LGI, EA 2606

LABORATOIRE GÉNIE INDUSTRIEL

CentraleSupélec

université PARIS-SACLAY

LGi

Industrial Engineering Research Department

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 (2) as-is and to-be production or activity systems.

These systems' purpose is to deliver adapted and optimal performances and create value 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) Department (Laboratoire Genie 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, ecoparks), complex products (airplanes, cars...), complex factories, transportation systems, health systems, energy networks, service systems and construction systems.

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

The systems studied 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.

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 preference.

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).

TEAMS

LGI is organized in 4 research groups, 5 transversal themes and 5 research chairs. The 5 transversal themes are: Mobility systems, Energy systems, Healthcare systems, Industry of future, Circular economy.

THE RESEARCH AXES OF THE 4 RESEARCH GROUPS

1. Design Engineering (DE)
Design complex products, services and systems, Define design processes and methods, User-centered design, Eco-design and design for a Circular Economy, Systematize innovation, Manage knowledge and skills.

2. Operations Management (OM)
Design and manage the supply chain, Manage production, Predict demand, Manage supply, Manage logistics and transportation, Size the industrial system, Manage health system operations.

3. Risks, Reliability and Resilience (R3)
Analyze and lower industrial risks, Increase system reliability and service continuity, Move from corrective to preventive maintenance, Enable flexibility and resilience.

4. Sustainable Economy (SE)
Modeling and simulating the technico-economy... of the development of electric vehicles and recharging stations, of the French energy mix, of global carbon capture, of the use of hydrogen, Circular Economy.

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

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

THE 5 ENTERPRISE CHAIRS

Supply Chain - *L'OREAL, SAFRAN, SAINT-GOBAIN* - Since 2010
Chair holder: **Evren Sahin**

Risk and Resilience of Complex Systems - *EDF, ORANGE, SNCF* - Since 2010
Chair holder: **Anne Barros**

Open Lab Carbon Economics in Mobility (continuing the Chair Armand Peugeot - Hybrid technologies and the economics of electro-mobility, since 2014) - *STELLANTIS* - Since 2024
Chair holder: **Yannick Pérez**

FlexTech – Human-Systems Integration - From Rigid Automation to Flexible Autonomy - *Armée de l'Air, CS GROUP, THALES / ESTIA* - Since 2019
Chair holder: **Guy André Boy**

Alliance Circular-IT - Digital solutions for circular industrial and territorial ecosystems - *MANITOU Group, General Electric Healthcare, MEWS Partners, Communauté d'agglomération Paris-Saclay (CPS), SIOM (Syndicat Inter-communal des Ordures Ménagères), CSTB (Centre Scientifque et Technique du Bâtiment)/ IRT SystemX* - Since 2022
Chair holder: **Bernard Yannou** assisted by **Ghada Bouillass**

HIGHLIGHTS 2023

Operational launch of the **CircularIT Alliance** (with the start of 4 PhD theses)

Renewal of the **RRSC Chair** (2nd season) and the **Supply Chain Chair** (4th season)

Closing of:

- season 2 of the Anthropolis chair and publication of a collective work: https://link.springer.com/book/10.1007/978-3-031-45795-1
- season 2 of the TotalEnergies Chair: Managing Procurement Risks in Complex Projects

Launch of:

- European ITN Marie Curie Training42Phase project (CS carries 2 WP)
- European ULTIMO project (following AVENUE project) on autonomous buses
- ANR project GreenLocal3D: Global approach for the recycling in short circuit of used plastic by additive manufacturing
- ANR JCJC ResuSpace project (CS carrier)
- ANR AMI PowDev project, part of PEPR TASE (CS holder)

Launch of ***Marcel Boiteux Lectures*** in economy

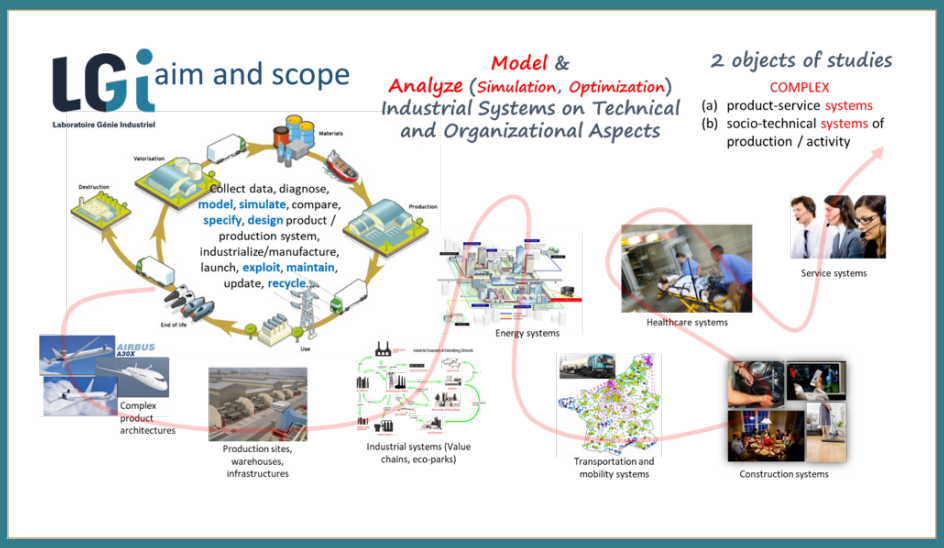

Figure 1
LGI studies production, activity or socio-technical systems along their life cycles

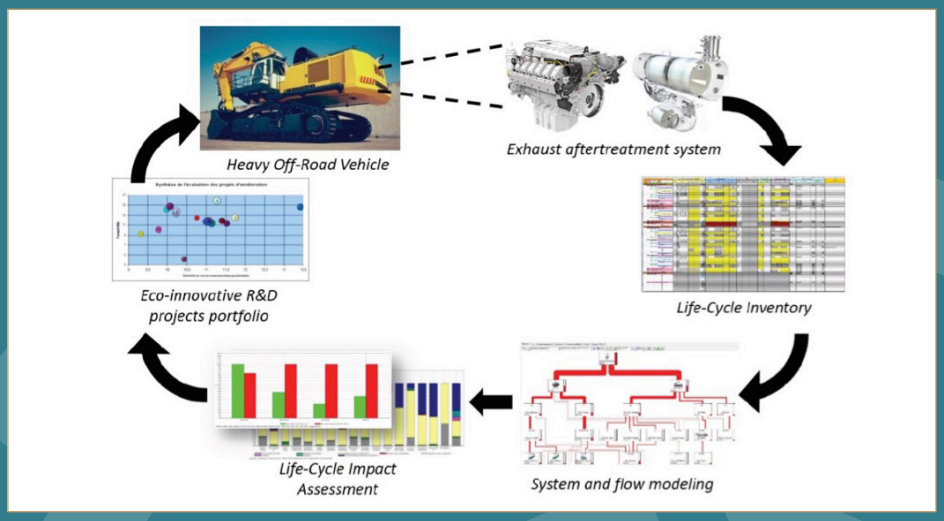

Figure 2
Life Cycle Assessment & Eco-Design of complex industrial systems

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

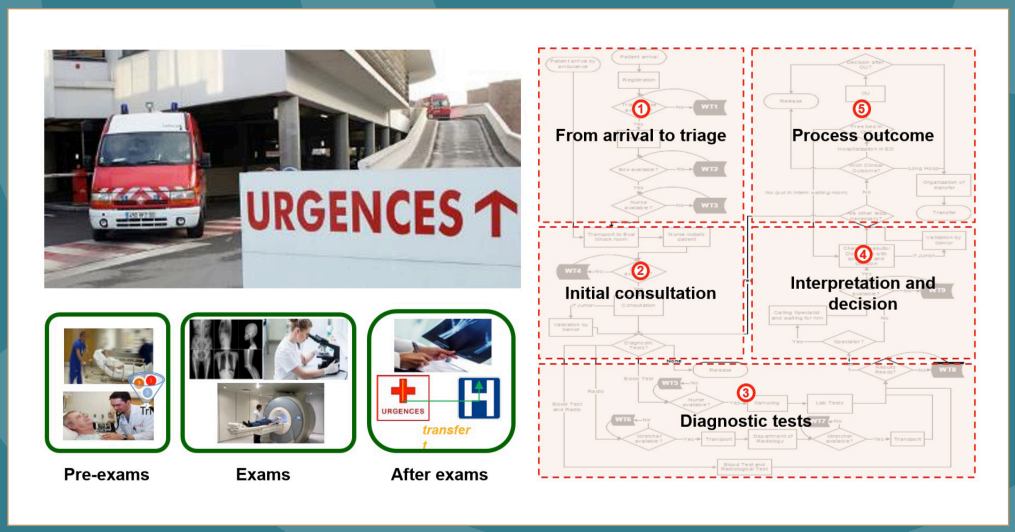

Figure 4
Optimization of patient flows in emergency services

Industrial Partners

- Automotive industry/transport: RENAULT, STELLANTIS, RATP, SNCF, Manitou Group, Style & Design
- Aeronautics and space: THALES, SAFRAN, CS Group, Armée de l'air, ESA
- Energy: EDF, RTE, ENGIE, CEA, AIR LIQUIDE, IFPEN
- Control: SCHNEIDER Electric, SIEMENS
- Consulting: BI Consulting, Mews Partners, ALTEN, IKOS
- Defense: DGA
- Goods: LVMH, L'OREAL
- Construction: EIFFAGE, VINCI CONSTRUCTION, CSTB
- Research institutes: CEA, IRT SystemX, VEDECOM, ARS (Agence Régionale de Santé), INRAE, CSTB
- It & networks: ORANGE, NOKIA Bell Labs
- Health: AP-HP (Assistance publique – Hôpitaux de Paris), General Electric Healthcare, Silver Valley, Institut Gustave Roussy, Hôpital La Pitié Salpêtrière, Hôpital Marie-Lannelongue
- Local authorities: CPS (Communauté d'Agglomération Paris-Saclay), SIOM (Syndicat Intercommunal d'Ordures Ménagères)

Academic Partners

More than 50 collaborations in France and abroad: **Australia** (University of Queensland, Université de Melbourne), **Austria** (University of Vienna), **Belgium** (Université de Louvain, Université de Mons), **Brazil** (UFRJ, PUC, Université de Lavras, UNIFEI), **Canada** (Mc Gill University, ETS), **China** (Beihang University, Ecole Centrale Beijing, Wuhan University of Technology, University of Honk Kong), **Denmark** (DTU), **Egypt** (the American University in Cairo), **Finland** (Aalto University), **France** (ERPI/Université de Lorraine, LISN/Université Paris-Saclay, CRD/Université Paris-Saclay, I2M/ENSAM Bordeaux, Université de Strasbourg, ESTIA, INRAE, UTC, ENSCI les Ateliers), **Germany** (Université de Magdeburg, TU Munich, Friedrich-Alexander University of Erlangen-Nuremberg, University of Mannheim), **Italy** (Université de Catane, Politecnico di Milano, Politecnico di Turino), **Japan** (Chiba University, RITE-Kyoto), **Lebanon** (Université de Beyrouth), **Luxembourg** (Université de Luxembourg), **Marocco** (Ecole Centrale de Casablanca), **Netherlands** (VU University Amsterdam), **Norway** (University of Stavanger), **Poland** (Poznan University of Technology), **Portugal** (University of Coimbra), **Qatar** (Hamad Bin Khalifa University), **Singapour** (SUTD), **Spain** (University of Valencia), **Switzerland** (HEC Lausanne, ETHZ), **Tunisia** (ENIT, ENIM), **Turkey** (Koç University), **UK** (University of Liverpool, University of Bath, The Open University), **USA** (Northwestern University Chicago, MIT, Penn State University, University of Michigan, Clemson University, Georgia University of Technology, Iowa State University, University of Minnesota, University of Illinois at Urbana-Champaign, Illinois University).

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www.lgi.centralesupelec.fr

Director: Bernard Yannou

+33 (0)1 75 31 65 21

bernard.yannou@centralesupelec.fr

Administration: Christèle Simon

+33 (0)1 75 31 66 06

christele.simon@centralesupelec.fr

CentraleSupélec
Campus Paris-Saclay
Bouygues building
9 rue Joliot-Curie
91190 Gif-sur-Yvette