# 2019

# Annual Report

## Laboratoire Génie Industriel
## Industrial Engineering Research Department

## LGI, EA 2606

Laboratoire Génie Industriel

CentraleSupélec

université PARIS-SACLAY

« Le Génie Industriel est la science du diagnostic, de la modélisation, de la simulation, de la conception, de l'exploitation et de la conduite du changement des systèmes d'activités.
*Industrial Engineering is the science of diagnostics, modeling, simulation, design, operation and change management of activity systems.*

Bernard Yannou, Director of LGI

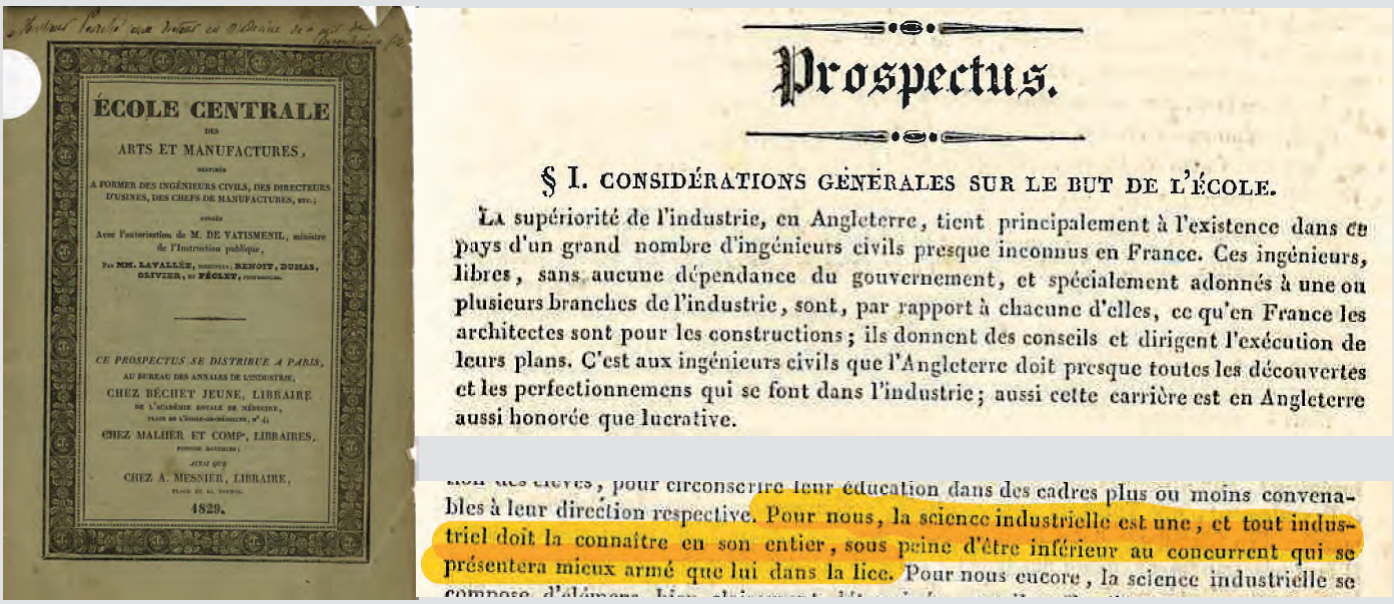
# This year...

**Il y a 190 ans**... CentraleSupélec a une longue tradition de service à l'industrie, d'excellence, d'enseignement et de diffusion des technologies de pointe et des approches organisationnelles adaptées à l'industrie et, au-delà, à tous les systèmes d'activités socio-économiques.
En effet, l'objectif de servir le développement industriel et socio-économique de la France était annoncé en préambule du programme pédagogique de l'Ecole Centrale des Arts et Manufactures lors de sa création en... 1829.
Le LGI s'insère dans cette tradition historique en faisant constamment évoluer ses axes de recherche pour répondre aux défis actuels et futurs. Ainsi, le LGI s'est donné trois axes stratégiques de développement :

- La modélisation d'une activité sous forme de système de systèmes (SoS)
- La digitalisation des activités et systèmes
- La durabilité des activités, sur le plan environnemental mais également socio-économique

***190 years ago...*** *CentraleSupélec has a long tradition of service to industry, excellence, teaching and dissemination of leading-edge technologies and organizational approaches adapted to industry and, beyond, to all systems of socio-economic activities.*
*Indeed, the objective of serving the industrial and socio-economic development of France was announced in the preamble of the pedagogical program of the Ecole Centrale des Arts et Manufactures when it was created in... 1829.*
*The LGI is part of this historical tradition but constantly evolves its lines of research to meet current and future challenges. Thus, the LGI has given itself three strategic axes of development:*

- *The modeling of an activity in the form of a system of systems (SoS)*
- *Digitalization of activities and systems*
- *Sustainability of the activities, both environmentally and socio-economically*


ÉCOLE CENTRALE
DES
ARTS ET MANUFACTURES,
1829.

Prospectus.

§ I. CONSIDÉRATIONS GÉNÉRALES SUR LE BUT DE L'ÉCOLE.

La supériorité de l'industrie, en Angleterre, tient principalement à l'existence dans ce pays d'un grand nombre d'ingénieurs civils presque inconnus en France. Ces ingénieurs, libres, sans aucune dépendance du gouvernement, et spécialement adonnés à une ou plusieurs branches de l'industrie, sont, par rapport à chacune d'elles, ce qu'en France les architectes sont pour les constructions; ils donnent des conseils et dirigent l'exécution de leurs plans. C'est aux ingénieurs civils que l'Angleterre doit presque toutes les découvertes et les perfectionnemens qui se font dans l'industrie; aussi cette carrière est en Angleterre aussi honorée que lucrative.

bles à leur direction respective. Pour nous, la science industrielle est une, et tout industriel doit la connaître en son entier, sous peine d'être inférieur au concurrent qui se présentera mieux armé que lui dans la lice. Pour nous encore, la science industrielle se

**La modélisation d'une activité sous forme de système de systèmes (SoS)** traduit le fait qu'on ne peut plus concevoir une solution (ou offre de valeur) sans modéliser les autres systèmes avec lesquels cette solution va interagir. Une solution doit contribuer du mieux possible à la performance globale du système de systèmes. Nous avons ainsi lancé avec l'ESTIA (Ecole Supérieure des Technologies Industrielles Avancées) la chaire FlexTech qui porte sur « l'intégration humains-systèmes dans les systèmes complexes à autonomie croissante ». De même, la chaire « Science des Systèmes et Défis Energétiques » portée jusqu'à présent par EDF s'ouvre maintenant à d'autres partenaires industriels (SNCF, AdP, Orange) pour traiter des problématiques de propagation inter-systèmes pour une résilience accrue du système de systèmes. Enfin, les collègues du LGI s'investissent dans la réforme de l'enseignement du cursus unifié en étant acteurs de la dominante 3A intitulée « Grands Systèmes en Interaction », particulièrement les mentions « Sciences de la Conception et des Systèmes » et « Gestion des Opérations et Supply Chain ».

**La digitalisation des activités et systèmes** se traduit par le fait que le LGI est investi sur le thème de l'Industrie du Futur. Anne Barros a été nommée co-responsable de la coordination des actions concernant l'Industrie du Futur à CentraleSupélec. Nous avons également mis en œuvre, en collaboration avec le LURPA de l'ENS Paris-Saclay, la première édition d'une université d'été internationale de deux semaines sur l'industrie 4.0, en juillet 2019. Avec 16 étudiants (de 8 pays et 4 continents), elle a été un succès et a pour vocation d'être une école internationale d'été phare de l'Université Paris Saclay. L'offre du Master Ingénierie des Systèmes Complexes de l'Université Paris-Saclay[1] a également évolué pour prendre en compte le digital et les systèmes. Enfin, notons des axes de recherche croissants sur les thématiques de l'utilisation des technologies de la blockchain pour l'évolution des activités de la supply chain ou encore les stratégies et techniques de maintenance prédictive (voir aussi par la suite le thème « Industrie du Futur »).

**La durabilité des activités, sur le plan environnemental mais aussi socio-économique** se traduit par la création d'une chaire « Pilotage de l'Economie Circulaire (PEC) ». L'originalité de cette chaire est de s'articuler et faire dialoguer deux points de vue complémentaires :

- Une approche d'économie centrée sur des indicateurs financiers permettant de piloter des décisions d'investissement « circulaires » à moyen et à long terme, intégrant des dimensions sociales et locales. Il s'agira d'intégrer dans les tableaux de bord stratégiques existants des indicateurs financiers permettant de traduire les bénéfices et les coûts engagés par une stratégie d'économie circulaire.
- Une approche de gestion industrielle qui consiste à produire des indicateurs de circularité[2] à l'échelle d'un périmètre industriel ou d'un territoire. Ces indicateurs auront pour objectif de mesurer puis op-

1 Voir ici : https://www.universite-paris-saclay.fr/formation/master/ingenierie-des-systemes-complexes

2 Voir : Saidani M., Yannou B., Leroy Y., Cluzel F., Kendall A. (2019). A taxonomy of circular economy indicators. Journal of Cleaner Production, 207, 542-559, doi: 10.1016/j.jclepro.2018.10.014, https://hal.archives-ouvertes.fr/hal-01954800v1

***Modeling an activity as a system of systems (SoS)*** *reflects the fact that you can no longer design a solution (or value proposition) without modeling the other systems with which that solution will interact. A solution must, in a way, best contribute to the overall performance of the system of systems. With ESTIA (Ecole Supérieure des Technologies Industrielles Avancées), we have therefore launched the FlexTech chair on "human-system integration in complex systems with increasing autonomy". Similarly, the "Energy Systems Science and Challenges" chair, hitherto held by EDF, is now open to other industrial partners (SNCF, AdP, Orange) to deal with issues of inter-system risk propagation for increased system resilience. Finally, the colleagues of the LGI are involved in the reform of the teaching of the unified curriculum by being actors of the 3A major entitled "Large Systems in Interaction" and by carrying particularly the mentions "Design and Systems Sciences" and "Operations Management and Supply Chain".*

***The digitalization of activities and systems*** *is reflected by the fact that the LGI is invested in the theme of the Industry of the Future. Anne Barros has been appointed co-responsible for the coordination of actions concerning the Industry of the Future at CentraleSupélec. We have also implemented, in collaboration with the LURPA of ENS Paris-Saclay, the first edition of a two-week international summer school on Industry 4.0, in July 2019. With 16 students (from 8 countries and 4 continents), it has been a success and has the vocation to be a flagship international summer school of the University Paris Saclay's offer. The offer of the Master's Degree in Complex Systems Engineering of the University Paris-Saclay has also evolved to take into account digital and systems. Finally, there are growing research axes on the use of blockchain technologies for the evolution of supply chain activities or predictive maintenance strategies and techniques. (see also the «Industry of the Future» theme).*

***The sustainability of the activities, both environmentally and socio-economically****, is reflected in the creation of a chair "canher en Monitoring the Circular Economy (PEC)". The originality of this chair is to articulate and dialogue two complementary points of view:*

- *An economic approach centred on financial indicators enabling medium and long-term "circular" investment decisions to be steered, integrating social and local dimensions. The aim will be to integrate financial indicators into the existing strategic management charts in order to translate the benefits and costs incurred by a circular economy strategy.*
- *An industrial management approach that consists in producing circularity indicators on the scale of an industrial perimeter or a territory. The objective of these indicators will be to measure, then optimize and pilot the reduction of material and energy flows.*

*More generally, the Sustainable Economy team is working on sustainability approaches with regard to energy mix policies and economic models for electric and autonomous mobility, and the Design Engineering team is working to strengthen ecodesign and circularity indicator approaches in the management of industrial systems. (see also the "Circular Economy" theme below).*

timiser et piloter la réduction des flux de matière et d'énergie.

Plus généralement, l'équipe Economie Durable travaille à des approches de durabilité en ce qui concerne les politiques de mix énergétiques et les modèles économiques pour la mobilité électrique et autonome, et l'équipe Ingénierie de la Conception travaille à renforcer les approches d'écoconception et d'indicateurs de circularité dans la gestion des systèmes industriels. (voir aussi par la suite le thème « Economie Circulaire »)

Enfin, Pascal da Costa a été nommé responsable de la coordination des actions « Développement Durable & Transitions » à CentraleSupélec.

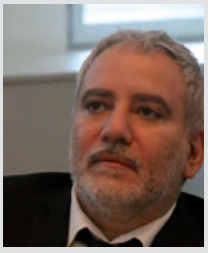
**Evolution des personnels**

Trois nouveaux enseignants-chercheurs ont rejoint le LGI en septembre. **Anne Barros**, Professeur en gestion des risques, fiabilité, sureté de fonctionnement, prend la direction de l'équipe **Sureté et Risques**. **Yannick Perez**, professeur d'économie de la mobilité intègre l'équipe **Economie Durable** et co-dirige la chaire Armand Peugeot. **Guillaume Lamé**, Maître de Conférences en supply chain et organisation des systèmes de santé, intègre l'équipe **Management des Opérations**.

*Finally, Pascal da Costa has been appointed head of the coordination of "Sustainable Development & Transitions" actions at CentraleSupélec.*

***Staff development***

*Three new teacher-researchers joined the LGI in September. Anne Barros, Professor in Risk Management, Reliability, Operational Safety, takes over the management of the Safety and Risks team. Yannick Perez, Professor of Mobility Economics, joins the Sustainable Economy team and co-directs the Armand Peugeot Chair. Guillaume Lamé, Assistant Professor in Supply Chain and Organization of Healthcare Systems, joins the Operations Management team.*



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# Aim and scope

Industrial engineering is a well-established discipline worldwide. Despite the variety of names of research departments, curricula and doctoral schools in international universities, it often amounts to "Industrial, System Engineering and Management". The objects of study of our scientific discipline are (1) Product-Service Systems and (b) as-is and to-be production or activity systems.
These systems purposely exist to deliver adapted and optimal performances and create values to users through functions and services. These systems are designed, manufactured and delivered, exploited, maintained, updated and recycled. These systems are described by their architecture, are made of components, are configurable and demonstrate different properties like robustness, flexibility, agility, resilience, safety... Our scientific language is also made of processes, resources, performances, costs, risks, business models, decisions, needs, preferences, competencies, projects, tasks, flows, stakeholders, value chains, supply chains, innovation, strategy, investments, economic and societal impacts...

The Industrial Engineering (IE) Research Department (Laboratoire Génie Industriel, LGI) studies production, activity or socio-technical systems along their life cycles. These systems are engineered by humans and must be observed, diagnosed, specified, designed, improved, manufactured, deployed, exploited, regulated, maintained and recycled. These systems (see Figure 1) are industrial systems (production systems, value chains, eco-parks), complex products (airplanes, cars...), complex factories, transportation systems, health systems, energy networks, service systems and construction systems.

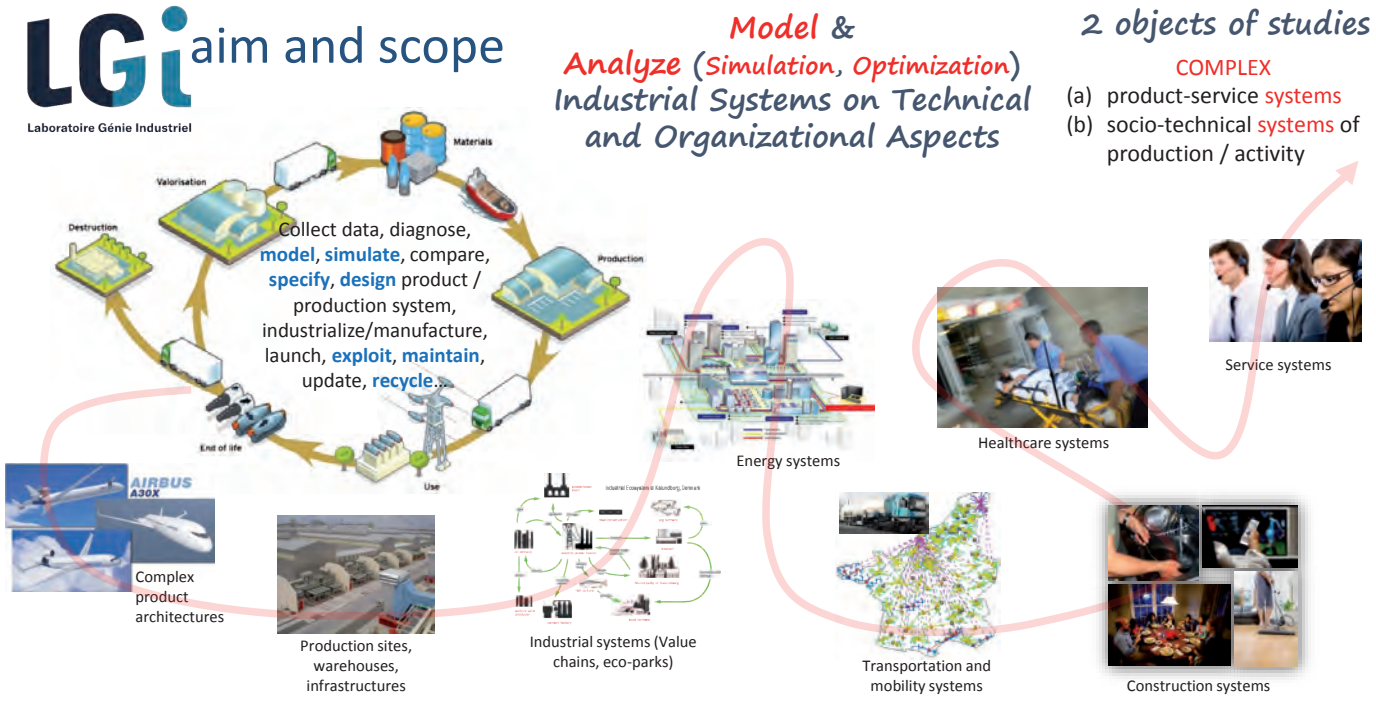


*Figure 1: LGI studies production, activity or socio-technical systems along their life cycles*

Key principles of our research are: multidisciplinarity, life-cycle thinking (see Figure 2), societal and economical issues, model-based engineering approaches.

The systems we study are often characterized by the following:

- the presence of sophisticated technical components but also of human agents (organizations, policy makers, operators),
- a large number of individual components that interact,
- heterogeneity of these components, each with specific individual behavior,
- systems that must often be analyzed at different physical, spatial and temporal scales and from different points of view (technical performance, cost, environmental impacts, material flows, skills...), see for instance Figure 3,
- a system feedback on its components and the emergence of macroscopic properties.

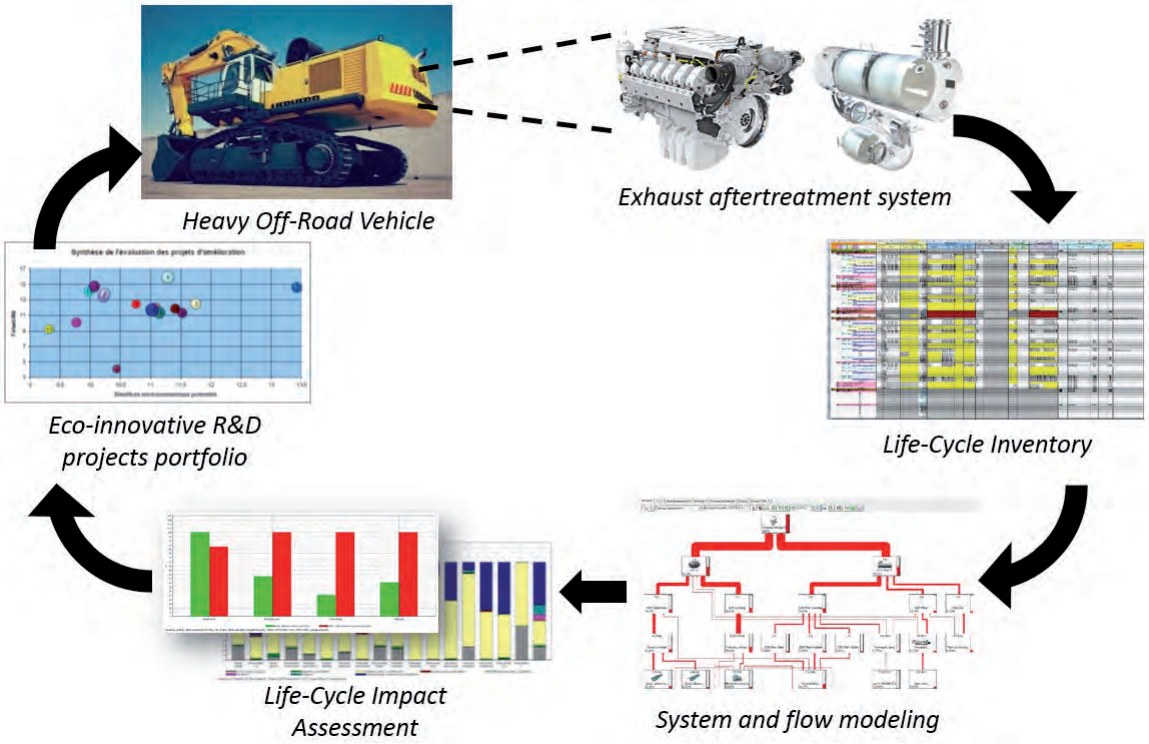


*Figure 2: Life Cycle Assessment & Eco-Design of complex industrial systems*


*Figure 3: Simulation of a kitting automated cell (robot-operator collaboration upstream of an assembly line)*

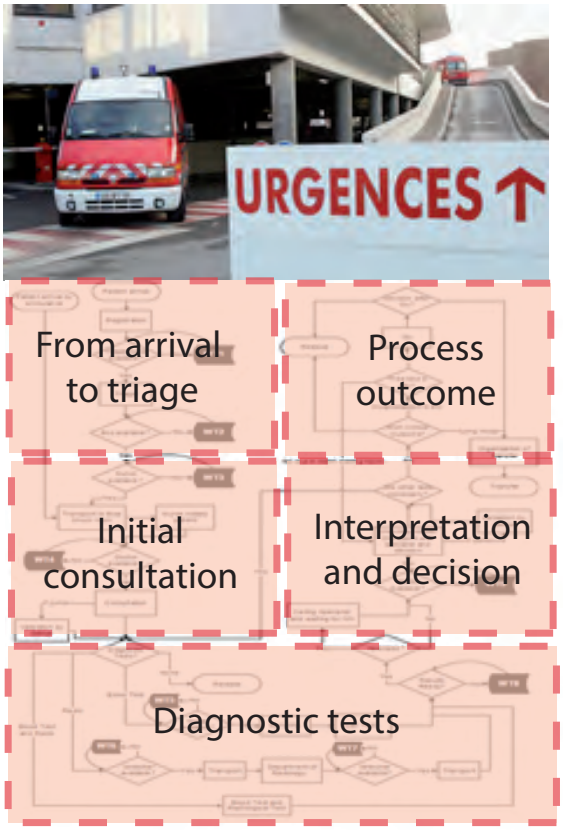


*Figure 4: Optimization of patient flows in emergency services*

The control of such systems presents many challenges and issues from both a technical and scientific point of view as well as practical and application perspectives like financial profitability, efficiency, continuity and reliability of service, security, resilience. The integration of technical systems is already challenging regarding, for example, aerospace, automotive or energy systems, but it is even more complex when it comes to inter-network systems ("System of Systems" paradigm) such as health systems, human mobility infrastructure, distribution of products and services, transport and regulation of energy, gas, water, and other socio-technical systems including human or various agents such as organizations with different and even contradictory strategies, goals and preferences.

Our scientific approach consists in adequately modeling for analyzing and simulating (see Figure 4) in order to better understand the system behavior through virtual experiments on models and, ultimately, finding optimal solutions for the design, deployment and monitoring. Often many life cycle phases of these systems must be modeled and analyzed: collection of needs and requirements specification, development (architectural design, dimensioning, validation, manufacture and market launch or startup), system management (its regulation, its maintenance, its failure modes, its upgrade, its dismantling and end of life).

# Organization

**LGI is organized in 4 research groups, 5 transversal themes and 10 industrial chairs. The 4 research groups have 3 research axis each (see Table 1). The 5 transversal themes are: Mobility systems, Energy systems, Healthcare systems, Industry of the future, Circular economy. The 10 industrial chairs are presented in Table 2.**

| | | | |
|---|---|---|---|
| 1. Design Engineering | Design of Complex Systems | Design of Sustainable Systems | Innovation Engineering |
| 2. Opérations Management | Operations management for the production and distribution of goods | Management of service operations | |
| 3. Safety and Risks | Complex systems and infrastructures, cyber-physical systems | Industry 4.0 and predictive maintenance | Resilience |
| 4. Sustainable Economy | Economy and Management of Innovation | Economy and Management of Mobility | Economy and Management of Energy |

*Table 1: The research axes of the four research teams*

| Chair | Industrial partners / academic partners |
|---|---|
| Maîtrise des risques liés aux achats dans les projets complexes (2013+)<br>*Control of procurement risks in complex projects* | Total |
| Anthropolis – Conception de systèmes urbains centrés utilisateurs (2014+) - *Human-centered urban systems design* | [RATP, SNCF, Renault, Alstom, Engie] till August 2019<br>2nd edition continued with [EDF, Engie, Nokia Bell Labs, Renault] since October 2019<br>/ IRT SystemX |
| Supply Chain (2010+) | [LVMH, Sanofi, Carrefour, Safran] till January 2019<br>3rd edition continued with [Safran, L'Oréal, Air Liquide] since September 2020 |
| Call Centers (2016+) | Interact'iv |
| Science des Systèmes et Défis Energétiques<br>*Systems Science and Energy Challenges* | EDF |
| Blériot-Fabre - Conception de systèmes aéronautiques embarqués robustes (2014+)<br>*Design of robust on-board aeronautical systems* | Safran |
| Armand Peugeot – Technologies hybrides et économie de l'électro-mobilité (2014+)<br>*Hybrid technologies and the economics of electro-mobility* | PSA Peugeot Citroën / Geeps, ESSEC |
| Economie de la Croissance Durable (2011+)<br>*Sustainable Growth Economy* | Capitaldon |
| FlexTech - Intégration humains-systèmes dans les systèmes complexes à autonomie croissante<br>*Human-system integration in complex systems with increasing autonomy* | ESTIA (Ecole supérieure des technologies industrielles avancées) |
| Pilotage de l'Economie Circulaire<br>*Monitoring of Circular Economy* | Communauté Paris-Saclay, SIOM (Syndicat Inter-communal des Ordures Ménagères, VALE NC) |

*Table 2: The 10 industrial chairs*

## Industrial Partners (currently)

- Automotive industry/transport: Renault, PSA, Valéo, Akka Technologies, RATP, SNCF, Alstom
- Aeronautics : Thalès, Safran, Airbus, AdP
- Energy : EDF, Total, Engie
- Information science: IBM, Place des leads, Interact-IV
- Control: Schneider Electric, Siemens
- Services: IWIPS, Leynaud & Associés, Etablissement Français du Sang, Mairie de Paris, Le Basic, CapitalDon
- Goods: LVMH, Sanofi, Carrefour, L'Oréal
- Construction: Bouygues Construction
- Research institutes: CEA, IRT SystemX, VEDECOM, Agence Régionale de Santé
- IT: Orange, Nokia Bell Labs

## Academic Partners (currently)

More than 50 collaborations abroad: Allemagne (Université de Magdeburg, TU Munich, Université de Nuremberg Erlangen), Angleterre (University of Liverpool, University of Bath, The Open University, University of Cambridge), Australie (University of Queensland, Université de Melbourne), Autriche (University of Vienna), Belgique (Université de Louvain, Université de Mons), Brésil (UFRJ, PUC, Université de Lavras), Canada (Mc Gill University, ETS), Chine (Beihang University, Ecole Centrale Beijing, Wuhan University of Technology, University of Honk Kong, UESTC), Danemark (DTU), Espagne (Université de Valence), Finlande (University of Helsinki, Aalto University), Italie (Politecnico di Milano, Politecnico di Turino), Japon (Chiba University, RITE-Kyoto), Liban (Université de Beyrouth), Luxembourg (Université de Luxembourg), Maroc (Ecole Centrale de Casablanca), Norvège (University of Stavanger), Pays-Bas (VU University Amsterdam), Singapour (SUTD), Suisse (HEC Lausanne, ETHZ), Tunisie (ENIT, ENIM), Turquie (Koç University), USA (Northwestern University Chicago, MIT, Penn State University, Georgia Institute of Technology, Iowa State University, University of Minnesota, University of Illinois at Urbana-Champaign, Illinois University).

# KEY FIGURES 2019

96 members
Faculties: 30
PhD Candidates: 52
Postdoctoral Researchers: 8
Technical and administrative staffs: 6
Visiting scholars: 3
Journals Papers: 61
Contracts: 1,59 M€, including Chairs

LGi DESIGN ENGINEERING

Industrial Engineering Research Department

# Design Engineering Research Group 2018

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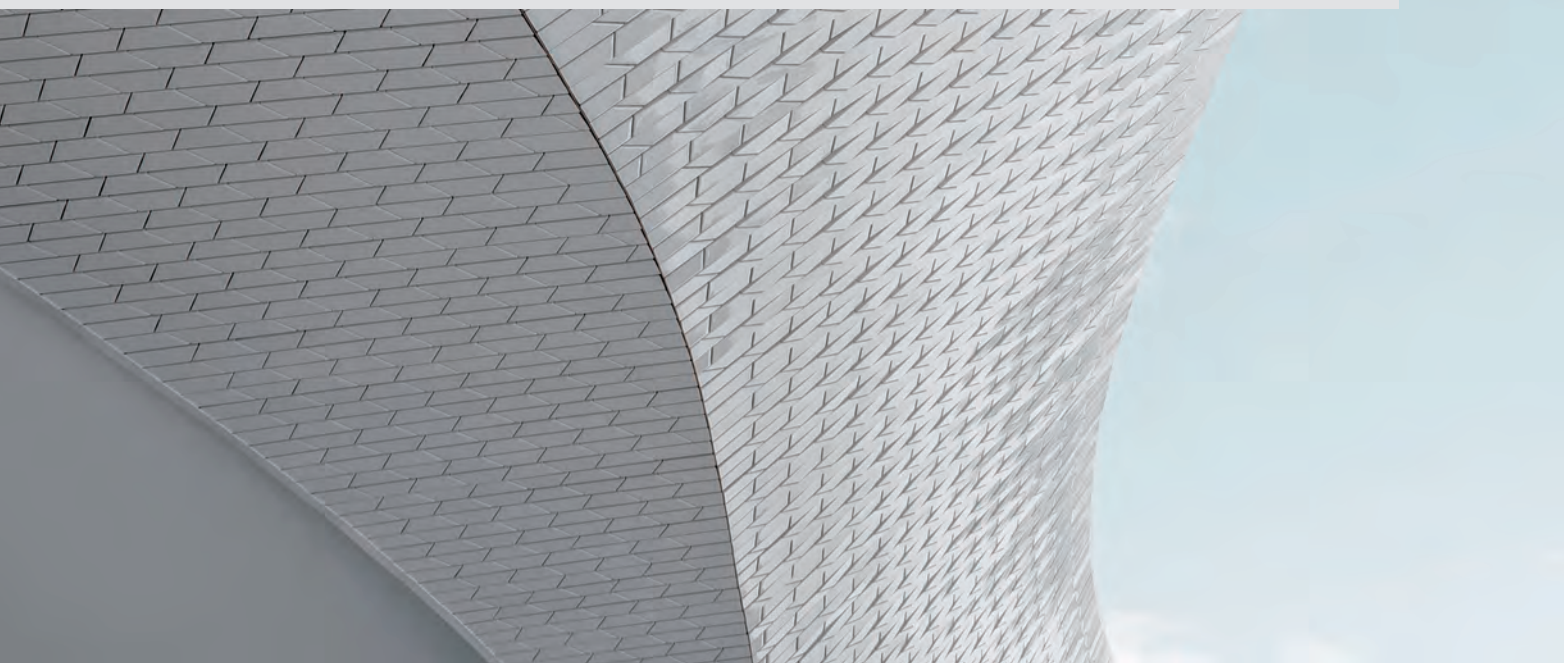

LGi DESIGN ENGINEERING

Industrial Engineering Research Department

**Head** | Franck Marle

**9 Faculty members**: Guy André Boy, François Cluzel, Marija Jankovic, Julie Le Cardinal, Yann Leroy, Franck Marle, Flore Vallet, Ludovic-Alexandre Vidal, Bernard Yannou
**4 Postdoctoral researchers**: Alexandre Bekhradi, Andreas Hein, Olivier Pialot, Michaël Saidani
**19 PhD candidates**: Ouail Al Maghraoui, Sylvain Bolifraud, Stélian Carmara Dit Pinto, Youssef Damak, Mathieu Dernis, Sarra Fakhfakh, Naouress Fatfouta, Ilia Iuskevich, Meriam Kiliani, Yiming Ma, Joseph Mansour Salame, Diya Moubdi, Lara Qasim, Chloe Rolos, Yasmine Salehy, Timothé Sissoko, Marcel Lowell Villanueva, Reza Vosooghi, Rongyan Zou.

# Research

## Research areas and results

Our research aims at assisting complex system design and engineering activities, combining the product/service, process and organizational dimensions. The main topics are about diagnosing, modeling, analyzing, simulating and optimizing those complex systems. Our team is organized around 3 axes:

1. **Design of complex systems**: it aims at developing methods and tools supporting decision-making with regard to design of products/services/systems, organizations, projects, and systems of systems. In 2019, results notably were a decision support framework to solve design problems, a model to know when to make decisions, a scenario-based modeling in a hospital's division, a shared autonomous vehicle simulation and service design model, and a decision-making process for assessing and selecting in-country value strategies in the context of complex designs.

The Chair FlexTech has been launched, hold by Prof. Guy Boy, and in collaboration with Armée de l'Air, Total, Dassault Systèmes and Thalès. The Chair with Total about complex projects has been renewed until 2022.

2. **Design of sustainable systems**: aims at developing methods and tools to model, measure and optimize sustainable performances of complex systems. In 2019, main results dealt with the development of eco-design methodologies (including architecture generation), and environmental impact assessment. The development of circularity indicators is still a main research topic. The launch of the chair "Monotoring circular economy" with Communauté d'agglomération Paris-Saclay, SIOM, Vale NC and the National Institute on Circular Economy (INEC) will support actively this activity research. New research works have also been initiated on eco-design of digital services and the generation of sustainable architectures of complex industrial systems.

3. **Innovation engineering** consists in bridging the gap between business strategy, R&D planning, product roadmaps, conceptual design and innovation processes. In addition, we are developing and enhancing a structured need seeker innovation methodology, named Radical Innovation Design®, for pulling disruptive innovations from the observation of painful usage situations. Main results in 2019 were about the modeling of travel experience to favor innovation in user-centered mobility, and about the integration of seniors in participative design, with the Silver Valley cluster.

## Research Project

We aim at integrating our design science-based approaches at a higher system level, integrating also the digitalization of such systems and associated organizations. More precisely, for axis 1, the research project deals with systems of systems design, deeper modeling of interdependencies between system and project components, synchronization or sequencing of multiple interrelated decisions, and integration of innovative management modes (notably considering the co-existence with traditional management modes). Axis 2 aims at developing and promoting circular economy, evolving from an evaluation to a management mode, including a prioritization of actions and investments. This will be based on the improvement of multi-criteria multi-scale and multi-actor simulation and optimization models. About the innovation engineering axis (axis 3), the project is twofold: characterizing the potential of a technology and digitalizing innovation. The first topic will enable companies to push innovative technologies on markets, but also to propose maturity roadmaps, with potential markets associated to each technological maturity level. The second one aims at making design and innovation activities more efficient, attractive and fluid.

## In 2019

32 Members
2 Research chairs
4 PhDs completed
13 Journals
19 Conference papers
2 Book sections

# Selected Publications

Franck Marle, Hadi Jaber, Catherine Pointurier. Organizing Project Actors for Collective Decision-Making about Interdependent Risks. *Complexity*, Wiley, 2019, 2019, pp.1-18.

Michael Saidani, Bernard Yannou, Yann Leroy, François Cluzel, Alissa Kendall. A taxonomy of circular economy indicators. *Journal of Cleaner Production*, Elsevier, 2019, 207, pp.542-559.

Reza Vosooghi, Jakob Puchinger, Marija Jankovic, Anthony Vouillon. Shared Autonomous Vehicle Simulation and Service Design. *Transportation research. Part C, Emerging technologies*, Elsevier, 2019, 107, pp.15-33.

Guillaume Lamé, Oualid Jouini, Julie Stal-Le Cardinal. Combining Soft Systems Methodology, Ethnographic Observation and Discrete-Event Simulation: A Case Study in Cancer Care. *Journal of the Operational Research Society*, Palgrave Macmillan, 2019, pp.1-18.

Michael Saidani, Alissa Kendall, Bernard Yannou, Yann Leroy, François Cluzel. Closing the loop on platinum from catalytic converters: Contributions from material flow analysis and circularity indicators. *Journal of Industrial Ecology*, Wiley, 2019, pp. 1143-1158.

Ouail Al Maghraoui, Flore Vallet, Jakob Puchinger, Bernard Yannou. Modeling traveler experience for designing urban mobility systems. *Design Science*, 2019, 5.

# Collaborations

**Academic Collaborations (in 2019)**
*Béatrice Bellini* (Université Paris Nanterre), *Carole Charbuillet* (Institut Arts & Métiers Chambéry), *Daniela Pigosso* (Technical University of Denmark, DTU), *Harrison Kim*, (University of Illinois at Urbana-Champaign, USA), *Alissa Kendall*, (UC Davis, USA), *Guillaume Lamé*, (Cambridge University, UK), *Anthony Delahaye, Laurence Fournaison, Hoang Hong Minh* (INRAE), *Thierry Gidel* (Université de Technologie de Compiègne), *Henriette Cornet*, (TUM Create, Singapour), *Nicolas Perry*, (Ensam Bordeaux), *Michel-Alexandre Cardin* (Imperial College), *Camille Jean* (ENSAM), *Sandro Wartzack* (Univ Magdeburg), *Pascal Le Masson* (Mines de Paris), *Chris Paredis* (Clemson University), *Benoît Eynard* (Université de Technologie de Compiègne), *Claudia Eckert* (Open University), *Dorjan Marianovic* (Univ. Zagreb)

**Industrial and institutional collaborations (in 2019)**
TOTAL, ESTIA, Armée de l'Air, Dassault Systèmes, Thalès, Renault, Airbus, Orange, DGA, Groupe PSA, Vinci Construction, RTE, iWips, Manitou, IRT SystemX, SNCF Réseau, Cluster Silver Valley.

**Invited Professor (in 2019)**
Michael Kokkolaras (McGill University, Canada)

# 4 Recent PhDs

Mathieu DERNIS "*Modeling and measuring values brought to host country for assisting decisions in In-Country-Value strategies elaboration*"

Ouail AL MAGHRAOUI "*Designing for urban mobility: modeling the traveler experience*"

Réza VOSOOGHI "*Shared Autonomous vehicle service design, modeling, and simulation*"

Timothé SISSOKO "S*upporting decision-making for solving design issues in the development phase of automotive vehicles*"

# Members

**Faculty members**

| | | |
|---|---|---|
|  | Guy André BOY<br>Professor<br>guy-andre.boy@centralesupelec.fr<br>Chair Holder “FlexTech” | Human-Systems Integration, Human-Centered Design, Cognitive engineering, Human-Computer Interaction, Human Factors and Ergonomics, Knowledge management, Artificial Intelligence, Complexity Science, Organization Design and Management, Advanced Interaction Media, Life Critical Systems, Modeling and Simulation, Aerospace Systems. |
|  | François CLUZEL<br>Assistant professor<br>francois.cluzel@centralesupelec.fr | Eco-design, Innovation engineering, Eco-innovation, Industrial ecology , Life-Cycle Assessment (LCA), Artificial intelligence in design, Design automation |
|  | Marija JANKOVIC<br>Associate professor<br>marija.jankovic@centralesupelec.fr | Complex system design, System architecture design, Innovation engineering, Collaborative engineering, Healthcare system engineering |
|  | Julie LE CARDINAL<br>Professor<br>julie.le-cardinal@centralesupelec.fr<br>Head of “Enterprises Sciences” Education Department | Facilitating decision-making, Systemic modeling, Knowledge management, Choice of actors, Complex system design, Healthcare system engineering |
|  | Yann LEROY<br>Assistant professor<br>yann.leroy@centralesupelec.fr | Ecodesign, Life Cycle Assessment, Sustainable design, Eco-innovation, Industrial Engineering Life Cycle Engineering, Recycling |
|  | Franck MARLE<br>Professor<br>franck.marle@centralesupelec.fr | Project management, Complex projects, Contracts & procurement, Project risks, Project vulnerability, Complexity modeling, Topological analysis, Propagation analysis, Clustering, Decision-making |
|  | Flore VALLET<br>Assistant professor<br>flore.vallet@centralesupelec.fr<br>Working for Chair “Anthropolis” with IRT-SystemX | Eco-design, Innovation engineering, Eco-innovation, Life Cycle Assessment, Urban mobility, Sustainable mobility, Industrial design |
|  | Ludovic-Alexandre VIDAL<br>Assistant professor<br>ludovic-alexandre.vidal@centralesupelec.fr | Project management, Risk management, Complexity, System thinking |
|  | Bernard YANNOU<br>Professor<br>bernard.yannou@centralesupelec.fr<br>Director of LGI | Design automation, Design methodologies, Product development, Innovation engineering, Ecodesign, Artificial intelligence in design, Design processes and management |

**Postdoctoral researchers & PhD candidates**

LGi

OPERATIONS MANAGEMENT

Industrial Engineering Research Department

# Operations Management Group 2019

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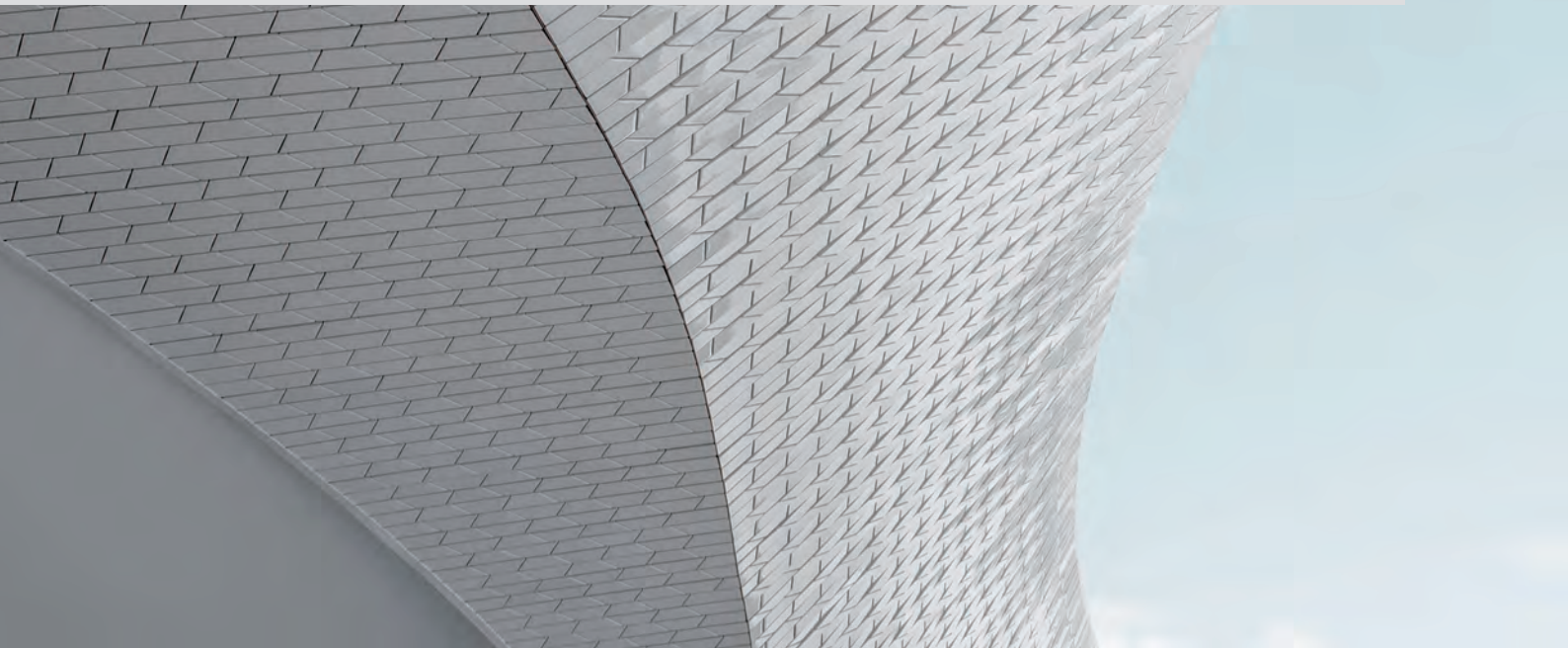

LGi OPERATIONS MANAGEMENT

Industrial Engineering Research Department

**Head** | Jakob Puchinger

**10 Faculty members**: Walid Behiri, Yves Dallery, Asma Ghaffari, Zied Jemaï, Oualid Jouini, Guillaume Lamé, Benjamin Legros, Jakob Puchinger, Fouad Riane, Evren Sahin
**1 Postdoctorale researcher**: Hicham Benbitour
**14 PhD candidates**: Ouail Al Maghraoui, Selmen Boubaker, Mathieu Dernis, Sadèque Hamdan, Najoua Lakhmi, Marc-Olivier Metais, Abood Mourad, Gustavo Santamaria-Acevedo, Haythem Selmi, Yue Su, Reza Vosooghi, Shaohua Yu, Yizeng Zeng, Zhe Yuan

# Research

The group's research activities are concerned with the development of approaches, methods and tools for designing, planning and managing systems for the production and distribution of goods and services. Our goal is to propose solutions to problems appearing in real-world applications. The group mainly covers the Operations Management research domain. Our research is mainly based on the complementarity of qualitative and quantitative approaches.

The first ones allow to qualify and structure the problems to be tackled with regards to its major challenges and dimensions (economic, environmental, human and societal, risk, ...). Second, starting from a formalized problem description, we base our work on quantitative approaches for modeling, analyzing, simulating, evaluating and improving performances and optimizing the studied systems. There exists multiple tools and methods supporting decision aid.

The use of those two complementary approaches will lead us to use, adapt and develop new methodological and formal approaches applicable in a more generic scope than the applications they were originally developed for.

The group addresses the following two main research areas

- **Operations management for the production and distribution of goods**: This is a major topic for many industrial companies in all sectors as well as for retail companies (large retail chains, specialized retail, e-commerce). The common challenge is the ability to improve the responses to client expectations while guaranteeing a sustainable development.

- **Operations management for services**: Optimizing the performances of service related activities is key to achieve client satisfaction (service quality, waiting times, etc.) and production efficiency (investment cost, operational cost, environmental impact, sustainability, etc.).

# In 2019

25 Members
3 Research chairs
5 PhDs completed
20 Journals
12 Conference papers
1 Book section

# 5 Recent PhDs

Ouail AL MAGHRAOUI *"Designing for urban mobility: modeling the traveler experience"*

Abood MOURAD *"The synchronization of shared mobility flows in urban environments"*

Selmen BOUBAKER *"Models for Assessing and improving supply chain agility"*

Zhe YUAN *"Optimal models for the flexibility of supply chain policies and capacities with uncertain demands"*

Réza VOSOOGHI "*Shared Autonomous vehicle service design, modeling, and simulation*"

# Selected Publications

Marwa Hasni, Mohamed Ziad Babaï, Zied Jemaï and Mohamed Salah Aguir, On the performance of adjusted bootstrapping methods for intermittent demand forecasting. *International Journal of Production Economics.,* 2019, 216. pp. 145-153.

Ernez Gahbiche, Kahled Hadj youssef, Alexandre Dolgui, and Zied Jemai, Decentralized versus Cooperative Performances in a Nash Game between a Customer and two Suppliers. *Flexible Services and Manufacturing Journal.,* 2019, 31 (2). pp. 279-307.

Mohammed Hichame Benbitour, Evren Sahin and Yves Dallery, The Use of Rush Deliveries in Periodic Review Assemble-to-Order Systems. *International Journal of Production Research*, 2019, 57 (13), pp. 4078-4097.

Tolga Bektaş, Jan Fabian Ehmke, Harilaos Psaraftis, Jakob Puchinger. The Role of Operational Research in Green Freight Transportation. *European Journal of Operational Research*, Elsevier, 2019, 274 (3), pp.807-823.

Gerhard Hiermann, Richard F. Hartl, Jakob Puchinger, Thibaut Vidal. Routing a Mix of Conventional, Plug-in Hybrid, and Electric Vehicles. *European Journal of Operational Research*, Elsevier, 2019, 272 (1), pp.235-248.

Benjamin Legros, Oualid Jouini. On the scheduling of operations in a chat contact center. *European Journal of Operational Research*, 2019, 274 (1), pp.303-316.

Abood Mourad, Jakob Puchinger, Chengbin Chu. A survey of models and algorithms for optimizing shared mobility. *Transportation Research Part B: Methodological.* Elsevier, 2019, Volume 123 (123), pp.323-346.

Guillaume Lamé, Oualid Jouini & Julie Stal-Le Cardinal, Combining Soft Systems Methodology, ethnographic observation, and discrete-event simulation: A case study in cancer care. *Journal of the Operational Research Society,* 2019.

# Collaborations

**Academic collaborations**
*France*: Université Pierre et Marie Curie, Université Paris-Saclay.
*International*: University of Minnesota (USA), Politechnico di Milano (Italy), VU University Amsterdam (The Netherlands), Koç University (Turkey), ENIT Tunis (Tunisia), SUTD (Singapore), University of Cambridge (United Kingdom), Centrale Casablanca (Morocco), Centrale Pékin (China), Beihang University (China), Johannes Kepler Universität Linz (Austria), AIT Austrian Institute of Technology (Austria), Eindhoven University of Technology (Austria), Technische Universität München (Germany), Northwestern Polytechnic University (China)

**Associated industrial chairs**
Supply Chain: Carrefour, LVMH, Safran, Sanofi
Anthropolis: Alstom, Engie, RATP, Renault, SNCF, IRT-SystemX
Call Centers: Interact'IV

**Industrial and institutional collaborations**, Agence Régionale de Santé, Carrefour, EDF, Eurodecision, Hôpital Henri Mondor, IBM, Michelin, Groupe Renault, Safran, Sanofi

**Associate editors**
Evren Sahin: Associated Editor in the Flexible Services and Manufacturing Journal
Oualid Jouini: Associate Editor dans Service Science (INFORMS journal); Associate Editor dans IMA Journal of Management Mathematics; Associate Editor dans Queueing Models and Service Management

**(Co-)Organized events:**
Organization by Evren SAHIN and her colleagues of the Fourth International Conference on Health Care Systems Engineering (HCSE 2019, Mother and Child University Hospital, CHU Sainte-Justine, Montreal ).

International research programme on urban Mobility at Insitut Pascal, Université Paris-Saclay, Septembre/ October 2019

International "healthcare systems design research" at University of Cambridge (december 2019)

**Our research networks** : CNRS, GdR Macs, GdR RO, Roadef

# Members

## Faculty Members

| | | |
|---|---|---|
|  | Walid BEHIRI<br>Assistant professor (ATER)<br>walid.behiri@centralesupelec.fr | Supply chain, Operations research |
|  | Yves DALLERY<br>Professor<br>yves.dallery@centralesupelec.fr<br>Chair Holder “Supply Chain Management” | Supply chain management, Supply chain design, Service operations |
|  | Asma GHAFFARI<br>Assistant professor<br>asma.ghaffari@centralesupelec.fr | Decision aid, Supply chain, Operations research, Decision making modelling and analysis |
|  | Zied JEMAÏ<br>Professor<br>zied.jemai@centralesupelec.fr<br>Chair “Supply Chain Management” | Supply chain management, Competition and coordination in supply chain, Inventory management of perishable items |
|  | Oualid JOUINI<br>Professor<br>oualid.jouini@centralesupelec.fr<br>Chair Holder “Call Centers” | Stochastic modeling, Service operations management, Call centers, Healthcare systems |
|  | Guillaume LAME<br>Assistant professor<br>guillaume.lame@centralesupelec.fr | Health services research, Healthcare operations management, Problem structuring methods |
|  | Benjamin LEGROS<br>Assistant professor<br>benjamin.legros@centralesupelec.fr<br>Chair “Call Centers” | Call centers, Stochastic modeling, Service operations management, Healthcare systems |
|  | Jakob PUCHINGER<br>Professor<br>jakob.puchinger@centralesupelec.fr<br>Chair Holder “Anthropolis” with IRT-SystemX | Urban mobility, Transport optimization, Combinatorial optimization, Exact and heuristic optimization methods, Operations research |
|  | Fouad RIANE<br>Professor<br>fouad.riane@centralesupelec.fr | Supply chain management, Supply chain design et optimisation, Opérations research, Operations management, Lean Six Sigma, Modeling and simulation of production systems of goods and services |
|  | Evren SAHIN<br>Professor<br>evren.sahin@centralesupelec.fr | Supply chain management, Production, Internal logistics, Operations management, Service operations management, Healthcare engineering |

**Postdoctorale researchers & PhD candidates**















LGi SAFETY & RISKS

Industrial Engineering Research Department

# Safety & Risks Research Group 2019

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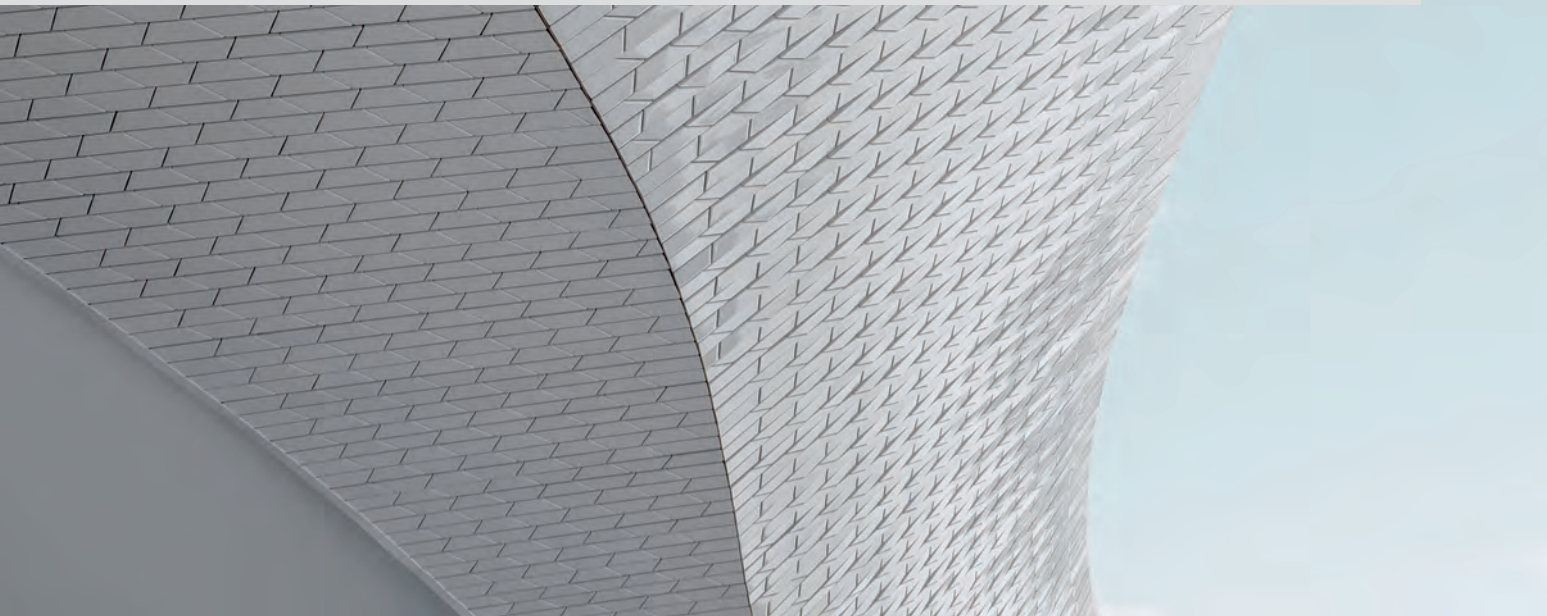


LGi SAFETY & RISKS

Industrial Engineering Research Department

**Head** | Anne Barros

**3 Faculty members:** Anne Barros, Yiping Fang, Zhiguo Zeng
**2 Postdoctoral researchers:** Islam Abdin, William Fauriat
**9 PhD candidates:** Benjamin Aupetit, Tasneem Bani-Mustafa, Andréa Belle, Léo Chartier, Hoang-Phuong Nguyen, Muxia Sun, Jinduo Xing, Daogui Tang, Hongping Wang

# Research

Our team is developing research activities for safety and risk analysis of complex engineered systems. Our models are mainly based on stochastic processes and data driven approaches with a strong focus on optimization and uncertainties quantification for decision making in design and operation. We are strongly connected to several industry partners with the chair Risk and Resilience of Complex System (LINK). This chair is supported by EDF, SNCF, Orange and Paris Airport. This is an arena to define study cases, share knowledge data and experiences, develop methods, implement benchmark and prototypes of tools. This chair is taking over the previous chair on Systems sciences and Energy Challenges supported by EDF.

Our research activity is organized around 3 main studied objects

**• Complex systems and infrastructures, cyber-physical systems**
The analysis of these systems cannot be carried out only with classical methods of system decomposition and logic analysis. A framework is needed to integrate a number of methods capable of viewing the problem from different perspectives (topological and functional, static and dynamic, discrete and continuous...), properly treating uncertainties by probabilistic and non-probabilistic methods. Our main contribution is to use stochastic processes, data driven approaches and Monte Carlo simulation to identify influent parameters and critical items, and to define proper level of abstractions for modelling. The modelling work is achieved in the perspective of providing decision indicators for Safety, Risk, Availability and Maintenance management with a careful quantification of uncertainties.

**• Industry 4.0 and predictive maintenance**
In the framework of Industry 4.0, our main contribution is to develop advanced models and optimization methods for dynamic risk management and predictive maintenance. This encompasses the assessment and modelling of components degradation with system usage, and the analyze and optimization of maintenance solutions. This can be done by multi-state physics, Bayesian and Markov chains models, Monte Carlo simulation. A particular focus is on failure prediction and prognostics of critical components, by data-driven approaches, e.g. adaptive artificial neural networks, support vector machines and the like. Regarding optimization, different methods are implemented in relation with optimization under uncertainties and robust optimization.

**• Resilience**
We intend to assess and optimize the resilience of complex systems and critical infrastructures by modeling and optimizing the processes of barrier management, mitigation, crisis management, recovery. One of the objectives is to guaranty business continuity by investigating in which degraded states the system should be put back in a minimal amount of time. The approaches developed are related to agent-based modelling and resilient communities.

Our teaching activity is organized around 4 master level courses

- Risk assessment and resilience of systems and infrastructures
- Practical risk and reliability analysis
- Engineering maintenance
- Mathematical models for decision making
- Data analysis for risk and reliability

## In 2019

14 Members
2 Research chairs
4 PhDs completed
21 Journals
8 Conference papers

# Some Publications

Islam Abdin, Y.-P. Fang, Enrico Zio, A modeling and optimization framework for power system design with operational flexibility and resilience against extreme weather events. *Renewable and Sustainable Energy Reviews, Elsevier*, 2019, 112, pp.706-719.

Jinduo Xing, Zhiguo Zeng, Enrico Zio, A framework for dynamic risk assessment with condition monitoring data and inspection data (2019). *Reliability Engineering and System Safety*, 191, art. no. 106552.

William Fauriat, Enrico Zio, An Importance Measure to Assess the Value of a Component Inspection Policy (2019). Proceedings - 2018 *3rd International Conference on System Reliability and Safety*, ICSRS 2018, art. no. 8688877, pp. 368-375.

Hoang-Phuong Nguyen, Jie Liu, Enrico Zio, Ensemble of Models for Fatigue Crack Growth Prognostics (2019). *IEEE Access*, 7, art. no. 8689036, pp. 49527-49537.

# Collaborations

**Academic collaborations**
*Europe:* Technical University of Denmark, Politecnico di Milano (Italy), Universitat Politècnica de València (Italy), ETH Zurich (Germany), Norwegian University of Science and Technology, Liverpool John Moores University (United Kingdom), Manchester University (United Kingdom). *Rest of the World*: Alzahra University (Iran), Beihang University (China), City University of Hong Kong (China), North China Electric Power University, Wuhan University of Technology (China), Zhejiang university, Sichuan University, Fuzhou University (both from China), Rugters university (USA), National University of Singapore, Idaho National Laboratory (USA), MIT (USA).

**Invited professors**
Visiting PhD students: Tangfan Xiahou, University of Electronic Science and Technology of China, China
Visiting Professors: Qingqing Zhai, Shanghai university, China.

**Associated industrial chairs**
Chair on Systems Science and the Energy Challenge, Fondation Electricité de France (EDF), www.ssde.fr
Chair Blériot-Fabre, SAFRAN

**Associated research institutes**
Critical infrastructure reliability and Safety Center, Beihang University, http://cresci.cn
European Commission Joint Research Center (JRC) Ispra, https://ec.europa.eu/jrc/en/about/jrc-site/ispra
Institut de la Science des Risques et de l'Incertitude (ISRI), CentraleSupélec
Laboratorio Analisi di Segnale e Analisi di Rischio (LASAR), Politecnico di Milano, www.lasar.polimi.it

**Industrial and institutional collorations**
EDF, SNCF, Orange, AdP, Alstom transport, campus France, CEA, Safran, Siemen, DNV-GL, Equinor.

# 4 Recent PhDs

Muxia SUN "*The reliability assessment and optimization of arbitrary-state monotone systems with epistemic uncertainty*"

Islam ABDIN "*Techno-economic modeling and robust optimization of power systems planning under a high share of renewable energy sources and extreme weather events*"

Tasneem BANI-MUSTAFA "*Multi-Hazards Risk Aggregation considering the trustworthiness of the assessment*"

Jinduo XING "*Business continuity of energy systems: a quantitative framework for dynamic assessment and optimization*"

# Events

**International conferences**
IEEE-2018 International Conference on System Reliability and Safety, 24-26 November 2018, Barcelona, Spain.

**Seminar**
EDF–CentraleSupélec Chair Day, EDF R&D Paris-Saclay, France

# Members

**Faculty members**

| | | |
|---|---|---|
|  | Anne BARROS<br>Professor<br>anne.barros@centralesupelec.fr | Stochastic modelling, Degradation modelling, Prognostics, Condition based and predictive maintenance, Reliability analysis |
|  | Yiping FANG<br>Assistant Professor<br>yiping.fang@centralesupelec.fr | Risk, Reliability and resilience assessment, Optimization, Complex engineering systems, Critical infrastructure, Uncertainty quantification, Stochastic and robust optimization |
|  | Zhiguo ZENG<br>Assistant Professor<br>zhiguo.zeng@centralesupelec.fr | Reliability, Dynamic risk analysis, Prognostics and health management, Uncertainty quantification |

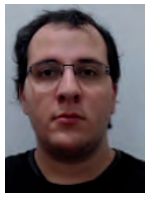
**Postdoctoral researchers & PhD candidates**










LGi

SUSTAINABLE ECONOMY

Industrial Engineering Research Department

# Sustainable Economy Research Group 2019

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**Administration** | delphine.martin@centralesupelec.fr
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LGi SUSTAINABLE ECONOMY

Industrial Engineering Research Department

**Head** | Pascal Da Costa

**8 Faculty members**: Danielle Attias, Jean-Claude Bocquet, Pascal Da Costa, Guy Fournier, Eléonore Mounoud, Isabelle Nicolaï, Yannick Perez, Mehdi Senouci.
**1 Postdoctoral researcher**: Fabio Antonialli
**17 PhD candidates**: Mathieu Dernis, Icaro Freitas Gomes, Rodrigo Gandia, Bassem Haidar, Eliane Horschutz Nemoto, Emma Jagu, Inès Jaroudi, Rémi Lauvergne, Emily Little, Arthur Lynch, Joseph Mansour Salame, Marc-Olivier Metais, Judith Pigneur, Emilien Ravigné, Fawaz Salihou, Franisco José Santos, Olfa Tlili.
**1 CS Student in research track**: Jean-Baptiste Grenier

# Research

The Sustainable Economy Group deals with researches in economics and management: assessment of innovations, including their economic impacts on organizations and the societies, with a special focus on eco-innovations and ecological transition, for the two key sectors of mobility and energy.

Here are the three research axes:

- **Economics and Management of Innovation**. This direction deals with the evolution of technical progress and the effectiveness of organizations. We seek a better understanding of the decisions of economic agents regarding investment and innovation, their microeconomic impacts on the growth of firms, the organization of production and operational efficiency. This research is conducted using optimization methods, econometric studies, as well as case and field studies.
- **Economics and Management of Mobility**. This second axis deals with decarbonated mobility, as well as with the links with the electricity market (i.e. hybrid energy market = electricity + transport) through the challenges of electric storage (electricity storage/unloading solutions through electrical vehicles). This research is conducted using technico-economic studies, econometric methods and strategic analyses, notably on innovative business models on sustainable mobility.
- **Economics and Management of Energy**. This third axis deals with renewable, fossil and mineral energy resources (from the extraction industry to the final use within production of consumption systems), with the aim of reaching the decarbonization of the energy mix of the economy. In this perspective, energy efficiency and the regulation of the markets tied to the energy transition are studied. This direction develops research methods in technico-economics, in forecasting, as well as analyses of global value chains.

# In 2019

27 Members
3 Research chairs
1 European project H2020
3 PhDs completed
7 Journals
18 Conference papers

# 3 Recent PhDs

Mathieu DERNIS "*Modeling and measuring values brought to host country for assisting decisions in In-Country-Value strategies elaboration*"

Olfa TLILI "*Hydrogen Systems: What Contribution to the Energy System? Findings from multiple modelling approaches*"

Judith PIGNEUR "*Developing an integrated analysis method of impacts for mineral raw materials chains*"

# Some Publications

Olfa Tlili, Christine Mansilla, Jochen Linßen, Markus Reuß, Thomas Grube, Yannick Perez et al.. Geospatial modelling of the hydrogen infrastructure in France in order to identify the most suited supply chains. *International Journal of Hydrogen Energy*, Elsevier, 2019.

Rémy Le Boennec, Isabelle Nicolaï, Pascal da Costa. Assessing 50 innovative mobility offers in low-density areas: A French application using a two-step decision-aid method. *Transport Policy,* Elsevier, 2019, 83, pp.13-25.

Quentin Hoarau, Yannick Perez. Network tariff design with prosumers and electromobility: Who wins, who loses?. *Energy Economics*, Elsevier, 2019, 83, pp.26-39.

Bassem Haidar, Pascal da Costa, Jan Lepoutre, Yannick Perez. Corri-door project: did it really boost the french electric vehicle market? *Energy Challenges for the Next Decade*, Aug 2019, Ljubljana, Slovenia.

Emilien Ravigné, Frédéric Ghersi, Franck Nadaud. Combining micro and macro simulations to assess the distributional impacts of energy transitions. Evidences from the French National Low Carbon Strategy. *EU Conference on modelling for policy support*, Nov 2019, Bruxelles, Belgium.

# Collaborations

2 School Paris-Saclay: Eng. ; Economics-Management
2 Doctoral schools Paris-Saclay: Interfaces; Economics-Management
2 Masters Paris-Saclay : Economie de l'Environnement, Energie, Transports (EEET); Industries de Réseau et Économie Numérique (IREN)

**National and International Scientific Network:**
*France:* Strate Ecole de Design, ESSEC, CEA Saclay, University Paris Dauphine, University of Montpellier, Club de l'Orme: the energy experts of Paris Saclay, Le Basic (Paris), VEDECOM: Pubic-private research institute about decarbonized mobility...
*International:* UNIGE Université de Genève (Suisse), Research Institute of Innovative Technology for the Earth (RITE) Japan, EU-LAC Foundation Germany, Helmholtz-Zentrum für Umweltforschung, Commission Européenne (ETIP-SNET), Brown University, Berkeley University...

**Member of:**
- SFM, AIMS, EEM, FAEE, IAEE, CEESAR,...
- Office Parlementaire de l'Evaluation des Choix Scientifiques et Technologiques, Florence School of Regulation.

**Associated Research Chairs**
- Chair Armand Peugeot on Electromobility and hybrid Technology by Peugeot-Citroën (with Essec).
- Patronage by endowment fund Capitaldon on Sustainable Growth.
- Chair Monitoring Circular Economy.

**European Project**: H2020 - AVENUE Autonomous Vehicles to Evolve to a New Urban Experience.

# Events

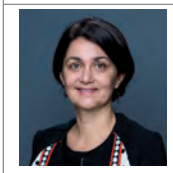
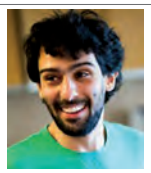
**Visiting:** Mehdi Senouci stayed in May 2019 with Professor Oded Galor at Brown University.
**Award:**
- Fabio Antonialli won the young award author of the international network of the automobile GERPISA for "International benchmark on experimentations with Autonomous Shuttles for Collective Transport"
- Rodrigo Marçal Gandia was awarded in the category of the best thesis project by the doctoral consortium gathered during the Brazilian national seminar SEMEAD 2019 (November 6 to 8).

**Conference:** 7th International Conference of the Chair Armand Peugeot : Electromobility Challenging Issues. CentraleSupélec, Gif-sur-Yvette, 5-6 December 2019.

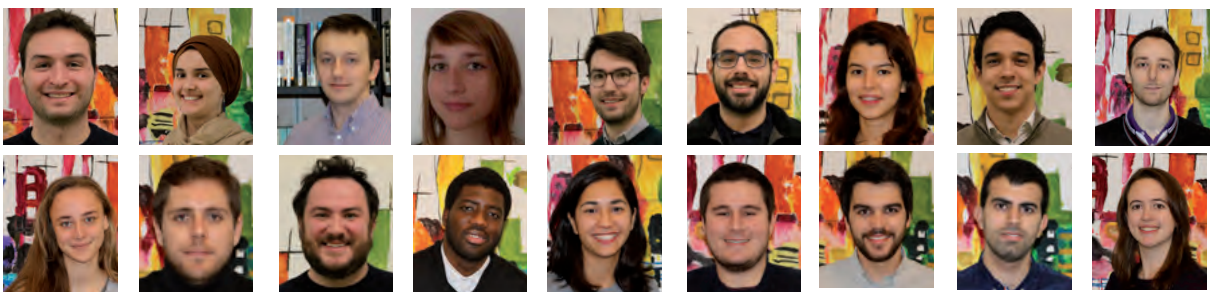
**Recruitment:** Yannick Perez, Full Professor at CentraleSupélec, from September 2019

# Members

**Faculty members**

| | | |
|---|---|---|
|  | Danielle ATTIAS<br>Adjunct Professor<br>danielle.attias@centralesupelec.fr<br>Chair “Electro-mobility” (PSA Peugeot Citroën) | Electromobility, New business models for Automotiv Industry, Innovative mobility and Public Policies |
|  | Jean-Claude BOCQUET<br>Emeritus Professor<br>jean-claude.bocquet@centralesupelec.fr | Complex system design, Design process and management, Value chain management, Technico economics of complex systems |
|  | Pascal DA COSTA<br>Professor<br>pascal.da-costa@centralesupelec.fr<br>Head of “Enterprises Sciences” Education Department | Sustainable development, Climate Change, Environment and energy, Ecosystem services, Optimal resources exploitation, Optimal pollution, Innovation |
|  | Guy FOURNIER<br>Professor<br>guy.fournier@centralesupelec.fr | Sustainable mobility, New innovative business models, emerging ecosystems of mobility, autonomous vehicles, electric vehicles, International economy and sustainable development |
|  | Eleonore MOUNOUD<br>Associate Professor<br>eleonore.mounoud@centralesupelec.fr | Sustainable development, Innovation, Management |
|  | Isabelle NICOLAÏ<br>Professor<br>isabelle.nicolai@centralesupelec.fr | Eco-innovation,Disruptive technology, Multi agents and criteria decision-making, User-centred design, Multimodal mobility, Business model |
|  | Yannick PEREZ<br>Professor<br>yannick.perez@centralesupelec.fr<br>Chair “Electro-mobility” (PSA Peugeot Citroën) | Market design, Energy economics, Electromobility |
|  | Mehdi SENOUCI<br>Assistant Professor<br>mehdi.senouci@centralesupelec.fr | Economic growth and fluctuations, Economic theory, International financial macroeconomics |

**Postdoctoral researchers & PhD candidates**



LGi Industrial Engineering Research Department

# Themes

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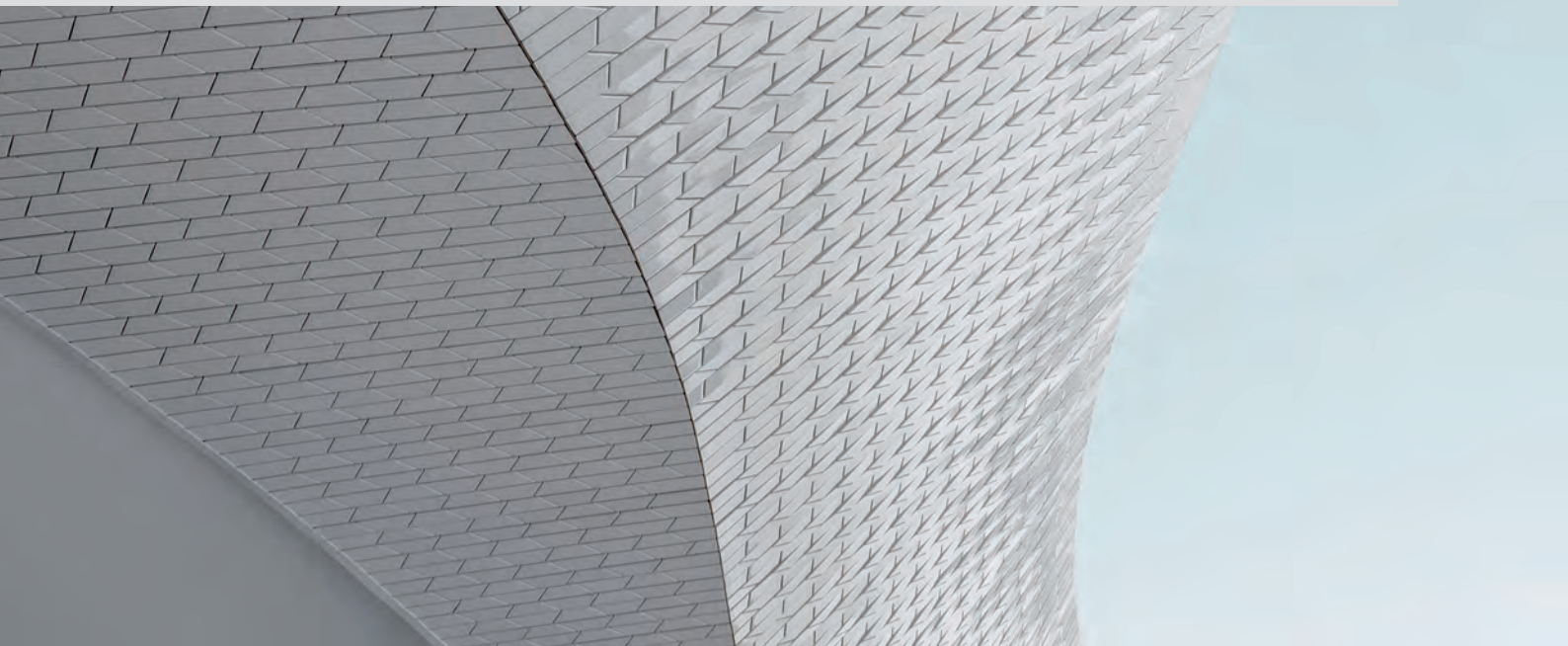

LGI MOBILITY SYSTEMS

Industrial Engineering Research Department

## Ambassadors

Danielle ATTIAS
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Isabelle NICOLAÏ
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Eco-mobility involves all mobility solutions and encompasses every type of transport – individual and shared, public and private – that contributes to providing a positive response to sustainable development issues. This eco-mobility may also be smart and connected.

These new mobilities need to be analyzed with a multidisciplinary approach, fitting into a context of prospective and disruptive innovation. Research approaches include engineering, economics and social sciences, and employ tools to model and design socio-technical mobility systems.

The models developed attempt to understand and satisfy stakeholder's mobility requirements in a transition context. The themes tackled by our research are the following:

- Sustainable urban mobility: we deepen and analyze the mobility eco-system (new usages, new services as MaaS, multi-modal transport system) in connection with the ecological, digital and social transition of the urban territories.
- Electro mobility economy: we study the link between the business models of electric vehicles and smart grids.

Our purpose is to offer a global and pertinent analysis and design approach of mobility systems while strengthening collaborations between LGI teams (engineering design, operations management, sustainable economy).

**Keywords:**

Sustainable urban mobility, electro-mobility, business model innovation, MaaS, mobility eco-system, urban transport automation, environmental performance evaluation.

**The main results in 2018 which are significant for partnerships between LGI teams are the following :**

- Contribution to the organization of an international "Interdisciplinary Research Program on Urban Mobility" at the Institut Pascal (Université Paris Saclay). Various researchers of LGI participated in September 2019 to this scientific hub dedicated to research, exchange of knowledge and development of new ideas and projects on urban mobility.
- A dynamic research network is developed in order to support and collaborate to address mobility system challenges especially within the European project H2020 AVENUE (Autonomous Vehicles to Evolve to a New Urban Experience), programme «Full-scale demonstration of urban road transport automation" (2018-2022). Other numerous results of mobility projects that have been published are listed in the teams' description.
- Renewal of partnerships through Armand Peugeot Chair on development of the automotive industry (ESSEC, Groupe PSA) and Anthropolis Chair on future mobility and urban life (jointly operated by IRT SystemX and LGI, with Communauté d'Agglomération Paris-Saclay, EDF, ENGIE, Nokia, Renault).
- New industrial collaboration with SNCF Réseau to deepen the action research on environmental performance (PhD support in collaboration with the engineering design and sustainable economy teams).
- New Collaboration with VEDECOM Institute for a PhD in optimization of charging infrastructures in a given territory.
- Continuation of international academic collaborations with new PhD in co-tutelle and post doc with U. Fédérale Lavras, Brasil.
- Rodrigo Gandia (co-tutelle PhD Student) has been awarded in the category of the best thesis project by the doctoral consortium gathered during the Brazilian national seminar SEMEAD 2019 organized by the Faculty of Economics and Management of the Federal University of Sao Paulo (USP).
- Fabio Antonialli (Avenue Post-doc at LGI) has been awarded the 2019 GERPISA young author's prize for his paper "International benchmark on experimentations with Autonomous Shuttles for Collective Transport".
- Guy Fournier, Professor at the University of Pforzheim and partner of the European project H2020, joined the LGI as an Associate Researcher.

LGi HEALTHCARE SYSTEMS

Industrial Engineering Research Department

## Ambassadors

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The “Healthcare System Engineering” (Systèmes de Santé, S2S) Research Group aims at developing new approaches, methods and tools for managing and organizing healthcare systems, by adapting approaches traditionally used in Industrial Engineering in order to integrate the specificities of healthcare systems. Healthcare systems considered by the group are diverse: hospitals, day hospitals, emergency departments, home healthcare, telehealth, m-health, etc.

Research objectives can be seen as twofold:

- Adaptation and transfer of concepts, methods and tools traditionally developed in Industrial Engineering for the case of healthcare
- Development of specific methods and tools needed for designing and good functioning of healthcare

**Scientific challenges are various**: healthcare system performance is multidimensional (societal, medical, economic); it is a complex system (human is a key element of this system, diversity and number of stakeholders, interdependence between decisions and system actors, need for a specific collaboration/coordination approaches and models); uncertainties pertaining to design, analysis, simulation and future behavior prediction are challenging. The research in this domain is multi-disciplinary with a clear systems orientation, combining domains such as **systems engineering, operations management, simulation and optimization.** The overall objective of developed approaches and methods is to create value for all stakeholders of the healthcare system (e.g. satisfy service quality for the patient, take into account healthcare professional preferences, optimize resource utilization, and manage costs related to organization processes).

“Healthcare System Engineering” Research group is constituted of researchers in majority coming from DE and OM research teams. It is coordinated by Evren Sahin (professor LGI, OM) and Marija Jankovic (Professor LGI, DE). The research group is dynamic: numerous collaborations with healthcare practitioners have been developed in past years, and in particular with the AP-HP. Dynamic and strong international research network is developed in order to support and collaborate to address healthcare system challenges.

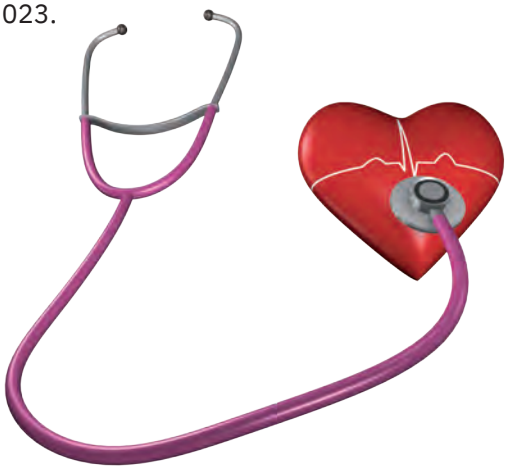
**Relevant events and results in 2019:**

- The team has hosted Dr Laure Gatin. Laure is an orthopedic surgeon at Raymond-Poincaré Hospital who spent a year at LGI (Nov.2018 - July 2019) to design and implement a new healthcare organization solution. She regrets that 12,000 residents of EHPAD suffering from acquired deforming hypertonia, cannot be transported to care centers. Her goal is to design a mobile patient care unit that goes directly to the place of life of patients, while ensuring continuous training to caregivers taking charge of them on a daily basis.
- Organization by Evren SAHIN and her colleagues of the Fourth International Conference on Health Care Systems Engineering (HCSE 2019, Mother and Child University Hospital, CHU Sainte-Justine, Montreal ). This conference provides an opportunity to discuss operations management issues in health care delivery systems. Scientists and practitioners have the opportunity to discuss about new ideas, methods and technologies for improving the operation of health care organizations.

**Projects:**

The IMMO research project on improving fetal heartrate monitoring in labour, with The Healthcare Improvement Studies Institute at the University of Cambridge. One of LGI’s researcher will contribute to the collection and analysis of ethnographic data to identify risks, hazards and failure modes in this process.

An Operations Management Approach for the Improvement of Cancer Care Delivery in Qatar: Predictive Models, Analysis, and Pathways Optimization for Patients with Hematological Malignancies. Qatar National Research Fund, 2020-2023.



## Keywords:

Complex system design, operations management, performance management, optimization, healthcare logistics, service systems, technology development and integration

LGi CIRCULAR ECONOMY

Industrial Engineering Research Department

## Ambassadors

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**Optimize material and energy flows in the design and manufacturing of goods and services**

Circular Economy aims at **minimizing the impacts of human activities on the Environment**, for example by pooling material, water and energy flows with a life cycle perspective and in an **integrated metabolism** approach. Circular Economy is deployed thanks to strategies like industrial ecology, eco-design of products and services, product-service systems, functional economy...
The four LGI teams are all implicated on Circular Economy issues. Current research themes deal with:

- **Eco-design** and **eco-innovation** methods and tools, including Life Cycle Assessment (LCA) of products and services, technologies families, value chains...
- **Industrial symbioses** and technico-economic analysis of **eco-industrial parks**
- **Circularity indicators** and analysis of prospective scenarios
- **Sustainable supply chain** (reverse logistics, ecosystem services and sustainable supply chains...)
- **Energy efficiency** and optimization of materials flows
- Technico-economic studies of **industrial value chains** including **externalities**
- **Decision making** in complex environmental under uncertainties

These research projects are applied in numerous industrial sectors, however **sustainable buildings, cities and mobility** are particularly targeted.

**2019 main facts**

- **Launching of the Chair "Monitoring Circular Economy", several partners including Vale NC, Communauté d'agglomération Paris-Saclay, SIOM.**
- **Completion** of the EcoSD collaborative research project AVEC "**Value Analysis for Eco-Design**" with DGA and recruitment of **Olivier Pialot for a post-doc** on this project.
- **1 PhD completed: Judith Pigneur** "Developing an integrated analysis method of impacts for mineral raw materials chains", Le BASIC.
- **Participation to the "Rando'Durables"**, sustainable event organized by the Communauté d'agglomération Paris-Saclay – Presentation of the LGI's activities on Circular Economy.
- **Launching of the EcoSD collaborative research project SODECO** "Sustainability of data supporting eco-design process. The case of connected vehicle» with PSA Group.
- **Launching of Joseph Mansour's PhD** thesis "Combining economic and environmental performances to pilot industrial projects", SNCF Réseau.
- **Launching of a research projet with the start-up Budget Our Planet:** "Carbon footprint calculation of academic activities".

- **To be launched in 2020: Erasmus+ European project – EUSL-ENERGY 2020 – 2023** "Europe Sri Lanka Capacity Building in Energy Circular Economy" in collaboration with universities from **Sri Lanka** (9 partners). https://www.euslenergy.com/
- In press: White book "**Les chantiers de l'éco-conception** - Les conditions d'une pratique pérenne par les acteurs de la construction", Paris, Presses des Mines, 2020.

**5-years ambition**

- **Innovative technology potential characterization**: The topic focus on how to embed innovative and sustainable technology into complex system. This topic aims at tackling issues related to modeling, simulating and optimizing multi-scale, multi-physics and multi-criteria to generate sustainable complex systems architectures.
- **Development of circularity indicators**: The issue is to define circularity indicators for products, services and value chains in order to highlights their circularity performance and moreover to drive industrial activities towards much more sustainability.
- **Performance assessment of projects in circular economy**: The main issue is to enrich the assessment process of such project integrating environmental impacts and social impacts. The objective is to propose new method to assess the impact investing (including, environmental, social, economic and governing aspects).


# Keywords:

Circular economy, Industrial ecology, Eco-design, Eco-innovation, Circularity, Material, Energy, Environmental impact, life cycle, Life Cycle Assessment (LCA), Material Flow Analysis (MFA), Industrial symbiosis, Eco-industrial park

LGi ENERGY SYSTEMS

Industrial Engineering Research Department

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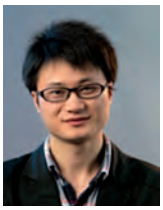

The research objectives are the modelling, simulation, analysis and optimisation of energy and electricity generation and distribution systems and the study of their interactions with the technical and economic environment. The theme therefore brings together all the cross-cutting research of the four LGI groups, on the design and technical and economic management of energy systems.

- Several research themes and scientific obstacles are the subjects of research:
  Economic viability, technical reliability, operational safety and risks related to energy generation, transmission and distribution;
- Comparative analysis of low-carbon electricity generation technologies, such as nuclear and renewable energies, as well as the study of electricity storage solutions (hydrogen, etc.);
- The integration of electric mobility into the dynamics of electricity supply and demand, the examination of new forms of low-carbon mobility solutions;
- Energy efficiency (eco-parks, cogeneration, transport, distribution, etc.), demand management (smart grids, erasure, etc.), and the effects of consumer behavior and use on energy consumption over the product life cycle (rebound effects, etc.);
- The management of the various externalities produced by the energy system (beyond CO2 emissions), including the impacts of nuclear waste and the extraction of fossil and mineral resources.

The researchers involved in the theme are at the forefront of the scientific community:

- Member of the Scientific Committee of the International Conference on the European Energy Market (P. da Costa, Y. Perez)
- Organization of the World Conference of the International Association of Energy Economists (IAEE) to be held in June 2020 (Y. Perez: Chairman, P. da Costa)
- Member of the European Safety and Reliability Association ESRA (E. Zio, A. Barros)
- Member of the Scientific Committee of the 29th European Safety and Reliability Conference (ESREL2019) (A. Barros, Y.-P. Fang)

### Selected Publications


- Daogui Tang, Yi-Ping Fang, Enrico Zio, & Jose E. Ramirez-Marquez (2019). *R*esilience of Smart Power Grids to False Pricing Attacks in the Social Network. *IEEE Access*, IEEE, 2019, 7, pp.80491-80505.
- Islam F. Abdin, Yi-Ping Fang & Enrico Zio (2019). A modeling and optimization framework for power systems design with operational flexibility and resilience against extreme heat waves and drought events. *Renewable and Sustainable Energy Reviews*, 112, 706-719.
- Quentin Hoarau & Yannick Perez, 2019, Network tariff design with distributed energy resources and electric vehicles, *Energy Economics*, Volume 83, September, Pages 26-39.
- Olfa Tlili, Christine Mansilla, Martin Robinius, Konstantinos Syranidis, Markus Reuss, Jochen Linssen, Jean André, Yannick Perez, Detlef Stolten. 2019, Role of electricity interconnections and impact of the geographical scale on the French potential of producing hydrogen via surplus electricity by 2035, *Energy* Volume 172, 1 April 2019, Pages 977-990.


## Keywords:

Energy systems, Reliability, Economic viability, Resilience, Renewable energies, Smart grids, Complex systems, Energy supply, Externalities, Energy mix

LGi

INDUSTRY OF THE FUTURE

Industrial Engineering Research Department

## Ambassadors

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**Objectives**

Industry of the Future (IoF), also called Industry 4.0 in Germany and Smart manufacturing in the USA, consists in outperforming the operational performances by transforming the production systems thanks to eight categories of disruptive digital technologies. Let us mention: collaborative robots and other intelligent machines (drones, AGVs), additive manufacturing, augmented reality and operator, simulations, horizontal and vertical integration of information, industrial internet, cloud and cyber security, big data and analyses.

Following one of the founding precepts of CentraleSupélec (see Fig. 1), our research aim is not only to grasp the abilities of IoF technologies to, under certain conditions, disrupt the production management systems of companies, but also to gain knowledge on how to choose an adequate subset of IoF technologies towards efficient manufacturing system evolutions that are smarter, more flexible and more reliable. Our objective is also to bring consciousness to companies on how to manage their transformation. Numerous dimensions of the industrial model must be rethought, as:

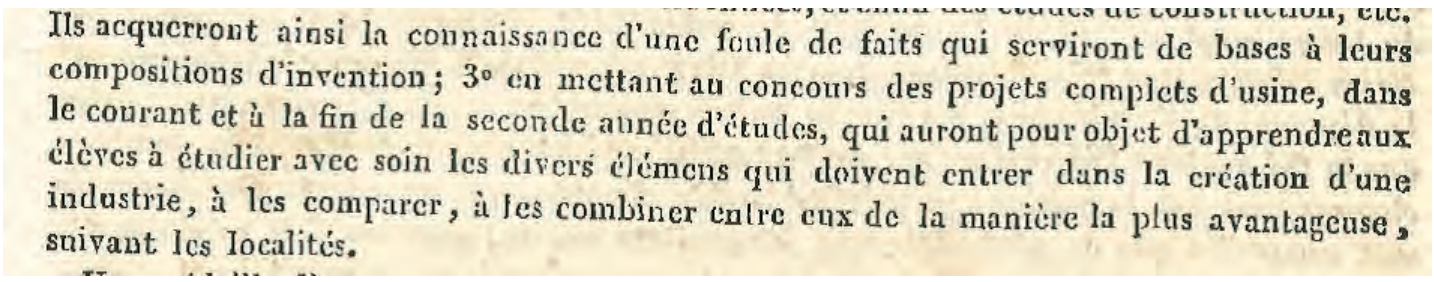
- Transformation of business models and supply chains by digital solutions as blockchain technology and increased production flexibility,
- Modernization of the production tool,
- More integrated design, marketing, supplier and sales functions,
- Switching from mass production of standard products to mass production of more customized products,
- Lower resource and energy consumptions as well as wastes,
- Evolutions of man-machine interfaces and function allocations,
- Modernization of infrastructures management and operation.

**In 2019:**

- Anne Barros has been nominated, along with Pedro Rodriguez (CS/L2S), in charge of coordinating actions concerning Industry of the Future at CentraleSupélec
- Bernard Yannou organized, along with Christophe Tournier (ENSPS/LURPA), a first edition of a 2-week International Summer School on Industry 4.0, in July 2019. With 16 undergrads (of 8 countries and 4 continents), it has been a success.
- CentraleSupélec and especially LGI are partners of the BCG (Boston Consulting Group) ICO (Innovation Centre for Operations) learning factory deve¬loped made to demonstrate the abilities of Industry 4.0 technologies to disrupt the production ma¬nagement systems of companies.
- LGI is an active member of the Move In Saclay project (http://www.moveinsaclay.fr/) to improve the mobility experience of people on the “plateau de Saclay” using a digital twin to track people moves and propose co-sharing and mobility advices.
- Oualid Jouini participates to an international research project with Qatar University whose aim is to optimize the operations of the Doha harbor using the blockchain technology.
- Safety and Risks LGI research group is leading a research activity on resilience of critical infrastructures through implementation of predictive maintenance. Four major French industrial partners are strongly involved in a 5-years chair to support this activity (EDF, SNCF, Orange, ADP Aéroports de Paris).

**A selection of articles published**

- William Fauriat, Enrico Zio. Estimation of the value of prognostic information for condition-based and predictive maintenance. *European Safety and Reliability Conference*, Sep 2019, Hanover, Germany.



Ils acquerront ainsi la connaissance d'une foule de faits qui serviront de bases à leurs compositions d'invention ; 3° en mettant au concours des projets complets d'usine, dans le courant et à la fin de la seconde année d'études, qui auront pour objet d'apprendre aux élèves à étudier avec soin les divers élémens qui doivent entrer dans la création d'une industrie, à les comparer, à les combiner entre eux de la manière la plus avantageuse, suivant les localités.

*Fig. 1: Excerpt of the 1828 curriculum program of Ecole Centrale des Arts et Manufactures*

- Jinduo Xing, Zhiguo Zeng, Enrico Zio. Dynamic business continuity assessment using condition monitoring data. *International Journal of Disaster Risk Reduction*, Elsevier, 2019, 41, pp.101334.
- Danya Bachir, Ghazaleh Khodabandelou, Vincent Gauthier, Jakob Puchinger, Mounim El Yacoubi. Inferring dynamic origin-destination flows by transport mode using mobile phone data. *Transportation research. Part C, Emerging technologies*, Elsevier, 2019, 101, pp.254-275.
- Daogui Tang, Yi-Ping Fang, Enrico Zio, José Emmanuel Ramirez-Marquez. Resilience of Smart Power Grids to False Pricing Attacks in the Social Network. *IEEE Access*, IEEE, 2019, 7, pp.80491-80505.
- Reza Vosooghi, Jakob Puchinger, Marija Jankovic, Anthony Vouillon. Shared Autonomous Vehicle Simulation and Service Design. *Transportation research. Part C, Emerging technologies*, Elsevier, 2019, 107, pp.15-33.
- Selmen Boubaker, Zied Jemai, Evren Sahin, Yves Dallery. Supply chain agility drivers and enablers. *International Conference on Industrial Engineering and Systems Management*, Sep 2019, Shanghai, China.
- Rongyan Zhou, Julie Stal-Le Cardinal, Employment Analysis Based on Panel Data in the Background of Industry 4.0, 2019 *INFORMS Annual Conference*, Seattle, USA.
- Rongyan Zhou, Julie Stal-Le Cardinal, Exploring the Impact of Industry 4.0 from a Macroscopic Perspective. In: *Proceedings of the 22st International Conference on Engineering Design* 2019, Delft: The Design Society.


**On going PhD Thesis**

- Rongyan ZHOU, “Using big data to drive industry management efficiency 4.0”
- William FAURIAT, “Risk Analysis in the framework of data driven approaches for decision making”
- Rémi LAUVERGNE, “Impacts et opportunités des nouvelles mobilités pour le système électrique”
- Hoang-Phuong NGUYEN, “Maintenance scheduling based on PHM approaches under nonstationary environment”
- Marc-Olivier METAIS, “Optimisation des infrastructures de recharge pour véhicules électriques dans un territoire”
- Yasmine SALEHY, “Total simulation of refrigerating machine usage performance for guiding R&D of innovative technological bricks”
- Daogui TANG, “Analysis of the resilience of Smart Grids to Social Networks Based Attacks”
- Shaohua YU, “Optimization models and methods for tour planning in smart urban logistics”
- Sarra FAKHFAKH, “Proposition of a Product and Service SoS design methodology in the context of new mobilities for an OEM”
- Andrea BELLE, “Prévention contre les attaques extérieures pour les infrastructures critiques”.

**Main partners**

The Boston Consulting Group, Sculpteo, Opeo, Pôle de Compétitivité Systematic (participation to “Digitalisation de l’Industrie et des Services” think tank of Pôle SYSTEMATIC), Dassault Aviation, Trendeo, Groupe Renault, La French Tech, Alliance Industrie du Futur (AIF), Thales, NTNU, Qatar University, Concordia University, ESCP Business School, BPI France, Turin University


# Keywords:

Industry 4.0, Smart Manufacturing, Industrial Internet of Things (IoT), Cyber-Physical System (CPS), Cloud computing, Robotization, Simulation, Information systems, Cybersecurity, Additive manufacturing, Augmented reality, Machine learning, Connected systems, Predictive maintenance.

LGi Industrial Engineering Research Department

# Industrial Chairs

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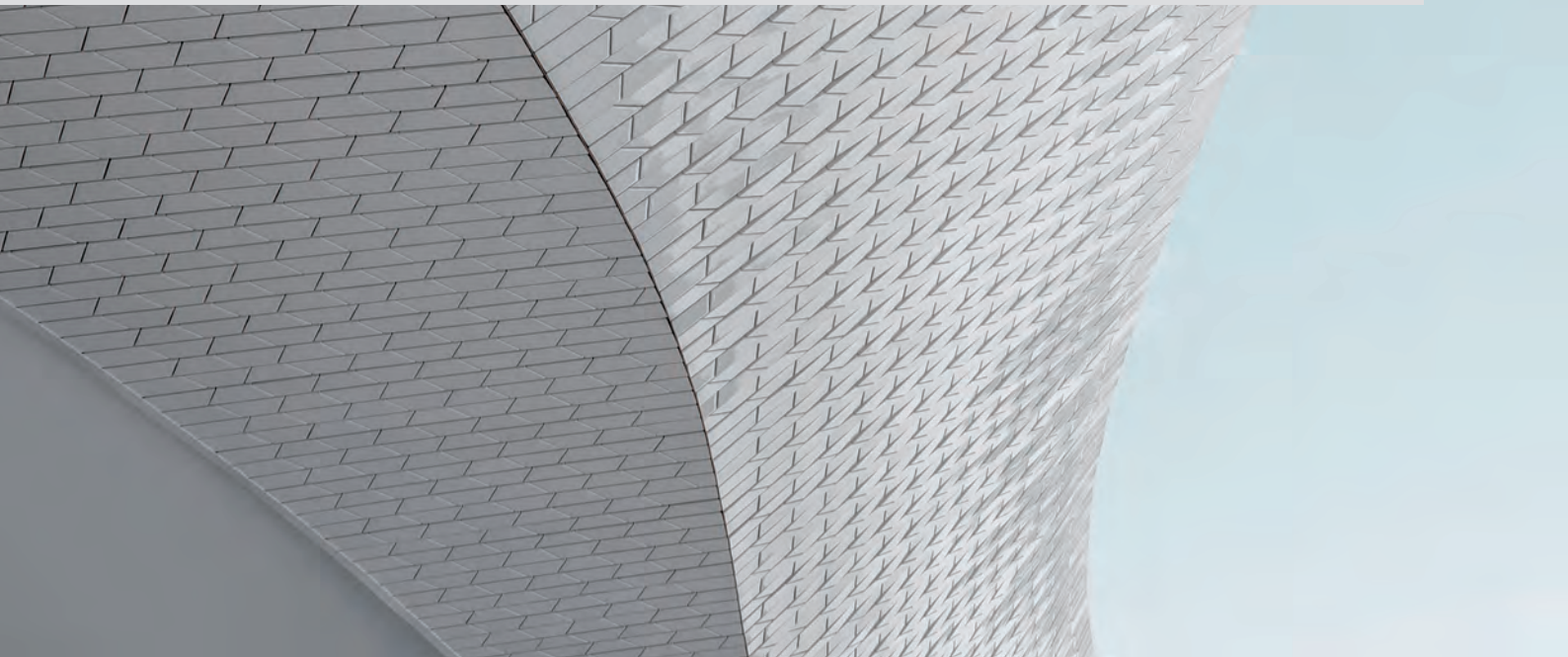

# AnthroPOLIS
HUMAN CENTERED URBAN DESIGN

**Partners:**
Alstom, Engie, RATP, Groupe Renault, SNCF

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Reza
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Shaohua
YU
PhD Candidate

# Research

The « Anthropolis » chair is constructing a vision of future mobility integrating the major challenges of urban life such as reducing carbon emissions and improving quality of life in cities. Anthropolis develops fundamental methods to design mobility systems and services with a human centered approach. We will explore the following three complementary topics: future mobility and urban life, mobility as a service, and future infrastructures.

**Indicators for 2019**
3 Phd theses defended
9 journals
9 conferences
1 public seminar

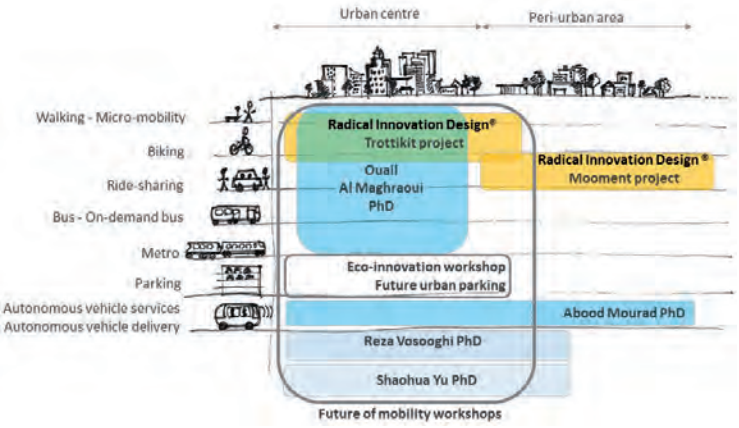
2019 was an important year for the Anthropolis Chair: its first project period was completed this spring, and it was successfully renewed for four years with the following five partners (Communauté d'Agglomération Paris-Saclay, EDF, ENGIE, Nokia, Renault). Three PhD theses (Ouail Al Maghraoui, Abood Mourad and Reza Vosooghi) where defended and a lot of our scientific results have been published.
The three main research topics for the following years are:
• **Future mobility and urban life**. A vision of the future of mobility will be developed proposing scenarios for 2030, 2040, and 2050. Anthropolis is particularly interested in mobility and non-mobility in tomorrow's society in order to answer questions on the future of urbanity and regional management.
• **Mobility as a Service**. The implementation of regional MaaS systems demands for a commitment by political decision makers as well as a real intention to collaborate by all stakeholders of urban and suburban mobility. How will new technologies influence new forms of MaaS and what forms of governance and new organisational models will emerge?
• **Future Infrastructures**. We are interested in the transformation, sharing and reversibility of future infrastructures in urban areas, including sensors, charging and shared mobility infrastructure, parking and roads.
Our research activities will involve partnerships with Morocco (Centrale Casablanca), China (Centrale Pékin) and other locations in Europe.

# Publications

Ouail Al Maghraoui, Flore Vallet, Jakob Puchinger, Bernard Yannou. Stimulating usage problem generation: An urban mobility case study. *Design Studies*, Elsevier, 2019, 64, pp.27-63.

Abood Mourad, Jakob Puchinger, Chengbin Chu. Owning or sharing autonomous vehicles: comparing different ownership and usage scenarios. *European Transport Research Review*, Springer Verlag, 2019.

Reza Vosooghi, Jakob Puchinger, Marija Jankovic, Anthony Vouillon. Shared Autonomous Vehicle Simulation and Service Design. *Transportation research*. Part C, Emerging technologies, Elsevier, 2019, 107, pp.15-33

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# Call Centers

## Optimization of multichannel operations in modern call centers

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INTERACTIV GROUP

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# Research

The chair "Call Centers" aims at proposing novel solutions for the operations management and optimization of multichannel call centers. It consists of adapting operations to the exponential growth of the technological progress while accounting for the human element, which is one of the most important features in call centers. In particular, the chair addresses the following research questions:

- Routing with high identification level for customers: In the new context of Web-RTC systems, the classical routing of customers to agents is no longer appropriate. Agents are becoming more and more active in selecting the jobs they handle. The objective is to study the effect of this change on performance and on agent behavior: are we converging toward a situation of hyper-specialization, or a situation with an increasing number of skills per agent?
- Advertizing during waiting: analysis of the impact of advertizing parameters on the customer behavior in commercial call centers. The objective is to understand how advertising may intensify or reduce the abandonment phenomena.

**Methodology**

- Quantitative approach for operations management
- Stochastic models
- Queueing systems
- Markov chains
- Markov decision processes
- Empirical analysis

**Contributions**

- Recommendations and insights for call center managers
- Contributions to the literature of service operations management
- Contributions to the literature of stochastic processes
- Scientifique approach for the developpement of Interactiv Group products in order to make them more flexible and performant

# Publications

Benjamin Legros, Oualid Jouini. On the scheduling of operations in a chat contact center. *European Journal of Operational Research*, 2019, 274 (1), pp.303-316.

Benjamin Legros, Oualid Jouini, Ger Koole. Should we wait before outsourcing? Analysis of a revenue-generating blended contact center. *Manufacturing & Service Operations Management*. Accepted, 2019.

# Supply Chain

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**Partners**:
Carrefour, LVMH, Safran and Sanofi.

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# Research

The Supply Chain chair includes in a unique partnership with several major companies. The supply chain chair was launched in 2008 with a first phase from 2008 to 2013, renewed in 2014 for a second season until 2018 (with Carrefour, LVMH, Safran and Sanofi as partners) and again renewed in 2019 for a third season until 2023 with Air Liquide, L'Oréal and Safran as partners.

The goal of this chair is threefold:
- Develop research and innovation in supply chain,
- Develop skills of managers and best practices in the four companies,
- Stimulate the interests of CentraleSupélec students for supply chain careers.

Among the topics addressed by the Supply Chain Chair
- Agility and resilience in supply chains: how to make supply chains more agile and resilient to cope with uncertain situations,
- Supply chain and enterprise performance: how to put forward the key role of supply chain in the financial and environmental performance of companies.
- Multi-echelon supply chains: how to efficiently manage supply chains with partial information and reverse flows
- Supply Chain and data analytics: how to use new data science techniques to optimize supply chain decision making

# Publications

S. Boubaker, Z. Jemaï, E. Sahin, Y. Dallery. A new metric to evaluate the supply chain agility. International Conference on Industrial Engineering and Systems Management, IESM 2017, Saarbrucken, Germany.

S. Boubaker, Z. Jemaï, E. Sahin, Y. Dallery. 2018. Supply chain agility: review of situations, 8th International Conference on Operations Research and Enterprise Systems (ICORES 2019), Prague.

S. Boubaker, Z. Jemai, E. Sahin, Y. Dallery, "Supply chain agility drivers and enablers", International Conference on Industrial Engineering and Systems Management, IESM 2019, Shanghai, China.

# Risk and Resilience of Complex Systems

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**Partners:**
EDF (historic partner), SNCF, Orange, Paris Airport

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# Research

**Operation**
The RRCS chair is taking over a previous chair on Systems sciences and Energy Challenges supported by EDF for 9 years. The aim is to use the past experience and to wide the scope with no limitation to energy production systems. It is a multi-partner chair with as main partners:
- EDF (historic partner)
- SNCF
- Orange
- Paris Airports

The interest is that the partners can share common concerns, contribute to the development of pooled models and exchange on use cases. Ultimately, they will benefit from the methods and tools developed by all the members of the chair. The chair is based on a team of 3 experienced permanent staff (two associate professors and one professor) and several PHD students. The chair has two main missions: to ensure a level of scientific excellence and to promote the transfer of knowledge / technology.

**Scientific project**
The main topics covered are risk analysis and optimizing the resilience of complex systems. The three lines of work identified to date by the partners are:

1. **Modeling systems of systems and interdependencies for risk management and resilience between several operators**
The objective is to understand how different systems interact with each other and to have, via modeling and then simulation work, an overall vision that allows to anticipate and optimize decisions.
Anticipating means predicting the dysfunctions of a subsystem (beyond on / off, studying and characterizing degraded modes), predicting the impact of a subsystem (including organizational and human factors) on the global system, anticipate disruptions from outside, identify the most critical elements to allocate surveillance, investment efforts.
Optimizing means improving the capacity to optimize the service overall, taking into account the multiplicity of players and their own objectives.
The proposed approaches are based on i) the sharing of methods to analyze incidents between systems, and to assess and manage the criticality of subsystems ii) the definition of appropriate metrics, iii) the development of a heritage policy, with a global vision, iv) enhancement of modularity and interchangeability between models to take into account the different building blocks of telecoms (very intertwined with obsolescence problems), energy and transport.

2. **Modeling and optimizing maintenance phases to reduce their impact on intra- and inter-operator service continuity**
The objective is to reduce costs (failure costs, CAPEX, etc.) through physical modeling of the system (digital twin) and its use to simulate and then optimize the planning of corrective, preventive and predictive maintenance actions.
Optimizing an effective predictive maintenance policy involves being able to aggregate the maximum amount of information from systems, including information not coming from sensors (human flows, behaviors for example) and to

exchange these information between different actors. This makes it possible to have reliable predictions about future failures and to anticipate them.
Optimal maintenance planning involves jointly optimizing predictive, preventive and corrective actions and managing the constraints specific to each actor to ensure continuity of service (allocation of resources in particular).
The envisaged approaches focus on critical costs such as those associated with the movement of teams, putting in competition strategies of the distributed system type versus movement of equipment. They must also take into account the fact that the systems evolve by themselves, repair themselves, reorganize (like the rerouting of Telecom traffic for example). The self-healing properties and issues to improve the next generations will have to be integrated.

3. **The development of a common platform of models and methods and the implementation of sensitivity studies**
This work axis is transverse to axes 1 and 2. It aims to feed them on the scientific level but also to contribute to the transfer of knowledge and technology between the partners and towards the operational staff.
On the scientific level, it is a question of characterizing and evaluating the sensitivity of the models developed for axes 1 and 2 to the quality of the data and information available to feed them. This data can be input data for the simulation (online data, type of degradation level or operating mode) but also learning data to estimate the parameters or the structure of the models (historical data).
In terms of transfer, it is a question of promoting the emergence of a common platform of models and methods, and of taking into account the difficulties linked to communication between models, multi-scale and multi-domain modeling, specification of interfaces, development of dedicated prototypes.

These three axes are fed by use cases proposed by the partners.

# Selected publications

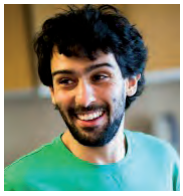

• Tang, D., Fang, Y.-P., Zio, E., Ramirez-Marquez, J.E. Resilience of Smart Power Grids to False Pricing Attacks in the Social Network (2019) *IEEE Access*, 7, art. no. 8737944, pp. 80491-80505.
• Wang, H., Fang, Y., Zio, E. Risk Assessment of Electrical Power Systems Considering Traffic Congestion (2019) *Proceedings - 2018 3rd International Conference on System Reliability and Safety*, ICSRS 2018, art. no. 8688718, pp. 386-389.
• Abdin, I.F., Fang, Y.-P., Zio, E. A modeling and optimization framework for power systems design with operational flexibility and resilience against extreme heat waves and drought events (2019) *Renewable and Sustainable Energy Reviews*, 112, pp. 706-719.
• Fang, Y.-P., Sansavini, G., Zio, E. An Optimization-Based Framework for the Identification of Vulnerabilities in Electric Power Grids Exposed to Natural Hazards (2019) *Risk Analysis*, 39 (9), pp. 1949-1969.

# CapitalDon

Capitaldon Sustainable Growth Chair (2011-2021)

Contact: pascal.da-costa@centralesupelec.fr

Pascal DA COSTA
Professor
Chair holder



Mehdi SENOUCI
Assistant Professor

Georges Vivien
HOUNGBONON
Postdoctoral
Researcher
2017-2018

Emilien RAVIGNE
PhD Candidate
2019-2021

# Research

The Sustainable Growth Chair is a private sponsorship by the Capitaldon endowment fund. His research topic is the impact of innovation and market structures, related to energy and the environment, in particular, on potential growth, dynamics economic systems, including redistributive effects (inequalities).
Emilien Ravigné's thesis, which began in 2019 and is due to be completed in 2021, is funded under this Chair and deals with the redistributive effects of climate policies, a highly topical subject.

**Keywords:**
Innovation-based growth, Economics of Climate and energy, Jobs, Inequalities and innovations, Redistributive effects.

# Selected publications

P. Da Costa and D. Attias (eds.), *Towards a Sustainable Economy: Paradoxes and Trends in Energy and Transportation*, Springer Nature, 2018.

G.-V. Houngbonon and M. Senouci, The impact of innovation on wage inequality in France, WP LGI/ED, 2018.

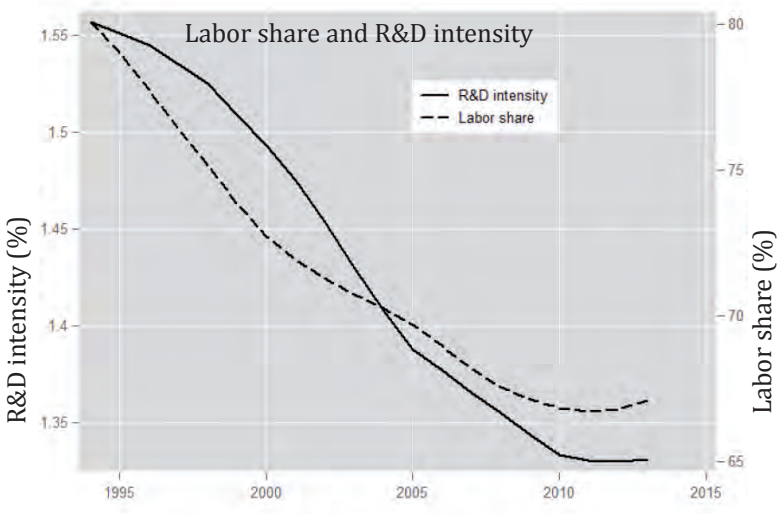
G. V. Houngbonon and P. da Costa, Declining Labor Share and Innovation, WP LGI/ED, 2017.

P. da Costa, L. Rougé, F. Henriet, Climate and economic policies in endogenous growth models with innovation, WP LGI/ED, 2015.

R. Coulomb and M. Magnier, The Impact of Political Majorities on Firm Value: Do Electoral Promises or Friendship Connections Matter? *Journal of Public Economics*, 2014.

F. Henriet, N. Maggiar, K. Schubert, Can France achieve the Factor 4 objective? An evaluation using a stylized energy-economy model", *Economy and Forecast*, 2014.

W. Tian and P. Da Costa, Inequalities in per capita CO2 emissions in European Union, 1990-2020, *11th International Conference on the European Energy Market (EEM)*, Krakow, IEEE, May 2014.




**Note**: Local polynomial smoothing of the trends in R&D intensity and labor share. We use the epanechnikov kernel with a polynomial of degree zero (constant) and the bandwidth of 2.36 for labor share and 3.56 for R&D intensity

**Declining Labor Share ans Innovation**
Georges V. Houngbonon & Pascal Da Costa

CHAIRE ARMAND PEUGEOT

Technologies hybrides et
économie de l'électromobilité

Contact: yannick.perez@centralesupelec.fr

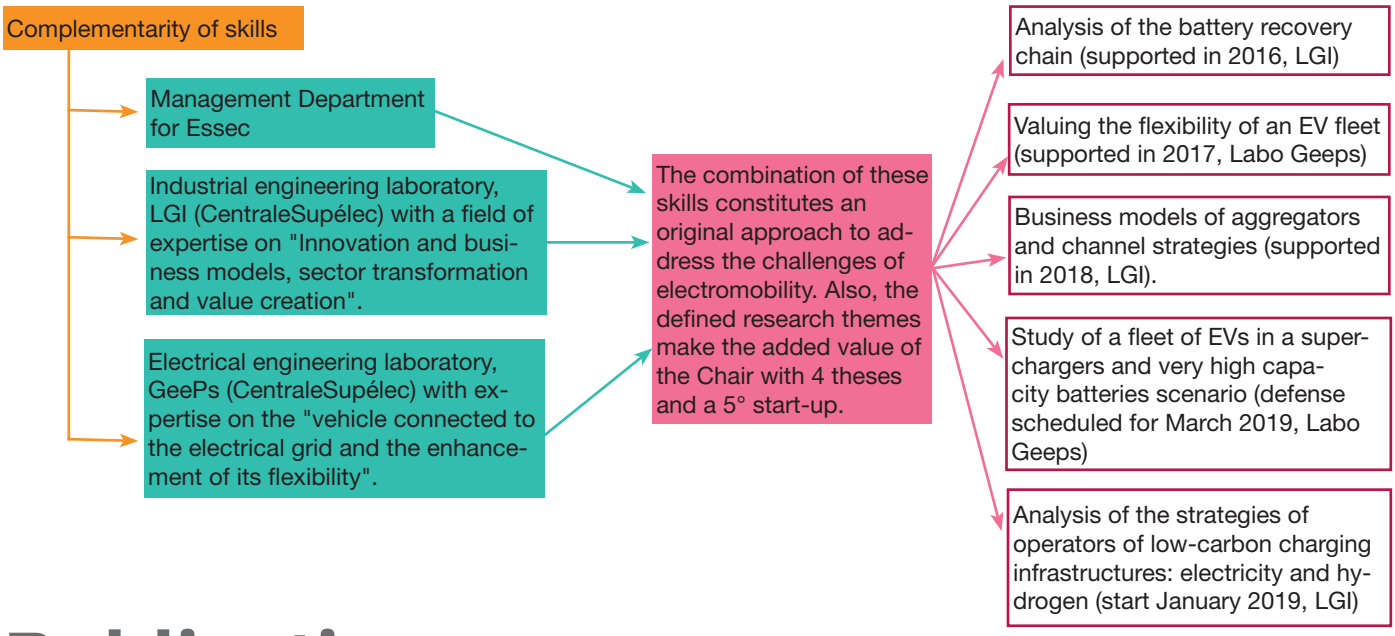
**Partners:**
PSA Groupe, ESSEC
Electrical engineering laboratory,
GeePs (Centralesupélec)

Chairholder
Yannick PEREZ
Full Professor in Economics

Bassem HAIDAR
PhD Candidate

# Research

**The objectives of the Chair**
The Armand Peugeot Chair, created in 2011, renewed in 2016 and in 2019, aims to provide research skills to contribute to the development of the electric and/or hybrid vehicle industry.The challenges of electromobility are complex and raise technical-economic, political, sociological and strategic issues for all car manufacturers, including the PSA Group.




# Publications


- Andrew Thompson and Yannick Perez 2020, *Vehicle-to-Anything (V2X) Energy Services, Value Streams, and Regulatory. Policy Implications*, Energy Policy Forthcoming.
- Quentin Hoarau & Yannick Perez, 2019, *Network tariff design with distributed energy resources and electric vehicles*, Energy Economics, Volume 83, September, Pages 26-39.
- Olfa Tlili, Christine Mansilla, David Frimat, Yannick Perez, 2019 *Hydrogen market penetration feasibility assessment: Mobility and natural gas markets in the US, Europe, China and Japan*, International Journal of Hydrogen Energy Volume 44, Issue 31, 21 June 2019, Pages 16048-16068.
- Ramírez Díaz Alfredo, Marrero Gustavo, Ramos-Real Francisco, Perez Yannick, 2018 *Willingness to pay for the electric vehicle and their attributes in Canary Islands*, Renewable and Sustainable Energy Reviews Volume 98, December 2018, Pages 140-149.
- Hoarau Quentin and Perez Yannick, 2018, *Interactions Between Electric Mobility And Photovoltaic Generation: A Review*, Renewable and Sustainable Energy Reviews 94 (2018) 510–522.
- Rodríguez Brito Maria Gracia, Ramírez-Díaz Alfredo Jesús, Ramos-Real Francisco J., Perez Yannick, 2018, *Psychosocial traits characterizing EV adopters' profiles: The case of Tenerife (Canary Islands)*, Sustainability 2018, 10, 2053.
- Vazquez Miguel, Hallack Michelle and Perez Yannick 2018, T*he dynamics of institutional and organizational change in emergent industries: The case of electric vehicles.* International Journal of Automotive Technology and Management Vol. 18, No. 3, pages 187-208, 2018

# Managing Procument Risks in Complex Projects

**Partner:**
Total

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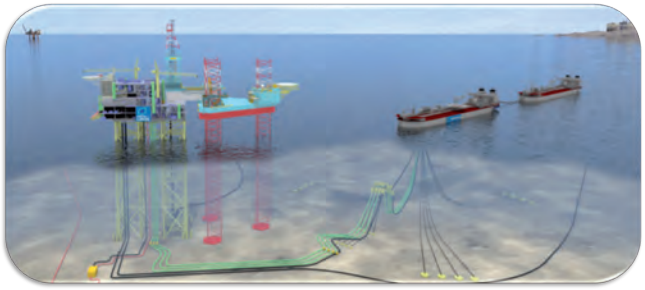


Franck Marle
Professor
Chair holder

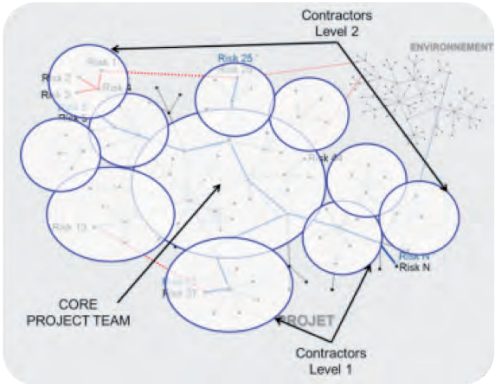
Meriam Kilani
PhD Candidate

# Research

The TOTAL Chair “Managing Procument Risks in Complex Projects” has been launched in 2012. Initial research objectives were threefold. First, to deeply analyze risks related to contracts and procurement activities in complex exploration & production projects. Second, to focus on a strategic upstream decision consisting in designing future contract-based project organization, called contractual strategy. Third, to integrate sustainable targets in design decisions, notably for developing host countries, called In-Country Value strategy.

The Chair activities in 2019 were:

- March 2019 : The end of the PhD about In-Country Value strategy selection (Mathieu Dernis).
- May 2019 : The renewal of the Chair for a next season (at least until 2022 and possibly 2024).
- June 2019 : The launch of a new PhD thesis (Meriam Kilani)




The updated research objectives for season 2 are the following:

- Coordinating multiple and interdependent decisions, related to different project phases, knowledge areas and organizational entities.
- Elaborating strategies for an optimal decision date, balancing risks and opportunities between early and late strategies.
- Organizing collective decision-making and governance

# Publications

Mathieu Dernis. Modélisation et estimation des valeurs apportées au pays hôte pour aider à la décision dans l’élaboration des stratégies In-Country-Value. Autre. Université Paris-Saclay, 2019. Français.

Meriam Kilani, Franck Marle. Robustness of Analysis of Simplified Networks. *21st International Dependency and Structure Modeling Conference*, DSM 2019, Sep 2019, Monterrey, CA, United States.

# FlexTech

## Human Systems Integration

of Increasingly-Autonomous Complex Systems

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**Partners**: French Air Force... and more to come.

## FROM RIGID AUTOMATION...
## ... TO FLEXIBLE AUTONOMY

We automated a lot during the 20th century increasing safety, efficiency and comfort in nominal situations, but leading to rigidity in off-nominal situations. It is time to develop research and innovation on flexibility that increases technological, organizational and human autonomy. At the same time, digitalization of our life and work spaces and supporting systems increases the need for research on both physical and cognitive tangibility. This is the reason why FlexTech develops interdisciplinary research and innovation at the cross-roads of systems engineering, artificial intelligence and human factors.

**This is the shift from HighTech to FlexTech**

Guy André Boy
Professor & Chair

Andreas Hein
Researcher

Dimitri Masson
Researcher

Eric Villeneuve
Researcher

Chloé Rolos
PhD Student

Stélian
Camara Dit Pinto
PhD Student

# Research

The FlexTech Chair started in September 2019 as a joint research effort associating CentraleSupélec LGI and ESTIA Institute of Technology. It focuses on providing research, education and community interaction to advance best practices in human-centered design (HCD) leading to improved human-systems integration (HSI) of complex life-critical systems.

FlexTech Chair philosophy is based on HCD and creativity, collaborative work, cognitive engineering, complexity analysis, organization design and management, modeling and human-in-the-loop simulation, advanced interaction media, and the study of life-critical systems. It is at the intersection of human and social sciences, systems engineering, human-computer interaction, and artificial intelligence. Our major goal is to make human-systems integration concrete and successful.

Two Ph.D. students are already working on research projects with Total on HCD of robotic systems and experience feedback integration into digital twins. Four more will be launched before the end of the year 2020 on future air combat systems.

# Publications

Boy, G.A. (2020). *Human Systems Integration: From Virtual to Tangible*. CRC Press – Taylor & Francis Group, USA.

Boy, G.A., Guegan, A., Vion, V. & Krob, D. (2019). Complex Systems Design and Management. Springer Nature Switzerland AG, ISBN-13: 9783030348427.

# Monitoring of Circular Economy

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Isabelle Nicolaï
Professor

Yann Leroy
Assistant Professor

Mickaël Saidani
Researcherr

No standard or methodological approach is divided to measure and monitor a company's transition to a circular model. Today, too often, companies limit themselves to measuring the impacts of their projects through their exposure to the 17 Sustainable Development Goals. In order for positive impact approaches to be credible, a benchmark needs to be developed which takes into account effective measures of the contributions of industrial activities throughout the life cycle of products.
Firms as well as investment funds demonstrate an explicit intention to generate positive social/environmental impacts through funded projects. They are comitted to measuring these impacts to report to stakeholders (including territories) of their contribution to a sustainable economy.

The aim of this industrial chair is to build a circularity indicators referential to steer industrial activities as well as investment decisions. This chair benefits from the support of INEC (Institut National de l'Economie Circulaire) and the commitment of the Institut Louis Bachelier. Communauté d'Agglomération Paris Saclay, SIOM, Vale NC have already expressed their ambition to engage in circular production systems developed in their territories.