

Description of deliverables

D7.1: Organization of Kick-off, Supervisory Board, and project meetings (see Gantt chart for planning)
D7.2: Consortium agreement (M2)
D7.3: Supervisory Board of the ROMSOC network (M2)
D7.4: Discussion platform (wiki) (M12)
D7.5: ESR recruitment final summary report (M12)
D7.6: Progress report (M13)
D7.7: Innovation report (M59)

D7.1 : Organization of Kick-off, Supervisory Board, and project meetings [1]

Organization of Kick-off, Supervisory Board, and project meetings (see Gantt chart for planning)

D7.2 : Consortium agreement [2]

Consortium agreement (M2)

D7.3 : Supervisory Board of ROMSOC [2]

Supervisory Board of the ROMSOC network

D7.4 : Discussion platform [12]

Discussion platform (wiki) (M12)

D7.5 : ESR recruitment final summary report [12]

ESR recruitment final summary report (M7)

D7.6 : Progress report [13]

Progress report (M13)

D7.7 : Innovation Report [59]

Innovation Report (M53)

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	Consortium agreement signed	1 - MATHEON-TUB	2	Consortium agreement signed (verified by D7.2)
MS2	Recruitment ESRs completed	1 - MATHEON-TUB	12	Recruitment ESRs completed (verified by D7.5)
MS16	All recruited fellows enrolled in PhD programme	1 - MATHEON-TUB	12	All recruited fellows enrolled in PhD programme (verified by D7.6)
MS17	Project check (meeting between REA and consortium)	1 - MATHEON-TUB	14	Project check (meeting between REA and consortium)

Work package number [9]	WP8	Lead beneficiary [10]	1 - MATHEON-TUB
Work package title	Ethics requirements		
Start month	1	End month	60

Objectives

The objective is to ensure compliance with the 'ethics requirements' set out in this work package.

Description of work and role of partners

WP8 - Ethics requirements [Months: 1-60]
MATHEON-TUB
This work package sets out the 'ethics requirements' that the project must comply with.

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D8.1	NEC - Requirement No. 1	1 - MATHEON-TUB	Ethics	Confidential, only for members of the consortium (including the Commission Services)	12
D8.2	DU - Requirement No. 2	1 - MATHEON-TUB	Ethics	Confidential, only for members of the consortium (including the Commission Services)	12
D8.3	M - Requirement No. 3	1 - MATHEON-TUB	Ethics	Confidential, only for members of the consortium (including the Commission Services)	12

Description of deliverables

The 'ethics requirements' that the project must comply with are included as deliverables in this work package.

D8.1 : NEC - Requirement No. 1 [12]

6.1. The applicant must confirm that the ethical standards and guidelines of Horizon2020 will be rigorously applied, regardless of the country in which the research is carried out. The applicant must confirm that the research performed outside the EU is compatible with the Union, national and international legislation and could have been legally conducted in one of the EU Member States.

D8.2 : DU - Requirement No. 2 [12]

8.1. Details on potential dual use implications of the project and risk-mitigation strategies must be provided and copy of ethics approval must be submitted (if applicable). 8.3. Details on what goods and information used and produced in your research will need export licences (in particular in support of first real-time remote telescope control system).

D8.3 : M - Requirement No. 3 [12]

10.1. Details on measures to prevent misuse of research findings must be provided.

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification

Work package number [9]	WP9	Lead beneficiary [10]	1 - MATHEON-TUB
Work package title	Open Research Data		
Start month	1	End month	60

Objectives

To formulate a Data Management Plan (DMP)

Description of work and role of partners

WP9 - Open Research Data [Months: 1-60]
MATHEON-TUB
The consortium participates in the Pilot on Open Research Data in Horizon 2020 which aims to improve and maximise access to and re-use of research data generated by actions. However, participation in the Pilot is flexible in the sense that it does not mean that all research data needs to be open. After the action has started, participants will formulate a Data Management Plan (DMP), which should address the relevant aspects of making data FAIR – findable, accessible, interoperable and re-usable, including what data the project will generate, whether and how it will be made accessible for verification and re-use, and how it will be curated and preserved.

Participation per Partner

Partner number and short name [10]
1 - MATHEON-TUB
2 - MathConsult
3 - JKU
4 - MICROGATE
5 - ITMATI
6 - INRIA
7 - U-HB
8 - BUW
9 - STM
10 - FAU
11 - MOX-PoliMi
12 - SISSA
13 - FVB-WIAS

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D9.1	Data Management Plan	1 - MATHEON-TUB	ORDP: Open Research Data Pilot	Public	6

Description of deliverables

The Data Management Plan (DMP) should address the relevant aspects of making data FAIR – findable, accessible, interoperable and re-usable, including what data the project will generate, whether and how it will be made accessible for verification and re-use, and how it will be curated and preserved

D9.1 : Data Management Plan [6]

Data Management Plan (M6)

Schedule of relevant Milestones

Milestone number[18]	**Milestone title**	**Lead beneficiary**	**Due Date (in months)**	**Means of verification**

1.3.4. WT4 List of milestones

Milestone number[18]	Milestone title	WP number[9]	Lead beneficiary	Due Date (in months)[17]	Means of verification
MS1	Consortium agreement signed	WP7	1 - MATHEON-TUB	2	Consortium agreement signed (verified by D7.2)
MS2	Recruitment ESRs completed	WP7	1 - MATHEON-TUB	12	Recruitment ESRs completed (verified by D7.5)
MS3	Personal career development plan ESRs	WP1	11 - MOX-PoliMi	8	Personal career development plan ESRs (verified by D1.1)
MS4	Project website online	WP6	3 - JKU	10	Project website online (verified by D6.1)
MS5	Selected benchmark cases of model hierarchies available	WP5	5 - ITMATI	12	Selected benchmark cases of model hierarchies available (verified by D5.1)
MS6	ESRs pass 1st-year Ph.D. evaluation	WP1	11 - MOX-PoliMi	18	ESRs pass 1st-year Ph.D. evaluation (verified by D1.3)
MS7	Specific model hierarchies for different coupling applications available	WP2	8 - BUW	19	Specific model hierarchies for different coupling applications available (verified by D2.2)
MS8	Software-based representation of selected benchmark hierarchies equipped with publically available data ready	WP5	5 - ITMATI	20	Software-based representation of selected benchmark hierarchies equipped with publically available data ready (verified by D5.2)
MS9	Specific reduced order modelling techniques for different applications available	WP3	12 - SISSA	22	Specific reduced order modelling techniques for different applications available (verified by D3.2)
MS10	New optimization methods in different industrial applications available	WP4	10 - FAU	45	New optimization methods in different industrial applications available (verified by D4.3)
MS11	Software for parameterized coupling interface available	WP2	8 - BUW	42	Software for parameterized coupling interface available (verified by D2.3)
MS12	Software for incorporation of reduced order models in model hierarchies available	WP3	12 - SISSA	39	Software for incorporation of reduced order models in model hierarchies available (verified by D3.3)
MS13	Benchmark cases	WP5	5 - ITMATI	47	Benchmark cases (verified by D5.3)
MS14	Ph.D. degrees ESRs awarded	WP1	11 - MOX-PoliMi	60	Ph.D. degrees ESRs awarded (verified by D1.5)

Milestone number[18]	Milestone title	WP number[9]	Lead beneficiary	Due Date (in months)[17]	Means of verification
MS15	Benchmarks for model hierarchies available for the use in training courses	WP5	5 - ITMATI	53	Benchmarks for model hierarchies available for the use in training courses (verified by D5.4)
MS16	All recruited fellows enrolled in PhD programme	WP7	1 - MATHEON-TUB	12	All recruited fellows enrolled in PhD programme (verified by D7.6)
MS17	Project check (meeting between REA and consortium)	WP7	1 - MATHEON-TUB	14	Project check (meeting between REA and consortium)

1.3.5. WT5 Critical Implementation risks and mitigation actions

Risk number	Description of risk	WP Number	Proposed risk-mitigation measures
1	Delay in recruitment	WP1	1. Large pool of high-quality MSc students at academic members with appropriate background for ROMSOC 2. Organization recruitment/ modelling week.
2	ESR doesn’t pass 1st-year evaluation, or early drop-out	WP1, WP7	1. Re-recruitment of a new ESR, 2. Set-up of a contingency plan to fund the new ESR during one year (SB).
3	(Late) drop-out of an ESR	WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8	1. High-quality recruitment strategy, 2. High frequency coaching 3. Very low past PhD dropout rate of professors in the consortium.
4	Delay in training/research progress ESRs	WP1, WP2, WP3, WP4, WP5	1. Extensive experience in PhD coaching at all beneficiaries, 2. Structured training and coaching plan monitoring strategy, 3. Close collaboration ESR's.
5	Delay in delivery of coupling software	WP3	Development of software for several specialized models in WP2.
6	Lack of synergy between ESRs	WP7	Increased meeting frequency between ESRs and supervisors.
7	Session proposal rejected at conf.	WP6	Submission of papers as regular papers
8	Delay in Software Implementation	WP3, WP4	Use of professional software development tools
9	Delay in benchmarking	WP5	Alternative ways to generate publically accessible data.
10	Lack of results MOR techniques	WP3	The research approach in WP3 allows for different (and partly alternative) threads for model reduction techniques.

1.3.6. WT6 Summary of project effort contribution

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9
1 - MATHEON-TUB	✓		✓		✓	✓	✓	✓	✓
2 - MathConsult	✓		✓		✓	✓	✓		✓
3 - JKU	✓		✓	✓	✓	✓	✓	✓	✓
4 - MICROGATE	✓		✓	✓	✓	✓	✓	✓	✓
5 - ITMATI	✓	✓	✓		✓	✓	✓		✓
6 - INRIA	✓			✓	✓	✓	✓		✓
7 - U-HB	✓			✓	✓	✓	✓	✓	✓
8 - BUW	✓	✓			✓	✓	✓		✓
9 - STM	✓	✓			✓	✓	✓		✓
10 - FAU	✓			✓	✓	✓	✓		✓
11 - MOX-PoliMi	✓	✓			✓	✓	✓		✓
12 - SISSA	✓	✓	✓		✓	✓	✓		✓
13 - FVB-WIAS	✓			✓	✓	✓	✓		✓

1.3.7. WT7 Tentative schedule of project reviews

No project reviews indicated

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project. It cannot be changed. The project number **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

2. Project acronym

Use the project acronym as given in the submitted proposal. It can generally not be changed. The same acronym **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

3. Project title

Use the title (preferably no longer than 200 characters) as indicated in the submitted proposal. Minor corrections are possible if agreed during the preparation of the grant agreement.

4. Starting date

Unless a specific (fixed) starting date is duly justified and agreed upon during the preparation of the Grant Agreement, the project will start on the first day of the month following the entry into force of the Grant Agreement (NB : entry into force = signature by the Agency). Please note that if a fixed starting date is used, you will be required to provide a written justification.

5. Duration

Insert the duration of the project in full months.

6. Call (part) identifier

The Call (part) identifier is the reference number given in the call or part of the call you were addressing, as indicated in the publication of the call in the Official Journal of the European Union. You have to use the identifier given by the Commission in the letter inviting to prepare the grant agreement.

7. Abstract

8. Project Entry Month

The month at which the participant joined the consortium, month 1 marking the start date of the project, and all other start dates being relative to this start date.

9. Work Package number

Work package number: WP1, WP2, WP3, ..., WPn

10. Lead beneficiary

This must be one of the beneficiaries in the grant (not a third party) - Number of the beneficiary leading the work in this work package

11. Person-months per work package

The total number of person-months allocated to each work package.

12. Start month

Relative start date for the work in the specific work packages, month 1 marking the start date of the project, and all other start dates being relative to this start date.

13. End month

Relative end date, month 1 marking the start date of the project, and all end dates being relative to this start date.

14. Deliverable number

Deliverable numbers: D1 - Dn

15. Type

Please indicate the type of the deliverable using one of the following codes:

R	Document, report
DEM	Demonstrator, pilot, prototype
DEC	Websites, patent fillings, videos, etc.
OTHER	
ETHICS	Ethics requirement
ORDP	Open Research Data Pilot
DATA	data sets, microdata, etc.

16. Dissemination level

Please indicate the dissemination level using one of the following codes:

PU	Public
CO	Confidential, only for members of the consortium (including the Commission Services)
EU-RES	Classified Information: RESTREINT UE (Commission Decision 2005/444/EC)
EU-CON	Classified Information: CONFIDENTIEL UE (Commission Decision 2005/444/EC)
EU-SEC	Classified Information: SECRET UE (Commission Decision 2005/444/EC)

17. Delivery date for Deliverable

Month in which the deliverables will be available, month 1 marking the start date of the project, and all delivery dates being relative to this start date.

18. Milestone number

Milestone number:MS1, MS2, ..., MSn

19. Review number

Review number: RV1, RV2, ..., RVn

20. Installation Number

Number progressively the installations of a same infrastructure. An installation is a part of an infrastructure that could be used independently from the rest.

21. Installation country

Code of the country where the installation is located or IO if the access provider (the beneficiary or linked third party) is an international organization, an ERIC or a similar legal entity.

22. Type of access

TA-uc	if trans-national access with access costs declared on the basis of unit cost,
TA-ac	if trans-national access with access costs declared as actual costs, and
TA-cb	if trans-national access with access costs declared as a combination of actual costs and costs on the basis of unit cost,
VA-uc	if virtual access with access costs declared on the basis of unit cost,
VA-ac	if virtual access with access costs declared as actual costs, and
VA-cb	if virtual access with access costs declared as a combination of actual costs and costs on the basis of unit cost.

23. Access costs

Cost of the access provided under the project. For virtual access fill only the second column. For trans-national access fill one of the two columns or both according to the way access costs are declared. Trans-national access costs on the basis of unit cost will result from the unit cost by the quantity of access to be provided.

Marie Skłodowska-Curie Actions (MSCA)
Innovative Training Networks (ITN)
H2020-MSCA-ITN-2017

Annex 1 to the Grant Agreement
(Description of the Action)
Part B

ROMSOC – GA number 765374

Version History

Vers.	Date	Comments, Changes	Authors, contributors
1.0	26.07.2017	Creation during GAP period, based on submitted proposal, after consultation with PO (Dora Horvath). Amongst other things, various Deliverables have been combined.	Theo A. Roelofs (MATHEON-TUB)
1.1	22.05.2018	Corrections of thus far unnoticed inconsistencies in the new numbering of Deliverables (Table 3.1.d, pp. 22-27 as follows: • ESR1: D2.6 changed to D2.3, D3.6 to D3.3, D4.4 to D4.3, D6.4 to D6.3, D7.5-D7.6 to D7.4, D7.7; • ESR2: D2.2 removed, D2.5 changed to D2.3, D6.4 to D6.3, D7.5-D7.6 to D7.4, D7.7; • ESR3: D4.4 removed, D6.4 changed to D6.3, D7.5-D7.6 to D7.4, D7.7; • ESR4: D4.4 changed to D4.3, D6.4 to D6.3, D7.5-D7.6 to D7.4, D7.7; • ESR5: D2.6 changed to D2.3, D6.4 to D6.3,D7.5-D7.6 to D7.4, D7.7; • ESR6:D3.6 to D3.3, D6.4 to D6.3, D7.5-D7.6 to D7.4, D7.7; • ESR7: D4.4 to D4.3, D6.4 to D6.3, D7.5-D7.6 to D7.4, D7.7; • ESR8: D2.6 to D2.3, D3.6 to D3.3, D6.4 to D6.3,D7.5-D7.6 to D7.4, D7.7; • ESR9: D2.6 to D2.3, D6.4 to D6.3,D7.5-D7.6 to D7.4, D7.7; • ESR10: D2.6 to D2.3, D3.6 to D3.3, D6.4 to D6.3, D7.5-D7.6 to D7.4, D7.7; • ESR11: D4.4 to D4.3, D6.4 to D6.3,D7.5-D7.6 to D7.4, D7.7. Corrections on the involvement of the ESRs in the various WPs (Table 1.1 (p. 10): in WP2 ESR10 has been added, in WP3 ESR3 has been changed to ESR8 and in WP4 ESR3 has been added); Following consultation with PO (Athina Zampara).	Theo A. Roelofs, Lena Scholz (MATHEON-TUB)
1.2	09.01.2019	The change of name of a partner organization, Philips Lighting to Signify, has been corrected (p. 5, p. 16, Table 1.3, p. 17 and p. 23, Table 3.1d) and of some Scientists-in-Charge at Partner Organisations (p. 5 and p.16/17 in Table 1.3); ESR1 has been removed from WP2 after discussion with responsible SIC (p.10, Table 1.1 and p. 22 in Table 3.1d); Figure 1 on p. 8 has been adapted accordingly (ESR1 removed from WP2).	Lena Scholz (MATHEON-TUB)
1.3	05.02.2019	Gantt Chart in Section 4 updated	Lena Scholz (MATHEON-TUB)
2.0	06.10.2020	Update of Table 1.2a, Table 3.1d, new end date M54 in Table 1.1, update of Gantt chart.	Lena Scholz (MATHEON-TUB)
2.1	05.11.2020	Update of Tables 1.1, 1.2a, 1.2b and 3.1d	Lena Scholz (MATHEON-TUB)
2.2	11.11.2020	Corrections in Table1.1, Table 1.2a, Table 3.1d, Gantt chart adapted	Lena Scholz (MATHEON-TUB)

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LIST OF PARTICIPANTS (*max. 2 pages*)

Consortium Member	Legal Entity Short Name	Academic (tick)	Non-academic (tick)	Awards Doctoral Degrees (tick)	Country	Dept./ Division / Laboratory	Scientist-in-Charge	Role of Partner Organisation
Beneficiaries								
Technische Universität Berlin	MATHEON-TUB	X		X	Germany	Research Center MATHEON	Volker Mehrmann	
MathConsult GmbH	Math-Consult		X		Austria	N/A	Andreas Binder	
Universität Linz	JKU	X		X	Austria	Industrial Mathematics Institute	Ronny Ramlau	
Microgate Srl	Microgate		X		Italy	N/A	Roberto Biasi	
Consorcio Instituto Tecnolóxico de Matemática Industrial	ITMATI	X		X[1]	Spain	R&D Department	Andrés Prieto Aneiros, Peregrina Quintela Estévez	
Institut national de recherche en informatique et automatique	INRIA	X		X[2]	France	Mokaplan project Team	Jean-David Benamou	
University of Bremen	U-HB	X		X	Germany	Center for Industrial Mathematics	Peter Maass	
Bergische Universität Wuppertal	BUW	X		X	Germany	Chair for Applied Mathematics / Numerical Analysis	Michael Günther	
ST Microelec-tronics	STM		X		Italy	CAD and Design Services	Salvatore Rinaudo	
Friedrich-Alexander-Universität Erlangen-Nürnberg	FAU	X		X	Germany	Chair of Economics, Discrete Optimization, Mathematics	Alexander Martin	
Politecnico di Milano	MOX-PoliMi	X		X	Italy	Laboratory for Modeling and Scientific Computing (MOX)	Christian Vergara	
Scuola Internazionale Superiore di Studi Avanzati	SISSA	X		X	Italy	MathLab	Gianluigi Rozza	

1 Doctoral degrees awarded through University of Santiago de Compostela (USC), where Peregrina Quintela is full professor, and the University of A Coruña (UDC), where Andrés Prieto is Associate Professor.
2 Jean-David Benamou is member of the Doctoral School of University Paris Dauphine, his PhD Students get their Degree from this University.

Weierstrass Institute for Applied Analysis and Stochastics (WIAS) im Forschungs-verbund Berlin e.V. (FVB)	FVB-WIAS	X		X[3]	Germany	WIAS	Michael Hintermüller	

Partner Organisations								
Universidade da Coruña	UDC	x		x	Spain	Mathematics Department	Andrés Prieto Aneiros	Resources of research and education
Microflown Technologies B.V.	Micro-flown		X		Nether-lands	R&D Department	Daniel Fernández Comesaña	Host secondment, deliver training
Université Paris Dauphin	UPD	X		X	France	CEREMADE	Jean-David Benamou	Enrolment in doctoral program
Signify	Signify		X		Nether-lands	Sector Technology Innovation	Wilbert IJzerman	Host secondment, deliver training
Sagiv Tech Ltd.	Sagiv-Tech		X		Israel	N/A	Chen Sagiv	Host secondment, deliver training
DB Cargo Polska S.A.	DB		X		Poland	Service Design Department (V.CE+PL-BP)	Marek Staszek	Host secondment, deliver training
Universidade de Santiago de Compostela	USC	x		x	Spain	Applied Mathematics Department	Peregrina Quintela Estévez	Resources of research and education
Danieli Officine Meccaniche SPA	Danieli		X		Italy	Danieli Research Center	Gianfranco Marconi	Host secondment, deliver training
CorWave	CorWave		X		France	R&D medical devices and active implants	Carl Botterbusch	Host secondment, deliver training
ArcelorMittal Spain	AMIII		X		Spain	ArcelorMittal Innovación Investigación e Inversión S.L. (AMIII)	Alejandro García-Lengomín Pieiga	Host secondment, deliver training
Humboldt University at Berlin	HUB	X		X	Germany	Faculty of Mathematics and Natural Sciences	Michael Hintermüller	Enrolment in doctoral program
Math.Tec GmbH	MathTec		X		Austria	N/A	Karl Knall	Host secondment, deliver training

3 Doctoral degree awarded through Humboldt-University at Berlin where Michael Hintermüller is full professor.

Stichting European Service Network of Mathematics for Industry and Innovation	EU-MATHS-IN	X			Nether-lands	N/A	Antonino Sgalambro	Dissemination

Data for non-academic beneficiaries:

Name	Location of research premises (city / country)	Type of R&D activeties	No. of fulltime employ-ees	No. of employ-ees in R&D	Website	Annual turnover (in Euro)	Enter-prise status (Y/N)	SME status (Y/N)
Math-Consult GmbH	Linz / Austria	Math-based Solutions (MSO incl. S/W) for producing industries and financial institutions	13	10	www. mathconsult. co.at	1.4 million	Y	Y
Micro-gate Srl	Bolzano / Italy	Adaptive optics; Control systems design and simulation; Embedded electronics; Optoelectronics	35	14	www. microgate. it	8 million	Y	Y
ST Micro-electro-nics	Catania / Italy	Sense and power technologies, automotive products, embedded-processing solution; Design Methods Developments, incl. Process, Device and Physical Modelling across technologies	43,600	8,700	www.st.com	7.40 billion US$ (net revenues)	Y	N

1. Excellence

1.1. Quality, innovative aspects and credibility of the research programme

1.1.1. Introduction, objectives and overview of the research programme.

Introduction: For the future competitiveness of the European economy the development of new and improvement of current products and processes is an essential factor in all key technology areas. Product development today is increasingly based on simulation and optimization of virtual products and processes that are described via mathematical models that encode the real physical product/process as well as free parameters that are used in optimization and control. Typically, deeply refined mathematical models are required to simulate the true physical processes, while for the optimization of design parameters usually less refined models need to be employed to handle the complexity. To achieve best performance of mathematical modelling, simulation and optimization (MSO) techniques, in particular in the industrial environment, a complete model hierarchy would be ideal which contains very fine and very coarse models and which can be used both for simulation and optimization on (high performance) computers in an effective way. The currently most favoured way in industrial applications to achieve such a model hierarchy is to use a sufficiently fine parameterized model and then to use model order reduction (MOR) techniques to tune the fine model to the accuracy, complexity and computational speed in simulation and parameter optimization. Although the mathematical models differ strongly in applications and industrial sectors, there is a common framework via an appropriate representation of the physical model via equations and functions. The main objective of this programme is to further develop this common framework and, driven by industrial applications from different sectors, to lift mathematical MSO and MOR to a new level of quality and to train the next generation of researchers in this approach. A particular feature of the programme is the treatment of high dimensional and coupled systems that describe different phenomena on different scales. Such systems present a major challenge for simulation and optimization and require new MOR techniques.

Aims and Research Objectives: The main research objective of the programme is to develop a common framework for the construction of model hierarchies (from very fine to very coarse) for parameterized, high dimensional, and coupled systems in a variety of different industrial sectors. The strength of a **common mathematical representation (modelling)** of real physical products or processes via partial differential and algebraic equations, by which the **behaviour can be simulated (simulation)** depending on parameters that can be varied **to achieve optimality (optimization)**, will be combined with appropriate **adaptive and tuneable model order reduction (MOR)** techniques, implemented in efficient software packages, that allow to find an optimal compromise between accuracy and computation efficiency.

The programme is structured in 7 work packages (WPs) as shown in Figure 1. WP1 deals with the training programme for the doctoral students and is described in Section 1.2, whereas WP5 will be concerned with the development of a number of benchmarks that are based on industrial applications. WP6 focussing on dissemination and WP7 on the management are described in Section 3. The core research programme involves WP2-WP4 defined with respect to three major (and overlapping) mathematical methodologies:

- WP2: Coupling methods,
- WP3: Model Reduction methods,
- WP4: Optimization methods,

that interact with three main applications fields:

- AF1: Optical and electronic systems,
- AF2: Economic processes (finance, industrial flow, transport networks),
- AF3: Materials systems.

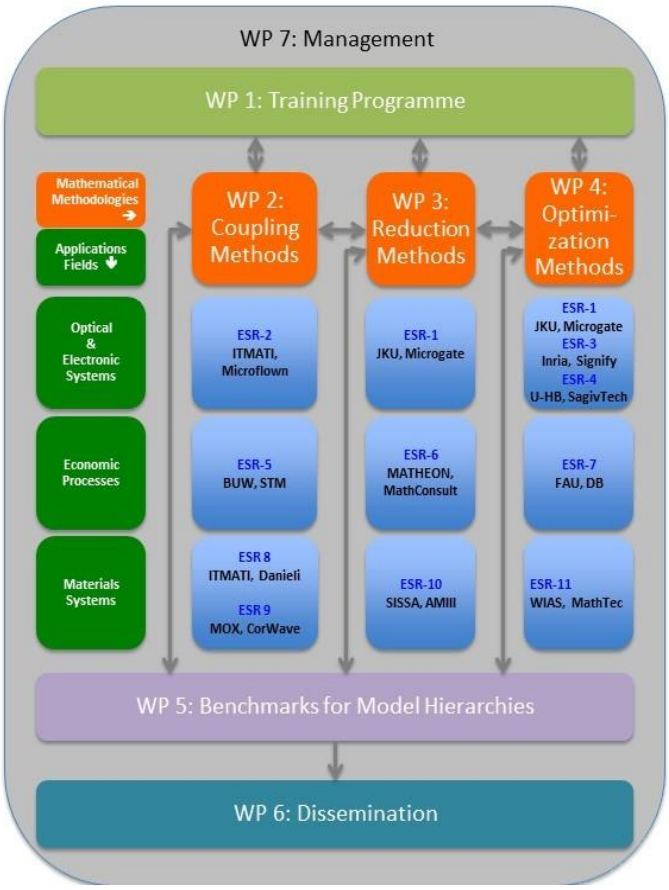


Figure 1: Structure of the Research Programme and WP interactions

The coupling of mathematical models describing different physical processes is a major challenge, in particular when the processes act on different scales and depend on different and/or common sets of parameters. The research objective in WP 2 is to address this challenge and to derive models that can be used for efficient simulation and optimization within user-defined error tolerances as required for the various industrial applications.

The common research objective of WP3 is the development and implementation of model and dimension reduction methods for high dimensional systems of partial differential equations with parameters and their application in different industrial sectors. A major challenge is the construction of adequate representations of the physically processes in function spaces so that the reduced order models keep their physical and mathematical interpretation within a prescribed accuracy.

To make efficient use of mathematical models in optimization with respect to free parameters or in control with free input functions, it is a major challenge, addressed in WP4 to integrate the modelling and optimization process and to balance the accuracy of the models with that of the approximate solution in the optimization.

Multidisciplinary and supra-disciplinary aspects: From an abstract modelling point of view, there are many analogies in the model hierarchies in different industrial sectors. To achieve a feasible work programme it is necessary to focus on sectors requiring more closely related model hierarchies, simulation and optimization methods. We have identified such sectors and focus on three application fields, in AF1 these are optical and electronic systems, in AF2 economic processes ranging from finance, industrial flow to transport networks and in AF3 the physical properties of materials.

ROMSOC aims to develop novel MSO techniques and associated software for the simulation and optimization in multi-disciplinary models with application in different industrial sectors. The common modelling themes are hierarchies of parameter-dependent systems ranging from high dimensional coupled dynamical systems and their discretizations to very coarse reduced order models. The common development of model hierarchies, with the aspect of adaptation to user defined accuracy and efficiency in different scientific disciplines and the strong transfer of synergies between different industrial sectors is **a special innovation of this programme**. It is based on a combination of **fundamental insights** in the mathematical modelling of the industrial problems arising in different sectors, **embedded in a well-designed and well-structured research and training programme.**

This ambitious goal can only be achieved through the creation of a blend of interdisciplinary understanding of 1) the underlying physical, engineering or economical problems, 2) the construction of model hierarchies from high dimensional fine grain models to highly reduced order models, 3) optimization theory and optimization methods, 4) numerical mathematics within an interdisciplinary and intersectoral environment, and 5) the implementation of all of these in industrial software.

Currently, MSO techniques are typically focused on very specific applications, while a more general framework of model hierarchies with user defined tolerances for use in optimization methods is usually out of reach for most industrial sectors, in particular for SMEs.

The intersection of the 5 topics will enable the development of novel MSO tools that can be implemented and adapted to the needs of industrial users, in particular SMEs, and allow harvesting the true potential of MSO and MOR in a large variety of industrial sectors.

Intersectoral aspects: To achieve major synergies between the mathematical methodologies and the different applications in different industrial sectors and **to lift the common framework to a new qualitative level** of hierarchical MSO, a joint training programme will developed. This programme will utilize the strengths of the participating academic and industrial partners that have different expertise in mathematical MSO and it will build upon their strong history of academic/industrial cooperation. **Major breakthroughs** can be expected when model hierarchies and MSO software are constructed in such a way that they can automatically adapt to different user needs in accuracy and computational efficiency.

The **complementary** and **synergistic** work of the partners will ensure that success is achievable. By delivering early-career training embedded in a cutting-edge research programme, ROMSOC will educate **the next generation of interdisciplinary researchers** to become experts in mathematical MSO and to become facilitators in the transfer of innovative concepts to industry. ROMSOC will establish **long-term collaborations between industrial sectors** and enhance the capacity of European research and development.

1.1.2. Research methodology and approach

Due to the high complexity of current industrial products and processes, research in MSO is very much dedicated to very specific applications. The development of a common framework that is transferable between different industrial sectors is a **major vision for innovation**. To achieve such an innovation with a long-term perspective, it is necessary to develop whole model hierarchies for complete industrial products or processes. The model hierarchy will include error estimates that allow evaluating the errors committed by stepping down in the hierarchy from a finer to a coarser model. At the same time the usual concepts of adaptivity and sparsity in the representation of functions will allow to measure the approximation errors in the simulation methods and parameter optimization methods. A key ingredient in this approach is the use of appropriate bases for the sparse representation of the functionality of the product. Here tensor product spaces will be the main setting which have recently turned out to be a driving force in improving efficiency of computational methods, but have not yet made their way into the industrial sectors yet. Sparse representations are particularly important in the design phase of industrial products, where parameters are employed for the optimization of functionality, or in the real time control of industrial processes. To achieve a true innovation, a close cooperation of academic and industrial partners is essential, to make sure that modelling, simulation, and optimization are integrated in a systematic way and implemented in software that allows users to find a compromise between model accuracy and computational efficiency. The education of the next generation of experts that are able to work in interdisciplinary teams towards these goals is an essential factor to achieve innovation breakthroughs. This approach is reflected well in the proposed work packages.

WP2: This WP focuses on the **coupling** of different physical phenomena in a joined system of partial differential equations. There is a strong synergy with WP3 concerning the treatment of coupled systems. Main coupling areas are thermal-mechanical, thermal-electrical, fluid-structure, fluid-optical and multi-rate models. The methodology will be constructed so that it

can be directly mapped into model hierarchies, and that it can be used in combination with available commercial and academic software. The innovative coupling methodology will be developed on the basis of industrial applications: for thermo-acoustic multi-layer flow velocity sensors, for industrial production flows, the thermo-mechanical behaviour of blast furnaces, and the development of pulsatile heart pumps.

WP3: The common theme in this WP is the development and implementation of efficient algorithms for the construction of automatically generated **reduced order parameterized models** from (coupled) systems of partial differential and algebraic equations. These reduced models are typically at the coarsest level of a model hierarchy and form the workhorse of efficient MSO methods. There is a strong synergy with WP2 and WP4 with respect to coupled systems and since the reduced order models form the basis for optimization methods. The innovative MOR methodology will be developed on the basis of industrial applications arising in the control of high performance telescopes in adaptive optics, the valuation of financial products, and the thermo-mechanical behaviour of blast furnaces.

WP4: Optimization methods are at the heart of every industrial design or planning process. They typically require vastly reduced parameterized models, to efficiently solve for an optimum. This WP focuses on an improved integration of efficient optimization methods with the (reduced order) parameterized coupled models as they are developed in WP2 and WP3. New optimization techniques will be developed on the basis of industrial applications in the control of high performance telescopes for adaptive optics, in computations of inverse free-form optical surfaces for extended sources in coil sensitivities of MR systems, in resource planning of rail transport and in optimal shape design for air ducts in combustion engines.

WP5: Based on the multitude of industrial applications, **benchmarks for model hierarchies** will be created that will form a basis for the interdisciplinary research and for the training programme. These will be equipped with publically available data and will be used for training in modelling, model testing, reduced order modelling, error estimation, efficiency optimization in algorithmic approaches, and testing of the generated MSO/MOR software.

Table 1.1: Work Package (WP) List

WP No.	WP Title	Lead Benefi-ciary #	Start Month	End month	Activity Type	Lead Benef.Short Name	ESR involvement
WP1	Training Programme	11	7	60	Education	MOX-PoliMi	1-11
WP2	Coupling Methods	8	7	60	Research, Education	BUW	2,5,8,9,10
WP3	Reduction Methods	12	7	60	Research, Education	SISSA	1,6,8,10
WP4	Optimization Methods	10	7	60	Research, Education	FAU	1,3,4,7,11
WP5	Benchmarks for Model Hierarchies	5	7	60	Research, Education, Dissemination	ITMATI	1-11
WP6	Dissemination	3	1	60	Dissemination	JKU	1-11
WP7	Management	1	1	60	Management	MATHEON-TUB	1-11
WP8	Ethics requirements	1	1	60	Ethics	MATHEON-TUB	1-11
WP9	Open Research Data	1	1	60	ORDP	MATHEON-TUB	1-11

1.1.3. Originality and innovative aspects of the research programme

The thematic concept of creating, for a complete industrial product or process, a model hierarchy ranging from fine grain detailed models to very coarse and simplified models (including automatically generated reduced order models) is a highly innovative concept in many different industrial sectors. In this programme it is combined with the emphasis of retaining the parameter dependence and the coupling of different physical phenomena and to make use of it in the development of accurate and efficient optimization techniques. Such an approach that adapts to user defined accuracy and efficiency desires requires interdisciplinary teamwork, a close interaction of academia and industry and the training of qualified professionals that can operate on this interface and have the right combination of research and professional skills. To achieve common strategies in the algorithmic design and software implementation, the WPs are designed to be able to exploit synergies on the methodological as well as on the application and software development level.

1.2. Quality and innovative aspects of the training programme

The objective of the ROMSOC training programme is to train eleven ESRs to PhD level by means of **joint courses and training events** on the one side and **collaborative research projects** on the other side. The strong demand for synergies between the MSO/MOR methods and the requirements of industrial users will be realized through common training schools in the areas of hierarchical as well as reduced order modelling, with a special emphasis on the preservation of parameter dependence and physical coupling. ROMSOC targets both technological and scientific priorities, their implementation in software and the testing and validation on industrial benchmark problems in a variety of industrial sectors.

1.2.1. Overview and content of the doctoral programme

The ROMSOC EID Network brings together 15 partners from academia and 11 from industry All academic partners have large experience in supervising industrial doctorates and the industrial partners all have previously integrated doctoral ESRs into their R&D programmes and provided unique training in a range of relevant skills with respect to the exploitation of industrial R&D. The cross-disciplinary nature of the training will facilitate mobility of the young scientists across sectors. The close involvement of the industrial partners in the research will significantly strengthen the societal relevance and quality of the training programme.

It is the mission of the ROMSOC consortium to maximize the potential of the ESRs in professional research via a coherent training programme delivered by leading scientists in both industry and academia. With the novel research concepts and the high academia/industry partnerships, this training programme is unique in Europe and it will subsequently lead to the establishment of a new field of research. It is of utmost importance to train the next generation of researchers in this innovative area and in their abilities to form the interface between industry and academia. The network arrangements ensure that students will become acquainted with colleagues at each of the partner institutions and with the leading research groups in the field in Europe and beyond.

1.2.2. Role of non-academic sector in the training programme

The non-academic partners will provide direct training for the ESRs in industrial research and development procedures on the basis of concrete research projects carried out within the industrial environment. The ESRs will learn to operate in interdisciplinary teams. The non-academic partners will provide real world data and access to industrially relevant research topics (possibly anonymized to protect IPRs).

In summary, the **ROMSOC EID Network** offers a **unique research environment,** where leading academics and innovative industries will **integrate ESRs** into their research teams for the training period, providing an excellent **structured training** programme in modelling, simulation and optimization of whole products and processes using adaptable model hierarchies.

The 6 main training objectives (TO) of ROMSOC are:

TO1: to further develop the innovative scheme of model hierarchies ranging from fine to coarse grain reduced order models preserving parameter dependence and physical coupling.

TO2: to enhance the attractiveness of careers in mathematical MSO through advanced training from international experts working with the most innovative methods in state-of-the-art laboratory facilities/infrastructures.

TO3: to provide academic, industrial and public sector employers with the next generation of researchers that have broad skills in interaction across disciplines and sectors and that have gained experience in industrial R&D.

TO4: to train researchers in their ability to transform abstract, fundamental ideas into commercial outcomes and the transferability across sectors.

TO5: to create an active, life-long network of young researchers across sectors whose personal contacts, support and expertise will help Europe to remain the world leader in using mathematical MSO/MOR in the design and improvement of industrial products or processes.

TO6: to increase expertise and to develop role models throughout Europe by training researchers with potential to become academic or industrial leaders.

The research training will be delivered to the ESRs on the one hand by working on individual but complementary projects towards the award of a PhD degree and on the other hand by providing joint schools and courses.

Table 1.2 a: Recruitment Deliverables per Beneficiary.

Researcher No.	Recruiting Participant (short name)	Start Month	Duration (months)
1	JKU, Microgate	9	36
2	ITMATI	10	36
3	INRIA	9	36
4	U-HB	14	17.33
5	BUW	14	36
6[a] 6[b]	MATHEON-TUB, MathConsult	9 15	1.47 36
7	FAU	13	36
8	ITMATI	10	36
9	MOX-PoliMi	7	36
10	SISSA	8	36
11[a] 11[b]	FVB-WIAS	8 31	6.33 29.53
Total			**378.66**

Note: ESR 6[a] and ESR 11[a] resigned from their working contract, requiring the re-recruitment for the two positions. The project of ESR4 was terminated, since EID requirements could not be fulfilled due to COVID-19 confinements.

Network-wide training courses are provided in three categories:

a) **Mandatory Training Courses (MTC)** on topics relevant for all ESRs, such as advanced programming skills, coupling methods for multiphysics systems, model order reduction techniques, and optimization techniques. These 4 MTC courses are mandatory for all ESRs.
b) **Elective Training Courses (ETC)** on selected topics relevant for sub-groups among the ESR cohort. From the 6 ETCs offered each ESR has to attend at least 2 courses most tailored to his/her educational background and needs.
c) **Transferable- and Soft-skills Training Courses (TSTC)** on more general topics relevant for future career paths both in academia and industry. These 3 TSTC courses are mandatory for all ESRs.

a) Mandatory Training Courses (MTC):

- **MTC-1: Multiphysics modelling (ITMATI):**
  ITMATI will organize a short school of two weeks for the doctorate students. This school will focus on establishing the main mathematical models arising from some applications considered in different ESRs. In particular, thermo-mechanical, fluids, fluid-structure

interaction and acoustics models will be deduced from the principles of the continuum mechanics, and the coupling phenomena between them will be analysed.

- **MTC-2: Parallel computing using MPI and OpenMP (MOX-PoliMi):**
  The course dedicated to the techniques of high performance computing and is aimed at experienced programmers who wish to be introduced to the problems of parallel programming or wish to maximize the efficiency of their applications on massively parallel systems. Effective techniques for developing and optimising programs for parallel scientific and technical computing are presented, along with interesting sample applications and development proposals.
- **MTC-3: Advanced Numerical Topics – PDEs (SISSA):**
  This course is given to PhD-students at SISSA and to master students in HPC (www.mhpc.it). It focuses on advanced methods in PDEs with a special attention to reduced order modelling. Reduced basis methods and POD are treated with a special focus: algorithms and their computer implementations. Learning by examples is the approach based on various parametric problems. A dedicated software library has been created: RBniCS.
- **MTC-4: Mixed integer linear and nonlinear optimization methods (FAU, together with CRC/TRR 154):**
  The FAU Erlangen-Nürnberg will organize a spring school for the doctorate students, which allows them to deepen their theoretical and practical knowledge on discrete optimization. This includes discrete modelling techniques, algorithms methods such as branch-and-bound and dynamic programming, decomposition approaches as Lagrange, Benders and Dantzig-Wolfe reformulation as well as the practical implementation of such techniques via state-of-the art optimization software (Gurobi, CPLEX, SCIP). The spring school will include lectures on the above topics as well as exercise classes in the form of a block course of 1-2 weeks. It will also feature invited lectures by renowned researchers in the field to enable the students to learn from their experience and to build contacts in their area of research.

b) Elective Training Courses (ETC):

- **ETC-1: PDAE modelling and simulation (BUW):**
  Coupled problems often comprise lumped elements, which are described by pure topological quantities, and distributed elements with space dimension of order one to three. Modelling these systems yields partial differential-algebraic systems, for short PDAEs, which link differential-algebraic (DAE) models for lumped elements with PDE models for distributed ones. DAE and PDE models are linked by source terms and boundary conditions. The block course will analyse PDAE models from a modelling perspective based on applications from different fields, an analysis perspective (well-posedness, sensitivity and property preservation), as well as a numerical perspective (co-simulation and dynamic iteration, multirate and MOR schemes). The course will combine theoretical lectures with hands-on-experiences gained by lab exercises.
- **ETC-2: Numerical methods for fluid-structure interaction problems (MOX-PoliMi):**
  Fluid-structure interactions problems arise in many engineering fields and efficient numerical strategies should be used for their solution. This course gives an overview on the most recent numerical strategies. We start with the small deformation regime, focusing on the treatment of the interface continuity conditions and highlighting the major role played by the added mass effect in partitioned schemes. We also address the most efficient monolithic strategies based on suitable preconditioners. Then, we introduce the large deformation regime, the Arbitrary Lagrangian/Eulerian method, and the treatment of the constitutive non-linearities.

- **ETC-3: Hierarchical Modelling (MATHEON-TUB):**
  MATHEON-TUB offers courses in mathematical modelling and model reduction on different level in the graduate programme. A specific two weeks training course on hierarchical modelling of systems will be specifically designed for the ROMSOC network and offered annually. Special emphasis will be put on the inclusion of coupled systems and reduced order models. The course will also worst case and statistical error estimates that can be used for the control of accuracy and computational efficiency.
- **ETC-4: Fundamentals of numerical and symbolic computation (JKU):**
  The lecture takes place each semester with varying content. Distinguished researchers present a special topic or a case study in their field of expertise in order to introduce basic notions and methods in computational mathematics. A special emphasis is placed on illustrating the interplay between symbolics and numerics. Possible topics include: inequalities in algebra and analysis, tensor spaces and numerical tensor calculus, solving nonlinear differential equations, elliptic functions and modular forms, fundamentals of stochastic numerics, wavelets.
- **ETC-5: Modelling and Numerical Methods based on Optimal Transportation (INRIA):**
  In recent years Optimal Transportation (OT) theory has become a mature area of mathematical analysis with a growing range of applications. Furthermore, the development of numerical methods for OT-related problems has experienced a surge of. The INRIA group will organize a school on this topic covering e.g. the following topics: Classical Optimal transportation theory; Gradient flows and non-linear diffusion models. Monge-Ampere equations with application to Free Form Optics; Multimarginal OT and its application to Generalized Euler flows and Density Functional theory.
- **ETC-6: Deep Learning (U-HB in cooperation with SagivTech):**
  The aim of this course is to provide an introduction to neural networks, specific concepts of deep learning applications as well as an overview of the underlying mathematical theory. A major focus will be on application in image processing and computer vision, including basic concepts for image classification, K-nearest neighbours, linear classification, SGD, backpropagation as well as more advanced deep learning building blocks (activation functions, layer types, convolutional neural networks for classification). Visualization concepts for applications in deep learning will include deep dream, visualizing filters in the input space and class activation maps. Hand-on sessions in Python, in either Keras or TensorFlow, are included in the exercise sections of the training programme.

c) Transferable- and Soft-skills Training Courses (TSTC):

- **TSTC-1: Communicating scientific research (MOX-PoliMi):**
  The principal aim of the course is to promote and spread the scientific culture in a broad sense, emphasizing its connection with other disciplines. In particular we'd take advantage of the great experience grown at "Laboratorio di Formazione Matematica e di Sperimentazione Scientifica" (Mathematics Department Politecnico) and of the strengthened collaboration between the Piccolo Teatro di Milano and the Politecnico.
- **TSTC-2: Study Groups with Industry (ITMATI):**
  Study Groups with Industry provide a forum for industrial scientists to work alongside academic mathematicians on problems of direct industrial relevance. They form an internationally recognized method of technology and knowledge transfer between academia and industry, usually lasting one week. ITMATI will organize two study groups during the funding period. Objectives include: insights into existing industrial problems; working links between applied mathematicians in academia and industry; increasing the awareness in the wider community of the power of mathematics in providing solution paths to real-world problems.

- **TSTC-3: Ethical aspects of the research (MATHEON-TUB):**
  Prof. Arne Manzeschke from the Evangelische Hochschule Nürnberg will lead this workshop as an external specialist. He is an internationally recognized expert on ethics and has co-designed the MEESTAR-model for the ethical evaluation of socio-technical arrangements. Taking this model as a starting point, the workshop will interactively address all relevant ethical aspects. This course will sensitize the participants for ethical aspects related to their research, will strengthen their ethical reasoning power and will thus build the basis for an ethics-aware attitude in and capacity for responsible science.

Table 1.2b: Main Network-Wide Training Events, Conferences and Contributions of Beneficiaries.

	Main Training Events & Conferences	ECTS (*if any*)	Lead Institution	Project Month (*estimated*)
	Mandatory Training Courses (MTC)			
MTC-1	Multiphysics modelling		ITMATI	M10
MTC-2	Parallel computing using MPI and OpenMP		MOX-PoliMi	M14
MTC-3	Advanced Numerical Topics: PDEs		SISSA	M20
MTC-4	Mixed integer linear and nonlinear optimization methods		FAU	M23
	Elective Training Courses (ETC)			
ETC-1	PDAE modelling and simulation		BUW	M18
ETC-2	Numerical methods for fluid-structure interaction problems		MOX-PoliMi	M17
ETC-3	Hierarchical Modelling		MATHEON-TUB	M12
ETC-4	Fundamentals of numerical and symbolic computation		JKU	M14
ETC-5	Modelling and Numerical Methods based on Optimal Transportation		INRIA	M21
ETC-6	Deep learning		U-HB	M25
	Transferable- and soft-skill Training Courses (TSTC)			
TSTC-1	Communicating scientific research		MOX-PoliMi	M19
TSTC-2	Study Groups with Industry		ITMATI	M11, M20
TSTC-3	Ethical aspects of the research		MATHEON-TUB	M11, M23, M37

1.3. Quality of the supervision (including mandatory joint supervision for EID)

1.3.1. Qualifications and supervision experience of supervisors

The lead scientists at each participating academic organization all have long-term experience in supervising Ph.D.-students, PostDocs, as well as master students, in particular such in industrial collaborations:

- **Volker Mehrmann (MATHEON)** has successfully supervised 32 Ph.D. projects and currently supervises 8 students. Out of these 6 were or are involved in industrial collaborations.
- **Ronny Ramlau (JKU)** has successfully supervised 11 Ph.D. projects and currently supervises 6 students.
- **Andrés Prieto (ITMATI, UDC)** is currently supervising 3 Ph.D. students, all of them involved in research topics related with industrial projects of different kind.
- **Peregrina Quintela (ITMATI, USC)** has successfully supervised 8 Ph.D. projects and is currently supervising 2 further Ph.D. projects. Her participation in 31 contracts of research with several firms has resulted in several dissertations, Masters and business practices for younger students.
- **Jean-David Benamou (INRIA)** is senior researcher at INRIA, has successfully supervised/co-supervised 3 PhD projects (one of them in collaboration with CEA) and is

currently co-supervising 2 PhD candidates. He is an expert on numerical methods for OT and related Monge-Ampère equations**.**

- **Peter Maass (U-HB)** has successfully supervised 34 Ph.D. projects and currently supervises 7 PhD. students. Several of these students were/are involved in industrial collaborations.
- **Michael Günther (BUW)** has successfully supervised 13 Ph.D projects and currently supervises 9 students. Out of these 8 were or are involved in industrial collaborations.
- **Alexander Martin (FAU)** has been the supervisor of 24 successfully finished PhD theses and currently supervises 12 PhD students at his chair at the FAU Erlangen-Nürnberg, which are all involved in industrial projects of different kinds.
- **Christian Vergara (MOX)** has successfully supervised 3 Ph.D. and he is currently supervising 2 further Ph.D. projects, all of this were/are involved in project in collaboration with medical doctors.
- **Gianluigi Rozza (SISSA)** has successfully supervised or co-supervised 7 PhD students, currently 2 are under his supervision already involved in their thesis preparation and 3 are at their pre-doc level and carrying out research within industrial partners.
- **Michael Hintermüller (WIAS)** has successfully supervised 6 Ph.D. projects and currently supervises 4 students.

1.3.2. Quality of the joint supervision arrangements

The excellence of the research and training is ensured, as partners are at the international forefront of research in mathematical MSO/MOR. The **academic beneficiaries** have well-established graduate programmes with high staff-student ratios. All ROMSOC supervisors have experience in supervision and the appropriate expertise to train ESRs (Table 1.3). Every ESR will have **an advisor and a co-advisor from different institutions academic/industry**. They will jointly supervise each three-year project ensuring a multicultural, multidisciplinary, and translational element to the training. Such intensive support for one doctoral student is unusual, but facilitates high-quality work supervision and mentoring. The supervisory time allocation is designated to be 10% for the principal supervisor with at least 5% of time of the co-supervisor(s). Because the students have a PI and co-PI the level of PI engagement in their projects and in their personal development will be very high. Supervisors will advise ESRs to complete a Training Needs Analysis before joining the network and support them in the development of a Career Development Plan that will detail the required training and how to achieve this (see Training Activities in Section 1.1.1). It will describe enrolment in a Ph.D. programme, training visits, and the secondments (Section 3.1.4). The plan will be revisited every 6 months. After one year, all ESRs will undergo a formal evaluation of their first year performances in their respective institutions.

Table 1.3 Joint Supervision arrangements

ESR #	Title of project	Academic supervisors	Industry supervisors
1	Real Time Computing Methods for Adaptive Optics.	Ronny Ramlau (JKU, 0.1), Andreas Neubauer (JKU, 0.05), Stefan Kindermann (JKU, 0.05), Victoria Hutterer (JKU, 0.05)	Roberto Biasi (Microgate, 0.1), Mauro Manetti Microgate, 0.1), Christian Patauner Microgate, 0.1)
2	Mathematical modelling and numerical simulation of coupled thermo-acoustic multi-layer systems for enabling particle velocity measurements in the presence of airflow.	Andrés Prieto Aneiros (ITMATI, UDC, 0.1)	Daniel Fernández Comesaña (Microflown, 0.1)
3	An Optimal Transportation computational approach of inverse free-form optical surfaces design for extended sources	Jean-David Benamou (INRIA, 0.15)	Wilbert IJzerman (Signify, 0.1), Gilles Vissenberg (Signify, 0.1)
4	Data driven model adaptations of coil sensitivities in MR systems	Peter Maass (U-HB, 0.1), Tobias Kluth (U-HB, 0.05)	Chen Sagiv (SagivTech, 0.1), Eri Rubin (SagivTech, 0.05)

5	Coupling of Model Order Reduction and Multirate Techniques for coupled heterogeneous time-dependent systems in an industrial optimization flow.	Michael Günther (BUW, 0.15), Jan ter Maten (BUW, 0.1), Andreas Bartel (BUW, 0.05)	Angelo Ciccazzo (STM, 0.2)
6	Model order reduction for parametric high dimensional models in the analysis of financial risk.	Volker Mehrmann (MATHEON-TUB, 0.1)	Andreas Binder (MathConsult, 0.2)
7	Integrated Optimization of International Transportation Networks.	Alxeander Martin (FAU, 0.05), Andreas Bärmann (FAU, 0.1)	Marek Staszek (DB, 0.05), Hanno Schülldorf (DB, 0.1)
8	Efficient computational strategies for complex coupled flow, thermal and structural phenomena in parametrized settings	Peregrina Quintela Estévez (ITMATI, USC, 0.1), Gianluigi Rozza (SISSA, 0.05)	Gianfranco Marconi (Danieli, 0.1)
9	Numerical simulations and reduced models of the fluid-structure interaction arising in blood pumps based on wave membranes.	Christian Vergara (MOX-PoliMi, 0.1)	Carl Botterbusch (CorWave, 0.2)
10	Coupled parameterized reduced order modelling of thermo-hydro-mechanical phenomena arising in blast furnaces	Gianluigi Rozza (SISSA, 0.1), Peregrina Quintela Estévez (ITMATI, USC, 0.05)	Alejandro Lengomin (AMIII, 0.1), Tomás Símaro (AMIII, 0.1)
11	Optimal Shape Design of Air Ducts in Combustion Engines.	Michael Hintermüller (FVB-WIAS, 0.1)	Karl Knall (MathTec, 0.2)

1.4. Quality of the proposed interaction between the participating organisations

1.4.1. Contribution of all participants to the research and training programme

The consortium has been carefully composed to address all the relevant competences required to achieve the ambitious research goals as well the requirements for a broad training programme.

On the methodology side this concerns the necessary mathematical fields:

- Mathematical modelling of multi-physics phenomena: **ITMATI, UDC, USC**;
- Continuous and discrete optimization: **FAU, MATHEON, WIAS, HUB, JKU**;
- Inverse problems: **JKU, INRIA, UPD, U-HB**;
- Numerical algorithms and scientific computing, in particular adaptivity in space-time discretization and error estimates, modelling in hierarchies and coupling of different systems with different physical behaviour and different scales: **all participants**;
- Model reduction with reduced basis methods and algebraic projection methods: **SISSA, MOX, MATHEON, BUW, JKU**;
- Tensor approximation: **MATHEON, SISSA, BUW**.

On the application side and concerning industrial applications, the consortium was chosen in a very selective way to include partners that bring in different competencies:

- Electronics and optics: **JKU, Microgate** (high performances telescopes); **ITMATI, UDC, Microflown** (acoustic particle velocity sensors); **INRIA, UPD, Signify** (illumination systems); **U-HB, SagivTech** (magnetic particle imaging);
- Economic processes: **MATHEON, MathConsult** (finance); **FAU, DB** (transportation); **BUW, STM** (industrial production flows);
- Materials: **ITMATI, USC, Danieli, SISSA, AMII** (steel and blast furnaces); **MOX, CorWave** (pulsatile heart pumps); **WIAS, HUB, MathTec** (air ducts in combustion engines).

In terms of the network-wide training programme each of the academic partners will contribute with their particular complementary expertise to one or more courses (see § 1.2 and Table 1.2b for more details). In terms of dissemination the network-of-national-networks structure of **EU-MATHS-IN**, currently in14 EU countries, will be of eminent importance.

1.4.2. Synergies between participants

Synergies between participants exist on several levels:

- Multi-disciplinary research cooperation is structured within and across WPs as depicted in Figure 1.
- Joint, multi-disciplinary training efforts are planned in the framework of network-wide training activities, as described in § 1.2.

The smooth fit between academic and industrial research and training ensures the successful delivery of not only new mathematical technologies for industry, but also uniquely equipped young professional with the entire range of skills needed in industry and the capacity to support training of the next generation professionals in industry.

1.4.3. Exposure of recruited researchers to different (research) environments, and the complementarity thereof

Each ESR will be exposed to highly complementary research training environments both in academia and industry through their respective secondments, as listed in detail in Table 1.3. Also, all ESRs participate in the network-wide training activities, as detailed in Section 1.2 and Table 1.2b. These secondments and training visits expose the ESRs to highly complementary research and training environments and thus strengthen the international and intersectoral aspect of the research training.

Furthermore, for enhancing the exchange among the ESRs and nurture networking within the ESR cohort ROMSOC will organize 2 **dedicated ESR workshops** (in conjunction with meetings of the Supervisory Board in M25, and M37[4]) for all ESRs. Topics will be set by the ESRs themselves to reflect their research stage and the corresponding challenges.

2. Impact

The development of a social market economy based on knowledge and innovation is one of the priorities of the European research strategy. To achieve this goal it is essential to enhance the quality of education, to strengthen the research performance, and to promote innovation and knowledge transfer to ensure that innovative ideas can be turned into new products and services that create growth, and improve quality of life.

2.1. Enhancing the career perspectives and employability of researchers and contribution to their skills development

ROMSOC will ensure that the following three key aspects of skills are embedded in the training experience. This will be guaranteed by involving the ESRs in courses and schools on the network level as well as on courses within the partner organizations.

Task-oriented research skills**:** ROMSOC assures interdisciplinary quality by making sure that ESRs (i) are trained in a broad range of methods (multi-physics modelling of coupled systems, model reduction, error estimation, optimization methods, industrial validation, benchmarking etc.); (ii) comprehend and master the integration of MSO methods in the solution of technical and commercial problems, (iii) appreciate and master the benefits of intersectoral and intercultural exchange.

Generic research skills**:** ROMSOC aims to educate professional researchers by training them in skills such as professional responsibility and integrity, as well as skills in publishing, networking and giving presentations to various audiences. ROMSOC will emphasise training these skills throughout all of its training activities.

Transferable skills**:** Transferable skills are most effectively learned when delivered by experts of the profession, such as advice on presentations by experienced keynote lecturers; skills on developing the business case taught by industrial leaders. It is a specific goal of the ROMSOC programme to train ESRs to be professional workers, to take responsibility for

[4] Further ESR networking opportunities are given in the framework of training courses (M8-M23), project meetings (M7, M42) and dissemination activities (M20, M32, M42).

their project and career management, reflecting on their own skills and actively pursuing their own training needs.

The structured training concepts of the ROMSOC programme will help the ESRs to mature in all fields of mathematical MSO and parameterized model reduction required in industrial sectors such as Optics and Electronics, Economic Processes and Materials. Key features are the modelling in hierarchies that include coarse to fine models and allow for error and efficiency control in simulation and optimization methods. The planned training programme will enable them to employ these techniques in different application fields and to transfer innovative developments in MSO and MOR directly to a variety of industrial sectors. The obtained knowledge and practice experience will make the ESRs capable to become successful as researcher and developers in a broad area of many key technology areas. Their skills in being able to act on the interface between industrial and academic research will enable them to become industrial leaders. The broad training will lead to increased career prospects and options for employability to many public and private sectors (involving industry and research institutes). This will be further strengthened by the training in transfer competence, such as project management skills including team leadership and multicultural aspects, organizational skills such as interdisciplinary tasks and fund raising, as well as presentation skills to specialists, to engineers and managers.

The programme will also encourage interaction with other researchers in international cooperation and stimulate the entrepreneurial mindset of the doctoral researchers due to the direct participation in laboratories of the industrial partners. This will position the ESRs to find high quality employment in all technology areas, but also those who wish to continue in academia after their PhD will have little problems to find a matching postdoctoral position.

2.2. Contribution to structuring doctoral/early-stage research training at the European level and to strengthening European innovation capacity, including the potential for:

Structuring research training at the European level: The development of innovative MSO and MOR techniques on the basis of model hierarchies in different industrial sectors requires a variety of interdisciplinary competences. This can typically not be achieved by training in a single institution. It is, however, necessary to educate the ability to deal with new, interdisciplinary challenges and to enhance the researcher's international competitiveness. In this respect the ROMSOC research and training programme will establish a new quality by increasing interdisciplinary understanding and transfer. Based on the intense interaction with the industrial partners, the programme will include specialised training modules, focused on commercial research topics as well as exploitation and transfer skills. ROMSOC will strongly profit from such training offers in the different institutions and will enhance the professional development of the ESRs. The cooperation with industrial partners will also have long-term benefit for the training programmes in the academic institutions, by adapting their programmes to needs in industry.

Long-term co-operation between partners: The research and training in ROMSOC will increase personal interactions and knowledge exchange between the different partners. This will lead to the establishment of formal training links and further exchange of bachelor, master and Ph.D. students. By exploiting the different expertise of the partners, long-term graduate training will be established which will enable the ESRs in their future jobs to increase the synergies promoted by ROMSOC in future joint research proposals and by the introduction of new tools into the market. This incubation period will lead to further research, and longer and increased interactions between the partners towards a long-lasting collaboration.

Enhancing Public-Private Research Training Collaboration: Increased strategic academic-industrial cooperation in research and training is critical to strengthen the European economy. The multidisciplinary aspect of ROMSOC will provide an ideal platform from which partners can develop long-term Continuing Professional Development (CPD) courses targeted to the needs in different industrial sectors. Such courses can be made available to

participants outside the network, for example through training events, as well as e-learning resources.

Mutual Recognition: All academic partners within the network have fully implemented or are working towards implementing the European Higher Education Area, formalising the basis of training recognition between institutions. Partners agree to recognise the research work carried out by ESRs while visiting each other's facilities. The implementation of the ROMSOC interdisciplinary training programme will set **new standards that can serve as a role model** for new graduate training programmes in Industrial Mathematics. It will be competitive to the highly structured PhD training programmes in North America, and increase the attraction of Europe as a destination for excellent students obtaining the best possible training.

Contribution of the non-academic sector to the doctoral/research training: The participating industrial partners all have long-standing expertise in hosting Ph.D. students and will provide in-house expertise in the development of adequate coupled system modelling, as well as the practical aspects of developing cutting-edge commercial simulation and optimization software. They will complement the doctoral training by exposing the ESRs to state-of-the-art training for industry professionals and to the requirements of real-world MSO software. Altogether, the expertise from the private sector will enhance the market value of the research training within ROMSOC.

2.3. Quality of the proposed measures to exploit and disseminate the project results

2.3.1. Dissemination of the research results

The participants of ROMSOC have strong records of dissemination via keynote presentations at international conferences, high impact journal publications and in reaching the general public through outreach activities. Where possible, partners make publications open access via preprints and open archives to reach the maximum possible audience. Publications and presentations to specialists and lay people will ensure impact beyond the lifetime of ROMSOC. EU-MATHS-IN with its network-of-networks in 14 EU countries ensures that ROMSOC will have access you a wide range of relevant stakeholder groups both from academia and industry (over 2,000 estimated users). See Table 3.1.a for a detailed description of WP6 on dissemination.

2.3.2. Exploitation of results and intellectual property

A major objective of the ROMSOC project is to implement the developed MSO and MOR algorithms from WP2 to WP4 into functionality that can be made available to the industrial partners via in-house software on the one hand, and to the general public via open-access software on the other hand. Combined with the benchmark collection developed in WP5, which allows algorithm testing and provides public data sets for the scientific community, the project will have an impact that goes much beyond the span and the lifetime of the consortium. This objective will provide the ESRs with an early focus towards exploiting results commercially, which will be vital to demonstrate the importance and ensure high relevance of their research. The means to achieve these goals are multi-fold:

Software development: The strong representation of many industrial sectors in ROMSOC provides a unique opportunity for driving the research direction based on industrial needs and validated upcoming market trends. As part of the projects the ESRs will have the opportunity to develop software. The initial software concepts will originate from the business-inspired benchmark cases in WP5. Within WPs 2-4 and the individual ESR projects, MSO/MOR software will be developed directly to the needs of the industrial partners, and, as long as it is not for the specific need of the company, it will be released as open access software and will allow strong dissemination of the results.

Scientific credibility: The ROMSOC consortium will ensure that all scientific results, methods and algorithms will be published in preprint and archive servers as well as peer-

reviewed journals. The developed model hierarchies including the reduced order parameterized models will be incorporated in the benchmarks of WP5.

IPR issues are discussed in more detail in Sections 3.2.2 and 3.2.7.

2.4. Quality of the proposed measures to communicate the activities to different target audiences

2.4.1. Communication and public engagement strategy of the project

Within the ROMSOC consortium it is well recognised that publicly funded researchers have to be accountable to all the stakeholders, i.e. towards industry and society. ESRs will also learn that it is crucial to promote science and technology in the general public to enhance European competitiveness. They will therefore receive training and experiences in the direction of outreach to the general public.

The ESRs will be trained in scientific publishing (in relevant peer-reviewed journals) and will have many opportunities to share findings with each other and stakeholders during the review meetings planned within the research network as well as with the scientific public during conferences and workshops. The acquired knowledge and the constructed benchmarks will be made available via the ROMSOC website. The developed methods and algorithms will be on the one-hand turned into company-in-house software (for the benefit of the industrial partners) and, on the other hand, open access software, open to EU members (for the benefit of the general European scientific community).

To achieve strong scientific exchange with peer groups, and to gain authority and respect for their research, the ESRs will be coached to present the results of their work at network meetings, as well as at workshops and conferences. The impact is a clear career benefit for the ESRs and a knowledge benefit for the stakeholders.

A number of outreach events and opportunities will be implemented in which ESRs and partners will organise or participate in events aimed at secondary school children to inform pre-college students on the industrial impact of research. The impact will be in helping to attract more bright young pupils to continue with science into a career and ESRs will also understand better their career prospects in industry and technology. ESRs will also contribute to “Girls-Days” at participating institutions, aimed to attract girls to follow technical studies, as well as events like ‘the long night of science’ or ‘math-inside’ hosted, e.g., on an annual basis in many major cities. The impact will be to contribute to the diversity and inclusion of companies in Europe, enriching innovative potential.

The website of ROMSOC will contain a section for public dissemination of the research projects. Impact will be the availability of findings in language and downloadable materials appropriate for non-specialist dissemination and to further train other EU scientists.

Details of the activities and progress of the network will be made accessible to relevant stakeholders. All these activities will be facilitated by dedicated Press/Outreach/Community partnership officers who are in place at most of the participating institutions. The participants will be required to present their involvement in these outreach activities at Supervisory Board meetings. With these activities the responsibility of public engagement for all researchers will be increased, and the relevance of the work for society will be demonstrated.

3. Quality and Efficiency of the Implementation

The ROMSOC consortium has been selected based on large expertise in past academic/industrial collaboration and on their strong history in educating next generation researchers. Another factor was the choice of compatible industrial sectors where MSO/MOR techniques and software are urgently needed and academic partners that have a proven interdisciplinary research profile. The coordination is carried out by V. Mehrmann, the former chair (2008-2016) of the research centre MATHEON, who has long term experience in

coordinating larger interdisciplinary national and international research consortia combining industrial and academic partners. The design of the work packages is based on the needs in different application fields as well as different methodologies and it is strongly directed towards the potential for joint training efforts.

3.1. Coherence and effectiveness of the work plan, including appropriateness of the allocation of tasks and resources

Table 3.1 d: Individual Research Projects

Fellow	Host institution	PhD enrolment	Start date	Duration	Deliverables, *cf. table 3.1b*
ESR 1	JKU, Microgate	Y	month 9	36 months	*D1.1-D1.5, D3.1-D3.3, D4.1-D4.3, D5.1-D5.4, D6.1-D6.3, D7.4, D7.7*
Project Title and Work Package(s) to which it is related: Real Time Computing Methods for Adaptive Optics. It is related to WPs 1, 3, 4, 5 and 6.					
Industrial Challenge: The new generation of planned earthbound Extremely Large Telescopes rely on Adaptive Optics (AO) systems. The resolution of the telescopes is degraded by atmospheric turbulences. AO systems correct for the influence of the atmosphere by measuring the incoming wavefront from guide stars and compute the optimal mirror shape as the real time solution to a large-scale inverse problem. Based on the experience of the AO team at JKU in development of high-level algorithms for AO systems[5] in cooperation with Microgate. **Objectives:** • Develop an energy efficient computational platform based on FPGAs for HPC. • Make high-level algorithms feasible for real data and verify performance of system. • Support Microgate in developing the first real-time remote telescope control system.					
Expected Results: • High level algorithms and real time software for extremely large telescopes. • Model for the influence of atmospheric layers on the AO system. • New model reduction techniques for optimal sparse layer configurations					
Planned secondment(s): The ESR will spend 50% of the time at Microgate, in the form of 3-months stays, possibly combined. The rest of the time, he/she will be at JKU.					

Fellow	Host institution	PhD enrolment	Start date	Duration	Deliverables, *cf. table 3.1b*
ESR 2	ITMATI	Y	month 10	36 months	*D1.1-D1.5, D2.1, D2.3, D5.1-D5.4, D6.1-D6.3, D7.4, D7.7*
Project Title and Work Package(s) to which it is related: Mathematical modelling and numerical simulation of coupled thermo-acoustic multi-layer systems for enabling particle velocity measurements in the presence of airflow. It is related to WPs 1, 2, 5, 6 and 7.					
Industrial Challenge: Microflown USP probes[6], which are able to measure particle velocity and acoustic pressure fields simultaneously are sensitive to the effect of wind, since they are based on thermal transducers and hence highly dependent on the variations of thermal flow velocity. Mathematical modelling and numerical simulation of thermo-acoustic coupled systems (involving USP probes, the compressible fluid in the presence of flow, and the multilayer windscreen) will play a key role in the design of novel windscreens to mitigate the flow effects on the measures of acoustic probes. **Objectives:** • Modelling and numerical simulation of different strategies to design effective windscreens • Develop efficient numerical strategies to solve coupled problems involving wave propagation phenomena • Validate the developed simulation environment performing a thorough experimental investigation					
Expected results: • Design of novel strategies of multilayer windscreens to mitigate flow-induced disturbances • Understanding limitation of accuracy on the use of USP probes in presence of airflow • Implementation of computationally efficient algorithms to solve thermo-acoustic coupled problems					

[5] M. Zhariy, A. Neubauer, M. Rosensteiner, and R. Ramlau, Cumulative Wavefront Reconstructor for the Shack-Hartmann Sensor, Inverse Problems and Imaging Vol. 5 (4): 893-913, 2011.
M. Rosensteiner and R. Ramlau, The Kaczmarz algorithm for multiconjugated adaptive optics with laser guide stars. J. Optical Society of America A Vol. 30 (8): 1680-1686, 2013.

[6] W.F.Druyvesteyn et al, A new sound intensity probe; comparison to the Bruel&Kjaer pp probe, J.audio.Eng.Soc.,vol.48,2000.

Planned secondment(s): The ESR will spend 50% of the time at Microflown, in the form of 6-months stays, possibly combined. The rest of the time, he/she will be at ITMATI and UDC.

Fellow	Host institution	PhD enrolment	Start date	Duration	Deliverables, *cf. table 3.1b*
ESR 3	INRIA	Y	month 9	36 months	*D1.1-D1.5, D4.3, D5.1-D5.4, D6.1-D6.3, D7.4, D7.7*

Project Title and Work Package(s) to which it is related: An Optimal Transportation computational approach of inverse free-form optical surfaces design for extended sources. It is related to WPs 1, 2, 3, 4, 5 and 6.

Industrial Challenge: In illumination optics free-form optical designs are now frequently used. To design these optical components Optimal Transport (OT) based methods are becoming more and more popular. But in these methods it is assumed that the source has an infinitesimal size, which is not realistic and s solved in practice with tedious iterative methods.[7]
Significant progress has been recently achieved on the numerical resolution of OT problems. Free-form (FF) Reflectors for idealized collimated source of illumination can be computed rapidly with resolutions of millions of points.[8] More realistic point source and extended illumination resolution, which are important for applications, are still open as the available OT solvers are unable to deal efficiently with the more complicated structure of these problems. It is well know that these more complicated problems can be relaxed into huge linear program. A numerical approach called Sinkhorn iterations and popularized recently by Cuturi for OT relies on the "entropic" regularisation of these linear program and alternate projection solver. Using GPU parallelization this again allows to solve regularized OT problems with millions of points.

Objectives:

- Develop numerical algorithms for the finite source OT problem
- Evaluation of the Sinkhorn iterations method
- Implementation of the algorithms on GPU

Expected results:

- New methods to iteratively move from a point source to an extended source efficiently
- Error estimations on the achieved target distribution compared to the desired target distribution
- Verification of the obtained results with available commercial software tools

Planned secondment(s): The ESR will spend 50% of the time at Signify, in the form of 6-months stays, possibly combined. The rest of the time, he/she will be at INRIA.

Fellow	Host institution	PhD enrolment	Start date	Duration	Deliverables, *cf. table 3.1b*
ESR 4	U-HB	Y	month 14	17.33 months	*D1.1-D1.5, D4.1-D4.3, D5.1-D5.4, D6.1-D6.3, D7.4, D7.7*

Project Title and Work Package(s) to which it is related: Data driven model adaptations of coil sensitivities in MR systems. It is related to WPs 1, 3, 4, 5 and 6.

Industrial Challenge: Magnetic particle imaging (MPI) is an evolving technology aiming at non-radiative, non-invasive imaging of functional parameters such as blood flow or targeted metabolic processes. In particular, reconstruction quality is limited due to the restricted approximation quality of PDE-based models. Data-driven approaches, based on neural networks and deep learning, would allow to incorporate expert information obtained from experimental measurements and to improve diagnostic potential of MPI technology[9].

Objectives:

- Analyze limitations of PDE-based models (Maxwell and derived models) for coil sensitivities.
- Develop concepts for data-driven operator adaptations under efficiency constraints.
- Implementation of deep-learning methods for model adaptation.

Expected results:

- Understanding limitations of PDE-based models for coil sensitivities with a wide range of further applications (MR imaging, medical and industrial applications).
- Theoretical results for data-driven model adaptation concepts.
- Implementation of efficient coil sensitivity models for MPI systems.

[7] Fournier, Florian. Freeform reflector design with extended sources. Diss. University of Central Florida Orlando, Florida, 2010.
[8] https://project.inria.fr/mokabajour/
[9] B. Gleich and J. Weizenecker: Tomographic imaging using the nonlinear response of magnetic particles, Nature, 435 (2005), pp. 1214–1217.
B. Gleich, J. Weizenecker, and J. Borgert, Experimental results on fast 2D-encoded magnetic particle imaging, Physics in Medicine and Biology, 53 (2008), pp. N81–N84.
T. Knopp, T. F. Sattel, S. Biederer, J. Rahmer, J. Weizenecker, B. Gleich, J. Borgert, and T. M. Buzug, Model-based reconstruction for magnetic particle imaging, IEEE Transactions on Medical Imaging, 29 (2010), pp. 12–18.

Planned secondment(s): The ESR will spend 50% of the time at SagivTech, in the form of 6-months stays, possibly combined. The rest of the time, he/she will be at U-HB.

Fellow	Host institution	PhD enrolment	Start date	Duration	Deliverables, *cf. table 3.1b*
ESR 5	BUW, STM	Y	month 14	36 months	*D1.1-D1.5, D2.1-D2.3, D5.1-D5.4, D6.1-D6.3, D7.4, D7.7*

Project Title and Work Package(s) to which it is related: Coupling of Model Order Reduction and Multirate Techniques for coupled heterogeneous time-dependent systems in an industrial optimization flow. It is related to WPs 1, 2, 3, 4, 5 and 6.

Industrial Challenge: In industrial circuit and device simulation, e.g. for estimating failure probabilities due to aging, simulation problems have to be run many times in the loop of an optimization flow. This can only be done by drastically reducing simulation costs via MOR. This is particularly challenging in for coupled systems of various simulation packages for the different subcomponents and physical domains.[10] For efficiency, MOR and multirate error estimates have to be linked to define overall error estimates, balanced to the accuracy requirements of the iteration level of the optimization flow.

Objectives:

- Combining advanced concepts of model order reduction (MOR) and multirating on hierarchies of submodels.
- Preservation of overall properties of the system (such as passivity, energy conservation etc.) and stability of the dynamic iteration process.
- Incorporation of manifold mapping techniques.

Expected results:

- Generation and analysis of test sets of coupled heterogeneous systems used in the optimization flow of ST Microelectronics
- New MOR techniques for hierarchies of subcomponent systems preserving stability of dynamic iteration schemes.
- Error estimates based on MOR and multirate error estimates allowing for adaptivity of the optimization flow.
- Implementation and validation of software of new techniques for test sets of industrial partner.

Planned secondment(s): The ESR will spend 50% of the time at STM, in the form of 6-month stays, possibly combined. The rest of the time, he/she will be at BUW.

Fellow	Host institution	PhD enrolment	Start date	Duration	Deliverables, *cf. table 3.1b*
ESR 6[a] ESR 6[b]	MATHEON-TUB, MathConsult	Y	month 9 month 15	1.47 months 36 months	*D1.1-D1.5, D3.1-D3.3, D5.1-D5.4, D6.1-D6.3, D7.4, D7.7*

Project Title and Work Package(s) to which it is related: Model order reduction for parametric high dimensional models in the analysis of financial risk. It is related to WPs 1, 2, 3, 5 and 6.

Industrial Challenge: In Computational Finance potential developments of assets and/or liabilities are usually modelled via Monte Carlo (MC) simulation of the underlying risk factors. For the valuation of financial instruments, however, techniques based on discretized convection-diffusion-reaction PDEs are often superior. The solution of these high-dimensional problems requires sparse representations in tensor formats[11] and an adaptation of the iterative solvers to this format.

Objectives:

- Hierarchical tensor representations MC and PDE methods arising in the valuation of financial risk
- Model order reduction for high-dimensional systems in tensor format
- Development of error estimates in model hierarchy.

Expected Results:

- Data sparse tensor discretizations of the MC and PDE models used for valuations.
- Projection based reduced order modelling techniques based on adaptive eigenvalue/singular value techniques with error estimates in tensor formats.
- Implementation of efficient algorithms.
- Comparison of MC and PDE techniques

[10] A. Bartel, M. Brunk, M. Günther, and S. Schöps. Dynamic Iteration for Coupled Problems of Electric Circuits and Distributed Devices. SIAM Journal on Scientific Computing 35: B315-B335, 2013.
Michael Günther and Adrian Sandu: Multirate generalized additive Runge Kutta methods. To appear in Numerische Mathematik (DOI: 10.1007/s00211-015-0756-z)

[11] P. Benner, V. Mehrmann, and D.C. Sorensen, (Ed.). Dimension Reduction of Large-Scale Systems. Springer, 2005.
M. Binder and M Aichinger: A Workout in Computational Finance, Wiley 2013.
W. Hackbusch, Tensor spaces and numerical tensor calculus, Springer, Heidelberg 2012.

Planned secondment(s): The ESR will spend 50% of the time at MathConsults, in the form of 6-months stays, possibly combined. The rest of the time, he/she will be at MATHEON-TUB.

Fellow	Host institution	PhD enrolment	Start date	Duration	Deliverables, *cf. table 3.1b*
ESR 7	FAU	Y	month 13	36 months	*D1.1-D1.5, D5.1-D5.4, D4.1-D4.3, D6.1-D6.3, D7.4, D7.7*

Project Title and Work Package(s) to which it is related: Integrated Optimization of International Transportation Networks. It is related to WPs 1, 2, 3, 4, 5 and 6.

Industrial Challenge: Transportation networks have an increasing share of border-crossing services. The conditions to implement such services are often different in neighbouring countries. For resource planning, this may make it necessary to change between resources at the border. It is a challenge to provide decision makers with suggestions on how to deal with differing regulations in the best possible way as well as to make suggestions for their harmonization to allow for an easier border-crossing transport.[12]

Objectives:

- Identification of requirements for resource allocation in major European countries and derivation of possible measures for technical adaptations of the infrastructure.
- Optimization models to maximize benefits from international transport
- Development of a model hierarchy representing different degrees of detail in order to cope with the complexity of the large network structures involved.

Expected Results:

- Integration of necessary decisions into existing modelling approaches for transportation network design.
- Decomposition techniques for the optimal harmonization of decisions along the whole hierarchy of planning.
- Efficient algorithms and software using tailor-made decomposition techniques

Planned secondment(s): The ESR will spend 50% of the time at DB, in the form of 3-months stays, possibly combined. The rest of the time, he/she will be at FAU.

Fellow	Host institution	PhD enrolment	Start date	Duration	Deliverables, *cf. table 3.1b*
ESR 8	ITMATI	Y	month 10	36 months	*D1.1-D1.5, D2.1-D2.3, D3.1-D3.3, D5.1-D5.4, D6.1-D6.3, D7.4, D7.7*

Project Title and Work Package(s) to which it is related: Efficient computational strategies for complex coupled flow, thermal and structural phenomena in parametrized settings. It is related to WPs 1, 2, 3, 4, 5 and 6.

Industrial Challenge: Present and future efforts in simulation-based sciences are dedicated to hierarchies of complex multi-physics problems, as well as parameterized systems characterized by multiple spatial and temporal scales. New MOR methodologies are required for coupled and parameterized problems in industrial and medical sciences. This concerns in particular fluid-structure interactions and thermo-fluid-dynamics and the use of these reduced models in Fluid-thermal MEMS.[13]

Objectives:

- The numerical simulation of the evolution of the fluid will be carried out using a turbulence and multi-phase model. A transport passive scalar phenomenon will also be modelled in the problem.
- Modelling and simulation of 3D thermal-fluid-structure phenomena.
- Numerical simulation will be performed on free or commercial software packages of proven quality.
- Reduced order modelling (computational, geometrical and parametric) for hierarchies of coupled multi-physics problems.
- Construction of test cases and carrying out numerical experiments.

Expected Results:

- New model reduction methods for coupled systems of fluid-structure interactions and thermo-fluid-dynamics.
- Error estimators for such coupled systems.
- Computational model reduction software.

12 A. Bärmann, F. Liers, A. Martin, M. Merkert, C. Thurner, and D. Weninger. Solving network design problems via iterative aggregation. Mathematical Programming Computation, 7(2):189–217, 2015.
A. Bärmann, A. Martin, and H. Schülldorf. A decomposition method for multi-period railway network expansion – with a case study for Germany. Technical report, FAU Erlangen-Nürnberg, 2015.

13 Quarteroni A, Manzoni A, Rozza G (2011). Certified reduced basis approximation for parametrized partial differential equations and applications. J. Math in Industry, 1, p. 1-49, doi: 10.1186/2190-5983-1-3.
Hesthaven J., Rozza G., Stamm B. Certified Reduced Basis Methods for Parametrized PDEs, Springer Briefs in Mathematics, 2015.

Planned secondment(s): The ESR will spend 50% of the time at Danieli, in the form of 6-months stays, possibly combined. The rest of the time, he/she will be at ITMATI and USC.

Fellow	Host institution	PhD enrolment	Start date	Duration	Deliverables, *cf. table 3.1b*
ESR 9	MOX-PoliMi	Y	month 7	36 months	*D1.1-D1.5, D2.1-D2.3, D5.1-D5.4, D6.1-D6.3, D7.4, D7.7*

Project Title and Work Package(s) to which it is related: Numerical simulations and reduced models of the fluid-structure interaction arising in blood pumps based on wave membranes. It is related to WPs 1, 2, 4, 5 and 6.

Industrial Challenge: Blood pumps are used to assist the ventricles when end-stage heart failure occurs. Pulsatile pumps are rarely used due to the high inertia of their rotors and low frequency pulsation, not like the native heart. This motivates the development of new pulsatile pumps that able to replace the high speed and shear impeller of current continuous flow rotary pumps. The result is much less trauma to the blood, reducing clotting and bleeding complications.

Objectives:

- Implement in the Finite Element academic software LIFEV (www.lifev.org) a computational methodology to solve the fluid-structure interaction arising between the pulsatile membrane and the blood.
- Optimization of the pump with respect to many possible scenarios and to better design the pump in view of some clinical objective.
- Modelling and simulation of the contact occurring between the membrane and the external support of the pump.
- Implementation of reduced models based on simplified fluid and/or structure models leading to efficient numerical schemes.

Expected Results:

- Software for the solution of fluid-structure interaction problem in pulsatile pump.
- 3D X-FEM simulation and error estimates for pulsatile pump
- Software for parameter simulation and optimization.

Planned secondment(s): The ESR will spend 50% of the time at CorWave, in the form of 6-months stays, possibly combined. The rest of the time, he/she will be at MOX-PoliMi.

Fellow	Host institution	PhD enrolment	Start date	Duration	Deliverables, *cf. table 3.1b*
ESR 10	SISSA	Y	month 8	36 months	*D1.1-D1.5, D2.1-D2.3, D3.1-D3.3, D5.1-D5.4, D6.1-D6.3, D7.4, D7.7*

Project Title and Work Package(s) to which it is related: Coupled parameterized reduced order modelling of thermo-hydro-mechanical phenomena arising in blast furnaces. It is related to WPs 1, 2, 3, 4, 5 and 6.

Industrial Challenge: In the blast furnace process knowing the thermo-mechanical behaviour of the fluid-channel ensemble improves process efficiency. The parameterization of developed models with respect to geometry design of several channels and to their material types is essential in order to quickly transfer the results to the design of new main runners. The project focuses on mathematical modelling of thermo-hydro-mechanical phenomena arising in the runner during the casting[14]. When fine coupled models are available then for the simulation reduced order models are needed. These have to be constructed with efficient methods that preserve the coupling and the parameter structure. The project focuses on model reduction and numerical simulation of thermo-hydro-mechanical effects.[15]

Objectives:

- Modelling of the 3D thermal-hydro-mechanical behaviour of the runner portion where the pig iron and slag are already separated.
- Selection of physical and geometrical parameters for the model reduction.
- Development of model reduction techniques for the coupled models.
- Selection of physical and geometrical sampling points for the model reduction methods

Expected Results:

- Coupled models for 3D thermo-fluid-structure interaction problems.
- Hierarchical modelling for nonlinear phenomena in blast furnaces.
- Reduced order models for 3D thermo-fluid-structure interaction problems.
- Advanced MOR techniques to deal with nonlinear materials.

14 P. Barral, P. Quintela y M.T. Sánchez. Mechanical behaviour in DC alloys casting processes. Archives of Computational Methods in Engineering, 21 (2014), 91-125.
15 Quarteroni A, Manzoni A, Rozza G (2011). Certified reduced basis approximation for parametrized partial differential equations and applications. J. Math in Industry, 1, 1-49, doi: 10.1186/2190-5983-1-3.

• Numerical implementation of MOR techniques and intensive testing for benchmarks.
Planned secondment(s): The ESR will spend 50% of the time at AMIII, in the form of 6-months stays, possibly combined. The rest of the time, he/she will be at SISSA.

Fellow	Host institution	PhD enrolment	Start date	Duration	Deliverables, *cf. table 3.1b*
ESR 11[a] ESR 11[b]	FVB-WIAS	Y	month 8 month 31	6.33 months 29.53 months	*D1.1-D1.5, D4.1-D4.3, D5.1-D5.4, D6.1-D6.3, D7.4, D7.7*

Project Title and Work Package(s) to which it is related: Optimal Shape Design of Air Ducts in Combustion Engines. It is related to WPs 1, 2, 4, 5 and 6.
Industrial Challenge: In order to increase the efficiency of a car engine, the optimal shape design of airducts with respect to flow properties is important. The addresses challenge is the analysis, design and numerical realization of solution algorithms for shape optimization problems for the stationary Navier-Stokes equations in a high Reynolds number regime and with geometric constraints.[16] **Objectives:** • Development of first-order optimality characterizations will be considered. • Construction of shape gradients with particular attention to geometric constraints representing the allowed construction space. • Development of a shape gradient-related descent scheme. • Initialization of the shape optimization process based on topological sensitivities.
Expected Results: • Error indicators for adaptive shape finite elements on the surface of the evolving geometry. • Numerical software for shape gradient descent scheme. • Application of new techniques to air-ducts from industrial partner.
Planned secondment(s): The ESR will spend 50% of the time at MathTec, in the form of 3-months stays, possibly combined. The rest of the time, he/she will be at FVB-WIAS.

3.2. Appropriateness of the management structure and procedures

3.2.1. Network organisation and management structure

The ROMSOC network consists of 13 beneficiary teams and 13 partner organisations, representing 15 academic and 11 industrial organisations. It will recruit, host, train and supervise 11 ESRs. For the network management we propose the following structure, as depicted in Figure 2, to clearly identify the various responsibilities as needed for optimal project implementation and communication between the various nodes and bodies.

The network **Coordinator** (V. Mehrmann, MATHEON-TUB) has a long-standing experience of managing large research consortia (having been chair of MATHEON for 8 years). He is responsible for the general management of the project and is also the link between the project and the European Commission. He will monitor the overall project planning, progress, and technical and financial reports. He will make sure that the exchange of the various staff members proceeds as smoothly as possible for a successful integration of the various components of the project. The **Training & Research Committee (TRC)** will be formed by one representative of each of the WP Leaders (see Table 1.1) and is chaired by the Coordinator. It will be responsible for coordinating the successful *operational implementation* of the Training and Research Tasks in the various WPs. The TRC will meet (physically or by telcons) quarterly.

Decisions concerning the network as a whole are taken by the **Supervisory Board (SB)**, composed of one person of each member of the network, i.e. both beneficiaries and partner organisation, plus two representatives elected by and among the ESR fellows. The SB, chaired by the Coordinator, will ensure an adequate exploitation of complementarities and synergies among the network partners; it takes into account the needs of both the industrial

16 Hintermüller, M and Laurain, A.: A shape and topology optimization technique for solving a class of linear complementarity problems in function space, Comput. Optim Appls., 46, pp 535-569, 2010.
Hintermüller, M.: Fast level-set based algorithms using shape and topological sensitivity information. Control and Cybernetics, 34, 305-324, 2005.

and academic sectors by establishing an appropriate balance between scientific-technological and transferable skills training, aiming at increased intersectoral employability of the researchers. The SB will be the platform for active and continuous communication and exchange of best practice, thus maximising the mutual benefits of academic-industrial partnerships. The SB will meet twice per year and use telcons whenever necessary.

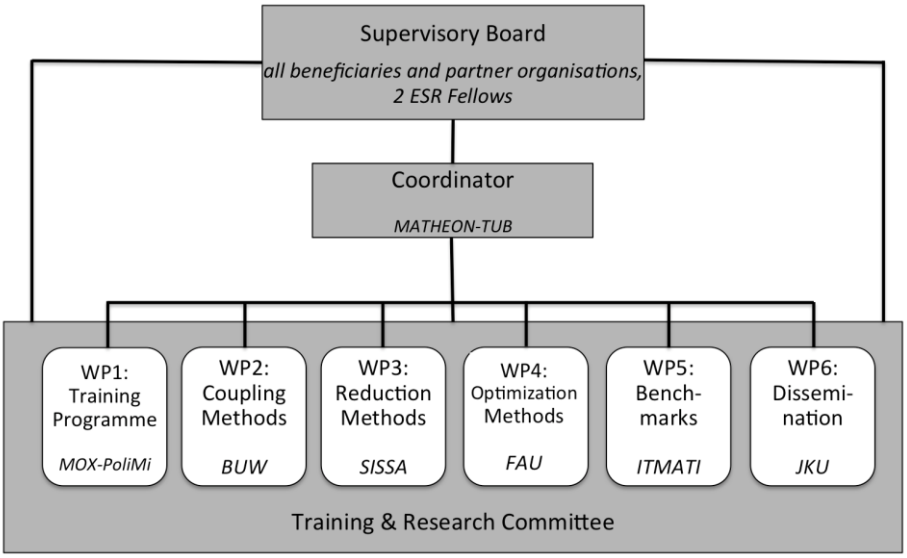


Figure 2: ROMSOC Network Management Structure

Further details on the network management procedures will be based on rules and regulations as agreed in the Consortium Agreement (CA).

Financial management Financial administration of the project will be done at the Coordinator's organization (MATHEON-TUB). A financial manager there will help the Coordinator, TRC and SB in the administrative and financial management of the project. EC-funds will be forwarded to the partners without undue delay. All fellows will be paid following the MC salary table, taking into account the Country Correction Coefficients, as well as national regulations. The support functions of the financial manager relate to the management of the budget and the distribution of the grant among participants, the payments and the preparation of annual reviews and financial reporting. Once distributed, each partner will be responsible for his/her portion of the grant. Beneficiaries have experience in EU projects. Part of the budget for management and overheads (to be agreed in the CA) will be allocated at MATHEON-TUB in support of the programme management (WP7). The CA will also contain regulations for a fair share of budget (institutional unit costs) and duties between beneficiaries and partner organizations within each ESR tandem.

Strategy for dealing with scientific misconduct Mainly triggered by the uncovering of recent cases of scientific misconduct, research organizations at national and European level have established new and sharper rules for good scientific conduct. A common theme in these rules is the four-eyes principle for supervision. Accordingly, ROMSOC will make sure that each ESR will be supervised by two doctoral advisors. A document describing adequate scientific conduct will be distributed to the ESRs at their appointment.

3.2.2. Joint governing structure

A Consortium Agreement (CA) will be negotiated between all participants, settling among other things the internal organization of the consortium, reflecting what has been described about the project management structure of ROMSOC. The CA also covers full rights and responsibilities of participants in respect of the confidentiality of any confidential information disclosed by the partners during the project, as well as the publication and communication of information during the project. The CA will also provide additional rules for dissemination. Settlements of internal disputes and Intellectual Property Rights (IPR) arrangements will be part of the CA as well. Any result generated before the effective date of the CA (i.e.

background) shall remain with the respective party bringing such background to the project. Any result generated by a party after said date, during and within the scope of the project (i.e. foreground) whether or not it qualifies for Intellectual Property Right (IPR) protection, shall vest in the party that generated such foreground. Any jointly generated foreground will be jointly owned where the rights and obligations associated to such jointly generated foreground will be regulated in the CA. Throughout the execution of the project, all partners will continuously contribute to the identification of foreground that may qualify for IPR protection and will act with the aim of achieving a meaningful outcome for the community following completion of the project.

3.2.3. Supervisory board

Role and % FTE	Responsibilities
Network coordinator 5% (Volker Mehrmann)	Run the network & communicate with the REA. Chair supervisory board, monitor progress and performance of partners, and ensure correct financial management: promote information exchange, facilitate dispute resolution, and coordinate reports for the REA.
Training Programme Lead 5% (Christian Vergara)	Ensure excellence in recruitment targeting ESRs from diverse disciplinary, sectoral and nationality backgrounds. Encourage ESRs in the active career management; assign mentors for support and career guidance. Monitor the training aspects.
Lead supervisor 10%, WP Leader 2%,	Appoint ESRs. Assist ESRs in Continuous Professional Development. Hold regular meetings with ESRs to ensure progress in research, provide feedback, assist in career development. Organise exchange visits and communicate with WP Leaders to ensure work progression. Report to project coordinator.
Co-supervisors 5-10%	Jointly supervise ESRs towards the successful completion of a PhD. Assist lead supervisors with advising ESRs in technical areas and monitoring quality of outputs.

See also section 3.2.1.

3.2.4. Recruitment strategy

ROMSOC aims to recruit the best ESRs, meaning we draw on candidates form all groups in society. The project office will issue partners with guidelines adhering to the Commission Recommendation (11 March 2005) on the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers, in particular concerning working conditions, recruitment transparency, equality in selection, and career development. Recruitment will follow the rules for the EID scheme.

Vacancies will be advertised as widely as possible at least 4 months before the anticipated start date for the ESRs to attract a significant number of the most able international candidates. Publicity will highlight the equal opportunities policy of the network and the interdisciplinary and intersectoral potential for candidates. We will focus on (a) electronic advertising (e-job markets, mailing lists) and websites and (b) word of mouth.

Initially, applications will be screened using the Marie-Curie eligibility criteria. Applicants will be informed about the recruitment process, selection criteria. Interviews will assess candidates according to: their existing skills, knowledge and relevant research/industrial experience; their capacity and enthusiasm to undertake training; the expected impact on their future career in academia or industry.

3.2.5. Progress monitoring and evaluation of individual projects

To monitor progress towards the research and training objectives, ESRs will have regular project meetings. These will involve weekly meetings with the supervisor(s) while in the home and visit labs and regular skype/teleconferences with collaborators in each WP. Face-to-face meetings for each WP will take place at network meetings.

Status of the activities will be compared to the planning (see Section 3.1.5) and timely finishing of deliverables is monitored. Proposed changes in activities or planning will be discussed in the supervisory board and if agreed upon, documented and archived.

Apart from the regular progress meetings, milestone review meetings will be organised with the supervisory board at the appropriate time. In these meetings, it will be decided whether a milestone can be passed and, if so, this decision will be documented and archived.

3.2.6. Intellectual Property Rights (IPR)

In case certain results are identified to be essential for the future business opportunities of the involved partners, the necessary steps will be taken to protect such results accordingly. The patenting and other protective measure procedures will proceed along the regulations set forth in the CA. The IP terms and conditions during the cooperation of ROMSOC will be based on a royalty-free basis. All background introduced to the project remains the property of the party introducing it. Publication of results based on confidential background, such as field data from operations, will require approval by the contributing party prior to publication. After completion of the project (i.e. during exploitation) access rights to background and to foreground could require fair and reasonable compensation, subject to agreement amongst the parties and reflected in the CA. All access rights needed for the execution and following completion of the project will be granted on a non-exclusive basis, will be worldwide and, in principle, will not contain the right to grant sub-license(s), but in any case, shall contain the right to have-made. The CA will further regulate rights and obligations for affiliated entities of a party, where those shall enjoy the same access rights conditions as the party participating in the project, and where such affiliated entities will need to grant the requested access rights to other parties if those are needed during execution and/or following completion of ROMSOC. The CA will also provide additional rules on the introduction, namely pursuant to notification, of background that has been made available under controlled license terms, e.g. so-called open source licenses. To the extent required for proper use of software results, sub-licensing rights on software results may be regulated in the CA if in the best interest of the project dissemination, where such sub-licensing rights shall not be in a manner where the so licensed software results would be subject to controlled license terms. Means to make software results available to the other parties or the public will be part of the CA if so needed.

3.2.7. Gender aspects

All academic partners in ROMSOC pay high attention to recruiting qualified female researchers. The Coordinator TU Berlin has been awarded with the “Total E-Quality-Predicate” for their gender and quality management controlling concepts as well as with the certificate “Audit Family Friendly University” by Beruf und Familie gGmbH, which states that the university takes up the social responsibility to support gender equality as well staff members with family obligations (work-life balance). Through several dedicated coaching and mentoring programmes at TU the number of female students in mathematics in Berlin has increased significantly in the last years and has now reached an average of 45%. We will draw on these successful concepts and closely cooperate with the Gender Representative at TUB to provide dedicated support to gender-specific issues whenever needed.

3.2.8. Data management plan

The ROMSOC network will produce mainly two kinds of research data: models to describe real-world systems and processes, and algorithms for simulation and optimization in the form of sophisticated software. Software will be made available to the industrial partners via in-house software on the one-hand, and to the general public via open-access software on the other hand. We will also create a collection of benchmarks for model hierarchies (WP5) and these benchmarks will be open access. Further details on Research Data Management will be elaborated as part of WP9, where a corresponding Data Management Plan will be delivered in the framework of the Open Research Data Pilot of the EU.

3.3. Appropriateness of the infrastructure of the participating organisations

All ROMSOC partners are equipped with adequate office, computing and library facilities and have access to necessary high performance computing infrastructures (hardware, software).

3.4. Competences, experience and complementarity of the participating organisations and their commitment to the programme

3.4.1. Consortium composition and exploitation of participating organisations' complementarities

The consortium has been carefully composed to address all the relevant competences required to achieve the ambitious research goals as well the requirements for a broad training programme. On the methodology side this concerns the necessary mathematical fields, such as continuous and discrete optimization, inverse problems, numerical algorithms and scientific computing, in particular adaptivity in space-time discretization and error estimates, modelling in hierarchies and coupling of different systems with different physical behaviour and different scales, model reduction with reduced basis methods and algebraic projection methods, as well as tensor approximation. On the application side and concerning industrial sectors, the consortium was chosen in a selective way to include partners which bring in different competence, such as coupled systems in electronics and optics (high performances telescopes, thermo-acoustic multi-layer flow velocity sensors, free form optics), economic processes (finance, transportation networks, and industrial production flows) and materials (blast furnaces, pulsatile heart pumps, air ducts in combustion engines) and where a synergy between the required MSO and MOR techniques models is anticipated. While bringing in different qualifications, all partners have a proven competence towards these two goals and in particular towards academic-industrial cooperation. They are highly engaged in training the next generation of researchers and have large experience in teaching and developing courses particularly directed towards interdisciplinary and industrial cooperation.

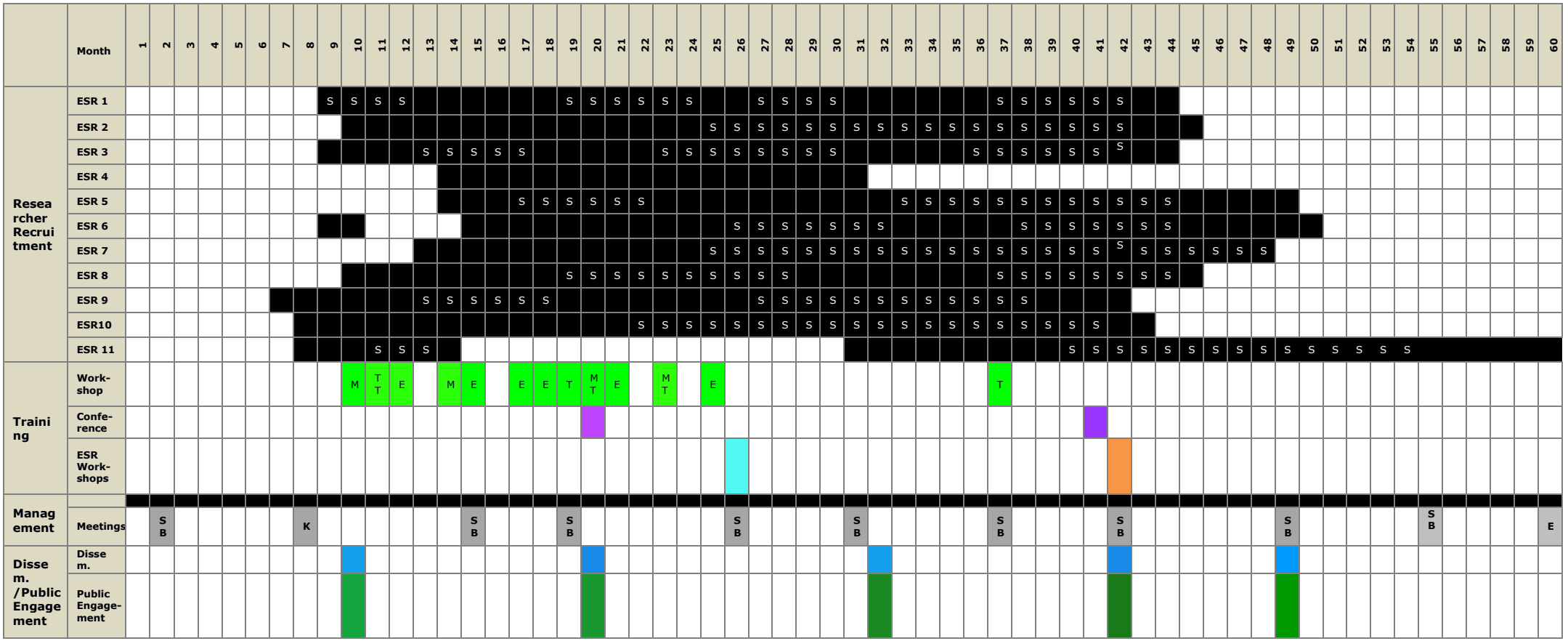
3.4.2. Commitment of beneficiaries and partner organisation to the programme

- Each of the beneficiaries and partner organizations is committed to ROMSOC since it is in line with their respective interests, not only for the technical milestones that are pursued, but also because ROMSOC will produce a cohort of eleven excellently trained researchers who act as ambassadors exemplifying the innovativeness of the participants. Furthermore, ROMSOC will initiate cross-fertilization to the benefit of all participating organisations.
- The recruitment and secondment schemes have been set up such as to fully exploit the specific competences of each partner, allowing not only the ESRs to acquire knowledge and skills in the best possible environments, from the best-placed persons, and at the ideal time in their research planning, but also a knowledge transfer between the participants through the mobility of the ESRs and the project meetings.
- The above-mentioned evident advantages for the participants are intrinsic drivers to be and stay committed to the programme.

DOCUMENT 2 (*no overall page limit applied*)

4. Gantt Chart

Reflecting ESR recruitments, secondments, training events, management and dissemination / public engagement activities



S = Secondment; SB=Supervisory board meeting; K = Kick-off meeting, E = End of project, M = MTC, E = ETC, T = TSTC, meetings in Brussels (possibly co-organized with REA/EC)

6. Ethics issues

6.1 Third countries

The applicant confirms that the ethical standards and guidelines of Horizon2020 will be rigorously applied, regardless of the country in which the research is carried out. The applicant confirms that the research performed outside the EU (i.e. in Israel in the framework of the project of ESR 4) is compatible with the Union, national and international legislation and could have been legally conducted in one of the EU Member States.

6.2 Dual use and misuse

In the framework of the project of ESR 1 the team consisting of Microgate (Italy) and the Industrial Mathematics Institute at the Kepler University Linz (Austria) focuses on the adaption and implementation of algorithms for a real-time control of Adaptive Optics (AO) Systems for Large Astronomical Telescopes. These telescopes have no military use and are intended for scientific use only. There is no direct military use of our work.

In general, Adaptive Optics technologies can be used by the military. In this case the principle is the same, however, the goals are different from the ones of our project. This leads to different technical realization and thus we believe there is no direct military benefit from our work.

Although parts of our published results might be used for military applications, in this project all effort will be put in their utilization for civilian purpose only.

If applicable, copies of export/import licences will be obtained, kept in the file and submitted to the REA upon request. If applicable the copy of ethics approval will be submitted.

As risk mitigation strategy we confirm that an external ethics expert (Prof. Arne Manzeschke from the Evangelische Hochschule Nürnberg) will monitor regularly the results and findings of the project for the potential of dual use or misuse.

ESTIMATED BUDGET FOR THE ACTION

			Estimated eligible[1] costs (per budget category)											EU contribution		
			A. Costs for recruited researchers						B. Institutional costs				Total costs	Reimburse-ment rate %	Maximum EU contribution[2]	Maximum grant amount[3]
			A.1 Living allowance		A.2 Mobility allowance		A.3 Family allowance		B.1 Research, training and networking costs		B.2 Management and indirect[4] costs					
	Number of units (person-months)	Form of costs[5]	Unit		Unit		Unit		Unit		Unit					
			Costs per unit[6]	Total a[7]	Costs per unit[6]	Total b[7]	Costs per unit[6,8]	Total c[7]	Costs per unit[6]	Total d[7]	Costs per unit[6]	Total e[7]	f = a+b +c+d+e	g	h	i
1. MATHEON-TUB	18.00		3 072.68	55 308.24	600.00	10 800.00	250.00	4 500.00	1 800.00	32 400.00	1 200.00	21 600.00	124 608.24	100.00	124 608.24	n/a
2. MathConsult	19.47		3 259.28	63 458.18	600.00	11 682.00	250.00	4 867.50	1 800.00	35 046.00	1 200.00	23 364.00	138 417.68	100.00	138 417.68	n/a
3. JKU	18.00		3 259.28	58 667.04	600.00	10 800.00	250.00	4 500.00	1 800.00	32 400.00	1 200.00	21 600.00	127 967.04	100.00	127 967.04	n/a
4. MICROGATE	18.00		3 318.37	59 730.66	600.00	10 800.00	250.00	4 500.00	1 800.00	32 400.00	1 200.00	21 600.00	129 030.66	100.00	129 030.66	n/a
5. ITMATI	72.00		3 035.36	218 545.92	600.00	43 200.00	250.00	18 000.00	1 800.00	129 600.00	1 200.00	86 400.00	495 745.92	100.00	495 745.92	n/a
6. INRIA	36.00		3 452.10	124 275.60	600.00	21 600.00	250.00	9 000.00	1 800.00	64 800.00	1 200.00	43 200.00	262 875.60	100.00	262 875.60	n/a
7. U-HB	17.33		3 072.68	53 249.54	600.00	10 398.00	250.00	4 332.50	1 800.00	31 194.00	1 200.00	20 796.00	119 970.04	100.00	119 970.04	n/a
8. BUW	36.00		3 072.68	110 616.48	600.00	21 600.00	250.00	9 000.00	1 800.00	64 800.00	1 200.00	43 200.00	249 216.48	100.00	249 216.48	n/a
9. STM	0.00			0.00		0.00		0.00	1 800.00	0.00	1 200.00	0.00	0.00	100.00	0.00	n/a
10. FAU	36.00		3 072.68	110 616.48	600.00	21 600.00	250.00	9 000.00	1 800.00	64 800.00	1 200.00	43 200.00	249 216.48	100.00	249 216.48	n/a
11. MOX-PoliMi	36.00		3 318.37	119 461.32	600.00	21 600.00	250.00	9 000.00	1 800.00	64 800.00	1 200.00	43 200.00	258 061.32	100.00	258 061.32	n/a
12. SISSA	36.00		3 318.37	119 461.32	600.00	21 600.00	250.00	9 000.00	1 800.00	64 800.00	1 200.00	43 200.00	258 061.32	100.00	258 061.32	n/a
13. FVB-WIAS	35.86		3 072.68	110 186.30	600.00	21 516.00	250.00	8 965.00	1 800.00	64 548.00	1 200.00	43 032.00	248 247.30	100.00	248 247.30	n/a
Total consortium	378.66		n/a	1 203 577.08	n/a	227 196.00	n/a	94 665.00	n/a	681 588.00	n/a	454 392.00	2 661 418.08	100.00	2 661 418.08	2 661 418.08

[1] See Article 6 for the eligibility conditions.

[2] This is the theoretical amount of EU contribution that the system calculates automatically (by multiplying all the budgeted costs by the reimbursement rate). This theoretical amount is capped by the 'maximum grant amount' (that the Commission/Agency decided to grant for the action) (see Article 5.1).

[3] The 'maximum grant amount' is the maximum grant amount decided by the Commission/Agency. It normally corresponds to the requested grant, but may be lower.

ESTIMATED BUDGET FOR THE ACTION

[4] The indirect costs covered by the operating grant (received under any EU or Euratom funding programme; see Article 6.3(b)) are ineligible under the GA. Therefore, a beneficiary that receives an operating grant during the action's duration cannot declare indirect costs for the year(s)/reporting period(s) covered by the operating grant (i.e. the unit cost for management and indirect costs will be halved for person-months that are incurred during the period covered by the operating grant), unless it can demonstrate that the operating grant does not cover any costs of the action.

[5] See Article 5 for the forms of costs.

[6] See Annex 2a 'Additional information on the estimated budget' for the details on the costs per unit.

[7] Total = costs per unit x number of units (person-months).

[8] The amount for the family allowance inserted by the system represents an average (with/without family). For the financial statements (Annex 4), this amount will be adjusted according to the actual family status of the recruited researchers (as specified in the 'researcher declaration').