

2020

Annual Report

Laboratoire Génie Industriel
Industrial Engineering Research Department

LGI, EA 2606

LGi

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.

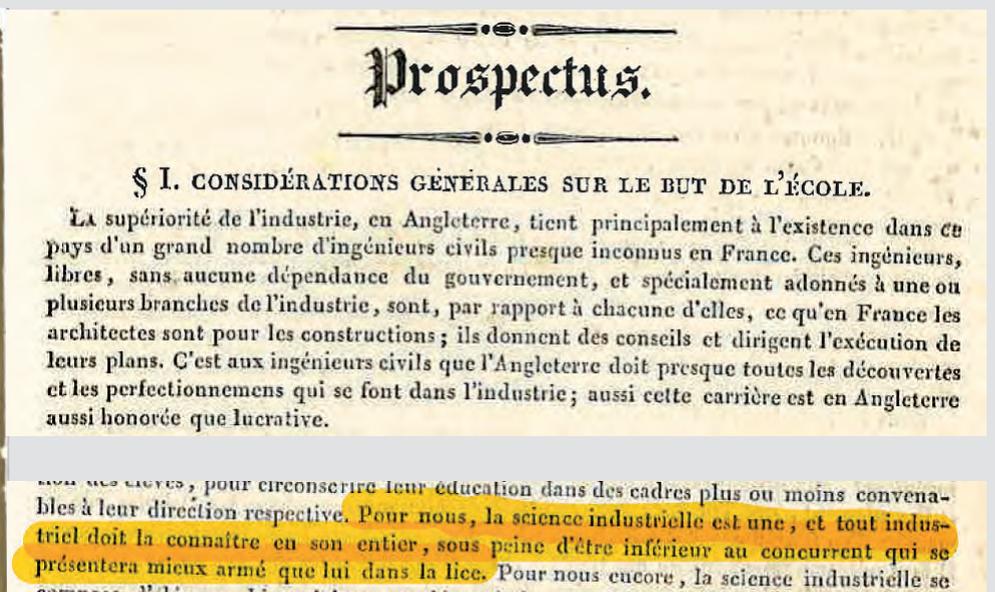
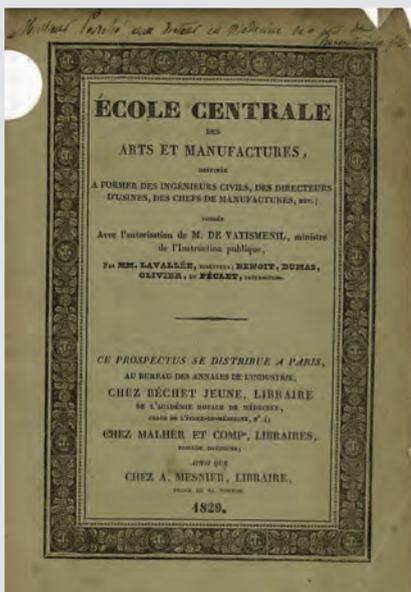
En effet, l'objectif de servir le développement industriel et socio-économique de la France était annoncé en préambule du programme pédagogique de l'Ecole Centrale des Arts et Manufactures lors de sa création en... 1829. Le LGI s'insère dans cette tradition historique en faisant constamment évoluer ses 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 digitlisation 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



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 fin 2019 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 ». Il s'agit de passer d'une automatisation rigide à une autonomie flexible en concevant les tâches des opérateurs en même temps que la partie technique, une recherche qui allie modélisation cognitive et simulation avec des jumeaux numériques. En décembre 2020, nous avons inauguré la chaire « Risques et Résilience des Systèmes Complexes ». La chaire qui était portée historiquement depuis 10 ans par EDF s'ouvre maintenant à d'autres partenaires industriels (SNCF, Orange). Entre ces trois opérateurs de réseaux (électricité, communication, ferroviaire), l'objectif est de simuler la propagation de défaillances entre systèmes interconnectés. Il s'agit de stimuler et de renforcer la fiabilité, la continuité de service pour un client final (voyage en train) pour, à la fois augmenter la résilience de ce Système de Systèmes en définissant notamment une politique de maintenance inter-systèmes plus concertée. Enfin, les collègues du LGI se sont investis dans la réforme de l'enseignement du cursus unifié en étant acteurs de la dominante 3A intitulée « Grands Systèmes en Interaction » qui a démarré en septembre 2020, particulièrement en portant 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-Saclay¹ 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

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 this solution will interact. A solution must contribute as much as possible to the overall performance of the system of systems. At the end of 2019, together with ESTIA (Ecole Supérieure des Technologies Industrielles Avancées), we launched the FlexTech Chair on «human-system integration in complex systems with increasing autonomy». The aim is to move from rigid automation to flexible autonomy by designing operator tasks at the same time as the technical part of the system, research that combines cognitive modeling and simulation with digital twins. In December 2020, we inaugurated the «Risks and Resilience of Complex Systems» chair. The chair, which was historically held by EDF for 10 years, is now open to other industrial partners, SNCF and Orange. Between these three network operators (electricity, communication, railway), the aim is to simulate the propagation of failures between interconnected systems. It allows to simulate and reinforce the reliability and continuity of service for an end customer (train travel), and at the same time increase the resilience of this System of Systems by defining, in particular, a more concerted inter-system maintenance policy. Finally, the colleagues of the LGI have invested in the reform of the teaching of the unified curriculum by being actors of the 3A curriculum entitled «Major Systems in Interaction» which started in September 2020, particularly by carrying 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 in-*

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

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 circularité² à l'échelle d'un périmètre industriel ou d'un territoire. Ces indicateurs auront pour objectif de mesurer puis optimiser 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

Hajar Hilali (supply chain) nous a rejoint sur un poste d'ATER (équipe MO).

Mokhtar Walid Bennaceur nous a rejoint sur un post-doctorat (équipe IC).



Hajar Hilali



Mokhtar Walid Bennaceur

Notre collègue Asma Ghaffari (recherche opérationnelle, optimisation, équipe MO) a fait le choix pour l'instant de s'éloigner de la carrière d'enseignante-chercheuse. Notre collègue Danielle Attias (finance, économie, équipe ED) a fait valoir sa retraite en obtenant l'éméritat. Andreas Hein, chercheur en Ingénierie Système et Intelligence Artificielle (équipe IC) nous a aussi quittés.

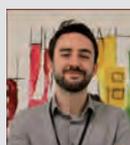
Signalons aussi le départ de trois chercheurs en post-doctorat :



Fabio Antonialli



Hicham Benbitour



William Fauriat

dustrial 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).

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

Staff development

Hajar Hilali (supply chain) joined us on an ATER position (OM team).

Mokhtar Walid Bennaceur joined us on a post-doctoral position (DE teams).

Our colleague Asma Ghaffari (Operations Research, Optimization, OM research group) has decided to move away from a career as a teacher-researcher for the time being. Our colleague Danielle Attias (finance, economics, SE group) also retired, while obtaining the emeritus. Andreas Hein, researcher in Systems Engineering and Artificial Intelligence (DE team) has also left us.



Asma Ghaffari



Danielle Attias



Andreas Hein

Let us also mention the departure of three post-doctoral researchers: Fabio Antonialli, Hicham Benbitour and William Fauriat.

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>

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.

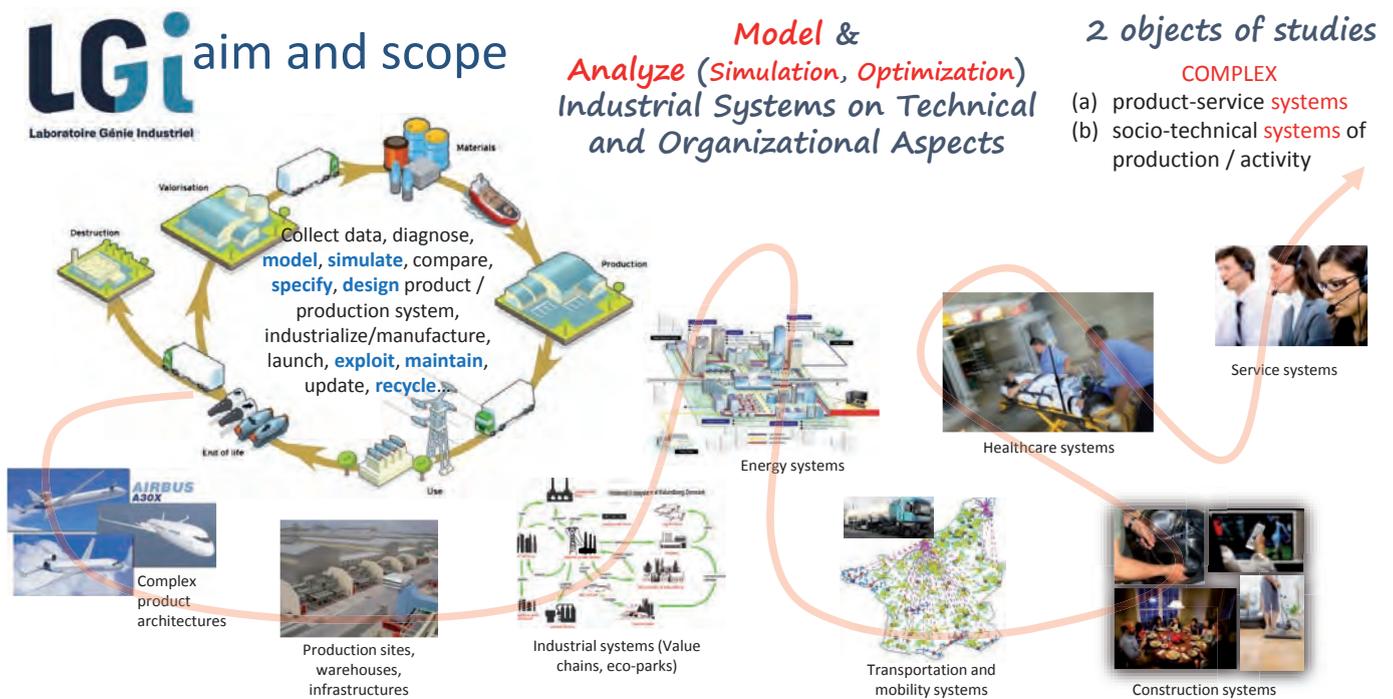


Figure 1: LGI studies production, activity or socio-technical systems along their life cycles

Key principles of our research are: multidisciplinary, 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.

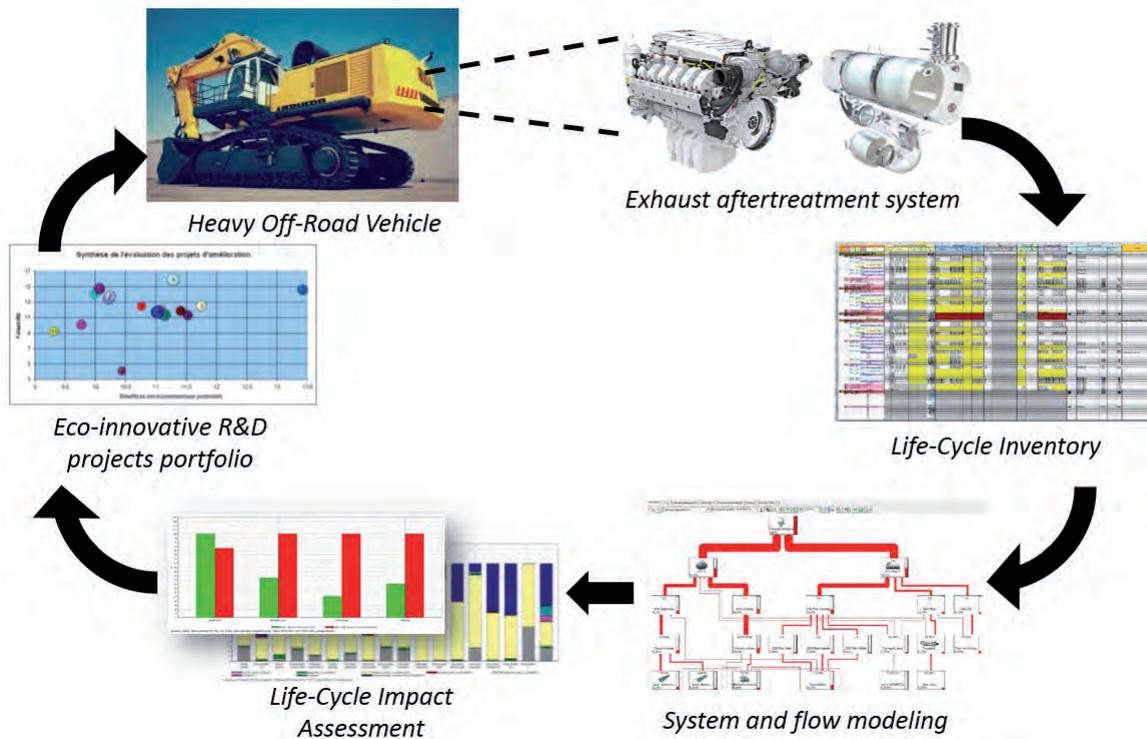


Figure 2: Life Cycle Assessment & Eco-Design of complex industrial systems



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

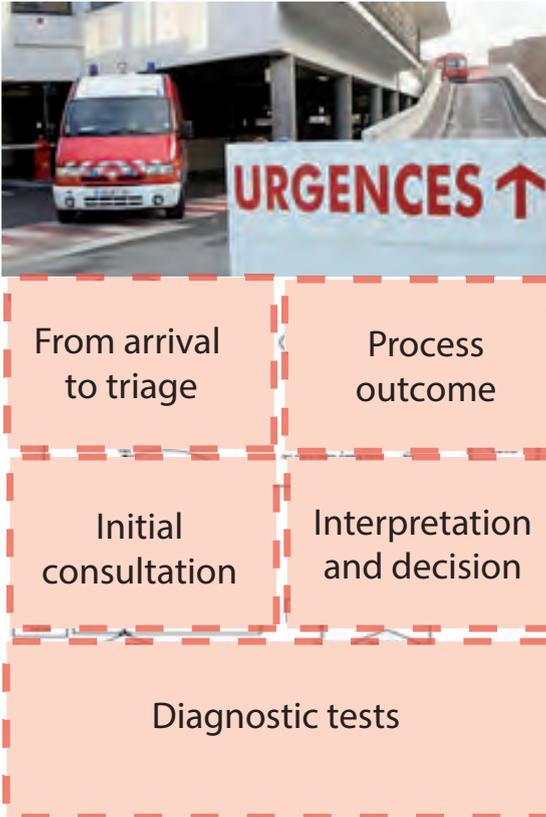


Figure 4: Optimization of patient flows in emergency services

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,
- 11 industrial chairs.

The 4 research groups have 3 research axes each (see Table 1).

The 5 transversal themes are: Mobility systems, Energy systems, Healthcare systems, Industry of the future, Circular economy. (see Figure 5)

The 11 industrial chairs are presented in Table 2.

LGI affiliates its PhD Doctorates at Doctoral School Interfaces, and the theses are delivered under the following disciplines: Industrial Engineering, Complex Systems Engineering, Computer Science.

LGI belongs to the Graduate School of Engineering and Systems Science of Université Paris-Saclay, through its Industrial and Manufacturing Engineering discipline topic.

Table 1: The research axes of the four research teams

LGi DESIGN ENGINEERING	Design of Complex Systems	Design of Sustainable Systems	Innovation Engineering
LGi OPERATIONS MANAGEMENT	Operations management for the production and distribution of goods	Management of service operations	
LGi SAFETY & RISK	Complex systems and infrastructures, cyberphysical systems	Industry 4.0 and predictive maintenance	Resilience
LGi SUSTAINABLE ECONOMY	Economics and Management of Innovation	Economics and Management of Mobility	Economics and Management of Energy

Figure 5: The 5 transversal themes

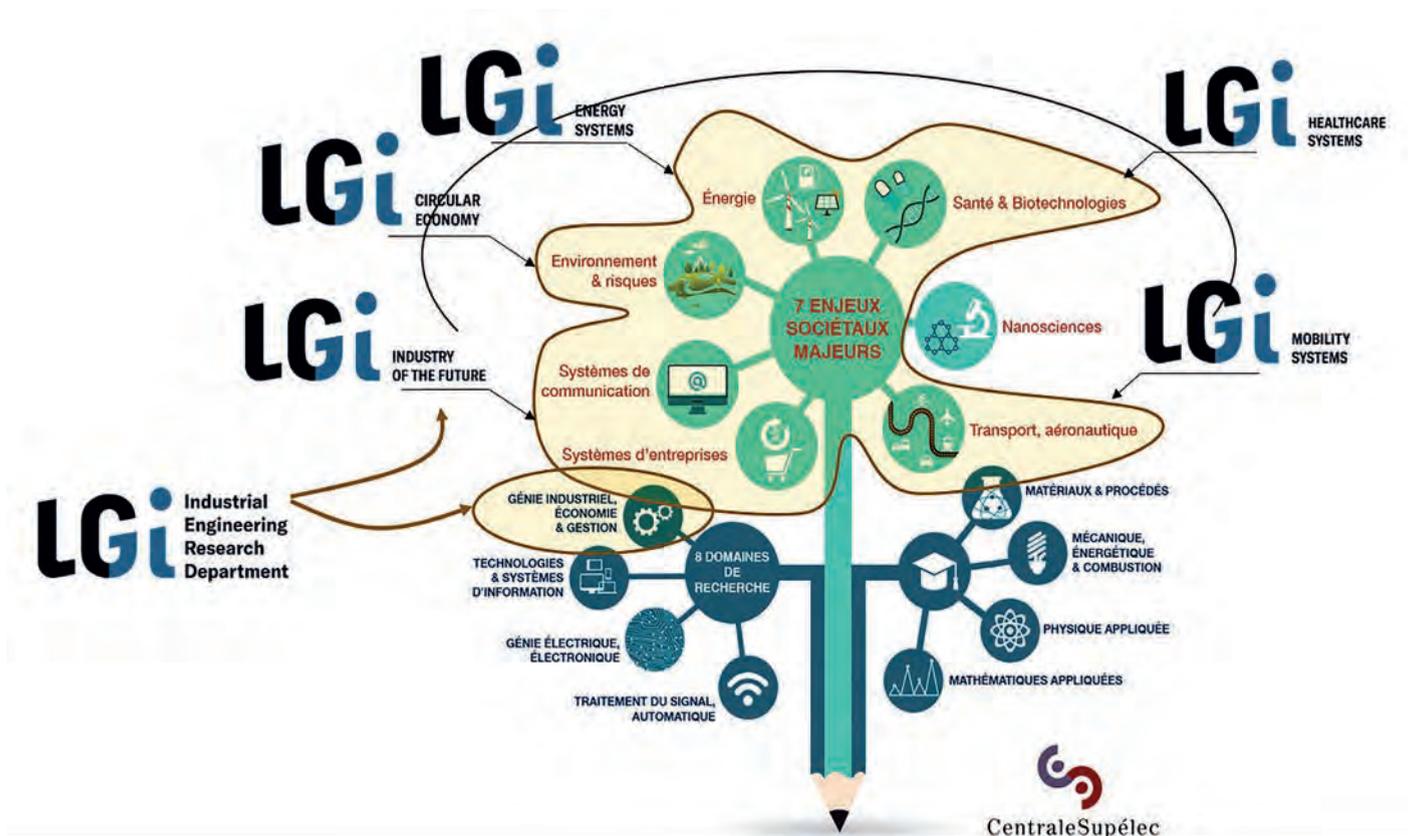


Table 2: The 11 industrial chairs

	Chair	Industrial partners / academic partners
	Maîtrise des risques liés aux achats dans les projets complexes (2013+) <i>Control of procurement risks in complex projects</i> Page 44	Total
	FlexTech (2019+)- Intégration humains-systèmes dans les systèmes complexes à autonomie croissante <i>Human-system integration in complex systems with increasing autonomy</i> Page 45	Armée de l'Air, CS group/ESTIA (Ecole supérieure des technologies industrielles avancées)
	Anthropolis – Conception de systèmes urbains centrés utilisateurs (2014+) - <i>Human-centered urban systems design</i> Page 36-37	EDF, Engie, Nokia Bell Labs, Renault / IRT SystemX, Communauté d'agglomération Paris-Saclay
	Supply Chain (2010+) Page 39	Safran, L'Oréal, Air Liquide
	Call Centers (2016+) Page 38	Interact'iv
	Risk and Resilience of Complex Systems RRSC (2020+) Page 40-41	EDF, SNCF, Orange
	Armand Peugeot – Technologies hybrides et économie de l'électro-mobilité (2014+) <i>Hybrid technologies and the economics of electro-mobility</i> Page 43	PSA Peugeot Citroën / CS/Geeps, ESSEC
	Economie de la Croissance Durable (2011+) <i>Sustainable Growth Economy</i> Page 42	Capitaldon
	Prévention & performance dans le BTP (2019+) <i>Prévention & performance in the construction industry</i> Page 47	Organisme Professionnel de Prévention du Bâtiment et des travaux publics (OPPBTP), Vinci Construction Terrassement (VCT), Eiffage Infrastructure, Groupe Legendre, Université de Sorbonne Paris Nord
	Blériot-Fabre - Conception de systèmes aéronautiques embarqués robustes (2014+) <i>Design of robust on-board aeronautical systems</i>	Safran
	Pilotage de l'Economie Circulaire PEC (2019+) <i>Monitoring of Circular Economy</i> Page 46	Communauté Paris-Saclay, SIOM (Syndicat Inter-communal des Ordures Ménagers, VALE NC)

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 Torino), 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).

Highlights 2020

Inauguration of Chair Risk and Resilience of Complex Systems, September 2020

KEY FIGURES

2020

95 members

Faculties: 28

PhD candidates: 53

Postdoctoral researchers: 8

Technical and administrative staffs: 6

Journals Papers: 42

Contracts: 2,01 M€, including Chairs



DESIGN
ENGINEERING

Industrial Engineering Research Department

Design Engineering Research Group 2020

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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

3 Postdoctoral researchers: Mokhtar-Walid Bennaceur, Andreas Hein, Michaël Saidani

19 PhD candidates: Sylvain Bolifraud, Rebecca Castagnoli, Stélian Carmara Dit Pinto, Youssef Damak, Nelly Dufau, Sarra Fakhfakh, Naouress Fatfouta, Tjark Gall, Ilia Iuskevich, Meriam Kiliani, Robin Lecomte, Yiming Ma, Joseph Mansour Salame, Diya Moubdi, Lara Qasim, Chloe Rolos, Yasmine Salehy, Marcel Lowell Villanueva, 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 complex systems through 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 2020, results in risk domain were notably an agile framework for managing project risks based on complex systems theory and an analysis of contract-related risks propagation through an original framework of interdependent performance factors. The automotive domain has been focusing on structuring knowledge support for the context of simulation-aided-design (one PhD completed). Lastly, several design and modelling approaches supporting design of Systems of Systems have been proposed. The contributions (3 PhDs completed) extended system architecture frameworks to 1), support autonomous car development based upon Operational Context modelling, 2) support collaborative development or Product Service Systems of Systems and 3) support reconfiguration combining design and use phase date (in the IoT context).

2. Design of sustainable systems: aims at developing methods and tools to model, measure and optimize sustainable performances of complex systems. In 2020, research activities particularly dealt with sustainable mobility, with the launch of an EcoSD project with Stellantis

on the eco-design of charging systems and batteries for the mobility on a territory or the launch of a MDPI Sustainability special issue on “Reconciling High tech and Low tech for sustainable urban mobility”. The development of eco-design methodologies for generating sustainable architectures of complex industrial systems, and the development of circularity indicators are still major research topics. On the latter, a call for project “Benchmark of circularity indicators and links with LCA” launched by ScoreLCA has been jointly won with Eeva.

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 and complete innovation methodology to innovate on complex systems from the viewpoint of users, named Radical Innovation Design® (RID). In 2020, first developments of a digital platform were achieved for supporting the RID methodology, along with important advances in decision making algorithms and a RID serious game has been designed and tested for teaching with fun. New researches have also been launched on the «Mobility of the future and urban life» theme of the Anthropolis chair and focus on plausible future mobility services integrated into the urban life of citizens by 2030-2050.

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 axis 3, the project is two-fold: characterizing the potential and maturity of an innovative technology on relevant markets, and digitalizing innovation in order to make innovation activities more efficient, attractive and fluid.

In 2020

31 Members

4 Research chairs

4 PhDs completed

7 Journals

19 Conference papers

2 Books

Selected Publications

Journal papers

Franck Marle (2020) An Assistance to Project Risk Management Based on Complex Systems Theory and Agile Project Management, Complexity, vol. 2020, Article ID 3739129, 20 pages.

Guillaume Lamé, Oualid Jouini, **Julie Stal-Le Cardinal**. (2020) Combining Soft Systems Methodology, Ethnographic Observation and Discrete-Event Simulation: A Case Study in Cancer Care, Journal of the Operational Research Society, Palgrave Macmillan, 71 (10), pp.1545-1562.

Harrison Kim, **François Cluzel, Yann Leroy, Bernard Yannou**, Gwenola Yannou-Le Bris (2020) Research perspectives in ecodesign, Design Science, 6, E7.

Reza Vosooghi, Jakob Puchinger, Joschka Bischoff, **Marija Jankovic**, Anthony Vouillon (2020) Shared autonomous electric vehicle service performance: Assessing the impact of charging infrastructure, Transportation Research Part D: Transport and Environment, Volume 81, 102283, ISSN 1361-9209.

Books

Guy Andre Boy (2020) Human-Systems Integration Design: From Virtual to Tangible, CRC Press, 240 pages, ISBN: 9780367357733.

Xavier Latortue, **François Cluzel, Bernard Yannou, Yann Leroy**, Christophe Gobin, François Cointe, Frédérique Delmas-Jaubert (2020) Les chantiers de l'éco-conception : Les conditions d'une pratique pérenne par les acteurs de la construction. Presses des Mines, 112 pages ISBN: 9782356715784.

Collaborations

Academic Collaborations (in 2020)

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), Anthony Delahaye, Laurence Fournaison, Hoang Hong Minh (INRAE), Michel-Alexandre Cardin (Imperial College), Camille Jean (ENSAM), Sandro Wartzack (Univ Magdeburg), Chris Paredis (Clemson University), Benoît Eynard (Université de Technologie de Compiègne), Claudia Eckert (the Open University), Dorjan Marianovic (Univ. Zagreb), Dimitri Masson, Eric Villeneuve (ESTIA), Benjamin Tyl (APESA), Giacomo Büchi (University of Turin), Roland Cahen (ENSCI - Les ateliers, Centre de recherche en design).

Industrial and institutional collaborations (in 2020)

Total, Armée de l'Air, Dassault Systèmes, Thales, Renault, Stellantis, Airbus, Orange, European Space Agency, DGA,

Stellantis, Vinci Construction, iWips, IRT SystemX, SNCF Réseau, Institut National de l'Economie Circulaire, Silver Valley, Vale NC, Communauté d'agglomération Paris-Saclay, SIOM, Budget our Planet, Will Be Group.

Member of : ACLCA/SETAC, AFIS, ASME, Design Society, DSM, EcoSD, IEEE, INCOSE, Silver Valley, S-mart.

Events

Speech at the French Academy of Technologies by Julie Le Cardinal : «Étude européenne sur les stéréotypes et la perception de la mixité dans les grands groupes », Women Initiative Foundation, March 10, 2020.

Master

Master Paris-Saclay: Ingénierie des Systèmes Complexes, parcours Sciences de la Conception & des Systèmes

4 PhDs Completed

Naouress FATFOUTA

"Towards a support system for simulation aided-design in the development phase of automotive industry"
June 26, 2020



Youssef DAMAK

"Operational Context-Based Design and Architecting of Autonomous Vehicles"
July 16, 2020



Lara QASIM

"System reconfiguration: A model-based approach. from an ontology to the methodology bridging engineering and operation."
December 2, 2020



Sarra FAKHFAKH

"Product Service Systems of Systems Development. Characterization, Modeling, and Analysis Approaches. Application in the automotive industry in view of new mobility solutions"
December 14, 2020



Members

9 Faculty members

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

3 Postdoctoral researchers & 19 PhD candidates





OPERATIONS
MANAGEMENT

Industrial Engineering Research Department

Operations Management Group 2020

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9 Faculty members: Yves Dallery, Asma Ghaffari, Zied Jemaï, Oualid Jouini, Guillaume Lamé, Benjamin Legros, Jakob Puchinger, Fouad Riane, Evren Sahin

3 Postdoctoral researchers: Adam Abdin, Hicham Benbitour, Hajar Hilali

12 PhD candidates: Fatima Ezzahra Achamrah, Tarek Chouaki, Rodrigue Fokouop Wafo, Sadèque Hamdan, Najoua Lakhmi, Marc-Olivier Metais, Laura Mariana Reyes Madrigal, Gustavo Santamaria-Acevedo, Haythem Selmi, Yue Su, Shaohua Yu, Yizeng Zeng

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.).

PhD completed

In 2020

22 Members
3 Research chairs
2 PhDs completed
8 Journals
5 Conference papers



Sadèque HAMDAN

“Optimization models for Air Traffic Flow Management”

December 14, 2020



Shaohua YU

“Modèles et méthodes d’optimisation pour la planification touristique en logistique urbaine intelligente”

December 18, 2020

Selected Publications

Shaohua Yu, Jakob Puchinger, Shudong Sun. (2020) Two–echelon urban deliveries using autonomous vehicles. *Transportation Research Part E: Logistics and Transportation Review*, Elsevier.

Chaaben Kouki, **Benjamin Legros**, M. Zied Babai, **Oualid Jouini** (2020) Analysis of base–stock perishable inventory systems with general lifetime and lead–time. *European Journal of Operational Research*, Elsevier.

Benjamin Legros, Oualid Jouini, Ger Koole (2020) Should we wait before outsourcing? Analysis of a revenue–generating blended contact center. *Manufacturing and Service Operations Management*, INFORMS.

Reza Vosooghi, Jakob Puchinger, Joschka Bischoff, Marija Jankovic (2020) Anthony Vouillon. Shared Autonomous Electric Vehicle Service Performance: Assessing the Impact of Charging Infrastructure and Battery Capacity. *Transportation Research Part D: Transport and Environment*, Elsevier.

Benjamin Legros, Oualid Jouini, O. Zeynep Akşin, Ger Koole (2020) Front–office multitasking between service encounters and back–office tasks. *European Journal of Operational Research*, Elsevier.

Abood Mourad, Jakob Puchinger (2020) Tom van Woensel. Integrating autonomous delivery service into a passenger transportation system. *International Journal of Production Research*.

Guillaume Lamé, Oualid Jouini, Julie Stal–Le Cardinal. (2020) Combining Soft Systems Methodology, Ethnographic Observation and Discrete–Event Simulation: A Case Study in Cancer Care. *Journal of the Operational Research Society*, Palgrave Macmillan.

Collaborations

Academic collaborations

France: Université Pierre et Marie Curie, Université Paris-Saclay.

International: University of Minnesota (USA), Politecnico 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 (Pays Bas), Technische Universität München (Germany), Northwestern Polytechnic University (China) Qatar University of Shariah

Associated industrial chairs

Supply Chain: Air Liquide, L'Oréal, Safran
Anthropolis: Alstom, Engie, RATP, Renault, SNCF, IRT-SystemX
Call Center: Interact'IV

Industrial and institutional collaborations, Agence Régionale de Santé, Carrefour, EDF, Eurodecision, Hôpital Henri Mondor, IBM, Michelin, Groupe Renault, Safran, Sanofi, General Electric Healthcare, Hospital La Pitié Salpêtrière

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
Guillaume Lamé: Area editor Health Systems

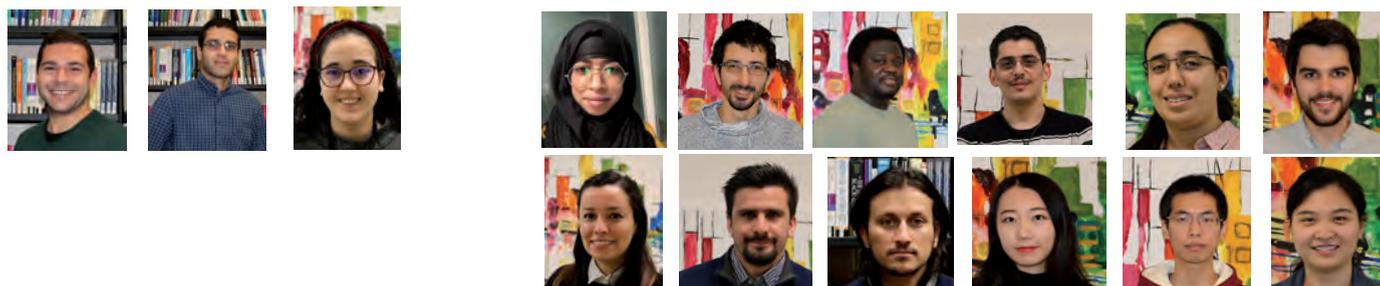
Our research networks : GdR Macs, GdR RO, Roadef

Members

9 Faculty members

	<p>Head :Jakob PUCHINGER Professor jakob.puchinger@centralesupelec.fr Chair Holder “Anthropolis” at IRT-SystemX</p>	Urban mobility, Transport optimization, Combinatorial optimization, Exact and heuristic optimization methods, Operations research
	<p>Yves DALLERY Professor yves.dallery@centralesupelec.fr Chair Holder “Supply Chain Management”</p>	Supply chain management, Supply chain design, Service operations
	<p>Asma GHAFARI Assistant professor asma.ghaffari@centralesupelec.fr</p>	Decision aid, Supply chain, Operations research, Decision making modelling and analysis
	<p>Zied JEMAI Professor zied.jemai@centralesupelec.fr</p>	Supply chain management, Competition and coordination in supply chain, Inventory management of perishable items
	<p>Oualid JOUINI Professor oualid.jouini@centralesupelec.fr Chair Holder “Call Centers”</p>	Stochastic modeling, Service operations management, Call centers, Healthcare systems
	<p>Guillaume LAME Assistant professor guillaume.lame@centralesupelec.fr</p>	Health services research, Healthcare operations management, Problem structuring methods
	<p>Benjamin LEGROS Assistant professor benjamin.legros@centralesupelec.fr</p>	Call centers, Stochastic modeling, Service operations management, Healthcare systems
	<p>Fouad RIANE Professor fouad.riane@centralesupelec.fr</p>	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
	<p>Evren SAHIN Professor evren.sahin@centralesupelec.fr</p>	Supply chain management, Production, Internal logistics, Operations management, Service operations management, Healthcare engineering

3 Postdoctoral researchers & 12 PhD candidates





Industrial Engineering Research Department

Safety & Risks Research Group 2020

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Head | Anne Barros

3 Faculty members: Anne Barros, Yiping Fang, Zhiguo Zeng

2 Postdoctoral researchers: Islam Adam, William Fauriat

9 PhD candidates: Benjamin Aupetit, Andréa Belle, Léo Chartier, Rui Li, Youba Nait Belaid, Hoang-Phuong Nguyen, Khaled Sayad, 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 2020

14 Members

2 Research chairs

2 PhDs completed

18 Journals

8 Conference papers

Some Publications

Bani-Mustafa Tasneem, Zhiguo Zeng, Enrico Zio, and Dominique Vasseur (2020) «A practical approach for evaluating the strength of knowledge supporting risk assessment models.» *Safety science* 124: 104596.

Bani-Mustafa Tasneem, Roger Flage, Dominique Vasseur, Zhiguo Zeng, Enrico Zio (2020) «An extended method for evaluating assumptions deviations in quantitative risk assessment and its application to external flooding risk assessment of a nuclear power plant.» *Reliability Engineering & System Safety* 200: 106947.

Zhang Aibo, Himanshu Srivastav, **Anne Barros**, Yiliu Liu (2020) «Study of testing and maintenance strategies for redundant final elements in SIS with imperfect detection of degraded state.» *Reliability Engineering & System Safety*: 107393.

Xing Jinduo, Zhiguo Zeng, Enrico Zio (2020) «Joint optimization of safety barriers for enhancing business continuity of nuclear power plants against steam generator tube ruptures accidents.» *Reliability Engineering & System Safety* 202: 107067.

Zhang Nan, Mitra Fouladirad, **Anne Barros**, and Jun Zhang (2020) «Condition-based maintenance for a K-out-of-N deteriorating system under periodic inspection with failure dependence.» *European Journal of Operational Research* 287, no. 1: 159-167.

Collaborations

Academic collaborations

Europe: Université de Technologie de Troyes (France), Politecnico di Milano (Italy), ETH Zurich (Switzerland), Norwegian University of Science and Technology (Norway), University of Stavanger (Norway), Edinburgh University (United Kingdom)

Rest of the World: Beihang University (China), Beijing Institute of Technology (China), City University of Hong Kong (China), Zhejiang University (China), Xi'an Jiaotong University (China), Ecole Centrale Casablanca (Morocco), Rutgers University (USA), University of Wollongong (Australia)

Associated industrial chairs

Chair on Risk and Resilience of Complex Systems
Chair Blériot-Fabre, SAFRAN

Associated research institutes

Institut de la Science des Risques et de l'Incertitude (ISRI), CentraleSupélec

Industrial and institutional collaborations

EDF R&D, SNCF, Orange, RATP, CEA, Safran, Siemen, DNV-GL, Equinor.

PhD completed



Hoang-Phuong NGUYEN

“Model-based and Data-driven Prediction Methods for Prognostics”

May 25, 2020



Benjamin AUPETIT

«Probabilistic model-checking of Altarica 3.0 models»

June 26, 2020

(Co)-Organized Events

Inauguration of Chair Risk and Resilience of Complex System, CentraleSupélec, France

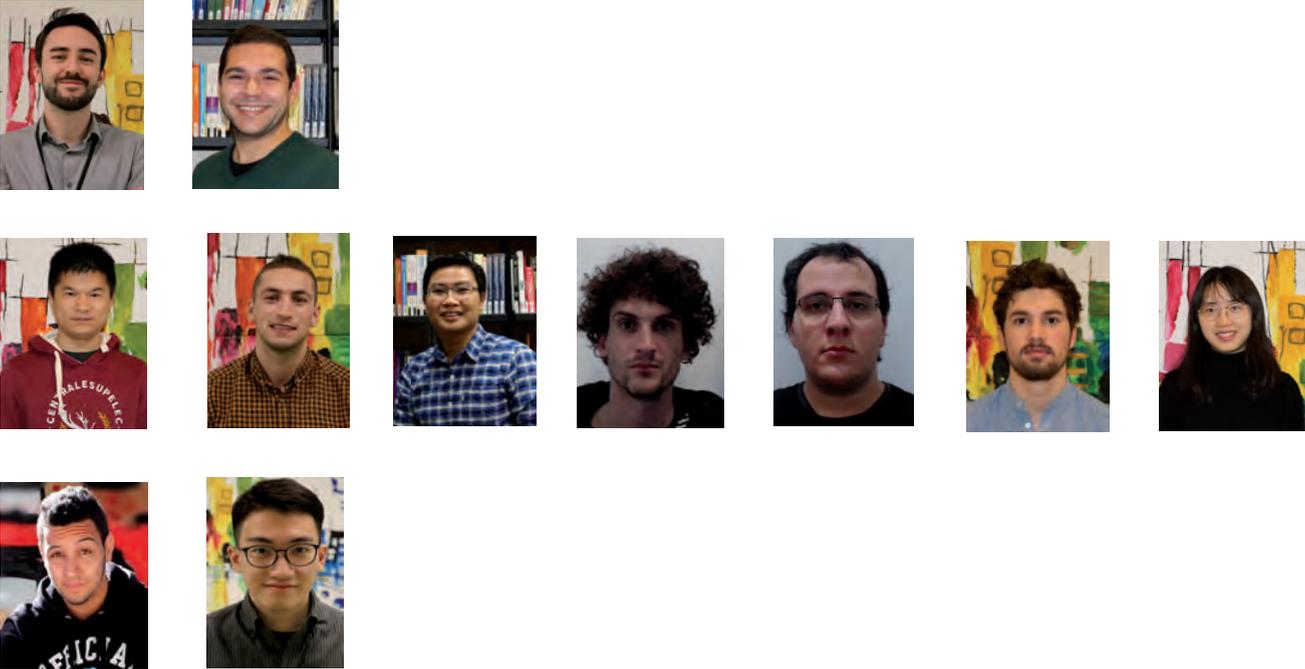
Conference session “Decision Programming for Optimizing Multi-Stage Decision Problems under Uncertainty” in ESREL 2020 PSAM 15

Members

3 Faculty members

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

2 Postdoctoral researchers & 9 PhD candidates





**SUSTAINABLE
ECONOMY**

Industrial Engineering Research Department

Sustainable Economy Research Group 2020

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7 Faculty members: Danielle Attias, Pascal Da Costa, Guy Fournier, Eléonore Mounoud, Isabelle Nicolaï, Yannick Perez, Mehdi Senouci.

1 Postdoctoral researcher: Fabio Antonialli

17 PhD candidates: Guilherme Alcantara Pinto, Thais Assis De Souza, 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, Emilien Ravigné, Laura Mariana Reyes Madrigal, Fawaz Salihou, Francisco José Santos

1 CS Student in research track: Jean-Baptiste Grenier

Research

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

Sustainable Economy' is articulated around three primary directions:

- **Economics and Management of Innovation.** This first direction deals with the evolution of technical progress and the effectiveness of organizations. We seek a better understanding of economic agents' decisions regarding investment and innovation, their microeconomic impacts on firms' growth, 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 direction deals with decarbonated mobility (research chair PSA), autonomous electric shuttles (H2020 project), mobility as a service (MaaS), as well as with the

links with the electricity market (i.e., hybrid energy market = electricity + transportation) through the challenges of electric storage (electricity storage/unloading solutions through electric vehicles). This research is conducted using techno-economic studies, econometric methods, and strategic analyses, notably innovative business models on sustainable mobility.

- **Economics and Management of Energy.** This third direction deals with renewable and nuclear energies, carbon capture and storage (CCS), intending to reach the decarbonization of the energy mix and the economy's carbon neutrality (with RTE, CEA, for example). In this perspective, energy efficiency and the regulation of the markets, including from a social justice perspective (redistributive effects of the carbon taxation, for example), tied to the energy transition are studied. This direction develops research methods in techno-economics, forecasting and prospective analysis, and analyses of global value chains

PhD completed



Rodrigo GANDIA *"Innovation in ecosystem business models: An application to MaaS and Autonomous vehicles in urban mobility system"*
July 9, 2020

In 2020

26 Members

4 Research chairs

2 European project

1 PhD completed

9 Journals

12 Conference papers

Some Publications

Fournier Guy, Boos Adrian, Wörner Ralf, **Jaroudi Ines**, Morozova Inna et al. Substituting individual mobility by mobility on-demand using autonomous vehicles – a sustainable assessment simulation of Berlin and Stuttgart. *International Journal of Automotive Technology and Management*, In press.

Emilien Ravigné, Pascal da Costa (2020) Economic and environmental performances of natural gas for heavy trucks: A case study on the French automotive industry supply chain. *Energy Policy*, pp.112019.

Icaro Silvestre Freitas Gomes, Yannick Perez, Emilia Suomalainen (2020) Coupling small batteries and PV generation: A review. *Renewable and Sustainable Energy Reviews*, 126, pp.109835.

Flore Vallet, Jakob Puchinger, Alexandra Millonig, Guillaume Lamé, **Isabelle Nicolai** (2020) Tangible futures: Combining scenario thinking and personas—A pilot study on urban mobility. *Futures*, 117.

Collaborations

Université Paris Saclay

2 School Université Paris-Saclay: *Engineering; Economics-Management*.

2 Doctoral Schools Paris-Saclay: *Interfaces; Economics-Management*.

3 Masters Paris-Saclay: *Economie de l'Environnement, Energie, Transports (EEET); Industries de Réseau et Économie Numérique (IREN); Economics*.

National and International Scientific Network

France: ESSEC, CEA-Saclay, University Paris Dauphine, AgroParisTech CIREN, VEDECOM: *Public-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, European Commission (ETIP-SNET), KTH Stockholm, Brown University USA, Berkeley University USA, Florence School of Regulation / European University Institute...

Member of

SFM, AIMS, EEM, FAEE, IAEE, CEESAR, French Office Parlementaire de l'Evaluation des Choix Scientifiques et Technologiques.

Associated Research Chairs

Chair Armand Peugeot on Electromobility and hybrid Technology by Peugeot-Citroën.

Chair Monitoring Circular Economy.

Chair OPPBTP, Vinci, Eiffage, Legendre on Prevention and Performance.

Patronage by endowment fund Capitaldon on Sustainable Growth.

European Project

H2020 AVENUE Autonomous Vehicles to Evolve to a New Urban Experience.

ERASMUS Mundus+ EUSL Europe Sri Lanka Capacity Building in Energy Circular Economy.

Events

New responsibility in an academic society

Emma Jagu selected as coordinator for the French Association of Energy Economics (FAEE).

Funding renewal

Chaire Armand Peugeot (with ESSEC and Geeps CS): 2020-2024.

Visiting

Seminar to launch the European project EUSL, Colombo (Sri Lanka), 10-20 February 2020: <https://eusl-energy.fi-rebaseapp.com>

Conference

Online International Conference of the Chair Armand Peugeot (CentraleSupélec), with the Chair Climate Economics (Dauphine), and the Chair Energy and Prosperity (IPP), 14 December 2020.

Members

7 Faculty members

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

1 Postdoctoral researcher & 17 PhD candidates





Themes

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Ambassadors



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

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

- Sustainable urban mobility: we rethink the mobility concept (new usages, new services, multi-modal transport, scenarios, governance system) for the ecological, digital and social transition of the urban

The main results in 2020 which are significant for partnerships between LGI teams are :

- The axis currently gathers 17 PhD students and post-doc registered in all LGI teams and who collaborate together.
- Contribution to the organization of an international "Interdisciplinary Research Program on Urban Mobility" at the Institut Pascal (Université Paris Saclay).
- Projet H2020, AVENUE Autonomous Vehicles to Evolve to a New Urban Experience, programme «Full-scale demonstration of urban road transport automation».
- Adam Abdin, as a post-doc researcher joined in 2020 the Future Cities Lab. This innovative structure is a joint research initiative between Ecole Centrale Pekin in China and CentraleSupélec in France. Its objective is to address the challenges related to planning, operating and managing increasingly complex future urban systems.
- Launching of Mariana Reyes-Madriral's PhD thesis on «Mobility as a Service (MaaS), concepts, governance and business models» supervised by Isabelle Nicolai (Sustainable Economy Team), Jakob Puchinger (Operation management Team and Anropolis Chair Holder) and Virginie Boutueil (LVMT-ENPC).
- Launching of Tjark Gall's PhD thesis on Future Mobility supervised by Bernard Yannou, Flore Vallet (Engineering design team), and Sylvie Douzou (EDF R&D)
- Launching of Robin Lecomte's PhD thesis on «Impacts of scenarios of Autonomous vehicles» co-supervised by Bernard Yannou and Roland Cahen (ENSCI- Les ateliers, Centre de recherche en design)

Keywords:

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

spaces or territories with the integration of the autonomous car.

- Electro mobility economy: we study the link between the business models of new electrical vehicles and the smart grid, and also at the services economy of new mobilities.

Our purpose is to strengthen collaboration links between LGI teams in order to offer a global and pertinent analysis of mobility systems.

- The Anropolis Chair, jointly operated by Centrale-Supélec and IRT Systemx was renewed in 2019 with new stakeholders to pursue the comprehension of urban mobility and to build a vision of future mobility integrating the challenges of urban life. Partners: EDF, Engie, Nokia Bell Labs, Renault, Communauté d'agglomération Paris-Saclay.



Main 2020's Publications on mobility

Icaro Silvestre Freitas Gomes, Yannick Perez, Emilia Suomalainen (2020) Coupling small batteries and PV generation: A review, Renewable and Sustainable Energy Reviews 126 109835.

Andrew Thompson and **Yannick Perez** (2020), Vehicle-to-Anything (V2X) Energy Services, Value

Streams, and Regulatory Policy Implications, Energy Policy 137 111136

Fabio Antoniali, Bruna Cavazza, **Rodrigo Gandia, Isabelle Nicolai,** Joël Sugano, André Luis Zambalde (2020) «Human or Machine Driving? Comparing Autonomous with Traditional Vehicles Value Curves and Motives to Use a Car.», World Review of Intermodal Transportation Research 9(2)

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 2020:

Pr. Le Cardinal served as an expert for the HAS (Haute Autorité de Santé) committee: « Cartographie des impacts organisationnels pour l'évaluation des technologies de santé »

Dr. Lamé is in advisory board «Healthcare Systems Design» SIG. of the Design Society.

Keywords:

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

Several journal publications in the peer review international journals have been accepted:

Duong, T.A., **Lamé, G.**, et al. (2020) ‘A process modelling approach to assess the impact of teledermatology deployment onto the skin tumor care pathway’, International Journal of Medical Informatics

Kelly, S..., **Lamé, G** et al. (2020) ‘Training in the use of intrapartum electronic fetal monitoring with cardiotocography: Systematic review and meta-analysis’, BJOG: An International Journal of Obstetrics and Gynaecology.

Lamé, G., Crowe, S. and Barclay, M. (2020) “What’s the evidence?”—Towards more empirical evaluations of the impact of OR interventions in healthcare’, Health Systems.

Huynh, S., **Lamé, G.**, et al. (2020) ‘Google trends peut-il prédire de nouveaux signes cutanés durant les épidémies?’, Annales de Dermatologie et de Vénéréologie, 147(12, Supplement), A199-A200.

Projects:

- « COVONCO » ARC (cancer foundation) project; Entrepôt de Données de Santé (clinical data warehouse) of AP-HP (Assistance Publique les Hopitaux de Paris) and the hospital Henri Mondor. Evaluation the impact of COVID 19 on cancer patients’ treatment
- « 3D4Care » (FabLab of CentraleSupélec); The faceshields design and production for the early Covid19 pandemic.
- “Analysis of the impact of media coverage and governments decision onto Covid19-related Google queries”, Dr. Tu Anh Duong
- Founding member “Hub PASREL – Technologie & Médecine de demain” defining “Future hospital” at Université Paris-Saclay

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.

2020 main facts

Research projects

- **Launching of the 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://eusl-energy.firebaseio.com/>
- **Launching of the ScoreLCA project** “Benchmark of circularity indicators and links with LCA” jointly with Enea after winning the call for project.
- **Launching of the EcoSD collaborative research project « Ecoconception d’un système d’infrastructures de recharge et de véhicules électriques dans une logique territoriale d’usages de mobilité »** with Stellantis
- **Continuation of the Chair “Circular Economy Monitoring”**, several partners including Vale NC, Communauté d’agglomération Paris-Saclay, SIOM
- **Continuation of the EcoSD collaborative research project SODECO**. Sustainability of data supporting eco-design process. The case of connected vehicle.

Publications

-Two selected publications (one journal paper and one book) for proposing roadmaps and recommendations for sustainable design methods and tools:

- Jeremy Faludi, Steven Hoffenson, Sze Kwok, **Michael Saidani**, Sophie Hallstedt, Cassandra Telenko, Victor Martinez (2020) A Research Roadmap for Sustainable Design Methods and Tools. Sustainability, MDPI, 12 (19), pp.8174. <https://doi.org/10.3390/su12198174>
- **Xavier Latortue, François Cluzel, Bernard Yannou, Yann Leroy**, Christophe Gobin, François Cointe, Frédérique Delmas-Jaubert (2020) Les chantiers de l’éco-conception : Les conditions d’une pratique pérenne par les acteurs de la construction. Presses des Mines, 112 pages ISBN: 9782356715784.

-Two special issue is the MDPI Sustainability journal with guest editors from LGI:

- Design to Drive Behavior Change for Sustainability and Circular Economy, **Yann Leroy**
- Reconciling High Tech and Low Tech for Sustainable Urban Mobility, **Flore Vallet**

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).

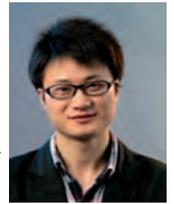
Keywords:

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

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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 (A. Barros)
- Member of the Scientific Committee of the 30th European Safety and Reliability Conference (ESREL2020) (A. Barros, Y.-P. Fang)
- Guest Editor of the special issue “Reliability, Security and Resiliency of Smart Grids” in *Energies* (Y.-P. Fang)

Selected Publications

- Ravigné Emilien, and P. Da Costa** (2020) «Economic and environmental performances of natural gas for heavy trucks: A case study on the French automotive industry supply chain.» *Energy Policy*: 112019

Thompson, Andrew W., and **Yannick Perez** (2020) «Vehicle-to-Everything (V2X) energy services, value streams, and regulatory policy implications.» *Energy Policy* 137: 111136.

- **Tlili Olfa**, Christine Mansilla, Jochen Linßen, Markus Reuß, Thomas Grube, Martin Robinius, Jean André, **Yannick Perez**, Alain Le Duigou, and Detlef Stolten (2020) «Geospatial modelling of the hydrogen infrastructure in France in order to identify the most suited supply chains.» *International Journal of Hydrogen Energy* 45, no. 4: 3053-3072.
- **Ravigné Emilien**, Frédéric Gherzi, and Franck Nadaud (Sept 2020) «From Factor-Four mitigation to Zero-Net Emissions: Is a fair transition possible? Evidence from the French Low-Carbon Strategy.» 7th annual conference of the French Association of Environmental and Resource Economists (FAERE), Grenoble, France.



Keywords:

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

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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 Centrale-Supélec (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 2020:

- The second edition of a 2-week International Summer School on Industry 4.0, that LGI co-organized in 2019 with ENS paris-Saclay and which should have been held in July 2020, has been cancelled due to the Covid-19 situation. .
- CentraleSupélec and especially LGI are partners of the BCG (Boston Consulting Group) ICO (Innovation Centre for Operations) learning factory developed made to demonstrate the abilities of Industry 4.0 technologies to disrupt the production management systems of companies.
- Rongyan Zhou won the Canadian Mitacts Globalink

Research Award for research in Canada. This allowed him to initiate research on the multi-tier supply chain theme with Concordia University.

- 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. Three major French industrial partners are strongly involved in a 5-year chair to support this activity (EDF, SNCF, Orange).

A selection of articles published

Zhou, R., Awasthi, A., & Stal-Le Cardinal, J. (2020). The main trends for multi-tier supply chain in Industry 4.0 based on Natural Language Processing. *Computers in Industry* (10.1016/j.compind.2020.103369)

R. Castagnoli, J. Stal-Le Cardinal (2020) Managing Complexity in Industry 4.0 Based Systems: A Qualitative Analysis. CSD&M, Paris.

Yasmine Salehy, Hong Minh Hoang, François Cluzel, Yann Leroy, A. Delahaye et al (2020) Energy performances assessment for sustainable design recommendations: Case study of a supermarket’s refrigeration system, *Procedia CIRP, ELSEVIER*, 90, pp.328-333 (10.1016/j.procir.2020.01.102)

Shaohua Yu, Jakob Puchinger, Shudong Sun (2020) Two-echelon urban deliveries using autonomous vehicles, *Transportation Research Part E: Logistics and Transportation Review, Elsevier*, 141 (10.1016/j.tre.2020.102018)

Chaaben Kouki, Benjamin Legros, M. Zied Babai, **Oualid Jouini**. (2020) Analysis of base-stock perishable inventory systems with general lifetime and lead-time, *European Journal of Operational Research, Elsevier*, (10.1016/j.ejor.2020.05.024)

Reza Vosooghi, Jakob Puchinger, Joschka Bischoff, Marija Jankovic, Anthony Vouillon (2020) Shared Autonomous Electric Vehicle Service Performance: Assessing the Impact of Charging Infrastructure and Battery Capa-

city, Transportation Research Part D: Transport and Environment, Elsevier, 81 (10.1016/j.trd.2020.102283)

Benjamin Legros, Oualid Jouini, O. Zeynep Akşin, Ger Koole (2020) Front-office multitasking between service encounters and back-office tasks, European Journal of Operational Research, Elsevier (10.1016/j.ejor.2020.04.048)

Olfa Tlili, Christine Mansilla, Jochen Linßen, Markus Reuß, Thomas Grube et al (2020) Geospatial modelling of the hydrogen infrastructure in France in order to identify the most suited supply chains, International Journal of Hydrogen Energy, Elsevier, 45 (4), pp.3053-3072. (10.1016/j.ijhydene.2019.11.006)

Michael Saidani, Erik Pan, Harrison Kim, Andrew Greenlee, Jason Wattonville et al (2020) Assessing the environmental and economic sustainability of autonomous systems: A case study in the agricultural industry, Procedia CIRP, ELSEVIER,90, pp.209-214. (10.1016/j.procir.2020.02.123)

Michael Saidani, Bernard Yannou, Yann Leroy, François Cluzel (2020) Dismantling, remanufacturing and recovering heavy vehicles in a circular economy - Technico-economic and organisational lessons learnt from an industrial pilot study Resources, Conservation and Recycling, Elsevier, 156, pp.104684. (10.1016/j.resconrec.2020.104684)

Hoang-Phuong Nguyen, Jie Liu, Enrico Zio (2020) A long-term prediction approach based on long short-term memory neural networks with automatic parameter optimization by Tree-structured Parzen Estimator and applied to time-series data of NPP steam generators, Applied Soft Computing, Elsevier, 89, pp.106116. (10.1016/j.asoc.2020.106116)

Chao Fang, Piao Dong, **Yiping Fang, Enrico Zio**. Vulnerability Analysis of Critical Infrastructure under Disruptions: an Application to China Railway High-Speed Acknowledgement. Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability, SAGE Publications, In press, (10.1177/1748006X19889149)

William Fauriat, Enrico Zio (2020) Optimization of an aperiodic sequential inspection and condition-based maintenance policy driven by value of information, Reliability Engineering and System Safety, Elsevier, 204, pp.107133. (10.1016/j.ress.2020.107133)

Franck Marle (2020) An Assistance to Project Risk Management Based on Complex Systems Theory and Agile Project Management, Complexity, Wiley, 2020, (10.1155/2020/3739129)

Abood Mourad, Jakob Puchinger, Tom van Woensel (2020) Integrating autonomous delivery service into a passenger transportation system, International Journal of Production Research, Smart city for sustainable urban logistics, (10.1080/00207543.2020.1746850)

Fournier Guy, Boos Adrian, Wörner Ralf, Jaroudi Ines,

Morozova Inna et al. Substituting individual mobility by mobility on-demand using autonomous vehicles – a sustainable assessment simulation of Berlin and Stuttgart., International Journal of Automotive Technology and Management, Inderscience, In press, (10.1504/IJATM.2020.112029)

PhDs Completed

- Hoang-Phuong NGUYEN, “Maintenance scheduling based on PHM approaches under nonstationary environment“

PhD Thesis and post-doctorates

- Rongyan ZHOU, «Exploration of Opportunities & Challenges brought by Industry 4.0 to the Global Supply Chains & the Macroeconomy by integrating Artificial Intelligence & more Traditional Methods»
- Rebecca CASTAGNOLI, “How Industry 4.0 is changing the performance of the manufacturing sector and how it is changing internationalization strategies”
- 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”
- 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, «Un cadre de modélisation basé sur la simulation pour l’analyse et la protection des réseaux intelligents contre les fausses attaques tarifaires»
- 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 Busi-

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.



Industrial Chairs

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Research

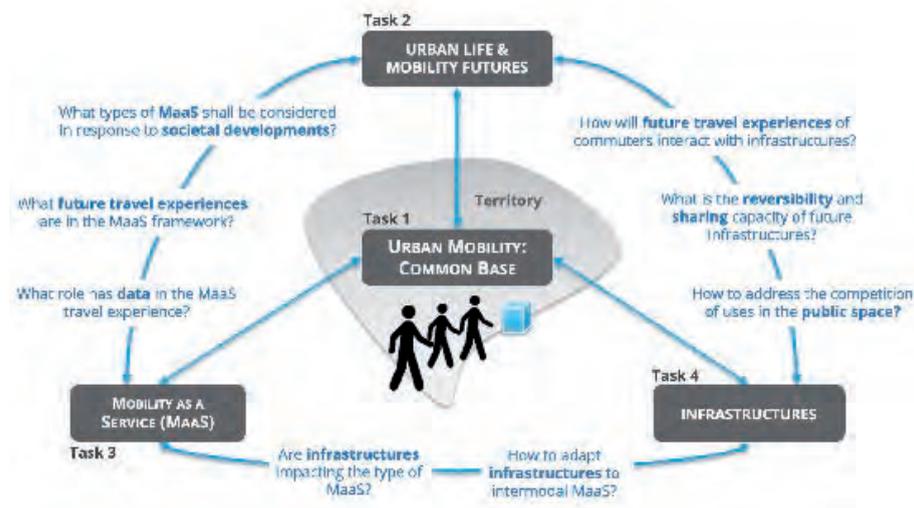
The Anthropolis Chair is constructing a vision of mobility futures by focusing on major challenges of urban life such as reducing carbon emissions and improving quality of life in cities. The Chair develops fundamental methods to design mobility systems and services with a human-centred approach. We explore the following three complementary topics: urban life and mobility futures, mobility as a service, and future infrastructures. The main research area is the Saclay Plateau, while other French and European cities are considered for comparative studies. We are collaborating with Centrale Casablanca (joint PhD supervision) and Centrale Pékin (Future Cities Lab) to enlarge our vision towards non-European cities.

Indicators for 2020

- 4 ongoing Phd theses
- 1 completed PhD thesis
- 6 journals
- 4 conferences
- 2 research seminar

In 2020 was the first full year of the second cycle of the Anthropolis Chair. Over the course of the year, four PhD candidates joined the team. Yue Sue and Tarek Chouaki started just at the end of 2019 with the respective topics of pickup and delivery problem with electric vehicles, as well as stochastic optimisation and reinforcement learning for the design of an on-demand mobility service by simulation, contributing to the research on future infrastructures. In autumn 2020, Tjark Gall and Mariana Reyes joined the chair, working on human-centred urban mobility futures, as well as mobility as a service respectively.

Various scientific contributions were published and disseminated across virtual events and workshops. In November 2020, the Anthropolis Chair and Future Cities Lab in Beijing initiated a research seminar series which aims at exchanging knowledge and ideas on the ongoing projects within the Chair and Lab and its affiliated and collaborators, as well as at communicating the research progress to external stakeholders. In 2020, two seminars were organized, with ten more scheduled for the first half of 2021.



Publications

Flore Vallet, Jakob Puchinger, Alexandra Millonig, Guillaume Lamé, Isabelle Nicolaï (2020) Tangible futures: Combining scenario thinking and personas—A pilot study on urban mobility. *Futures*, Elsevier, 117, 10.1016/j.futures.

Tarek Chouaki, Jakob Puchinger (Sep 2020) Agent based simulation for the design of a mobility service in the Paris-Saclay area. 23rd EURO Working Group on Transportation Meeting (EWGT), Paphos, Cyprus.

Shaohua Yu, Jakob Puchinger, Shudong Sun (2020) Two-echelon urban deliveries using autonomous vehicles. *Transportation Research Part E: Logistics and Transportation Review*, Elsevier, 141, 10.1016/j.tre.

Future Cities Lab

Partners: Centrale Pekin

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Adam
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Indicators for 2020

- 1 post-doctoral researcher
- 3 new master students (2 in China, 1 in Paris)
- 3 research seminars
- 3 local and international collaborations (Nokia Bell Labs, LGI, Université Laval- Canada)

Research

The Future Cities Lab. is a multi-national joint research initiative between Ecole Centrale Pekin, Beihang University in China and CentraleSupélec in France. The Future Cities Lab is co-financed by the “Région Ile-de-France” and the City of Beijing and is co-directed by Prof. Hai-Jun Huang and Prof. Jakob Puchinger. The aim of the research conducted within the Future Cities Lab. is to address the challenges related to planning, operating and managing increasingly complex future urban systems, in particular with respect to the interdependence between critical infrastructure systems, such as the transportation, the energy and the healthcare systems. In addition, through the joint collaborations, the Future Cities Lab. seeks to act as a foundation to advance knowledge related to these complex challenges as well as a platform for exchange between researchers both from China and France.

In 2020, two research-master students in China joined the Future Cities Lab. to study the challenges related to the integration of electric mobility and its impact on power grids. The respective topics cover, for the case of Beijing

-The techno-economic modelling and assessment of the potential for shared autonomous electric vehicles to provide power grid services;

-The resilience assessment of electric based autonomous mobility systems and power distribution grid;

In addition, a research-master student joined on the French side by fall 2020 to investigate a similar topic focused on Ile-de-France with the aim of facilitating a comparison between the two major urban areas and potentially arriving to significant observations.

Several research collaborations have, also, been initiated; in particular with colleagues from other LGI teams (Economics, Risk and Resilience), as well as a research collaboration on the topic of accessibility in future urban mobility with researchers from Nokia Bell Labs, France and Université Laval, Canada.

The Future Cities Lab. is also participating in animating the research seminar series initiative in collaboration with the Anthropolis Chair.

Call Centers

Optimization of multichannel operations in modern call centers

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Partner:
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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?

- Advertising during waiting: analysis of the impact of advertising 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
- Scientific approach for the development of Interactiv Group products in order to make them more flexible and performant

Publications

B. Legros, O. Jouini, Z. Aksin and G. Koole (2020) Front-office multitasking between service encounters and back-office tasks. *European Journal of Operational Research*, 287(3):946-963.

Supply Chain

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KEYWORDS:

Inventory management
Decision making in uncertainty & agility
Data analytics
Optimization & performance evaluation

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

- Multi-echelon supply chains: how to efficiently manage supply chains with partial information and reverse flows
- Dynamic flow models of supply chains with risks: how to simulate and optimize the behavior of a supply chain to maximize the chance of meeting the customer due date in the context of various uncertainties regarding the duration of activities
- 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
- Supply Chain and data analytics: how to use new data science techniques to optimize supply chain decision making

Risk and Resilience of Complex Systems

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Partners:

EDF (historic partner), SNCF, Orange



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Postdoctoral
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Andréa BELLE
PhD Candidate

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

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.

Publications

• **Zeng Z., Fang, Y. P.,** Zhai, Q., & Du, S. A Markov reward process-based framework for resilience analysis of multistate energy systems under the threat of extreme events. *Reliability Engineering & System Safety*.

• **Bani-Mustafa Tasneem,** Roger Flage, Dominique Vasseur, **Zhiguo Zeng,** Enrico Zio (2020) «An extended method for evaluating assumptions deviations in quantitative risk assessment and its application to external flooding risk assessment of a nuclear power plant.» *Reliability Engineering & System Safety* 200.

• Zhang Nan, Mitra Fouladirad, **Anne Barros,** and Jun Zhang (2020) «Condition-based maintenance for a K-out-of-N deteriorating system under periodic inspection with failure dependence.» *European Journal of Operational Research* 287, no. 1: 159-167



Pascal DA COSTA
Professor
Chair holder



Mehdi SENOUCI
Assistant Professor



Emilien RAVIGNE
PhD Candidate

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 is funded under this Chair and deals with the redistributive effects of climate policies, a highly topical subject.

Keywords:

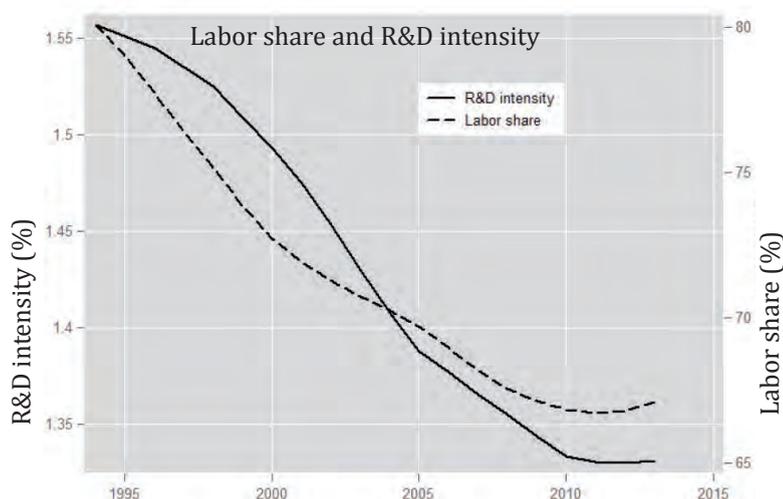
Innovation-based growth, Economics of Climate and energy, Jobs, Inequalities and innovations, Redistributive effects.

Publications

G. V. Houngebnon and **Pascal da Costa**, Declining Labor Share and Innovation, forthcoming.

From Factor-Four mitigation to Zero-Net Emissions: Is a fair transition possible? Evidence from the French Low-Carbon Strategy, F. Gherzi, Franck Nadaud, **Emilien Ravigné** (Dec 2020, Paris) Evaluation des Politiques Publiques, AFSE; Direction Général du Trésor, .

Quels impacts distributifs des politiques environnementales ? What are the distributive impacts of environmental policies? **Emilien Ravigné** (2020) Regards croisés sur l'économie, Association Regards Croisés sur l'Économie.



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 and Innovation
Georges V. Houngebnon & Pascal Da Costa



Technologies hybrides et économie de l'électromobilité

Contact: yannick.perez@centralesupelec.fr



Yannick PEREZ
Full Professor in Economics
Chair holder



Bassem HAIDAR
PhD Candidate

Partners:

PSA Groupe, ESSEC
Electrical engineering laboratory,
GeePs (Centralesupélec)

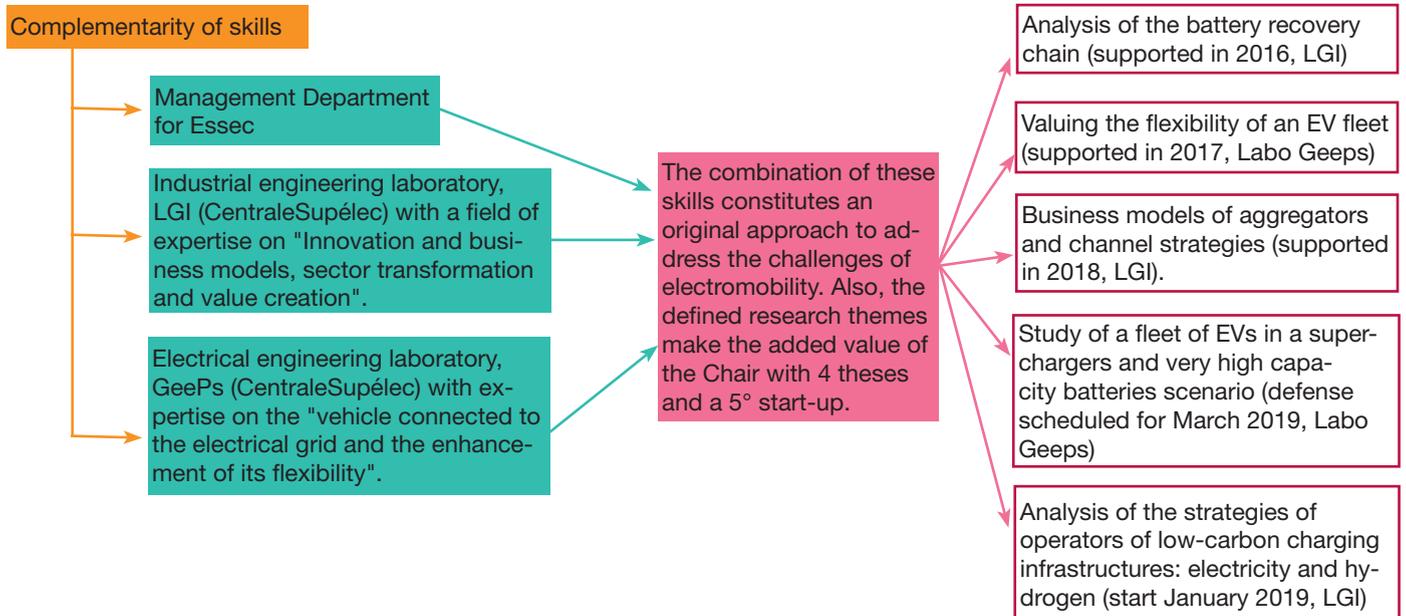
Keywords:

Smart grids, électromobilité, smart charging, infrastructures, modélisation, analyses économiques, analyses de marchés, hydrogène, batteries, tarifs, market design, véhicule to Grids, DSO, TSO, vehicles To everything

Research

The objectives of the Chair

The objectives of the Armand Peugeot Chair, created in 2011, renewed in 2016 and in 2020, 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 Stellantis.



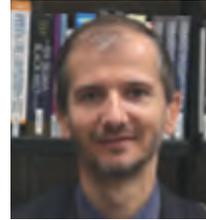
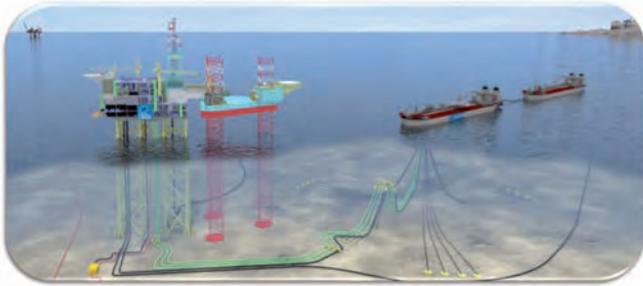
Publications

- Icaro Silvestre Freitas Gomes, **Yannick Perez**, Emilia Suomalainen (2020) Coupling small batteries and PV generation: A review, Renewable and Sustainable Energy Reviews 126.
- Andrew Thompson and **Yannick Perez** (2020), Vehicle-to-Anything (V2X) Energy Services, Value Streams, and Regulatory. Policy Implications, Energy Policy 137.

Managing Procurement Risks in Complex Projects

Partner:
Total

Contact: franck.marle@centralesupelec.fr



Franck Marle
Professor
Chair holder



Meriam Kilani
PhD Candidate

Keywords:

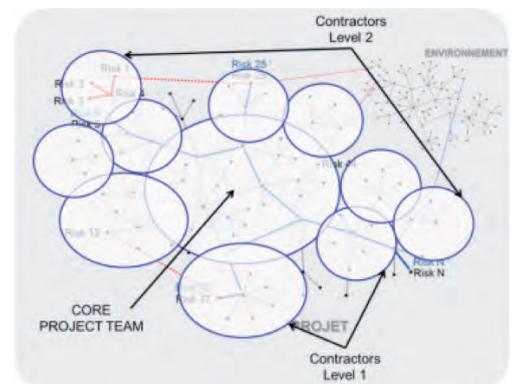
**Coordinated decision-making
interdependence modeling
compatibility
morphological approach
quality function deployment.**

Research

The TOTAL Chair “Managing Procurement 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 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



FlexTech

Human Systems Integration of Increasingly-Autonomous Complex Systems



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Partners: French Air Force, CS Group

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 holder



Andreas Hein
Researcher



Dimitri Masson
Researcher



Eric Villeneuve
Researcher



Chloé Rolos
PhD Candidate



Stélian
Camara Dit Pinto
PhD Candidate

Research

The FlexTech Chair continue to evolve with three PhD students working on Human Systems Integration (HSI) on increasingly autonomous complex systems: (1) function allocation between servicing robots and human operators remotely interacting among each other; (2) experience feedback integration into a digital twin for process control remote management; (3) learning digital twin for remote maintenance of helicopter engines. This research work is carried out with oil and gas industry and a helicopter engine manufacturer.

The PRODEC method for HSI engineering design has been developed and tested on various projects. PRODEC proved to be effective in HSI to better integrate people's requirements into engineering design.

We worked on a man-machine teaming project, MOHICAN, funded by DGA and supervised by Thales. We developed metrics for the assessment of operational performance, trust and collaboration of fighter pilots with virtual assistants. This was carried out based on the use of PRODEC, human-in-the-loop simulations, formative evaluations and agile incremental human-centred design.

Publications

Boy, G.A. (2020). Human Systems Integration: From Virtual to Tangible. CRC Press – Taylor & Francis Group, USA (<https://www.taylorfrancis.com/books/9780429351686>).

Kolski, C., **Boy, G.A.**, Melançon, G., Ochs, M. & Vanderdonckt, J. (2020). Cross-Fertilisation Between Human-Computer Interaction and Artificial Intelligence. In A Guided Tour of Artificial Intelligence Research. Springer Nature Switzerland AG, by P. Marquis et al. (eds.) https://doi.org/10.1007/978-3-030-06170-8_11.

Monitoring of Circular Economy, PEC

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Professor
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Yann Leroy
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Mickaël Saidani
Researcher

The basement of today's consumer society is finding its limits in the face of environmental, health, social and employment challenges. Collective awareness has made it possible to initiate ecological and inclusive transition processes, particularly with the promotion of circular economy. But at the moment, there is no standard or methodological approach that allows a company to move from an impact reduction model towards a positive value creation model. 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 financial institutions demonstrate an explicit intention to generate positive social/environmental impacts through funded projects. They are committed to measuring these impacts to report to stakeholders (including territories) of their contribution to a sustainable economy.

Keywords:

- 2 Internships
- 2 students project
- 1 students' workshop
- 2 technical reports
- 1 round table «**Producible Trade Show**»

The aim of this industrial chair is to build a circularity indicators referential to steer industrial activities as well as investment decisions integrating the evaluation of impact investing.

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.



Prévention et Performance- dans le BTP

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Isabelle Nicolai
Professor



Christian Michelot
Professor
Chair holder



Guilherme Alcantara
Pinto
PhD Candidate

Keywords:

Prevention
Performance
Evaluation
BTP
Indicators
Health
Security

LGI contributes to the research program led by the «Prevention and Performance Chair». The OPPBTP, Vinci Construction Terrassement, Eiffage Infrastructures, Groupe Legendre and CentraleSupélec have decided to join forces to promote a positive approach to prevention at work.

In one of the most accident-prone sectors, the building and public works industry, the Chair's participants have decided to collaborate on the modelisation of interactions between prevention investments and company performance. These interactions will be analyzed by taking into account the economic, organizational and social representations of the building activity. The Chair is made up of a series of projects analyzing the impact of companies' actions in favor of the prevention of workplace accidents.

The P&P Chair includes three axes around the analysis of prevention-performance relationship:

1. Understanding this relationship through research-action in firms
2. Experimenting with this relationship by creating a serious game intended for the construction industry players
3. Managing this relationship by creating relevant indicators that take into account the economic and extra financial dimensions.

The «sustainable economy» team contributes more specifically to the third axis of the chair with a PhD work initiated by Guilherme Pinto Alcantara on the proposal of a dashboard allowing to integrate prevention indicators with the taking into account of their positive and negative impacts on the global performance of the company.

Events 2020:

Conference *Prourable* -
<https://www.prourable.com/>)

