Challenges in organisation & research of risk governance of Nanotechnologies

Monique Groenewold, RIVM

6TH SAF€RA Symposium *Safety in the new economy and energy transition*

May 19, 2022

NANORIGO: Grant N°814530
RiskGONE: Grant N°814425
Gov4Nano: Grant N°814401

Content

- Short introduction Risk Governance
- State of the art in EU research on Nano Risk Governance
  - NMBP-13 projects: expected impact and results
- Changing policy ambitions: green deal and Chemical Strategy for Sustainability, new demands for nanotechnology
- Regulatory Research needs: results of two Gov4Nano summits

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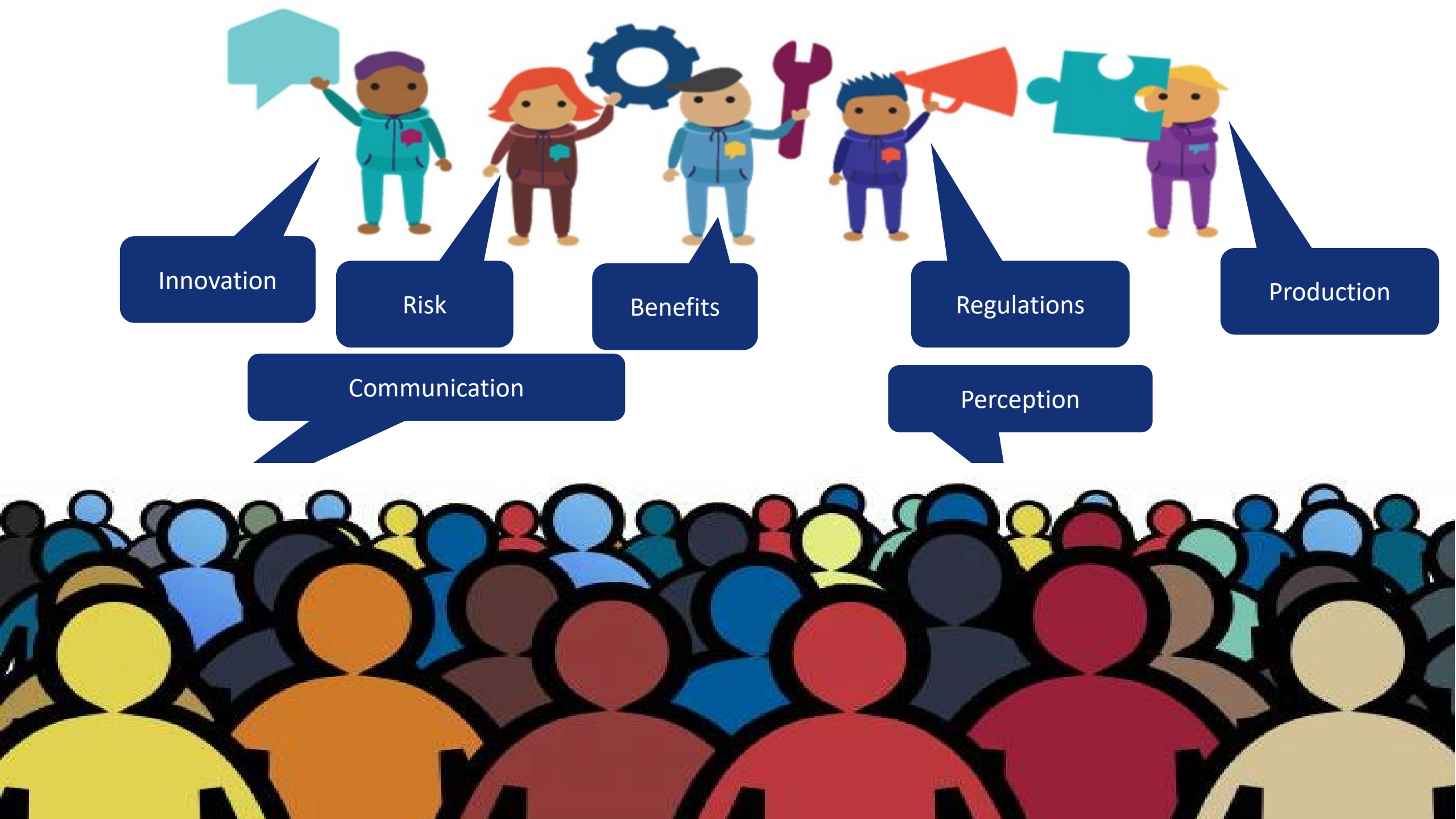
Innovation
Risk
Benefits
Regulations
Production
Communication
Perception

Governance

Risk governance

Governance refers to the actions, processes, traditions and institutions by which authority is exercised and decisions are taken and implemented.

- Involves **Multi-disciplinary** sciences and
- **multi-stakeholder** approaches
- A FRAMEWORK for risk governance is based on a defined and structured **process** to addressing **risk** in a comprehensive and holistic manner
  - Identification
  - Assessment (hazard, exposure, vulnerability)
  - Evaluation of acceptability, decision-making
  - Management and regulatory-relevant recommendations
  - Communication of risks

There exist already many ‘frameworks’ and tools, primarily for risk and safety assessment of nanotechnology

Environment International 95 (2016) 36–53

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Review article

Frameworks and tools for risk assessment of manufactured nanomaterials

Danail Hristozov [a,*], Stefania Gottardo [b], Elena Semenzin [a], Agnes Oomen [c], Peter Bos [c], Willie Peijnenburg, Martie van Tongeren [d], Bernd Nowack [e], Neil Hunt [f], Andrea Brunelli [a], Janeck J. Scott-Fordsmand [g], Lang Tran [d], Antonio Marcomini [a]

nature nanotechnology

ARTICLES

https://doi.org/10.1038/s41565-018-0120-4

A framework for sustainable nanomaterial selection hazard, a

Mark M. Falinski[1], I and Julie B. Zimme

Engineered nanomateri rials ectio nhan sidera bsta cons dily c nipul ewor d cor

Nano Today (2014) 9, 546–549

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/nanotoday

NEWS AND OPINIONS

A unified framework for nanosafety is needed

Janeck J. Scott-Fordsmand [a,*], S. Pozzi-Mucelli [b], L. Tran [c], K. Aschberger [d], S. Sabella [e], U. Vogel [f], C. Poland [c], D. Balharry [g], T. Fernandes [g], S. Gottardo [d], S. Hankin [c], M.G.J. Hartl [g], N.B. Hartmann [d,1], D. Hristozov [b], K. Hund-Rinke [h], H. Johnston [g], A. Marcomini [b], O. Panzer [i], D. Roncato [j], A.T. Saber [f], H. Wallin [f], V. Stone [g]

Ref. Ares(2018)2843782 - 31/05/2018

GoNano

Risk Governance and Research & Innovation Priorities in Nanotechnologies

First briefing report with a focus on food, health and the energy sector

caLIBRAte nano risk governance

Home | Events | Nano-Risk Governance Portal | NanoSafety Cluster Week | Partners | Results | Resc

News / Get involved: Test risk governance models

Get involved: Test risk governance models

Are you involved in activities concerning R&D, production, marketing, use, risk assessment and management, inspection, insura

caLIBRAte invites you to get involved in the project and test one of the models identified as potentially suitable:

- *Nanosafer Control Banding*
- *GUIDEnano*
- *LICARA nanoscan*
- *BAUA Sprayexpo 2.3*
- *Stoffenmanager Nano*
- *ANSES CB Nanotool*
- *Control banding nanotool*
- *Precautionary Matrix*
- *ISO / TS 12901-2*
- *ConsExpo Nano*
- *SimpleBox4Nano (SB4N)*
- *SUNDs*

The caLIBRAte framework will link different nano-specific models and methods into a system-of-systems (SoS), which companie assessment, prioritisation and management of occupational, consumer and environmental risks associated with production and models will be aligned to support decisions along the research and innovation value chain, from basic research to market launch

So, what else do we need?
Framework for nanotechnology risk governance

1. **Integrate** important concepts, principles and tools
2. Access to **data** and guidance on how to obtain high quality data / outcome of knowledge-based risk assessment
3. Access to **tools** for risk assessment and risk management
4. Provide recommendation on **responsible** and transparent communication between **stakeholders**
5. Support to identify future scientific and regulatory research needs: address **current as well as future challenges**

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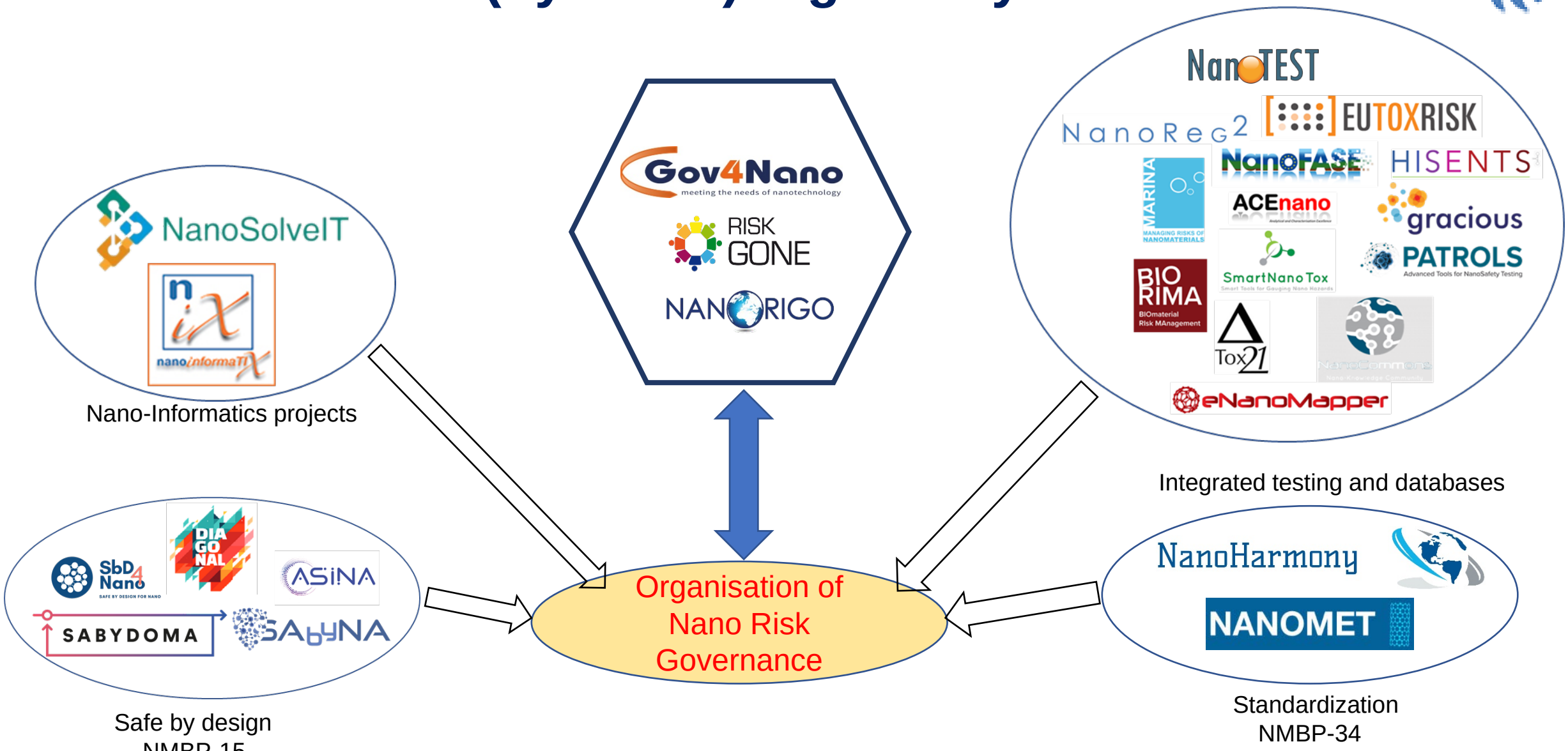
- Regulatory Research needs: results of two Gov4Nano summits

Research work in (dynamic) regulatory context



Societal challenge

- Nanotechnology has high economic potential and thereby impacts a broad range of industries and applications
- Interaction of engineered nanomaterials with the living environment is complex and is marked by uncertainty and ambiguity
- Urgent need to develop appropriate risk governance structures, to ensure full potential trough trust of all stakeholders

Gov4Nano
meeting the needs of nanotechnology

- €8.6M budget
- 01/19 to 12/22
- 32 partners
- 15 countries
- Coordinated by RIVM (NL)
- Grant agreement No. 814401

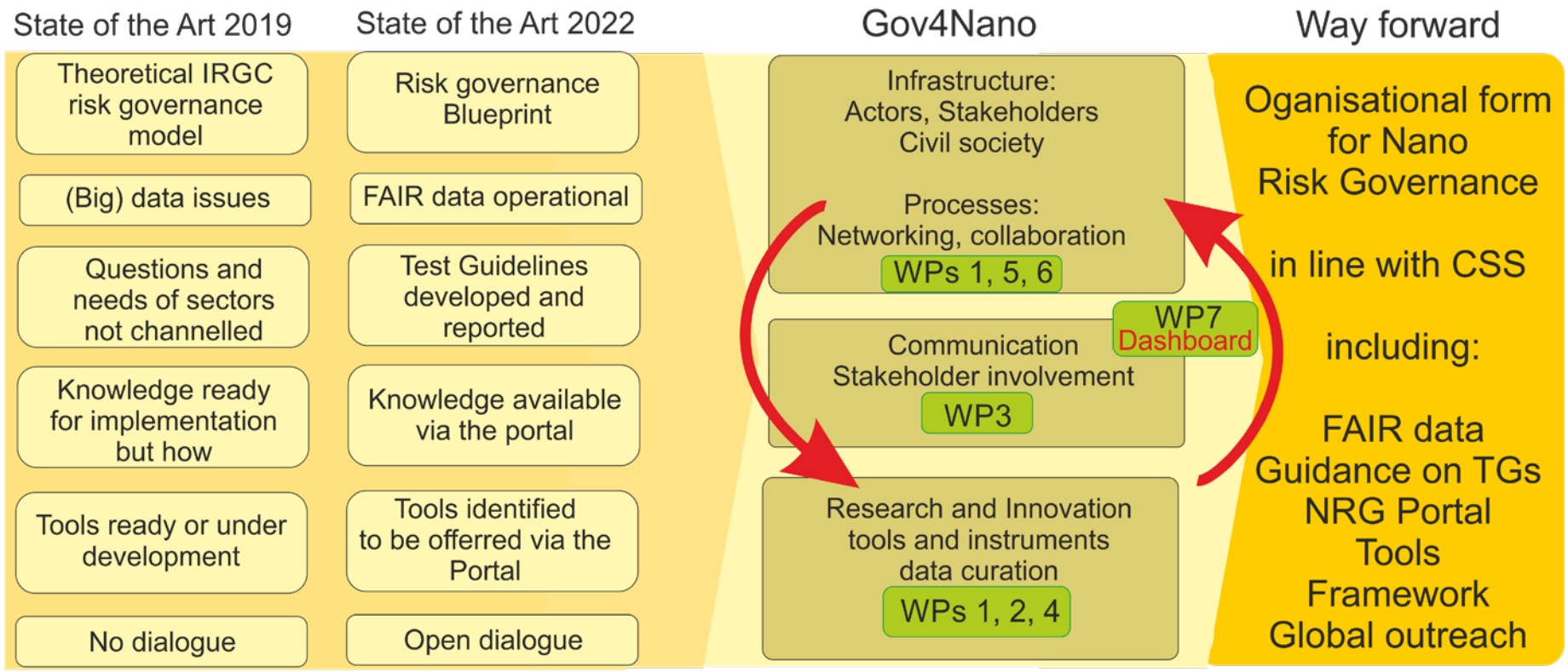
NANORIGO

- €4.7M budget
- 01/19 to 02/23
- 28 partners
- 14 countries
- Coordinated by Aarhus (DK)
- Grant agreement No. 814530

RISK GONE

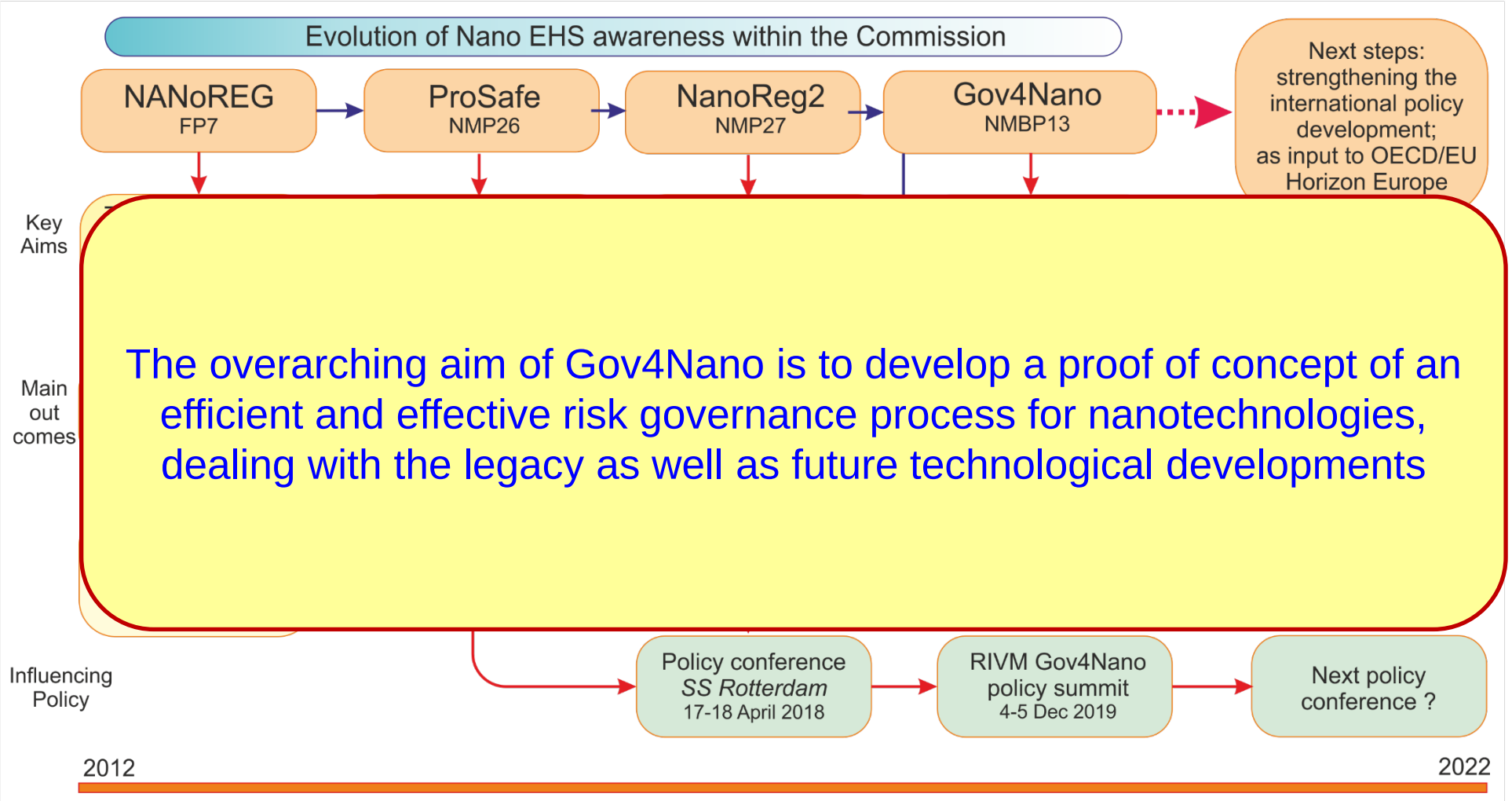
- €5M budget
- 01/19 to 02/23
- 22 partners
- 17 countries
- Coordinated by NILU (NO)
- Grant agreement No. 814425

Setting the scene: the need for Gov4Nano

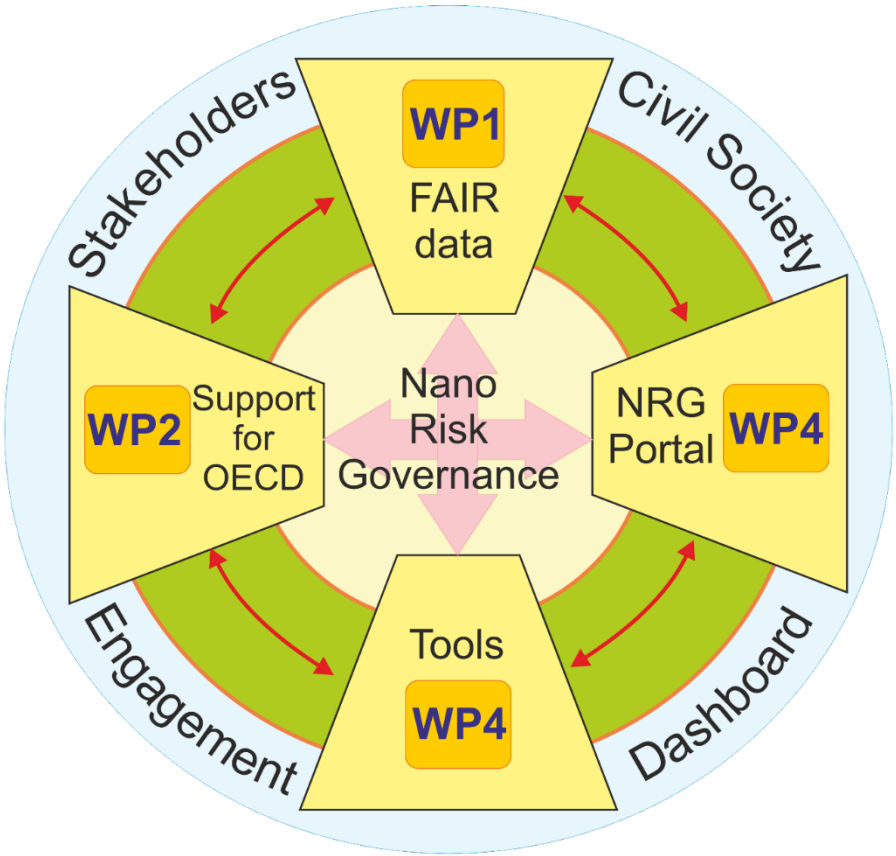


Agile and adaptable: meeting the changing needs of society

The process to Gov4Nano and the aims



Key building blocks for Nano Risk Governance



- **Cover all domains**: chemicals, biocides, consumers, food, medicine
- **Connect** key organizations and stakeholders (EU and global)
- **Integrate** important concepts, principles and tools
- Access to **data** and guidance on how to obtain high quality data
- Access to **tools** for risk assessment and risk management
- Support to identify future scientific and regulatory research needs
- Address **current & future challenges**
- **Responsible** and **transparent** communication between **stakeholders**

Outcome

- Proof of concept of an effective risk governance process
- Operational Nanotechnology Risk Governance Framework
- Nano Risk Governance Portal
- Blue print for an organization for Nano Risk Governance

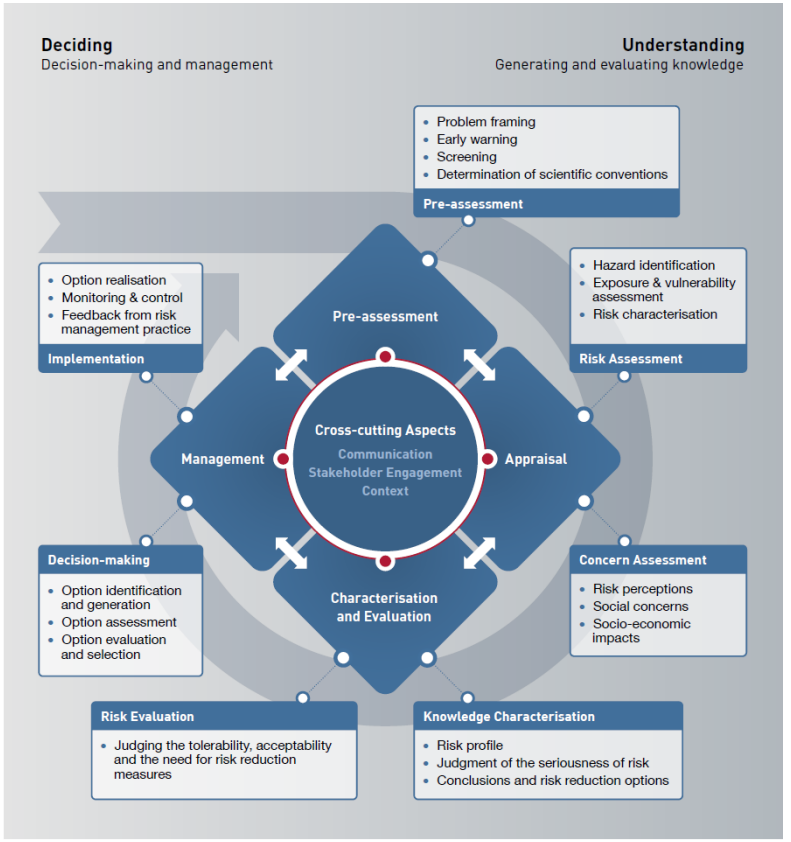
Risk Governance Framework for decision making

Organisation for Nano Risk Governance

Supporting Infrastructure data, tools & instruments

Nano Risk Governance Framework

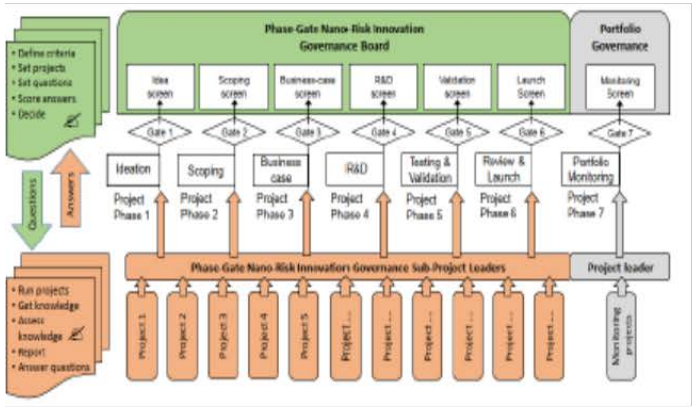
- All domains: chemicals, biocides, consumers, food, medicine
- Connecting key organizations and stakeholders (EU and global)
- Decision making framework
- Future-proof based on International Risk Governance Council
- Integrates scientific data and operational tools
- Participative and pro-active role for stakeholders
- Based on existing risk governance infrastructure

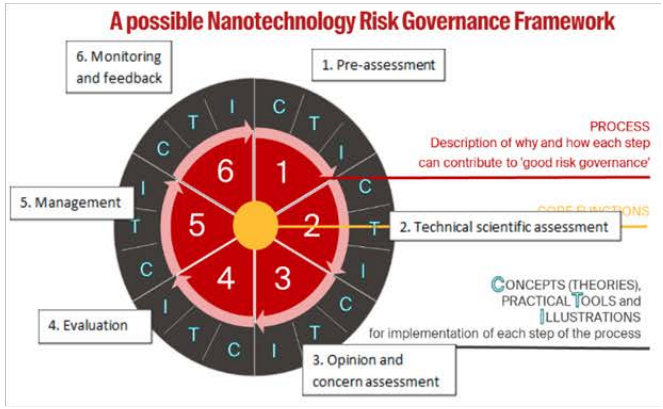


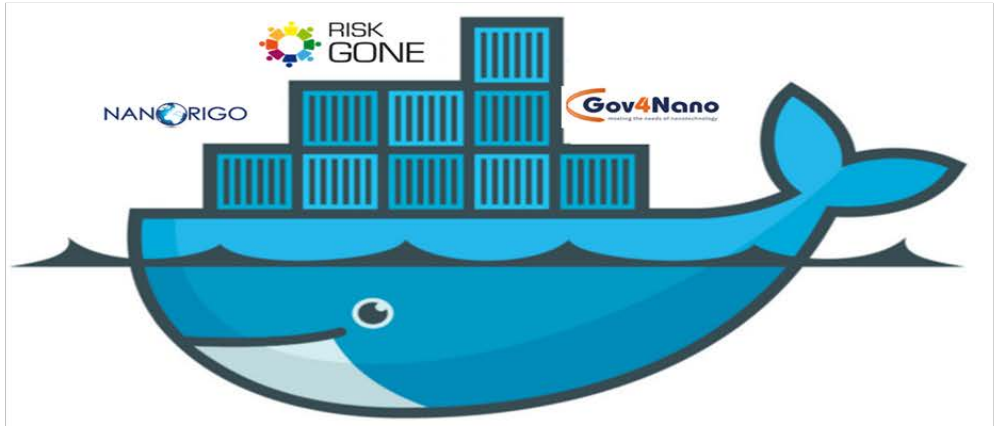
https://irgc.org/risk-governance/irgc-risk-governance-framework/

Nano Risk Governance Framework

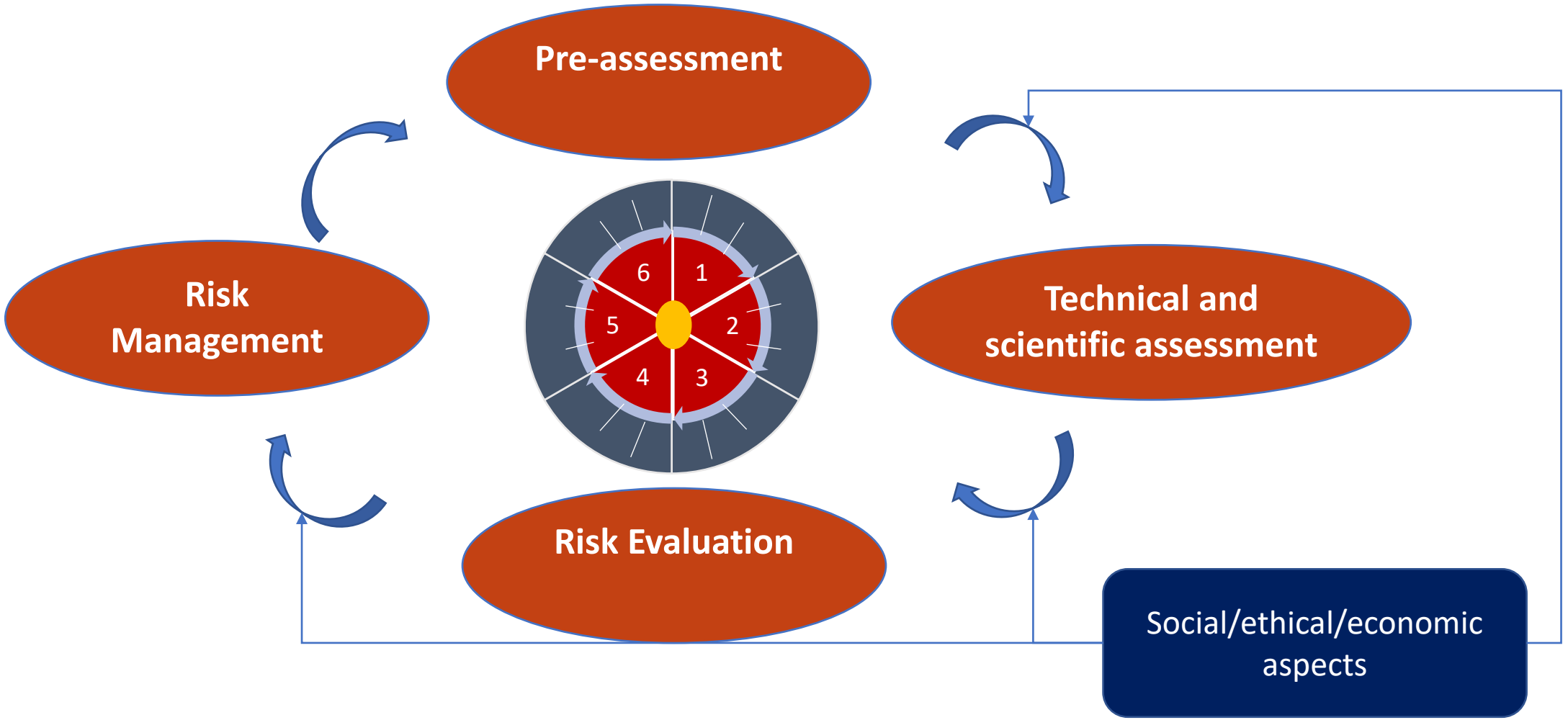
Validated framework and tools ⟺ Software Architecture ⟺ Stakeholder involvement







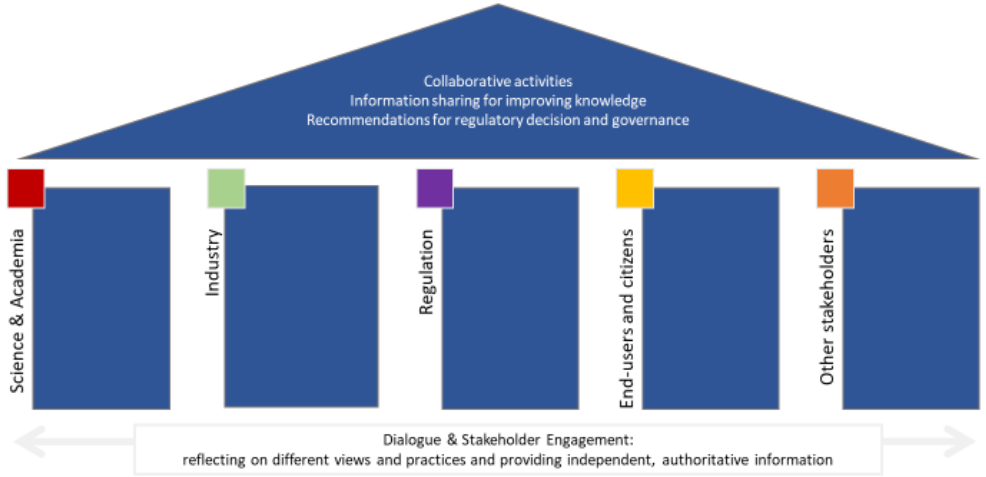
Nano Risk Governance Framework – under construction



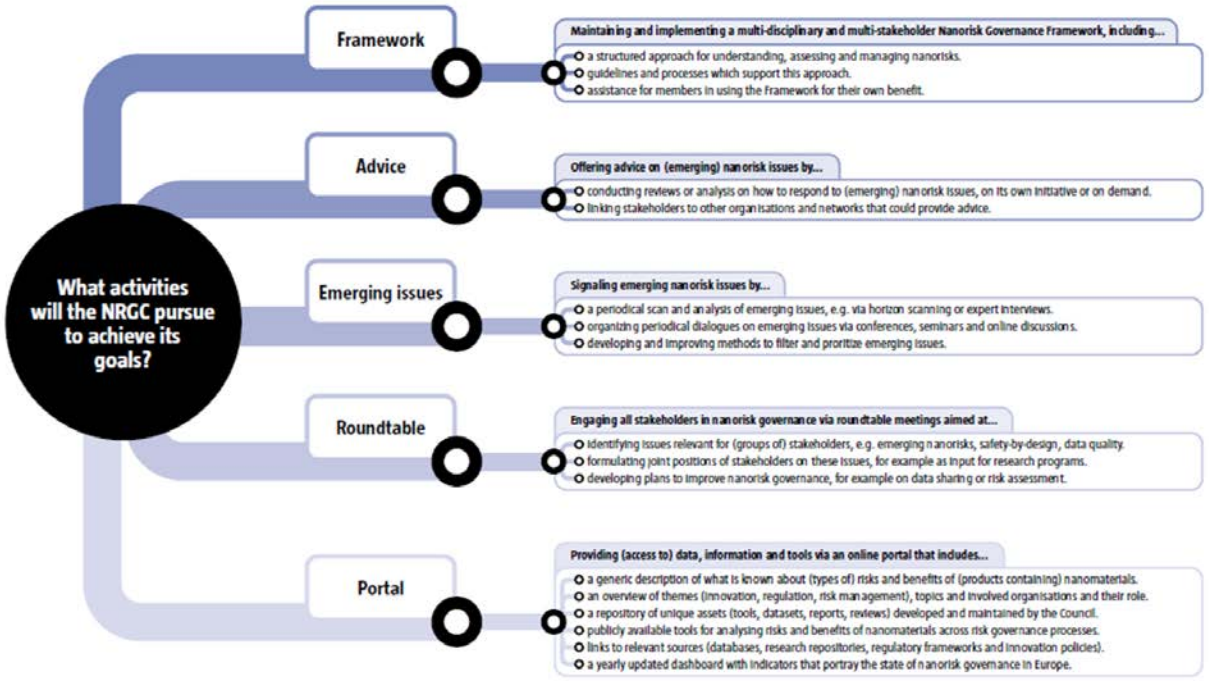
Perception, opinion and concern assessment → Public opinions → Perception and concern of affected stakeholders → May matter as much as technical assessment

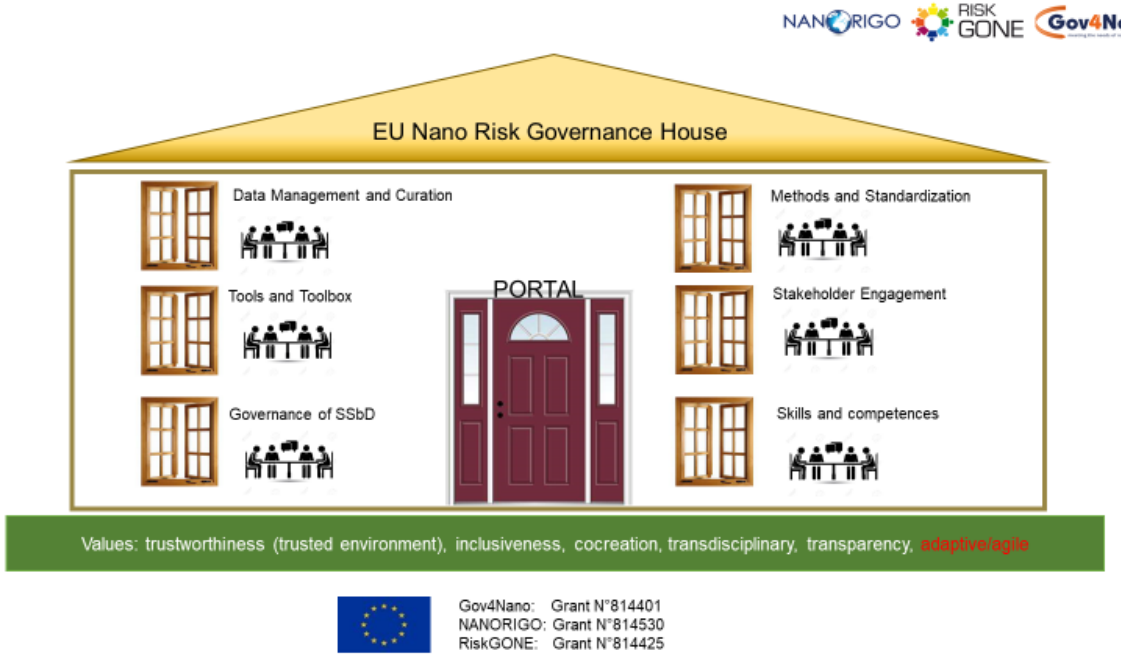
Organisation for Nano Risk Governance

- The main purpose is: fostering safe and sustainable development and use of nanomaterials in Europe.
- Put the framework into practice
- Overarching, independent, trustworthy body
- Bridge between knowledge generators and decision makers
- Services for all stakeholders



A new concept: the EU Nano Risk Governance House





Gov4Nano: Grant N°814401
NANORIGO: Grant N°814530
RiskGONE: Grant N°814425

Ambition: To foster safe and sustainable development, use and disposal of (products containing) nanomaterials in Europe

Nano Risk Governance Portal

- Infrastructure integrates academic, industry and regulatory information
- Support decision making framework & council
- Validated state-of-the-art tools
- NANoREG, caLIBRAte, NanoCommons & NanoReg^2
- QA/QC processes and decision tree
- Process for collection and harmonisation of data
- Covers applicability and acceptance (regulatory or industrial)

Content

New NMBP-13 tools

Existing Tools from previous projects / Other developers (validated or evaluated)

FAIR DataBase(s)

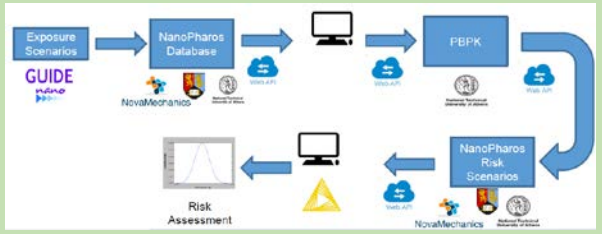
Standards and Guidances

Selection of nodes

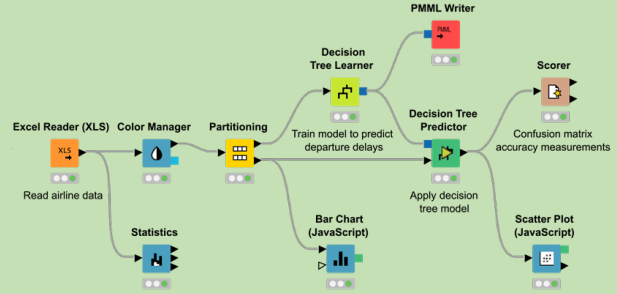
Possible interoperable Software Architecture

Technical Implementation

Docker



KNIME Analytics platform



Workflows

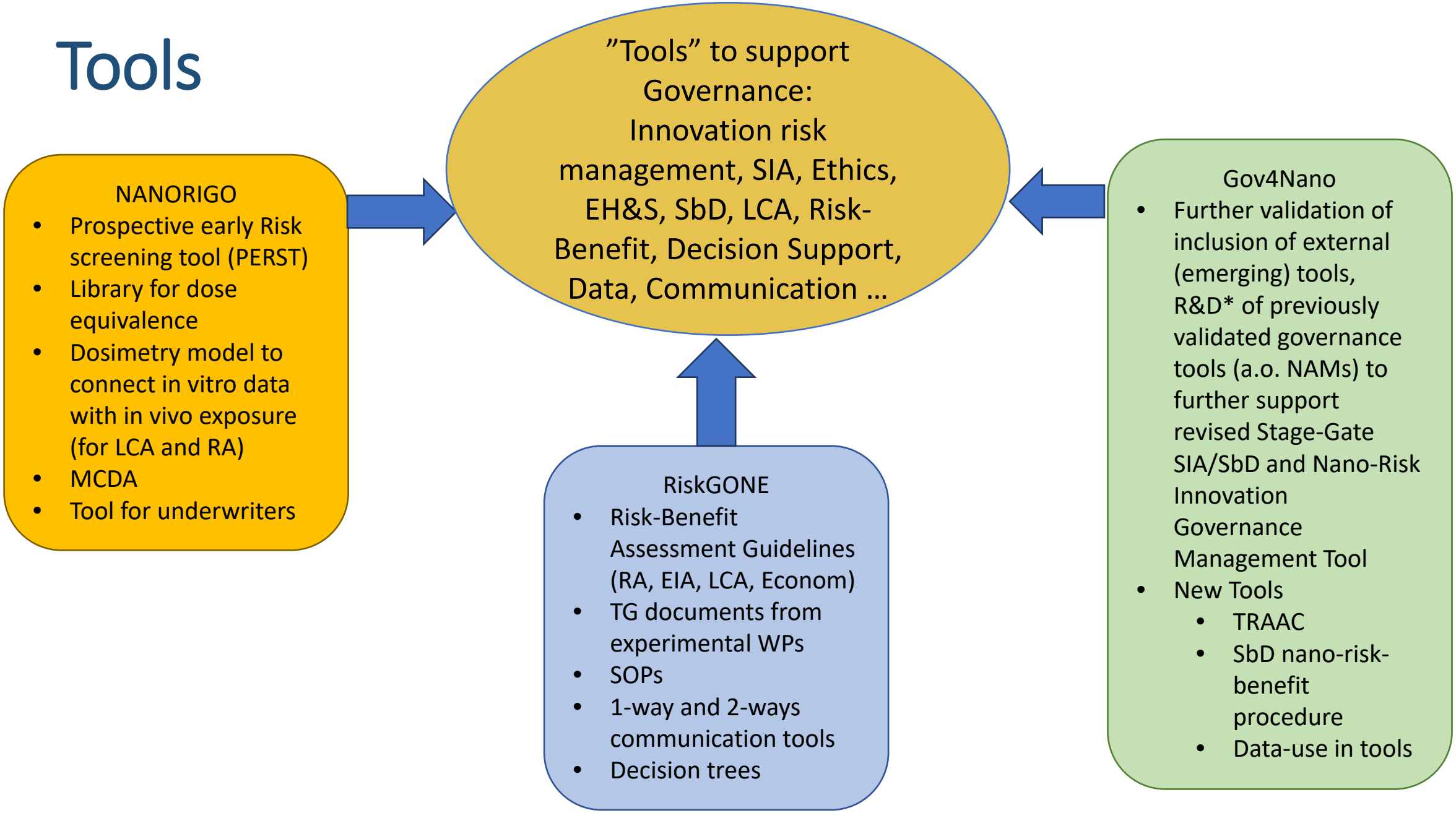
Guiding Logic

Nano Risk Governance Framework

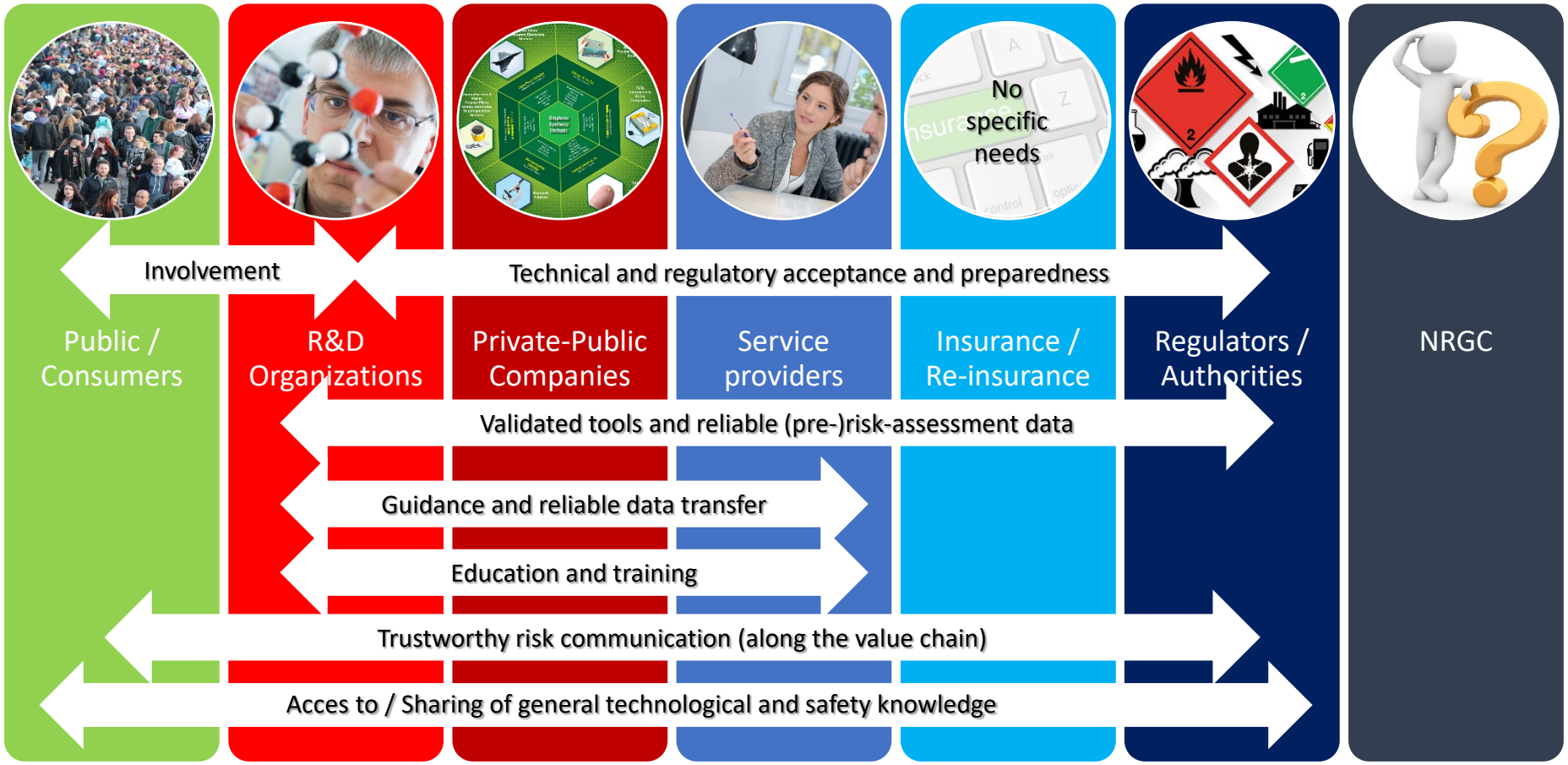
Building blocks

Guidance – Decision Trees

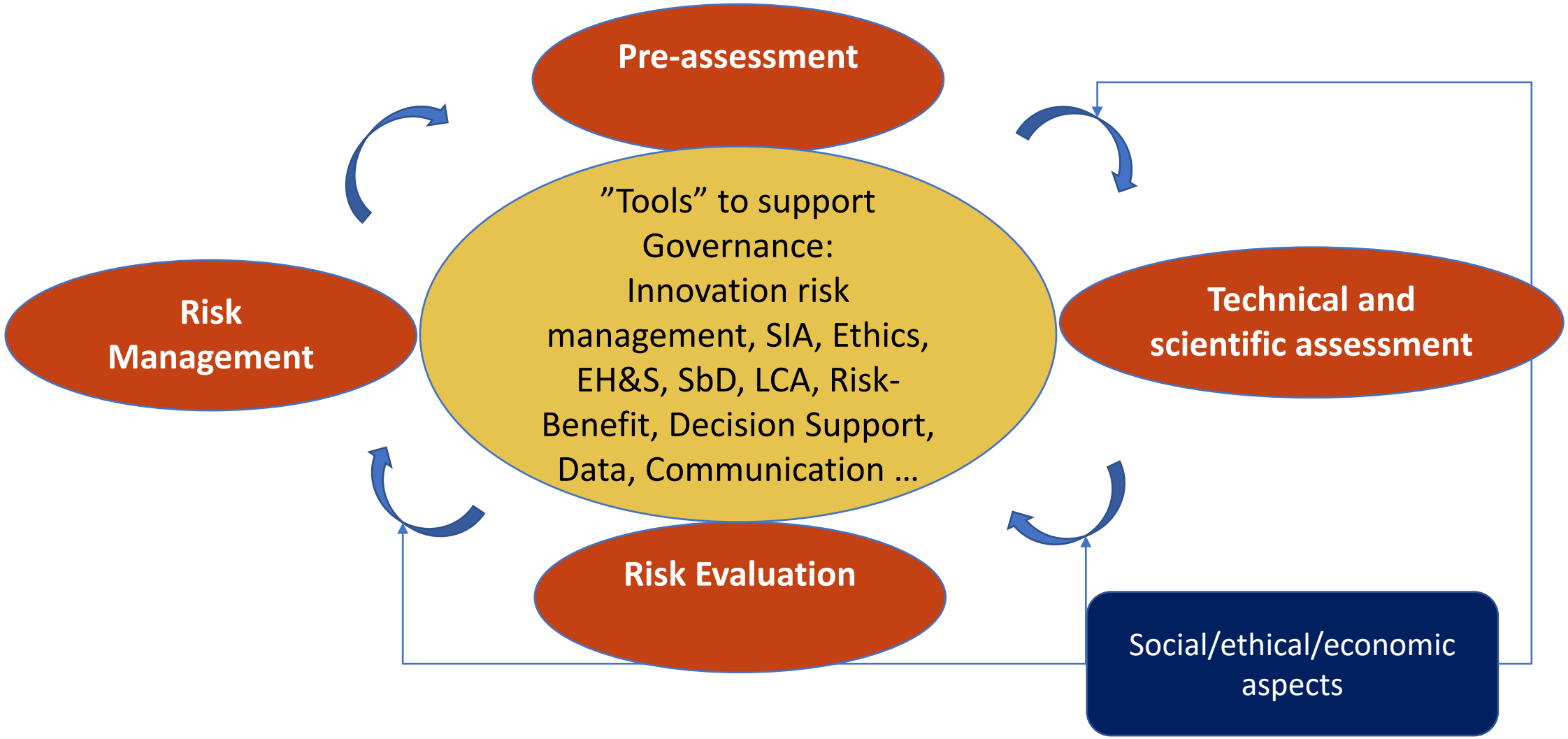
Tools


”Tools” to support Governance: Innovation risk management, SIA, Ethics, EH&S, SbD, LCA, Risk-Benefit, Decision Support, Data, Communication …
NANORIGO
Prospective early Risk screening tool (PERST)
Library for dose equivalence
Dosimetry model to connect in vitro data with in vivo exposure (for LCA and RA)
MCDA
Tool for underwriters
RiskGONE
Risk-Benefit Assessment Guidelines (RA, EIA, LCA, Econom)
TG documents from experimental WPs
SOPs
1-way and 2-ways communication tools
Decision trees
Gov4Nano
Further validation of inclusion of external (emerging) tools, R&D* of previously validated governance tools (a.o. NAMs) to further support revised Stage-Gate SIA/SbD and Nano-Risk Innovation Governance Management Tool
New Tools
TRAAC
SbD nano-risk-benefit procedure
Data-use in tools

Main needs from stakeholders



Nano Risk Governance portal – under construction



Portal & tools -
Scientific support for guidelines

- Collaboration with Malta Initiative to join (EU) forces
- Nano-specific adaptations of OECD TG/GD
- Dedicated regulatory risk research & experimental work
- Specific endpoints to be addressed: surface chemistry, solubility, reactivity and dustiness of nanomaterials, ecotoxicity and in vitro cytotoxicity and in vitro genotoxicity

The Malta Initiative

The Malta Initiative –
A European Action to Develop OECD Test Guidelines for Nanomaterials

- A joint route towards standardisation, testing guidelines and guidance documents.

NanoHarmony

NANOMET

Gov4Nano
meeting the needs of nanotechnology

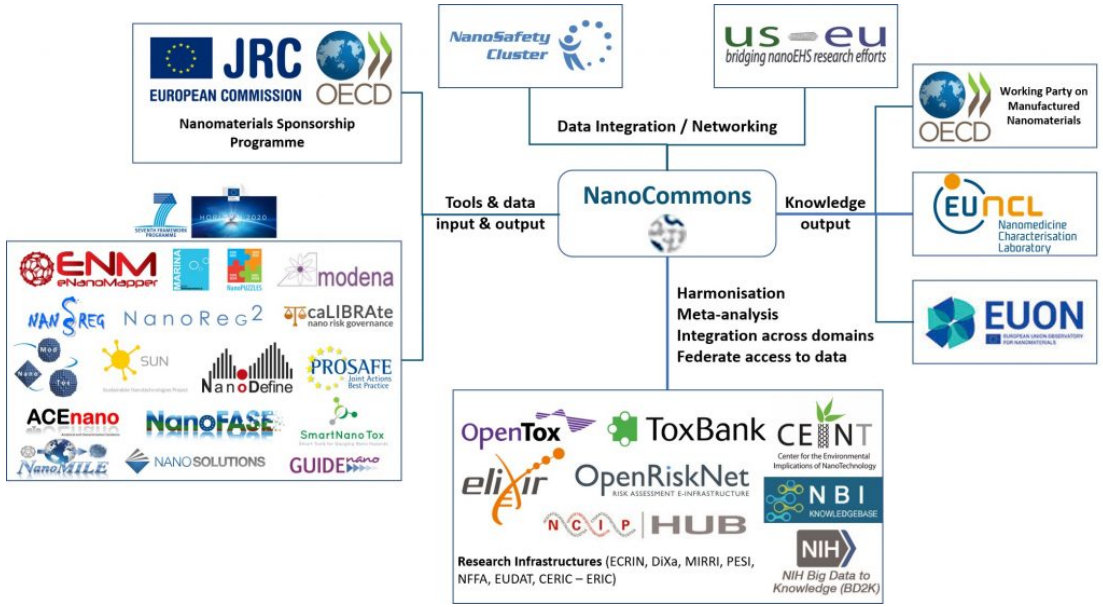
OECD

RISK GONE

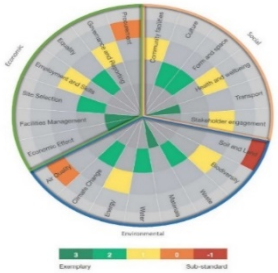
Testing and Assessment

Section 1 Physical Chemical Properties	Section 2 Effects on Biotic Systems	Section 3 Env. Fate and Behaviour	Section 4 Health Effects
TG on determination of the (volume) specific surface area of manufactured nanomaterials **(EU) WNT 1.3**	Adaptation of OECD TGs 201 [illegible]2 and 203 for the determi[illegible] ecotoxicity of[illegible] **WPMN** ENV/CBC/NANO(2021)7	TG on dissolution rate of nanomaterials in aquatic environment **(DE) WNT 3.10**	GD on the adaptation of *in vitro* mammalian cell based genotoxicity TGs for testing of manufactured nanomaterials **(EU)**
TG on particle size and size distribution of manufactured nanomaterials **(DE) WNT 1.4**		TG for nanomaterial removal from wastewater **(US) WNT 3.11**	Applicability of the key event based TG 442D for *in vitro* skin sensitisation testing of nanomaterials **(CH) WNT 4.133**
GD on determination of solubility and dissolution rate of nanomaterials in water and relevant synthetic biological media **(DK/DE) WNT 1.5**		GD on assessing the apparent accumulation potential for nanomaterials **(ES) WNT 3.12**	TG on toxicokinetics to accommodate testing of nanoparticles **(NL/UK) WNT 4.146**
GD on identification and quantification of the surface chemistry and coatings on nano- and microscale materials **(DK/DE) WNT 1.6**		GD to support implementation of TG 312 for nanomaterial safety testing **(CA/DE) WN T 3.14**	Integrated *in vitro* appro[illegible]stinal fate or orally ing[illegible]rials **(IT) WPM**[illegible] ENV/CBC/NANO(2021)8
TG on determination of surface hydrophobicity of manufactured nanomaterials **(EU) WNT 1.7**		GD on environmental abiotic transformation of nanomaterials **(AT) WNT 3.16**	GD on th[illegible]determination of concentrations of nanoparticles in biological samples for (eco)toxicity studies **(UK) WNT**
TG on determination of the dustiness of manufactured nanomaterials **(DK/FR) WNT 1.8**		Scoping review for a tiered a[illegible]or reliable bioaccu. assess. of MN[illegible]rganisms minimising us[illegible]vertebrate tests **(UK) WPM**[illegible]**approval** ENV/CBC/NANO(2021)9	
		Assessment of the durability of NMs and their surface ligands in env. surroundings (biodurable/ biodegradable) **(SA/Korea) WPMN**	

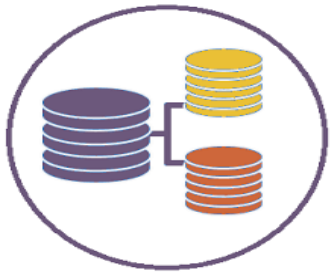
Data management – overall picture



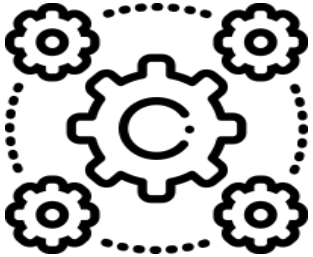
Data management plans



Quality/fitness for re-use scoring of datasets



Datasets to support case studies

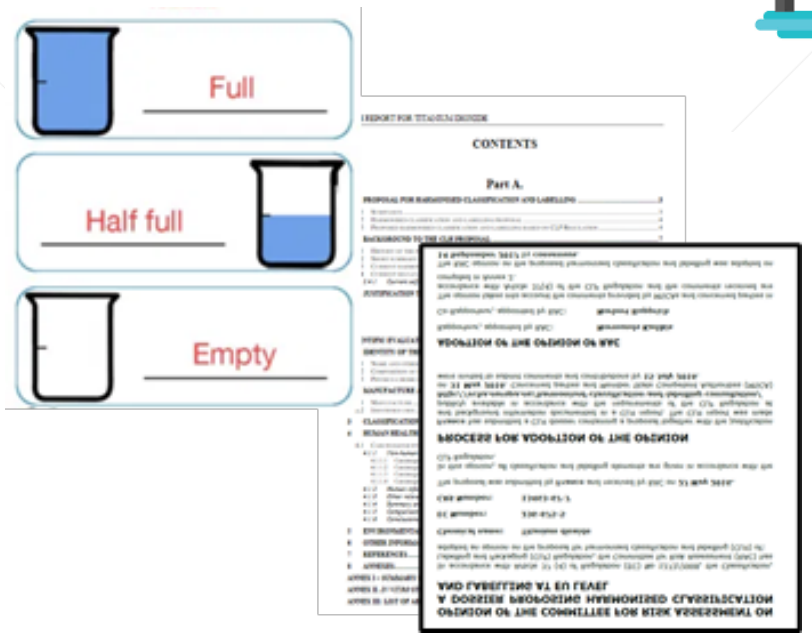


Interoperability and automation

Data management from concept to implementation…….

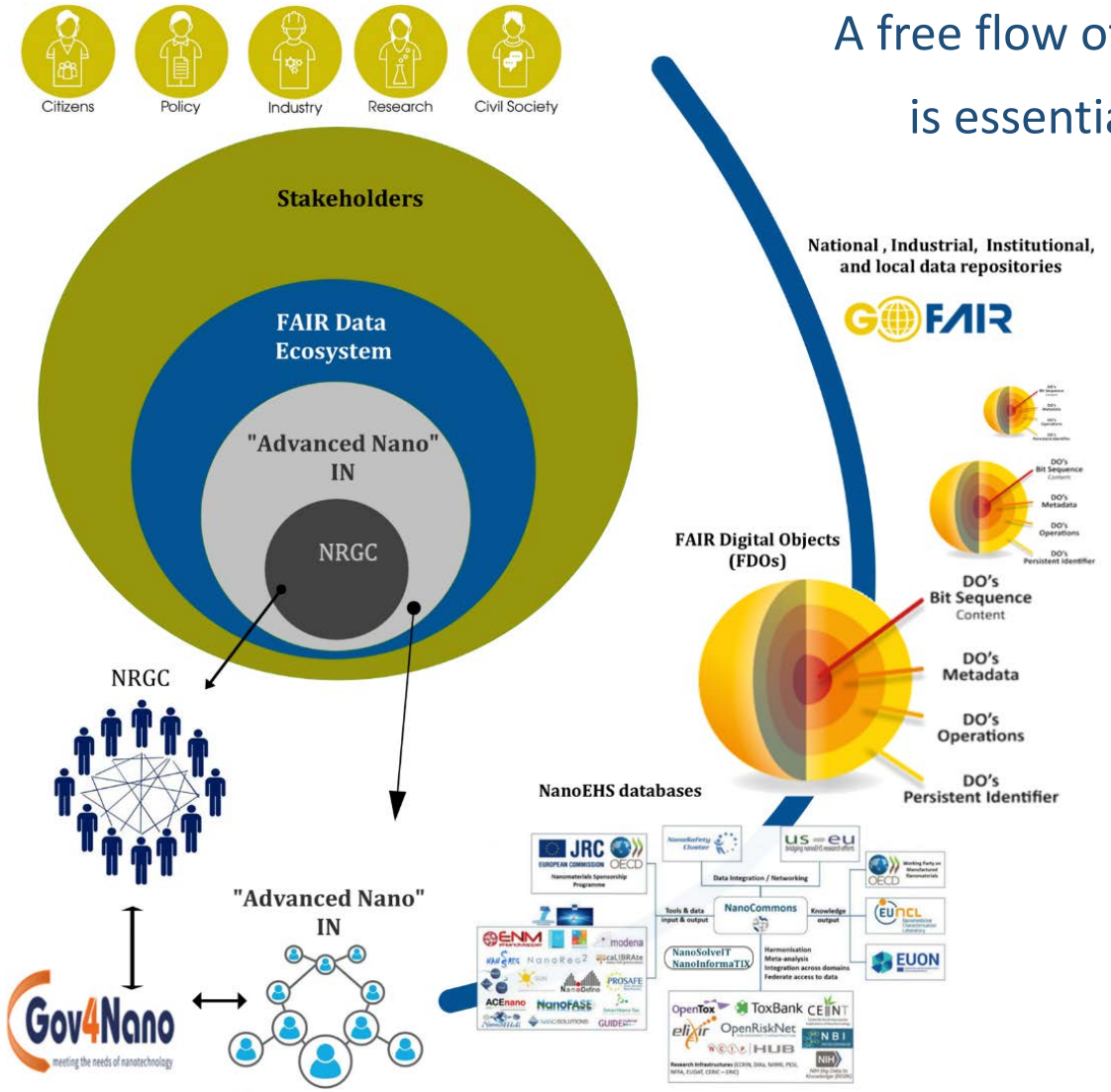
Conceptualisation & user needs documentation

Community consensus on data standards (metadata, FAIR metrics) => stepwise SOP for data quality / re-usability



Operationalisation & automation (tooling) to facilitate data re-use, decision making & sustainability

FAIR databases are key –
Findable, Accessible, Interoperable and Reusable



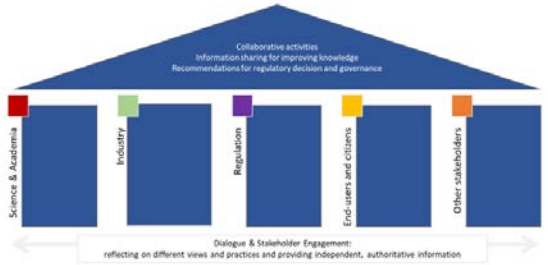
A free flow of high-quality, FAIR, NanoEHS data is essential for effective risk governance

- Science-based decision making
- Reuse of existing data
- Harmonisation of data templates

Advanced Nano

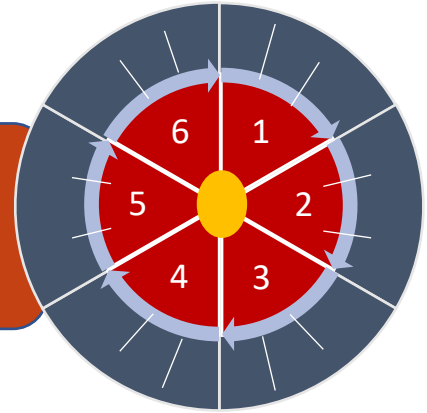
NANOEHS--GO FAIR IMPLEMENTATION NETWORK

www.go-fair.org/advancednano/



House of Nano-Risk Governance

Nano-Risk Governance Framework



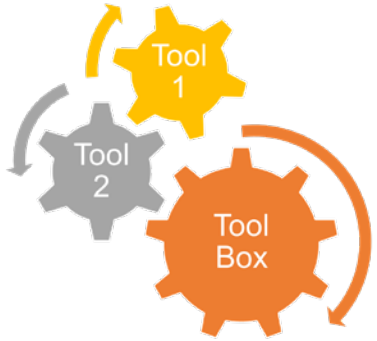
Nano-Risk Governance Portal

Stakeholder Needs and Priorities?

Guidances and guidelines

FAIR – databases

”Tools” to support Governance: Innovation risk management, SIA, Ethics, EH&S, SbD, LCA, Risk-Benefit, Decision Support, Data, Communication …



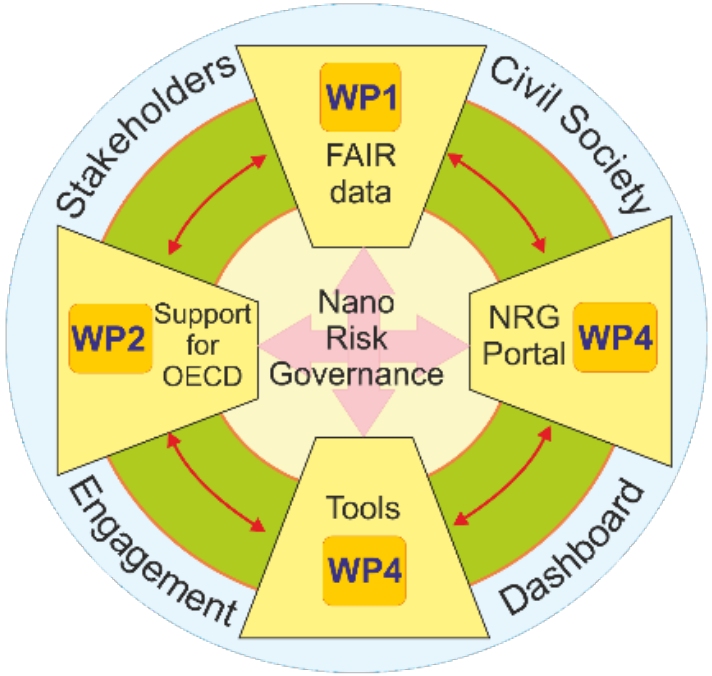
Suitable & Valid?

Systematic approach for efficient and effective Nano Risk Governance

- infrastructure for stakeholder engagement & collaboration
- networks for harmonization, improved data quality, international collaboration
- coordination and prioritization research needs for regulatory risk assessment
- monitoring system

- Access to **high quality data** & tools for decision making

- **Improved standardisation and validation process**



- Implementation **FAIR principles**

- **Risk governance portal and platforms**: knowledge & information sharing

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1. NEW POLICY AMBITIONS: EU Green Deal

The European Green Deal is about **improving the well-being of people**. Making Europe climate-neutral and protecting our natural habitat will be good for people, planet and economy. No one will be left behind.

The EU will:

Become climate-neutral by 2050

Protect human life, animals and plants, by cutting pollution

Help companies become world leaders in clean products and technologies

Help ensure a just and inclusive transition

EU Strategies: providing direction and goals

…many more..

Key role for new materials

Potential to provide technical solutions for pressing global challenges, i.e. for energy revolution, digitalisation, or health care

So PACE of development and application of (advanced) nanomaterials is stimulated by GD policy ambitions – MODERN INNOVATION POLICY

URGENCY for solutions

Pollution crosses 'planetary boundary'

The production of plastics and other pollutants now outstrips our ability to monitor it and threatens global ecosystems. Researchers at the Stockholm Resilience Centre conclude that chemical pollutants have crossed a 'planetary boundary'. The concept stems from an influential 2009 *Nature* paper that suggested nine boundary conditions in the Earth system that could, if crossed, result in tipping points that could harm human life. At the time, the impact of chemical pollutants was not known — but now, we've gone too far, say the researchers. "The total mass of plastics now exceeds the total mass of all living mammals," says ecotoxicologist and study author Bethanie Carney Almroth. "That to me is a pretty clear indication that we've crossed a bound
on chemical po
authors call for a global organization focused
dustrial waste products,

ENVIRONMENTAL Science & Technology

pubs.acs.org/est

Policy Analysis

Outside the Safe Operating Space of the Planetary Boundary for Novel Entities

Linn Persson,* Bethanie M. Carney Almroth, Christopher D. Collins, Sarah Cornell, Cynthia A. de Wit,* Miriam L. Diamond, Peter Fantke, Martin Hassellöv, Matthew MacLeod, Morten W. Ryberg, Peter Søgaard Jørgensen, Patricia Villarrubia-Gómez, Zhanyun Wang, and Michael Zwicky Hauschild

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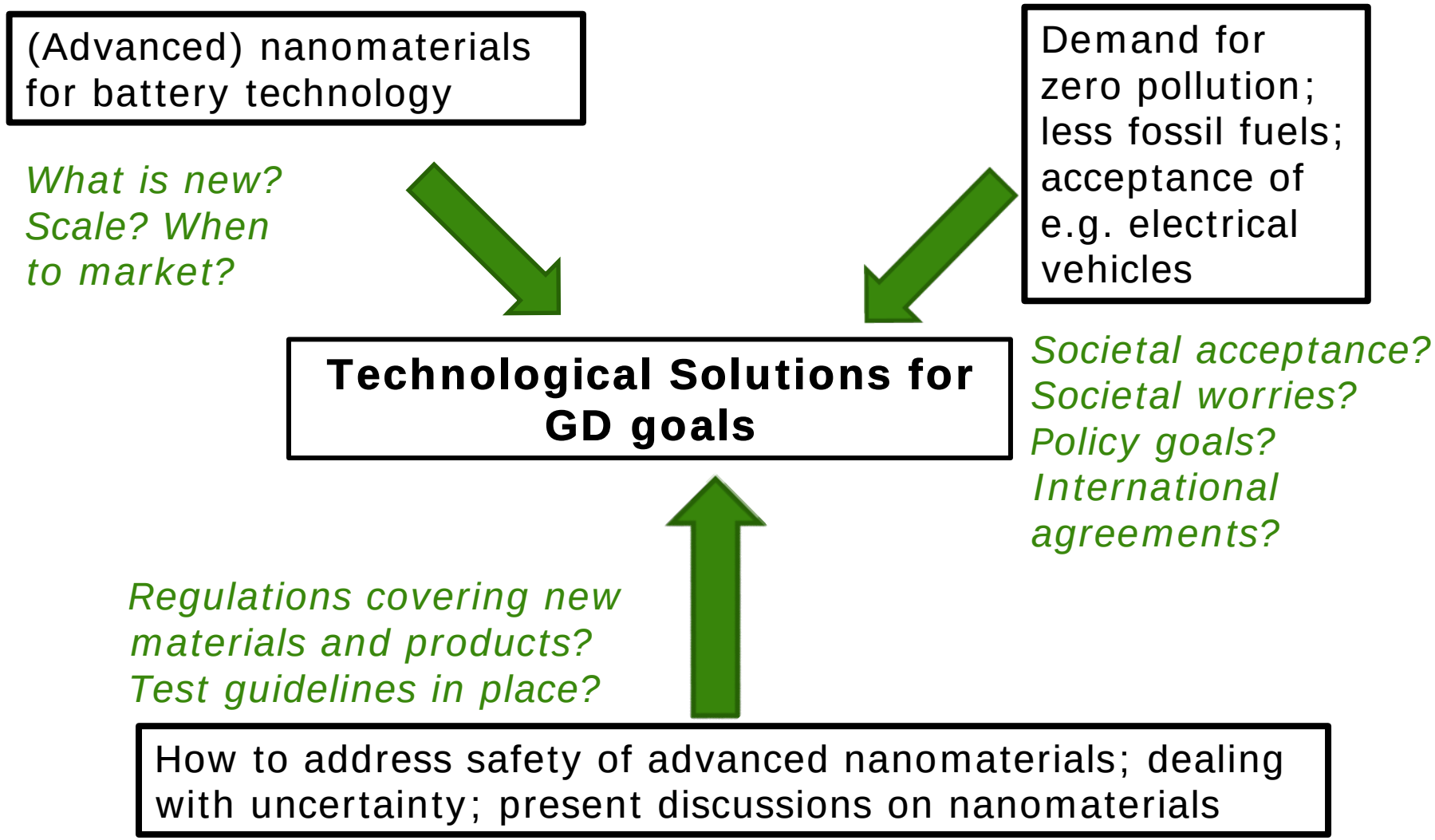
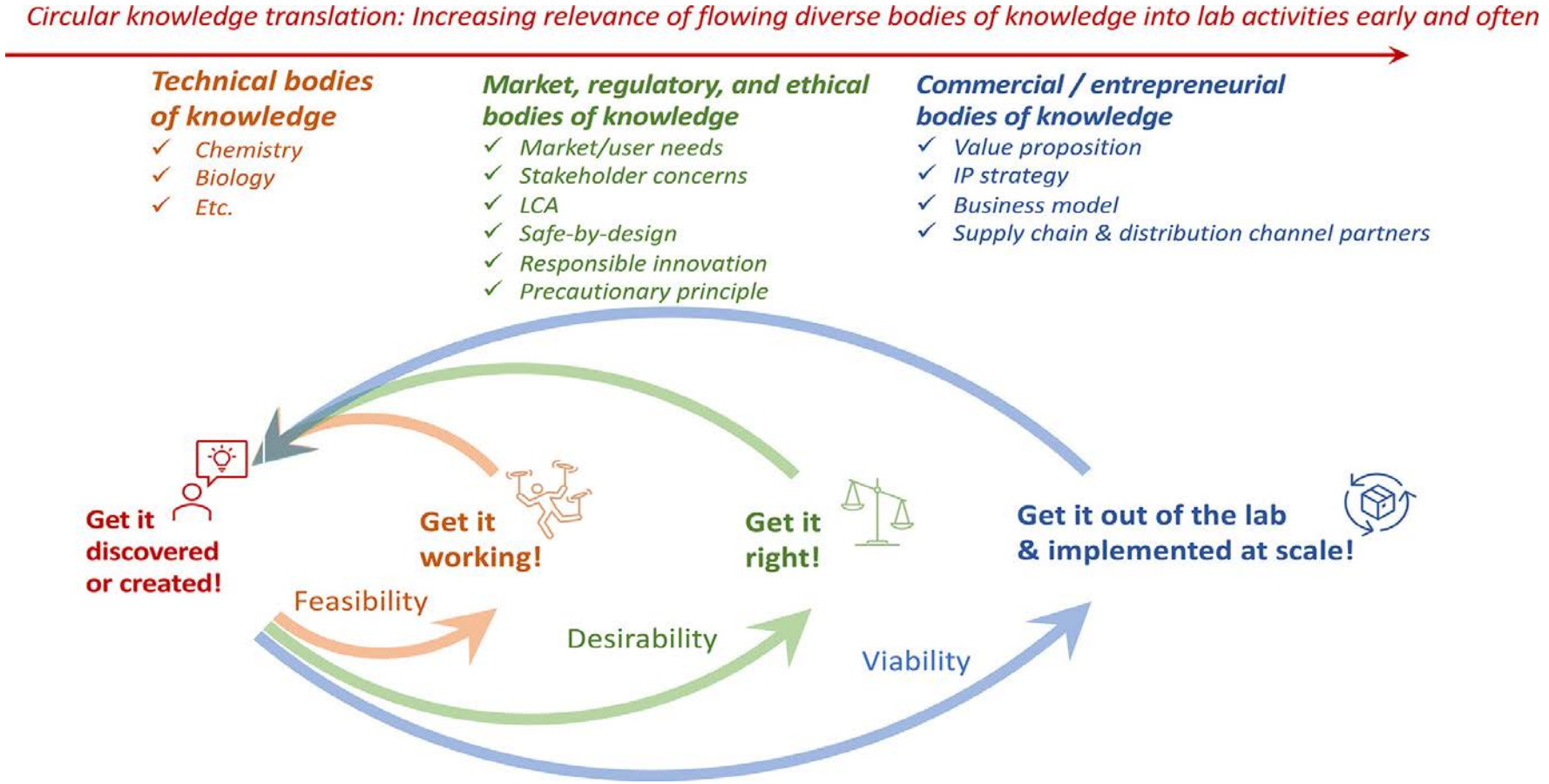
January 2022

Gov4Nano meeting the needs of nanotechnology

Technological solutions, regulatory perspective



2. New technology development, new nanomaterials



Circular knowledge translation. Created by Wojciech Chrzanowski, Goretty Dias, Steven Maguire, and Elicia Maine, 2021.

Nanotechnology for a Sustainable Future: Addressing Global Challenges with the International Network4Sustainable Nanotechnology. Pokrajac et al. ACSnano; December 2021

DOI: (10.1021/acsnano.1c10919)

3. NEW CHEMICALS RISK ASSESSMENT

PARC: HE-partnership programme (2022-2029) – coordinated by ANSES, France -

New techniques; new analytical methods

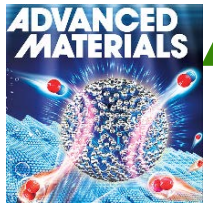
Machine learning & AI

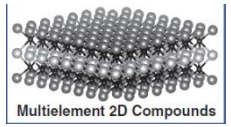
New Alternative Methods: NAMs

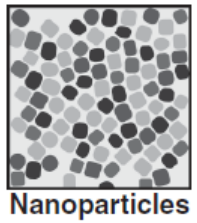
Etc.

3 developments affecting RA of nano

New materials for innovations







INNOVATION CHALLENGES

SCIENTIFIC/RA CHALLENGES

POLICY AND SOCIETAL CHALLENGES

Present

2030-2050

New chemicals RA

Non-toxic
Zero pollution
Sustainability

EU Strategies: Chemicals Strategy for Sustainability

OBJECTIVES

- better protect citizens and the environment
- boost innovation for safe and sustainable chemicals

ACTIONS relevant for risk assessment nanomaterials

- banning the most harmful chemicals in consumer products – only essential use
- account for mixture effects
- boosting SSbD
- establishing a simpler “one substance one assessment” process for the risk and hazard assessment of chemicals
- playing a leading role globally by championing and promoting high standards

EU Strategies: Chemicals Strategy for Sustainability

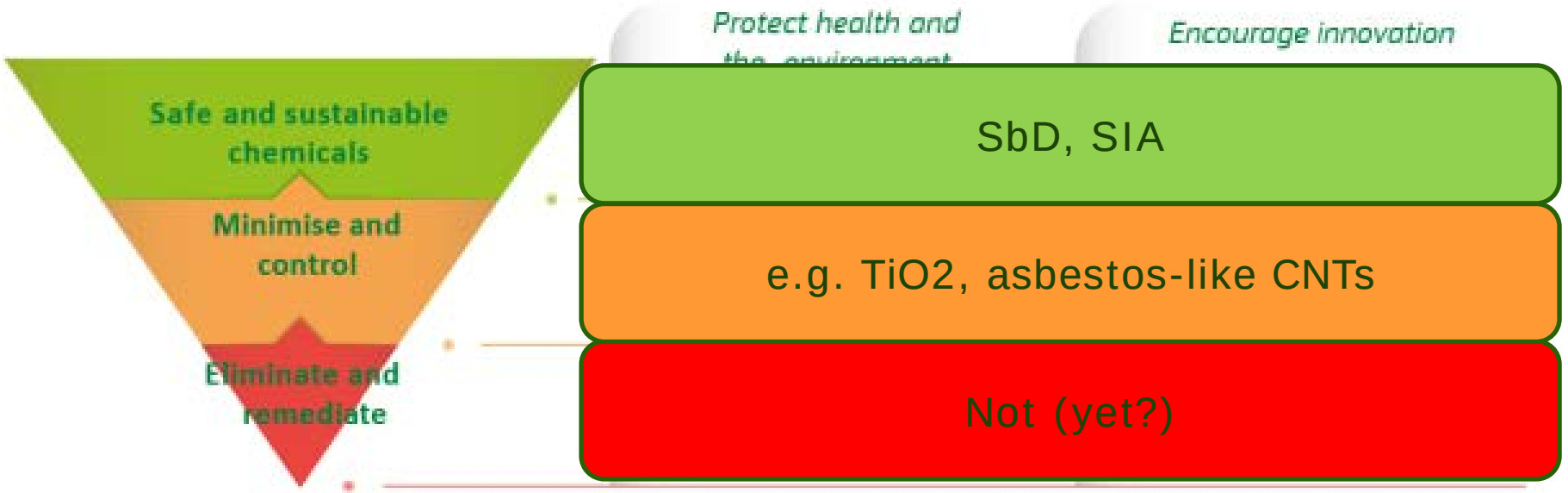


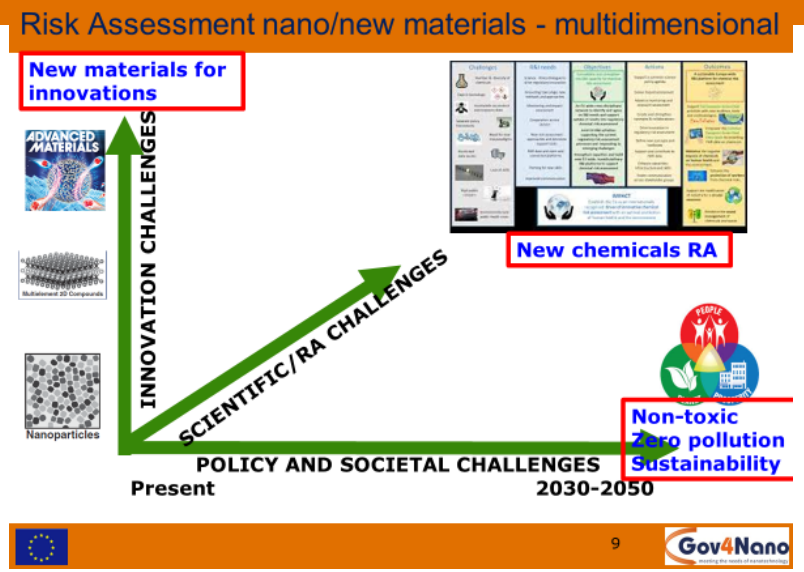
Figure: The toxic-free hierarchy – a new hierarchy in chemicals management

Nano dossier: keeping pace with policy ambitions

EXAMPLES	FOCUS
Elaboration on toxicological endpoints	Additional toxicological endpoints: immunotox, ED, neurotox, respiratory effects, specific organs
Elaboration on specific populations	Vulnerable groups, e.g. children
Harmonization, standardization	Development of standardized methods
Innovation in chemicals risk assessment	New techniques, digitization (like AI), etc.
Do no harm to man and its environment	Safe, sustainable, circular
Transregulatory	One substance, one assessment
Safe-by-Design	Safe-and-Sustainable-by-Design

Needs beyond toxicological knowledge

- Knowledge and information sharing:
  how to organize?
- Innovation supportive regulations:
  how to connect?
- Innovation in risk governance:
  how to adapt?
- Co-creation:
  how to operationalize?
- Dialogue:
  do we have the skills and competences for it?
- …..



Content

- Short introduction Risk Governance
- State of the art in EU research on Nano Risk Governance
  - NMBP-13 projects: expected impact and results
- Changing policy ambitions: green deal and Chemical Strategy for Sustainability
- Regulatory Research needs: results of two Gov4Nano summits

Transregulatory risk assessment summit (2019 & 2022)

To provide a forum to discuss knowledge needs for risk assessment, and to translate these needs into research questions for the scientific Community

- **Share lessons:** facilitating mutual learning amongst experts and stakeholders in an interdisciplinary and inter-domain fashion.
- **Identify priorities**: ensuring most urgent scientific information needs and regulatory issues are integrated in policy research agenda, in support to regulatory oversight and compliance.
- **Promote harmonization**: finding common solutions to relevant topics such as data gaps, test guidelines and harmonization of methods.
- **Identify operational research agendas**: translate nano-specific issues in inputs for research agendas, funding mechanisms and other incentives to support and further develop risk analysis approaches, knowledge and data.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement 814401

What do regulatory risk assessors want and need?

Ideal situation

- Regulatory requirements are in line with risk assessment needs
- Integration of knowledge among regulatory domains
- Consultation of regulatory risk assessors
- Structural inventory of knowledge gaps/needs
- Structural funding despite urgency of needs
- Monitoring system to ensure efficiency of process

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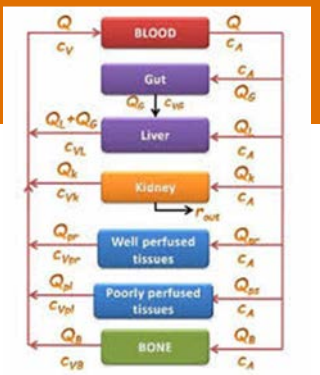
Results RRAS and follow up survey I



Research question to pursue (challenge)	Regulatory risk assessment issues to overcome (scope)
Develop case studies on prediction/measurement of the toxicokinetic behaviour, including - **transformation of NMs inside the body (internal exposure)** - **testing methods** - **measured data , considering issues of data quality and reliability**	Lack of knowledge on which physico-chemical characteristics are essential for risk assessment purposes within and across domains (definition) Lack of guidance in dealing with toxico-kinetics of nanomaterials (exposure)
Use- to the extent possible- lessons learned from other nanomaterials	Lack of understanding of the exposure pathways inside (human) body and outside (human) body (exposure) Lack of insight in reliability of in silico, in-vitro and in-vivo models toxico-kinetics and hazard (hazard) Limited availability of exposure/ release case studies, including measurements and guidance on exposure data, toxicokinetic data (risk assessment/ risk management) Data quality and reliability for the purpose of characterization and testing is questionable (definition)

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Results RRAS and follow up survey II

Research question to pursue (challenge)	Regulatory risk assessment issues to overcome (scope)
Identify the minimal panel of parameters to determine equivalence/similarity in the different areas of regulatory risk assessment (identity is covered in this), with respect to: - **Phys-chem (intrinsic and extrinsic),** - **Bioloqical interactions,** - **Toxicokinetics (ADME).** **Speed up the adoption of described parameters** **Identify parameters and criteria for grouping and read across (equivalence)**	Lack of knowledge on which physico-chemical characteristics are essential for risk assessment purposes within and across domains (definition). Lack of harmonised understanding of equivalence of nanomaterials in regulatory context (e.g. parameters and methods to test equivalence) (definition) Lack of grouping strategies (when are NM similar?) (definition)

Equivalence

Similarity

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Results RRAS and follow up survey III

Research question to pursue (challenge)	Regulatory risk assessment issues to overcome (scope)
Identify the usefulness of currently available non-nanomaterials exposure models for nanomaterials (external exposure). **If useful, validate the models for nanomaterials with measured data: share data, generate new data, incentives**	Lack of validated exposure models (exposure) Limited availability of exposure/ release case studies, including measurements and guidance on exposure data, toxicokinetic data (risk assessment/ risk management)

EXPOSURE

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Main conclusion RRAS and survey

- RRAS results are confirmed by follow up survey amongst more risk assessors from different domains
- RRAS results support recommendations from the ProSafe White Paper (2017)
  - *Recommendation 6: Where possible, calls for nanosafety projects should be far more specific in giving clear instructions to ensure that data and results generated are of a type and form which allows their use in topics of regulatory relevance, such as choice of materials, test methods to be applied, SOPs and data management. The NanoSafety Cluster could play a role in defining such conditions.*

- Risk assessors expressed the need for more informal transregulatory exchange of views and issues

REF: ProSafe (2017) The ProSafe White paper: Towards a more effective and efficient governance and regulation of nanomaterials. last visited July 2020

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2nd Regulatory Risk Assessment Summit (2022)

Keeping pace with European ambitions for safe and sustainable nanomaterials and products:

Main Actions

- banning most harmful chemicals in consumer products (unless essential) including PFAS;
- *"one substance one assessment"* for risk and hazard assessment of chemicals;
- account for the cocktail effect of chemicals when assessing risks from chemicals;
- boosting production and use of safe and sustainable by design chemicals;
- global role by promoting high standards and not exporting chemicals banned.

1. One substance one assessment
2. New endpoints for risk assessment (nano)

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Summary

ECHA-NMEG

Environment: **emission scenarios, relevant PECs**

Human health: dermal absorption, **irritation & corrosion (skin / eye),** reproduction/development toxicity, carcinogenicity/**long-term toxicity**

› Research needs

– Physico-chemical properties

- stability of the nanomaterials
- surface chemistry/reactivity

– Human health endpoints

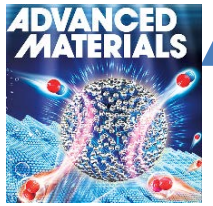
- dispersion stability in biological media and related dosing in toxicity testing
- dermal exposure route
- endocrine disruption, immunotoxicity, neurotoxicity, reprotoxicity

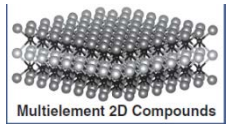
– Environmental endpoints

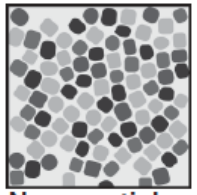
- long-term testing (including interference of feed)
- biotic and abiotic degradation/transformation persistence
- interactions with natural (particulate) matter (adsorption/desorption, heteroaggregation) mobility

Chemicals Strategy for Sustainability
Towards a toxic-free environment

New materials for innovations







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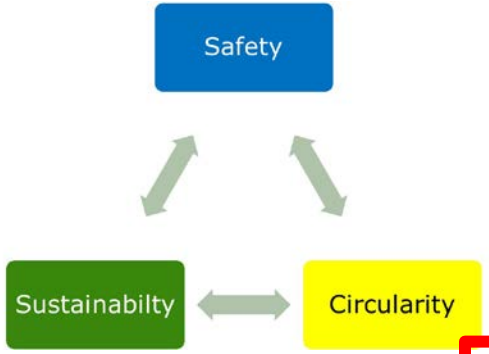

Non-toxic
Zero pollution
Sustainability

Nanosafety community

Proactive

Share lessons learned

Open to finding solutions with other regulatory communities and domains


Thank-you for
your attention

Thanks to all partners and people in NMBP-13 projects

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