# LabEx Tec 21's 2022 call for proposals

Tec 21 (http://www.tec21.fr) brings together the research community in mechanical and process engineering in Grenoble. Tec 21 has been selected as a "Laboratoire d'Excellence» and is supported by the French Government under the "**Investissements d'Avenir**" (investments for the future) initiative (http://investissement-avenir.gouvernement.fr). Tec21 has been renewed and extended for the 2020-2024 period.

## 1) Call for proposals: objectives

The main objective of the Tec 21 community is to gather new knowledge and to develop new methods in mechanical and in process engineering. The main aim is to address new scientific challenges arising from present societal issues in areas such as sustainable development, alternative resource management, green technologies, environmental impact, risk management, health care...

Such challenges often imply considering new mechanisms, new objects, complex interactions... understanding/modeling of which requires:

- improving macroscopic descriptions by the integration of more and more refined fundamental mechanisms arising at small scale(s),
- developing connections between mechanics and disciplines such as chemistry and biology using multi-physics approaches, often to be developed in a multi-scale context.

Such multi-scale multi-physics approaches will help to produce more reliable and versatile predictive tools for engineers, decision-makers or public services. They should also favour the emergence of new technologies. The present call for proposals is therefore mainly oriented towards fundamental research with the following objectives:

- to fund projects of the highest quality, with the potential to advance the frontiers of knowledge and/or to develop innovative methods,
- to foster the emergence within the Tec 21 community of strong pluridisciplinary groups on specific challenging scientific issues,
- to develop long-term international cooperation.

Within this framework, the following subject-area is preferentially supported:

**WP1 - Coupling fluid and solid mechanics**
**WP2 - Coupling fluid mechanics with bio-physico-chemical phenomena on a micro/nano-scale**
**WP3 - Engineering for human health**
**WP4 - Advanced numerical and experimental methods**

### WP1 - Coupling fluid and solid mechanics

Solid and fluid mechanics need to be combined in a large variety of natural as well as industrial systems, especially when looking at intimate coupling between fluid and solid phases (e.g. in very dense systems), or during transitions between solid-like and fluid-like behaviours. Progress is necessary in the mechanics and multi-scale characterisation of geomaterials (soil, rock, concrete, snow...), of industrial complex media (paste, fibre suspensions, porous media, metallic alloys, semi-conductors...), of very dense multi-phase flows (e.g. mud flows...), where one has to account for material complexity such as heterogeneities, anisotropy, polydispersity, prestress which can be pre-existing and/or induced by deformation and flow through processes such as migration, aggregation, fragmentation/fracture, and/or induced by other processes such as biocementation, suffusion, solidification… Extension of models and characterisation techniques to nano-scales are also required to better account for interactions between objects, for interfacial conditions … and to enrich modelling approaches notably based on generalized continuum media, multiscale homogenisation.

Current research themes:

a. **Solids in fluids**: The mechanical behaviour and the rheology of systems in which the scales of the solid elements and of the system are not clearly separated is an open issue. This particularly encompasses problems related to the flows of very dense suspensions involving segregation, migration, agglomeration, clustering, erosion, transport and deposition of sediments...
b. **Fluids in solids**: The percolation of a fluid within a solid matrix is a challenging task either due to the complexity of the porous solid network or of the complex fluids interacting with the solid skeleton (e.g. impregnation and drying in (micro-nano-)porous or fibrous materials, two-phase flows in porous networks, solidification...).
c. **Solid-fluid transition and associated instabilities:** Gravity movements triggering and stopping involve mechanical transitions between quasi-static and inertial deformation regimes. Progress is required on the characterisation of mechanical bifurcations (e.g. diffuse instabilities), on the formulation of unified rheological models, on the characterisation of rheological transitions and of fluidisation processes of solid-liquid-gas systems (wet snow, unsaturated soils…).
d. **Flow-structure interactions:** The interactions between flows of complex rheology and structures give rise to several fundamental issues such as the characterisation of energy dissipation and impact forces as a function of flow regime, the influence of dynamical coupling and structural damage...

**WP2 - Coupling fluid mechanics with bio-physical-chemical phenomena on a micro/nano-scale:**

Fluids are widely exploited to transfer mass, heat, energy... and the control of how they flow is often the key to process efficiency. Yet, in many circumstances, because of complex dynamic phenomena (turbulence, two-phase flows...) or because of strong couplings with chemical reactions or with biochemical transformations..., flows cannot be correctly predicted and controlled. Crucial progress regarding these issues is expected from the association of fluid mechanics with chemical and process engineering, over a wide range of scales in order to predict, control and/or intensify processes. Progress in these areas will contribute to the development of eco-technologies and clean technologies. In particular, new separation and fractionation processes need to be developed in order to comply with the so-called biorefinery concept aiming at preparing new molecules from vegetal biomass. Another goal concerns the development of efficient and controlled, bio filtration techniques.

Current research themes:

a. **Advanced fluid mechanics:** Multi-scale fluid mechanics including - for single phase flow - turbulence structure, intermittence in turbulence, micro-mixing (including high Schmidt numbers), turbulence control... and for multiphase flows - modelling of dense gas-liquid flows, interactions between turbulence and inclusions (bubbles, drops, solid particles), clustering, channelling, dispersion, spatial-temporal organisation at meso- and large- scale and their consequences on flow stability (sedimentation, flotation…), analysis of flow situations involving strong, unsteady (steep in time) gradients in shear, temperature…
b. **Interfacial dynamics and transfers:** Coupling flows and interfaces (fluid-fluid or fluid-solid boundaries), in particular with respect to heat transfer, phase change, chemical transfer and reactions, adsorption-desorption processes... with a special emphasis on complex interface topologies. This topic also includes wetting/dewetting dynamics. Efforts must be deployed in priority to integrate phenomena at both micrometer and nanometer length scales into the continuous modelling approaches.
c. **Flow and bacteria / bio filtration:** Coupling flow and living matter (such as bacteria) to understand the growth of biofilms under flow, i.e. spatial-temporal structuration of biofilms up to clogging, physiology adaptation to the flow-induced stress and its consequences on growth rate, adhesion… Ultimately the aim is to optimize and to control bioreactors.
d. **Bio refinery:** Develop new separation, and fractionation processes (membrane filtration, selective precipitation, liquid-liquid or liquid-solid extractions, catalysis, etc.) in order to prepare new molecules from vegetal biomass. This topic includes the design and modelling of new processes, as well as biobased material production (3D printing of multiphase gel, film casting, filtration, compression molding …). Low energy consuming processes as well as chemical modification routes of biomass that can be easily integrated on an industrial scale are important study topics.

### WP3 - Engineering for human health:

This subject-area is dedicated the dynamics of matter within living organisms, using concepts and methodologies from mechanics (fluids as well as solids) and soft matter physics. The association of all these disciplines is expected to lead to a better fundamental understanding of key processes in human biology. The main applications here are in human biology, e.g. cell mechanics and motility (cancer, vascular diseases...), thrombosis... as well as medicine, e.g. designing new medical devices or biomaterials or understanding the functioning of sub-systems e.g. heart, blood circulation, speech generation...

Current research themes:

a. **Cellular level:** Multi-scale modelling of the cell (at the nano-micro scale, i.e. the acto-myosin system scale), including cell growth, biological signalling, cell substrate or flow interaction along with the understanding and modeling of the spatio-temporal cell response under applied mechanical stress and within their microenvironment (3D cell migration in fibrous media, cell signaling).
b. **Connecting biology and mechanics:** Representation/prediction of the mechanical behavior of biological tissues (hyper-elasticity, visco-elasticity, poro-elasticity) based on reliable multi-scale approaches (micro and nano) for the analysis of cell/ECM/fluid systems, understanding the growth of tissues. Modeling and simulation of biological flows including fluid-structure interactions, under the influence of the different scales (micro and nano) e.g. in the mechanics of blood clotting (recruitment process, fibrin polymerisation, cell/platelet aggregation). Simulation of the functioning of whole organs within their physiological/mechanical environment is also worth to be attempted.
c. **Development of new biomaterials and biomedical devices.** This topic includes the development of new biomaterials (scaffolds, prosthesis, organ-on-a-chip, diagnostic tests, drug delivery systems) as well as establishing proofs of concept for diagnostic tools with clinical relevance.

### WP4 – Advanced numerical and experimental methods

Developing new methods such as modelling concepts, simulation, measuring techniques, signal processing, data analysis... are closely connected to scientific progress. Such developments are required for all the above-mentioned themes. The projects must be strongly innovative, able to go far beyond the current state of the art, and must have a large potential impact on the research activities in the Tec21 community (too specific proposals will not be favoured). These projects should clearly indicate how they complement, extent and/or built on the methods already used/developed within Tec21, and what are their medium term perspectives in terms of dissemination (internal as well as external to Tec21).

Current research themes:

a. **Advanced modelling and/or simulation approaches:** Emphasis will be put on developing new modelling concept and/or simulation approaches addressing issues for which current predictive tools either do not exist, or are too poor and unsatisfactory. Typical actions may include the description of complex systems, of the coupling between scales (double scale methods…), between diverse phenomena (mechanical, physico-chemical and/or biological processes…), of fluid-structure interactions accounting for the full deformability of objects and interfaces at different scales
b. **Advanced measuring techniques**: There is a strong need to provide fully resolved - both in space and time - fields at various scales (meter, micrometer and nanometer scale). Key issues in this area are related to the extent of the dynamical range (space and/or time), to the simultaneous capture of multivariable fields, to Eulerian and Lagrangian approaches as well as their combination, to the investigation of (complex) dynamics or (complex) systems, the development of refined data processing...

## 2) Opportunities

The 2022 edition of the Tec21 call for proposals is structured as follows:

| Grant | Topics supported | # of grants | Proposal submission deadline | Results calendar |
|---|---|---|---|---|
| Post-doc grant: one year **!!: Involvement of two laboratories from the Tec21 perimeter is mandatory** | All WPs | 3 Post-Doc fellowship | January 17th 2022. | May 1rst, 2022 |
| Outgoing grant[1)] | All WPs | 3 Outgoing grants | | |
| Short duration visitor grant[(2)]: to welcome foreign researchers for up to 2 months. **!!: short stay of one month only will also be allowed** | All WPs | 2 short visitors grants | | |

NB. Visitors are invited to give at least one seminar during their stay.

[(1)] Outgoing grant is to help permanent researcher who plans to spend one month (at least) abroad either in a university or in an industry. The objective is to help them building collaborations and/or moving to new research topics. Outgoing grant is a fixed amount of 3.3 Keuros, including one travel (back and forth) and per diems.

[(1)] Short visitor grant includes a fixed amount (per diem in France up to 2 months) and one travel (back and forth).

## 3) Proposal preparation and submission instructions

Proposals should be sent to cecile.bordier@tec21.fr before January 17th 2022
Each proposal (in English) will be submitted as a single pdf file (maximum size 10 Mo) organised as follows (see template):

**Front page**

- Project title
- Project PI and co-PI (with name, address, phone numbers, e-mail)
- Selected program (PhD program, Postdoc program, Outgoing program, Short visitor program, long visitor program) - select one only
- Selected research theme(s) - select 1 or 2 maximum

**Second page**

- Summary (half a page): project content and expected breakthrough
- Summary (half a page): structuring effect and collaborative aspects for the Tec 21 research community

**Next pages – project description (max 6 pages excluding annexes)**

- Context and objectives (1 page)
- Scientific program, including the research strategy (3 pages).
- Project organisation: tasks, schedule, work program for the recipient of a Post-Doc or PhD fellowship when applicable (1 page)
- Indicate the potential impact of expected research results (potential benefits to society) if relevant. (half a page)
- Involved members (half a page): for all investigators: names, institution, involvement (% time), skills and role in the project. For Post-Doc to be hired, expected role only.
- Annex: Curriculum Vitae of the main investigators including significant publications. References and letters of support are welcome.

## 4) Evaluation of proposals

All proposals (excepted short visitor and outgoing grant) will be analysed by 3 external reviewers selected by the Tec 21 Steering Committee according to the subject. The Steering Committee may involve extra reviewers depending on the proposed topic. Each reviewer will send a report to Tec 21 commenting on the following items:

i. Scientific quality and originality: The potential for the project to advance knowledge and understanding, or to propose new methods (in modelling, simulation, instrumentation). Does the proposed program explore creative and original concepts?

ii. Project organisation: Is the research strategy convincing? Is the proposed scientific program well organised and realistic?

iii. The qualification of the team and its ability to conduct the project,

iv. The adequation between the available resources and the project's objectives,

v. Potential impact of expected research results.

Based on these reports, the final decision will rest upon the Steering Committee. The Steering Committee will pay particular attention to proposals which give rise to the development of strong multidisciplinary groups on specific challenging scientific issues, within the Tec 21 community.

vi. Outline the project's benefits for the Tec 21 community: structuring effect and/or collaborative initiatives and/or key scientific outcomes useful for various WPs...

## 5) Who can apply?

All calls are open to the international scientific community with the only mandatory condition that the PI or the co-PI of the project is a Tec 21 permanent researcher.

=> The Tec 21 management team can help potential post-doc or short/long term visitor grants candidates to build a project in collaboration with one or more research teams within Tec 21. If interested, please contact: cecile.bordier@tec21.fr