Graphene Flagship

M. García-Hernández (CSIC)

Leader WP3-Enabling MATERIALS & Member of the EB

Madrid, 15th November, 2017

Graphene

- **Paradigmatic material with unique properties**
- **Discovery: 2004 Mancherter (Geim & Novoselov), Nober prize 2010**
- **Outperforming many other materials with a broad range of applications**

> **Optoelectronics**
> **Fast/flexible electronics**
> **Composites & coatings**
> **Spintronics**
> **Sensors**
> **Biomedical**
> **Energy**

Our Mission:

Bring graphene disruptive technologies *from European laboratories to Europeans in* **ten years** *space of time*

Actors

Academics & Fundamental science

Companies & Production technologies

Spain (2010) : Leadership in graphene exports & and leadership in fundamental science

Pilot Action: May 2011-April 2012

| Partner	Acronym	Laboratory Name	Name of the contact
1(coordinator)	CUT	Chalmers tekniska hoegskola	Jari Kinaret
2	UNIMAN	The University of Manchester	Andre Geim
3	UNILAN	Lancaster University	Vladimir Falko
4	UCAM _DENG	The Chancellor, Masters, and Scholars of the University of Cambridge	Andrea Ferrari
5	AMO	Gesellschaft fuer angewandte Mikro- und Optoelektronik mit beschraenkter Haftung AMO GmbH	Daniel Neumaier
6	ICN	Catalan institute of nanotechnology	Stephan Roche
7	CNR	Consiglio nazionale delle ricerche	Vincenzo Palermo
8	NOKIA	Nokia OYJ	Jani Kivioja
9	ESF	Fondation Européenne de la Science	Ana Helman
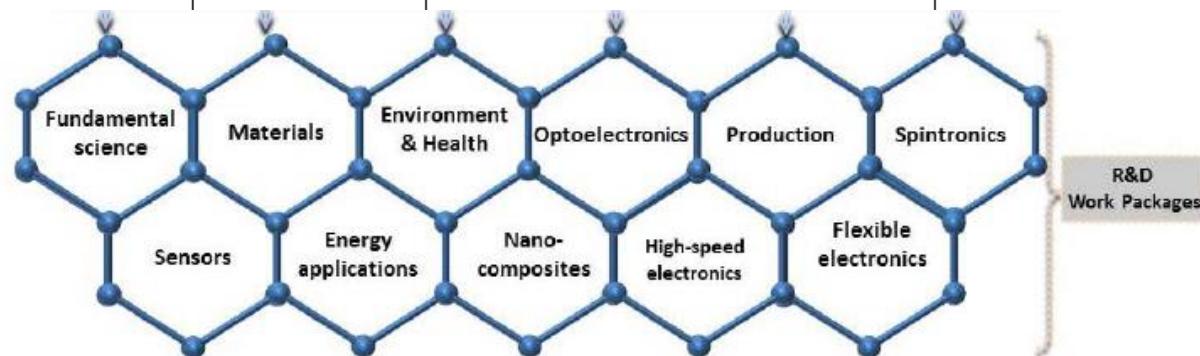
Figure 8: *Organization of the CP-CSA instrument of the Flagship*

FLAGSHIP ROADMAP

Platform

One Atom Thin

Linear spectrum

Strength

Graphene

High mobility

Highly flexible

Unique optical properties
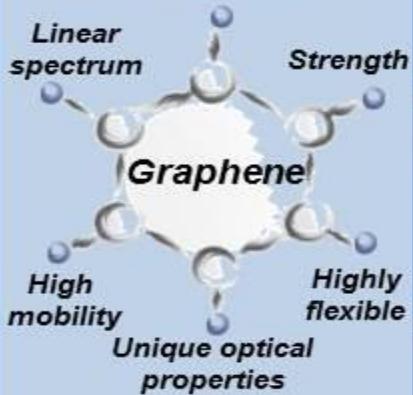
Hybrid 2d structures
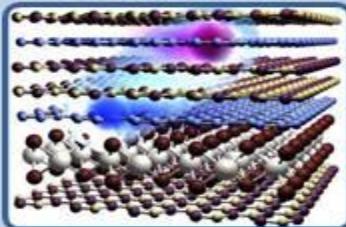
Industrial
Academic

Industrial workshare
Academic workshare

Production techniques
- Large scale synthesis
- On demand growth
- Nanoribbons
- Growth on flexible substrates
- Inks
- Interfaces
- Doping
- Superstructures
- Toxicology
- ...

Components
- Transistors
- Spin valves
- Flexible displays
- RF tags
- Ultra-light batteries
- Solar cells
- Ultrafast lasers
- Composite materials
- Prostheses
- Sensors
- ...

System Integration
- Flexible electronic
- Superfast optical communication
- Ultrafast low-power electronics
- Self-powered devices
- Automotive
- ...

Industrial workshare
Academic workshare

Vision beyond 2023

ICT
- Faster
- Cheaper
- Flexible

Energy storage and conversion
- Efficient
- Cost effective
- Renewable
- Sustainable

Health
- Cost effective
- Bio compatible

- **Societal benefits**
- **Jobs**
- **Education**

2013   2016   2023

6

MAT2010-122279-E

Paco Guinea &Mar Garcia-Hernandez

Coordination Spanish Roadmap

Co-organization workshop Graphene industrial day at CSIC/Madrid

Organization of various spanish workshop on graphene applications: Composites, Spintronics, Electronics

Organization of topical meetings facilitated by CDTI

Organization of the spanish ndustrial day prior to Graphnee Industrial day

Lots of meetings with industrial & academic partners

October 2010, Madrid CSIC
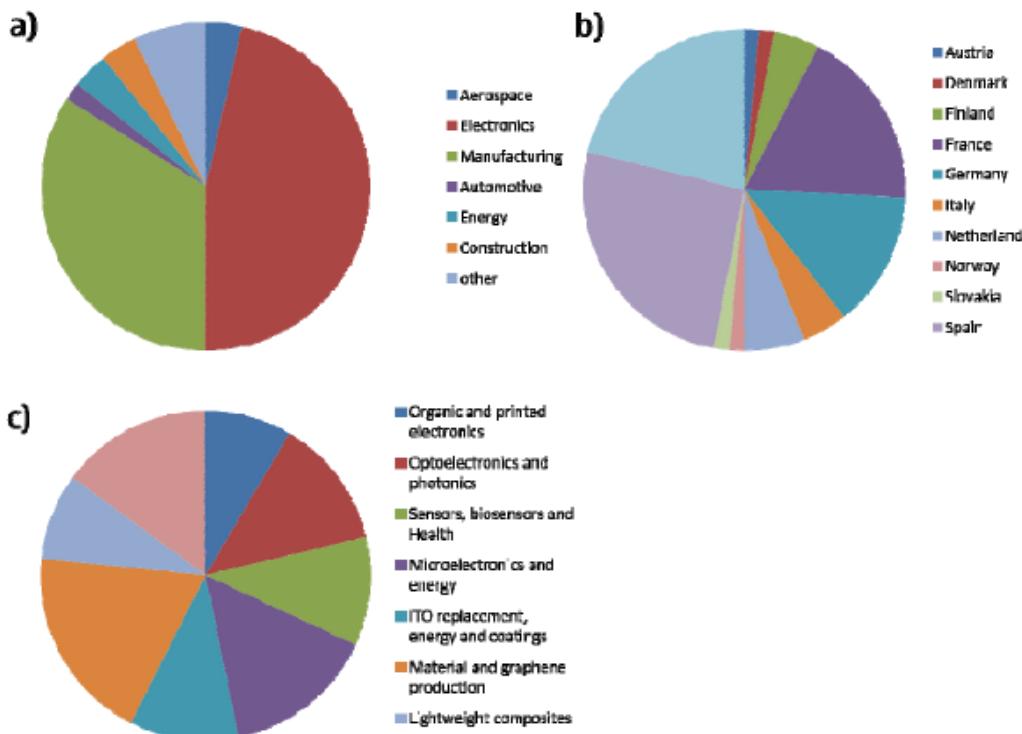
Figure 9: *A summary of the participating 63 companies in the industrial workshop in Madrid in October 2011: a) Companies were presenting different industries and b) 11 different European countries. According the advance survey companies are seeing graphene to have a major impact in various different technology areas (Fig c.).*

Eol Flagship Graphene
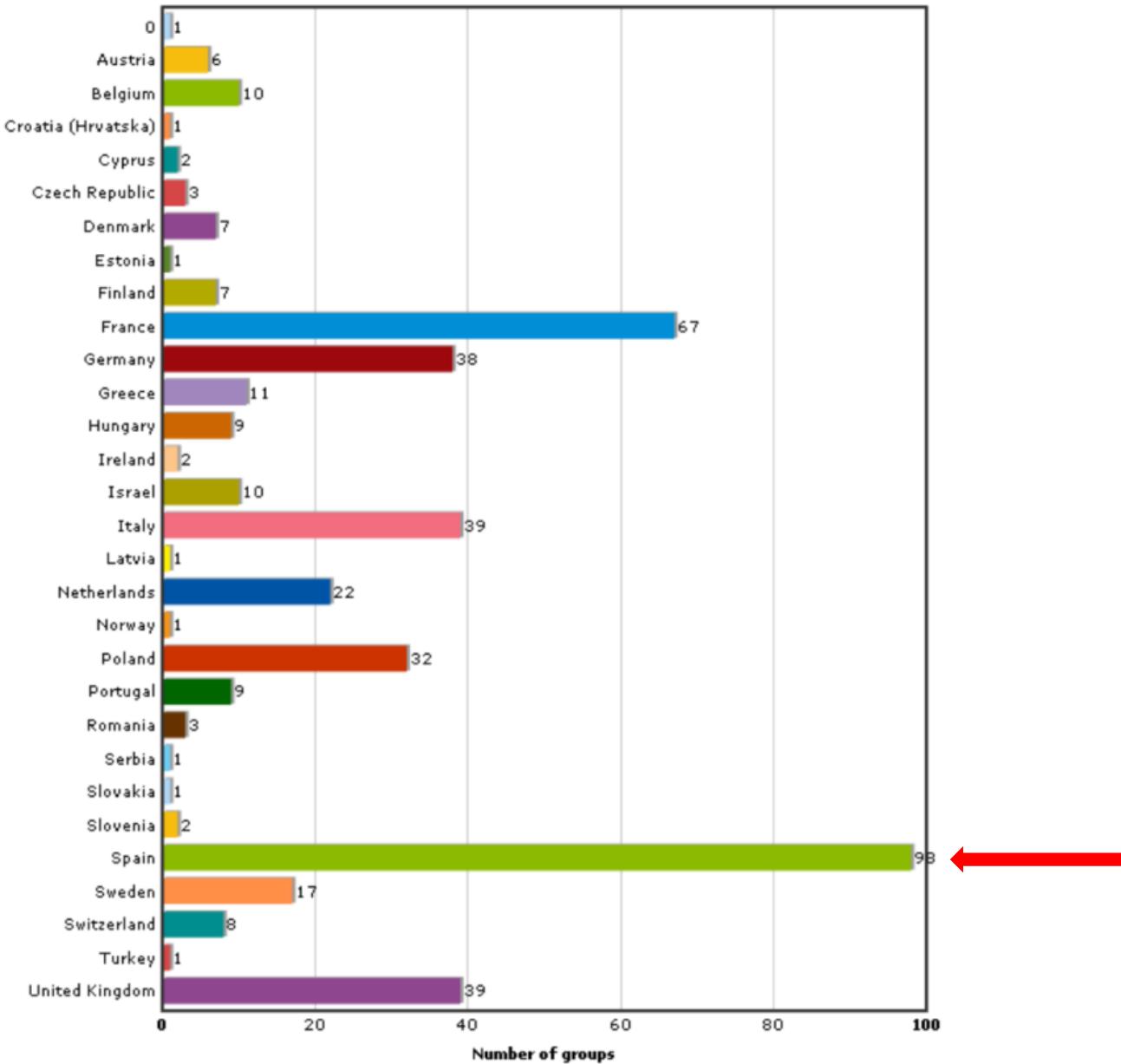
Consortium FP7 & evolution
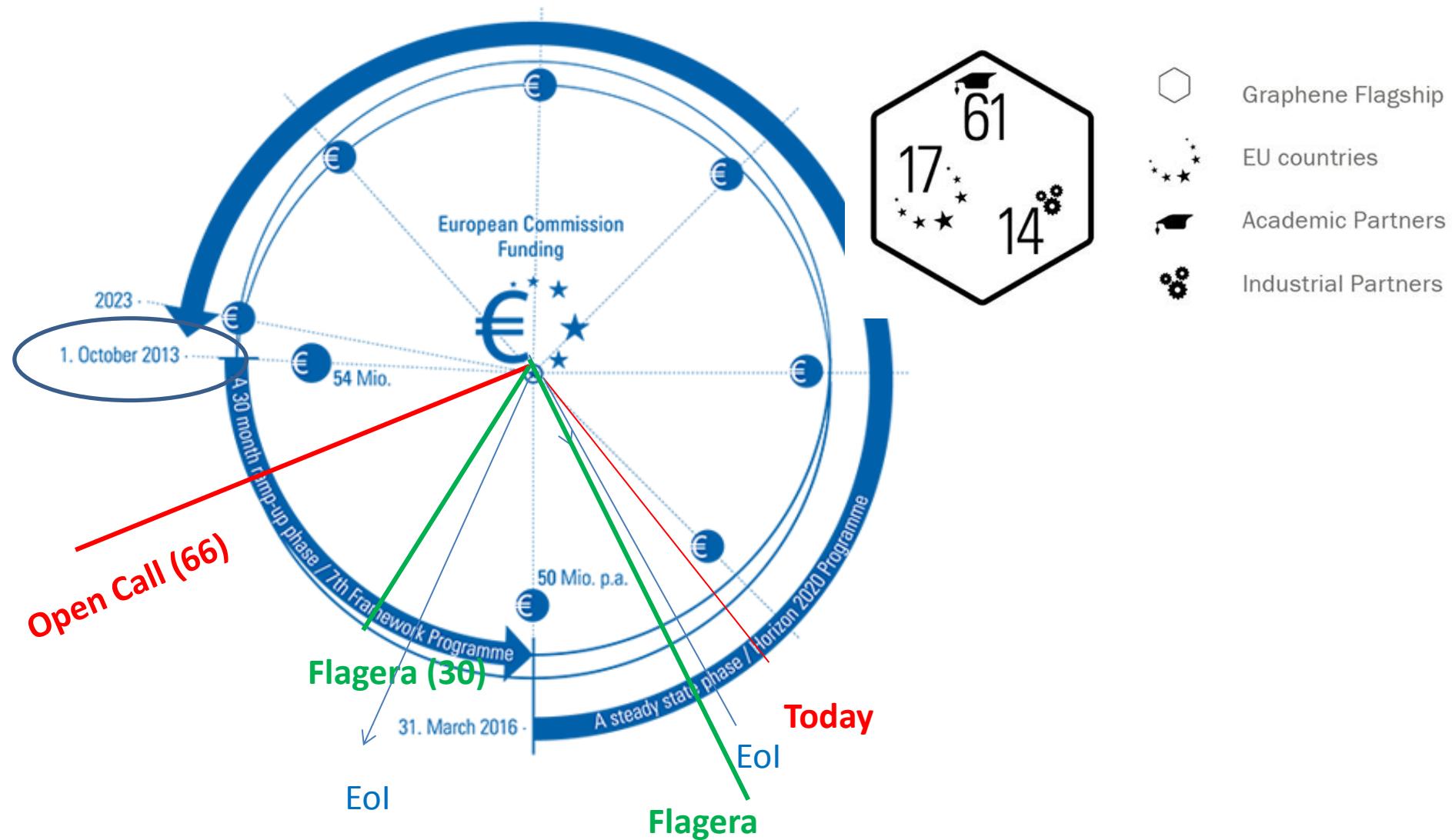
Ramp Up (Oct 2013- March 2016)

12% Spanish revenues
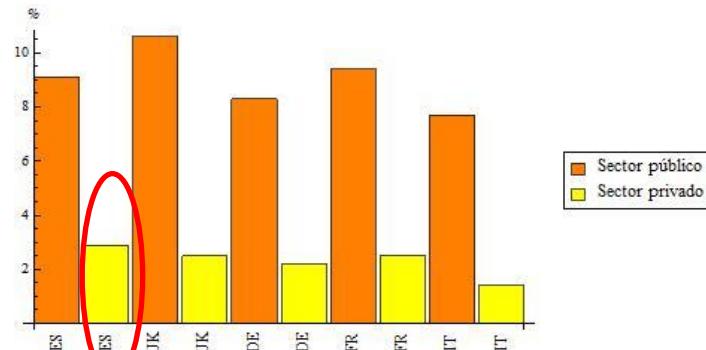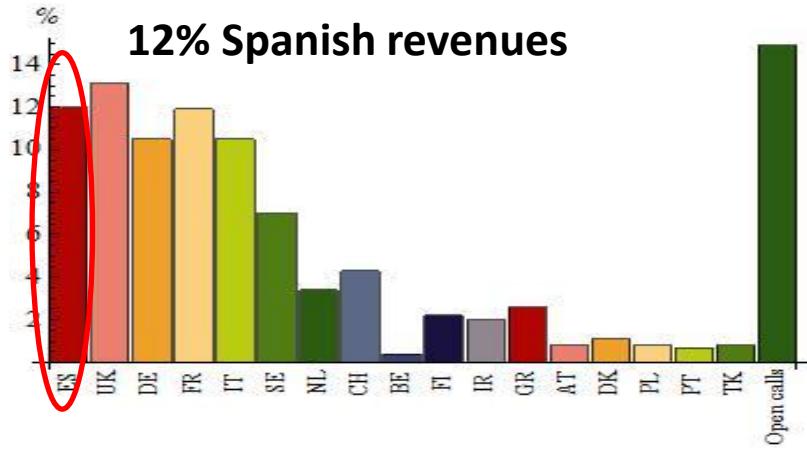
Industrial Share
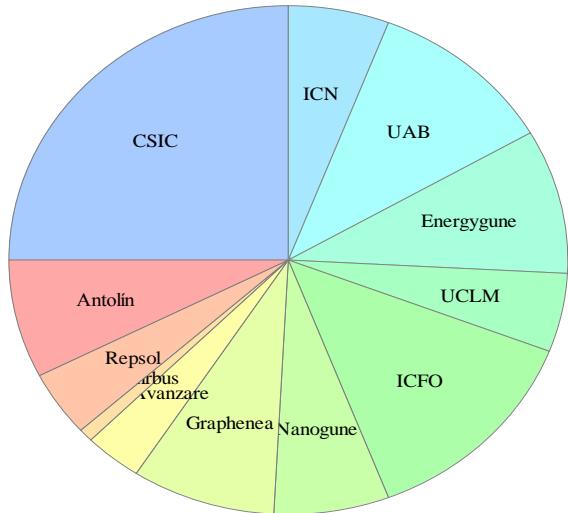
Institutions

Gobernance

Persona	Institución	Atribuciones en la Gobernanza
Francisco Guinea	CSIC/ICMM	Miembro del "Strategic Advisory Council"
Mar García-Hernández	CSIC/ ICMM	Leader WP " Materials y miembro del "Scientific Panel"
Cesar Merino	Grupo Antolín	Deputy "Production"
Stephan Roche	ICN/CIN2	Deputy "Spintronics"
Frank Koppens	ICFO	Deputy "Optoelctrónica"

Open Call Statistics
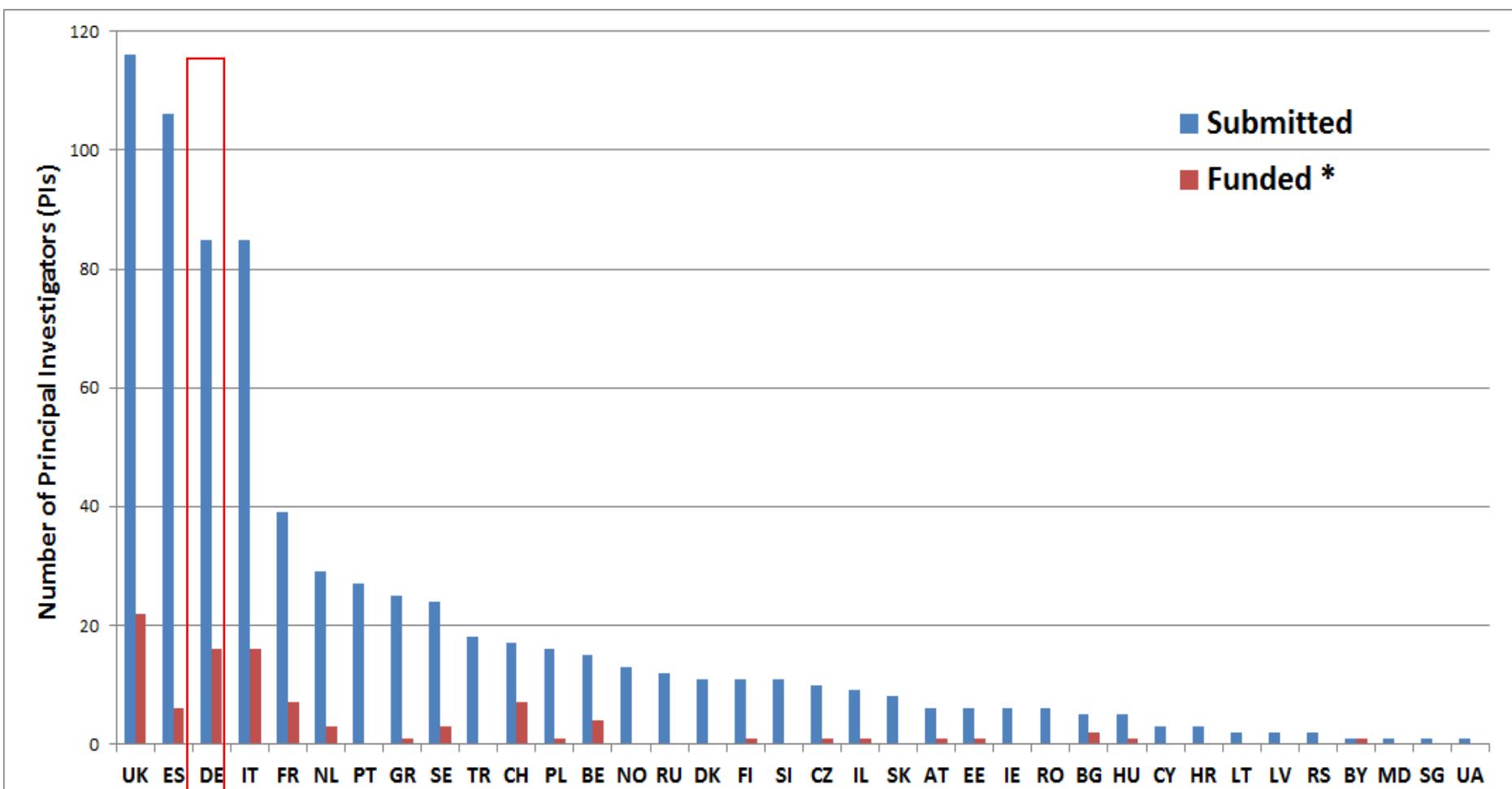
Statistics after Open call

- **66 new partners** ⟹ **Total 140 Partners**

- **33% industrial when initially were 20%**

- **New countries contributing: Bileorusia, Bulgaria, Chequia, Estonia , Hungary , Israel.**

- **Contribuciones mayoritarias: Italy (23), Germany(23), Spain(18), UK(17) y France(13)**

Flagship in H2020

Framework Partnership

Core Project 1
152 partners, 2016-18

Core Project 2
> 120 partners, 2018-20

Core Projects 3-
> 120 partners, 2020-

National projects

FLAG-ERA

Regional projects

Other EU projects

Excellence Network (Dec2015- Dec 2017)

- **GOOD PRAXIS CODE IN LABELING**
- Spanish Graphene Alliance (major producers)
- Contribute to setting transversal technological platform GRAFIP

  - GRAFIP
  - Coorganización of 5 Workshop   on graphnee applications
    - Building & civil engineering (Barcelona)
    - Energy (Vitoria)
    - Transport (Madrid)
    - Packaging(Valencia)
    - Biomedical and sensors

# Divisions and Work Packages in Core1

- The Graphene Flagship has
  - Four scientific divisions
  - One administrative division
  - 20 Work Packages
    - **15 on research and innovation**
    - Five on operative management aspects
  - **One external division**
    - **Associated members and partnering projects**

EC-funded part in CORE1

- **H2020: Core 1 started on April 1, 2016**
  - **152 partners in 23 countries; about 1/3 industry, 1/2 academia and 1/6 other**
  - **15 S&T work packages, 5 supporting work packages**
  - **450 full-time equivalent persons, over 1,300 individuals**

- **53 Associated Members, many of whom are involved in 16 Partnering Projects**

- **Progress along the value chain materials-components-systems towards higher technology readiness levels**

CHALMERS
UNIVERSITY OF TECHNOLOGY

GRAPHENE FLAGSHIP
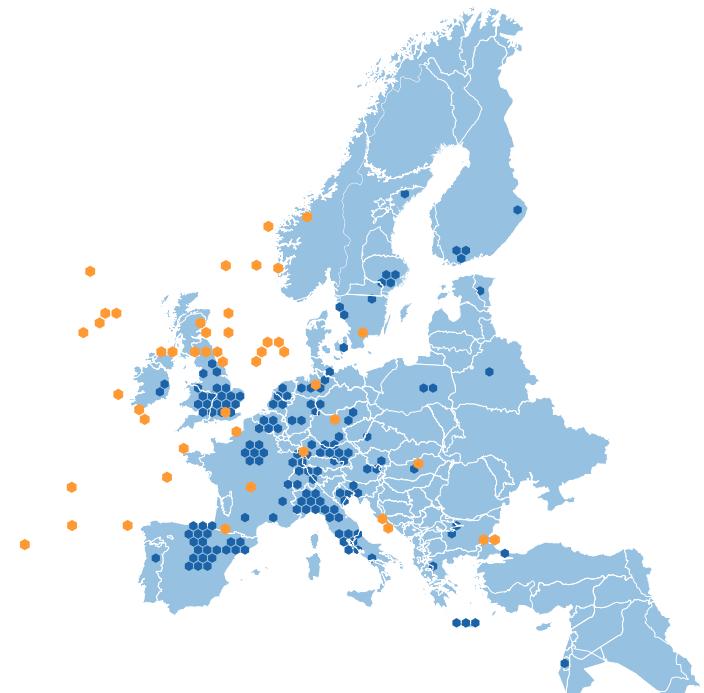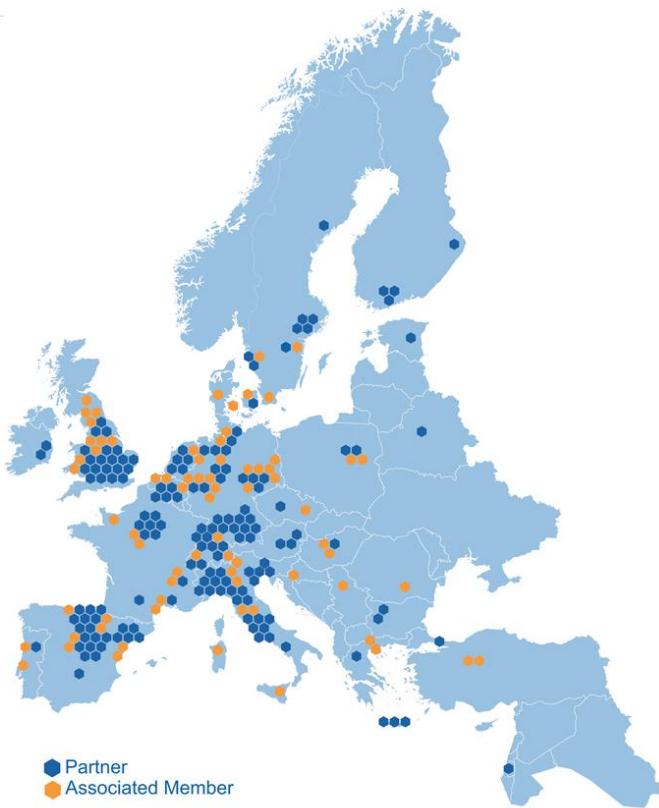
Airbus
Autonomous University of Barcelona
Avanzare
The Biomedical Research Networking center in Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN)
CIC BiomaGUNE
CIC energiGUNE
CIC NanoGUNE
CSIC Spanish National Research Council
Fundación IMDEA Nanociencia
Fundación para la Investigación, Desarrollo y Aplicación de Materiales Compuestos
Graphenea
Grupo Antolin
ICFO Institute of Photonic Sciences
ICN2 Catalan Institute of Nanoscience and Nanotechnology
*Institut d'Investigacions Biomèdiques August Pi i Sunyer (IDIBAPS)
*Internacional de Composites S.A. (Aernnova)
*Institute of Chemical Technologies Emerging Rioja
*nvision systems & technologies
Repsol
*Tecnalia Research and Innovation
University of Castilla-La Mancha
*The University of Zaragoza
* Aido

ASSOCIATED MEMBERS

AIMPLAS
Autonomous University of Madrid
Graphene Nanotech S. L.
National Institute for Agricultural and Food Research and Technology (INIA)
Polytechnic University of Catalonia
University of the Basque Country
Walter Pack

Evolution of the flagship

- The flagship has more than doubled in size since its launch:

Year	Partners	Academic	Industrial	Other	Budget/yr
2013	75	48	16	8	18 M€
2014	142	76	41	25	24 M€
2016 (H2020)	152	75	52	25	45 M€

GLOBAL EFFORT Ramp up	Actual PM M1-12	Actual PM M13-30	Total Actual PM
TOTAL	1399	5582	**6980**

Executive Board Core2

Annick Loiseau	CNRS	Academia
Ken Teo	Aixtron	Industry
Wolfgang Templ	Alcatel-Lucent	Industry
Vittorio Pellegrini	IIT	Institute
Kostas Kostarelos	UNIMAN	Academia
Mar Garcia-Hernandez	CSIC	Academia
Bart van Wees	RUG	Academia
Costas Galiotis	FORTH	Institute
Amaia Zurutuza	Graphenea	Industry
Frank Koppens	ICFO	Institute

Key Performance Indicators (M1-M30)

KPI	Target	Achieved
Number of scientific publications	305	782
Number of citations (without self-citations)	1500	4595
Number of invited talks at conferences	130	465
Number of invention disclosures	38	45
Number of patent applications	26	49
Number of patents	11	0
Number of prototypes	4	36
Number of PhDs and Postdocs recruited into the Flagship	139	225
Number of spin-offs established	2	2
Number of products on market	8	13
Number of industry/academy collaborations, in particular SME collaborations	6	165
Number of enterprises that actively use university facilities	29	36
Number of appearances in public media including popular science publication	40	40
Number of press releases	20	102
Number of companies attending industrial workshops organised by the flagship	30	84
Number of member states and associated countries engaged in a dialogue with the flagship either directly or through an ERA-NET	18	26

KPIs

Numeric		
	Achieved M12	Target M24
Students	47	33
Publications	160	109
Invited talks	158	104
Individual Awards	5	0
Prototypes	4	0
Invention disclosures	7	15
Patent application	11	15
Number companies using facilities	13	4
Spin offs	1	1
Products into market	8	7
Industry –Academy Agreements	41	30
Standarized methods	5	12

High impact publications

Source	Number of contributions
Science	2
Advanced Materials	7
Nature	1
Angewante	9
JACS	16
Nature Comm	9
2D Mat	14
Nano Lett	4
ACS Nano	10
Phys Rev. Lett	5
Small	3
Nanoscale	7
Total	87

MORE THAN 160 PUBLICATIONS

½ of the publication in high impact journals

Future evolution

- **Continue moving towards higher technology readiness levels but keeping the fundamental science component as well**

- **Focus the activities: try to combine technology push (*what is doable?*) and market pull (*what is worth doing?*)**

- **Focusing decisions based on four input streams:**
  - **EC reviews (backward-looking)**
  - **Our internal reviews (forward-looking)**
  - **Our technology and innovation roadmap**
  - **Our Science and Technology Fora**

Graphene disruptive technologies
- from academic laboratories to society