GRAPHENE FLAGSHIP

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CHALMERS

FET flagships:

*"FET Flagships are ambitious large-scale, **science-driven**, research initiatives that aim to achieve a visionary goal.*
*The scientific advance should provide a strong and broad basis for future **technological innovation** and economic exploitation in a variety of areas, as well as novel benefits for society."*

Graphene Flagship mission:

*"To take **graphene and related layered materials** from a state of raw potential to a point where they can revolutionize multiple industries. This will bring a new dimension to future technology – a faster, thinner, stronger, flexible, and broadband revolution. Our program will put **Europe** firmly at the heart of the process, with a manifold return on the EU investment, both in terms of **technological innovation and economic growth**."*

→ *Graphene Flagship has a growing industrial component with focus on utilization*

Year	Partners	Academic	Industrial	Other	Budget/yr
2013	75	48	16	8	18 M€
2014	142	76	41	25	24 M€
2016	154	75	54	25	45 M€

Flagship in H2020

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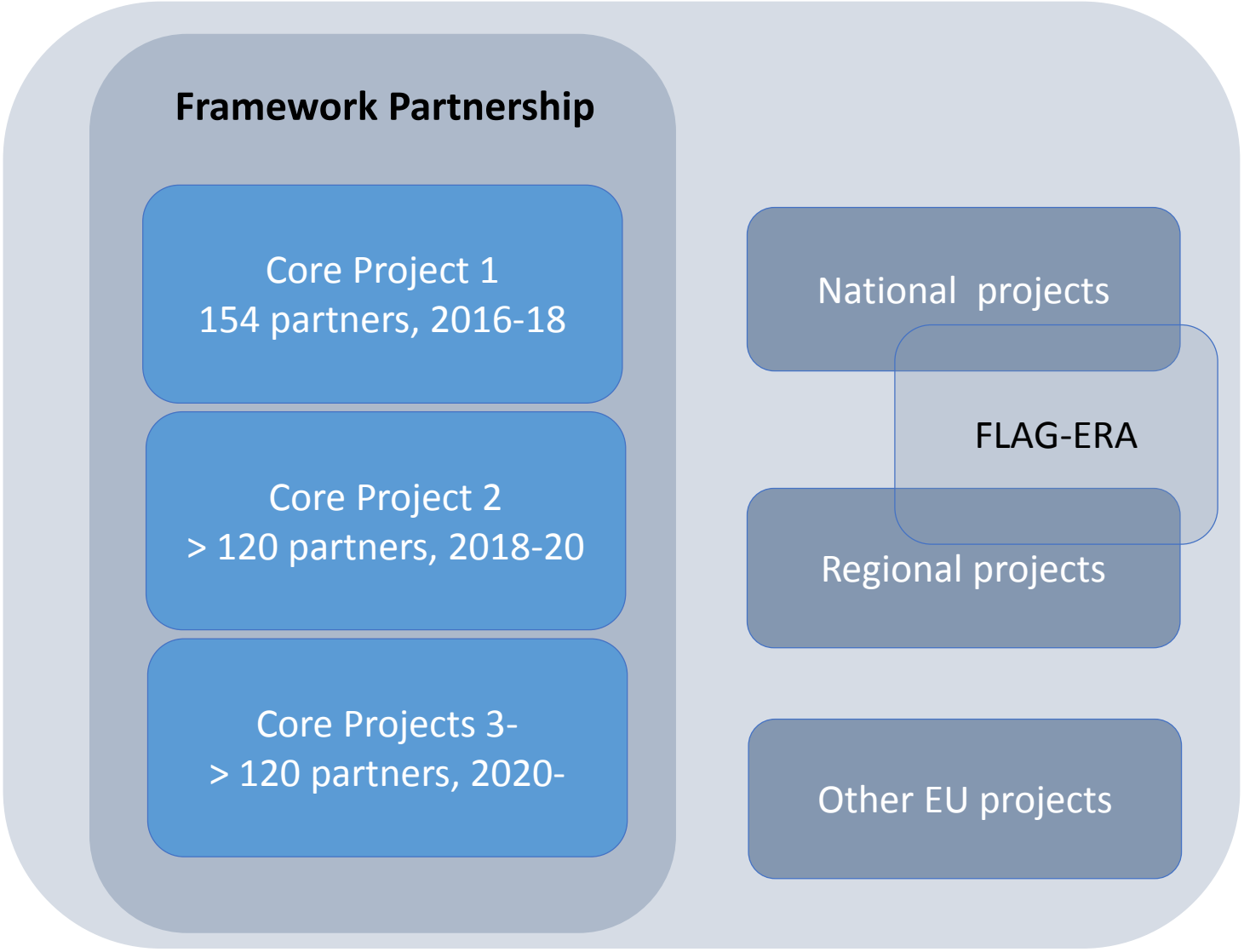

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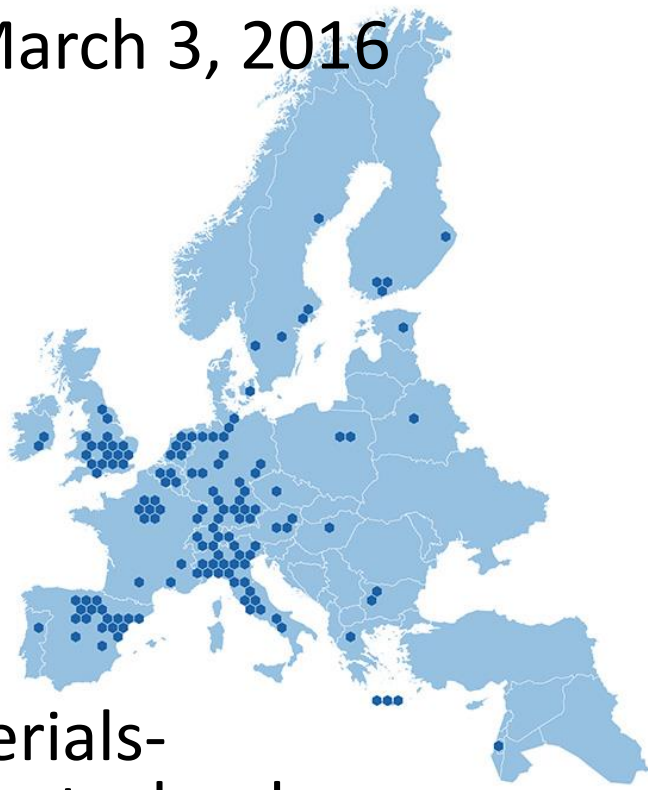
EC-funded part

- H2020: Core 1 contract signed on March 3, 2016
  - 154 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, 1,000 individuals



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

Core 1 work packages

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- Administrative
  - Management (J.Kinaret)
  - Research management (K. Boustedt)
  - Innovation (K. Hjelt)
  - Dissemination (M. Fogelström)
  - Alignment (A. Helman)
- Division 1 (V. Fal'ko)
  - Enabling technologies (V. Fal'ko)
  - Enabling materials (M. Garcia Hernandez)
  - Spintronics (B. van Wees)
- Division 2 (M. Prato)
  - Health & environment (M. Prato)
  - ***Biomedical technologies (K. Kostarelos)***
  - Sensors (H. van der Zant)
- Division 3 (D. Neumaier)
  - Electric devices (D. Neumaier)
  - Optoelectronics (F. Koppens)
  - Flexible electronics (H. Sandberg)
  - ***Wafer-scale system integration (M. Romagnoli)***
- Division 4 (G. Gebel)
  - ***Energy storage (V. Pellegrini)***
  - ***Energy generation (G. Gebel)***
  - ***Polymer composites (V. Palermo)***
  - ***Coatings & foams (X.-L. Feng)***
  - Production (K. Teo)
- Division 5
  - External (N.N.)

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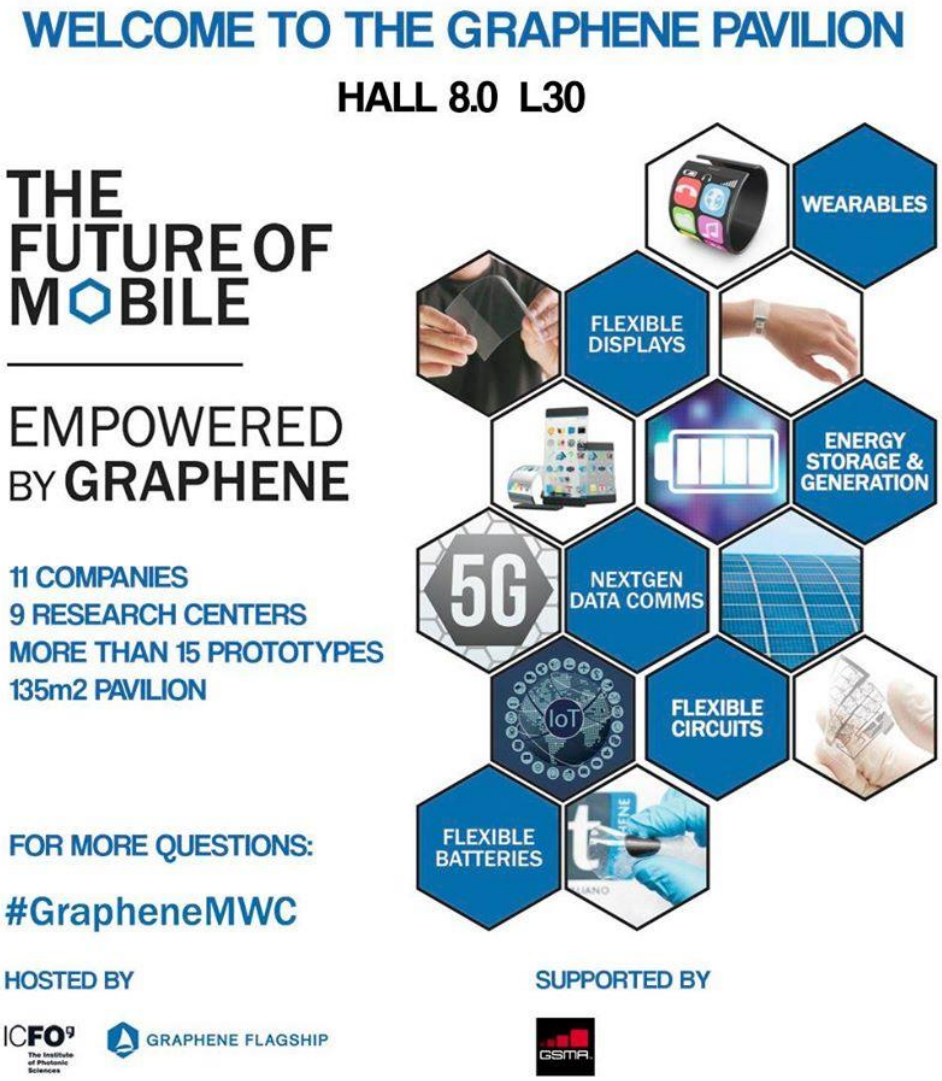
Estimated technology readiness levels

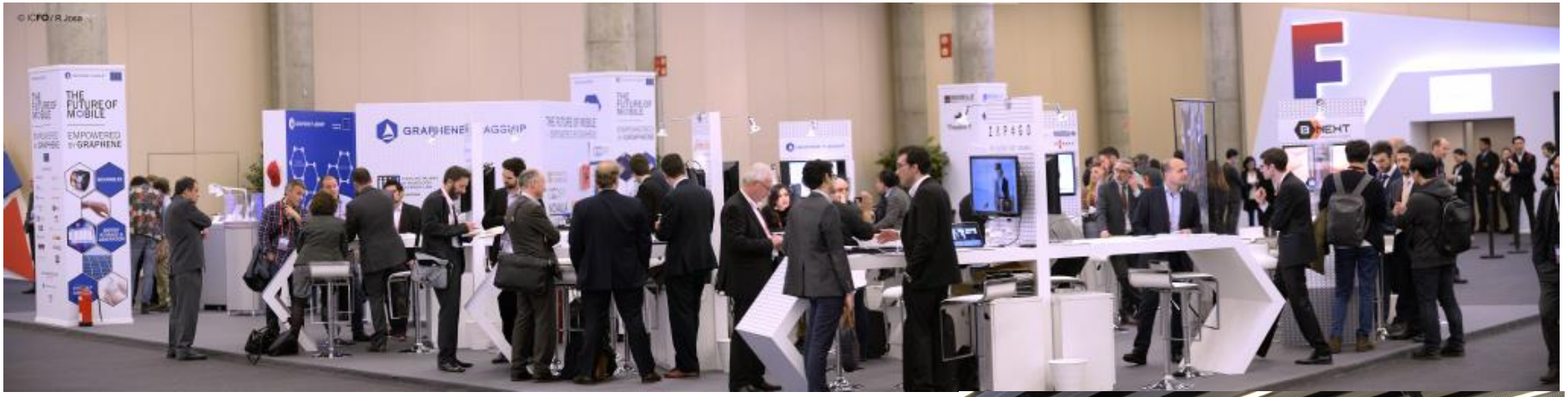
	Materials	Electronics	Optoel. & photonics	Sensors	Flexible	Energy	Composites & Membranes	Production
TRL 9							Sports equipment	Chemical exfoliation CVD
TRL 8								R2R CVD
TRL 7			Touch screen	Magnetic field	Packaging?			
TRL 6				Humidity, pressure		Supercaps, batteries		
TRL 5								
TRL 4		Freq. multiplier, amplifier			Flexible screen		Anti-corrosive coatings	Other LMs
TRL 3	Other LMs		Data transmission					
TRL 2								
TRL 1								

Emerging areas: nanofluidics, medical technologies

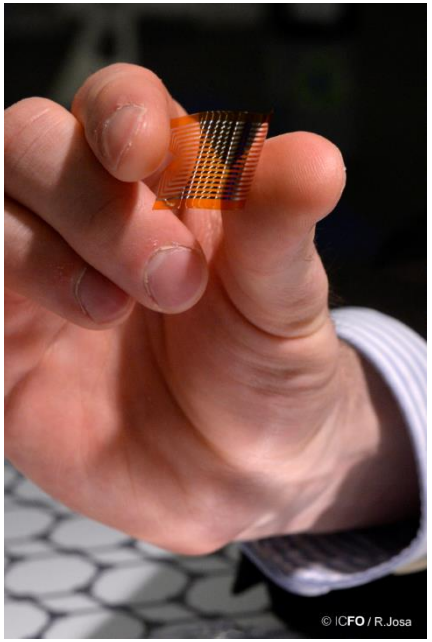
Highlights: Mobile World Congress

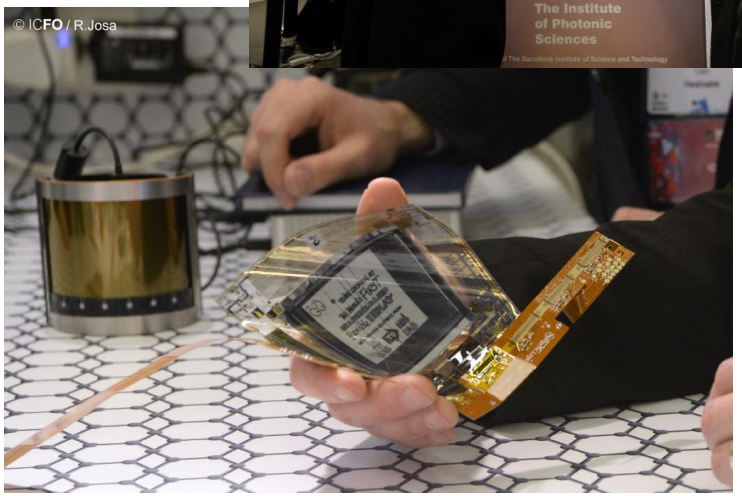
- A *very* large congress in Barcelona on Feb 27 – March 2. About 100,000 physical visitors, all major players (except Apple) were present
- Conference organizer GSMA invited us to showcase graphene, and sponsored us with about 290,000 € as 135 m^2 free exhibition space and a number of tickets
- Huge media attention! Visitors included EU commissioners, ministers, business leaders, celebrities,… - everyone





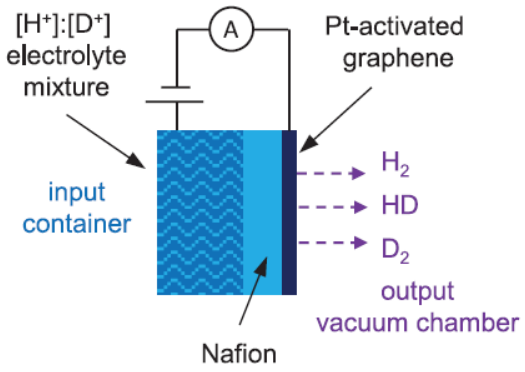
A few highlights: electronics, flexible demonstrators, biomedicine, coatings,…



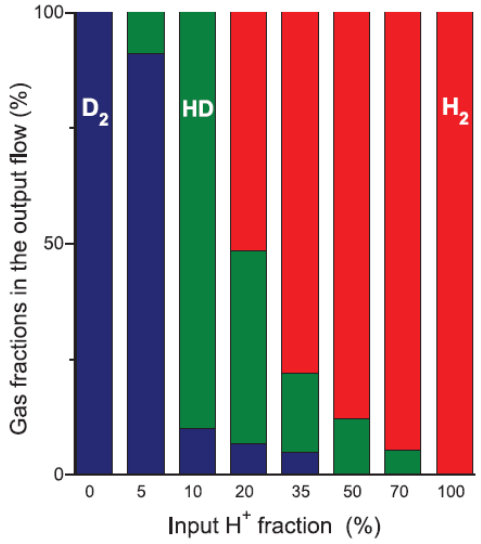


Other examples

- Graphene Study school on sensors, biomedicine and membranes in Les Houches in January (59 participants)
- Graphene Connect industrial workshop on biomedical technologies in Grenoble, February (40 participants)
- High-profile articles, *e.g.* A.K. Geim *et al*, Science on Jan 1, 2016 : isotope sieve



Ordinary hydrogen (H) and its heavier isotope, deuterium (D), can be separated by a graphene membrane.
Larger gas molecules can be separated by structured membranes: examples of nanofluidics.
Applications in, *e.g.*, energy production, climate control and biotechnology.



Some key performance indicators

Indicator	Target (M30)	Actual (M24)
Publications	329	606
Invited talks	149	608
Patent applications	38	22
PhD students and postdocs recruited	164	275
Enterprises using university facilities	29	77
Prototypes	7	17
Products on the market	8	16

International collaboration

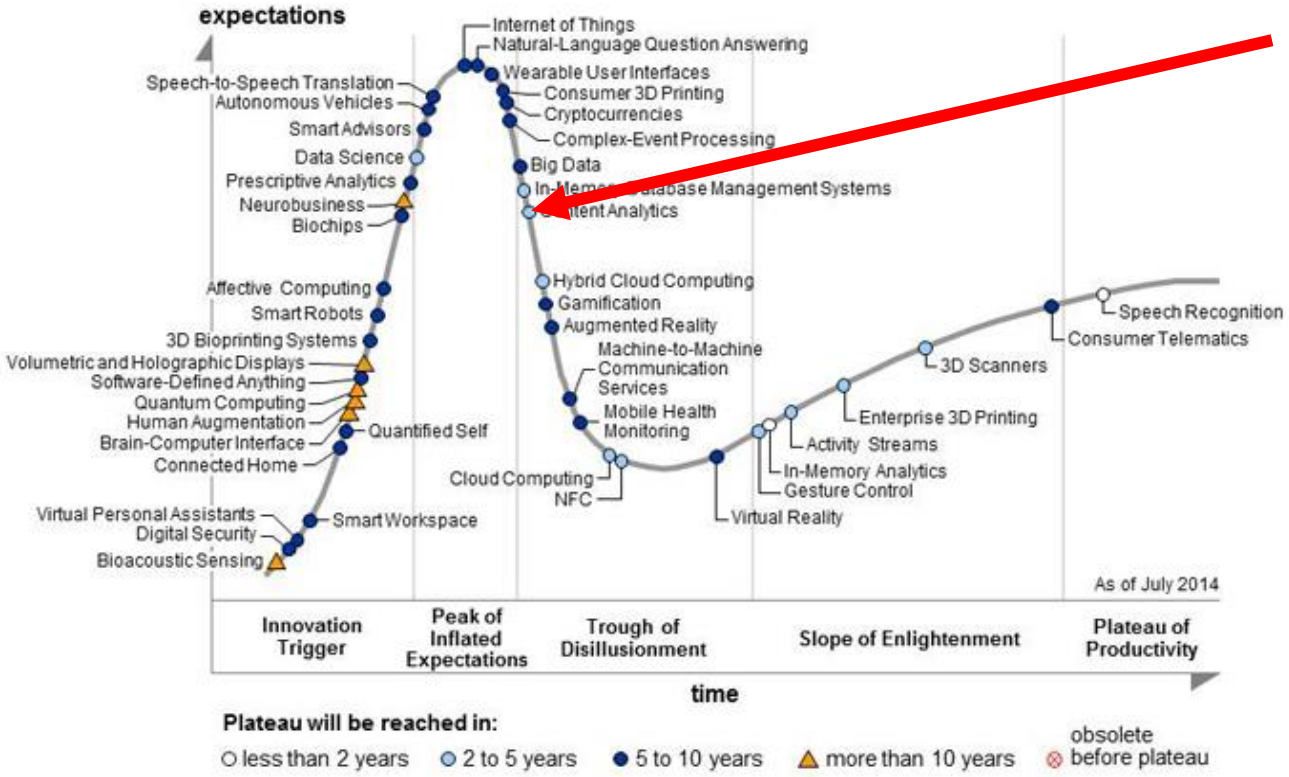
- International workshops in USA, Korea and Japan in 2015, to be followed by similar workshops in Copenhagen, Manchester and Barcelona in 2016.
- Mobility grant scheme with 5000 € support for young researchers' international visits, to be launched in April. A reciprocal scheme by the NSF (US) will be announced soon.

Associated members

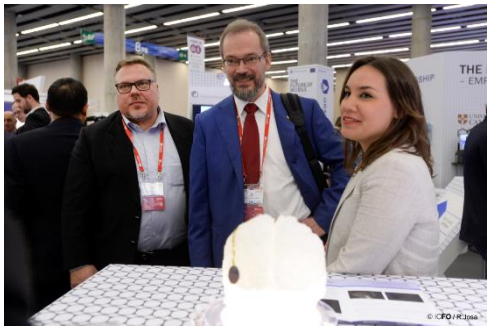
- Currently 44 AMs, one of which (ABB) becomes a partner in Core 1
- The AMs come from 17 countries. Largest number come from Germany (14)
- 6 AMs have joined as individual organizations, not through a larger project
- Of the 13 AMs that joined before the JTC1, 11 are companies
- Of the 30 AMs from the 13 PPs coming from the JTC1, 5 are companies
- We expect that a few more AMs will be approved in early April (mostly/only companies)
- List on the next page: **boldface** = company

AM	Country	Project
Netzsch Feinmahltechnik	Germany	Polygraph NMP
NetComposites	UK	Polygraph NMP
Imerys	Switzerland	Polygraph NMP
Leibniz Institute of Surface Modification	Germany	Gladiator NMP
SURAGUS GmbH	Germany	Gladiator NMP
Aristotle University of Thessaloniki	Greece	Gladiator NMP
Organic Electronic Technologies	Greece	Gladiator NMP
Nano-Carbon	Poland	-
Graphensic	Sweden	-
LEGO	Denmark	-
Bosch	Germany	-
TALGA Advanced Materials GmbH	Germany	-
NAWA Technologies	France	-
Autonomous University of Madrid	Spain	HiMagGraphene
Center for Energy Science (MTA EK MFA)	Hungary	GRIFONE
University of Duisburg-Essen	Germany	NU-TEGRAM
National Graduate School of Engineering & Research Center in Caen	France	NU-TEGRAM
University of Twente	Netherlands	NU-TEGRAM
Institute Ruđer Bošković	Croatia	NU-TEGRAM
Soleil Synchrotron	France	Sograph
TopGaN	Poland	GraNitE
Catholic University of Leuven	Belgium	2Dfun
Bilkent University	Turkey	2Dfun
University of Sassari	Italy	G-Immunom
Ankara University	Turkey	G-Immunom
University Hospital Cologne	Germany	G-Immunom
International Center of Biodynamics	Romania	Graphtivity
University of Ruhr Bochum	Germany	Graphtivity
Brains On-line	Netherlands	Graphtivity
Leibniz Institute for Polymer Research	Germany	GRMH2TANI
ONERA	France	GRMH2TANI
Brandenburg Technical University	Germany	GRMH2TANI
GLEXYZ	Portugal	GRMH2TANI
University of Konstanz	Germany	iSpinText
Budapest University of Technology and Economics	Hungary	iSpinText
Lund University	Sweden	TAILSPIN
Leibniz University of Hanover	Germany	TAILSPIN
University of the Basque Country	Spain	TRANS2DTM
University of Antwerp	Belgium	TRANS2DTM
Jacobs University of Bremen	Germany	TRANS2DTM
Polytechnic University of Catalonia	Spain	TUGRACO
University of Siegen	Germany	TUGRACO

Future considerations: disruptive technologies evolution



Technology is slowly maturing, and a shift towards higher TRL is evident in the composition and focus of the Graphene Flagship: more industrial partners, new WPs on biomedical technologies and system level integration, new Head of Innovation with industrial and entrepreneurial background (Dr Kari Hjelt).



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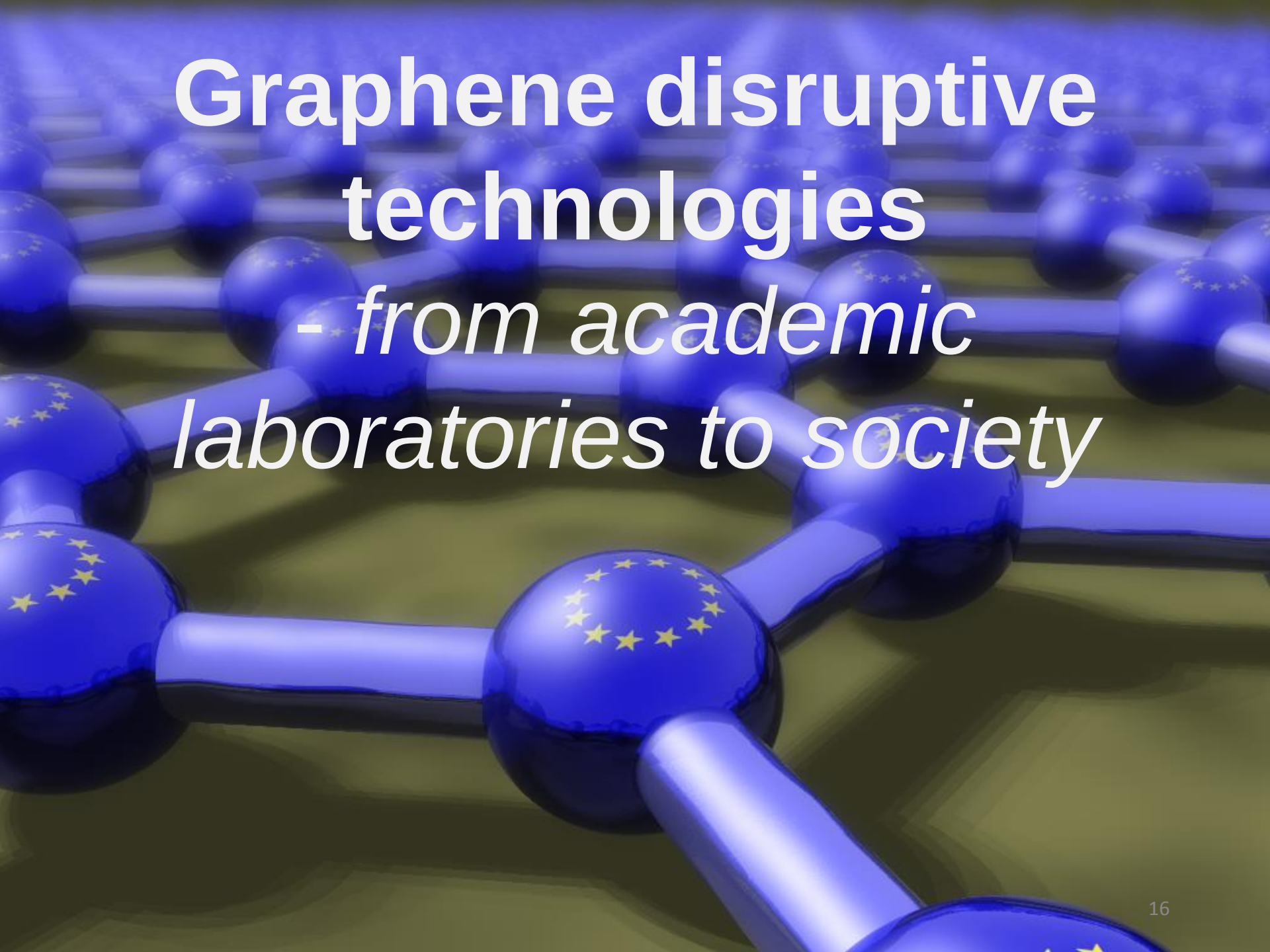
Considerations for Core Project *vs*. PPs

- Advantage/Need of a large, comprehensive project is unclear for projects that are on a very low technology readiness level (fundamental research):
  Very low TRLs are suitable for PPs
- Mutual competition may become problem in a large consortium for projects that are very close to market
  High TRLs are suitable for PPs
- Member state funding systems may be able to react faster than the core project (at least 18 month planning cycle, e.g. Nov. 2014 – April 2016):
  Emerging hot topics may be suitable for PPs
- Core projects are not exhaustive even in the topics they cover (e.g. sensors):
  Need collaboration with MS's and Core projects
- A comprehensive list of suggestions was produced at our Science and Technology Forum in November in Paris and communicated to FLAG-ERA


Graphene disruptive technologies
- from academic laboratories to society