



NEREID

ICT-CSA: Micro- and Nano-Electronics Technologies

Grant Agreement n° 685559

Francis Balestra (francis.balestra@grenoble-inp.fr)

Grenoble INP/CNRS, Coordinator of Nereid

European Industry Partnerships Collaborative Event

Amsterdam, April 17, 2019

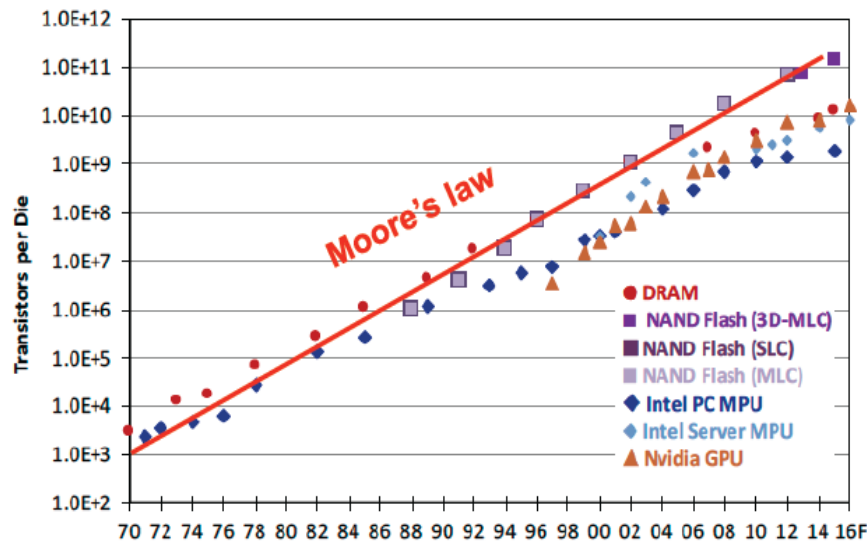
Title : *NanoElectronics Roadmap for
Europe: Identification and Dissemination*



European partnerships strategic directions & Research priorities in a global context

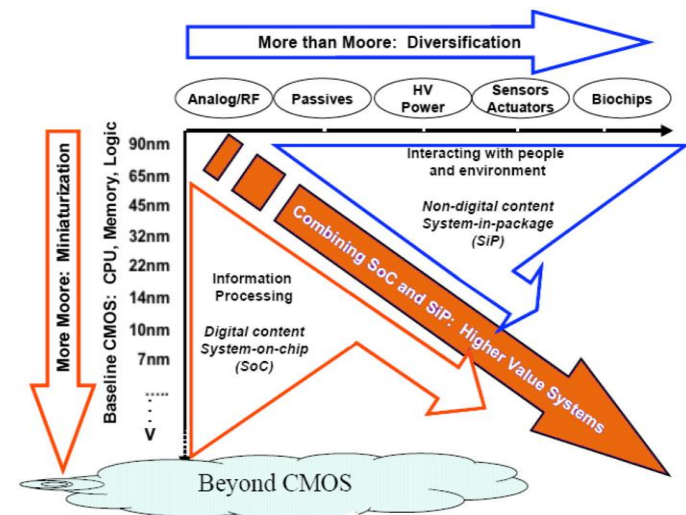
Change of paradigm at international level

From More Moore to ...



- From device density to ...
- From device cost driven to ...
- From single figure of merit to ...
- From Technology push to ...

More than Moore and heterogeneous integration



- ... functionality increase
- ... system cost driven
- ... multiple parameters
- ... Application pull
- ... full supply chain
- ... sustainability

A new roadmap for Europe

-Taking into account the specificity of the European industrial and academic landscape and European applications needs

-Used:

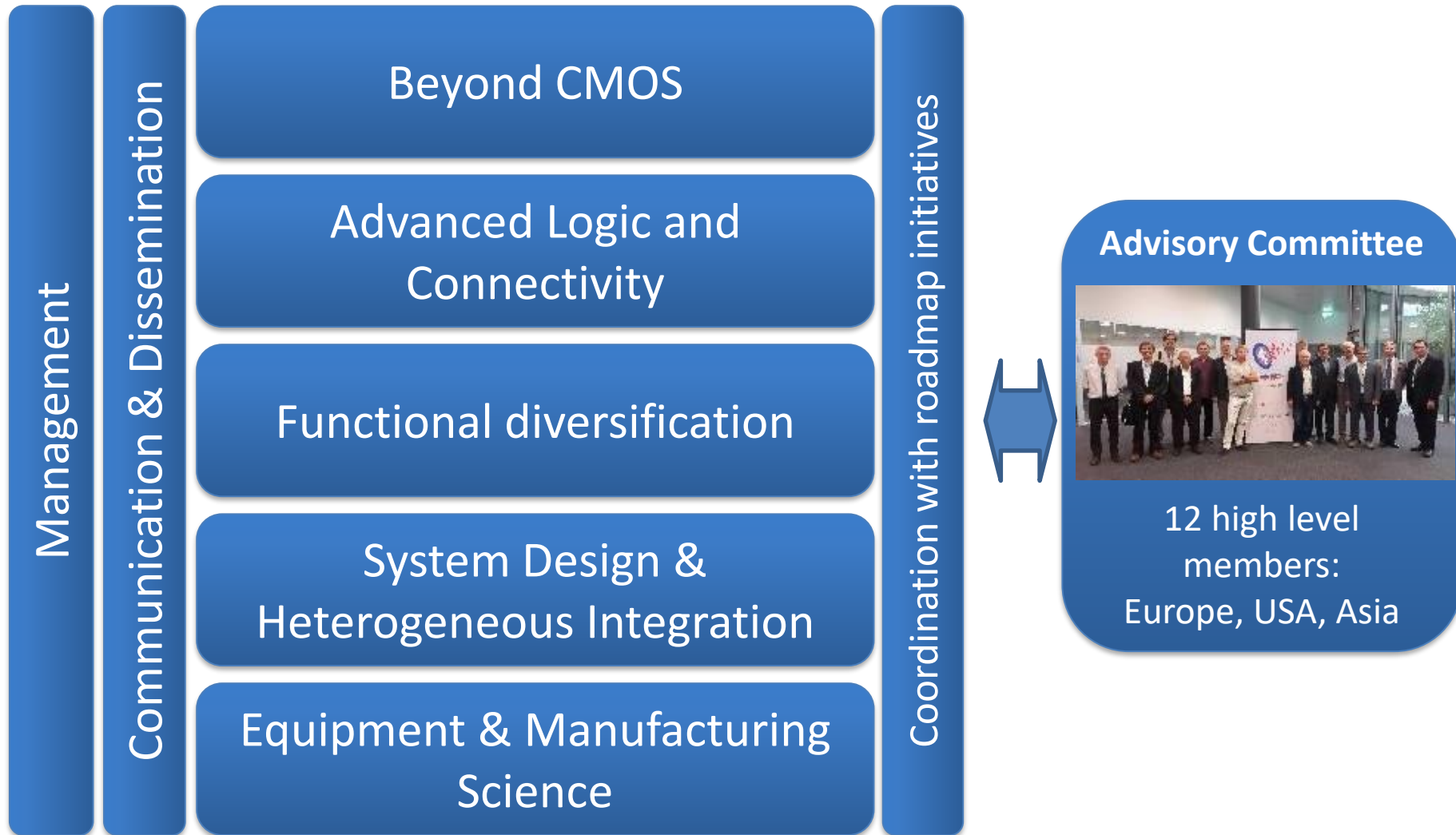
- as input for research programmes of European and national organizations
- to better coordinate academic and industrial research
- For equipment, semiconductors and application development.



NEREID Roadmap Flow



NEREID Structure & coordination with other regions

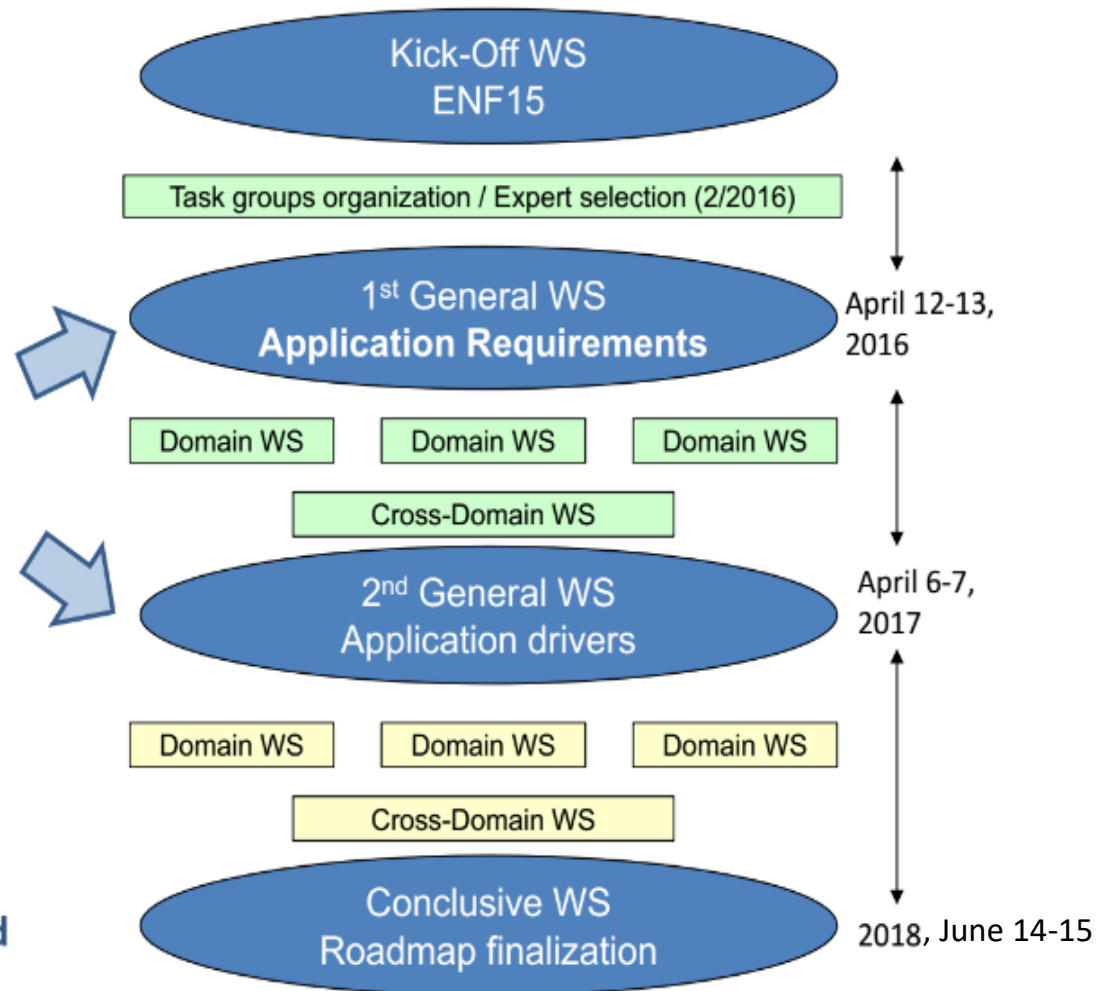


NEREID Roadmap Process

- From European application needs to specific technical workshops

• Automotive
• Medical
• Security
• Energy
• Industrial
• IoT
• Mobile convergence

- Large participation of (>100 !) experts (internal, external ; application, technology) from leading European academic and industrial institutions in Workshops



NEREID: Tasks and Topics



WP	Work Package	Tasks
1	Management (INP, SINANO)	1. 1 Administrative management (Grenoble INP)
		1.2 Technical Management (SINANO Institute)
2	Beyond CMOS (VTT)	2.1 Emerging devices (VTT)
		2.2 Computing paradigms (ICN2)
3	Advanced Logic & Connectivity (imec)	3.1 Nanoscale FET (G-INP)
		3.2 Connectivity (LETI)
4	Functional Diversification (LETI)	4.1 Smart sensor (EPFL)
		4.2 Smart Energy (IUNET)
5	System Design & Heter. Integr. (PoliTo)	5.1 System Design (PoliTo)
		5.2 Heterogeneous Integration (Tyndall)
6	Equipm. & Manufact. Science (FhG)	6.1 Equipment and Materials (imec)
		6.2 Manufacturing Science (FhG)
7	Communication & Dissemination (EDAcentrum)	7.1 Set-up of web node and comm. Tools (ECN)
		7.2 Planning of Dissemination events (ECN)
8	Coordination with roadmap initiatives (EPFL)	Advisory Board

NEREID: Industrial co-Leaders



WP	Description	Industrial co-leaders
WP1	Management	AENEAS
WP2	Beyond CMOS	IBM Zurich
WP3	Advanced Logic and Connectivity	STMicroelectronics
WP4	Functional diversification	Infineon (Smart Energy) NXP (Smart Sensors)
WP5	System Design & Heterogeneous Integration	Infineon
WP6	Equipment & Manufacturing Science	ASML & ASMI (Equipments) STMicroelectronics (Manufacturing)
WP7	Communication & Dissemination	AENEAS
WP8	Coordination with roadmap initiatives	

NEREID Roadmapping: 2 approaches



Top-down (GW):

Expected applications evolution vs time: Energy, Automotive, Medical/Life science, Security, IoT/Smart connected objects, Mobile convergence, Digital Manufacturing (Low power, ...)

Which function ?
Performance evolution vs time of generic function (e.g. Sensing, Computation, Communication, Energy management/harvesting) ?

Needed evolution vs time of different possible underlying technologies

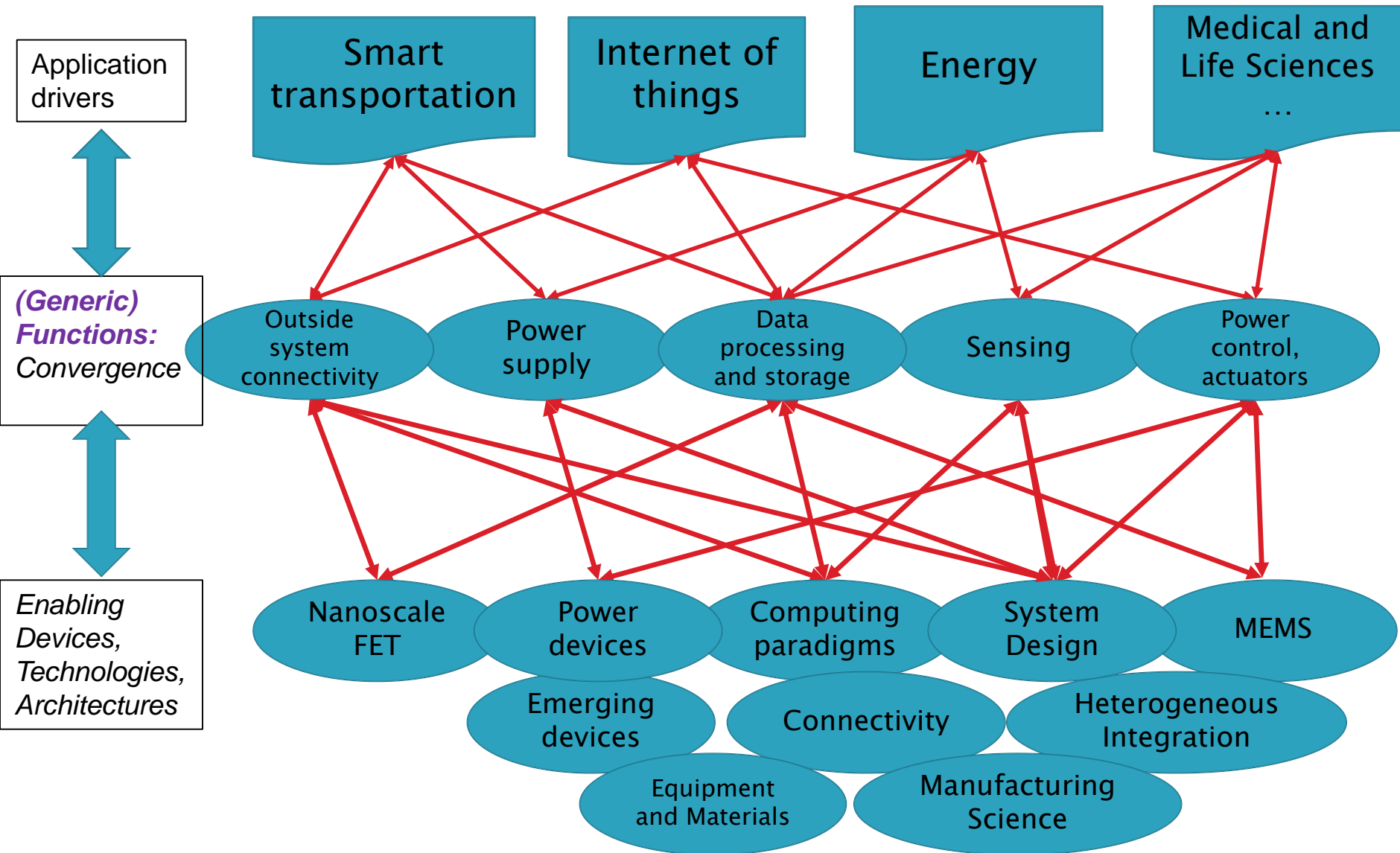
Bottom-up (DW):

Future Technologies availability vs time

Which technology can satisfy the required function performance for each application, including possible gaps: refinement of analysis

Additional ideas for future products and applications

Process Flow



Strategy for the Roadmap



Application requirements

Short term

Medium term:

Performance of function
or technology, or novel
functionality

Long term:

Performance of function
or technology, or novel
functionality

Convergence

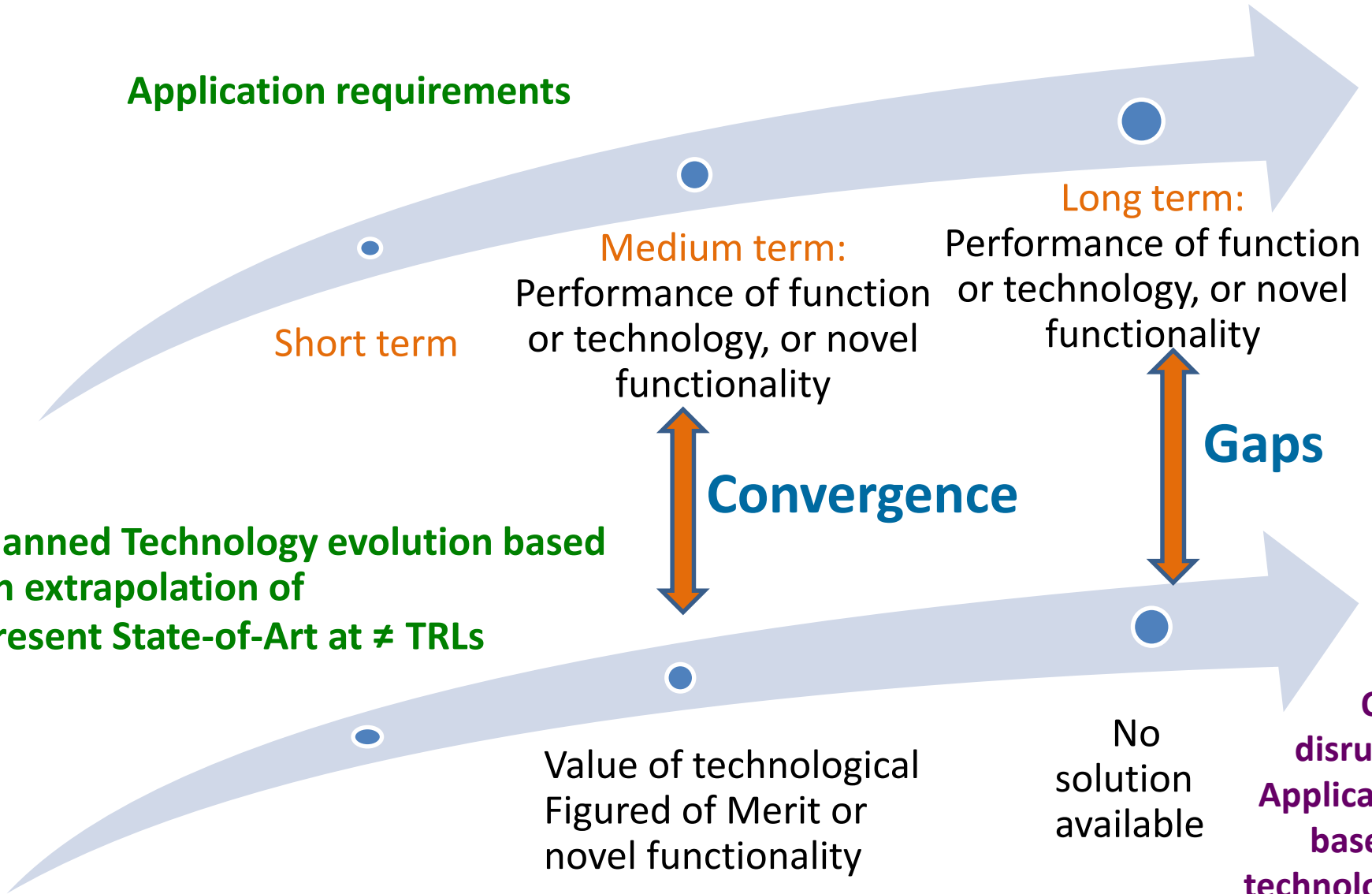
Gaps

Planned Technology evolution based
on extrapolation of
present State-of-Art at \neq TRLs

Value of technological
Figure of Merit or
novel functionality

No
solution
available

Other
disruptive
Applications
based on
technological
evolution



Roadmap

=> take into account recommendations of all Events...

- **Proposed structure of the final roadmap**
 - I. General Introduction (main objectives of NEREID roadmap)
 - II. Roadmapping Process
 - III. Application domains
 - IV. Interactions with other international activities
 - V. Workpackage chapters considering all tasks: WP2-6
 - VI. General recommendations
 - VII. General Conclusion



Roadmap (2)

- **V. WP Chapters:**

1. Executive summary

2. Relevance

- 2.1 Competitive value

- 2.2 Societal benefits

3. Vision (of the WP topic)

4. Scope and ambition (of the WP topic)

5. Main Concepts (*see next slide*)



Roadmap (3)

			Medium term: 5+	Long term: 10+
Concept n				
a) Key research questions or issues				
• XX				
b) Potential for application or Application needs and Impact for Europe				
• XX				
c) Technology and design challenges				
• XX				
	2023	2026	2029	2033
d) Definition of FoMs (quantitative or qualitative) or planned evolution (based on SoA @ 2017 and evolution vs time)				
• XX				
e) Other issues and challenges, and interaction with other Tasks/WPs.				
• XX				

5.n.1 Competitive situation (of concept n)

5.n.2 Recommendations (on Concept n)



Roadmap available at:



<https://www.nereid-h2020.eu/roadmap>

Dissemination, International collaboration

- **Dissemination, Communication:**

Web site, Press Release, Publications and Conferences/Workshops/Forums, Posters, Video, Leaflets, Newsletters, Presentation of the Roadmap at European and International events

- **International Collaboration:**

Advisory Board Meeting with US-Asia-Europe, Participation of NEREID representatives (all WP/Task Leaders) in **IRDS meetings** and **International Focus Teams** (1st IRDS Roadmap June 2018), Participation of **IRDS in NEREID Workshops**, **Sinano** is the European representative in IRDS, NEREID in charge of the **long term grand challenges of IRDS** and of some **Market Drivers** (Automotive & Medical), Participation in the IRDS **International Roadmap Committee + Overall Roadmap Technology & System Characteristics**



Next Steps

- **Activities relevant to be supported in the future:**
 - **Roadmapping project/Ecosystem analysis (R&D, RI, Training)/International collaboration** for the update and extension of the Roadmap (Horizon Europe, ...) very important for future applications, e.g. digital hardware and smart systems for IoT edge AI, Automotive, Security, Health, Industry 4.0
 - **R&D long term projects/programs** (e.g. Mission of 10 years, TRLs 1=>7) covering long, medium and short term activities (in series) involving Industry (driving short term projects), RTO (driving medium term), Academia (driving long term)
 - **3 levels of Research Infrastructures** driven by Academia (long term), RTOs (medium term) and Industry (short term)

A fruitful European and International
collaboration has been developed in
NEREID (2015-2018)

Thank you !

<https://www.nereid-h2020.eu/roadmap>

Contact : francis.balestra@grenoble-inp.fr

Panel Session 2: Industry-driven priorities

Key Enabling Technologies & Research Priorities

Francis Balestra (francis.balestra@grenoble-inp.fr)

Grenoble INP/CNRS, Coordinator of H2020 NEREID



Advanced Logic and Memories (NEREID TASK 3.1)

- Nanowires
- FinFET
- FD-SOI
- Negative Capacitance FET (NCFET)
- Carbon Nanotubes (CNTFET)
- Memories, Concept 1 - OxRAM:
- Memories, Concept 2 - CBRAM
- Memories, Concept 3 - PCM
- Memories, Concept 4 - MRAM
- 3D sequential integration
- Reliability, Characterization, Modelling

Connectivity (Wireline and Wireless) ***(NEREID TASK 3.2)***

- The Outdoor Wireless Applications
- The Outdoor Wireline Applications
- The Indoor Wireless Applications
- The Indoor Wireline Applications
- The Device to Device Wireless Applications
- The In Package/Device Photonics Wireline Applications

Smart Sensors (NEREID TASK 4.1)

Sensors for Automotive applications:

- Sensors for navigation and car's basic system performance
 - *Motion Sensors
 - *Pressure Sensors
- Advanced drive assistance systems (ADAS) for autonomous cars
 - *Images Devices
 - *Radar Sensor
- Pollution/Air quality monitoring based on gas sensors

Sensors for medical and healthcare applications:

- Physiological Signal Monitoring
- Implantable sensors: Bionics
- Molecular Diagnostics

Research Priorities (4)



Smart Energy (NEREID TASK 4.2)

- Si based power devices
- GaN-devices and substrates
- SiC-based substrates
- Alternative Wide Bandgap Semiconductors: AlN, Ga₂O₃, Diamond

Energy for Autonomous Systems (NEREID SubTASK 4.2.1)


- Mechanical EH: Electrostatic transduction
- Mechanical EH: Piezoelectric transduction
- Mechanical EH: Electromagnetic transduction
- Thermal energy harvesting
- Photovoltaic Energy Harvesting
- RF energy harvesting/wireless power transfer
- Energy storage - Microbatteries
- Energy storage - Microcapacitors
- Micro-Power Management

System Design and Heterogeneous Integration (NEREID Workpackage 5, WP5)

In this chapter, the main concepts are classified by connecting the three applications

- Automated Driving;
- Implantable Devices;
- Environmental Monitoring and Wearable Systems,

with different elements of Application-Aware Hardware-Software-Co-Design. These Elements comprise Functionalities, Implementation Qualities and Criticalities and Needs.

A solid purple vertical rectangular bar.

Equipment and Manufacturing Science (NEREID Workpackage 6, WP6)

- More Moore
- More-than-Moore
- Manufacturing Science

Beyond-CMOS – Emerging devices and Computing Paradigms (NEREID Workpackage 2, WP2)

- Steep slope switches: Tunnel FETs
- Neuromorphic circuits and computing
- Spintronics
- Quantum Photonics
- Phonon, Brownian and nano-opto-mechanical computing

A fruitful European and International
collaboration has been developed in
NEREID

Thank you !

<https://www.nereid-h2020.eu/roadmap>

Contact : francis.balestra@grenoble-inp.fr