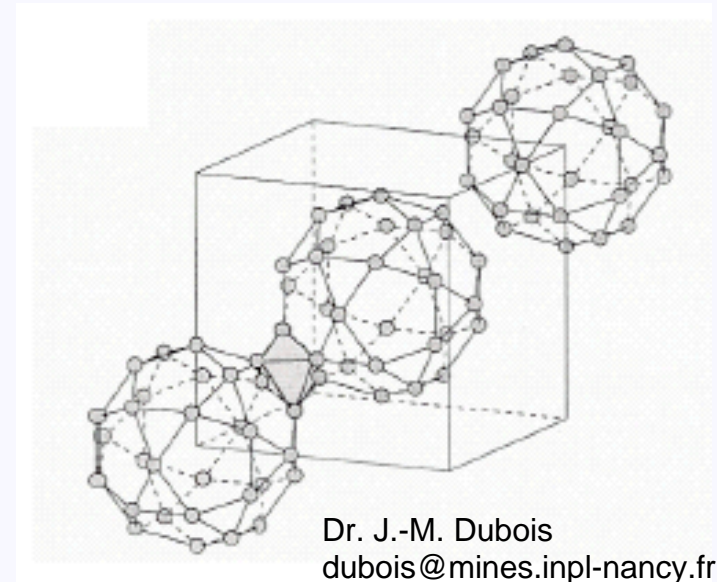

CMA Complex Metallic Alloys

The route to industrial applications

Complex Metallic Alloys: New metallic materials!

Today: Metals-based industries today rely largely on materials based on elementary metals and binary metallic alloys to which a number of additional elements are added in smaller quantities to tailor them for particular properties.

CMAs: Complex metallic alloys are formed with crystal structures based on giant unit cells containing many tens, up to more than a thousand atoms per cell. As a result, these materials can offer unique combinations of properties, which are excluded in conventional materials.



CMA's potential properties

(Intrinsic and extrinsic)

Surface properties

- ✓ Wetting (hydrophobic)
- ✓ Oxidation resistant
- ✓ Corrosion resistant
- ✓ Low friction (vacuum)
- ✓ Cold-welding reduction (in vacuum)
- ✓ Low adhesion to metals (in vacuum)
- ✓ High hardness
- ✓ Textures (nanoscale)

Energy properties

- ✓ Adjustable thermal conductivity
- ✓ Adjustable electrical conductivity
- ✓ Adjustable Seebeck coefficient
- ✓ Enhanced hydrogen storage capacity
- ✓ Good infrared light absorption and high temperature stability for heat-conversion

Other properties

- ✓ Mechanical properties
 - Strengths
 - Elasticity
 - Hardness
- ✓ Temperature stability
- ✓ Optical properties
- ✓ Magnetic properties
- ✓ Nano size grains

CMA materials with unique *combinations* of functional properties

- ✓ Substantial electric conductivity combined with low thermal conductivity
- ✓ Combination of good infra-red light absorption properties with high-temperature stability
- ✓ Combination of high hardness with reduced solid-solid adhesion and wetting by polar liquids

- ✓ Electrical and thermal resistance tuneable by composition variation
- ✓ Heat-insulation properties can be obtained under suitable conditions
- ✓ Excellent high-temperature performance and low corrosion sensitivity have been shown
- ✓ Attractive thermoelectric properties
- ✓ High absorption of hydrogen (Ti-based CMAs)

CMA's potential application

Energy applications

- ✓ Heat insulations
- ✓ Thermoelectric applications
- ✓ Hydrogen storage

Coating applications

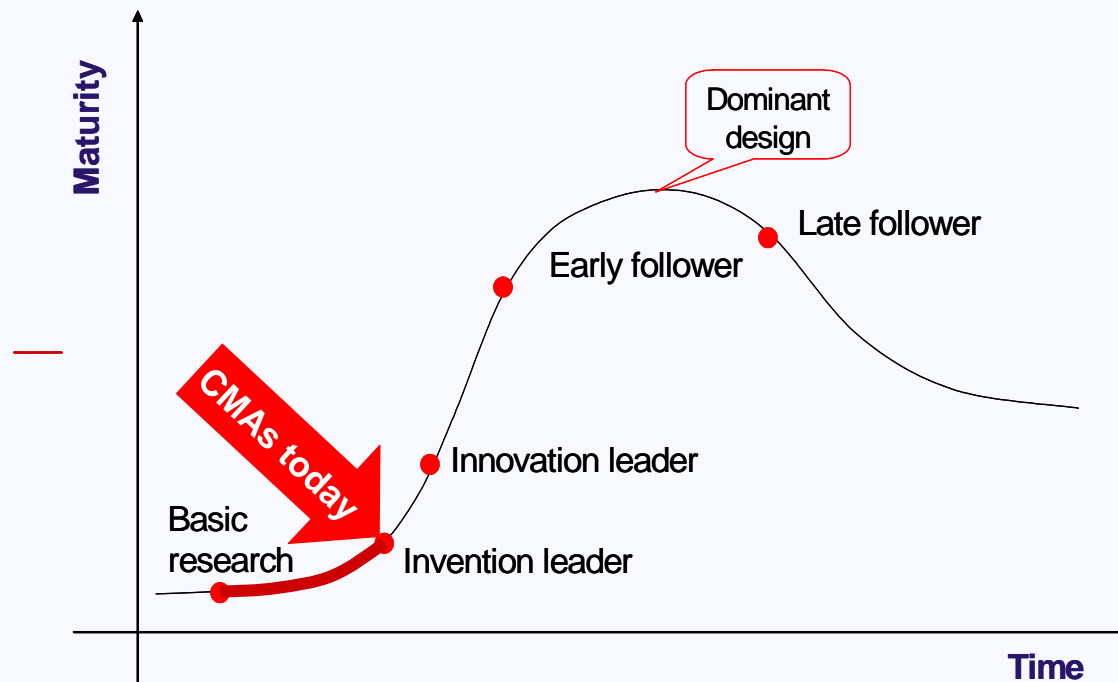
- ✓ Tribological applications
- ✓ Cold welding reduction
- ✓ Abrasion reduction
- ✓ Wetting adaptation
- ✓ Corrosion protection
- ✓ Nanostructured materials

Other applications

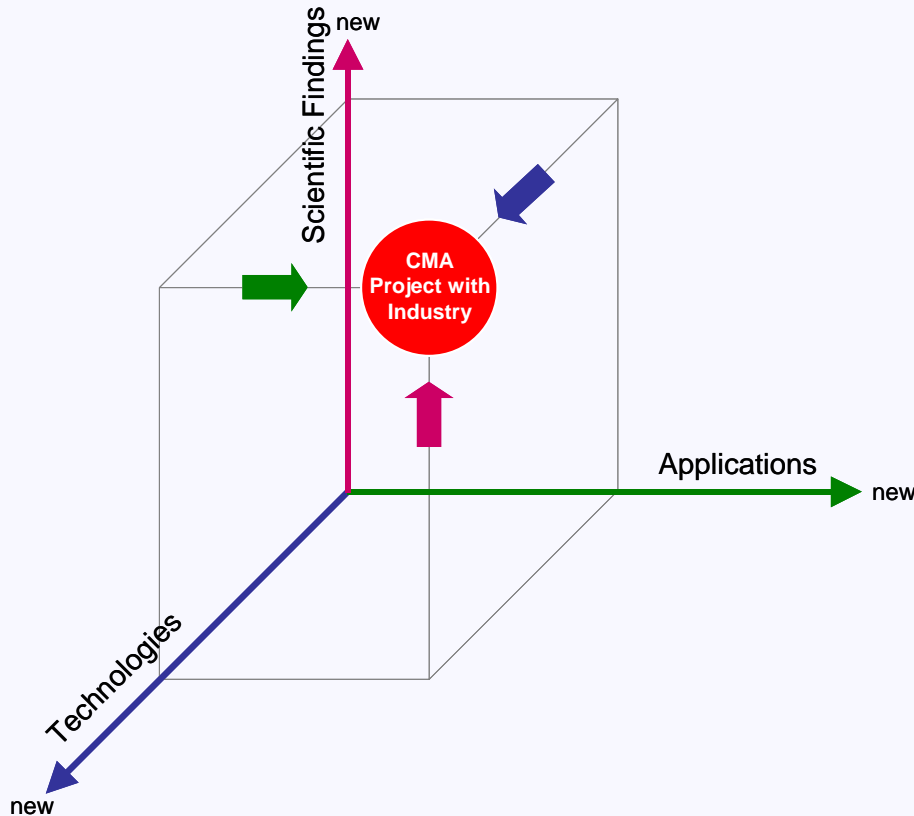
- ✓ Applications where high temperature stability is required
- ✓ Metallic and polymer-based materials reinforced by precipitates or dispersions of nanoparticles of the CMA family.
- ✓ Catalysis
- ✓ Magnetic applications
- ✓ Optical applications

Maturity of CMA applications

- ✓ Industry has the opportunity to collaborate at an early stage with outstanding experts on mid and long term requirements



How to collaborate

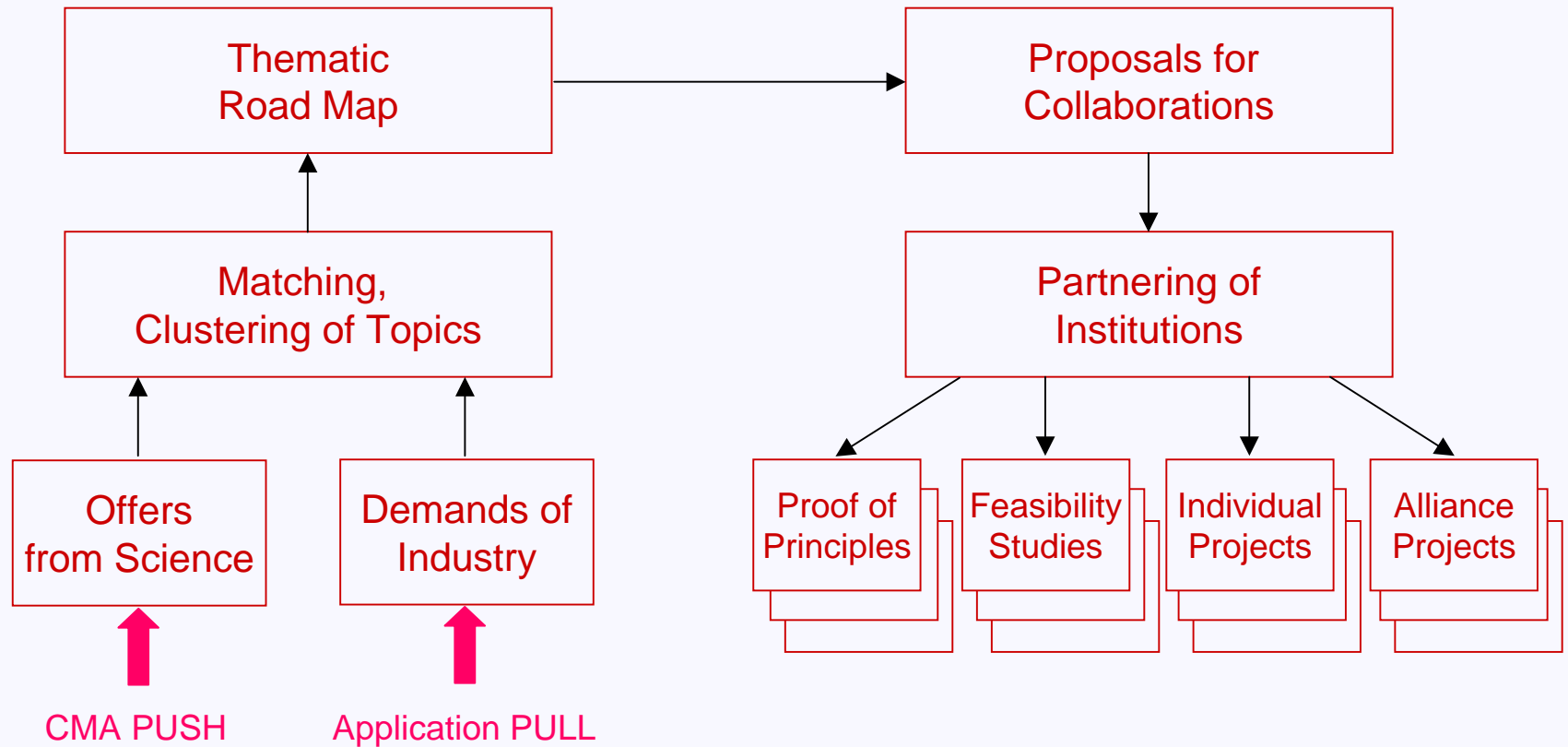


Common projects Science-Industry:

- ✓ Analytics of complex problems where CMA-knowledge and applications may have a high potential
- ✓ Specification of mid and long term requirements, definition of strategies to reach common objectives
- ✓ Proof of principles
- ✓ Feasibility studies
- ✓ Strategic Projects

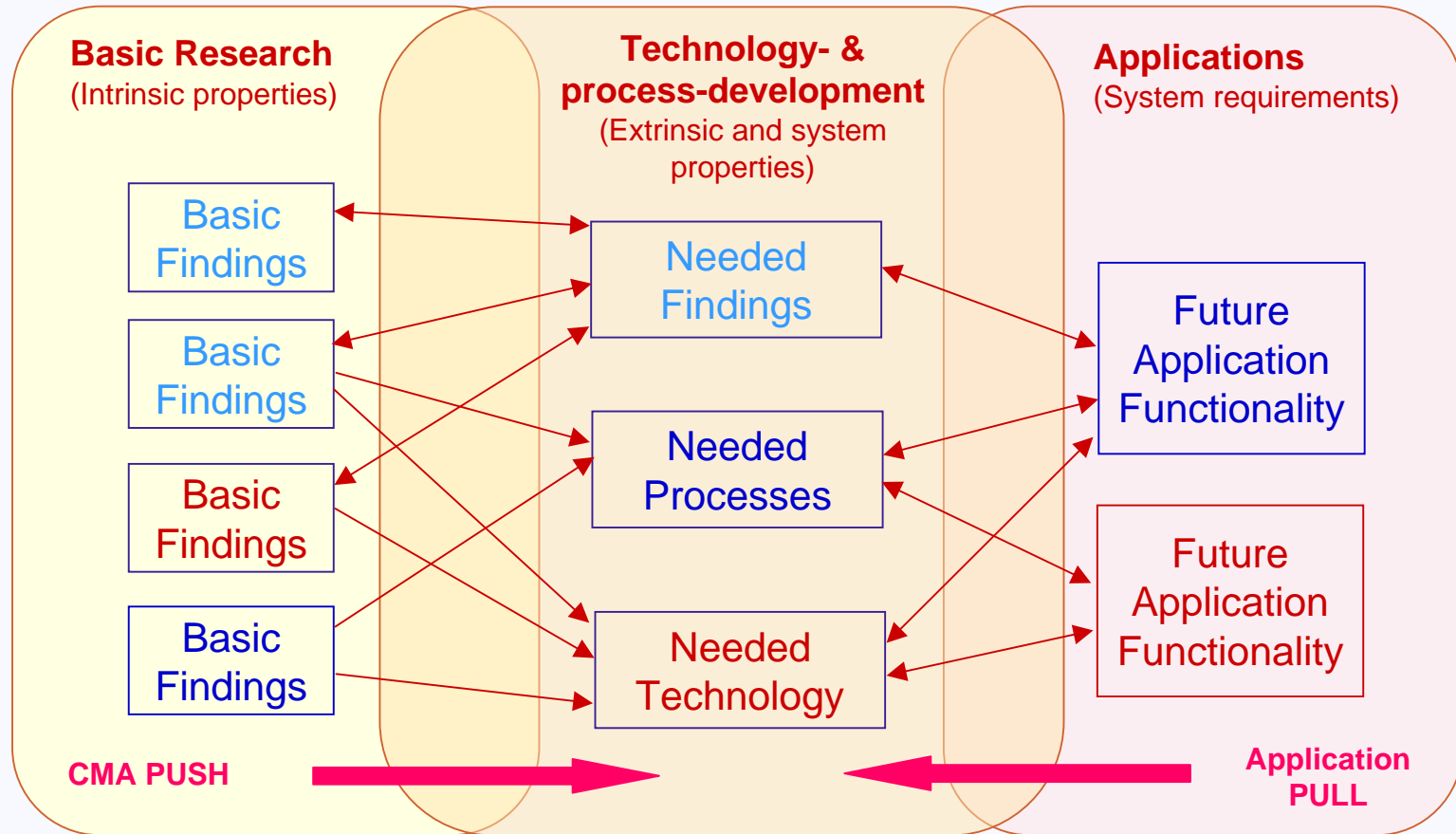
CMA Innovation process

CMA the Road to Collaborations



Road Map

Outline of CMA Thematic Road Maps



First steps towards a collaboration *Industry - NoE CMA*

Enterprises

- ✓ Identify actual and future needs of future functionalities (mechanical, electrical and thermal properties of surfaces and bulk materials)
- ✓ Identify lack of knowledge (complex problems) where CMA-knowledge may have a high potential for solutions.
- ✓ Identify requirements for continuing education

CMA, Network of Excellence

- ✓ Provide strategic consultancy and road maps for solutions
- ✓ Provide analytical support to industry
- ✓ Offer training and education to industry

Second steps of a collaboration *Industry - NoE CMA*

Enterprises

- ✓ Partnership with NoE to convert the Road Map into action:
 - Proof of principles
 - Feasibility studies
 - Individual projects
 - Alliance projects

- ✓ .. (add topic)

CMA, Network of Excellence

- ✓ Partnership with Industry to convert the Road Map into action:
 - Proof of principles
 - Feasibility studies
 - Individual projects
 - Alliance projects

- ✓ ..(add services related to topic)

Innovation means seeing
what everybody sees and anticipating
what no one has anticipated



Thank you for your attention