



Labex



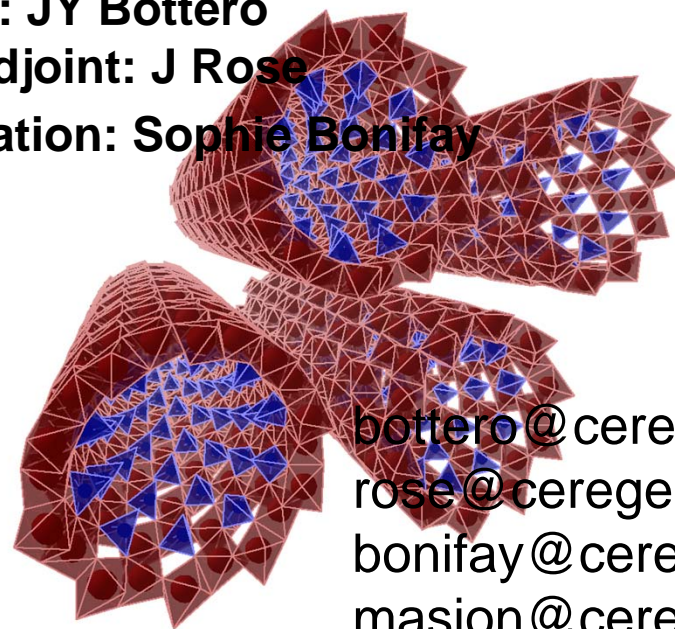
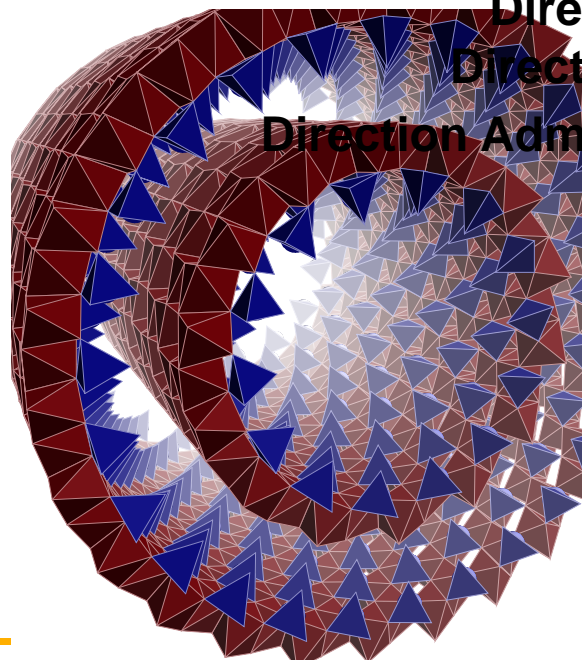
# ***Toward safer and eco-designed innovative nanomaterials***

***“The new generation of materials safer by design”***

**Directeur : JY Bottero**

**Directeur Adjoint: J Rose**

**Direction Administration: Sophie Bonifay**



[bottero@cerege.fr](mailto:bottero@cerege.fr)  
[rose@cerege.fr](mailto:rose@cerege.fr)  
[bonifay@cerege.fr](mailto:bonifay@cerege.fr)  
[masion@cerege.fr](mailto:masion@cerege.fr)



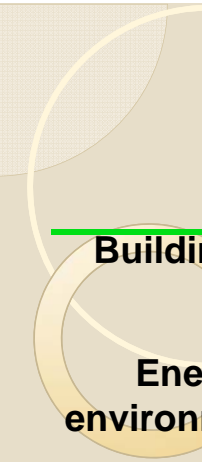

**Serenade**

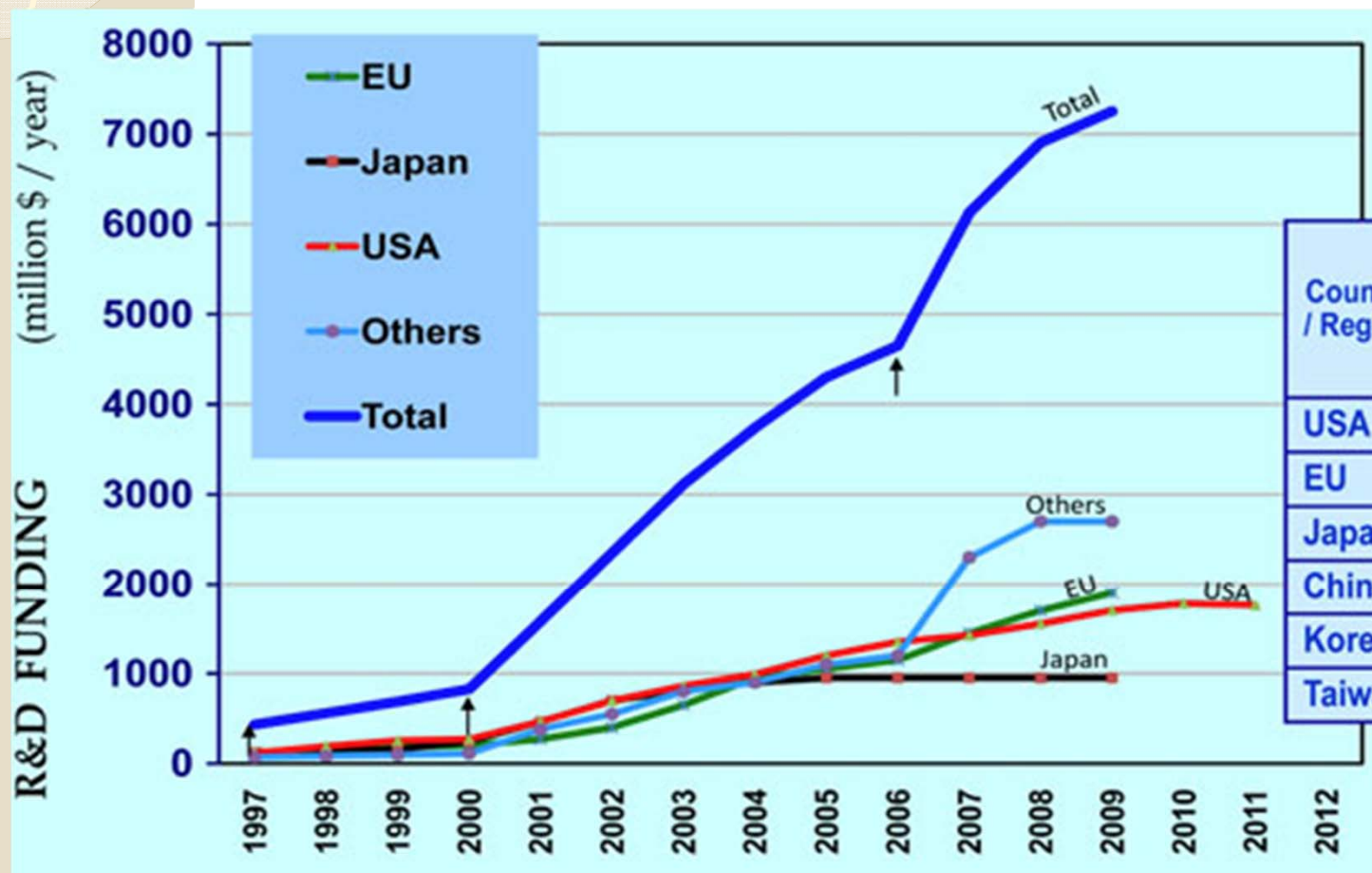
# Objectives :

- Design nanomaterials **safer for both human health and the environment** in order to promote the **sustainable and responsible development and competitiveness** of National SMES and companies involved in nanotechnologies.
- Implementation of **metrological tools** for occupational workers, population and environment media
- Implementation of technologies for the **end of life** of the products: recycling, waste management, water treatment,
- Develop a **new approach of the entrepreneurship** by integrating findings on marketing, communication or ethics, which are to day at the core of many nanotechnologies debates into a wider frame and shaping a sustainable market infrastructure for their innovations.



Context: Industrial sectors of nanomaterials and maturity relative to the market and indicating the products in current development (red line)

 <b>Building</b>  <b>Energy environnement</b>  <b>Textiles</b>  <b>Agro-industry-alimentation</b>  <b>Chemistry</b>  <b>Transporation</b>  <b>Electronic</b>  <b>Optic</b>  <div>  <b>Medicine</b> </div>				
	<b>Light and stable materials</b>	<b>OLED</b>	<b>Additifs anti-feu, isolants thermiques et sonores</b>	<b>Peinture anti-bactériennes, auto nettoyante</b>
	Photo-synthèse artificielle	Cellules photo-voltaïques	de grande surface	Revetements anti-corrosion, anti-usure
	Suivi des fonctions vitales.Soutien des mouvements actifs	Vêtements intégrant des dispositifs électroniques	Textiles super-isolant thermiques	Textiles anti-odeurs et salissures
	Label RFID indicateur de fraîcheur et sécurité des aliments	Emballages biodégradable et barrière	Plastiques anti-microbiens, indicateurs de pathogènes .....	Barrière au gaz pour les boissons gazeuses
	Matériaux auto-cicatrisants	NTC; Adhésifs réutilisables	Semi-conducteurs organiques. Puits quantiques	Noir de C; SiO <sub>2</sub> , CeO <sub>2</sub> , TiO <sub>2</sub>
	Vernis adaptatifs	Cellules photovoltaïques pour véhicules	Capteurs électromagnétiques	Revêtements anti réfléchissants, anti-buée. Injecteur. Renforts de pneumatiques
	Processeur ADN	Spintronique; Electronique moléculaire	Mémoire Ferro-électrique; Ecran à base de NTC	Disques durs magnéto résistance géante
	Processeur tout optique	Cryptographie quantique	Cristaux photoniques      OLED Microscope optique à résolution nm	LEDs blanches; Verres résistants à la rayure
	Ingénierie tissulaire. Reconnaissance précoce du cancer	Interface neuronale	Implants bio-compatibles; traitements cancer; Hyperthermie	Revêtements anti-bactériens; nano marqueurs; agents de contraste
	<b>10 to 15 years Concept</b>	<b>5-10 years Prototype</b>	<b>0- 5 years Ready for the market</b>	<b>Distribution</b>



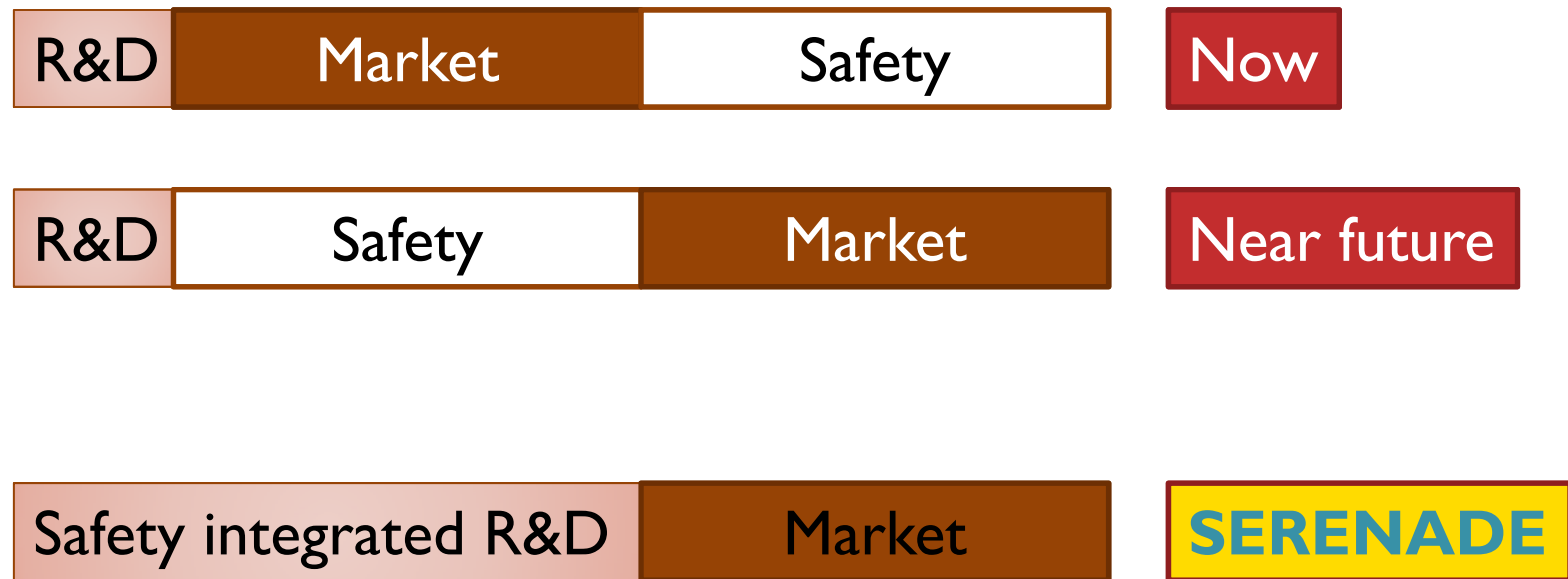
M Rocco J Nano Particle Res 2010



Serenade

# OECD Context

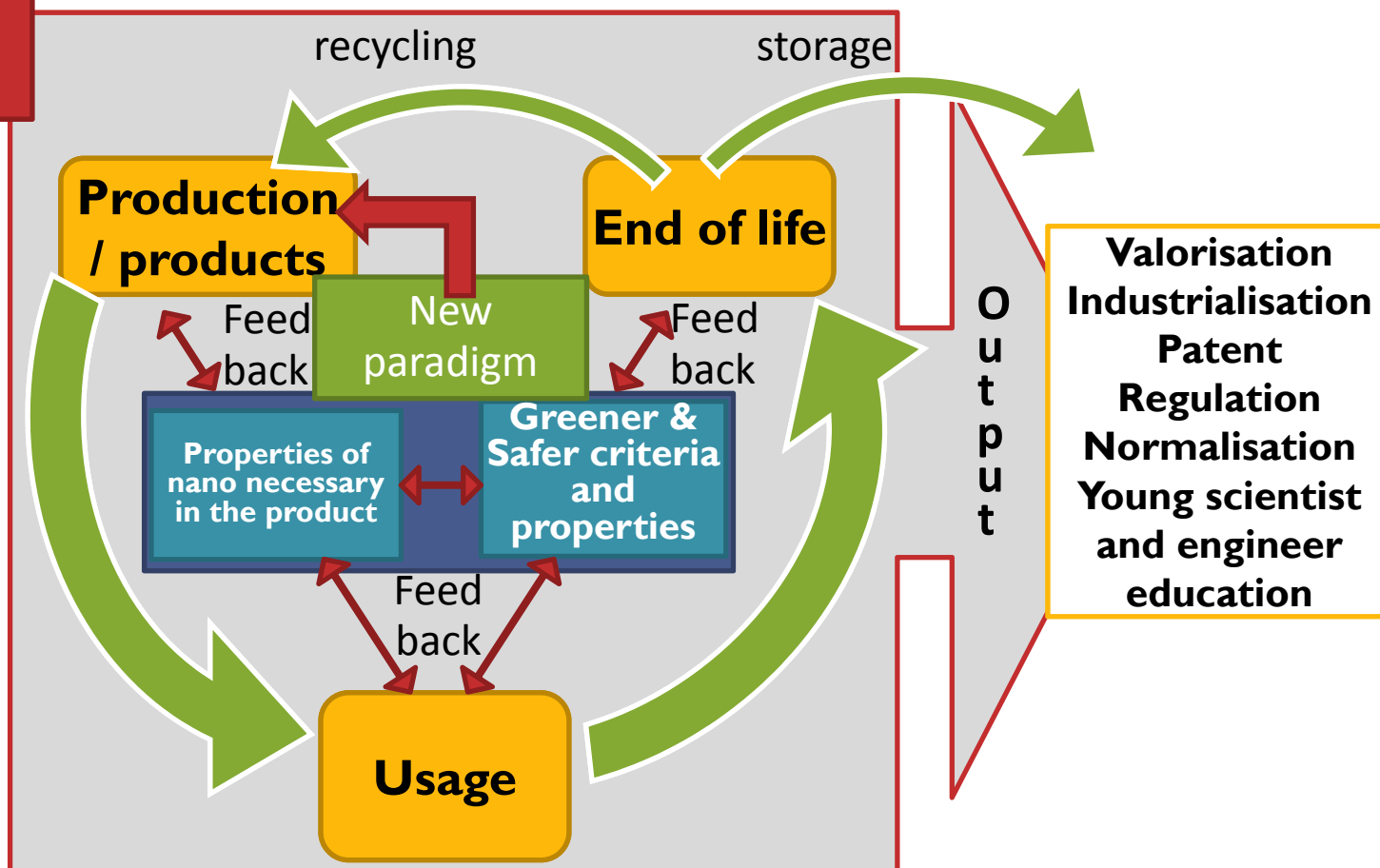
---





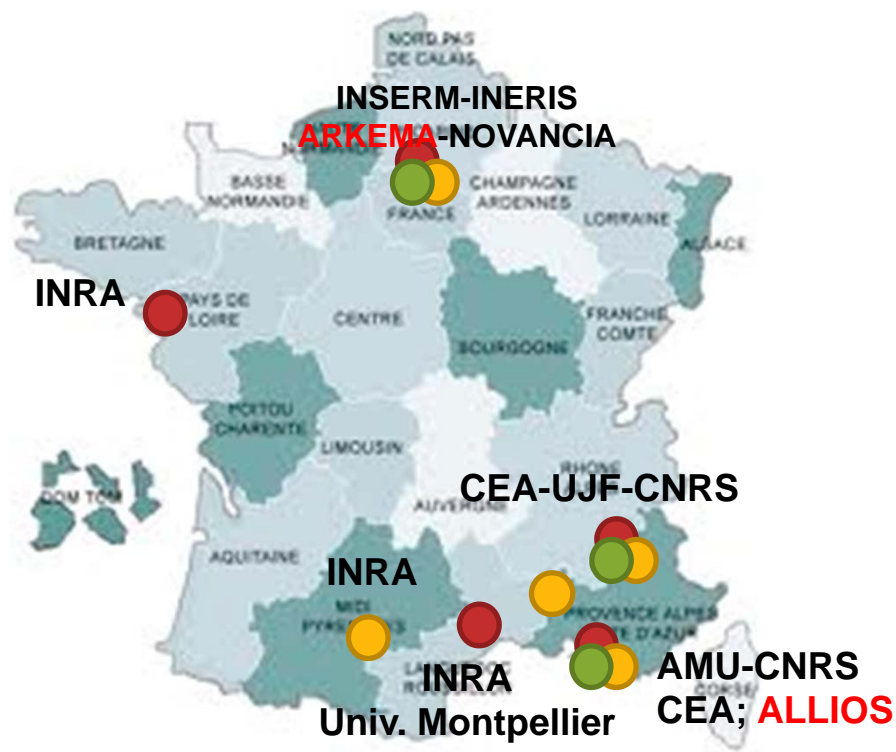
# Serenade Principles: Towards new generation of Nanomaterials; new concepts of synthesis

Nanomaterials life-cycle analysis





# Partners



- Synthesis, properties, modeling
- Ecotoxicity/toxicity
- Life cycle assessment

## Support letters:

Suez-Environment

Ital Cementi

Union des Industries de la Chimie

Danone

# INTERNATIONAL NETWORKING



## USA CEINT :

**Duke Univ., Univ. of  
Kentucky, Virginia Tech,  
Stanford Univ. Carnegie  
Melon**

## CANADA:

Univ. of Montreal



## EUROPE:

UK: IOM, Univ. Birmingham,  
SZ: EPFL, EAWAG, EMPA  
AT : Universität Wien



## AUSTRALIA

Univ. New South Wales

- Synthesis and properties
- Ecotoxicity/toxicity
- Life cycle assessment

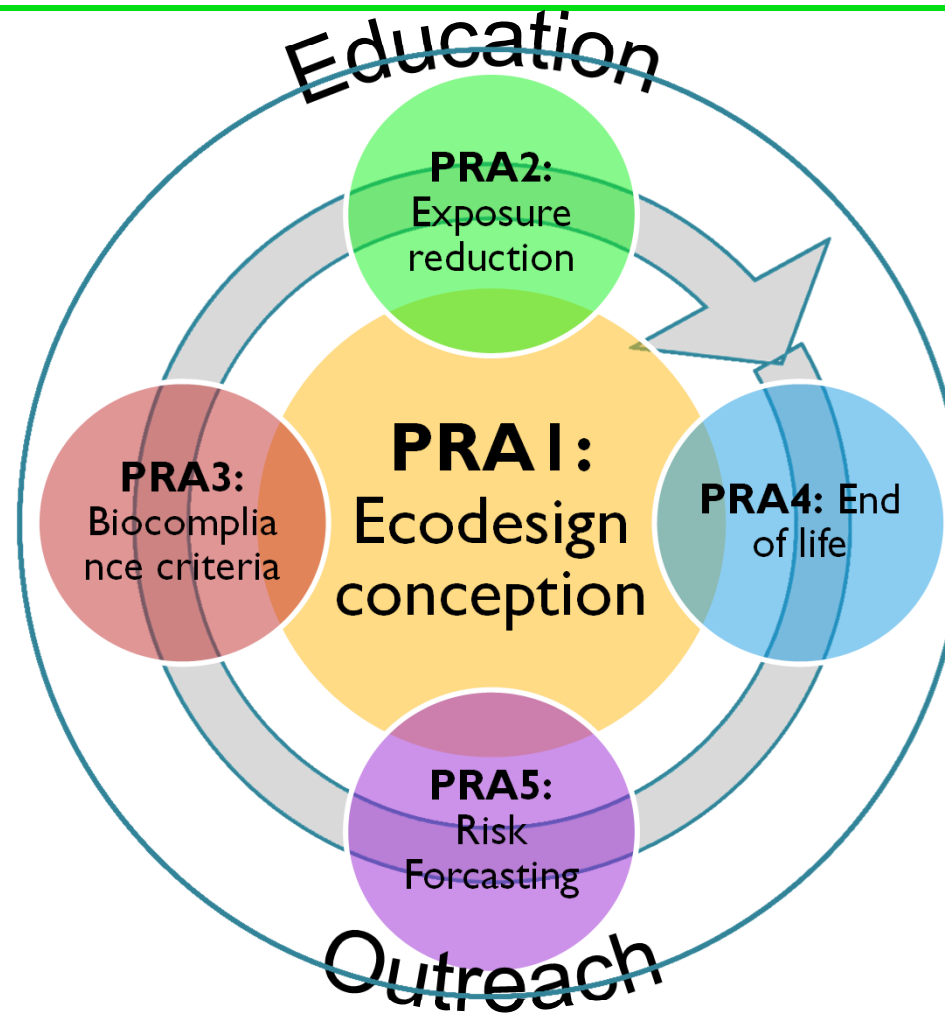


**Serenade**



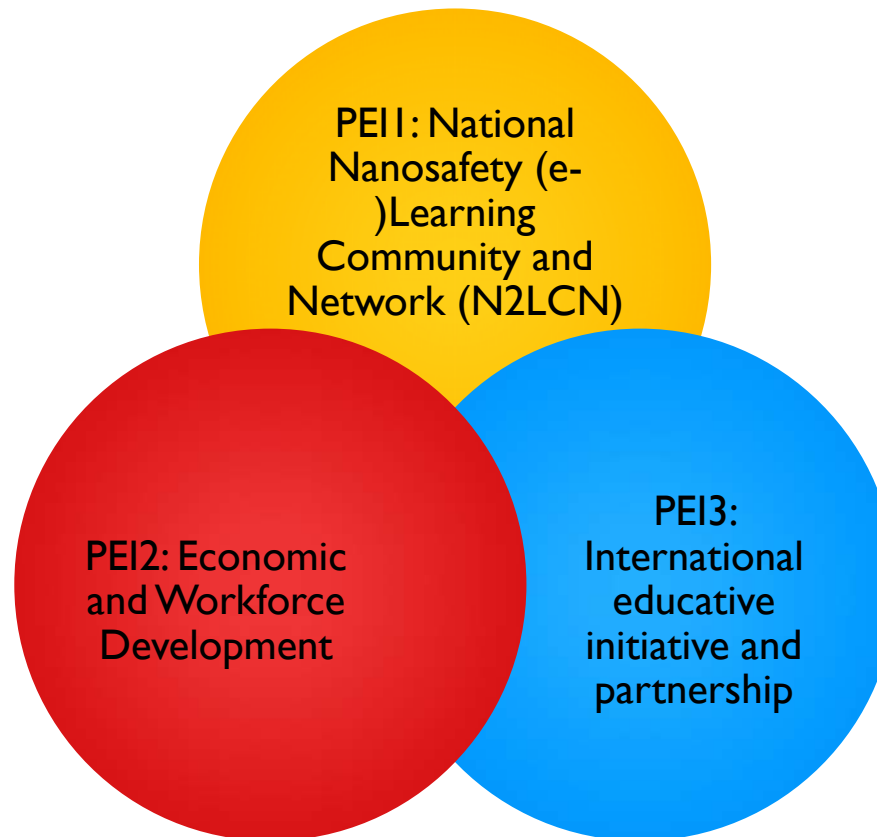
# Priority Research Actions initiatives (PRA) and Priority Educative Initiatives (PEI) necessary to fulfil the objectives:

---



# Priority Research Actions initiatives (PRA) and Priority Educative Initiatives (PEI) necessary to fulfill the objectives:

---



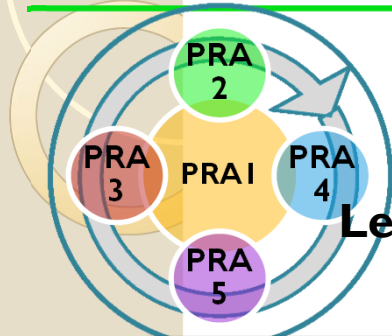
# Strengths of the project:

---

- **Development of an integrated approach**, including all aspects of the nanosafety issues (safe production, detection-characterisation, expology, toxicology, eco toxicology, surface reactivity, LCA, etc.) and with a strong and active participation of major industrials (ARKEMA, ALLIOS, “CALCIA, SUEZ, DANONE”).
- SERENADE takes directly **benefit** from
  - the nanosafety platform **Equipex NanoID** program for detection and characterisation of NMs in complex media
  - **other platforms** such as: NPs/NMs detection and characterization (ISA, IBISA BIIBS, MASSALYA), mesocosms (INERIS mesocosms, ROVALTAIN, iCEINT-mesocosms, IBISA GRAP), in vivo tox. (ANIMEX), exposure during life cycle (NanoBench, ARDEVIE).
- The project is organised around the **whole life cycle** of nano-products considering the actual nanomaterials characteristics.
- The project takes strongly into account Innovation management and sustainability strategies: **Management under conditions of uncertainty** (economic and health risk)



# Priority Research Actions initiatives (PRA)



**PRA1: Ecodesign conception and synthesis of nanoparticle enabled products**

**Leader: ARKEMA Contributors: ALLIOS, CEA, INERIS, INRA, NOVANCIA**

UV absorption (sunscreen, outdoor paint...), bactericide (surface treatment, food packaging), photocatalytic (self cleaning surfaces (cement, glasses, etc), etc)

Properties of nano necessary in the product

Greener & Safer criteria and properties

biodegradability, CO2 emission, etc)

•PRA 1-1). Synthesis of safe by design nanomaterials and nanoproducts.  
(Leader ARKEMA, partners :ALLIOS, INRA, CEA,CEREGE)

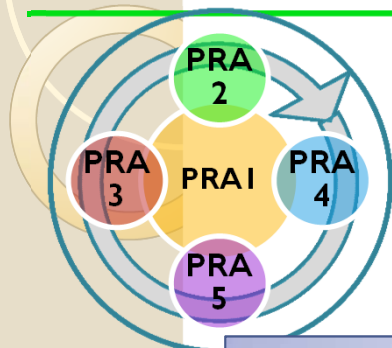
define general guidelines including sustainable criteria and taking into account the evolution of the materials within the whole life cycle.  
Starting from core properties of NM (size and aggregation state, surface functionalisation, chemical stability...

•PRA 1-2). Innovation management and sustainability strategies: Management under conditions of uncertainty  
(Leader: NOVANCIA: partners: INERIS, ARKEMA, ALLIOS)

build a methodology that

- i)Manages uncertainties both for benefits and risks of each application
- ii)Helps manufacturers in deciding, acting on their own responsibility, whether or not to put their product on the market, and
- iii)Ensures the traceability of data or actions undertaken to manage the uncertainties along the value chain.

# Priority Research Actions initiatives (PRA)



## PRA2: Exposure reduction throughout the life cycle

**Leader: CEA**

**Contributors: CEREGE, INERIS, LCE, BIA, IATE...**

•PRA 2.1. Exposure at the workplace  
**(Leader CEA partner:  
INERIS, LCE)**

Safer production lines : modelling  
Secured pilot platform : Grenoble  
Nanosafety platform  
Worker exposure measurement

•PRA 2.2 Limitation of  
nanomaterial release from  
nanoproducts throughout the  
life cycle

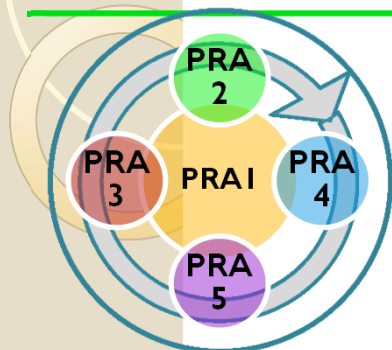
**Leader CEREGE Partners:  
CEA, INERIS**

Aging procedure based on realistic  
scenario (ARDEVIE Center,  
mesocosms, ...)



**Serenade**

# Priority Research Actions initiatives (PRA)



## PRA3: Biocompliance criteria

**Leader:** *INSERM*  
*INRA, UJF, IMBE, LCE*

**Contributors:** *CEA, CEREGE, IBEB, INERIS,*

•PRA 3-1) Modeling surface  
bio-reactivity (ab initio  
calculations)  
leader: ISTERRE; partners: CEA, INERIS

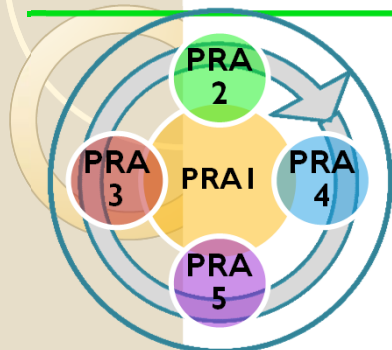
•PRA 3-2) Biodistribution of  
NMs in animals and mesocosms  
leader CEA partners: INERIS, TOXALIM,  
CEREGE, LCE, IBEB, IMEP, LBME

•PRA 3-3) Toxicity and  
ecotoxicity, fate and  
bioaccessibility  
leader: INSERM-INERIS, partners:  
LBME, TOXALIM, IMEP, IBEB, CEREGE

•PRA 3-4) Ecosystemic effects  
and tools for a life cycle  
approach  
Leader: CEREGE, partners : IBEB, IMBE,  
INERIS



# Priority Research Actions initiatives (PRA)



**PRA4: End of life of the nanoproducts**

**Leader: *INERIS***

**Contributors: *CEREGE, INRA, CEA***

Recycling

Treatment

Disposal

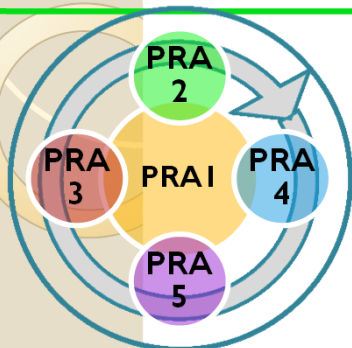
Energy valorisation, NM recovery, CO<sub>2</sub> & energetic balance...

Special focus on waste  
water, Bio-sludges, and  
Incineration  
(predominant sink)



**Serenade**

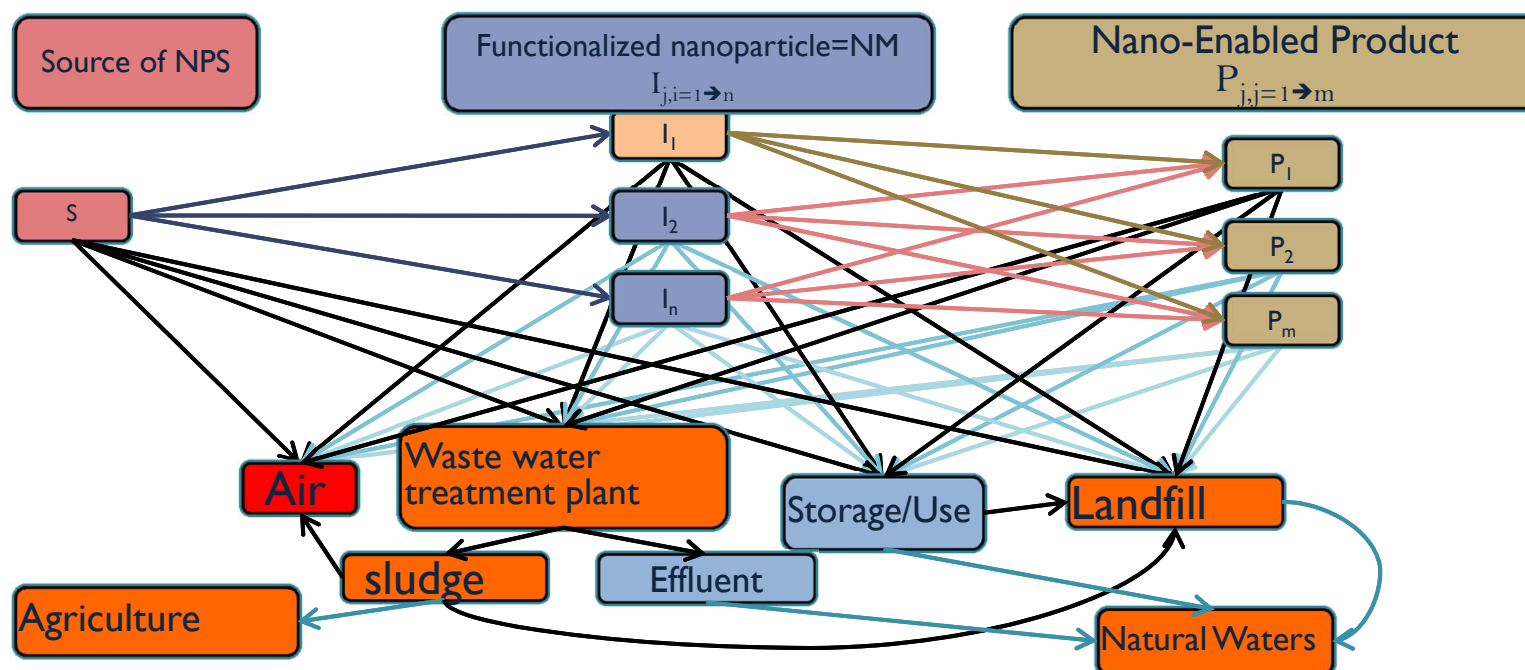
# Priority Research Actions initiatives (PRA)



**PRA5:** Risk forecasting modeling throughout Life Cycle Analysis

**Leader:** *CEREGE* **Contributors:** *INERIS, ARKEMA, ALLIOS...*

Develop a predictive risk model based on the life cycle from the production to the end of life and allowing an updating as new information are obtained



# Priority Education Initiatives (PEI)

## PEI: Development of the National Nanosafety (e-)Learning Community and Network (N2LCN)

Leaders: UJF, UM2, AMU, Univ Paris Est, NOVANCIA, partners: CEA, INERIS.

The aim is to develop a National Nanosafety (e-)Learning Community and Network (N<sup>2</sup>LCN)

Convergence of master degrees in many fields

**viz. material engineering ,  
environment engineering, risk  
manager, public health, TES,  
entrepreneurship**

Development of common and  
standardized educative  
materials

training materials

e-learning resources

use of state-of-the-art  
infrastructure and facilities

specific national master in  
'Nanosafety and safer design of  
nanomaterials'

# Priority Education Initiatives (PEI)

---

## PEI2: Economic and Workforce Development:

**Leader: Novancia Partners:** *AMU, CEA, INERIS, INSTN.*

marketing of nano-based products,

Specialists Master's Safe-by-design innovation and Business Development (Advancia)

continuous training (specialist's master degree),

INSTN :continuous training of workforce with a special focus on nanosafety issues.

Skills certification of “nano” workforce.

INERIS : Nano-CERT. voluntary skill certifications of nano-workforce

# Priority Education Initiatives (PEI)

## PEI3: International educative initiative and partnership

### Nano-TRAIN:

to provide Master and PhD students, as well as early post-doctoral fellows with an overview of current state-of-the-art in nanotechnologies development, eco-design, industrial ecology, nanoparticles interactions with the biosphere as well as more specific knowledge on nanoparticles properties and characterization

European summer school:  
International Schools on  
Nanocarbons

iCEINT GDRI:  
Research Experience for  
Undergraduate Program (CEINT –  
CEREGE), ...

Erasmus Mundus Action 2-STRAND2 program  
(=Partnerships with countries and territories covered  
by the industrialized Countries Instrument (ICI)

# Gouvernance

